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Evaluation of the Ecosystem Services of the Central Marsh in Southern Iraq

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Abstract:

Ecosystems provide humans with services that include benefits from food, fresh water, climate regulation, and socio-economic assets. The Mesopotamian marshlands are among the largest wetlands in the Middle East and they provide various benefits. However, ecosystem services of the Marshlands are consistently undervalued in national economic analysis and decision making. This study focusses on the Central Marshes, the first National Park in Iraq, and is the first attempt at valuing a series of ecosystem services from a valuable natural ecosystem in Iraq. We adopted the Toolkit for Ecosystem Services Site-Based Assessment (TESSA) for the determination of biophysical and economic values of services at the site level. Data on key ecosystem services (as determined by 30 interviews with residents of the Marshes) included the trading of fish, harvested plants, water buffalo milk, and fodder were collected across six months in 2014. We valued the ecosystem services within the CM (40,000 ha) over a 6-month period to have a total value of 860,078.23 USD. This estimated total value was the sum of 86,637.25 USD from harvested plants, 551,334.80 USD from trading fish, 167,303.70 USD from trading water buffalo milk, and 54,804.00 USD from trading fodder. The average income per individual in Iraq in 2014 was 6720 USD (World Bank data - <https://data.worldbank.org/country/iraq>): thus, the CM provided an average salary for 256 people. Our results provided greater understanding of the ecosystem services contributed by the Central Marshes and has highlighted the crucial role of nature in supporting sustainable well-being for humans living in the area. In addition, the results can be used to enhance local policy, to aid management plans of the National park, and to estimate lost and damage that could result from impact of climate change on the area.

Keywords: Ecosystem Services, Central Marsh, Mesopotamia, Nature Conservation, Climate Change.

Introduction:

Ecosystem services (ESs) were defined in a range of ways but one of the most used is the definition by the Millennium Ecosystem Assessment (MEA) in 2005 which described them as the benefits humans gain from the natural environment (via functioning ecosystems). The MEA categorised services into four categories: supporting (e.g. soil formation); provisioning (e.g. food, clean water), regulating (e.g. pollination, carbon sequestration) and cultural (e.g. ecotourism, spiritual) (1). Global ESs were estimated to be worth \$125 trillion/year in 2011, and the loss and damage to ecosystems were estimated to be between \$4.3-\$20.2 from 1997 to 2011 (2). Pressures on ecosystems increased significantly in the last 50 years (3) which resulted in a range of policy actions.

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The International Convention for Biological Diversity (CBD) adopted 20 targets to conserve biodiversity including two targets focused on ESs (target 14: “by 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable”, and target 15: “by 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15% of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification”). Major threats to ESs include rising human global populations and changes in land use (4). In addition, decreasing human resilience, removing large numbers of whole functional groups of species, increasing pressures such as the impact of pollution and waste, and climate change are other drivers of ecosystem changes which make them more vulnerable (5,6).

The MEA (2005) indicated that unprecedented changes, in human history, have been made to the planet's ecosystems in recent decades. Attention paid to valuing ESs has increased significantly since the publication of the MEA, and countries have been encouraged to include ESs in national budgets and policies [e.g. Aichi target number 14, which focuses on maintaining and enhancing ESs; (2, 7)]. Moreover, there has been a surge of recent interest by the academic community to explain, analyse, and predict the value of the ESs (8, 9, 10). Although ESs are best valued through interactions between natural capital (world stock of natural assets), human capital (presence of people in the system), social capital (the communities), and built capital (built environment) (2), most previous studies have valued ecosystem goods and services only within and across biomes. For example, some studies performed the valuation based on estimations from sixteen biomes (11), eleven biomes (12) or ten biomes (13).

Wetlands provide significant services to support sustainable human well-being, and the value of all ESs that are provided by one hectare of wetlands has been estimated at \$30,000/ha (14). The Central Marsh (CM) in southern Iraq is an example of long-term interactions between local people and nature. ESs of the CM are public goods that are free for everyone without any control from the government or local authority. Despite the huge benefit gained from the CM there is no adequate information regarding the value of ESs from this site. The current study is of particular importance as the CM is threatened with a range of environmental problems (e.g. climate change, water supply) (15).

Broad scale evaluations at the biome level provide a general assessment of global ESs, which uses sophisticated modelling approaches (2,14). While assessments on this scale are important, placing a value on ESs at the site level is crucial to support local and national policies, especially in the light of the substantial changes that have occurred to natural systems and the accelerating impact of climate change (16). Enhancing and embedding ESs in local and national policies require engaging stakeholders and decision-makers and sharing data when assessing the services (17). Therefore, ecosystem assessments have been increasingly popular, for example the TESSA valuation toolkit was adopted by eleven organizations under the umbrella of the Cambridge Conservation Initiative for the rapid assessment of ESs at sites of biodiversity conservation importance (16).

