"Wise use of wetlands"

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Wetlands include some of the world's most productive ecosystems and they have a wide range of natural functions which are of value to humanity. Wetlands are also one of the most threatened habitats because of their vulnerability and attractiveness for 'development'. The first global conservation convention, the Ramsar Convention, focused solely on wetlands and it has recently been strengthened and elaborated with regard to the wise use of all wetlands, not just those with statutory protection. This article highlights the functions and values of wetlands and explains how 'wise use' can contribute to their sustainable utilization.

It is now widely appreciated that wetlands, far from being the wastelands of past perceptions, can have a wide range of valuable functions which provide goods and services for humans. Wetlands, for instance, may have local and international significance as regulators of the hydrological cycle both as regards water quantity and quality, as nurseries and habitat for freshwater and marine fish and shellfish, as producers of natural raw materials such as timber and fur, and as refuges for endangered species of plants and animals. The role of wetlands as staging grounds for waterfowl, migrating across international frontiers, has long been accepted. This international role was recognized when the Convention on Wetlands of International Importance especially as Waterfowl Habitat was signed at Ramsar, Iran, in 1971. In addition, the architects of that Convention also required the "wise use" of all the wetlands "within the boundaries of Contracting Parties". This article charts the background to the rapidly growing interest in the functions and values of wetlands and examines the threats to wetlands worldwide. The "wise use" of wetlands is defined and elaborated particularly in the context of the evolution of ideas about conservation as reflected in the developing concept of biosphere reserves by the Unesco Man and the Biosphere (MAB) Programme. Finally, ideas on the achievement of wise use of wetlands are developed through a series of case-studies.

Wetland definitions include three main components (Mitsch and Gosselink, 1986):

- Wetlands are distinguished by the presence of water.
- Wetlands often have unique soils that differ from adjacent uplands.
- Wetlands support vegetation adapted to the wet conditions (hydrophytes), and conversely are characterized by an absence of flood-intolerant vegetation

The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) defines wetlands as ‘areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine waters, the depth of which at low tide does not exceed six metres’ and may include ‘riparian and coastal zones adjacent to the wetlands, or islands or bodies of marine water deeper than six metres at low tide lying within’. In addition, wetlands are ecotones since they are transition zones from uplands to deep-water aquatic systems. This transition position also often leads to high diversity in wetlands and has given some wetlands the distinction of being cited as amongst the most productive ecosystems on Earth (Mitsch and Gosselink, 1986) (Fig. 1).

There are, however, large differences in the productivity of different wetland types, both natural and in relation to human utilization. Table 1 shows that for six African floodplain systems the productivity in kcal/100m^3 of water varies by almost two orders of magnitude. The reasons for the differences relate to the movement of water between surface and groundwater at the various sites, the varied density of human habitation on the floodplains and the type of crops grown. The large productivity of the Bénué, for example, derives largely from the highly developed cultivation of sorghum during the flood-recession phase. A theme common to all of the systems is the importance of protein in the diet and the mostly greater importance of fish over meat (Drijver and Marchand, 1985).

[Figure 1: The relationship between net primary productivity and biomass density (from Etherington, 1983; after Leith and Whittaker, 1975)]

Table 1. The productivity of six African floodplains as a function of water use (in kcal per 100m^3)

Products	Kafùe	Sudd	Niger	Tana	Logone	Bénue
Meat	450	40	83	357	321	96
Milk	964	168	319	1859	820	504
Fish	360	96	401	50	729	447
Rice	0	0	853	1093	962	0
Other	0	0	0	1849	1714	19017
Total	1774	304	1656	5208	4546	20064

Source: Drijver and Marchand, 1985.

