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Approaches to Maintain Biodiversity in Irrigated Landscapes

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Introduction

Developing and managing water for agriculture has been and will remain instrumental in providing food and livelihood security. However, this has come at a high environmental price. The costs range from progressive degradation, fragmentation and drying up of aquatic and terrestrial ecosystems through to their total and irreversible loss, affecting valuable ecological services on which people also depend for their livelihoods. Given this context, is it possible to change the way business is done, and manage water in agriculture to meet the goals of food, livelihoods and environmental security?

Given this inevitable use of water for agriculture, is possible to do irrigation in a way that better supports biodiversity and healthy ecosystems? There are indeed many ways to do this, often not very costly or difficult to implement. Major challenges though are to mainstream these solutions into design and management processes, and to devise incentives for their implementation. Here we list some possible on-site options within irrigation to mitigate damage or promote more sustainable ecosystems.

On-Site alternatives for mitigation of impacts:

Within irrigation systems there are a number of options that will have the potential to maintain or enhance biodiversity. Many of these are not necessarily expensive or difficult.

Maintain habitat integrity and connectivity
The strategy is to maintain natural or desired vegetation or waterbodies within the irrigated landscape to provide habitat for plants and animals. Even if land and water bodies must be converted to irrigated agriculture, some non-crop habitat should be kept intact. In addition to this habitat, provide connectivity between habitat locations.

A number of well-established ecoagriculture strategies that can be applied within irrigation, such as hedgerows and corridors of natural vegetation interconnecting parcels of irrigated land (McNeely and Scherr, 2003 provide numerous case examples). In large irrigated areas, canals and roads often lined with trees are dominant features of landscapes, and can serve as important

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passages for biotic movement and as habitats. Hydraulic structures often block pathways. While these cannot always be prevented, they managed to enhance connectivity. At critical times, canals should have water, requiring that gates or sluices should not necessarily be closed. Trees and vegetation along canals is often targeted to be removed. Keep in mind their value as providing habitat and connectivity before taking such actions.

Promote diversity in landscapes (landscape mosaics)
One reason that traditional tank cascades in Sri Lanka support biodiversity is that they provide mixed, heterogeneous landscapes – small tanks, irrigated paddy fields, forests, and villages in small areas. In many larger irrigated landscapes, it is important to break up large mono-cropped areas by identifying, and create landscape mosaics. These protect and link natural habitat patches and provide for elevated biodiversity (Case 1 and 2).

Choose the right infrastructure and operation:
Most infrastructure considerations are based on functions of delivering water to crops – flexibility in delivery and storage so that water can be used when crops need it. More attention needs to be paid to infrastructure that supports the multiple uses of water. For example, canal designs that allow for movement of fish may not require so many weirs and gates. Unlined canals may better support flora and fauna. Dual canal systems can allow delivery of different quantities of water over variable time intervals to two types of crops. For example, the Walawe Left Bank irrigation canal system currently under construction in southern Sri Lanka is intended to provide for different water delivery regimes for paddy and banana crops. Modification of larger-scale hydraulic infrastructure, for example, through the provision of dam multiple release outlets rather than single near-bottom releases, as well through changes in the operation of dam releases generating downstream flow regimes, can result in enormous reductions in ecological impacts on-site, as well as off-site.

Social mobilization
Engaging local communities dependent on irrigation, including farmers and other stakeholders in the process of biodiversity conservation is a critical element of managing water sustainably for meeting food and environmental needs. Awareness raising on the implications of alternative regimes of water use and the tradeoffs is essential. This can be done through workshops, public awareness campaigns, and through normal meetings of water users.

Promote institutions to support sustainable irrigation
Local organizations and supporting laws and regulations play a key role in ensuring effective, sustainable and equitable management of water for agriculture. Participatory irrigation management involving communities is an effective way of dealing with local problems. Typically efforts have been placed on mobilizing communities and strengthening organizations to manage irrigation delivery and maintenance, and less emphasis on overall natural resource management. Local organizations could certainly be engaged in maintaining healthy ecosystems within the irrigated area.

