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An Initial Assessment of the Economic Value of Coastal and Freshwater Wetlands in West Asia

Florian V. Eppink [1,2,*], Luke M. Brander [3,4] and Alfred J. Wagtendonk [3]

[1] Landcare Research, Private Bag 92170, Auckland Mail Centre, Auckland 1142, New Zealand
[2] Institute for Biodiversity, Nuβbergerstraβe 6a, D-93059 Regensburg, Germany
[3] Institute for Environmental Studies, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands;
E-Mails: lukebrander@gmail.com (L.M.B.); alfred.wagtendonk@ivm.vu.nl (A.J.W.)
[4] Division of Environment, Hong Kong University of Science and Technology, Pokfulam Road,
Hong Kong, China

* Author to whom correspondence should be addressed; E-Mail: eppinkf@landcareresearch.co.nz;
Tel.: +64-09-574-4186.

Abstract: Many countries in West Asia, defined in this study as the Arabic-speaking countries of the Arabian Peninsula plus Turkey and Iran, have enacted environmental conservation laws but regional underlying drivers of environment change, such as rising incomes and fast-growing populations, continue to put pressure on remaining wetlands. This paper aims to inform conservation efforts by presenting the first regional assessment of the economic value of coastal and freshwater wetlands in West Asia. Using scenario analysis we find that, dependent on the discount rate used, the present value of the regional economic loss of not protecting wetlands by 2050 is between US dollar 2.3 billion and US dollar 7.2 billion (expressed in 2007 US dollars). The method used for this assessment, however, is not suitable for expressing national realities adequately. We therefore suggest that detailed localized studies are conducted to improve insight into the drivers and the social and economic effects of wetland loss in West Asia.

Keywords: economic valuation; ecosystem services; mangroves; wetlands; value transfer

1. Introduction

Many governments in West Asia, here defined as the Arabic countries of the Arabian Peninsula plus Turkey and Iran, have enacted laws to protect environmental resources since the 1990s [1], but pressures facing the environment have increased. A report by UNEP and other regional organizations [2] describes how the region is characterized by rapid population growth, which is expected to rise from 334.5 million individuals in 2008 to over 580 million in 2050. Population growth, increased wealth and strategies to diversify economies away from a dependence on oil export are causing ever-growing water scarcity, desertification, salinization of groundwater, pollution of water bodies and other land use developments that are unsustainable.

As defined by Article 1 of the Ramsar Convention, wetlands are "*areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*" [3]. Wetland types found in the West Asian region include mangroves, sea grass beds, brackish wetlands, *wadis* (riverbeds that typically are flooded only after heavy rain), bogs, and freshwater marshes [4]. West Asia contains approximately 107,000 km^2 of wetlands, excluding wadis. For comparison, the Pantanal wetland system in South America covers 150,000 km^2. Nonetheless, given the prominence of environmental issues related to water supply and quality in West Asia, remaining wetland areas in the region are at grave risk.

It has long been recognized that losing natural resources such as wetland ecosystems affects human welfare [5,6]. Nowadays the local and global benefits in the form of goods or services to human society provided by ecosystems are known as ecosystem services [7,8]. The ecosystem services of wetlands are manifold (e.g., Barbier *et al.* [9] and Russi *et al.* [10]) and include climate regulation that occurs as wetlands capture carbon dioxide, methane and nitrous oxide; nursery provision for fish populations; flood protection to inland settlements; regulating groundwater recharge; filtering nutrients and pollutants from surface water; and providing opportunities for recreational and educational activities. When wetlands decline in terms of area or ecological quality this puts the delivery of such ecosystem services at risk.

The impact of social and economic developments on freshwater and coastal wetlands in West Asia is significant and the policy response in the region has been inadequate [11]. Urban expansion takes place on scenic coastal locations or even in marine ecosystems off-shore. Development is driven by population growth, but also by the desire to diversify economies towards tourism. These developments destroy coastal wetlands including mangroves, coral reefs and sea-grass beds directly. There are also indirect effects caused by increased run-off from wastewater, fertilizers, and desalinization plants, as well as damage to resources caused by tourist visits. A drive to increase agricultural production has in the past led to great loss of freshwater wetlands via upstream water extraction and conversion of wetlands. Overfishing causes further imbalances in ecosystems that are already fragile.

One cause of the overexploitation of wetlands, and many natural resources in general, is that the full suite of benefits they provide are rarely accounted for in decision making in an integrated approach. Consequently wetlands are "too cheap" in economic terms and there is little economic incentive for their conservation as compared to the economic benefits of, e.g., a new office block or aquaculture. The ecosystem services framework proposed by the Millennium Ecosystem Assessment [7] and The

Economics of Ecosystems and Biodiversity [12,13] can help inform policy makers about the benefits of wetlands. To include economic considerations in national decision making is an approach that has been taken up by governments around the globe in their National Biodiversity Strategy Action Plans. Its actual implementation in policy has been less widespread [14], however, and still has scientific hurdles to overcome [15].