Functions and benefits of wetlands

The essential ecological roles of wetlands are translated into important benefits to humankind through the relevant ecosystem elements and functions in Table 2. Specific examples of the value of wetlands from the text Waterlogged Wealth (Maltby, 1986) are:

- **Genetic conservation**. In the 1960s, scientists from the International Rice Research Institute in the Philippines screened almost 10,000 varieties looking for a gene giving resistance against grassy stunt virus, a disease then devastating rice crops. Eventually, just two seeds of Oriza nirana, an Indian wild rice, were found to have the resistant genes. Researchers returned to the wild habitat to collect more but found none with the correct gene. Today, all the world's rice crop contains genes from those two wild rice seeds.

- **Water treatment**. In Waldo, Florida, United States, sewage purification by flooded cypress groves is calculated to be 60 per cent cheaper than comparative mechanical and chemical methods.

- **Nutrient removal**. In many developed countries, agricultural pollution and sewage causes nitrate levels in rivers, lakes and groundwater to reach levels dangerous to health and to cause eutrophication of marine and freshwaters. Plants such as duckweed can remove up to 67 per cent of such nitrogen in their growth, and water hyacinth up to 92 per cent.

- **Freshwater fisheries**. The Inner Delta of the Niger river in Mali produces about 100,000 tons (fresh weight) of fish per year and supports many of the villages in the area.

- **Productivity**. The marshy Niantic river in Connecticut, United States, yields an annual scallop harvest greater than that of prime beef on an equivalent area of grazing land.

- **Firewood**. The mangrove Sundarbans of India and Bangladesh provide a commercial crop of firewood as well as 80 per cent of the fish caught in the Ganges-Brahmaputra estuary.

- **Coastal fisheries**. The value of shrimp fisheries in Thailand has been put at $2,000 per hectare a year.

- **Nurseries for ocean fisheries**. Two-thirds of the fish caught worldwide are hatched or spend part of their life-cycle in tidal areas.

- **Tourism**. Some 5 million Americans spend over $638 million a year on visiting wildfowl refuges in the United States. 250,000 nature lovers visit Texel Island in the Netherlands annually, and wildlife safaris to the Okavango Swamp in Botswana are worth $13 million a year.

- **Flood prevention**. On the Charles river in the United States, the value of wetlands preventing serious flooding has been put at $13,500 per hectare a year.

- **Coastal protection**. At Brisbane International airport, Australia, the cost of planting 51,000 mangrove seedlings in 1981 was $228,271, that is $450 per plant.

- **Energy and carbon dioxide storage**. Peatlands cover 500m^2 per hectare and are important ‘sinks’ of carbon, locking it up in dead plant matter. It has been estimated that organic soils store 500 times the carbon released from burning fossil fuels each year. Their destruction could accentuate the greenhouse effect.

- **Wildlife habitat**. Chinese wetlands are home to over 90 per cent of the endangered Siberian cranes. In the United States, 35 percent of all rare and endangered animals are wetland species.

- **Of all the commercially important North Sea populations**, 60 per cent of the brown shrimp, 80 per cent of plaice, 50 per cent of sole and nearly all of the herring are dependent on the shallow waters of the Netherlands Wadden Sea at some part of their life history.

Table 2 shows the various functions of wetlands and the multiple uses to which they are, or can be, put.

[Photo: A fisherman's wife preparing freshly caught fish on the shore of the Muni lagoon near Winneba in Ghana.]

Table 2. Wetland functions and their human utilization

Role	Elements	Function	Importance to humankind	Unwise use
Store/sink	Rare, threatened or endangered plant and animal species and communities	Genetic diversity Recolonization source	Gene pool Science/education Tourism Recreation Heritage	Excessive or uncontrolled harvest Damage removal or pollution
	Representative plant and/or animal communities	Ecological diversity Habitat maintenance	Gene pool Science/education Tourism Recreation Heritage	Excessive or uncontrolled harvest Damage removal or pollution
	Peat	Nutrient, contaminant and energy store Habitat support Water storage	Fuel, Palaeo-environmental data Horticultural use Heritage Medicinal products	Drainage Harvest faster than accumulation Destruction
	Human habitation sites	Archaeological remains	Heritage/cultural Scientific Recreation	Destruction Lowering the water-table
Pathway	Terrestrial nutrients, water and detritus	Food chain support Habitat support	Food production Water supply Waste disposal	Interruption or abnormal change of flows Pollution
	Tidal exchanges of water detritus	Food chain support Habitat	Fish, shellfish and other food production	Pollution Barriers to flow Dredge and fill