Here we aim to calculate the current value of the CM's main ESs (of direct value to people) at the site level (the value of carbon storage is not

made). Such a study will provide a tool to estimate the economic value that could be lost from the CM in the future owing to an increased frequency in droughts that may result from climate change.

Materials and Methods:

Site description and history

The Central Marsh (CM) is characterised as a socio – ecological site due to the high levels of interaction between local people and nature for approximately one thousand years (18). The CM (46° 59.33 East 30° 57.53 North) is surrounded by the Tigris River from the east and north, and the Euphrates River from the south. The area is located between three Iraqi governorates: Missan in the north, Thi – Qar in the south and west, and Basrah in the south and east. The site covers 3000 km² and mainly received water from the Tigris River in the past (up to the 1970s), while the site currently is highly depended on the water of the Euphrates River. The marsh is formed by dense aquatic plants and several permanent freshwater lakes such as Zichri and Baghdadia lakes (19). Chibayish City, an urban centre, is at the core of the CM and the most famous area that represents the marshlands (20). However, before becoming urban, Chibayish City contained the houses of local people (called Ma'adan), which floated on the water. The meaning of word Chibayish in Arabic is derived from the way that local people used to build their houses (people cut reeds from the marsh and then compress it as layers inside the water to form a small area of reed that is able to float on the water, which is then used as a foundation for further construction). The local people of the CM relied totally on the services provided by the ecosystem in the past, where they used to cultivate rice as the main crop for food. However, the majority of their economy and food relied on water buffalos (milk and meat), fishing, and bird hunting. Thus, the local people were displaced/migrated outside the marsh after the disaster of marsh's desiccation in 1990s (20, 21). Buffalo numbers decreased significantly in Iraq from 141,450 in 1986 to 98,700 in 1993 (22) due to four reasons: (i) buffalo farmers quit to search for another job in the cities; (ii) increased buffalo were slaughtered during times of economic sanction on Iraq; (iii) reduced fertility; (iv) and increased incidence of buffalo diseases. Numbers of buffalos decreased significantly after 1993 in the marshlands due to desiccation (90% of the Ma'adan migrated from the CM north towards cities like Chibayish; 23). However, a reverse migration happened after the marshlands were restored in 2003.

Forty-two important bird areas (IBAs) were recorded in Iraq according to the criteria of Birdlife International, with twenty-six of them located in the

south of Iraq. The Central Marsh was indicated as one of the most important sites for birds in the south of Iraq (site 38 in (24)). In addition, the site was listed as one of the Mesopotamian wetlands of international importance (site 27 in (25)). The Central Marsh was surveyed seasonally (using rapid survey methods) from 2005 to 2010 as one of the Key Biodiversity Areas of Iraq (KBAs; 15).

Valuing the CM's Ecosystem Services

We used TESSA (developed as part of the MEA) to assess ESs in the CM. TESSA was designed to come up with a rapid estimate of the value of ESs, while being flexible enough to allow users to develop and modify the assessment methods according to local context and the availability of experts and resources. The toolkit helps the user to identify which services to assess, what data need to be measured, what methods or sources can be used to obtain the data, and how to communicate the results for effective conservation of biodiversity. The toolkit provides specific guidance on implementing practical methods for assessing some of the services that are likely to be most important to the range of stakeholders in each ecosystem. These methods range from collecting new data from local field surveys or stakeholder workshops to using existing datasets or published studies to extract site-relevant information. In every case, it is expected that the methods and guidance will be adapted to suit the local context (16). We designed our study based on TESSA with modifications according to the circumstances of our selected site, the Iraqi Central Marsh.

The following protocol from TESSA was adopted. The first steps in an assessment were to: i) define the site based on its biological importance and perceived threats; ii) explore policy content; and iii) identify ecology, sociological and political issues. Next, we carried out a rapid appraisal to: i) identify and engage stakeholders; ii) identify habitats and drivers of change; and iii) identify services and beneficiaries. Data were then acquired and analysed, and the results were communicated to various stakeholders.