In both the scientific and "grey" literature there are very few publications about the economic value of natural resources in West Asia. Al-Madani *et al.* [16] assess the impacts of dredging and land reclamation on the mangroves and other coastal wetland types of Bahrain. They argue that the effect on fisheries would have macro-economic impacts as well, as at the time 10.5% of the Bahraini working population was active in the fisheries sector. Shaltout *et al.* [17] consider the species richness of *sabkha* (salt flat) areas in Saudi Arabia, without looking at social or economic benefits. Other researchers have estimated several non-market values of wetlands in Iran [18], the potential tourism value of Iranian wetlands [19], and a *wadi* in Oman [20].

This paper presents the first large scale assessment of the economic value of coastal and freshwater wetlands in West Asia. In the following section, we provide a brief overview of the general concept and approach to estimate the total economic value of natural resources. Subsequently, we describe our specific method applied, data used and our results. We conclude with our most important findings and by suggesting steps to improve this type of analysis when the policy context requires more detailed information.

2. Total Economic Value of Natural Resources and Value Transfer

In this section we provide an introduction to the total economic value (TEV) of natural resources and the valuation technique employed in this study. The TEV of natural resources is the aggregate of a range of different value types generated by natural resources (e.g., Turner *et al.* [21]). Figure 1 illustrates TEV and its value components. If we disregard "option value" because it is not a frequent subject in applied studies, the main distinction is between use values and non-use values. Use values are divided into direct use values, benefits that originate from using or actively experiencing natural resources, such as recreation and the production of food, and indirect use values that stem from ecosystems' ability to self-regulate and ensure stable delivery of other environmental flows. Non-use values derive from a psychological or emotional attachment to nature. Although in practice the value categories cannot always be strictly maintained, TEV is an accepted framework for assessing the value of natural resources in monetary terms. An EPA-SAB report [22] discusses monetary values as opposed to other value systems. That discussion, however, is beyond the scope of this introduction.

There are several techniques for estimating the monetary value of natural resources, for which there often are no or only imperfect markets. These techniques can be based on prices of substitute or complimentary goods, time and money spent to visit natural parks, or surveys of users of environmental goods and services. Insightful discussions of these various techniques are provided by Freeman [23] and Van Beukering *et al.* [24]. Most of these techniques, however, have a high cost in terms of time and resources.

Figure 1. Composition of the Total Economic Value (TEV) of natural resources. Source: TEEB [7], Chapter 5.
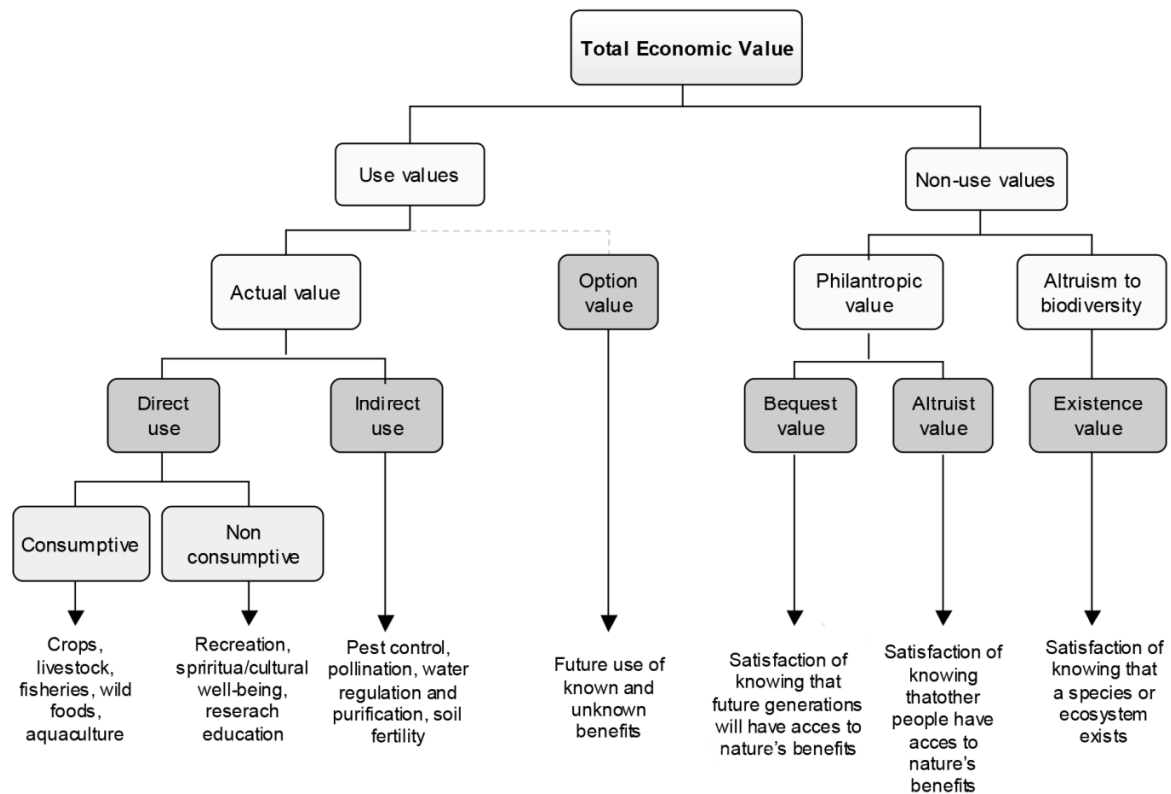
A cost-effective technique is value transfer, where one takes existing value estimates from one or more study sites and applies them to the site of interest, the policy site. This technique is relatively fast because it is based on results from published valuation studies. It can also be used for "scaling up", which is the process of taking values estimated from localized changes in individual study sites to assess changes in multiple policy sites in a larger geographic area [25]. For this assessment of the economic value of wetlands in West Asia, value transfer was considered the best and most effective option to generate the desired indicative results.

