RESEARCH REPORT



90

# Working Wetlands: Classifying Wetland Potential for Agriculture

Matthew P. McCartney, Mutsa Masiyandima and Helen A. Houghton-Carr

International Water Management Institute

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*Cover photograph* by Dominique Rollin shows a wetland garden near Chibuto, Mozambique.

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# Contents

## Acronyms

| | |
|---|---|
| FAO | Food and Agriculture Organization of the United Nations |
| MCA | multi-criteria analysis |
| NAMBOARD | National Agricultural Marketing Board (Swaziland) |
| NIMP | National Irrigation Master Plan (for Zanzibar) |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| WHO | World Health Organization |
| WWP | Working Wetland Potential |

# Summary

In many developing countries, improvement in natural resource management is widely perceived to be the key to sustainability, and central to overcoming both developmental and environmental problems. The trade-off between environmental protection and development is most acute in fragile ecosystems such as wetlands. Wetlands are of value because they play an important role in maintaining environmental quality, sustaining livelihoods and supporting biodiversity. Many wetland functions effectively "work" for the benefit of people. However, social and economic factors often result in pressure to make wetlands work harder, for example, through their utilization for agriculture. Astute development and management of wetlands can add considerable value to the "goods" and "services" that they provide, but care is needed because inappropriate use undermines long-term benefits.

In this report, a "working wetland" is defined as a managed wetland in which a rational compromise is made between its ecological condition and the level of human utilization. A systematic and semi-quantitative method of evaluation is presented, which enables the classification of the "potential" of using a working wetland for specified agricultural activities. The approach, which is underpinned by the concept of "wise use," is based on a form of multi-criteria analysis that integrates biophysical and socioeconomic aspects of wetland utilization. The "potential class" emerges from the aggregation of two values. The first of these arises from an appraisal of both the biophysical and socioeconomic suitability of using the wetland for agriculture. The second results from an assessment of the possible hazards, in relation to both social welfare and the ecological condition of the wetland. The method, which is demonstrated by application to three case studies, is a pragmatic approach that provides a context for making explicit the trade-offs associated with wetland agriculture. It enables a preliminary screening of proposed activities prior to more detailed environmental and health impact assessments.

# *Working Wetlands: Classifying Wetland Potential for Agriculture*

*Matthew P. McCartney, Mutsa Masiyandima and Helen A. Houghton-Carr*

## Introduction

The wise use of wetlands is defined as *their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem* (Ramsar Convention Secretariat 2004). The key tenet of the approach is that all the benefits provided by wetlands must be incorporated in resource planning and decision-making. This is recognition of the need to integrate conservation and development, i.e., to change the focus of wetland management from protection to wise use. The concept of wise use acknowledges that human development necessitates adjustment of wetland ecosystems, but differs from conventional natural resources management because much higher priority is given to those processes that sustain the ecosystem and the people that depend on them (Davis 1993).

The needs of agriculture for flat, fertile land with a ready supply of water mean that wetlands are often a potentially valuable agricultural resource. In many arid and semi-arid regions, the capacity of wetlands to retain moisture for long periods, and sometimes throughout the year, has meant that their use for cultivation is widespread and a long-established land-use practice. The Food and Agriculture Organization of the United Nations (FAO) has highlighted the importance of wetlands for agriculture in Africa (Frenken and Mharapara 2002). However, past experience has shown that, although wetland agriculture can bring significant benefits in terms of food security, health and income, ill-considered development often equates to a loss in natural capital, deleterious environmental impacts and harmful consequences to people's livelihoods. Furthermore, it is sometimes the case that benefits of wetland agriculture accrue to a relatively small number of people, while the negative consequences are borne by the poorest and most vulnerable in society (Woodhouse et al. 2000). Consequently, wetland resource planning and management requires a clear vision of the relative importance of agricultural production and natural resource conservation. A recent resolution of contracting parties to the Ramsar Convention (i.e., resolution V111.34) calls for increased research to develop guidelines to enhance the positive role and minimize the negative impacts of wetland agriculture (Ramsar Convention Bureau 2002).

How to optimize the benefits that can be derived from a particular wetland in an equitable way and within the context of a specific social, economic and ecological setting—in short, how to achieve wise use—remains far from clear. Involvement of local people is now widely recognized as a prerequisite to successful planning and management, particularly where access to wetland resources is essential to livelihood security (Ramsar Convention Secretariat 2004). There is need for tools that integrate social, economic and environmental factors and indicate the costs and benefits (not just monetary) of different development options. Against this background, the ideas presented in this report are of value because they describe the development of a semi-analytical approach that provides a framework for identifying, analyzing and organizing the complex factors that link people, agriculture and wetland ecosystems.

This paper reports on a form of multi-criteria analysis that provides a formal approach for evaluating the suitability of a wetland for specific agricultural uses, and ensures that explicit consideration is given to the possible consequences of such utilization. The method is based on a hybrid of ideas taken from concepts and methodologies related to: (i) environmental flow assessments, (ii) land suitability classification and (iii) the hazard evaluation procedures used in the design of dams. The approach, which elaborates the idea of working wetlands, is generic, though the examples presented are for case studies from southern Africa.

## Wetlands, Natural Resource Planning and Sustainable Development

As with any natural resource, the sustainable utilization of wetlands, which underpins the concept of wise use, requires a comprehensive understanding of developments at the interface between human societies and the natural world. This requires consideration of a large number of extremely complex and interrelated issues and poses intricate technical, social and political problems. A key difference between sustainable and traditional natural resource management is in the evaluation of trade-offs in relation to all costs, benefits and risks (Haimes 1992). To assist decision-makers, a wide range of methods, and tools have been developed. These include methods of environmental valuation (Emerton and Bos 2004; Barbier et al. 1997), environmental and health impact assessment (e.g., World Bank 1991; World Health Organization 1999) and various methods of multi-criteria analysis (Harboe 1992).

It is widely recognized that a multi-criteria approach is appropriate for reasonable sustainability planning (Maness and Farrell 2004). Multi-criteria analysis (MCA) has been developed with the recognition that stakeholder choices are rarely made with respect to just one criterion, but are always multidimensional and that, furthermore, it is not possible to express all criteria as monetary values (Stirling 1997). MCA approaches are designed to incorporate both qualitative information and quantitative data, and encompass a broad range of variables. MCA methods are increasingly being used for river basin and natural resource management (e.g., Maness and Farrell 2004; Giupponi and Rosato 2002; Anand Raj 1995).

Because they combine information from a wide range of sources and can merge quantitative and qualitative elements in a single number, indices are now widely used, in combination with MCA, as tools to assist with planning and management of complex issues. The assumptions on which they are based must be understood but, if properly applied, indices simplify problems, increase the tangibility of complex issues and make decision-making easier (Streeten 1994; Sullivan et al. 2003). Examples of recently developed indices relating to human development and sustainability include the human development index (UNDP 2003), the environmental sustainability index (World Economic Forum 2002), the ecological footprint (Wackernagel and Rees 1996), the water poverty index (Sullivan et al. 2003) and water footprints of nations (Chapagan and Hoekstra 2004). All these indices provide a context for assessing development impacts in relation to a variety of social and/or environmental criteria.

The Ramsar convention on wetlands recommends identification of the *true values of wetland ecosystems in terms of their many functions, values and benefits, and inclusion of these environmental, economic and broader social values in decision-making and management processes* (Ramsar Convention Secretariat 2004). Various approaches have been developed to assess the benefits derived from the ecological functions of wetlands (Howe et al. 1991; Smith et al. 1995; U.S. Army Corps of Engineers 1995; Chapman and Kreutzwiser

1999; Kotze and Breen 2000). There is also some guidance on estimating wetland water requirements. These explicitly recognize that within a managed catchment, the water allocated for the maintenance of wetland ecosystems should be a function of the benefits people obtain from the wetlands (Ramsar Convention Secretariat 2004). However, there is currently no guidance on how to determine appropriate agricultural use within wetlands. The method developed in this study is an initial attempt to develop a pragmatic approach for explicit consideration of agriculture in the evaluation and prioritization of wetland development options.

### Working Wetlands

In this report, a *working wetland* is defined as a managed wetland in which there is a compromise between the condition of the wetland ecosystem and the level of human use. The idea is derived from that of a "working river," formulated by Australian researchers in an attempt to assist thinking about environmental flow allocations. The working river concept recognizes that human development requires rivers to be "worked" for human benefit, and that the more "work" required from a river (e.g., in terms of hydropower, water for domestic water supply and irrigation, etc.) the greater the river will be modified from its natural condition (Whittington 2002).

The concept of working wetlands applies the same idea to wetlands. Working wetlands will not look like, nor will they function in the same way as, pristine wetlands. There is a relationship between the type and level of work a wetland does and its "naturalness." In general, the more work the wetland is made to do, the less natural it will become. Hence, a compromise must be reached between economic gains from the work the wetland is made to do and the associated change in ecosystem functions. The compromise struck between the level of work and the loss of naturalness will depend on the value communities and other stakeholders place on any wetland.

In this report, the potential of proposed development activities, primarily agricultural, are considered in relation to long-term sustainability. In a working wetland, specified activities are considered to be of high potential if socioeconomic benefits are amplified in the present, while still assuring choice and benefits for future generations.

## Conceptual Framework

The concept of wise use stresses an anthropocentric view of ecosystems, which, while not rejecting their intrinsic value, places the greatest emphasis on optimizing their utility as a resource. Hence, the fundamental principle underpinning wise use is that wetlands are of value because they provide people with a diverse range of benefits. In any instance, these benefits, commonly referred to as "goods" and "services," are directly dependent on the ecological "condition" of the wetland. Human ingenuity enables the modification of the ecological condition of wetlands and, in so doing, the alteration of the suite of goods and services provided; some will be enhanced whilst others are reduced or lost. The concept of working wetlands seeks to add value to the goods and services, but without undermining either the biophysical or socioeconomic sustainability of the system. Present management of ecosystems tends to exploit one dominant good or service, with little or no consideration of the range of benefits provided or of the trade-offs being made (Revenga et al. 2000). An integrated approach is required that explicitly considers the entire range of benefits a given wetland provides and assesses what society will gain and lose as a consequence of a change in condition. This is the only way to optimize the benefits from a particular wetland.

## Ecological Condition of Wetlands

The concept of sustainability usually links goals of social development with those of ecological conservation. The underlying premise is that natural ecosystem functions keep the planet fit for life, enhance people's well-being and are sustainable. Ecosystems modified by human interventions (in this context considered "non-natural") either lose the ability to perform these functions, or develop reduced efficacy with a consequent decline in their overall contribution to human welfare. The dichotomy is that short-term socioeconomic development (i.e., improved quality of life and economic welfare) is invariably dependent on the modification of the environment and necessarily changes the condition of ecosystems (Falkenmark 2003).

Clearly, any rational assessment of wise use depends on an evaluation of the ecological condition of a potential working wetland. The Conference of the Parties of the Ramsar Convention has defined the ecological "character" of a wetland as "the sum of the biological, physical and chemical components of the wetland ecosystem and their interactions which maintain the wetland and its products, functions and attributes" (Ramsar Convention Bureau 1999). However, the concept of ecological condition is imprecise. As with all ecosystems, wetlands are dynamic systems that interact in multiple and complex ways with the surrounding landscape, and adapt and evolve over time. Consequently, "ecological condition" is not a static attribute of a wetland and, as such, is very hard to differentiate; there is no baseline state against which to characterize the condition of a wetland.