Involving local people in the design of data collection methodologies regarding ESs helps to identify focal services and provides a clear image of the relationship between local people and the site (16). Participatory Rural Appraisal (PRA) methods have been widely used to involve rural people in local projects to enhance local planning and strategies (26). This method was conducted in our study to identify focal socio – economic activities in the study area and to orient our data collection methods. Data in this method was extracted directly from residents living in the CM by undertaking

direct interviews (sample size was 30 - the interview was conducted in, or close to, where people lived) (a PRA semi-organized interview tool was used to collect data, in which questions that did not have yes and no answers were prepared before the interview - questionnaire is shown in Table 1). Participatory mapping, modelling, and walking transects to collect data have been used worldwide and adopted by scientists, because they provide more factual results in comparison with other socio-economic methods (26, 27).

Analysis of the preliminary data collected using the PRA survey helped to inform our work and led us to design more precise and focused methods and questions to collect data on the key ESs identified (Table 1). Data on the trading of fish, harvested plants, water buffalo milk, fodder, and hunted birds were collected by conducting six months of monitoring of local economic activities (from January to June 2014). We divided the study site into three zones and three transects according to the local activities that were highlighted by the PRA survey (Figure 1 and Figure 2). Four main economic assembly points were observed during the surveys period (an economic assembly point is defined as a place where the trading of goods occurred) in zone one (two out of the four sites were located in zone one-transect one, one point was located in zone one-transect two, and one in zone one-transect three). Between two-seven observations were undertaken per month (minimum number of observations at a trading point were 2 per month and maximum number of observations were 7 per month). For all the economic activities monitored, we calculated mean amounts of each resource traded within a typical day within the focal month. We then multiplied the mean daily output (for days in a given month) by the available working days within each month. We did this for each of the six survey months, before finally obtaining a monthly average output across the six months. We monitored the following economic activities:

Trading of water buffalo milk.

Water buffalo activities in the marshlands can be divided into two activities: winter and summer activities. Buffalos spend 10h-12h inside the marsh in summer to cool their bodies, because the buffalos dissipate heat poorly by sweat glands (buffalo skin has fewer sweat glands compared with cattle) (22). Hence, the buffalo rely on the marsh's plants for food in summer, while they eat mulch a lot in winter, because they do not enter the water and rely on the owners to feed them a mixture of plants and fodder during the day (the fodder is mixed corn, wheat, bran and other grains; 22). Due to the bad security situation in the middle of Iraq

and restoration of the marshlands after 2003, the reverse migration of buffalo farmers from cities to the marsh continued to increase, especially in the Central Marsh even after declaring the CM as a national park (15). Increasing numbers of water buffalo could have a positive impact on the GDP of the CM's local people. The numbers of water buffalos were estimated at 40,008 after the re-flooding in the marshes of Missan and Thi – Qar provinces including the Central Marsh (22). The same study indicated the presence of 4,424 lactating buffalo in the marshes of Thi-Qar province, which produced 22,055 liters of milk daily (milk production of a buffalo was estimated as 3-7 liter/cow/day). While, the milk production was estimated as 4-5 liter/cow/day in summer and 15 liters in winter, the price of the milk (direct from the families not from dealers) was estimated at 2,000 ID \approx \$10 USD/25kg in 2007, while the price of buffalo ranged between \$417 to \$2,083/head in 200. However, due to current environmental challenges that have resulted from water scarcity, the buffalo and Ma'adan (locals) could be faced with the prospect of migration out of the CM once again. Thus, there is an urgent need to evaluate the situation of water buffalo in the Central Marsh after declaring the site as a protected area (Category IV IUCN Protected Area), and to estimate the economic value of water buffalo and its milk production in the CM.

The PRA survey highlighted that there was economic activity involving the trading of water buffalo milk in Chibayish city. We identified that there was a total of ten dealers who worked in zone one to buy and sell the milk. We monitored the economic activity of the dealers for six months. Three to five observations per month were conducted to record the daily volume of milk that was collected from local people by the ten dealers and sold to other provinces. There were 15-20 working days in a month. For each of our survey days, we calculated the total volume of milk sold by all dealers. We then calculated the mean amount of milk sold for a typical day within that month, which was then extrapolated to one month by multiplying this mean by 15 working days per month. Finally, we calculated the monthly value of milk trading in the area in USD by multiplying the extrapolated amount for one month by the price of milk per ton.