All value transfer exercises entail a degree of uncertainty that are caused by errors in the value data ("measurement error"), biases in the valuation literature ("publication selection bias"), and errors caused by statistical analysis ("generalization error") [26]. Measurement error in primary valuation estimates may result from weak methodologies, unreliable data, analyst errors, and the whole gamut of biases and inaccuracies associated with market and non-market valuation methods. Publication selection bias arises if there is an editorial preference to publish statistically significant results and novel valuation applications rather than replications or if the available stock of knowledge is skewed towards wetlands for which there is high awareness and policy interest. Generalization error occurs when values for study sites are transferred to policy sites that are different without fully accounting for those differences. Potentially important differences between wetlands that will result in different ecosystem service values include the determinants of supply (wetland scale, quality, functioning and the availability of complementary ecosystems) and demand for wetland services (population, income, preferences and the availability of substitute ecosystems) [27].

In addition, generalization error can occur when the spatial resolution of the data used to map spatial phenomena differs between the study and policy sites. Such differences may be in terms of population characteristics as well as physical or environmental characteristics of the natural resource or wetland.

There are several options of technical sophistication when conducting a value transfer exercise. On the one extreme, one can employ "unit transfer" to apply directly a value found for a study site to the policy site(s). If the policy sites are very similar to the study site, this can be an acceptable approach. At the other end of the scale of complexity is "meta-analytic value transfer", which uses a multitude of valuation publications to generalize from their findings through statistical analysis of ecological and socio-economic variables [28]. The product of the statistical analysis is a "meta-analytic value function", which can be used to estimate monetary values. This approach may minimize the degree of errors when values are transferred across ecosystems with substantially different characteristics [29,30].

3. Method

The approach used in this study combines various data sources and model outputs as shown in Figure 2. There are three types of data that constitute the pillars of our method. The first pillar is the output of the "Integrated Model to Assess the Global Environment—Global Biodiversity" (IMAGE-GLOBIO) integrated assessment model [31,32] which predicts loss of area for a suite of habitat types including wetlands (component A in Figure 2). A data set developed from primary valuation studies constitutes the second pillar (component B in Figure 2). The third pillar is provided by spatial ecological and socio-economic variables that are used in a statistical meta-analysis of the valuation literature to give a function that relates wetland value to various explanatory variables (component C in Figure 2).

Figure 2. Schematic representation of the method.
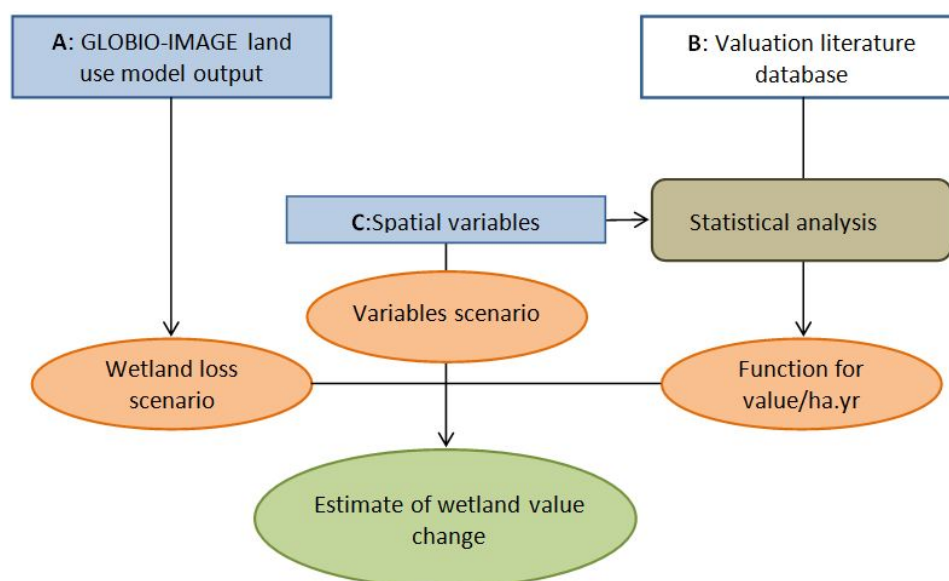
To define a baseline scenario for freshwater and coastal wetland change as well as mangrove change for the period 2000–2050 and 2010–2050, respectively, this report makes use of the results of the IMAGE-GLOBIO integrated assessment model [31,32]. IMAGE-GLOBIO is a modeling framework developed to calculate the impact of five environmental drivers on terrestrial biodiversity. The IMAGE model is based on cause-effect relationships derived from the literature and uses spatial information on drivers of change for macro-economic modeling to calculate sectoral changes in supply and demand. The output of IMAGE comprises spatially explicit changes in urban construction, agriculture and infrastructure. These outputs are in turn used in the GLOBIO model, which derives changes in the extents of a range of habitat types. It should be noted that IMAGE-GLOBIO predicts area changes but does not cover changes in ecosystem quality. Hence impacts from, e.g., brine disposal from desalinization plants are not included in this analysis. Since the model furthermore does not predict area loss of wetlands or mangroves specifically, we allocate loss predictions from neighboring non-wetland habitats to the wetland sites. Underlying this step is the assumption that local developments in terms of population growth, urban sprawl, and conversion affect wetland in equal measure as they do non-wetland habitats.