	and nutrients	support Nursery for aquatic organisms	Waste disposal	
	Animal populations	Support for migratory species including fish	Harvest Recreation Science	Overexploitation Interruption of migration routes Obstruction Habitat degradation
	Lakes and rivers	Waterways	Navigation	Obstruction Reduced flows and levels
Buffer	Water bodies, vegetation, soils and depressions	Flood attenuation	Reduced damage to property and crops	Filling and reduction of storage capacity
	Water bodies, vegetation, soils and depressions	Detention and retention of nutrients	Food production Improved water quality	Removal of vegetation Drainage and flood protection
	Water bodies, vegetation, soils and depressions	Groundwater recharge and discharge	Water supply Habitat maintenance Effluent dilution River fisheries Navigation	Reduction of recharge Overpumping Pollution
	Water bodies and peat	Local and global climate stabilization	Equable climate for agriculture and people	Desiccation
	Water bodies	Large volume Large area	Cooling water	Drainage Filling Thermal pollution
Producer	Production of plants	Food, materials and habitat for migratory species and	Harvest of timber, thatch fuel and food Science Recreation	Overgrazing Overexploitation Drainage Excess change to dry land or

		grazing animals		**other agricultural uses**
	Animal production	**Fish, shellfish, grazing and fur-bearing animals**	**Harvest and farming**	**Overexploitation** **Excess change** **Habitat degradation**
	Organic matter	**Methane production** **Nutrient cycling**	**Fuel** **Plant growth**	**Drainage** **Desiccation**
Sink	**Lakes, deltas, floodplains**	**Sediment deposition and detention**	**Raised soil fertility** **Clean downstream channels** **Improved water quality downstream**	**Channelization** **Excess reduction of sediment throughout**
	Lakes, swamps and marshes	**Bio-chemical self-purification** **Nutrient accumulation**	**Natural filter for contaminants** **Treatment of organic wastes, pathogens and effluents**	**Destruction of the ecosystem** **Over-loading of the system**

Source: Hollis et al., 1987.

Threats to wetlands

Wetlands cover 6 per cent of the world's land surface, and are found everywhere, in all climates and countries, from the tundra to the tropics. However, wetlands everywhere are under threat from agricultural intensification, pollution, major engineering schemes and urban development. The conterminous 48 states of the United States had lost, by the mid-1970s, 54 per cent of their original wetlands with 87 per cent of the recent losses being to agriculture (Tiner, 1984). California has lost 91 per cent of its wetlands, the Louisiana delta has been losing l04km2 each year recently (Buffington, 1987) and the national loss rate for wetlands in the 1970s was 185,000 hectares a year (Tiner, 1984).

In November 1986, a fire at the Sandoz chemical plant in Basle (Switzerland) released toxic chemicals into the river Rhine with the resultant transmission to France, the Federal Republic of Germany, the Netherlands and the North Sea. On a longer time scale, the canalization of the Rhine in the nineteenth century reduced its length by over 100 kilometres. This increased stream velocities by up to 30 per cent in some places, caused a fall in the water-table of between 3 and 4 metres over an area up to 3 kilometres from the river and resulted in the river lowering its bed by 3 to 4 metres at Duisburg. As well as the expensive compensatory measures necessary at the port of Duisburg, it has been estimated that in South Baden the desiccation caused agricultural damage of $139 million, damage to forestry of $24 million, and fisheries suffered by $8 million (Braakhekke and Marchand, 1987). These disadvantages seriously detract from the economic advantages accruing to navigation interests from shortening the river.