Trading of fish: the PRA survey highlighted that there was economic activity involving the trading of fish in Chibayish city. One main economic assembly point was used in Chibayish city (transect one - zone one) to sell fish to other provinces and the resulting economic activity was monitored for six months in 2014 (three - five observation per month). The local government bans fishing in the

CM yearly from February 15th to April 15th. However, in reality, fishing fluctuated in this period and our observations suggested that the ban is not well-enforced (people were observed fishing on a daily basis during our survey although fewer were seen during the ban). We used a General Linear Method (GLM) in Minitab 17 to analyse the trading of fish and to calculate the monthly mean amount of fish traded and to identify the most traded fish species. The total value of trading fish in Chibayish city was calculated by multiplying the extrapolated mean amount of fish traded by price per ton during the survey time using the same methods as for the buffalo milk, which was then multiplied by 90 working days within 6 months.

Collection/trading of harvested plants: The economic trading of harvested plants was conducted in the four main assembly points within zone one. Local people (from Chibayish city near zone one) go inside the CM to cut plants daily and then sell them at noon at the main four assembly points in the city. We collected data three times in January, three times in February, five times in March, four times in April, and three times in May and June (please see the exact dates in Table 2. We used a GLM in Minitab 17 to analyse plant data and to identify differences in plant cutting at the three transects, and to calculate the monthly mean harvested plants mass in tones and total value of this mass in USD during the survey period. We estimated the monthly harvested plant mass by multiplying the survey mean (three – five observations/ survey) by 15 working days per month.

Trading of fodder: the PRA survey highlighted the economic activity of fodder trading in Chibayish city. We identified four dealers of fodder (by using PRA results) in the city (zone one). Fodder is essential as additional food for water buffalo. Water buffalo normally graze in the CM during the day and are given fodder as additional food in the evening by the local people. Water buffalo graze in the marsh when the water temperature and quality is suitable for swimming and drinking, which means that grazing times during the day differ seasonally. We monitored the economic activity of the four dealers for six months. Three to five observations per month were collected to record the daily amount of fodder sold to the local people as food for the buffalo. The mean daily amount of fodder sold within the monthly observations was calculated and then we extrapolated this value to the amount fodder sold in a month by multiplying by the 15 working days per month. We then calculated the monthly value of fodder trading in the area in USD by multiplying the extrapolated amount for one month by price of fodder per ton.

Hunting/trading of economically important bird species: Hunted bird species were monitored at the main market of Chibayish city for seven months from December to June 2014 (two to seven) observations per month (we did two observations per day during the day of the survey; one at the morning and one at the afternoon. Each visit is one hour long; to ask the sellers and count the species

and the numbers). Hunting and trading of bird species in the CM and Chibayish city was found to be an opportunistic, essentially random activity and there were no specific stalls that sold hunted birds in the main market of the city. As a result, we did not analyse the data for bird hunting, and just provided list of hunted birds in the area of study.

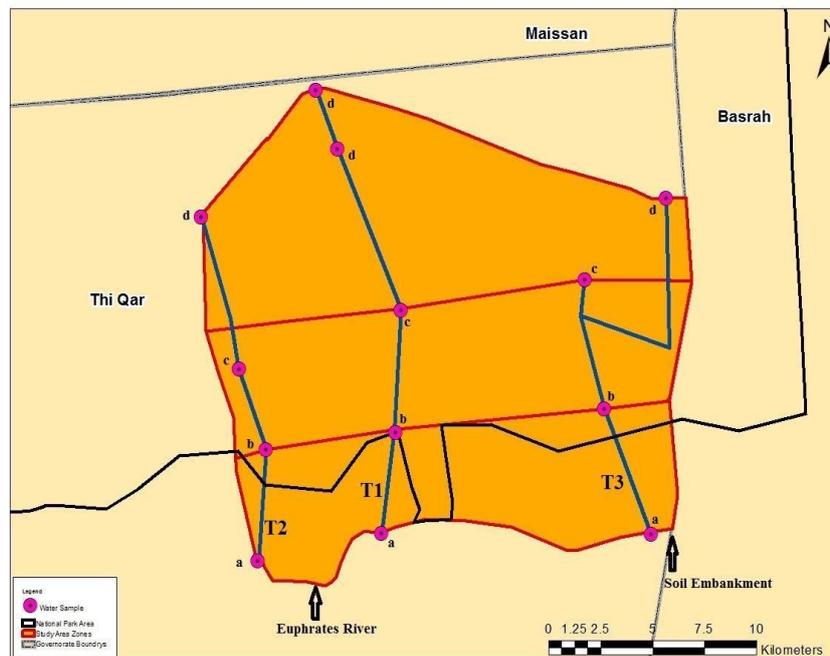


Figure 1. Study area (the central marsh) showing the three transects (T1, T2, and T3) and Euphrates River zone a, b, c, and d. Note: the zones are demarcated by horizontal red lines.