***Off-site alternatives for mitigation of impacts*:**
Irrigation alters hydrologic flow paths to deliver water to crops and drain it away, thus impacting the quality and quantity of river/wetland flows, all of which affect the ecological character of systems. Managing irrigation systems so as to maintain environmental water requirements for wetlands can serve to greatly minimize the impacts of irrigation. These off-site effects are not

often the direct concern of irrigation managers serving farmers. But they are of major concern to water and overall resource managers.

Environmental Flows

The hydrological regime and its natural variability are recognized as central to the structure, functioning and biodiversity of wetlands (Richter *et al.*, 1997b). Various hydrologic events comprising the regime link to specific ecological functions. For wetlands to be able to retain their character or some level of degradation accepted by society, and thereby provide ecological services to humans, both their water quantity and quality requirements must be defined and met - the science of environmental flow assessment (Tharme, 2003; Dyson *et al.*, 2003). As ecosystems and their species are known to be dependent on complex combinations of higher flows/flood pulses as well as low flows, it is increasingly recognized as insufficient to deliver a single bulk quantity of water to rivers, distributed in an unvarying manner over time. Rather, water needs to be managed to make sure that natural flow patterns are mimicked to the extent possible or agreed in terms of the desired future condition of the ecosystem (Richter *et al.*, 1997b). There has been considerable work on approaches for determining such ecosystem water requirements (environmental flows), to support biodiverse, healthy ecosystems both in their role as users of water and as the base of the freshwater resource - Tharme (2003) describes a range of methodologies in use globally at present and highlights their relative merits and limitations.

Even if the required environmental flow to maintain a certain level of ecosystem functioning is known, getting that water to the right place at the right time is another matter. Two additional procedures are required – first a formal, negotiated allocation of water to the ecosystem within the basin allocation and tradeoff process, and second an actual distribution of supplies (i.e. the implementation and follow-up monitoring phase). Water allocation rules are put in place to ensure that various parties receive a portion of developed water supplies. These are important for irrigation at two levels: within the irrigated area, and within a river basin. While allocation of water to farmers is the norm for irrigated areas, it is uncommon to find allocations to environmental uses. Similarly within river basins, allocations to cities, industries and agriculture commonly have been in place, but now more and more there is at least recognition of the need to allocate some water to the environment - increasingly, this is being based on observed direct linkages between changes in ecosystem character and the delivery of important ecological services to people (e.g. fish as food, high quality drinking water, riparian trees for house construction, and so on). A first step in allocating water equitably and in a sustainable way that addresses the concerns of all users, including ecosystems, is for all users to get a seat at the table and negotiate out how much allocation is required. Once the allocation has been made, the next step is to actually deliver the water to the use. Very few examples of operational implementation exist or of follow-up at present (Tharme, 2003; Postel and Richter, 2003).

River Basin Management (IWRM)

As impacts occur at larger scale than the irrigation system, or outside of the irrigation, institutional arrangements need to incorporate means to deal with both on-site and off-site effects. Nested institutional structures can help deal with the problem. Irrigation organizations that have the responsibility of delivering water service to farmers may not by themselves be responsive to downstream problems they cause, unless there is another authority to deal with the problem. River basin organizations in theory should be able to manage these larger scale upstream-downstream issues, while not having to manage the details of irrigation service delivery.

Managing for Multiple Uses

Irrigation managers typically deliver services to crop-based farmers. Yet activities like livestock and fisheries are integral components of agriculture that seem to be neglected in the development and management of irrigation (for example the Walawe Left Bank project – Case 2). In this sense, fishers, herders, use of water for drinking and small industrial activities, and people dependent on other ecosystem services are 'off-site', external to their management regime. An action then is to internalize these non-crop irrigation uses of water into management, and include these stakeholders in water allocation and overall management decisions.