A plan to construct six dams on the rivers feeding the internationally important wetland at Ichkeul in Tunisia has been shown to be likely to change this 126km2 lake and marshland. Hundreds of thousands of waterfowl winter on the freshwater lake and others pause there for food both before and after migrating over the Sahara. The dam scheme will raise salinities in most years to those associated with the sebkhas common in the Maghreb, kill off the waterfowl’s food plants, make grazing impossible on the marshes and destroy the fishery associated with the lake. However, a sluice is planned to control water exchanges with the sea but even when this is completed, insufficient river water is likely to pass into the lake to prevent significant ecological changes.

Ichkeul will remain seriously threatened until the present policy of extracting the maximum amount of water possible for potable supplies and irrigation is modified. A ‘wise use’ strategy of water allocation would recognize more fully the substantial benefits from a $600,000 per annum fishery, grazing resources in the dry season for around 3,000 animals, internationally important concentrations of waterfowl and a nationally unique tourist attraction.

In West Africa, Ketel et al. (1987) have identified 114 dam projects, which are likely to have an impact on wetlands, with 51 per cent operational at present. They also list seventy-eight other ‘wetland intervention’ projects in the region and conclude that ‘there is no clear indication that the total number of dams planned is decreasing because of environmental or social problems related to these projects’. This is surprising since there is growing evidence that, even on short term economic grounds, large-scale irrigation schemes are often less efficient than traditional small-scale systems. Table 3, for example, compares the efficiency per unit of water of traditional extensive systems of cultivation, grazing and fishing with an intensive modern irrigation project. whilst both systems produce about the same gross profit margin, the extensive system produces a wide range of foodstuffs compared with the rice-only irrigated system. In addition, when the interest charges arising from the irrigation scheme are taken into account, the net profit from the irrigated rice turns into a loss of $0.65 per 100m^3, whilst the extensive traditional methods benefit from the 'free services of nature' and turn in a net profit of $0.42 per 100m^3 (see Table 3).

Table 3. Productivity per 100m^3 of water for a natural floodplain (inner delta of the Niger) and an irrigated rice scheme (Office du Niger)'

	Niger inner delta					**Office du Niger**	
	Meat	**Milk**	**Fish**	**Rice**	**Total**	**Rice**	**Total**
Total weight(t)	**10**	**118**	**100**	**78**		**100**	
Weight/100m3 (g)	**44**	**506**	**427**	**235**		**5 003**	
Value/100m^3($)	**0.02**	**0.20**	**0.17**	**0.03**	**0.42**	**0.55**	**0.55**
Protein/100m^3(g)	**8**	**17**	**77**	**18**	**119**	**190**	
Energy/100m^3(kcal)	**83**	**318**	**401**	**853**	**1 656**	**13 749**	
Inputs/100m^3($)						**0.12**	
Fertilizer	**0**	**0**	**0**	**0**	**0.01**		
Management	**0**	**0**	**Very small**	**Very small**	**0.08**		
Oxen etc.	**0**	**0**	**Very small**	**Very small**	**0.03**		
Profit margin per 100m3 ($)					**0.42**		**0.43**
Loss of interest per 100m^3 ($)					**0.00**		**1.08**
Net profit per 100m^3 ($)					**+ 0.42**		**- 0.65**

1. The assumptions underlying this table are detailed in Drijver and Marchand, 1985.

Source: Drijver and Marchand, 1985.

Adams (1985) examined the downstream impacts of a dam and irrigation scheme in the Sokoto valley in northern Nigeria. The Bakolori dam was built in the mid-1970s to supply a 30,000-hectare irrigation scheme. The dam reduced the magnitude of the wet-season floods which supported an extensive and sophisticated agricultural system and a fishery upon which 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 showed how a more complete economic appraisal of the scheme at Bakolori would have been less favourable than the calculation upon which it was approved.

[Photo: A Ghanaian fisherman works with his son on the afternoon’s catch from the coastal lagoon.]

[Photo: Fishermen at work in the Muni lagoon near Winneba in Ghana.]

