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Sustainable wetland management strategies under uncertainties

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Summary

Wetlands are widely recognized as transitional areas between terrestrial and aquatic systems. They provide multifunctional benefits, most prominently relating to the ecosystem, the economy and to scenic quality. Extensive areas of wetlands have been lost, either as a direct result of redesignation for other uses, especially industrial and recreational, or by qualitative degradation arising from water pollution. Although researchers have been involved in prolonged debate over wetland sustainable use management issues, the uncertain substitutability and irreversibility factors surrounding wetland functions have rarely been addressed. In considering policies for wetland resource management, decision rules and procedures must be adapted to reflect those uncertainties. In this study, the author incorporates the concept of the "safe minimum standard of conservation" approach to take account of natural and social uncertainties attending public decisions. By this approach, not only is the role of uncertain substitutability and irreversibility prioritized in addressing wetland sustainable use management strategies, but related policy implications may also be considered.

Introduction

Prior to media coverage regarding endangered black spoonbills wintering in Taiwan's wetlands, few Taiwanese residents knew exactly what *wetlands* were. Even worse, wetlands were equated with *wastelands*. However, with support from environmental groups and the mass media, many have come to recognize wetlands as *wealthlands* for various species of wild life. Wetland conservation, though, seems to focus only on protecting the 'animal rights' of migratory birds and waterfowl. If the more highly designated wetlands were more sensitively managed, in addition to ethical and aesthetic considerations, they could serve multi-functional purposes. Wetlands provide a multitude of ecological, economic, and landscape benefits, for instance in re-cycling nitrogen, in stabilizing ecosystems, in scientific research and education concerning bio-ecological adjustment processes, in flood conveyance and water storage, in water purification, as a water supply, in groundwater recharge, in leisure and recreation, and as a source of outstanding scenic beauty (Lovelock, 1979; Turner, 1992; Mitsch and Gosselink, 1993). Because those values have long been overlooked, wetlands are being destroyed by such as garbage dumping and industrial development, activities that all spell regression in the quantity and quality of wetlands. This destruction represents not only a loss in scenic beauty, but also threatens already endangered wildlife to the point of extinction. Furthermore, their disappearance can ultimately endanger the sustenance of life on a global scale (Lovelock, 1979).

Despite the many positive functions they offer, wetlands are under continuous pressure from human activity, such as drainage schemes. In addition, experts and researchers of different disciplines project conflicting perspectives as to whether wetlands should be developed or preserved. However, with the advent of the *sustainable development* concept, initially advocated by the International Union for the Conservation of Nature and Natural Resources (IUCN), the United Nations Environment Programme (UNEP), and the World Wildlife Fund (WWF), and World Commission on Environment and Development (WCED) (1987), the sustainable use of resources has gained the support of various disciplines, despite a measure of differing interpretation. These differences arise from varying perceptions as to whether resource development is 'irreversible' and whether different resources are

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'substitutable.' Originating from Ricardo's relative scarcity, individuals with 'optimistic' or 'technocentric' perspectives tend to believe that reversibility and substitutability offer great scope; therefore, the problems in question can be solved via technological means. Consequently, policy implications regarding intergenerational resource use tend to avoid over intervention in resource allocation (e.g., Solow, 1986). On the other hand, originating from the Malthusian absolute scarcity doctrine, individuals with 'pessimistic' or 'biocentric' perspectives tend to believe that the uniqueness of a resource (particularly a natural resource) renders it almost irreplaceable. Thus, policy implications tend toward maintaining human and environmental capital in a steady state (e.g., Daly, 1991). However, owing to the objective and subjective uncertainties of irreversibility and substitutability, these contrasting doctrines both offer advantages and limitations. Therefore, how to allocate and employ resources presents a relevant and challenging task in sustainable development.

Ciriacy-Wantrup (1952) introduced the safe minimum standard of conservation (SMS) strategy, *i.e.*, an approach to making public policy decisions in situations of uncertainty, which was later expanded by Bishop (1978) and Toman (1994). This study employs the SMS approach to explore wetland management faced with uncertainties to attain the goal of sustainable development. The aims are to (a) examine the uncertainties involved in wetland sustainable use, (b) explore the feasibility and constraints of applying the SMS approach to wetland management, and (c) propose future directions for wetland sustainable management.

Definition, functions, and status of wetlands in Taiwan

For Taiwanese people, the word "wetland" is an extremely vague term. Before discussing sustainable wetland management strategies, the following questions must be answered: What is the function of wetlands? What are the attributes of these functions? What is the status of Taiwanese wetlands?

What is a wetland?

Most people consider wetlands simply as places where waterfowl and other wildlife are found. Some would describe them as a 'piece of beautiful scenery.' Such imprecise description, however, cannot serve the specific purposes of researchers and those who manage and regulate wetlands. Most expert opinion in the field would accept the following definitions: (1) The Convention on Wetlands of International Importance (Ramsar Convention) definition: "Areas of marshes, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low-tide does not exceed six metres" (Turner, 1992: 12). (2) US scientific definition, US Fish and Wildlife Service: "Wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plants and animal communities living in the soil and on its surface (Kusler, 1983: 11).