The value transfer technique employed here is meta-analytic value transfer. This technique includes a suite of ecological and socio-economic characteristics of wetland sites that might affect their value [27]. We use this technique because there are very few publicly available valuation studies of freshwater or coastal wetlands in West Asia. Therefore, all value observations come from other regions of the world. Applying a straightforward unit transfer approach would almost certainly entail large estimation errors. As indicated earlier, a more integral statistical analysis has been found to minimize errors in such conditions.

The data collected for this study are value observations from mangroves and other wetland types from studies that have been conducted across the world. These value observations tend to be of individual ecosystem services or TEV, although some studies provide value observations for a set of ecosystem services. For the purposes of the statistical analysis, however, each observation is essentially treated as an observation of TEV. We separate value observations for distinct ecosystem services and include ecosystem service type as an explanatory variable in the statistical analysis. For a detailed description of the literature databases and the statistical analyses used in this study, we refer to [25] for wetlands and [33] for mangroves Both publications are available online with Open Access, and are also directly available from the corresponding author upon request, but we show an overview of the statistical results in Table 1.

The statistical analyses produce meta-analytic value functions that can be used to estimate values of mangroves as well as freshwater and non-mangrove coastal wetlands. This requires spatially distributed observations of ecological and socio-economic variables. Constructing the maps of freshwater and coastal wetlands in West Asia was performed using the publicly available Global Database of Lakes, Reservoirs and Wetlands [4]. Intermittent wetlands such as wadis can be clearly identified in the map representation of this database, but are excluded from the analysis because the meta-analytic value transfer function is not applicable to this wetland type.

Table 1. Meta-analytic value functions for mangroves, and coastal and freshwater wetlands. The dependent variable is the natural log of the dollar value per hectare per year for the respective ecosystems.

Variable	Coefficient (Mangroves) [1]	S.E.	Coefficient (Wetlands) [1]	p-value
Constant	−0.590	2.193	−0.970	0.709
Coastal protection [2]	1.456 ***	0.491	-	-
Water quality [2]	1.714 **	0.752	-	-
Fisheries [2]	0.860 **	0.355	-	-
Fuel wood [2]	−1.085 **	0.437	-	-
Contingent valuation [2]	-	-	0.317	0.625
Choice experiment [2]	-	-	−0.524	0.581
Hedonic pricing [2]	-	-	−2.328 **	0.043
Travel cost method [2]	-	-	−0.705	0.261
Replacement cost [2]	-	-	−0.383	0.538
Net factor income [2]	-	-	−0.125	0.843
Production function [2]	-	-	−0.091	0.896
Market prices [2]	-	-	−0.215	0.712
Opportunity cost [2]	-	-	−1.164	0.165
Marginal valuation [2]	-	-	0.828 *	0.053
Inland marshes [2]	-	-	−0.211	0.726
Peatbogs [2]	-	-	−2.266 ***	0.004
Salt marshes [2]	-	-	0.073	0.901
Intertidal mudflats [2]	-	-	−0.239	0.672
Flood control [2]	-	-	0.626	0.169
Water supply [2]	-	-	−0.106	0.828
Water quality [2]	-	-	0.514	0.288
Commercial fishing/hunting [2]	-	-	0.042	0.917
Recreational fishing [2]	-	-	−1.355 ***	0.002
Recreational hunting [2]	-	-	−0.119	0.786
Natural materials [2]	-	-	−0.153	0.732
Fuel wood [2]	-	-	−0.959	0.198
Non-consumptive recreation [2]	-	-	0.218	0.626
Aesthetic [2]	-	-	0.432	0.370
Natural habitat [2]	-	-	1.211 **	0.012
Mangrove area (ha; ln)	−0.343 ***	0.065	-	-
Mangrove abundance (km^2 within 50km radius; ln)	0.248 ***	0.082	-	-
Wetland area (ha; ln)	-	-	−0.218 ***	0.000
Wetland abundance (ha within 50km radius; ln)	-	-	−0.125	0.118
Roads (km within 50 km radius; ln)	−0.312 *	0.175	-	-
GDP per capita (US$; ln)	0.785 ***	0.174	0.430 ***	0.004
Population (within 50km radius; ln)	0.284	0.149	0.503 ***	0.000
N	130		222	
R-squared	0.45		0.36	

[1] Statistical significance is indicated with ***, **, and * for the 1%, 5%, and 10% level, respectively;

[2] A dummy variable for which the sample mean is applied to the policy sites.