‘Wise use’ of wetlands: the Ramsar Convention and Unesco biosphere reserves

Whilst the original documentation of the Ramsar Convention did not define ‘wise use’ nor identify ways in which it could be achieved, it has been the subject of conference resolutions. The first conference at Cagliari (Italy) in 1980 approved a recommendation emphasizing that wise use of wetlands involves establishment of comprehensive wetland policies based on a nation-wide inventory of wetlands and their resources. The next conference at Groningen (Netherlands) in 1984 adopted a recommendation which identified Action Points for Priority Attention in the field of wetland conservation. Its annex listed national measures which would promote wise use.

The original signatory members of the Convention, predominantly developed nations, have generally implemented the wise-use requirement through the establishment of specially protected sites. This approach now needs to be expanded because such a large area of the world's wetlands has now been lost and the varied functions of wetlands and the multiple demands made upon them have become widely appreciated.

In most developing countries the rural economy is closely dependent upon the productivity and hydrological benefits of wetlands. There is a most urgent need in these countries to maintain wetlands and to establish a mechanism for environmentally sound management, or wise use. The need to broaden the concept of wise use under the Ramsar Convention beyond specially protected areas mirrors very effectively the evolution of the concept of the Unesco biosphere reserves since their launching in 1971.

Originally, biosphere reserves aimed at the 'conservation of natural areas and the genetic material they contain'. Recent discussions have emphasized that local populations have a constructive role to play and human utilization should not be excluded from the biosphere reserve concept (Unesco, 1986). Batisse (1986) has argued that nowadays a biosphere reserve has three basic foci:

- Conservation and protection of natural areas.
- Research of international significance.
- Development of problem-oriented research, demonstration, education and local participation programmes.

Each biosphere reserve includes one or more core areas which are strictly protected and consist of typical samples of natural or minimally disturbed ecosystems. The core areas are normally surrounded by a buffer zone, which must be strictly delineated and often corresponds to a single and autonomous administrative unit. The core areas and the buffer zone are surrounded by a transition area which may also constitute a protective buffer, which often may not be strictly delineated and corresponds more to a biogeographic than to administrative limits (Batisse, 1986). For wetland biosphere reserves, the transition area could be defined hydrologically as the entire basin feeding water to the wetland. This would allow the managers of such reserves to utilize an integrated river basin approach for the management and conservation of wetland biosphere reserves and the human utilization of the surrounding buffer and transition areas (Holland, 1987).

Defining wise use

Acknowledging the work of the International Union for the Conservation of Nature and Natural Resources' Wetlands Programme Advisory Committee (Hollis et al., 1987), the 1987 Regina (Canada) Conference of the Parties to the Ramsar Convention adopted the following definition: 'The wise use of wetlands is their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem'.

The conference noted that sustainable utilization is 'human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations'. The natural properties of the ecosystem were defined as 'those physical, biological or chemical components, such as soil, water, plants, animals and nutrients, and the interactions between them'.

This definition draws attention to the maintenance of not only internationally important wetlands, but all those which bring benefit to humankind, even if only on a local scale. The reference to 'natural properties of the ecosystem' provides a clear insight into what natural functions need to be maintained by wise use. The components that support a wetland often originate well outside its boundary. Similarly, the benefits that wetlands provide to society are frequently manifest beyond the wetland. Wise use of wetlands therefore often requires that appropriate conservation measures be taken beyond the boundary of the wetland. For example, ensuring a continued supply of water of appropriate quality may require soil conservation measures in the headwaters, minimal upstream diversions of river-water, and the protection of water courses from industrial pollution. When these ideas are fused with Batisse's (1986) schematic distribution of biosphere reserve functions, the diagrammatic representation in Figure 2 results.

Achieving wise use

Wise use of wetlands clearly requires action on an extensive scale, giving consideration to all factors affecting the wetland. This will probably cut across the traditional administrative responsibilities of government departments. Careful synthesis and integration is likely to result in national wetland policies. The major items for developing such policies should include:

- A national inventory of wetlands.
- Identification of the benefit and values of these wetlands.