The environmental flow assessment methods developed for rivers in South Africa use "habitat integrity" as a general indicator of the ecological condition of the whole or part of a river, as measured against a hypothetical natural situation. In this context, the habitat integrity "reflects the degree to which, temporally and spatially, a balanced, integrated composition of physical and chemical characteristics has been maintained compared to those of undisturbed rivers of the region" (Kleynhans and Kemper 2000). In the current study, this general approach has been extended to wetlands, so that their ecological condition is broadly defined in relation to a hypothetical "undisturbed" state. Clearly, this will be a subjective assessment. However, it should not be considered a value judgment since a working wetland that is "extensively modified" may still provide many benefits to society. Ultimately, it is for local communities and other stakeholders to choose the condition in which a wetland should exist, hopefully based on a sound understanding of the trade-offs associated with ecological change.

## Wetland Values

*For millions of people "swamps" long suited only for draining have become "wetlands" worth conserving.* (McNeill 2000)

Throughout history, wetlands have played an important role in human development. They have brought benefits, but also caused difficulties, for people. Their perceived value, which has always been largely dependent on social perceptions of the use and benefits to be gained from them, has varied from place to place and, as the quote above illustrates, has changed over time.

Wetland values arise through the interaction of the ecological functions they perform with human society (figure 1). Until recently, in many parts of the world, wetlands were considered, with few exceptions, as unproductive wastelands associated with disease, difficulty of access and danger. This is because some wetland functions do not benefit people, but are harmful. For example, provision of habitat for mosquitoes that transmit illnesses is a function of many wetlands that has a huge negative impact on human well-being and, historically, was one reason for draining many of them (Honingsbaum 2001).

In recent years, greater insight into the ecological processes that occur in wetlands has brought about a radical change in perception. Wetlands are now widely viewed as valuable ecosystems that play an important role in maintaining environmental quality, sustaining livelihoods and supporting biodiversity. For example, many seasonally saturated wetlands make a vital contribution to the livelihoods of millions of people living in the arid and semi-arid areas of Africa (Scoones 1991). A crude estimate of the global economic value of wetlands (i.e., the value attributed to direct physical benefits, but neglecting wetland-related costs) is US$70 billion a year (Schuyt and Brander 2004). People also gain *nonphysical* benefits from wetland functions. These are associated with spiritual enrichment, cognitive development and aesthetic experience.

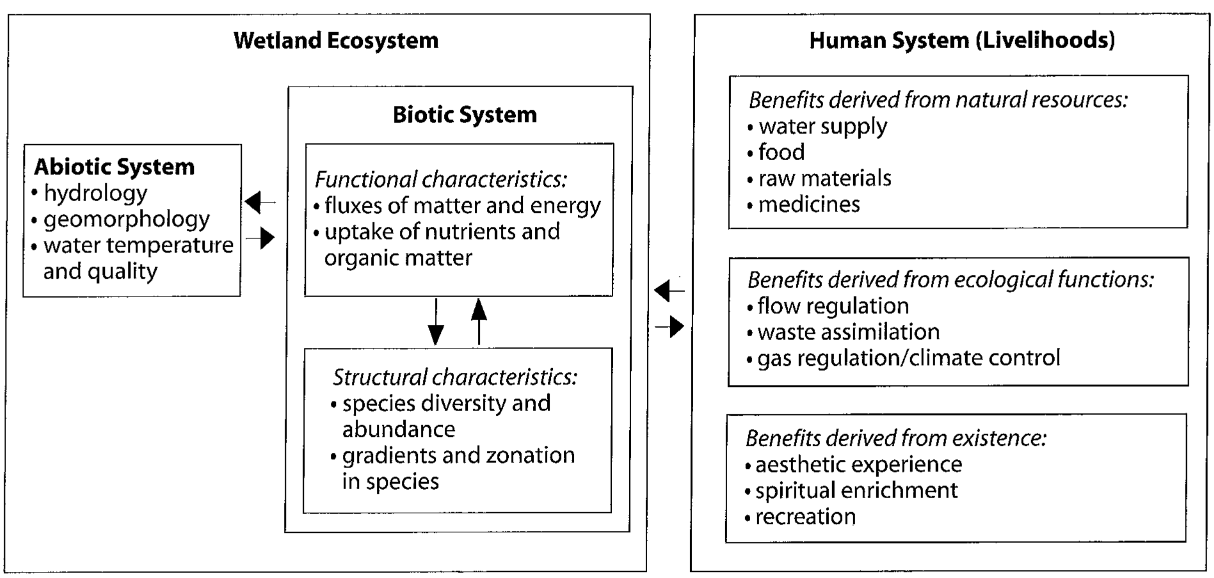
Hence, wetlands bring a wide variety of tangible and intangible benefits to large numbers of people. The way in which they do so is complex and multifunctional and is directly related to the ecological functions and, hence, the condition of the wetland. However, wetlands are also associated with many costs. In the past, it has often been the case that while the costs were recognized the less quantifiable benefits to human welfare have tended to accrue without communities and decision-makers fully appreciating them. As a result, the benefits have often gone unrecognized in development and resource planning, and management.

## Trade-offs

> *Secure and equitable access to and control of resources—and fair distribution of the costs and associated benefits and opportunities derived from conservation and development—will be the foundation of food and water security.* (Cosgrove and Rijsberman 2000)

It is social and economic factors that drive human-induced changes to the condition of wetlands. In any given situation, the underlying

FIGURE 1.
Influence of wetland ecosystems on human livelihoods (modified from Lorenz et al. 1997).



causes are a complex mix of policies, practices for economic growth, demographic changes and inequities in the control of resources. However, generally it is attempts to maximize benefits through exploitation of certain functions that result in changes to the condition of a wetland. It is possible that some ecological change can result in an overall increase in the total long-term benefits derived from a wetland, but change beyond a certain point results in a net decrease in benefits. It is also possible that benefits gained from highly modified systems may be large in the short-term, but decrease in the long-term. For example, a common perception is that agriculture in wetlands tends to "mine" natural capital (e.g., depletes organic matter and erodes soil) in providing short-term food security or economic benefits, but at the cost of potential benefits for future generations. However, while this may often be the case, there is little evidence that highly modified working wetlands are intrinsically unsustainable over the long-term. Intensive management and infrastructure development can contribute positively to the provision of some goods and services. Numerous working wetland systems, for example, many of the rice cultivation systems across Asia, illustrate that highly modified wetland systems, if carefully managed, can be very productive and the benefits can be maintained for many centuries.

In the past, the ecological conditions of wetlands have been extensively modified to increase their agricultural productivity. That is, to make them explicitly "working wetlands." Agricultural interventions often have significant effects on the ecology and hence functioning of wetland ecosystems. Consequently, while the ability of a working wetland to provide food may be increased, other potential benefits may be reduced. For example, because of fertilizer application or irrigation, the ability of the wetland to provide clean water may be diminished. Clearly, wise use, which attempts to maximize long-term benefits, requires at least recognition, and ideally explicit evaluation, of these trade-offs.

For a specific wetland, a clear appreciation of which ecological goods and services the wetland is providing, and a good understanding of how these are linked to the ecological condition, are prerequisites for trade-off analysis. However, for purposes of planning and management, there are a number of difficulties in the explicit evaluation of trade-offs:

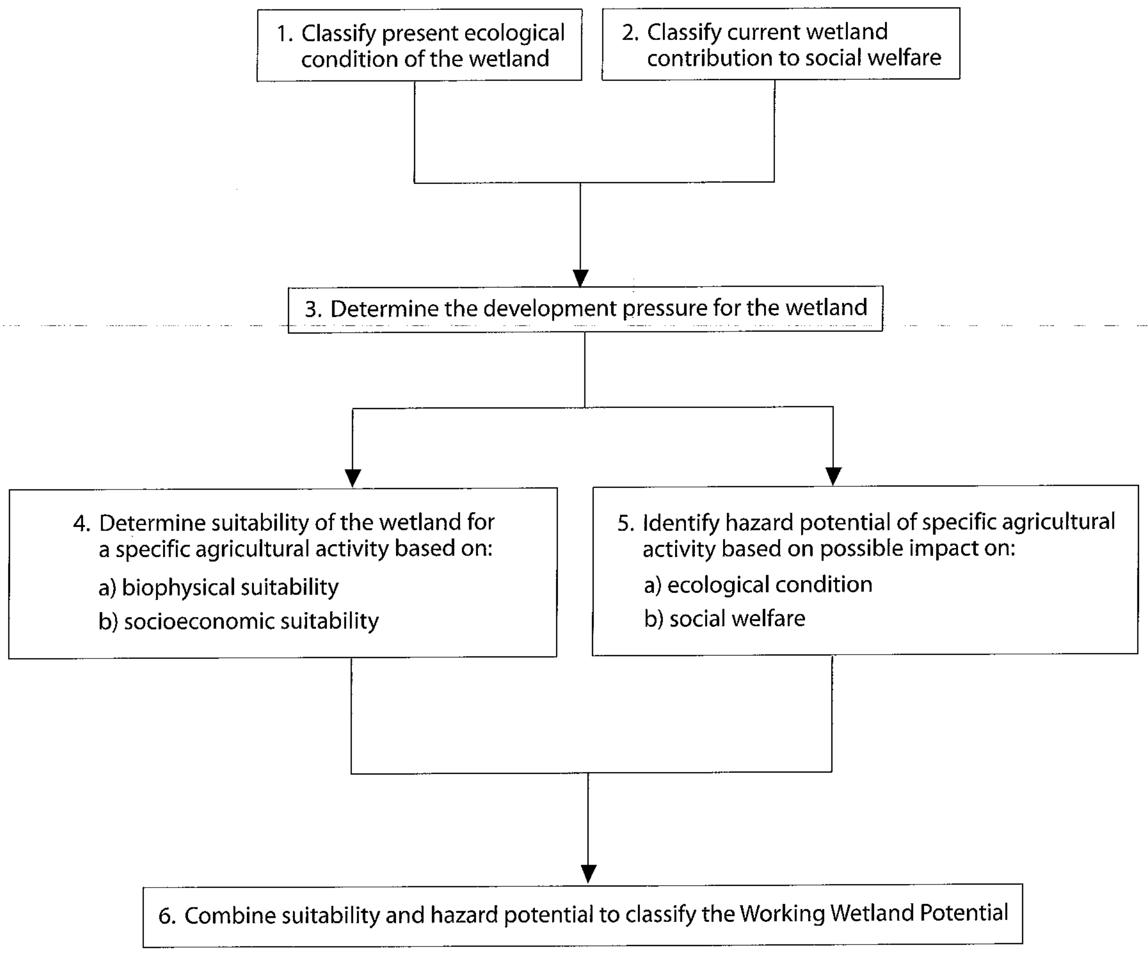
1. Wetlands interact with their surrounding environment in highly complex ways that depend on geomorphic constraints, climate and key attributes of the local biota. Consequently, the precise nature and significance of many wetland functions remain far from clear. Even with site-specific studies, it can be very difficult to ascertain the specific functions of a particular wetland, and it is even more difficult to predict all the consequences of agricultural activities.
2. Traditional methods of trade-off assessment are based on variations of cost-benefit analyses that are dependent on the financial valuation of different aspects of a system. However, because the contribution of wetland goods and services to human welfare are effectively in the form of "public goods," it can be extremely difficult to define them in monetary terms. Economists continue to develop techniques to value the diverse array of wetland benefits (Barbier et al. 1997), but currently the value of many wetland functions are often underestimated.
3. Some benefits are experienced far beyond the boundaries of the wetland. In some instances, benefits may accrue at the global level (e.g., carbon sequestration as a control of climate) whilst costs (e.g., high prevalence of malaria) tend to be local. Furthermore, while economic gains are often immediate, the negative consequences of changing the ecological condition of a wetland may not be felt for many decades.