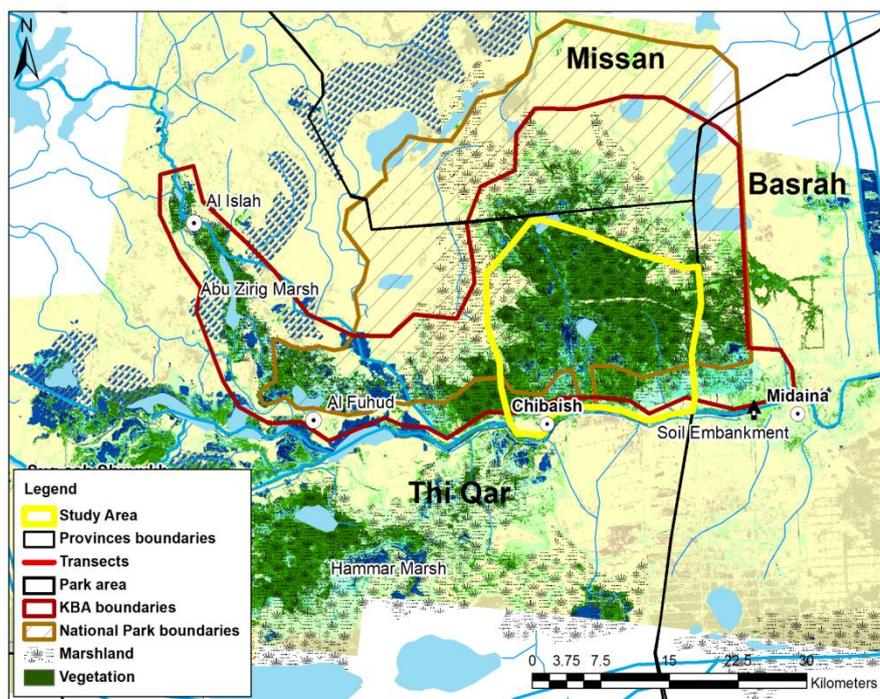


Figure 2. Detailed map of the study area (enclosed by the line in yellow). Boundaries of the protected area and KBA are also shown by the brown and orange lines respectively.

Table1. PRA questionnaire showing both questions and answers (data were collected from 30 residents in the CM using face-to-face interviews). The answers were collected from people working in Chibayish city authority, people working in NGOs and people working in the focal economic activities. Sample size was 30.

PRA Questions	Answers
1. What are the most important activities for the CM's local people and source of income?	Water buffalo grazing Selling milk of water buffalo Plant harvesting from the CM and selling the plants. Fishing in the CM Feeding water buffalo by using plants of the CM and fodder.
2. What are the most important natural resources in the area?	Local people in the CM are highly dependent on two main natural resources: the Euphrates River and ESs that are provided by the CM.
3. What is the difference between historical and current activities for local people?	CM "Ma'adan" Arabs still use the resources of the wetland like their Sumerian predecessors. Local people sell their goods "that are collected from the CM" daily to other provinces. There are daily economic trading activities on the main street of Chibayish city. There are no strict controls and rules from the government, the local authority and farmers' associations (fishing is prohibited for 2 months/year during the fish breeding season; although, this rule can help to control fishing, the rule is flexible and there is no enforcement) therefore, the trade is highly dependent on the local people's' situation, relationship, and daily income.
4. Is there any trade for the natural resources? What are the methods for trading?	Although, the local people's activities are effectively random, there are four main economic assembly points that can be monitored and provide a clear representation of the local people's activities. "Ma'adan" Arabs are not farmers (they buy their daily agricultural products from the market, which come from other provinces) and they are highly dependent on natural ESs. Historically, there is a strong relationship between the Ma'adan and water buffalo, which is considered the most important and main domestic animal (considered one of the important landmarks in the area). 17,000 water buffalo heads were counted in Chibayish city and area of the CM (report of agriculture ministry, 2014). The Ma'adan's settlements, movements inside the marsh, migration, daily income and daily food, are highly dependent on water buffalos.
5. What is the most important trade/economic locations or assembly points in the area?	There was increasing interest by the government and non-governmental institutions started after 2003 in the marshlands of southern Iraq. There is clear input for the marshlands' management plans by the Iraqi ministry of Environment, ministry of Water Resources, ministry of municipalities, ministry of Agriculture and local authorities.
6. What are the most important domestic animals in the area?	There are many small projects that were completed in the area. However, there are two main productive programs/projects that reflected positively on the area and supported local management plans: 1) New Eden (NE) master plan that was funded by the Italian government and implemented by Nature Iraq (National NGO) in cooperation with ministry of Environment, water resources, and municipalities, and local authority. There are several landmark projects that were conducted by the NE program such as: the construction of nine gates to control the water of the Euphrates River that goes to the CM, announcing the CM as 1 st national park in the country, and conducting a KBA survey for 220 natural sites in Iraq including the CM.
7. Which governmental ministries are involved in the marshlands' management?	2) Chibayish City urban plan. This project helped to control projects on the border and buffer zones of the national park. 3) Canadian-Iraq Marshlands Initiative (CIMI) that was funded by the Canadian International Development Agency (CIDA). This initiative focused mainly on supporting academic work and publications on the marshlands with cooperation with some Iraqi universities. 4) Strategy for Water and Land Resources in Iraq (SWLRI). This project focused all over Iraq including the CM.
8. What are the most important programs/projects started after 2003?	