Conclusions

It is possible to design, construct, and manage irrigation systems to maintain and in some instances, even enhance biodiversity. Many of these solutions are not necessarily high cost, nor difficult to implement. The problem is that these are not mainstreamed into design and operation procedures for irrigation, and in training programs for engineers.

This conclusion is important because of the significant negative environmental, social/livelihoods and other impacts from irrigation development offsetting significant economic and poverty reduction gains. Irrigation systems, which are designed without enough consideration of the ecological consequences, can seriously alter environmental balance. As a consequence, biodiversity, livelihoods, and even long-term productivity are threatened. Dealing with the negative effects of irrigation development and management is a priority issue.

A high degree of biodiversity can and does exist in irrigated landscapes. Roles of biodiversity need to be better understood - in terms of agroecosystems, maintenance of ecological character of natural systems so as to provide ecoservices. There is a need to continue to assess natural resource use by people and its economic and broader livelihoods value. There is increasing evidence of the importance of access to and use of natural resources by rural poor. There are a number of ways to maintain and protect biodiversity and bright spots from which lessons can be learned on how to enhance biodiversity in irrigated landscapes. Traditional irrigation practices have much to offer in best practice management. While we have listed a few examples in the paper it would be worthwhile to further compile these practices to spread lessons learned.

The challenge in the very near future is to bring about some fundamental changes about how we think about, design, and manage irrigation. There are ways to do irrigation much better, but it is necessary to spread this knowledge, and get the incentives right so that ecoagriculture practices in irrigation are implemented. Several actions are required for this to happen including gaining a better understanding of positive and negative impacts and why they occur, developing practical solutions, spreading the knowledge, and getting the incentives and institutions in place to support ecoagriculture in irrigated landscapes.

Case 1: Positive impacts of agriculture on wetlands: small tank systems of Sri Lanka (adapted from Vidanage & Kallesøe 2004).

Sri Lanka has one of the oldest traditions of agriculture in the world, dating back to 500 BC. A hydraulic civilization has evolved since that time of localized irrigation schemes, predominantly for rice cultivation, centered on cascades of small tanks (water storage reservoirs). Within the country's dry zone, there are thousands of such ancient, man-made wetlands of varying sizes and forms, some operational and others abandoned. During the rainy season they provide water for local cultivation and domestic supply, while their frequent drying-out in the dry season allows for livestock grazing. They are also recognized as constituting one of the richest sources of biodiversity in the country. Many such traditional tank systems are under increasing threat, largely from their marginalization in favor of the seemingly more productive uses of 'modern' large-scale irrigation and hydropower, as well as accelerated siltation and eutrophication, endangering both livelihoods and environmental security.

Some 600 small tanks in the Kala Oya Basin, northwestern dry zone, occur in conjunction with a large-scale irrigation scheme, the Mahaweli Irrigation Expansion Project, with the latter the recipient of 65% of basin water. Some 400 000 rural people are engaged in farming as their principally livelihood source, half of whom are poor (monthly income below US$ 15). A socio-economic assessment of 429 tanks revealed that they are used for cultivation of rice and other crops (with values per total inundated tank area of 216-39 US$/ha/year for individual crops), as well as domestic uses (1469 US$/ha/year) such as bathing, clothes washing and household water supplies, and water for livestock (335 US$/ha/year). They also provide many other ecological services (in US$/ha/year): fish (351), lotus flowers for use in Buddhist temples and ceremonies (72), lotus roots and other edible plants as food (107), as well as reeds and wild animals. Other services not addressed in economic terms include hydrological functions (mitigation of downstream flooding, replenishment of groundwater reserves), nutrient retention and purification. These uses amount to an average value of US$ 425 per household per year, and almost US$ 3000 per hectare of inundated area. Benefits were greatest for the poorer families for whom alternative sources of income and domestic water supply were limited.

Case 2: Expansion without extinction: biodiversity conservation in irrigation systems, southern Sri Lanka (Tharme and others, unpubl. data).