## Operationalizing the Conceptual Framework

Decisions about whether or not to use (or continue to use) a wetland for specific agricultural activities must resolve conflicting needs. However, as the discussion above has shown, it is difficult to put an economic value on many wetland benefits, so simple economic evaluation is not sufficient. Decisions need to be based on consideration of many factors that cannot be defined in monetary terms. The objective of the approach presented in this report is to build on the ideas outlined in the conceptual framework, to provide a simple and pragmatic procedure that enables explicit and systematic consideration of both the opportunities and the possible consequences of agricultural development in a wetland.

A simple form of multi-criteria analysis is used to evaluate the potential of specific agricultural activities. In the approach, key criteria relevant to the decision of whether the agricultural activities within the wetland should be allowed, or increased, are identified and weighted based on experience and perceptions. The classification system effectively functions as an initial screening process to assist in determining the extent to which health and environmental impact assessments are required prior to undertaking the proposed agricultural

FIGURE 2.
Proposed approach to determining the Working Wetland Potential (WWP).



activities. The method is intended for use by land-use planners and others working directly with farmers and other wetland users. It is hoped that it can, in conjunction with other management tools, contribute to an integrated approach to wetland management.

The method is perceived as a useful but intermediate step en-route to developing a more deterministic approach for trade-off analysis, based on a multi-disciplinary modeling methodology designed to formally quantify trade-offs between competing objectives (Crissman et al. 1998). This more sophisticated approach will be designed over the next 2-3 years as part of the Challenge Program on Water and Food project entitled *Wetlands-based Livelihoods in the Limpopo Basin: Balancing Social Welfare and Environmental Security* (Masiyandima et al. 2003).

In the current method, a six-step process is proposed (figure 2). Each step is described in more detail in the following sections. This procedure is not intended to be a one-off procedure, as the state of any given wetland is not static and its potential for any agricultural activity changes over time with either increasing or decreasing demand for the resources, or shifting dependence on resources. It is therefore an iterative process that can be applied as a first screening step when changes to the wetland are perceived.

## Assessing the Ecological Condition of a Wetland

The present condition of the wetland is classified on a qualitative scale varying from "natural" to "extensively modified" (table 1). Evidently, this must be based on a perception of the ecological condition of the wetland in its natural "state." In many instances this will be based on: expert knowledge; comparison with similar wetlands in the region, of the same "type," that have been left undisturbed; and on historical knowledge of the wetland users and local communities. This is necessarily a subjective assessment. However, it is important to remember that this is not a value judgment since, as discussed above, from a human perspective all classes may have some desirable as well as some non-desirable characteristics. Even wetlands classified as "extensively modified" have desirable features and, providing they can be sustained, this may be the state in which society would like the particular wetland to remain.

## Assessing a Wetland's Contribution to Social Welfare

To evaluate the present contribution that a wetland makes to social welfare requires an understanding of five primary components:

1. The importance of people's reliance on wetland resources such as water for drinking and domestic purposes, fish and wetland plants for food, and natural vegetation for thatching, construction and medicines.

2. The extent to which people's livelihoods depend on current agricultural activities (e.g., cultivation, pastoralism or aquaculture) within an already working wetland.

3. The extent to which differences in gender and socioeconomic status (i.e., differences between the relatively "better-off" and "disadvantaged") influence benefits obtained from the wetland. This is particularly important when considering issues of equity. Recent studies of the economic importance of wetlands for communities illustrate significant differences in the benefits provided to different sectors of society (e.g., Masiyandima et al. 2004; McCartney and van Koppen 2004).

4. The importance of benefits accrued at the landscape scale (e.g., through flood control or modification of water quality) for people, most specifically those living downstream, that may be far removed from the wetland.

TABLE 1.

Assessing the ecological condition of a wetland.

| Description | Example | Possible desirable features | Possible negative features |
|---|---|---|---|
| **Natural** Natural habitat and functions are unmodified. | Either no human interaction or only human intervention to maintain "natural" system (e.g., nature reserves, and national parks where human populations are excluded). | High biodiversity.[a] Habitat for rare species. Natural hydrological functions (e.g., flood attenuation, etc.). High aesthetic value. | Source of disease; e.g., malaria, and schistosomiasis. No natural resource exploitation available for local people. |
| **Largely Natural** Few modifications. A small change from natural habitats and biota may have taken place, but the wetland "natural functions" are essentially unchanged. | Small amount of human intervention (e.g., fishing, hunting, and collection of medicinal plants) but limited long-term impact. | People's livelihoods benefit from natural resources and the extraction is sustainable in the long-term. | Source of disease; e.g., malaria and schistosomiasis. |
| **Moderately Modified** A loss of and change from natural habitats and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. | Some land-use change (e.g., < 20% of wetland area) and/or minor modification to natural hydrological regime. | Some agricultural production supports some people's livelihoods. Natural resource exploitation is still possible and sustainable. | Limited water control, so crops/livestock at risk from flooding/drought. High labor requirements to control weeds and natural pests. Prevalence of disease may increase as people spend longer in the wetland. |
| **Largely Modified** A large loss of natural habitat, biota and basic wetland functions has occurred. | Significant land-use change (e.g., 21-75% of wetland area) and/or significant modification of the natural hydrological regime. | Agricultural production supports many people's livelihoods. | Significant reduction in natural resource exploitation. Loss of beneficial hydrological functions. Some soil erosion. Prevalence of disease may increase as people spend longer in the wetland. |
| **Extensively Modified** The loss of natural habitats, biota and basic ecosystem functions (i.e., natural goods and services) is extensive. | Wetland ecosystem very significantly altered from its perceived "natural" condition. For example, extensive land-use change (>75% of wetland area) and highly modified hydrological regime (e.g., through drainage). | High and reliable agricultural production sustains many people's livelihoods. Reduced incidence of water-related disease due to improved socioeconomic conditions. | Massive reduction in biodiversity. Loss of beneficial hydrological functions, possibly including pollution of water sources. Soil erosion. Low aesthetic value. Risks of disease may still exist. |

[a]In general, natural diverse habitats are highly valued and many wetlands have high biological diversity. However, in some wetland types, biodiversity is naturally low and human interventions (e.g., application of fertilizers to wet grassland to improve pasture or cutting and draining of peat bogs) will increase the diversity of communities and species in the wetland. Consequently, the number of species a wetland contains is not, in itself, a sufficient indicator of ecological condition.

TABLE 2.
Assessment of a wetland's contribution to social welfare.

| | Description |
|---|---|
| **Major Contribution** | For the large majority of the local population (i.e., > 75%), the wetland constitutes the most important contribution to their livelihoods and welfare through provision of water, food supplies, medicines, income, employment and/or cultural integrity. Many of those benefiting are the most vulnerable in society (i.e., the poor, women and children) with limited alternative livelihood options and so are particularly at risk from changes in the condition of the wetland. In addition, or alternatively, the wetland makes a very significant contribution to the welfare of large and vulnerable (e.g., poor) populations living downstream (e.g., through flood attenuation or maintenance of water quality in a river used for domestic water supply). |
| **Significant Contribution** | For more than 50% of the local population and/or for the most vulnerable (e.g., the poor, women and children) the wetland provides a significant and vital contribution to their livelihoods and welfare. In addition, or alternatively, the wetland makes a significant contribution to the welfare of some people living downstream. |
| **Moderate Contribution** | For more than 25% of the local population, the wetland provides an important, but not necessarily vital, contribution to their livelihoods and welfare. In many cases alternatives could be found. In addition, or alternatively, the wetland provides some benefits to relatively small downstream populations, but overall the wetland is not a major contributor to their welfare. |
| **Small Contribution** | For less than 25% of the local population, the wetland provides an important, but not necessarily vital,contribution to their livelihoods and welfare. In many cases alternatives could be found. The wetland is not a major contributor to the welfare of anybody living downstream. |
| **No** or **Negative Contribution** | The wetland provides no benefits to anybody in the local community and in fact the welfare of the majority may be adversely affected through harmful attributes of the wetland (e.g., habitat for disease vectors). The wetland either does not contribute or negatively influences the welfare of downstream populations. |

5. The importance of benefits accrued at the global scale (e.g., through carbon sequestration and maintenance of habitat of unique cultural and/or ecological value).

It is essential that, as far as possible, information, particularly pertaining to local community utilization, be gathered through sociological, ideally participatory, assessments. On the basis of information obtained the extent to which a wetland contributes to social welfare is classified on a qualitative scale varying from "major contribution" to "negligible contribution" (table 2). This assessment could be made more rigorous and analytical by defining the classes in terms of a numerical social welfare function. The value of such an approach will be tested in the Challenge Program project on wetlands based livelihoods (Masiyandima et al. 2003).

## Identifying the Development Pressure for a Working Wetland

Having ascertained the existing ecological condition of the wetland and its contribution to social welfare, an assessment must be made of the development pressure acting for change in the wetland. This must be determined through consultation with local communities and other stakeholders. Within the context of the working wetland concept, this analysis must clearly identify the goals and the objectives for the wetland. There should be a clear expression of what the stakeholders wish to gain or achieve from the wetland. For the present purpose, this relates particularly to agricultural activities within the wetland, but since the approach is generic there is no reason why it cannot relate to other uses of the wetland, such as domestic water supply. Therefore, specifically, and realizing that they are interlinked, it must identify:

- The desired "ecological condition" of the working wetland (i.e., the condition that should prevail when all objectives are met).
- The exact agricultural uses and associated activities, which might be undertaken within the working wetland (i.e., crops that might be grown, livestock management practices or aquaculture schemes that might be implemented).
- The benefits, and to whom they will accrue, as a result of modifying the ecological condition.

The evaluation of the development pressure should identify desired objectives that are unequivocal and measurable. Although different stakeholders will often have different and opposing interests in a working wetland, it is important that, as far as possible, different objectives are prioritized so that the evaluation can focus on those that are of highest priority. When evaluating the desired ecological condition, it is also important to consider the extent to which wetland conservation is of local, regional, national or international importance. To a large degree, this will depend on how unique the wetland is perceived to be across a range of scales.

## Assessing the Suitability of a Wetland for Agriculture

The suitability of a wetland for the agricultural activities defined through identification of the development pressures is dependent on a complex combination of wetland attributes, as well as catchment characteristics and the broader socioeconomic setting in which the wetland is situated. Consequently, both biophysical and socioeconomic criteria need to be evaluated when considering the suitability of a wetland for the proposed agricultural activities.

The biophysical suitability, in this context, is a reflection of the "fitness" of the wetland for a specific agricultural use. The biophysical requirements of different agricultural activities differ considerably, so biophysical suitability has to be assessed in relation to specific uses or crops envisaged. For example, the biophysical characteristics that would make a wetland suitable for cattle grazing are very different to those that are required for growing rice, which in turn differ from those needed for growing maize. This is why, when identifying the wetland development pressure, there is a need to specify exactly the agricultural uses and the activities associated with these uses. The suitability of the wetland for each has to be assessed separately. It should be remembered that present agricultural practices provide useful insight into the potential and possible impacts of future agricultural activities. The biophysical suitability classes presented in table 3 are based on the FAO land suitability classification system derived as a component of a framework for land evaluation (FAO 1976).

The socioeconomic suitability is a reflection of both the likely magnitude of benefits in social welfare, and the extent to which the social "conditions" are able to ensure those benefits will be realized, if the proposed agricultural activities go ahead. The extent to which the institutional arrangements will support activities and the capacity of local communities to undertake agricultural activities, as well as the extent to which markets for agricultural produce already exist, are all key criteria that need to be considered. The definitions used for assessing socioeconomic suitability encompass gender issues and also whether or not proposed activities are pro-poor (table 3). As with biophysical suitability, the extent to which the socioeconomic conditions are suitable for the utilization of a wetland for agriculture depends on different uses and management practices, and so must be evaluated in relation to specific agricultural uses.