Table 2. List of survey dates in the CM from December 2013 to June 2014.

Month	Dec, 2013	Jan, 2014	Feb, 2014	Mar, 2014	Apr, 2014	May, 2014	Jun, 2014
Day of the survey	16	17	17	19	16	17	9
	17	19	18	20	17	18	10
	18	20	19	21	18	19	11

Results:

Two plant species were the most commonly traded in the 40,000 ha study area: *Typha domingensis* and *Phragmites australis*. Plant

surveys showed differences between months in the mean amount of plants harvested. April had the highest mean of 34.75 tons \pm 0.45 (SE) and January had the lowest mean of 9.17 tons \pm 0.23 (SE). The

estimated value of harvested plants used for trading during the six-month survey period was 86,637.25 USD (Table 3). The site with the highest level of harvested plant economic activity in the CM was in transect one (Fig. 3).

The majority of economic activity relating to the trading of fish focused around just six species within the study area: *Liza abu* (local name Khishni), *Silurus triostegus* (local name Jirri), *Cyprinus carpio* (local name Samti), *Tiliapia zilli* (local name Bulti or Shanak), *Aspius vorax* (local name Shilik), and *Barbus luteus* (carasobarbus) (local name Himri). *Tiliapia zilli* was the most traded species followed by *Silurus triostegus* and *Liza abu* (Fig. 4). *Cyprinus carpio* was the most expensive species at 2,000 USD per ton and *Liza abu* was the cheapest species at 400 USD per ton (Table 4). Analysis showed that there were differences between months in the mean amounts of fish sold from the CM. May and June had the highest means (9.86 tons \pm 0.72 (SE) and 9.52 tons \pm 1.13 (SE) respectively) and the highest level of economic activity related to fish trading was in transect 1. The total estimated value of trading fish in the CM during the six-month survey period was 551,334.80 USD (Table 3).

Socio-economic survey results showed that the water buffalo *Bubalus bubalis* is one of the most important animal species in the CM and trading buffalo milk is an important local economic activity. The results showed that March has the highest mean amount of milk sold at 4.86 \pm 0.03 tons (SE) and May and June had the lowest mean amounts of 1.77 tons \pm 0.01 (SE) and 0.98 tons \pm

0.01 (SE) respectively (Fig. 5). The total estimated value of trading water buffalo milk in Chibayish city during the six-month survey period was 167,303.70 USD (Table 3). The results also showed that using fodder as an additional food for water buffalo is an important economic activity in the area. The mean amount of fodder sold varied between months. The largest amount of fodder sold was in January at 2.58 tons \pm 2.29 (SE) and the lowest was in June at 0.69 tons \pm 0.23 (SE). The estimated value of trading fodder in Chibayish city during the six-month survey period was 54,804.00 USD (Table 3).

Bird hunting was recorded as an important economic activity in the CM. Twelve bird species were recorded as traded in the main market of Chibayish city: Common Coot *Fulica atra*, Great Crested Grebe *Podiceps cristatus*, Eurasian Teal *Anas crecca*, Northern Pintail *Anas acuta*, Mallard *Anas platyrhynchos*, Purple Heron *Ardea purpurea*, Northern Shoveler *Spatula clypeata*, Purple Gallinule *Porphyrio porphyrio*, Marbled Teal *Marmaronetta angustirostris*, Grey Heron *Ardea cinerea*, Garganey *Spatula querquedula*, and Black Francolin *Francolinus francolinus* (Table 5). The value in USD of these economically important bird species was not included in the total estimated value of the CM's ESs as the opportunistic nature of the hunting and the *ad hoc* nature of trading made it very difficult to monitor accurately.