The agricultural sector plays a major role in Sri Lanka's economy, and irrigation has received a high priority in development initiatives, contributing to greater agricultural productivity and improved livelihoods for the rural poor. It also has resulted in widespread loss and degradation of the island's ecosystems, in addition to knock-on socioeconomic effects due to declines in the provision of valuable ecological services to people. Biodiversity in Sri Lanka is especially vulnerable to large-scale developments because of the island's small size, and increasing population pressure on its already highly fragmented natural landscape - an estimated 560 animal and 690 plant species are presently threatened with extinction.

An existing irrigation system in the Walawe Catchment of southern Sri Lanka (in area over half of a final proposed total of 15 000 ha) is currently undergoing expansion under Walawe Left Bank Irrigation Upgrading and Extension Project Phase-2 SL-P48 (Figure 1). The water resource agency, Mahaweli Authority of Sri Lanka (MASL), and consulting engineers, Nippon Koei Japan (NK), are establishing 5152 ha under new irrigation, with an associated human resettlement programme. According to a Mahaweli Economic Agency 1992 study, an estimated 6018 households (26 685 people) whose main livelihood is agriculture (primarily paddy, upland crops and chena cultivation), are located within the proposed extension area. The construction area comprises mostly semi-degraded dry zone forest with an ancient system of some 17 seasonally water-filled small tanks, traditionally used for crop cultivation, domestic, livestock and other services, and now being rehabilitated for routine irrigation.

The International Water Management Institute (IWMI) and the World Conservation Union (IUCN) Sri Lanka, are collaborating with MASL and NK, through a pre- to post-development assessment of the extent to which both biodiversity and people's reliance on natural resources, linked to their socio-economic status, are altered by the progressive establishment of the scheme and shift towards a landscape mosaic of natural and agroecosystems. Preliminary results revealed a high baseline biodiversity in natural rock outcrop forests, as well as tank wetlands, than in existing farmlands such as rice fields and chena habitats. Overall, a total of some 223 floral species, including alien invasive plants (e.g. *Prosopis juliflora*, *Opuntia dillenii*, *Eichhornia crassipes*), and 307 vertebrates (15 endemic and 34 nationally threatened species, IUCN Sri Lanka 2000) were recorded from the area prior to the first steps in extension of the irrigation scheme. The composition of different groups of vertebrates in the project area, and their conservation status, is shown in Figure 2. The comparatively high number of birds, inhabiting both terrestrial and wetland ecosystems is highlighted. Also a variety of natural resources, including non-timber forest products and fish, were found to be of direct livelihoods importance for local communities, especially the rural poor. Of the 15 fish recorded from freshwater habitats, the tilapia *Oreochromis mossambicus* is dominant, with the local fishery almost entirely dependent on this species.

A number of ecoagriculture strategies (McNeely & Scherr 2003) aimed at managing the system for both agricultural production and the protection of (wild) biodiversity have been initiated, through collaboration among project partners and increasing mobilisation of local communities. These strategies, some of which are only in the early stages of implementation, included first the delimitation and agreed protection of priority tank catchments as biodiversity refuges. Selection of biodiversity refuges was based on ensuring the presence of representative habitat mosaics for each of the three different strata of the project area, the degree of naturalness of vegetation/habitat types, any key habitat patches, as well as species richness of fauna and flora (Figure 3). It is envisaged that the refuges will be connected in future with a retained/created corridor network of natural/near-natural vegetation within the project area (hedgerow concept), to minimise local species extinction, facilitate natural patterns of faunal movement and plant dispersal, and foster integrated pest management (IPM). A Biodiversity Park for storage of genetic material and community use has been delimited and its main features designed. Other strategies under implementation include the planting of appropriate indigenous trees along roadsides and within fuelwood plantations; habitat enrichment through multi-tiered home gardens that mimic the structure of natural forest; translocation of large mammals to protected areas (notably, Asian elephants); and a social mobilisation programme to foster community awareness and, more critically, to ensure long-term biodiversity conservation with agriculture through active participation of local people in appropriate biodiversity-agriculture initiatives.