Using table 3, and in relation to specific proposed agricultural activities, the wetland is classified from "highly suitable" (class 5) to permanently "not suitable" (class 1). The class selected should be determined by whichever of

TABLE 3.
Assessing the suitability of a wetland for proposed agriculture activities.

| Class | Biophysical | Socioeconomic |
| --- | --- | --- |
| **5 Highly Suitable** | Ideal hydrological regime. No morphological or climatological restrictions for a given agricultural use. No need for water control and only acceptable levels of other inputs. | The proposed agricultural use will benefit a large number of people, including the poorest in the community, and specifically will improve the welfare of women and children. Existing markets, local institutions and capacity of the local population are sufficient to maximize benefits from a given agricultural use. |
| **4 Moderately Suitable** | Minor hydrological, morphological or climatological limitations that, in aggregate, are moderately severe for sustained application of a given agricultural use. The limitations will reduce productivity and/or increase required inputs (possibly including the need for water control). Overall, the advantage to be gained from agricultural use is still attractive. | The proposed agricultural use will benefit the poorest in the community and will not have any adverse impacts on the welfare of women or children. Some constraints to benefits from agricultural use arising from small deficiencies in existing markets, local institutions and capacity of the local population. However, strategies can be devised to overcome deficiencies relatively easily. |
| **3 Marginally Suitable** | Hydrological, morphological or climatological limitations that, in aggregate, are severe for sustained application of the proposed agricultural use. The limitations will reduce productivity and/or benefits, and/or increase required inputs; e.g., inadequate water influx may increase risk of drought and necessitate significant investment in water control. However, current technology still means that investment may be worthwhile. | The proposed agricultural use will benefit the poorest in the community and will not have any adverse impacts on the welfare of women or children. Deficiencies in existing markets, local institutions and capacity of local population, in aggregate, mean that considerable effort will be required to ensure agricultural activities will bring a net benefit to communities. |
| **2 Currently Not Suitable** | Hydrological, morphological or climatological limitations that, in aggregate, cannot be overcome with existing knowledge at a currently acceptable cost. The limitations are so severe as to preclude successful, sustained use of the wetland for the proposed agriculture at present. | Although a few people may benefit, socioeconomic constraints (i.e., in markets, local institutions and/or capacity of the local population) preclude any possibility of net enhancement to communities from sustained use of the wetland. However, the situation should be reevaluated if conditions change in the future so that current limitations might be overcome (e.g., if access to markets was greatly improved through construction of a road). |
| **1 Not Suitable** | Hydrological, morphological or climatological limitations that appear so severe as to preclude any possibilities of successful sustained use of the wetland for any proposed agriculture now or in the future. | Socioeconomic constraints appear so severe as to preclude any possibilities of successful, sustained use of the wetland for any desired agriculture. It is likely that proposed activities will have a negative impact on the welfare of the majority of the community, including women and children. |

the two criteria (i.e., biophysical or socioeconomic) gives the lowest suitability rating. This assumes that equal importance is attached to biophysical and socioeconomic suitability.

- Segments of the population whose health is differentially affected by exposure to hazards or changes in the environment (e.g., the very young or the very old, etc.).

## Assessing the Possible Hazards Associated with Wetland Agriculture

Assessment of the possible hazards is an evaluation of the potential consequences of implementing specific agricultural activities within a working wetland. It is based on an assessment of the risks both to existing livelihoods (i.e., in relation to the extent to which the wetland currently supports social welfare) and the current ecological condition of the wetland. This assessment must be undertaken within the context of the development pressure identified for the wetland and the likely benefits that will accrue.

The hazard rating is classified (table 4) from "none" (i.e., class 5) to "high" (i.e., class 1). As with the assessment of suitability, the class selected is determined by whichever of the two criteria that gives the numerically lowest hazard rating as this will be the overriding factor.

In evaluating the ecological hazards, it is important to consider the "uniqueness" of the wetland at local, national and international scales. The more distinctive a particular wetland is, the greater the risk of loss of species and, hence, the greater its conservation value. In evaluating potential impacts on social welfare, careful consideration needs to be given to:

- Inequities or disproportional adverse environmental or health impacts affecting low-income or various disadvantaged groups (i.e., depending on the context: ethnic groups, indigenous people, minorities and women/children).
- Adverse effects on groups that depend on consumption of the wetland's natural resources or those who have traditional livelihoods (e.g., pastoralists).
- Adverse effects on those people who live downstream of the wetland.

Clearly, the greater the understanding of how a wetland functions and the ways in which it supports livelihoods, the greater will be the confidence with which assessments of hazard can be made. However, in light of the large uncertainties that often exist in relation to cause and effect relationships, it is recommended that the precautionary principle be applied.

## Evaluating the Working Wetland Potential

The Working Wetland Potential (WWP) is determined as the product of the value determined in the suitability assessment and the value determined in the hazard rating (table 5).

The WWP is an indicator of the potential of using a particular wetland for specific agricultural activities. Five WWP classes are defined (table 6). The classes are a pragmatic recognition that, however desirable, it is not possible to conduct detailed environmental and health impact assessments for every proposed agricultural activity. The WWP is effectively a preliminary screening process that identifies what level of environmental and health reviews are necessary for the proposed activities.

The WWP separates activities that offer substantial benefits and pose inherently low risks, both for the environment and social welfare, from activities that offer relatively few benefits and/or potentially pose moderate or high risks for the environment and/or social welfare. For the former, only low-level environmental impact or health-impact assessments are necessary. For the latter, detailed environmental and health-impact assessments should be conducted (i.e., usually requiring the efforts of a multidisciplinary professional team and possibly long-term monitoring), or the proposed activities should be redefined. Between these extremes,

TABLE 4.
Assessing the hazard rating associated with using a wetland for proposed agricultural activities.

| Hazard rating | Impact on ecological condition | Impact on social welfare[a] |
|---|---|---|
| **5 None** | No significant change in ecological condition—may even result in an increase in the "naturalness" of the wetland. The wetland is most likely to be classed as extensively modified. | Wetland welfare class is negligible so there is little risk that change will bring highly significant adverse impacts. No adverse impacts for communities living downstream. |
| **4 Very Low** | Some change in the ecological condition—a decline in the "naturalness" is possible, but no significant impacts are anticipated and extirpation of species is highly unlikely. The wetland may already be modified (i.e., classed as largely or extensively modified), but there is no desire to improve. | Wetland welfare class is small so there is a relatively low risk that change will bring significant adverse impacts. Nevertheless care should be taken and consideration given to alternative sources of welfare for those who may be affected. No adverse impacts for communities living downstream. |
| **3 Low** | Measurable change in the ecological condition—a noticeable decline in "naturalness"—is possible and the prospect of extirpation of some species cannot be discounted. However, the wetland is not unique and there is no reason to believe that rare or endangered species are threatened. The wetland may already be modified, (i.e., classed as largely or extensively modified) but there is no desire to improve. | Wetland welfare class is moderate so there is a low risk that change will bring adverse impacts, including perhaps for communities living downstream. However, it is anticipated that strategies can be devised to overcome the worst negative impacts relatively easily, and the advantages to be gained outweigh the drawbacks. |
| **2 Moderate** | Significant change in the ecological condition—a noticeable decline in "naturalness"—in wetlands classed as "natural" or "largely natural." Extirpation of some species cannot be discounted. However, the wetland is not unique and there is no reason to believe that rare or endangered species are threatened. | Wetland welfare class is significant or major so there is a moderate risk that change will bring adverse impacts, including perhaps for communities living downstream. However, it is possible that the worst negative impacts can be overcome, and the advantages to be gained may still outweigh the drawbacks. |
| **1 High** | Highly significant negative change in the ecological condition is likely within unique wetland ecosystems of recognized international importance (most likely classed as "natural"). There is a high possibility of dire consequences for rare or internationally important species. | Wetland welfare class is significant or major so there is a high risk that change will bring adverse impacts. Possibilities for mitigating negative impacts are believed to be limited. Regular to permanent significant adverse impacts for communities living downstream. |

TABLE 5.
Determination of the Working Wetland Potential (Suitability class x Hazard class) in relation to proposed agricultural activities.

| Suitability class | Hazard class | | | | |
|---|---|---|---|---|---|
| | 1 (high) | 2 | 3 | 4 | 5 (none) |
| 1 (not) | **1** | **2** | **3** | **4** | **5** |
| 2 | **2** | **4** | **6** | **8** | **10** |
| 3 | **3** | **6** | **9** | **12** | **15** |
| 4 | **4** | **8** | **12** | **16** | **20** |
| 5 (high) | **5** | **10** | **15** | **20** | **25** |

*Note:* Values of Working Wetland Potential (WWP) are in bold.

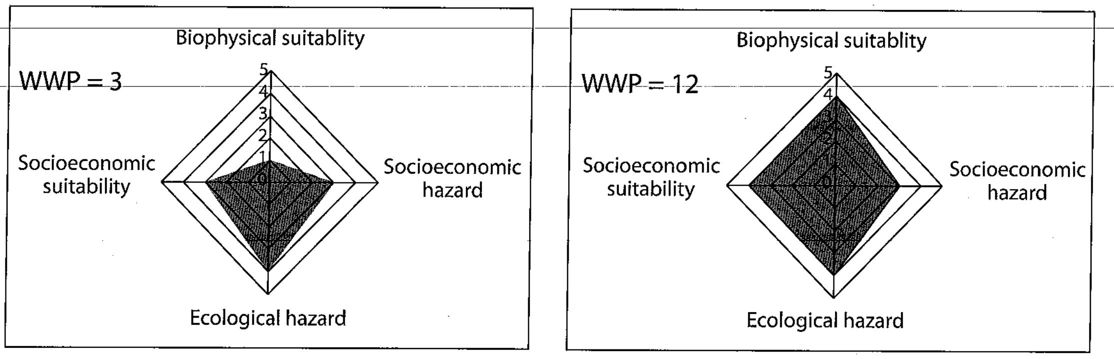
simplified environmental and/or health "examinations" that relate only to specific issues requiring special attention are necessary (table 6). The function of these examinations is to identify modifications in the proposed activities that avoid or reduce potential negative impacts. The five classes are the minimum required to allow each potential working wetland to be appropriately categorized while still providing some meaningful distinction between the different classes.

It should be remembered that the WWP refers solely to the suitability and possible hazards associated with specified activities in the particular wetland under consideration. Results from one wetland cannot be extrapolated or transferred to another wetland. Furthermore, should any aspect of the ecological condition of the wetland and the wetland's perceived contribution to social welfare or the development pressure change, the evaluation of the WWP should be redone.

TABLE 6.
Definition of Working Wetland Potential (WWP) classes for proposed agricultural activities.

| WWP class | | Description |
|---|---|---|
| **> 21** | **High** | Suitability is high and there are no potential risks. Consequently, the benefits of the proposed activities will considerably outweigh the costs. Exempt from the need for comprehensive environmental or health impact assessments. |
| **16-20** | **Moderate** | Suitability is high or moderate and hazard rating is none or very low. Consequently, it is highly likely that the benefits of the proposed activities will outweigh the costs. However, low-level environmental and/or health impact assessments should be conducted to assess how minor constraints can be overcome. |
| **11-15** | **Marginal** | Suitability is marginal or better and hazard rating is low or better. Constraints limit the benefits that may be derived from the proposed agricultural activities. Care must be taken before proceeding with proposed activities, usually including detailed environmental and/or health impact assessments. |
| **6-10** | **Low** | Suitability is low or better and hazard rating is moderate or better. Either the benefits may be great but the risks are high, or the risks are low but the likely benefits are not very significant. Consequently, considerable care needs to be taken, usually comprising both detailed environmental and health impact assessments (perhaps including modeling exercises) and long-term monitoring both before and after proposed activities are implemented. |
| **< 5** | **None** | Either the wetland is not suitable for the specified agricultural activities or the environmental or socioeconomic risks associated with the proposed activities are deemed too high or the ecological value of the wetland is considered too great to make implementing the proposed activities worthwhile. |

FIGURE 3.
Examples of the graphical representation of the components contributing to WWP.