Regardless of the classification system employed, three criteria for wetlands present themselves: wetland hydrology, wetland soils, and hydrophilic vegetation. The Ramsar Convention definition focuses more on water and soils; that of the US Fish and Wildlife Service covers water, soil, and vegetation; and the US Army Corps of Engineers' definition pinpoints only one indicator, vegetative cover, to determine the presence or absence of a wetland. Although minor differences separate these definitions, wetlands can be generally defined as 'lands transitional between terrestrial and aquatic systems where marine water is less than six meters and soil consists of marshes or peatland.' This definition provides a clear picture. However, delineating wetland 'boundaries' remains a problem. As far as management is concerned, distinct 'natural criteria' and 'production function criteria' are adequate for delineating wetland boundaries. Natural criteria can refer to soil types (e.g., clay), distance from surface water (e.g., 100 or 200 m), and quantity and quality of vegetation. Production function criteria can relate to the quantity and variety or uniqueness of waterfowl, quantity of fish, crustaceans, and uniqueness of factors such as landscape.

Functions of wetlands

Wetlands are lands falling between terrestrial and aquatic systems. Sediments or nutrition brought down from upper streams are trapped in them, which not only contribute to water cleansing, but also facilitate the growth and maintenance of plants and shallow water wildlife. On the other hand, wetland vegetation and shallow water (micro-) organisms provide shelter and a major food supply for fish, shellfish, waterfowl, and other wildlife; therefore, wetlands attract numerous species to rest, nurse, and nest there. Inland wetlands may store water during times of flood and slowly release it to downstream areas, subsequently lowering flood peaks and further recharging underground water. In addition, numerous organisms partake in ecological cycles in wetlands. For instance, the tissues of defunct wetland plants and animals are transformed into minute fragments of food and vitamin rich detritus that provide a source of nutrition for other organisms (for details see Kusler, 1983; Mitsch and Gosselink, 1993). Lovelock (1979), in exploring GAIA (Mother Earth), proposed that the kernel of life on our planet is not to be found on land, but rather in bogs of bay areas, in wetlands, and on continental shelves between latitudes 45 degrees North and 45 degrees South. He demonstrates that anoxic microbes release methane (CH_4) to the atmosphere, maintaining a not overly high level of oxygen, while carbon generated by organisms maintains a not overly low level of oxygen. Through this process, the earth sustains oxygen concentration at a steady level. In addition, nitrogen is a critical element in life support systems. The cycling of nitrogen requires the seasonal migration of waterfowl to accomplish the process. In this regard, wetlands, fruitful and diversified habitats for waterfowl, play an influential role in sustaining life on earth. Therefore, in Lovelock's view, wetlands contribute to improve regional micro-climates and to stabilizing the life cycle, which helps sustain viability for various organisms globally. From this perspective, wetlands 'probably' confer economic, ecological, and scenic benefits. The reason for stating 'probably' is that the present state of scientific knowledge cannot verify whether or not certain functions are critical, or in fact, even exist.

Because wetlands functions depend on water, soils, and vegetation; where vegetation is scarce, the water purification function is dramatically reduced, and that lack indirectly deprives species of shelter and food sources. When the soil's function of storing and releasing water changes, the function of flood prevention and underground water recharge is also affected. Water, soil, and vegetation have inter-dependent ecological relationships, the 'exact' connection between which is not easily demonstrated. In addition, not all wetlands share the same quality and quantity of water, soil, and vegetation. Thus, the actual functions of wetlands in water purification, flood prevention, underground water recharge, and as wildlife habitats remain in dispute. Furthermore, a certain degree of uncertainty arises regarding the stabilizing function of the biosystem referred to by Lovelock, because the claimed process involves ascertaining whether or not oxygen maintains a steady state (21 percent oxygen) through carbon absorbing oxygen and CH_4 releasing oxygen. CH_4 has been proven to be one of the causes of global warming, contributing 13 percent of global warming gases, conjoined with carbon dioxide (52 percent) and CFC (22 percent) (Ekins *et al.*, 1992: 15). How to balance the quantity of CH_4 to maintain a steady state in the atmosphere remains a controversial issue among scientists. To this extent, many uncertainties exist regarding the functions of wetlands. Other than the recreational function, the significance of other wetland functions requires further exploration. Furthermore, if wetlands do indeed boast the function of maintaining a steady state in the ecosystem, as suggested by Lovelock, a further uncertainty arises, which is whether or not additional wetland improvement strategies can help maintain that steady state?

The status of Taiwan's wetlands

More than six percent of the earth's land surface, or 8.6 million km^2, is wetland (Mitsch and Gosselink, 1993). However, drainage and other human related developmental activities (industrial, residential, and agricultural) have dramatically diminished wetlands. In the United States, since the late 1700s, 53 percent of wetlands have been lost (4700 million ha). Recent average annual losses of wetlands there, from 1950s to 1970s, have ranged from between 180 000 to 190 000 hectares (about 8.5 percent of the total land area). During the 1970s and 1980s, an annual average 50 000 ha of wetlands vanishes (about 2.5 percent of total land area) (Mitsch and Gosselink, 1993: 45–51). In Taiwan, there are more than twenty wetlands, comprising a total area of around 10 000 ha (about 0.3 percent of total land area). As far as is known, no thorough going studies of the chronic quantitative changes in Taiwanese wetlands have been undertaken.

In the face of the combined threats to the quantity and quality of Taiwan's wetlands, considerable gaps of knowledge concerning the natural ecological environment still persist. In qualitative terms of wetland, wetlands suffer primarily from waste water emission, soil erosion, and garbage dumping. Although wetlands are capable of purifying water, this function depends on vegetation types and density. Excessive pollution impinges on the sustenance of plants and animals. For instance, data from the Norfolk Broads reveal that harnessing the fresh water resource as part of the waste water treatment system causes species of plants and animals of the wetlands to decline (Turner, 1988: 127). In quantitative terms of wetland, pressures arising from industrial development completely change wetland conditions. It is this issue that has most concerned the general public, environmentalists, and governmental bodies. In general, development offers considerable, short-term benefits, though these vary according to the type of development; whereas, conservation probably offers substantial, long-term benefits, though these are attended with some uncertainties.