In total, the estimated value of the CM's ESs for six months (January – June) in 2014 calculated from monitoring four local economic activities was 860,078.23 USD (Table 3).

Table 3. Value of the CM's ESs in USD between January and June 2014. Across the entire study period (sample sizes where one replicate is one day of monitoring trading at a particular trading point): N = 162 estimates of plants sold, N = 210 estimates of milk sold, N = 84 estimates of fodder sold and N = 126 estimates of fish sold.

Mean amount \pm SE (tons) sold / day	Jan	Feb	Mar	Apr	May	Jun	Mean over 6 months	Value of 6 months in USD
Harvested plants	9.17 \pm 0.23	12.00 \pm 0.21	23.60 \pm 0.27	34.75 \pm 0.45	22.67 \pm 0.56	13.33 \pm 0.19	19.25 \pm 3.91	\$ 86637.24 Mean of 6 months*90 working days*\$50/ton
Fish	6.05 \pm 0.47	2.81 \pm 0.16	0.38 \pm 0.04	5.30 \pm 0.41	9.86 \pm 0.72	9.52 \pm 1.13	5.65 \pm 1.52	\$551,334.47 Mean of 6 months*90 working days*\$1083.33/ton
Water buffalo milk	3.47 \pm 0.04	4.20 \pm 0.03	4.86 \pm 0.03	3.28 \pm 0.02	1.77 \pm 0.01	0.98 \pm 0.01	3.10 \pm 0.60	\$ 167, 303.72 Mean of 6 months*90 working days*\$600/ton
Fodder	2.58 \pm 2.29	1.93 \pm 0.31	1.55 \pm 0.30	1.13 \pm 0.18	1.25 \pm 0.21	0.69 \pm 0.23	1.52 \pm 0.58	\$ 54,802.80 Mean of 6 months*90 working days*\$400/ton
								Total = 860,078.23 USD

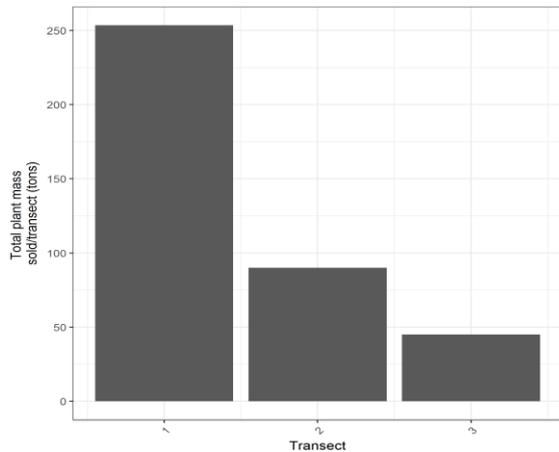


Figure 3. Total plant mass sold/transect (tons). N = 162 estimates of plants sold across entire study period.

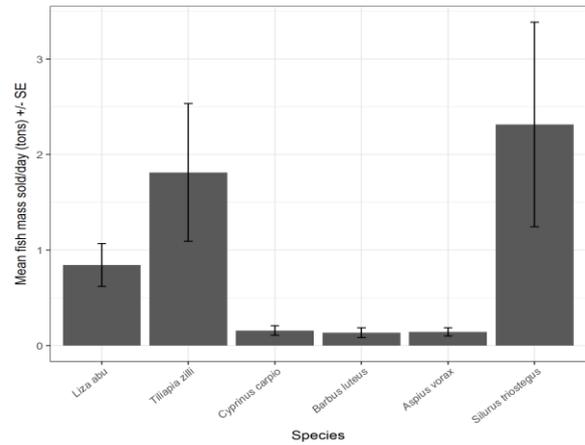


Figure 4. Mean \pm 1 SE (between-subjects) Mass of six fish species in the CM. Data from January to June 2014. N = 126 estimates of fish sold across the entire study period.