WWP = 3
Very low WWP, highly constrained by biophysical suitability

WWP = 12
Higher WWP, but somewhat constrained by socioeconomic hazard

To facilitate easy identification of the factors influencing the potential of using a wetland for the specified agricultural activities, the component variables used to calculate the WWP (i.e., pertaining to suitability and hazard) can be displayed graphically. In figure 3, the area of the shaded polygon is an indicator of the magnitude of the WWP and the positions of the polygon corners indicate the extent to which each of the variables is a limiting factor in using the wetland for the specified agricultural activities. Such diagrammatic representations are common for scientific indices. For example, the key elements comprising the water poverty index are represented in a water-poverty "pentagon" (Sullivan et al. 2003).

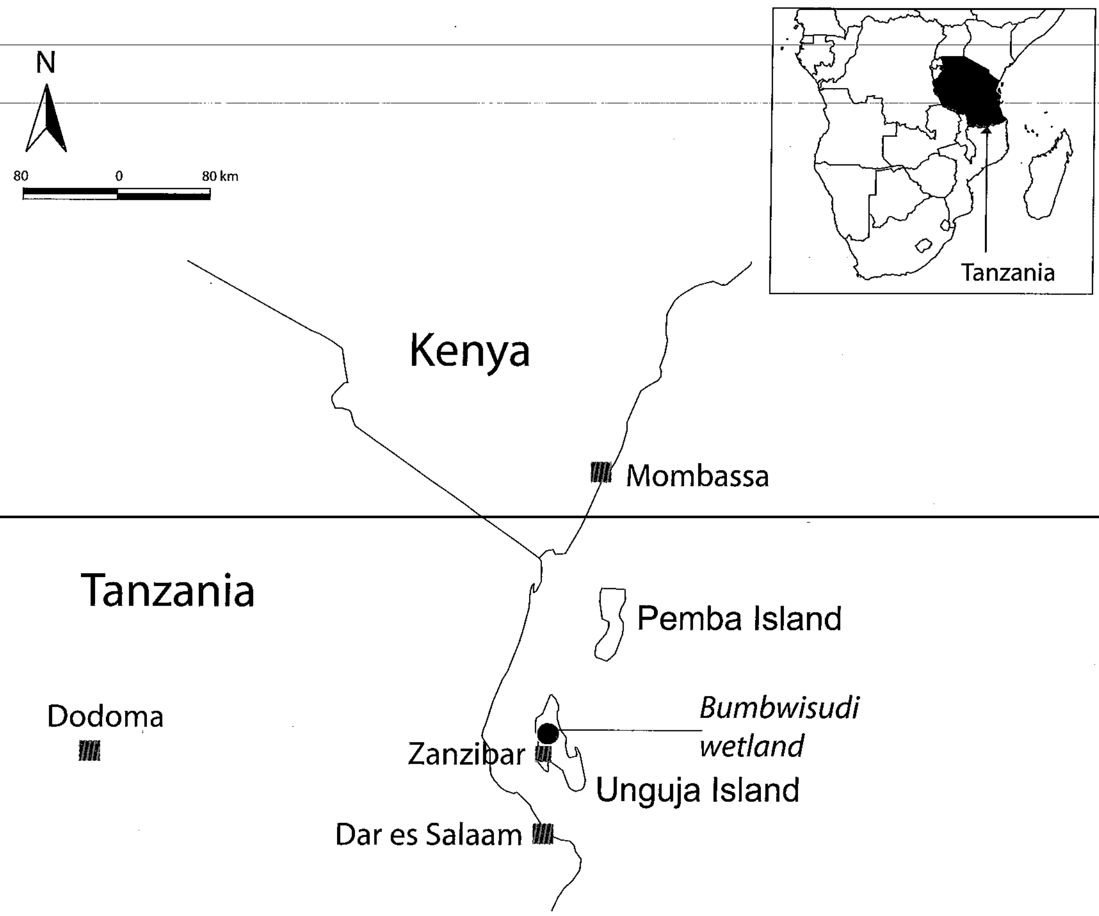
## Case Studies

To demonstrate the methodology outlined in the previous section, it is applied to three contrasting case studies.

### Bumbwisudi Wetland, Zanzibar, Tanzania

There are approximately 5,100 ha of wetland on the two islands that comprise Zanzibar (i.e., Unguja and Pemba). The Bumbwisudi wetland, located on the island of Unguja (figure 4), covers an area of 560 ha and so comprises some 11 percent of the total wetlands of Zanzibar. It is estimated that Bumbwisudi wetland contributes, in some way, to the livelihoods of more than 95 percent of the 2,728 households in seven villages close to it. The population in the area rose from 7,232 in 1988 to 11,973 in 2002. This has increased human pressure on the wetland. The National Irrigation Master Plan (NIMP) for Zanzibar (2003) promotes the use of the wetlands of Zanzibar for agriculture, with the dual aims of improving food security and alleviating poverty. As part of this plan, it is proposed to increase irrigated cultivation, particularly of rice, within the Bumbwisudi wetland. The issue to be resolved is the potential of using the wetland for this purpose.

FIGURE 4.
Location of the Bumbwisudi wetland.




Unless otherwise stated, all the data used in the following analysis are from a recent study that utilized both participatory techniques and a detailed household questionnaire to investigate the utilization of the wetland (Shaaban et al. 2004).

### *Current Ecological Condition*

Rice is a staple food in Zanzibar and currently about 390 ha of the Bumbwisudi wetland is used for rice cultivation. Of the 390 ha, 30 ha is irrigated using groundwater pumped from boreholes located in the wetland. Analyses of aerial photographs show that, in recent years, there have been considerable changes in the land cover of the wetland and its environs. These analyses indicate that between 1977 and 1989 significant declines in dense vegetation cover and mixed cropping are associated with comparable increases in sparse vegetation and rice cultivation. There have been no formal studies, but discussions with villagers and Department of Environment officials indicate that populations of frogs, butterflies, grasshoppers, lizards and birds (e.g., grey heron, black-shouldered kite, white-browed coucal, wood owl, green wood hoopoe and woodpeckers) have all declined in recent years.

Using the definitions in table 1, the current ecological condition of the wetland is classified as "extensively modified."

### *Wetland Contribution to Social Welfare*

At present, the wetland provides a diverse range of agricultural and nonagricultural benefits to the local communities (figure 5). As well as rice, the wetland is used for cultivating sweet potatoes, cassava and vegetables. Wetland cultivation is important for both food security and income generation. On average, households consume between 40 and 60 percent of what they grow in the wetland and sell the remainder. Cultivation, both in the wetland and the uplands surrounding it, is by far the largest contributor to household income. Crops grown in the wetland typically provide from 6 to 20 percent of the total household income generated from cultivation.

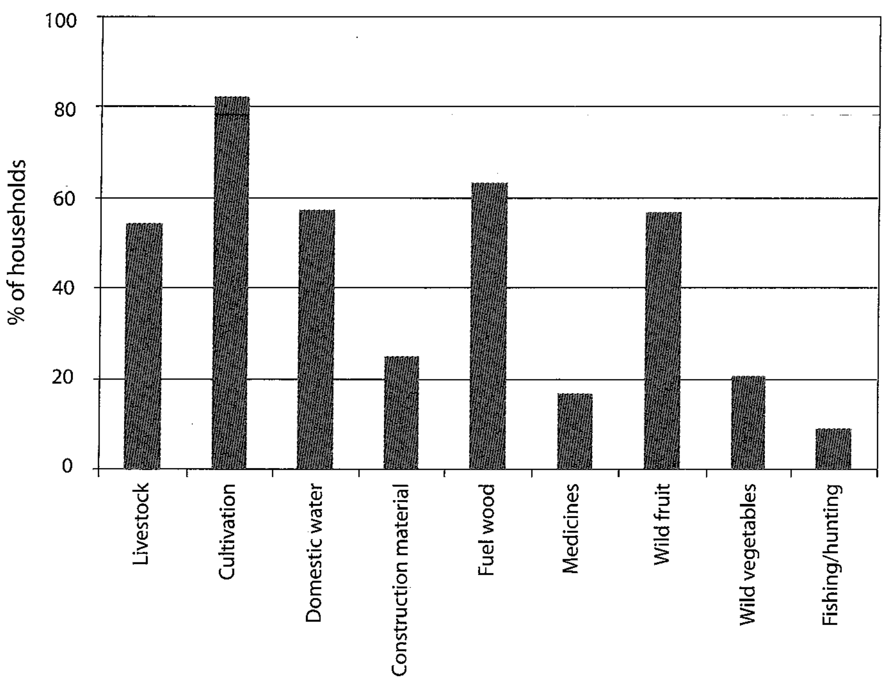
In addition to supporting cultivation, the wetland provides a range of other benefits. The irrigation boreholes supply domestic water, via overhead tanks and pipes, to some villages. Other households obtain water from shallow, hand-dug wells (i.e., 6-10 m deep) located in the wetland. In total, 58 percent of all households obtain domestic water, which is used for drinking as well as cooking and washing, from the wetland. Approximately 20 percent of households, primarily the better-off, use it for grazing cattle. A significant proportion of households, but particularly the poor, use vegetation collected within the wetland for a variety of purposes including construction materials, fuel wood, medicinal plants, wild fruits and wild vegetables. It is primarily women who are involved in the collection of wild plants for food and medicines, while men collect construction materials and fuel wood. The wetland is not used for any cultural or religious ceremonies.

Using the definitions in table 2, it is clear that the wetland makes a "major contribution" to social welfare.

### *Defining Development Pressure*

At present, 30 ha of rice is irrigated in the Bumbwisudi wetland. Irrigation enables two rice crops a year and increases productivity, from at best 1.7 ton $ha^{-1}$ under rainfed conditions to typically in excess of 4.0 ton $ha^{-1}$. The water for irrigation is obtained from boreholes, approximately 30 m deep, located in the wetland. Seventeen boreholes were drilled in the early 1980s to supply water for 150 ha of rice

FIGURE 5.
Percentage of households using the Bumbwisudi wetland for different purposes.




*Source:* Derived from data in Shaaban et al. 2004.

irrigation. However, only four of these are still operational, which is why only 30 ha of rice is currently irrigated. Specifically for the Bumbwisudi wetland, the NIMP proposes the rehabilitation of ten disused boreholes and the installation of two new boreholes. It also proposes the rehabilitation of 2,400 m of irrigation canal and the construction of an additional 12,470 m of lined canal for rice irrigation. The total cost is estimated to be US$421,000.

The survey conducted by Shaaban et al. (2004) indicated that a significant majority of people in the communities surrounding the wetland would be in favor of the development proposed in the NIMP. Both women and men identified insufficient water as a major constraint to their livelihoods, and more than 65 percent of households aspire for more wetland cultivation. It would seem that the desire of local people is for a "hard working" wetland that remains significantly altered from its natural ecological condition.

### *Assessing the Potential Suitability of the Wetland for Proposed Agricultural Activities*

Current activities within the wetland indicate that the major biophysical constraint to utilization of the wetland for rice and other cultivation is insufficient water in the dry season. Where irrigation is provided, this constraint is overcome. Hydrogeological studies indicate that the wetland is underlain by a shallow limestone aquifer of high transmissivity that recharges rapidly with the onset of rain. Within the existing wellfield, total recovery can be effected by a single sustained storm, and borehole yields between 30 $l\ s^{-1}$ and 60 $l\ s^{-1}$ are reliable almost anywhere in the vicinity of the wetland. These data suggest that there would be no physical limitations with the plan to reinstall and rehabilitate boreholes. Another potential constraint to the plan is soil fertility. No official studies have been conducted, but it is believed that the wetland soils are increasingly deficient in nitrogen and phosphorus. It is anticipated that soil fertility could be improved using appropriate fertilizers.