- Definition of the priorities for each site in accordance with the needs of, and socio-economic conditions in, each country.
- Proper assessment of environmental impact before development projects are approved, continuing evaluation during the execution of projects, and full implementation of environmental conservation measures which take full account of the recommendations of this process of environmental assessment and evaluation.
- Use of development funds for projects which permit conservation and sustainable utilization of wetland resources.

In the developed world where agriculture and other land uses are intensive, most human uses of wetlands destroy wetland elements and functions. In those countries major wetlands usually require protection within national parks or reserves. Realization that wetlands cannot be managed in isolation from upstream inputs and the flow of benefits downstream as well as off-site, has led to the development of wetland legislation and policies at the local and national level. In addition to the creation of parks and reserves, legislation may require that alteration of wetlands and stream courses tributary to, and downstream from, the protected site may be subject to regulation. Ironically, because of the destruction of wetlands in the past and the reduction of wetlands areas in developed countries, such a rigorous approach to wetland conservation is now politically possible.

Most wetlands in developing countries, and in the undeveloped areas of rich nations, retain a wide range of their natural functions. Many. rural economies in Africa, South-East Asia and the Arctic regions of Canada are dependent on the utilization of these wetlands. Accordingly, it is neither practicable nor desirable that all extractive activity be precluded from all wetland systems. Rather, mechanisms for sustainable utilization of wetlands and wetland resources need to be developed and promoted. Such wetlands are the core of an extensive system of multiple use and environmentally sound management of the wetland resources. Figure 2 suggests that the wise use of wetlands requires the integration of the work of hydrologists, ecologists, marine experts, agronomists and soil scientists within a framework set by the local population. Environmentally sound management requires management plans to be drawn up in close collaboration with the communities dependent upon the wetlands. In many cases the elaboration of pilot projects which demonstrate and promote wise use will be required.

Since the 1960s many wetlands have been destroyed through projects that have sought unsuccessfully to develop the rural economy by changing these wetlands without regard to their sensitivity. This experience has demonstrated that in developing countries the fundamental principle for sustainable utilization of wetlands is the management of wetlands as part of complex systems. The development community and national governments now have a major opportunity to conserve wetlands and so contribute to sustainable development by ensuring that this principle is adhered to in future investment policy. This wise use of wetlands thus makes them an asset rather than an obstacle for sustainable development.

[Photo: Fishermen's wives prepare the catch on the edge of the freshwater portion of the Panbros lagoon near Accra, Ghana. The road where the people are sitting was built for the salt pans which are behind the people.]

[Photo: Two fishermen use a seine net in the Sakumo lagoon near Tema, Ghana. Most of the fishermen who work this lagoon have jobs in industry but many of them use their free time to catch fish to help feed their families.]

[Figure 2: A schematic representation of the natural properties and components in the wise use of a wetland incorporating aspects of the current Biosphere Reserve concept (modified from Batisse, 1986).]

Case-studies of wise use

A river basin approach to biosphere reserve management, Manu, Peru

Manu National Park comprises, in an almost undisturbed state, the entire Manu river basin and part of the Madre de Dios river basin. The total area of the Manu biosphere reserve is 1,881,200 hectares, of which 1,532,806 hectares are national park, 257,000 hectares are in the reserve area, which acts as a buffer zone, and 91,395 hectares are included in the cultural area. The area has long been inhabited by tribes of Indians, among them the Machiguengas, the Yaminahuas and the Amahuacas. Whilst there are development pressures from technologically developed groups around the edge of Manu, researchers have suggested that the local populations of Indians are not involved in these ecological changes (Gonzales, 1981, Olano, 1986).