Figure 1: Location of project area.

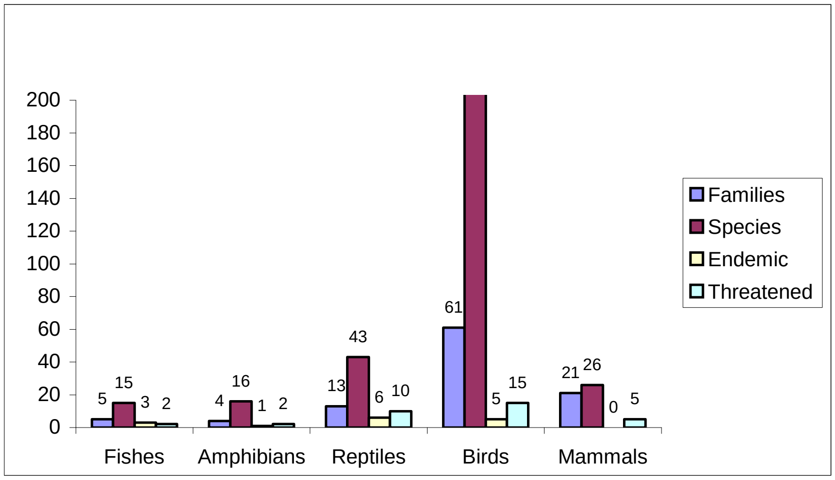

Figure 2: Faunal composition in the project area.

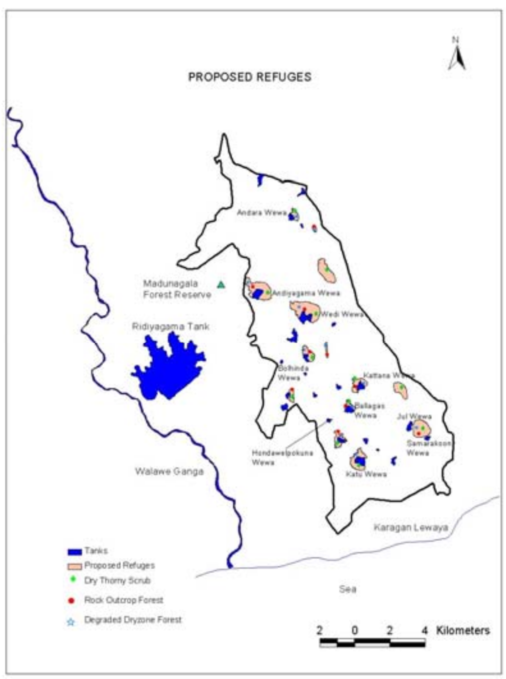

Figure 3: Location of biodiversity refuges within the project area.

References

Dyson, M., Bergkamp, G., Scanlon, J. (eds). 2003. *Flow. The essentials of environmental flows.* IUCN, Gland, Switzerland and Cambridge, UK. xiv + 118 pp.

McNeely J.A., Scherr S.J. 2003. *Ecoagriculture. Strategies to feed the world and save wild biodiversity*. Future Harvest and IUCN (World Conservation Union). Island Press, Washington. 323 pp.

Postel S.L., Richter B.D. 2003. *Rivers for life. Managing water for people and nature*. Island Press, Washington. 253 pp.

Richter, B.D., Baumgartner, J.V., Wigington, R. & Braun, D.P. 1997b. How much water does a river need? *Freshwater Biology* 37: 231-249.

Tharme, R.E. 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. *River Res. Applic.* 19: 397-441.

Vidanage S.P., Kallesøe M. 2004. *Kala Oya River Basin, Sri Lanka: integrating wetland economic values into river basin management*. Environmental Economics Programme, IUCN Sri Lanka Country Office, Colombo, Sri Lanka.