Substitutability and reversibility issues of wetland sustainable use

The context of wetland sustainable use

The wetland 'sustainable use' concept derives from the 'sustainable development' concept promulgated by IUCN, UNEP, and WWF (1980, 1991), and WCED (1987). The purpose of such development is "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 8). It is "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs." (WCED, 1987: 9) Although a certain latitude of interpretation prevails, most would agree that sustainable development implies that the current generation desires to increase its 'welfare' without compromising the 'welfare' of future generations. However, what does 'welfare' comprise? Some researchers focus on 'input' capitals. For instance, Ekins *et al*. (1992) suggest that welfare includes ecological, human, social/organizational, and manufactured capital. Turner (1993) proposed that sustainability should not reduce man-made, natural, humanpower, and cultural capital. Register (1987) pointed out that welfare should include the 'natural' values of life, beauty, and equity. This study emphasizes the environmental, economic, and cultural aspects of welfare.

Wetland sustainable use is defined here as ensuring 'that it increases the needs of environment, economy, and culture of the present generation without compromising the ability of future generations to meet their own needs.' This definition signals two important elements rarely discussed in previous studies, those of intergeneration and needs. That is to say that it requires a shift from 'considering property rights of the present generation' to 'considering intergenerational property rights.' Accepting that it implies that the present generation must appropriately transfer property rights pertaining to environment, economics, and culture to future generations. In addition, the welfare indicator must be modified from that of satisfying individual 'wants' to meeting 'needs,' implying that each generation must make appropriate adjustments regarding consumption, because needs have limits and wants have none.

The 'win-win' concept of environment, economy, and culture of the present generation is generally accepted. However, unless certain pertinent issues are clarified, this concept may become a cliché, or, even worse, come to constitute a 'lose-lose' situation. Whether economy, environment, and culture can be progressive at the same time must first be classified. From a co-evolutionary perspective, by adjusting value judgment, institutions, techniques, knowledge, and social organization, environment, economy, and culture can be co-evolutionary (Norgaard, 1988). However, if economic needs are to be met, 'natural inputs' are inevitably required and this implies 'cultural adjustment' (in this case, a culture indicates a way of life). Therefore, co-evolution is achievable only when economic development is within the threshold of the self-adjustment ability of environment and culture. The question of what that threshold is, remains unresolved. This perspective further implies that natural resource use policies will be constrained by 'compatible use' rather than by 'transferal development' factors. However, resources differ in their self-adjustment abilities and values. In this regard, whether a policy implication is appropriate requires further examination. In addition, a more fundamental issue concerns whether individuals across generations are willing to increase economic welfare at the expense of environmental and cultural welfare? If so, then the appropriate strategy would be to increase the 'total output' of environment, economy, and culture, rather than 'individual output,' to meet people's needs. However, because the total output comes from the stock of natural, human, and cultural capital, dramatically decreasing 'individual' capital stocks would give rise to another issue: can science and technology restore regressed capital? If so, then maintaining individual capital in a steady state (e.g., Daly, 1991) would be unnecessary. Although the former issue (subjective substitutability) and the latter (objective reversibility) are both real ones, certain limitations are attached.

Uncertainty of subjective substitutability

Complete substitutability is a basic hypothesis in neoclassical economics. However, whether it actually exists is a matter of psychological debate. Therefore, in facing the 'subjective substitutability' uncertainty issue, Maslow's (1970) need-hierarchy theory may be relevant. Maslow suggests that the highest hierarchy need (e.g., self-esteem) can induce long-lasting and true happiness. However, the higher hierarchy becomes valid only when lower hierarchy needs (e.g., biological needs) are satisfied. A number of economic psychologists agree with this proposition, maintaining that there is a hierarchy of human preference. Once humanity's lower hierarchy preference is satisfied, a higher hierarchy preference then becomes the main preference. Needs in the same hierarchy are easily substituted; whereas, the substitutability of needs in different hierarchies is restricted (e.g., Van Raaji, 1986).

From this perspective, when lower hierarchy needs cannot be satisfied, people will employ resources associated with higher hierarchy needs to produce materials that meet those lower hierarchy needs. Because functions pertaining to wetland areas are mostly higher hierarchy needs, nearby 'poor residents' will contend that 'we cannot even feed ourselves, how can we have time to enjoy bird-watching?' Therefore, to secure their lower hierarchy needs, they will prefer wetland development to conservation. In contrast, to fulfill their higher hierarchy needs, wealthy people will approve of conservation and oppose wetland development. However, if wetland development can indeed provide real benefits, some wealthy people will approve of development, as long as they know that wetlands existing elsewhere are reachable by air and that they possess the means to avail themselves of the environmental amenities provided by those wetlands. If the need hierarchy theory is valid, then, for the poor, environmental and cultural regression can be substituted by increasing economic benefits (so long as air, water, and food are still available); for the rich, substituting environmental and cultural benefits for economic benefits is less possible. In Taiwan, the annual *per capita* Gross National Products (GNP) exceeds US$12,000 dollars, thereby limiting the substitution of environmental and cultural benefits for economic benefits. When uncertainties attach to wetland conservation benefits, individuals will likely increase their subjective substitutability, because they are mortal and worry that they probably do not have the time to enjoy wetlands' future benefits or that these benefits will not even exist.