All the villages in the vicinity of the Bumbwisudi wetland are located, on reasonable roads, within 20 km of the island capital Zanzibar Town. A new tarmac road, traversing the wetland from east to west, is planned for the near future. This will further improve accessibility and possibly provide additional opportunities for the transport of agricultural produce to new markets. However, a major constraint identified by the survey was the complaint from farmers that their produce is undercut, particularly in the dry season, by cheap imports from the Tanzanian mainland and Kenya. The farmers attributed this to lack of marketing of their produce, and to economies of scale that enable relatively large commercial farms on the mainland to produce food more cheaply.

The Bumbwisudi water users group is theoretically responsible for the operation and maintenance of the current irrigation scheme. Nominally there are 469 members of the group. However, it is reported that in recent years the group has been fairly moribund because members are demoralized by water shortages and the lack of funds to maintain the boreholes and pumps. In 2002, only 150 farmers paid their annual subscription fee of 400 Tanzanian shillings (i.e., US$0.4) per 0.1 ha, which is levied as a contribution to operation and maintenance costs. Currently, the government pays for the electricity to operate the borehole pumps.

In summary, it seems that the biophysical constraints to the NIMP could be relatively easily overcome, but the socioeconomic constraints are more severe and considerable efforts would be required to ensure that the scheme is sustainable in the long term. Using the classification system presented in table 3, in relation to biophysical attributes, the wetland is deemed moderately suitable (i.e., class 4) but from the socioeconomic standpoint it is only considered marginally suitable (i.e., class 3). Thus, in terms of overall suitability, the wetland is given the lower classification, class 3.

### *Assessing the Hazard Potential Associated with Increasing Wetland Agriculture*

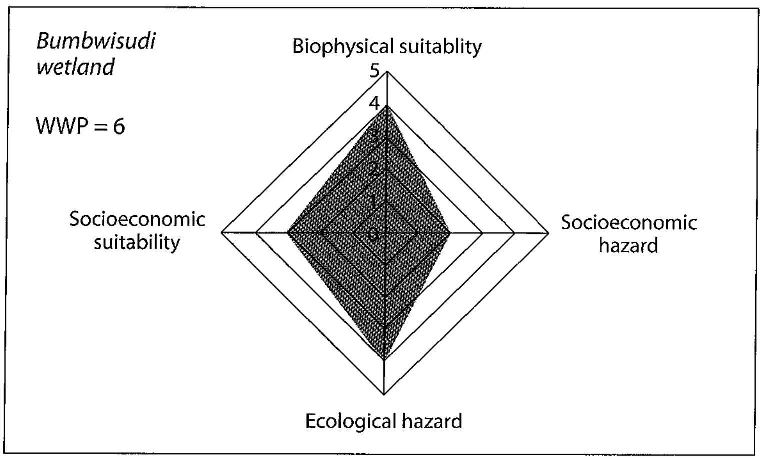
In assessing potential hazards, water quality is a particularly important issue because so many households depend on water originating in the wetland for all domestic uses, including drinking. In the past, government subsidies resulted in extensive use of agrochemicals in the wetland, but there is currently little use because they are no longer subsidized and only a few households can afford them. Nonetheless, given the apparent decline in soil fertility it is possible that there will be increased pressure to utilize fertilizers in the future. To date, there has been no hydrochemical monitoring and the likely impact of increased agrochemical use on groundwater and/or surface water quality, and the potential implications for health, cannot be assessed.

Although no figures are available, local people attribute the relatively high prevalence of malaria, bilharzia and liver flukes in their communities to wet season cultivation in the wetland and particularly to irrigated rice agriculture. Currently, some conflict is reported between livestock keepers and cultivators in the wetland. Increased irrigation could exacerbate these tensions because less land would be left fallow and so available for grazing in the dry season. No formal studies have been conducted on existing or potential hazards, but there is no

BOX 1.

Summary of WWP Classification for the Bumbwisudi Wetland.

| | | | | | |
|---|---|---|---|---|---|
| Wetland name | Bumbwisudi | | | | |
| Location | 6° 03' S, 39° 17' E | | | | |
| Current ecological condition | "Extensively modified" | | | | |
| Contribution to social welfare | "Major contribution" | | | | |
| Development pressure | Rehabilitation of rice irrigation infrastructure to enable double cropping | | | | |
| Potential suitability | | | | | |
| *Biophysical* | 4 | *Socioeconomic* | 3 | *Overall* | 3 |
| Hazard potential | | | | | |
| *Ecological Condition* | 4 | *Social welfare* | 2 | *Overall* | 2 |
| Working Wetland Potential | 6 | | | | |



record of current, or past, activities adversely impacting either people or irrigation schemes located downstream of the wetland. There is no evidence that the implementation of NIMP proposals would do so, but the possibility cannot be completely discounted.

In summary, it seems that the wetland ecological condition, which is currently classified as extensively modified, is unlikely to change significantly. Consequently, in relation to the ecological condition, using table 4, the hazard potential of the proposed scheme is classified as very low (i.e., class 4). However, currently the wetland makes a very significant contribution to social welfare and there is a reasonable possibility that the implementation of NIMP proposals could, through pollution of water resources and/or by increasing people's exposure to disease vectors, have significant adverse health impacts. Consequently, in terms of the potential impact on social welfare, the hazard potential of the scheme is classified, using table 4, as being moderate (i.e., class 2). Thus, the overall hazard rating of the proposal is given the lower classification, class 2.

### *Evaluating the Working Wetland Potential*

The extent to which the NIMP proposal to increase rice irrigation in the Bumbwisudi wetland is appropriate is determined by combining the suitability and hazard potential indices. Combining suitability class 3 and hazard class 2 gives a WWP of 6 (table 5). This indicates that considerable care should be taken before and during implementation of the proposed activities (table 6). In this case, it would clearly be advisable to conduct a comprehensive health impact assessment and an evaluation of possible downstream impacts before proceeding with the scheme. A summary of the WWP classification process for the Bumbwisudi wetland is presented in box 1.

## Grasslands Dambo, Zimbabwe

This example is based on the hypothetical possibility that a community might choose to utilize a headwater wetland for cultivation. To make the assessment realistic, information available for a real wetland located in the *highveld* (land at an altitude of over 1,200 m) of Zimbabwe is used. However, it should be stressed that in reality there is currently no known community pressure to utilize this wetland. The wetland is located in an agricultural research station, but for the purposes of this exercise it is assumed that the wetland is in communal land.

*Dambos* (seasonally saturated wetlands) are common in the headwaters of many southern African rivers. The dambo being considered is located close to Marondera (figure 6), 70 km southeast of Harare, in a 3.33 $km^2$ catchment that comprises the headwaters of the Manyame River, a tributary of the Zambezi. Situated in a predominantly grassland region, it is typical of many parts of the Zimbabwean highveld where dambos comprise about 28 percent of the surface area (Whitlow 1984). The catchment relief is low with slopes less than 4 percent and altitude ranging from 1,654 to 1,611 meters above sea level. The area of the dambo is 1.21 $km^2$ (i.e., 36% of the catchment). Within the dambo, a well-defined, irregularly shaped clay lens, located at depths generally less than 2.5 m, impedes vertical drainage, resulting in soil saturation during the wet season and elevated soil moisture contents in the dry season (McCartney 2000). In the hypothetical situation proposed, it is suggested that a local community wishes to utilize approximately 30 percent of the dambo for growing vegetables for sale in Marondera and Harare. The issue to be resolved is the potential of using the wetland in this way.

FIGURE 6.
The location of the Grasslands dambo.


***Current Ecological Condition***

A recent botanical survey, including analyses of aerial photographs, found that the vegetation structure and composition within the catchment, which includes the dambo, have been influenced by past and present management practices, particularly livestock grazing and land clearance for crop farming (Mapaure and McCartney 2001). Currently, the dambo is used for relatively light grazing. Cattle are stocked at about 3-4 hectares per cow on a rotational basis. However, there is evidence of minor erosion in the vicinity of the stream that originates in the dambo. Cultivated land and settlements occupy just over 16 percent of the catchment area and 12 percent of the dambo. There is evidence, based on the presence of dominant vegetation classes, that larger areas of the dambo were cultivated in the past (Mapaure and McCartney 2001).

Natural woodland, dominated by *Brachystegia spiciformis* (Miombo), occurs on the interfluve (i.e., upslope portions of the catchment) and covers about 12 percent of the catchment. About 24 percent of the catchment, primarily on either side of the dambo at the eastern end of the catchment, comprises plantations of exotic trees, particularly *Eucalyptus* species. These are old trees (estimated to be at least 20 years old) that have grown to heights of up to 30 m. Although the survey showed relatively high species diversity largely due to subtle differences in soil moisture resulting from upslope variations in the soil profile and water table regime, no rare or internationally important species were identified. There is no information on fauna.

Using the definitions in table 1, the current ecological condition of the wetland is classified as "moderately modified."

### *Wetland Contribution to Social Welfare*

Currently, the wetland provides physical benefits to very few people in the local community. Only about 5 households are involved in current cultivation and few local people benefit directly from cattle grazing. A few women collect hyperrhenia grasses from the wetland for thatching. Some people (mainly children) collect wild honey from the wetland and surrounding woodlands for sale by the main road from Marondera to Harare.

It has long been conceptually believed and reported that dambos act as regulators of flow, storing water during the wet season and releasing it during the dry season, thereby maintaining dry season river flows. Since the Manyame River is the main water supply for the city of Harare, this would seem to be a very important hydrological function of the wetland and one that should not be put at risk by changing the land use within the wetland. Indeed, the perceived need to maintain downstream river flows was a key reason for colonial governments banning dambo cultivation in Zimbabwe (then Rhodesia) in the 1920s and 1950s. However, recent studies have indicated that most (i.e., 86%) of the water stored in this dambo at the end of the wet season, and potentially available for dry season flow, is evaporated (McCartney 2000). Therefore, it seems that this function is not as important as previously thought.

Using the definitions in table 2, it is clear that currently the wetland makes only a "small contribution" to social welfare.

### *Defining Development Pressure*

The hypothetical development pressure derived for this example is that the community would like to extend cultivation to cover approximately 30-40 percent of the dambo. This would be in the form of small gardens, utilizing residual soil moisture, to grow vegetables.

### *Assessing the Potential Suitability of the Wetland for Proposed Agricultural Activities*

There is evidence from other dambos in the near vicinity that the biophysical conditions are generally suitable for growing maize and vegetables. In some instances, this cultivation has been continuous for decades. Studies have shown that variations in soil and water properties over relatively small distances make dambos difficult to utilize for large-scale agriculture but these are exactly the features that provide opportunities for small-scale farmers. Use of residual moisture in the dambos, in combination with minimal hand irrigation from shallow wells, enables the growing season of vegetables (e.g., potatoes, tomatoes, cabbage, green beans, rape and kale) to be extended up to seven months into the dry season even in drought years (McCartney et al. 1997).

The greatest benefits are likely to be achieved through ridge and furrow cultivation to avoid waterlogging, and small-scale irrigation, perhaps using shallow hand-dug wells and treadle pumps. Hence it is likely that, as elsewhere in Zimbabwe, communities could relatively easily overcome the minor biophysical constraints associated with gardening in the wetland. Hence using the definitions presented in table 3, the biophysical suitability of the wetland is classified as "moderately suitable" (i.e., class 4).

Currently it is believed that there are no socioeconomic constraints to utilizing the wetland in the way proposed. There are good communication links to the large towns of Marondera and Harare and it is likely that markets for produce grown in the wetland could be relatively easily established. Some extension service inputs might be necessary to train people in specific cultivation techniques and some effort might be needed to coordinate household production to maximize benefits. Hence, using the definitions presented in table 3, the socioeconomic suitability of the wetland is classified as "moderately suitable" (i.e., class 4).