For mangroves we can perform a separate analysis because a detailed spatial dataset of mangroves has recently become available [34]. Moreover we have a separate database of mangrove valuation studies that was used to develop a separate meta-analytic value transfer function. In order to avoid double-counting of mangrove and wetland areas in the two assessments, an overlay of the mangrove and wetland maps was made to remove mangrove areas from the wetland map. The two maps are shown in Figure 3.

Figure 3. Maps of wetland distributions in West Asia. Study nations are colored brown, non-study nations are grey and water bodies are light blue. (**a**) Wetland distribution in 2000. Different wetland classes are indicated by color: Yellow for freshwater marsh and floodplain; dark blue for coastal wetland including estuary, delta, and lagoon but excluding mangrove; red for pan, brackish/saline wetland; and green (visually exaggerated for illustration purposes) for bog, fen, and mire; (**b**) Mangrove distribution in 2010, indicated by dark blue. Mangrove areas have been visually exaggerated for illustration purposes.

(**a**)

(**b**)
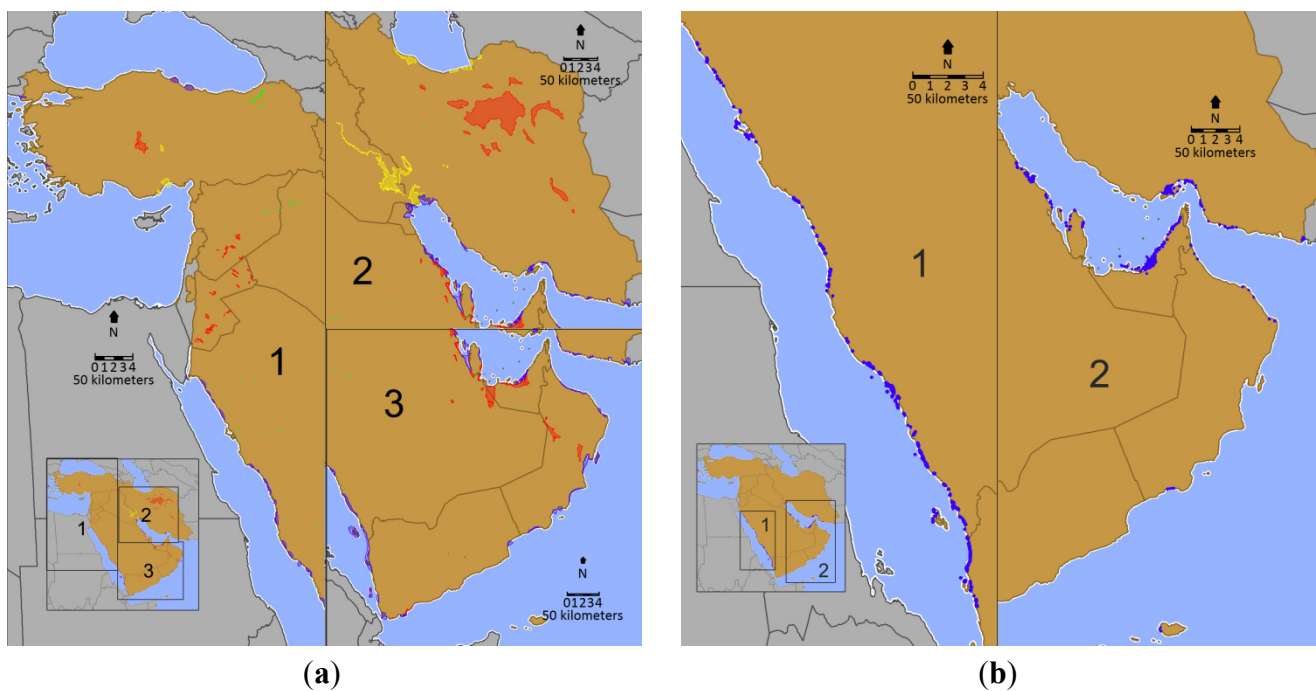
The meta-analytic value functions furthermore require the development of socio-economic spatial variables for each West Asian site. For detailed descriptions of the selection of these variables, we refer to [25,33]. We use the FAO 1998 Roads of the World database for the infrastructural variables to approximate accessibility of wetlands. The Global Rural-Urban Mapping Project [35] (adjusted version with matched UN country totals) indicates population density numbers to represent the local number of wetland beneficiaries for each site in the meta-analytic value function for freshwater and non-mangrove coastal wetlands. The MODIS 500 m Global Urban Extent map [36] contains urban extent, which approximates the same variable but in the value function for mangroves. Each map was transformed appropriately for the various neighborhood analyses used to construct the socio-economic and environmental variables.