Research for more than ten years at the Cocha Cashu Biological Station reveal that the diversity of plants and animals in the Manu National Park far surpasses that of any other protected area (Peru, 1986). For example, in only 4 km2 of forest around Cocha Cashu, 550 species of birds and 1,147 species of vascular plants have been recorded. Recent work conducted at the Cocha Cashu biological station suggests that forest disturbance due to modern and past river dynamics is partially responsible for the high biological diversity in the upper Amazon basin in part because many distinct habitats are generated by erosional and depositional activity of rivers (Salo et al., 1986). Thus the fact that the Manu biosphere reserve encompasses the entire Manu river basin not only guarantees the maintenance of good water quality in the river and thence the biological and genetic diversity of the area, but also allows riverine ecologists an opportunity to test hypotheses in a protected complex of wetland habitats which may serve as a ‘control’ for other similar riverine systems throughout the world.

A national planning framework: the Master Plan for Water Resources in Norway

The development of watercourses in Norway for decades created the basis for steadily increasing production and use of energy (Norway, 1985). This development took place, however, without a co-ordinated plan for the whole country. Moreover, in the last few years, conflicts with other users have become progressively greater and the so-called hydro-power epoch is now acknowledged to be drawing to a close. It became essential to consider the exploitation of the remaining watercourses in a larger perspective, which took into account other user interests. The Master Plan for Water Resources has been prepared by the Ministry of Environment in collaboration with the Ministry of Petroleum and Energy, the Norwegian Water Resources and Electricity Board and other relevant authorities. It provides a professional basis for evaluation through studies of: hydro-power; nature conservation; outdoor recreation; wildlife and fish; water supply and pollution; preservation of ancient monuments; agriculture and forestry; reindeer cultivation; protection from flooding and erosion; transport; ice and water temperature; and climate and regional economy. This is a formidable but ‘wise’ list.

A local management plan: Panbros lagoon, near Accra, Ghana

The Panbros lagoon west of Accra in Ghana is, in many respects, typical of the hundreds of coastal lagoons of West Africa. It has a high productivity for fish and crabs; it yields thousands of tons of commercially exploited salt; its occasional overflows take nutrients, detritus and young fish into the sea; it probably meets the Ramsar criteria for international importance for its migratory waterfowl and has many bird species breeding within it; the river feeding it is the source of the potable water for about half of the 1.4 million inhabitants of Accra; and the water-works reservoir supports a flourishing fishery and marginal rice fields. At present, all of the environmental regulations for the Panbros lagoon are single function rules.

A Management Plan for the Panbros lagoon is being developed by the Ghanaian Game and Wildlife Department. An international training course in wetland management and bird protection sponsored by the Department, the Royal Society for the Protection of Birds (RSPB) in the United Kingdom, and World Wildlife Fund International has produced an initial draft of this plan. The plan advocates an integrated view of the resources of the whole basin. Rules are proposed to manage the water-level in the lagoon for the benefit of salt extraction, fish production and wildlife. An extension of the operating rules for the reservoir could provide for the early flooding of the lagoon and its marshes in order to maximize the duration and extent of the productive inundation. Likewise a more secure future for the rice farmers around the reservoir could be provided by careful manipulation of its water-level. Such wise use of the lagoon and its resources requires no major capital expenditure and yet it could permanently increase supplies of rice and fish, conserve an important habitat with its diverse flora and fauna including international bird migrants, and develop the economy of the many villages around the lagoon.

The Weija dam was built to replace a smaller dam that failed in 1968 with substantial loss of life. The new dam at Weija was constructed with a view to the escalation of water needs and, at present, it has considerable spare storage capacity. Its operational rules presently require a top water-level below that strictly necessary for the safety of the structure, a daily supply of 91 Ml/day to the capital of Accra and a maximum release of no more than 198 m^3/sec to safeguard an important downstream road bridge. The private operator of the salt pans in the lagoon maximizes production by preventing freshwater flooding of his pans. He does this through informal discussions with the dam manager to limit releases or the bulldozing of the sand bar to provide an open link between the freshwater part of the lagoon and the sea. The fishermen of the lagoon have to accept the natural regime as modified by the dam and the bulldozer, the rice farmers have no way of preventing the reservoir inundating their fields and the considerable nature conservation interest of the lagoon is, as yet, without positive management.