Therefore, in seeking to utilize wetlands to increase environmental, economic and cultural welfare, the debate cannot exclude the possibility of substitutability, nor can the possible constraints be neglected. When subjective substitutability prevails, completely prohibiting wetland development particularly for those with poor natural attributes may be unsustainable. On the other hand, where subjective substitutability is attended by decided constraints, completely developing wetlands is equally unsustainable, particularly for those of superior natural quality. This is because human welfare is not a single indicator of environment or economy but, rather, a broad spectrum of manifest indicators which include environment, economy, and culture. The appropriate manner for dealing with this issue is to carefully evaluate all the factors before deciding on conservation or development.

Uncertainty of objective reversibility

In addition to the uncertainty issue of subjective substitutability, the same issue arises with objective reversibility. Since Krutilla (1967) raised the question of irreversibility related to developing environmental resources, researchers have been extremely concerned with it. They have argued that if the question is neglected then natural resources will suffer excessive and premature development. As Henry (1974, 1006) puts it: "a decision is considered irreversible if it significantly reduces for a long time the variety of choices that would be possible in the future." Although he does not clearly define what 'a long time' implies, the degree of irreversibility influences the range of future choices, which further affects optimal decision making over conservation or development.

Therefore, when wetland development reaches a certain point of irreversibility, the option value, the bequest value, and the existence value of wetlands disappear, and consequently, when present and future generations express a need for wetland resources, that need can never be fulfilled. However, due to the uncertainty of technology, certain uncertainties pertaining to 'irreversibility' are still present (see Miller and Lad, 1984; Viscusi, 1985; 1988; Usategui, 1990). Those who are "overly pessimistic" point to possible technological constraints and claim, therefore, that certain natural resources are difficult, if not impossible, to restore or to be substituted (e.g., Daly, 1991). Conversely, those who are 'overly optimistic' take the opposite view (e.g., Solow, 1986). In fact, although the 'potential of science and technology' cannot be denied, neither can it be overly relied on. This is the central theme of *Our Common Future* (WCED, 1987). This document insists that resource extraction, investment, technology development and institutional change must be coordinated to attain sustainability. Regarding wetlands, some contend that present day levels of knowledge do not easily permit higher rank wetlands to be restored; however, it may be possible to restore lower rank wetlands (Turner, 1988).

Because of the reversibility uncertainty attached to wetland development, the conversion of wetlands for the current generation may not be definitely unsustainable. In addition to the possibility of reversibility, the question of whether or not wetland use is sustainable is not simply a 'yes or no' choice, but one of whether it helps 'to satisfy opportunities of needs of the present and future generations.' Some would argue that if there are 'no' wetlands, how can the sustainability of wetland use be attained? However, taking an extreme view, if people are starving to death because wetland conversion is prohibited, then, equally, there will be no sustainability. Besides, if lower rank wetlands are converted for the purpose of 'developing a restoration technology,' the conversion of those wetlands may further facilitate maintaining other higher rank wetlands, which may not be unsustainable. Furthermore, if the restoration technology can be transferred to future generations, whether such conversion is less sustainable than transferring lower rank wetlands is worth discussion. Similarly, owing to the low reversibility possibility (or high reversibility costs), the conversion of higher rank wetlands may not be sustainable.

The uncertainty attaching to both subjective substitutability and objective reversibility, deciding which strategy to adopt for wetland sustainable use presents a problem.

Wetland management strategy: The safe minimum standard of conservation

If the goal of wetland sustainable use is to be achieved, the development rights and types of wetlands must be first defined. By doing so, the uncertainties surrounding wetland use can be reduced, which step further reduces unnecessary information costs. However, what should be the criteria for evaluating wetland development? Moreover, in terms of management practice, how can the delineated development areas be effectively managed to fully achieve stated goals?

Criteria of wetland development types

Assume that all potential wetland types can be fitted into a two-tier system: protection and development. In terms of location, the former constitutes a conservation area where wetland use cannot violate protection purposes; the latter constitutes a developmental area, that is, it is available for development. Which strategy should be adopted for delineating development or protection areas? Most researchers agree that the welfare criteria of resource allocation are efficiency and equity. Are these two criteria appropriate for wetland development in light of the uncertainties pertaining to subjective substitutability and objective reversibility discussed in previous sections?

Safe minimum standard of conservation criteria. In economic analysis, the concept of efficiency may include either the Pareto criterion or the Kaldor-Hicks compensation principle. According to the Pareto criterion, the individual welfare of one member in society may be better off without making other members worse off. In the Kaldor-Hicks principle, after fully compensating the losers' losses, the benefits of the gainers still retain a surplus (*i.e.*, the total consumption surplus in society is greater than zero) (Boadway and Wildasin, 1984; Freeman, 1993). In the real world, resource allocation always benefits certain individuals leaving others worse off. As a result, the Pareto criterion cannot identify whether society as a whole is better or worse off. In such a situation, the Kaldor-Hicks principle is more valid than the Pareto criterion and can, therefore, provide the theoretical foundation for cost-benefit analysis in neoclassical economics. In such analysis, as long as the present value of net benefit of development (B_d) is larger than the present value of net benefit of conservation (B_p), the most 'efficient' resource allocation will be development. Conversely, if B_p is larger than B_d, conservation will prevail. In this regard, according to the 'efficiency' criterion, wetlands should be developed when the net developmental benefits are larger than the net conservation benefits. If the net developmental benefits are less than the net conservation benefits, wetlands should be preserved. The major limitation to this approach is wetland functions are subject to the uncertainties of substitutability and reversibility. How to effectively estimate the benefits pertaining to these uncertainties requires further exploration. Moreover, intergenerational and intragenerational equity issues require further discussion as well as the same issues in relation to natural species.