Employing the data and the meta-analytic value functions in a comparative scenario analysis enables us to estimate the value of regional wetlands. The baseline scenario of habitat loss derived

from the IMAGE-GLOBIO model has previously been used to assess the cost of policy inaction to halt global biodiversity loss, *i.e.*, the failure to introduce additional environmental policies or to strictly implement existing policies [37]. We use outputs for the scenario of wetland loss as well as predictions for the various socio-economic spatial variables in our scenario.

For each site, patch-specific parameter values for the spatial variables are substituted into the meta-analytic value function to estimate values per unit area (US dollar/ha/yr). The value of wetlands is approximated by calculating a price per hectare in 2050 for a situation with wetlands kept at the level of 2010 (mangroves) or 2000 (freshwater and non-mangrove coastal wetlands) as projected by IMAGE-GLOBIO. Values for socio-economic variables for the year 2050 are inserted in the meta-analytic value function but mangrove area variables (mangrove area and abundance) are used for the years 2010 and 2050. This yields two estimates of the marginal values of wetlands, one at a high level of conservation and one with a degree of wetland loss. For each wetland patch, the two values are averaged to achieve a better estimate of the change in value of each patch for the duration of the scenario (see, e.g., [21,25]).

Lower and upper bound values are then calculated using the 95% prediction intervals for each wetland site, which are computed using the method proposed by Osborne [38]. The prediction intervals provide an indication of the precision with which the estimated value function can predict out-of-sample values, *i.e.*, value estimates that are not in the database with valuation literature. The prediction intervals do not, however, reflect a number of other sources of uncertainty in the analysis, including inaccuracies in the data used to construct the maps of West Asian wetland sites or the assumptions used to describe the baseline change in the extent and spatial distribution of mangroves.

Regarding this final issue, a few remarks should be made. Reviewers have pointed out apparent errors in the map of wetlands that affect our results. For instance, the data set does not show any wetlands in Lebanon. Therefore the country does not appear in the results even though Lebanon does contain a number of smaller wetlands, including four sites designated as Wetlands of International Importance under the Ramsar Convention. Furthermore the data show no wetlands in the north and north-west of Iran where there should be, and the extent of the Iranian saltpans appears to be too large. A final point addresses the limitation of the automatic method used to allocate mangrove and wetland patches to national territories, which is that wrong allocations can be made depending of the exact position of wetlands sites relatively to the country borders. One example concerns the Mesopotamian marshes on the border of Iraq and Iran, which are mostly allocated to Iran. This means that the results for Iran are exaggerated, whereas the results for Iraq are underestimated. At the regional level which is the target scale of our analysis, of course, these national deviations cancel out.

4. Valuation Results

4.1. Mangroves

Here we provide an estimate of the value of the change in economic value due to the loss of mangrove area in West Asia under a business-as-usual scenario for the period 2010–2050. This estimate represents the benefits foregone by not maintaining the stock of mangroves or equivalently the cost of policy inaction to conserve this stock of natural capital.

Table 2 presents the area loss of mangroves as well as the foregone economic value from lost mangroves, aggregated to the country level. Comparing the 2010 stock of mangroves to the projected 2050 stock, the annual value of lost economic value from mangroves in West Asia is estimated to be approximately 34.8 million US dollars in 2050 (2007 prices), with a 95% prediction interval of 26.5 million US dollar to 43.1 million US dollars.

Table 2. Change in mangrove area and value in West Asia by country 2010–2050.

Country	Mangrove Area in 2010 (1000 ha)	Change in Mangrove Area 2010–2050 (%)	Change in Total Value (1000 USD/yr)	Prediction Interval 95% (1000 USD/yr)	Present Value 2010 (1000 USD; 4% Rate)
Emirates	12	−7	−13,195	−12,402 to −13,989	−101,149
Bahrain	0.1	−14	−65	−0.6 to −154	−496
Iran	12	−41	−15,565	−9672 to −21,474	−119,315
Oman	0.3	−4	−109	−87 to −131	−837
Qatar	0.4	−7	−178	−103 to −252	−1361
Saudi Arabia	8	−18	−4548	−3456 to −5649	−34,862
Yemen	1	−23	−1117	−759 to −1479	−8563
Total [1]	33.9	−21.9	−34,776	−26,480 to −43,129	−266,583

[1] May deviate from the sum of country statistics due to rounding.

To calculate the present value of these losses in the year 2010 this study assumes that the loss of area extent occurs linearly over time: In 2010 the losses from foregone benefits are small but they increase to the full loss in 2050. With a discount rate of 4% the present value of the foregone benefits from mangrove loss equals 267 million US dollars; with a discount rate of 1% it is 538 million US dollars.