Since biophysical suitability and socioeconomic suitability are both deemed to be class 4, this is the overall suitability index given to the wetland.

### *Assessing the Hazard Potential Associated with Increasing Wetland Agriculture*

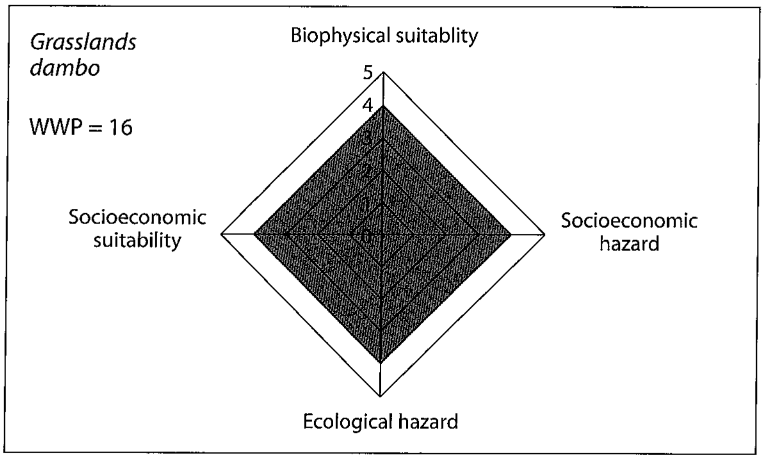
Despite the legislation prohibiting it, dambo cultivation is a common practice in many areas of the highveld in Zimbabwe. It is not known to be associated with any particular health risks. Given the current very small contribution that the wetland makes to social welfare, the proposed increase in garden agriculture is anticipated to have only a very low chance of adverse impacts on social welfare (i.e., class 4).

There is little doubt that an increase in gardening would result in the ecological condition of the wetland moving towards being "less natural." However, past human activities have resulted in the current wetland condition still being "moderately natural." Furthermore, there seems little chance that the proposed cultivation would lead to the extirpation of any species or threaten any rare or endangered species. Therefore, in terms of the impact on the ecological condition of the wetland, the hazard potential is classified as "very low" (i.e., class 4).

BOX 2.

Summary of WWP classification for the Grasslands dambo.

| | | | | | |
|---|---|---|---|---|---|
| Wetland name | Grasslands | | | | |
| Location | 18° 11' S, 31° 28' E | | | | |
| Current ecological condition | "Moderately natural" | | | | |
| Contribution to social welfare | "Small contribution" | | | | |
| Development pressure | Extended cultivation (small gardens) to cover 30-40% of the dambo | | | | |
| Potential suitability | | | | | |
| *Biophysical* | 4 | *Socioeconomic* | 4 | *Overall* | 4 |
| Hazard potential | | | | | |
| *Ecological Condition* | 4 | *Social welfare* | 4 | *Overall* | 4 |
| Working Wetland Potential | 16 | | | | |



Thus combining the hazard potential for social welfare and the hazard potential for the ecological condition, the hazard rating of the proposal is class 4.

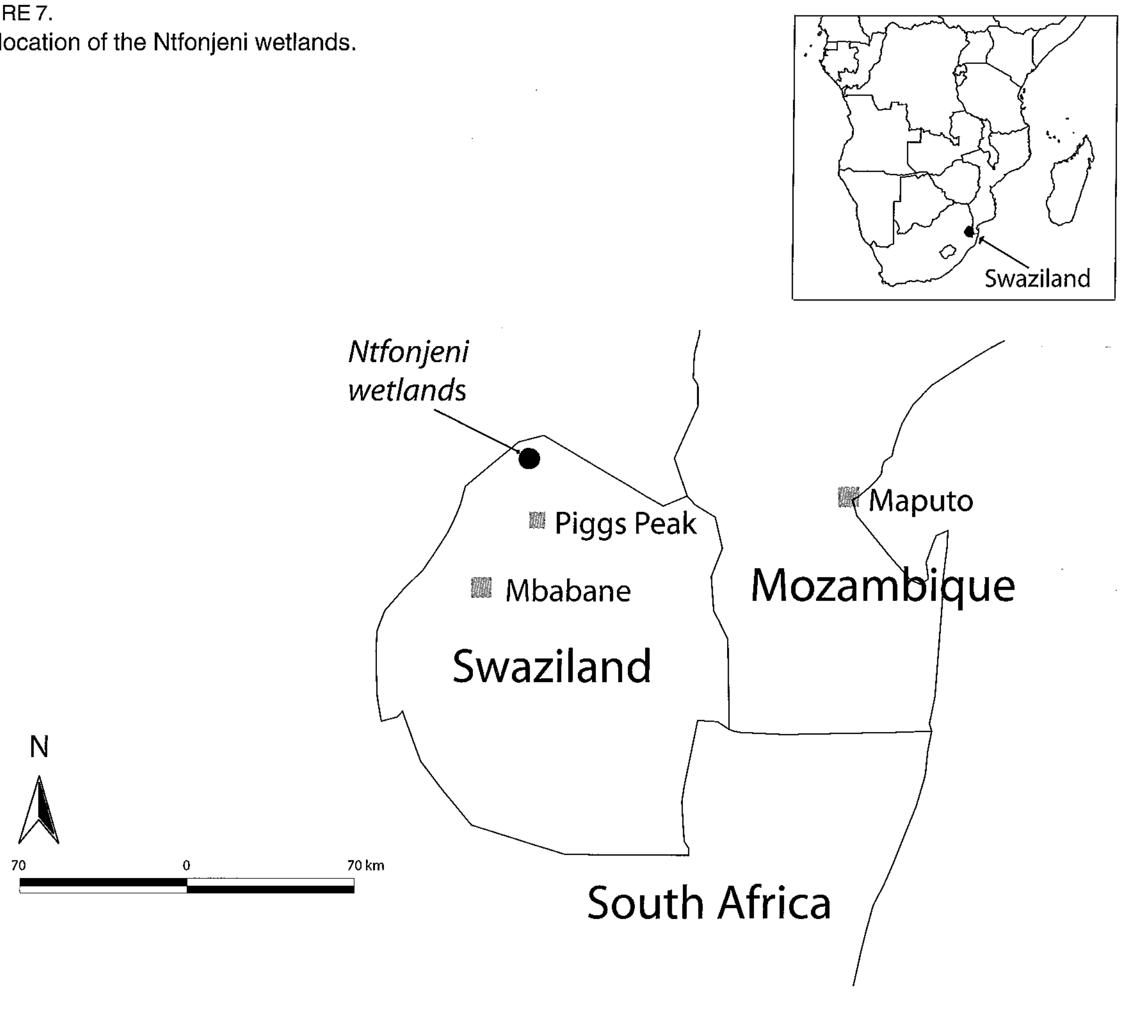
### *Evaluating the Working Wetland Potential*

The potential of the wetland for the proposed increase in smallholder cultivation is determined by combining the suitability and hazard potential indices. Combining suitability class 4 with hazard class 4 gives a WWP of 16 (table 5). This indicates that there is moderate potential for the proposal and it could go ahead, with some consideration given to minor constraints, but without the need for substantial environmental and health impact assessments (table 6). In this case, it would probably be advisable to introduce cultivation slowly and evaluate the impacts over time. A summary of the WWP classification process for the Grasslands dambo is presented in box 2.

## Ntfonjeni Wetlands, Swaziland

Within the Ntfonjeni catchment, a tributary of the Lomati River located in the northeast of Swaziland (figure 7), two adjacent wetlands called Manyangeni and Kandwandwe are utilized for cultivation. Both wetlands provide a range of other benefits, including pasture for cattle, domestic water and plants for crafts and medicinal uses. The farmers would like to intensify the existing use through the introduction of irrigation and also expand the areas under cultivation. The issue to be resolved is the potential for intensifying and expanding cultivation in these wetlands.

FIGURE 7.
The location of the Ntfonjeni wetlands.



Unless otherwise stated, all the data used in the following analysis is from a recent study that utilized a combination of participatory techniques and a household questionnaire to investigate the utilization of the wetlands (Mwendera 2002; Mwendera 2003).

### Current Ecological Condition

The Ntfonjeni catchment has an area of 367 ha. The wetlands are floodplain wetlands located at an altitude of about 470 m. Mean annual rainfall is 780 mm, falling predominantly between the months of November and February. Both wetlands have sandy-clay soils and are flooded during the wet season. In the dry season the water table is shallow; typically less than 50 cm below the ground surface. Currently only a small area of each wetland is cultivated (table 7). Cultivated crops depend on residual soil moisture and there is no irrigation. The farmers at Kandwandwe have constructed a drainage channel, which is maintained regularly, to reduce flooding in the cultivated area. However, hydrological analysis indicates that current farmer interventions have had a negligible impact on downstream flow regimes. Similarly, hydrochemical analyses indicate that there have been no adverse impacts on the water quality of the stream.

Using the definitions in table 1, the current ecological condition of the wetlands is classified as "largely natural."

### Wetland Contribution to Social Welfare

There are 15 and 12 households in the vicinity of the Manyangeni and Kandwandwe wetlands, respectively. As well as cultivation, the wetlands are also used for water supply, harvesting natural vegetation and livestock grazing and watering (figure 8). Although both communities have piped water supplied by the Rural Water Supplies Branch of the Ministry of Natural Resources and Energy, all households find this insufficient and also obtain water for domestic purposes (i.e., drinking, bathing and laundry) from the wetland. This water is obtained from two boreholes, which tap a shallow unconfined aquifer in each of the wetlands. The boreholes were installed with assistance from UN agencies (i.e., WHO and UNDP).

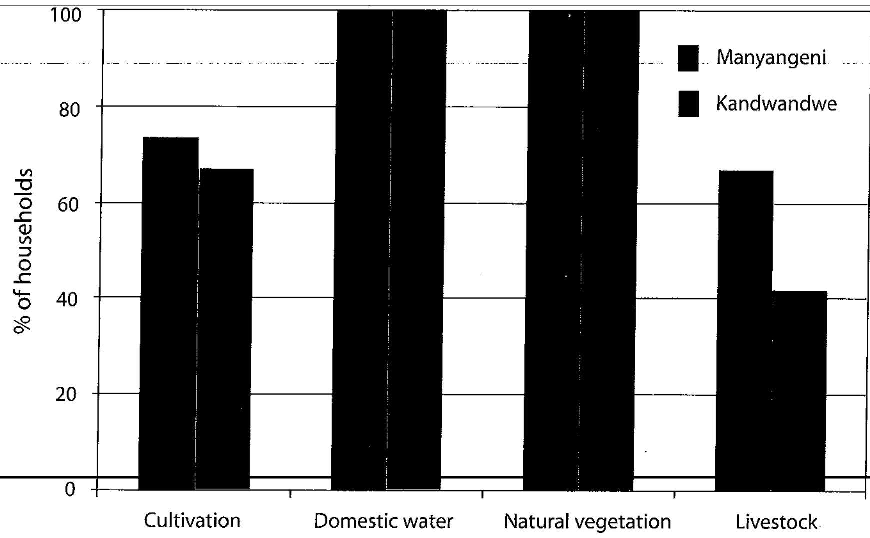
All households use natural vegetation from the wetlands. Different plants are used for a variety of purposes, including the making of traditional sleeping and burial mats, baskets, calabashes, ropes, food mats, beer strainers and widow's head dresses, and for medicinal purposes. Traditionally it is women who harvest wetland plants. In addition, wetland soils are used for making pots and other household items.