Owing to these uncertainties, environmental economists advocate the SMS approach. Ciriacy-Wantrup (1952) first proposed this approach, indicating that species habitats are limited renewable resources. Restated, development exceeding a certain ecological threshold will induce irreversibility. Therefore, SMS should be adopted to protect the living space of delineated species. By adapting the minimax principle of game theory, pure uncertainty, and irreversibility, Bishop (1978) expanded SMS strategy to protect endangered species. He suggested that the social and natural uncertainties that impinge on endangered species necessitate the SMS approach. The basic decision rule of SMS, Bishop holds, is to "adopt the safe minimum standard unless the social costs are unacceptably large" (Bishop, 1978: 13). Such a strategy immediately raises questions as to how *large* costs would be before becoming intolerable. That sticking point depends on the willingness of the present generation to bear costs so that the position of future generations will be less uncertain. These choices must "ultimately rest with society and the institutions it has created to deal with such issues" (Bishop, 1978: 14).

The SMS approach differs from neoclassical economic cost-benefit analysis. Bishop (1978) contends that the decision criterion of ($B_d > B_p$) does not function adequately due to the future uncertainties of benefits and development irreversibility. That is, since it is difficult to accurately evaluate B_p (e.g., future benefits of gene pools), he advocates the SMS approach as a more appropriate strategy. The SMS approach concurs with the neoclassical approach in accepting that when ($B_d - B_p$) < 0 a conservation strategy is beneficial to society. The approaches differ, however, when ($B_d - B_p$) > 0. In this case, the SMS approach proposes that the decision making process should depend on whether or not the burden is acceptable to society and advocates that the criterion should be the amount of 'burden' rather than 'efficiency.' The approach thus implies that when the net opportunity cost (*i.e.*, the difference between net developmental and net conservation benefits) is still acceptable to society, wetlands should be preserved. If the cost is not acceptable, then wetlands should be developed with appropriate compensation. This social equation raises considerable implications for sustainable wetland management. While wetland conservation may reduce the welfare of the present generation, it will preserve the rights of future generations to use wetlands (e.g., wetlands in the future may offer extremely important ecological functions). Regarding present generation rights, it is for that generation to determine whether or not the 'burden' is acceptable. In addition, objective losses could be compensated by transferring wetlands to future generations (*i.e.*, the bequest value).

Those advocating 'environmental rights' demand that wetlands be preserved. Anyone designating wetlands as developmental areas will be stigmatized as 'selling out environmental rights.' However, taking account of resource constraints, multi-dimensional human welfare, and uncertainties, this demand could be branded as an 'unsustainable use' approach. Because wetlands do not all share the same values, from the sustainable management perspective, designating wetland uses should differ accordingly (e.g., conservation and development areas). Criteria for delineation could reflect the degree of reversibility and substitutability. Here, environment, economy, culture, and time cost serve as measuring indicators. The indicators do not have to be *monetary* units. They could involve satisfaction or intrinsic satisfaction as discussed by environmental psychologists (e.g., Lee and De Young, 1994) or *emergy* as considered by ecological economists (e.g., Odum, 1990). Such costs may be determined in the current generation either by interdisciplinary studies or by general public opinion.

Figure 1 depicts the SMS approach for wetland sustainable use. The right hand side of the figure indicates the developmental area and reveals that the net wetland conservation opportunity cost (*i.e.*, the difference between developmental and conservational benefits) cannot be tolerated by the present generation; therefore, those wetlands are a fit case for development.

On the left-hand side of the figure, the net conservation opportunity cost is still acceptable to society. Therefore, those wetlands should be designated as protection areas, and conversion to other uses in the present generation forbidden. As the degree of reversibility and substitutability change, the SMS line may be adjusted accordingly. It is this view that is held by certain environmental economists when facing uncertainties. Restated, when the information is complete, decision making is made easier. However, decision making need not be delayed in all situations of uncertainty. Whether or not delays should occur depends on what benefits may be induced by the delayed-decision. This notion is termed the 'quasi-option value,' the 'information value' (e.g., Conrad, 1980; Miller and Lad, 1984; Fisher and Hanemann, 1987) or adaptive value (Chavas, 1993). The notion is similar to 'leave optional space,' except that the 'optional space' (*i.e.*, the conservation area) is determined by the SMS line, which in turn is determined either by inter-disciplinary groups or by society at large. Not all uncertain situations require 'optional space.'

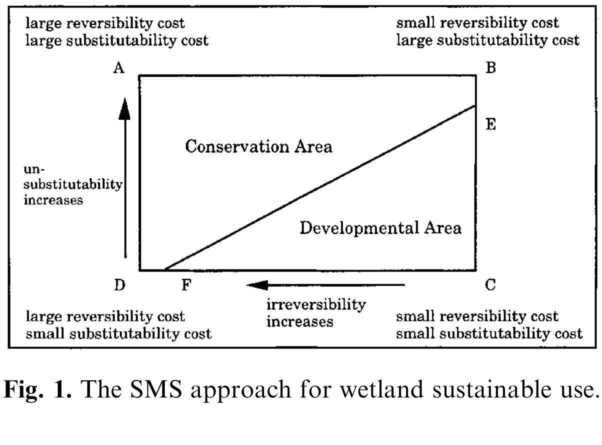

Fig. 1. The SMS approach for wetland sustainable use.