At the national level the results differ largely with the distribution of mangrove area extent. The Emirates, Iran, Saudi Arabia and Yemen have relatively large mangrove stocks. With larger stocks the chance of mangrove loss increases, which is reflected by the percentage change in mangrove area. Table 2 also shows, however, that the Emirates do not lose as large a share of their mangroves as, e.g., Yemen does. This is the result of the different development levels of the two countries in the base year 2010. In the Emirates there already exist dense urban and road infrastructures that reduce the need and possibility for expansive development that puts mangroves at risk. On the other hand, it is likely that our scenarios underestimate mangrove loss for some countries in the Arabian Peninsula, such as Bahrain and the Emirates, where large development projects necessitated extensive land reclamation. The model used to derive the scenario cannot adequately capture such activities.

4.2. Coastal and Freshwater Wetlands

To estimate the economic value of wetland losses we performed the same general steps as described above. The scenario timeframe for freshwater and coastal areas, however, is 2000–2050. The values of foregone benefits from wetland loss, aggregated to the country level, are presented in Table 3. Comparing the 2000 stock of freshwater and coastal wetlands to the projected 2050 stock, the annual value of lost wetlands in West Asia is estimated to be approximately 262 million US dollars in 2050 (2007 prices), with a 95% prediction interval of 96 million US dollars to 507 million US dollars.

Assuming a linearly increasing loss in area extent between 2000 and 2050, the present value of the foregone benefits equals 2 billion US dollars at a 4% discount rate, or 6.8 billion US dollars when assuming a discount rate of 1%.

Table 3. Change in wetland area and value in West Asia by country 2000–2050.

Country	Wetland Area in 2000 (1000 ha)	Change in Wetland Area 2000–2050 (%)	Total Value Change (1000 USD/yr)	Prediction Interval 95% (1000 USD/yr)	Present Value 2000 (1000 USD; 4% Rate)
Emirates [2]	785	−0.01	−252	−152 to −352	−1938
Bahrain	274	−2	−865	−52 to −6196	−6649
Iran [2]	4466	−3,9	−91,351	−28,984 to −188,878	−702,082
Iraq	934	−0.6	−25,580	−19,849 to −31,376	−196,594
Jordan	189	−29	−22,096	−5580 to −38,985	−169,816
Oman	1112	−4	−20,946	−2,220 to −61,433	−160,981
Qatar	115	−6	−4221	−185 to −13,374	−32,447
Saudi Arabia [2]	1857	−5	−76,954	−30,958 to −135,679	−591,430
Syria	87	−1	−1714	−1487 to −1941	−13,173
Turkey [2]	457	−3	−10,130	−1897 to −18,499	−77,853
Yemen	395	−0.7	−7952	−4796 to −11,158	−61,112
Total [1,2]	10,672	−3.8	−262,061	−96,161 to −507,871	−2,014,076

[1] May deviate from the sum of country statistics due to rounding; [2] Numbers do not include a small number of high-area loss, high-value wetland sites.

The countries that will suffer the largest welfare loss from not conserving freshwater and coastal wetlands are Iran and Saudi Arabia. This result stems mostly from the fact that these countries contain the largest area of wetlands, as the predicted relative losses in area are close to or a little above the West Asian average.

Iraq, Jordan, and Oman will forego roughly equal benefits from losing their wetlands but the causes are different. In Oman the per-hectare values and the rate of loss are relatively low compared to the average of the total wetland set, but the country has a large area of wetlands that can be lost. The wetland sites in Jordan have similarly low values, but the predicted rate of area loss is very high. Iraq, finally, has a very low loss rate but the per-hectare value is above average due to high predicted increases in population density around wetland sites.

Predictions for several countries signal a high upward risk in losses from not investing in wetland conservation. The country with the highest relative upward risk is Bahrain, which is predicted to incur an annual welfare loss of 865,000 US dollars in 2050. This may not seem like a significant sum but the prediction interval is long-tailed towards much higher losses. At the high end is an annual welfare loss of 6.2 million US dollars. Such an increase in annual losses would have severe implication for the estimate of the present value of these losses. The predictions for Oman and Qatar also have long-tailed prediction intervals, meaning that there is a risk that their losses may turn out to be significantly higher than the value in the third column of Table 3.

There are a few wetlands where high values per hectare and high area losses combine to produce losses in excess of US$ 25 million and up to well over US$ 100 million. The countries where these wetland sites are located are the Emirates, Iran, Saudi Arabia and Turkey, as shown in Figure 4.

Together these sites represent less than 0.1% of the total number of modeled wetland sites in this study but they more than double the predicted regional loss of wetland value.

Figure 4. Location of high-loss wetlands, indicated in red.

We did not include these very high loss estimates, which are not repeated in any of the other sites. The excessive impact of this small subset of the sample may be caused by anomalies in the data. The resulting estimate of regional wetland value loss is of course more conservative, but arguably more reliable. Nevertheless, these wetland areas are sites where a high loss of area and a high economic value combine to generate potentially very high losses of wetland value. The simultaneous occurrence of these conditions per se merits a closer inspection and monitoring of these sites.

5. Conclusions

In many West Asian countries the economic benefits generated by coastal and freshwater wetlands are not yet sufficiently reflected in development policies. As a first step to fill this information gap, this study has provided an initial estimate of the economic value of West Asian wetlands. The regional total of the present value of the foregone benefits of not conserving mangroves and other wetlands is between 2.3 billion US dollars (4% discount rate; see Tables 1 and 2) and 7.2 billion US dollars (1% discount rate). This regional total does not reflect variations between or within nations, but it suggests that there is a significant potential welfare benefit from integrating wetland values in development decisions.