National inventories: New Zealand

Two wetlands inventories are presently under way in New Zealand. The National Wetlands Inventory (NWI), undertaken by the New Zealand Acclimatisation Society, emphasizes habitat, wildlife and recreational uses of wetlands and provides a data base for management of the local wildlife resource. The Wetlands of Ecological and Representative Importance (WERI), undertaken by the New Zealand Commission for the Environment, focuses on wetland classification and values and identifies representative wetlands (Simpson, 1985). The two inventories are complementary [-] The WERI as an urgent response to protect wetlands, the NWI as a long-term process to assist wetland management. Us[ing] the WERI methodology, each wetland can be classified in an ecological hierarchy according to hydrological character, landforms, biological communities and the dominant plant species. The prime objective of WERI is to compile existing information on wetlands and transform these data into a form suitable for assessing wetland values (Simpson, 1985, p. 9):

As the inventory is being compiled, wetlands are being destroyed through land development processes largely funded by the tax payer. . . The inventory is a tool to assist the implementation of any new policy. Like the cutting down of native forests, the destruction of wetlands was once more central to our cultural development. That phase of necessity is over . . . WERI reminds us that the time for change is long overdue.

The legislative approach: federal laws in the United States

Historically, there has been a strong but fragmented federal role in the management of water resources in the United States. During the past century, federal programmes evolved from single purpose projects to include multiple benefits derived from water development programmes. Until the 1970s the primary emphasis of federal involvement in water resources management was economic, as marked by the development of the Principles and Standards which established the framework from which federal agencies conducted the cost/benefit analysis, fundamental in deciding if a project would be approved. The federal agencies which were traditionally responsible for implementing wetland related programmes - U.S. Army Corps of Engineers, the Bureau of Reclamation, Soil Conservation Service, and Tennessee Valley Authority - are largely civil engineering, construction-oriented agencies (Holland and Balco, 1985).

As a result of the environmental movement of the 1970s, many federal and state programmes began to shift from emphasis on economic benefits towards considering the impact of human actions on ecosystems. The most conspicuous federal example is the passage of the National Environmental Protection Act (NEPA) in 1969. Those federal agencies that did not take the NEPA mandate too seriously soon found themselves in the courthouse losing their cases, and in some instances, their programmes (Holland and Balco, 1985).

More recently, under the Emergency Wetlands Resources Act of 1986, the U.S. Fish and Wildlife Service was directed by Congress to designate and acquire wetlands having broad socio-economic values. The Service's Research and Development Activity has led the way in providing the basis for classifying and inventorying wetlands. This provides the statistical basis for determining whether these habitats and their diverse species are increasing, decreasing or stable. This inventory technique has now been made part of the operational arm of the service, in the National Wetlands Inventory, which continues to inventory and map the wetlands of the United States (Buffington, 1987).

Conclusions

The wetlands scattered across the globe today are the product of many years of geological, hydrological, and meteorological processes, combined with the activities of living organisms, and overlain by human land-use patterns. Wetlands management must take into consideration that wetlands are dynamic systems that change over time. Just as the wetlands themselves have changed, management strategies have evolved to reflect a general increase in scientific knowledge. In the history of wetlands protection the year 1971is important because the Ramsar Convention was first adopted and the initial concept of biosphere reserves was initially introduced. Ideas on both the Ramsar Convention and biosphere reserves have changed and developed over the last sixteen years. These changes have led to an appreciation that the wise use of wetlands requires a broad view of wetlands as part of a whole basin (including upland hills to coastal marshes) as well as a perception of the wetland within the complexities of human social and economic systems.

Perhaps this overview can serve as a reminder that plans for the wise use of wetlands should be co-ordinated with local, regional, national and international organizations to include a whole basin approach for management and protection of these complex and diverse systems. Acceptance of wetlands as highly productive ecosystems with a wide range of functions important to humans has grown, along with the recognition that losses and threats to these systems are severe. When wetland destruction becomes a socially unacceptable activity, we shall know that the message about the wise use of wetlands has finally been heard.

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