In addition to considering 'burden,' instead of 'efficiency,' as the decision-making criterion, the equity criterion should also be examined. However, the criterion is not easily defined. In general, researchers agree with Rawls' (1971: 302–303) two justice principles: a. equal basic liberties; b. (a) fair equality of opportunity and (b) the greatest benefit of the least advantaged (the differentiate principle or maximin principle). Varian (1974: 64) defines an allocation as *equitable* if "no agent prefers some other agent's bundle to his own." He further defines an allocation as *fair* if it is both equitable and Pareto efficient. The equity issue relating to wetland sustainable management is quite complicated because it involves inter-generational, intra-generational, and species equity. The following analyses focus only on inter- and intra-generational equity issues.

The equity decision criteria. Regarding the inter-generational equity issue, since future generations are yet unborn, the above criteria are not applicable. Therefore, whether the issue is applicable across generations may be clarified by considering the following statement: "The distribution of rights and assets across generations determines whether the efficient allocation of resources sustains human welfare across generations (Howarth and Norgaard 1992: 473). This statement implies that whether the distribution of wetland use across generations is equitable depends on an increase (at least non-decline) of human welfare of the present and future generations. Figure 1 demonstrates this notion, indicating that the larger the conservation area is implies that the current generation can transfer more free rights relating to wetland use to future generations. Restated, the current generation enjoys fewer rights to 'freely utilize' wetlands. How may development areas or conservation areas be delineated to satisfy intergenerational equity? Deep ecologists emphasize resilience or assimilative capabilities and thus prefer designating all areas for conservation. Classical economists emphasize cost and benefit analysis and tend to prefer allocating all areas for development. Neoclassical economists and ecologists alike consider the limits of regenerative capacity, which results in a more neutral viewpoint. However, neoclassical economists are inclined to believe in the feasibility of substitution and technology and, as a result, prefer larger developmental areas. Ecologists, who have less faith in those factors, opt for larger conservation areas. Besides the environmental aspect, human welfare also includes cultural and economic dimensions. In this regard, designating all wetlands as conservation areas may constitute 'unsustainable use.' For instance, if wetlands with low reversibility and substitutability costs (*i.e.*, lower rank wetlands) were converted into low pollution, 'high-tech' parks or wetland relocation research and development centres, the short-term benefits would be large and the long-term benefits could probably be as unexpectedly large as those of wetland conservation. In addition, wetland conversion technology could be accumulated and transferred to future generations. In terms of inter-generational equity, this kind of wetland use would not necessarily imply depriving future generations' rights. Similarly, designating the whole area for development may be an equally 'unsustainable use.' For instance, if wetlands with high reversibility and substitutability costs (*i.e.*, higher rank wetlands) were converted to high pollution industrial use, the short-term benefits could be large, but the long-term ecological or cultural costs could be extremely large (including the disappearance of wetland functions and negative externalities). In terms of inter-generational equity, this kind of wetland use compromises the rights of future generations and thus, conflicts with the inter-generational equity concept. By the same terms, if larger reversibility and substitutability costs and developmental external costs exist, wetlands should be assigned for conservation; if smaller reversibility and substitutability costs are the case and perhaps external benefits, then they should be assigned for development.

Based on liberty and equitable opportunity principles, intragenerational equity means that everyone in the present generation should have fair opportunity and liberty to participate in delineating conservational and developmental areas (*i.e.*, procedural justice). Restated, the SMS line in Fig. 1 is determined by society at large, not by people in certain areas or with certain disciplines. This finding adheres to the 'power of the people' political ideology. A further meaning of equitable opportunity is that the present generation as a whole may partake in deciding whether to develop or conserve. Therefore, if wetlands are designated as conservation areas, no individuals can claim or enjoy the right to develop them. Conversely, if wetlands are designated as development areas, no individual can claim or enjoy the right to conserve them. However, if wetlands are designated as both conservational and developmental areas, individuals in different areas will have unbalanced rights. Restated, regardless of the nature of designation, inequity will be generated as suggested by Varian (1974).

Since inequitable situations are unavoidable, compensation instruments should be considered. The final criterion of intragenerational equity is now examined, that is the greatest benefit of the least advantaged (this implies the poor have more development rights than the rich). In spatial allocation, if a rural area is less developed (or is poorer) than an urban area, the latter should have more conservation responsibility regarding wetlands in the same hierarchy. However, the current situation in Taiwan is contrary to that desirable condition. For instance, benefits enjoyed by urban residents are partly exchanged from wetlands. When urban residents become richer, they request rural residents to conserve wetlands for them or for future generations. This conjures a picture of urban residents taking advantage of rural residents, which situation is contrary to Rawls' (1971) "the greatest benefit of the least advantaged" principle of justice. If wetlands in rural areas can generate more benefits, the losses associated with any 'development rights' due to conservation should be fully compensated; further, the compensation should accrue to rural areas rather than to urban areas. In this manner, the 'win-win' situation of urban and rural areas can be truly realized. Therefore, in terms of intragenerational equity, rural or less developed areas should enjoy priority in developing wetlands. In contrast, urban or more developed areas should have priority in preserving wetlands. In this regard, deciding on which kind of wetland use (*i.e.*, development or preservation or both) is liable to result in greater intragenerational justice or equity is relatively difficult.