It should be emphasized that the results of a large-scale study such as this should be treated as indicative rather than absolute. There are several reasons for such caution. One is the availability and reliability of data and models at large spatial scales, which may not capture very well the national realities and variations in economic and infrastructural development. Consequently, where this analysis has predicted low national economic loss, this should not be taken to mean there is absolutely no risk

of high losses. Furthermore, in some respects the loss of mangroves and wetlands is a regional concern. The loss of local wetlands may have effects on ecosystem services beyond national borders, such as nursery support for fisheries. It is therefore recommended to view the results presented here as a preliminary assessment to help regional decision makers recognize the value of coastal and freshwater wetlands.

Proceeding from here to integrating ecosystems, ecosystem services and biodiversity into various policy fields, a policy goal that is also referred to as "mainstreaming" biodiversity, requires more in-depth environmental-economic studies. Such integration is necessary, however, to identify costs and benefits, winners and losers from any policy change that affects humans and ecosystems. The value estimate presented here, for instance, does not distinguish explicitly between ecosystem services even though locally, individual services may well respond differently to an environmental change. Restricting public access to a wetland, for instance, may improve habitat services but will reduce the benefits derived from recreation. The existence of such trade-offs in ecosystem services mean that even seemingly innocuous policies, such as the efforts of regional government to make national economies less dependent on mineral resources by stimulating the tourism sector, may have an unforeseen effect on the net change in wetland ecosystem services. In its Fourth National Report to the CBD, for instance, the Kingdom of Morocco acknowledges both the economic importance and the great damage to natural resources done by the tourism sector [39].

By considering the full suite of impacts on wetlands and their ecosystem services at all planning levels, governments are mainstreaming the value of wetlands and can reduce economic impacts by sharing economic losses, and improve compliance with existing or new policies. Both aspects are crucial to achieving sustainable and equitable policies for managing natural resources. TEEB [40] describes the various steps that are needed for a full policy relevant assessment of the economic impacts of policies that affect ecosystems and Russi *et al.* [10] provide guidelines for assessments of wetlands specifically. This assessment framework stresses the importance of having a clear policy purpose within which a valuation of ecosystem change can take place.

A policy goal for an assessment should be defined through a dialogue between various stakeholder groups. Only if all parties acknowledge and share ownership of an environmental problem is a sustainable solution viable. This dialogue should be repeated throughout an assessment to ensure the project still lives up to expectations and needs. For many countries in West Asia, however, such interaction between decision makers and the general public is still a new and unfamiliar policy instrument [11]. This situation may pose a challenge for studies about the economic impacts of ecosystem change in West Asia.

Moreover it can be a long process to find a sustainable solution to an environmental conflict. Even after a full assessment is concluded it is likely that monitoring and occasional revision of the implemented policy are needed. Preferences may change over time after which there may no longer be a strong enough incentive to uphold previous agreements. Alternatively, economic circumstances may change so that a resource that provided benefits that were previously considered economically irrelevant may become highly valuable. For instance, this study has presented estimates of the value of wetlands that are insignificant compared to income levels in some countries. Nevertheless there are states in West Asia that have recently experienced severe economic shocks that, in other regions of the world, would have severely limited national options to provide technological solutions to environmental

problems. For some West Asian nations such restrictions are relevant only in the very long run, but for others they may be much closer.

An additional challenge is that there is little information about the value of West Asian ecosystems publicly available. It would be of immense value if more case studies were performed in the region and published. Given the range of ecosystems in the region case studies should strive to cover new ecosystems at risk from policy change. The breadth of knowledge provided in this way would potentially allow swift and cost-effective transfer of knowledge and policies across the region.

Furthermore such case studies could develop local capacity by involving local researchers. Given the current lack of experience with this type of assessment, it is likely that relevant expertise in the region is scarce. Hence there is a need to introduce both researchers and decision makers to this type of environmental-economic assessment.

The countries of West Asia are increasingly becoming aware of the environmental problems caused by fast-growing populations and increasing consumption levels. The continued and active participation of the governments of West Asia in international conservation frameworks, as illustrated by the submission of National Biodiversity Strategy and Action Plans or the designation of Ramsar wetland sites, indicates a willingness to conserve wetlands. By rationalizing decisions on conservation and development these efforts can be streamlined, but a lack of information and expertise remains a major hurdle to such improvements. To our opinion his study has provided a first step that shows there is a large potential benefit to conserving ecosystems, but further research is needed before ecosystems and biodiversity can be acknowledged in decision making.

Acknowledgments

Author Contributions

Florian Eppink initiated the study, performed and assessed the valuation exercise, and wrote the article. Luke Brander developed the valuation literature database and conducted the statistical analysis. Alfred Wagtendonk performed the spatial analyses.

Conflicts of Interest

The authors declare no conflict of interest.

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