During the wet season, cattle are normally confined in kraals. But, in the dry season, both wetlands are used for grazing and the stream that flows through them is used for livestock watering. The farmers utilizing the wetlands for

TABLE 7.
Characteristics of wetland cultivation in the Ntfonjeni catchment.

| | Manyangeni | Kandwandwe |
|---|---|---|
| Total area of wetland (ha) | 4.50 | 12.00 |
| Wetland as proportion of catchment (%) | 1.2 | 3.3 |
| Area of wetland that is cultivated (ha) | 0.35 | 0.20 |
| Proportion of wetland that is cultivated (%) | 7.8 | 1.7 |
| Number of cultivated plots | 15 | 10 |
| Size of wetland plots ($m^2$) | 100-300 | 10-300 |

FIGURE 8.
Percentage of households in each community using the Ntfonjeni wetlands for different purposes.




*Source:* Derived from data in Mwendera 2002.

cultivation are predominantly women, because at the present time many rural men are engaged in paid employment in Swaziland's towns or in South Africa. The women grow taro, okra and pumpkins, predominantly for home consumption, but also to earn some income. These crops make a significant contribution to both household income and food security.

Using the definitions in table 2, these wetlands are classified as making a "major contribution" to social welfare.

### *Defining Development Pressure*

In Ntfonjeni, households would like to increase crop production by intensifying the use of existing cultivated areas and by expanding the area cropped. They believe that intensification can be brought about by installing irrigation infrastructure and fencing to protect cultivated areas from cattle in the dry season. The Irrigation Section of the Ministry of Agriculture supports the use of treadle pumps for utilization of shallow groundwater, but prohibits cultivation within 33 m of rivers and streams.

### *Assessing the Potential Suitability of the Wetlands for Proposed Agricultural activities*

Activities within the wetland indicate that lack of water is the major biophysical constraint to the cultivation of the crops currently grown in the wetland. It is not clear if provision of water would enable farmers to diversify crops, but it seems probable. The shallow boreholes that have been installed provide water all year, and the stream that flows through the wetlands is perennial. Consequently, it seems probable that treadle pumps could be successfully used to abstract shallow groundwater.

At Ntfonjeni, farmers have limited access to government extension services and they cite this as a major constraint to their ability to optimize benefits from the wetlands. Another constraint is the lack of markets. The nearest town, Piggs Peak, is 20 km away and the farmers find it difficult to transport their produce there. However, there is the prospect that the National Agricultural Marketing Board (NAMBOARD) would buy their produce on site, if they can meet agreed quotas. This system is believed to work well with organized farm associations that can produce reasonable quantities to an agreed timetable. Currently, for each of the wetlands at Ntfonjeni, there is a loose association of farmers with a group leader. Although ultimately the local "chief" controls the use of wetland resources, at Ntfonjeni he has given this authority to women's groups. The group leader is responsible for allocating plots in the wetland to members. However, neither group has a formal constitution and neither has any form of subscription charge; so they have no financial resources.

In summary, it seems that there are both biophysical and socioeconomic constraints to increasing wetland agriculture. But in both instances these could be relatively easily overcome; the biophysical through increased extension services and utilization of treadle pumps, and the socioeconomic by strengthening the farmer groups and perhaps forming a cooperative to negotiate with NAMBOARD for assistance with marketing of produce. Thus, using the definitions presented in table 3, both the biophysical and socioeconomic suitability are classified as "moderately suitable" (i.e., class 4), and this is the overall suitability class given to the wetland.

### *Assessing the Hazard Potential Associated with Increasing Wetland Agriculture*

Currently the Ntfonjeni wetlands make a significant contribution to the livelihoods of all households in the area. Increased wetland agriculture would undoubtedly result in the wetland becoming less natural. However, the studies conducted at Ntfonjeni indicate that many of the farmers are environmentally aware and appreciate the other benefits that accrue from the wetland. More than half leave some land uncultivated to preserve natural vegetation harvested for other uses.

McCartney et al. (2001) present a crude "rule of thumb" to estimate the maximum number of treadle pumps that can be used "safely" (i.e., with limited impact on water resources) in headwater wetlands of this type. The rule takes into account the ratio of the wetland area to the total catchment area, the mean annual rainfall, the volume of water typically extracted using a treadle pump and the dry season contribution of water to the wetland from upslope. With the lack of anything more sophisticated, this rule was applied and results indicate that, in these two wetlands, a "safe" upper limit on the number of treadle pumps is 15 and the total area that could be safely cultivated is 6 ha (table 8). Currently 0.55 ha is cultivated (table 7) and so this analysis indicates that intensification using up to 15 treadle pumps would have limited impact on water resources, though there should not be a significant increase in the area cultivated without a more detailed evaluation.

The primary concern pertaining to increased cultivation would be the possible impact on water quality. Currently there is no information on the status of soil fertility and it is believed that few, if any, farmers use agrochemicals. However, if cultivation was intensified, there may be increased desire to utilize chemicals that could pollute the shallow groundwater currently used by all households for domestic purposes.

TABLE 8.
Estimate of the maximum number of treadle pumps that can be used "safely" in the Ntfonjeni wetlands.

| | Ntfonjeni wetlands |
|---|---|
| Catchment area (km$^2$) | 3.67 |
| Wetland area (km$^2$) | 0.165 |
| Ratio of wetland to total catchment area | 0.044 |
| Average annual rainfall (mm) | 780 |
| Proportion of inflow from upslope | 0.555 |
| Total, annual inflow from upslope (m$^3$) | 160,394 |
| Dry season inflow from upslope (m$^3$)[a] | 32,079 |
| Maximum number of treadle pumps[b] | 15 |
| Maximum area irrigated (ha)[c] | 6 (36) |

[a] Assuming that 20% of the inflow occurs in the dry season, as was observed in hydrology studies.

[b] Assuming that a treadle pump removes, on average, 2,160 m$^2$ to provide 500 mm of evapotranspiration over 0.4 ha and limiting the maximum number to that which would extract the average dry season inflow.

[c] Number in brackets is the percentage area of the wetlands that can be irrigated safely.

Using the definitions presented in table 4, the hazard rating for the likely impacts on both the ecological condition and social welfare is classed as "low" (i.e., class 3).

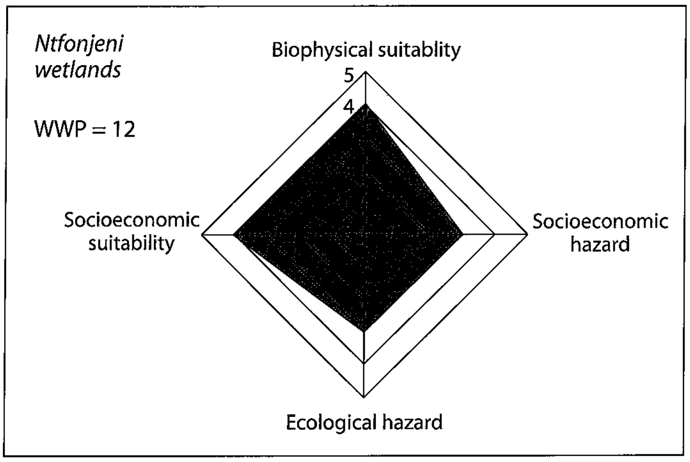
### *Evaluating the Working Wetland Potential*

The potential of the wetland for the proposed increase in cultivation is determined by combining the suitability and hazard potential indices. Combining suitability class 4 with hazard class 3 gives a working wetland potential index of 12 (table 5). This indicates that there is marginal potential for the proposal (table 6). Care should be taken in proceeding with the proposed activities. A detailed assessment should be conducted to assess the possible impacts of the proposed activities on water quality. An environmental impact assessment should be conducted, perhaps by the Ministry of Agriculture, to assess both the environmental and the social implications of expanding the area under cultivation beyond 6 ha. Alternatively, the proposal to increase the cultivated area could be dropped and the working wetland potential reevaluated. A summary of the WWP classification process for the Ntfonjeni wetlands is presented in box 3.

BOX 3.

Summary of WWP classification for the Ntfonjeni wetlands.

| | | | | | |
|---|---|---|---|---|---|
| Wetland name | Ntfonjeni | | | | |
| Location | 25°49' S, 31°22' E | | | | |
| Current ecological condition | "Largely natural" | | | | |
| Contribution to social welfare | "Major contribution" | | | | |
| Development pressure | Increased crop production through irrigation and expansion of the cropped area | | | | |
| Potential suitability | | | | | |
| *Biophysical* | 4 | *Socioeconomic* | 4 | *Overall* | 4 |
| Hazard potential | | | | | |
| *Ecological Condition* | 3 | *Social welfare* | 3 | *Overall* | 3 |
| Working Wetland Potential | 12 | | | | |



## Concluding Remarks

It is now widely understood that fulfilling long-term human needs requires wiser management of all natural resources. History has shown that human actions undertaken without full consideration of the social, environmental and economic implications can have adverse repercussions. It is certain that past alteration of some wetlands was in society's best interests, but other wetlands have been degraded as a result of human activities and this has resulted in net costs to society.

Many developing countries are currently experiencing problems of environmental degradation of wetlands and the natural capital that they present. The biotic impoverishment and environmental disruption of wetlands, caused by past and continuing mismanagement, severely constrain the options for future management.

Sustainable utilization of wetlands requires a holistic approach that enables the entire range of benefits and costs to be taken into account. It is social and economic factors that drive human-induced wetland change and so these must be of central concern in their wise use. The working wetland concept described in this report provides a context for coherent consideration of the use of wetlands for agriculture through deliberation of the relevant socioeconomic and environmental factors governing use.

### Research Needs for Improving the Approach

The WWP approach is believed to be the first attempt to explicitly integrate social and biophysical aspects of a wetland system in a single index pertaining to agricultural utilization. It is a pragmatic attempt to assist wetland managers and natural resource planners to make rational decisions about the use of wetlands for specific agricultural activities. However, it remains a tool in development and there are recognized limitations in the current methodology. The purpose of this final section is to identify the research tasks needed to strengthen the method.

Since the purpose of the WWP approach is to provide a graphic way of determining and visualizing the potential of utilizing a particular wetland for specific agricultural activities, it can legitimately be criticized as simplistic in the way it summarizes human-wetland interactions. In particular, since the greatest emphasis is on local requirements, which tend to be influenced mostly by considerations of immediate socioeconomic development and livelihood needs, there is a danger that broader environmental issues are given less credence. As it stands the likelihood is that the approach will tend to underestimate the human use of ecological capacity, specifically in relation to factors such as carbon sequestration and the maintenance of biodiversity. This is a problem that is likely to be exacerbated in many developing countries by the lack of information on the biodiversity and ecological attributes of individual wetlands. In many places, the lack of faunistic and, to a lesser extent, floristic information hinders the evaluation of wetland ecological condition and, hence, the ecological hazard. Furthermore, the approach is still rather subjective in its application and different stakeholders will almost certainly attribute different values to the four components that comprise the index.

In light of the constraints, further research is required to:

- Develop nonsubjective methods of rapid assessment that enable the value of wetland ecological functions, including maintenance of biodiversity, to be determined, not just at local but also catchment and even global scales.
- Determine methods of reconciling different stakeholder perceptions and more objective numerical procedures for calculating the

components of the index. The implications of applying variable weights to the different components should be investigated.

- Broaden the approach beyond an assessment of agricultural potential to a more comprehensive options assessment.

These and other approaches to improve the implementation of the method will be investigated through continuing research, conducted by IWMI and partners in southern Africa (Masiyandima et al. 2003). As it stands, the method ensures that many crucial questions pertinent to the use of wetlands for agriculture are made explicit and at least considered in the planning process. It is hoped that future research will improve the rigor of the approach and bring more light to the question of how to secure and improve people's quality of life while simultaneously safeguarding the ecological benefits derived from wetland ecosystems.

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