Management of wetland conservation areas and developmental areas

The SMS approach and the equity decision criterion can both help determine wetland development types. To achieve various goals for different wetland types, management or regulation instruments must be adopted.

Management of wetland conservation areas. Depending on the degree of reversibility and substitutability, wetland conservation areas can be categorized as a two-tier system: 'preservation area' and 'conservation area.' Preservation areas should completely exclude human activity to prevent damage to surrounding ecosystems. Conservation areas have connotations of prudent use and require an optimal plan of management over time to satisfy specific human purposes (Randall, 1987: 407–408). In Fig. 1, moving closer to the upper-left corner (point A) implies increasing the preservation area by designation. In contrast, areas closer to the EF line should be designated for conservation, and compatible uses permitted. Because reversibility and substitutability costs are large (*i.e.*, development benefits are smaller than conservation benefits or the net opportunity cost of conservation is acceptable to the current generation), and the equity decision criterion has been considered, those areas are designated as conservation areas by the current generation. In such areas, specially devised regulations should prohibit uses which are not in character with conservation purposes. Those contravening the regulations should be punished. If human activities are detrimental to conservation purposes, those responsible should be required to restore wetlands.

Fig. 2. Taiwanese fisherman beside power station wetlands.

Fig. 4. White egrets, Taiwan wetland.

As to management of preservation areas, the 'inalienability rule' should be adopted to prohibit any kind of commercial activity. No activities in preservation areas should be permitted, even where wetland owners are inclined to allow such activity. Again, people contravening the regulations should be punished and bear the responsibility of restoring any damage to the wetlands. As to the management of conservation areas, the 'development permit' approach could be adopted to accommodate compatible uses (e.g., wetland natural parks). However, the permit review criteria should focus on protecting the natural and ecological functions of wetlands before considering socio-economic functions. If, and only if, the former is fulfilled can the latter be considered (*i.e.*, the lexicographic preference approach). Adopting such an approach would not only protect the environmental rights of the present and future generations, but also avoid unnecessary social costs. For instance, suppose that converting a wetland to industrial use were proposed. Since such use contradicts conservation purposes, it could be summarily rejected. As a result, no development permit review would be necessary, nor any payment of land owes application fees or organization review fees.

At first glance, the preservation management approach seems to oppose the efficiency principle since it excludes the market mechanism and, hence, prohibits trading. However, permitting trading in preservation areas, not only compro-

Fig. 3. Taiwanese fishing nets on beach.

Fig. 5. Taiwan wetland in forest area.

mises the environmental amenities provided by wetlands for the present and future generations, but the opportunity of transferring wetlands to future generations will also vanish. With respect to higher rank wetlands, the losses of values or rights may be extremely large; therefore, prohibiting trading may constitute a more efficient approach. In this case, the approach can not only take inter-generational equity issues into account, but can also prohibit social costs created by rent seeking activities. Managing conservation areas adopts the development permit approach to satisfy the functions of experiencing and viewing wetlands. Development permits should be granted only to those who can maintain the original wetland landscape.

Management of developmental areas. The development permit method is the preferable management approach for developmental areas. If and only if an application is permitted can development activities begin. In developmental areas, reversibility and substitutability costs are still varied. For instance, areas closer to the SMS line (EF line) in Fig. 1 have higher reversibility and substitutability costs; therefore, the weighting should vary according to area. In developmental areas, the lexicographic preference method needs not to be adopted. In Fig. 1, areas closer to the EF line should have more natural and ecological weighting than socio-economic weighting. Conversely, areas closer to point C claim more socio-economic weighting. In this regard, areas closer to the EF line can be developed for partly compatible recreational uses; whereas areas closer to point C can be converted to less compatible uses, such as industrial purposes. The reason for not adopting the lexicographic preference method is not only to maintain the developmental rights of the current generation, but also to allow future generations inherit the development fruits created by the current generation.

To avoid environmental costs, when applying the development permit criteria, performance standards should take account of the impact of development activities. Performance standards can ensure that developmental activities remain within environmental carrying capacity. To make the standards more accessible, *land use suitability analysis* should be adopted to analyze the development potential and limits of wetland resources in different location. Therefore, in developmental areas, if management instruments capable of limiting negative externalities are applied, negative development effects could possibly be reduced. Considering again Fig. 1, to ensure the use rights of the present generation and to maintain the use opportunities of future generations, the degree of strict management or permission can be gradually reduced from the upper-left corner to the lower-right corner.

Some uncertainties and implicit interest conflicts arise in wetland use. Admittedly, resources are scarce and human welfare is multi-dimensional. Therefore, either all wetlands are treated as basic human rights and become prohibited for conversion or development, or they are treated as common goods and allowed to be transferred or developed, and will be unsustainable. Therefore, solving the conflict of wetland resource use does not permit adopting either a ‘pure ethic’ or ‘pure benefit’ approach. Instead, the wetland resource should be recognized as but one of many important dimensions of human welfare. The task should be to find the balance between environmental and other values. In the light of the above analyses, the SMS approach and the equity decision criteria should be adopted for classifying wetlands into conservation areas and developmental areas to balance the conflicts among the various values. Moreover, varied managerial approaches should be adopted according to the degree of reversibility and substitutability (see Table 1).

Examining the safe minimum standard of conservation

The efficiency criterion, if used to determine development types, may give rise to some conflict with the equity decision criteria, particularly in relation to the intergenerational equity issue. However, if the SMS approach is adopted, not only subjective and objective uncertainties are considered, but also wetland development types can be determined by society. Therefore, the SMS approach offers but slight conflict with the equity criteria. However, the approach does suffer some disadvantages. In addition to the information costs that arise from searching for information concerning development and conservation benefits and other uncertainties, there are ‘trading costs’ of communicating with society to reach the agreement. These two costs should also be considered in calculating the net social cost of conservation.

Moreover, to avoid biases induced by the SMS approach, the degree of subjective reversibility and of objective substitutability uncertainties must first be reduced. The former requires attention from natural scientists or ecologists; the latter from psychologists or economists. Second, a standard for measuring of conservation and development benefits requires establishing a general acceptance. In general, economists adopt money as the measurement unit. Although society has stronger feelings about this measurement unit, this unit is criticized by some ecologists in that it is a subjective value, not an objective one. Some ecologists employ ‘emergy’ as the measurement unit. Even though *emergy* takes into account the conversion between bio-physical materials and energy, people have weaker feelings with this measurement unit.

Table 1. Management policies for wetland sustainable use

Development types	The safe minimum standard of conservation criteria	The equity decision criteria	Management policies
Conservation areas	(a) Bp > Bd (b) Bd > Bp: The burden (Bd − Bp) can be accepted by the present generation	(a) Reversibility and substitutability costs are large (b) Development external cost is large (c) Urban or wealthier areas have priority in the designation process	(a) Preservation area: inalienability rule (b) Conservation area: development permit – lexicographic preference (with the priority of ecological functions)
Developmental areas	(a) Bd > Bp: The burden (Bd − Bp) cannot be accepted by the present generation	(a) Reversibility and substitutability costs are small (b) Development external cost is small (c) Rural or poorer areas have priority in the designation process	(a) Close to EF line: development permit – natural and ecological weighting are larger (b) Close to C point: development permit – socio-economic weighing are larger (c) Performance standard and land use suitability analyses

Besides, the uncertainties surrounding natural systems are no less than those of socio-economic systems; therefore the reliability of conversion to *emergy* is not without suspicion. Psychologists who are familiar with subjective value judgment usually adopt satisfaction as the measurement indicator, although this shares the same problem as monetary indicators which ignore objective values. In addition, in view of the subjective and objective uncertainties, whether quantitative indicators can fully evaluate uncertainties needs further investigation. In this case, qualitative indicators must be adopted. Therefore, evaluating the net social cost probably requires integrating evaluation methods across disciplines. When such integration is impossible, the appropriate approach is to list all the evaluation results for decision-makers to make the final decision.

Before the basic research is completed, wetland resources should be mandated not to be developed because development without information may cause higher rank wetlands to disappear and result in unsustainable use as mentioned above. In terms of academic research results, the basic studies to some extent have already been undertaken. However, because studies of wetlands in Taiwan have long been neglected, the research findings available are not applicable to the Taiwanese case. This lack results in debate between conservationists and developers. Therefore, if the goal of wetland use is to achieve sustainable development, the Taiwanese government should create more incentives for basic research. The SMS approach provides a new direction regarding wetland sustainable use, particularly *vis-a-vis* subjective reversibility and objective substitutability.

Conclusions

Taiwanese environmentalists play an influential role in changing the popular perception of Taiwanese wetlands from 'wastelands' to 'wealthlands,' and from 'no price' to 'priceless.' It is believed that the wetland total conservation proposal, advocated by Taiwanese environmental groups, is a strategy lacking preparatory basic research. It is not considered that those groups actually advocate treating all wetlands as 'liberty' rights and be fully protected. Because human welfare is multi-dimensional and because substitutability and reversibility uncertainties are attached to wetlands, totally prohibiting development and totally relaxing development controls are both unsustainable policies. If sustainable use is an acceptable goal, then the conflicts between wetland conservationists and developers must be resolved.

To balance the ecological values of wetland conservation and the economic values of wetland development, the critical issues of wetland subjective substitutability and objective reversibility uncertainties must be addressed. In doing so, the SMS approach proposes that the decision should be rest on whether the burden of conservation is acceptable to the present generation. Although the SMS approach incurs some extra costs, it does empower the present generation with the opportunity of 'free participation' and helps fulfill intergenerational equity. In addition, faced with tremendous uncertainties and conflicts of interest, the top-down approach not only violates democratic notions and concept of equity, but also generates 'conflict costs.' Therefore, the bottom-up approach of the SMS strategy enjoys advantages of great relevance.

In applying the SMS approach to wetland management issues, classifying conservation and development areas is a necessary tool in resolving conflicts between conservation and development. In the framework of wetland sustainable use, based on whether the burden is acceptable and on justice and equity considerations, classifying all wetlands as conservation areas is not prerequisite. In some cases, wetlands classified as developmental areas may be more sustainable. To retain the different functions of various development types of wetlands, a range of management systems and review criteria are also necessary. Theoretically, the larger costs of reversibility and substitutability imply a more strict management criteria and greater weightings to ecological functions.

To attain sustainable wetland management, ideological conflicts should be eliminated and more of the natural and socio-economic attributes of Taiwanese wetlands should be examined. Through interdisciplinary cooperation, seeking feasible solutions should be the basic approach to and goal of wetland sustainable use. Meanwhile, although not all wetlands in Taiwan require designating as conservation areas, further total development of wetlands should be prohibited before thorough studies of reversibility and substitutability are completed. In view of the reversibility and substitutability uncertainties, such an approach is probably a preferable strategy for attaining sustainable wetland management.

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