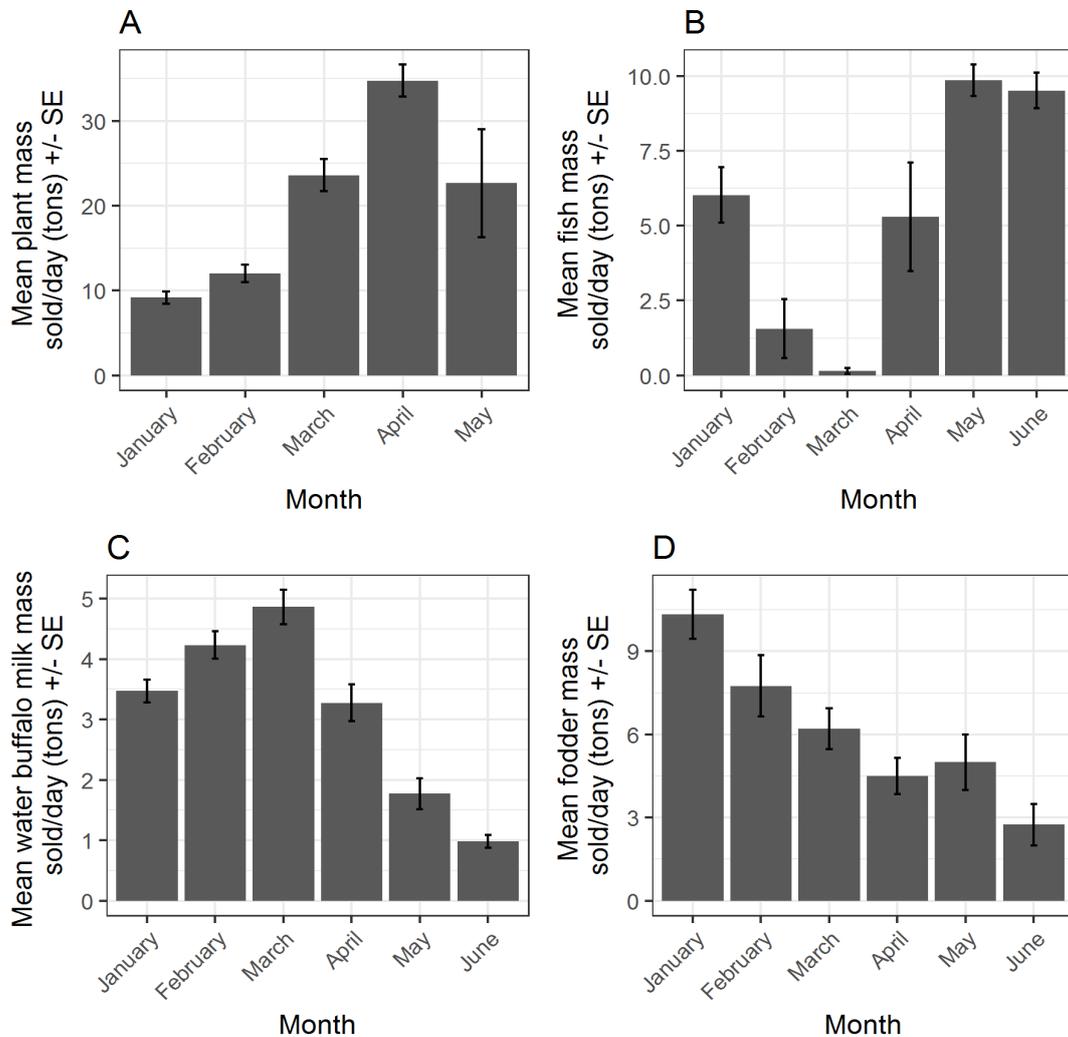


Figure 5. Mean \pm 1 SE (between-subjects) amounts traded per day for A) plant mass, B) fish mass, C) water buffalo milk, and D) fodder in the CM from January to June 2014. Across the entire study period: N = 162 estimates of plants sold, N = 210 estimates of milk sold, N = 84 estimates of fodder sold, and N = 126 estimates of fish sold.

Table 4. Fish species price in USD per ton in the CM from January to June 2014 (data were collected during the study survey).

	<i>Liza abu</i>	<i>Tilapia zilli</i>	<i>Cyprinus carpio</i>	<i>Barbus luteus</i> (<i>carasobarbus</i>)	<i>Aspius vorax</i>	<i>Silurus triostegus</i>
\$/ton	400	1,250	2,000	1,000	1,000	850

Table 5. Numbers of hunted birds in the CM from December 2013 to June 2014.

Species	Total hunted	Month
Coot	201	Dec to Mar
Great Crested Grebe	5	Jan
Eurasian Teal	18	Dec and Jan
Northern Pintail	40	Dec and Jan
Mallard	64	Dec, Jan, and Feb
Purple Heron	7	Dec, Jan, and Mar
Shoveler	4	Jan
Purple Gallinule	16	Mar and Apr
Marbled Teal	4	Apr
Grey Heron	4	Feb
Garganey	6	Apr

Discussion:

We valued the ESs of the surveyed area within the CM (40,000 ha out of the total NP area of 141,615 ha) to be 860,078.23 USD during the six-month survey period in 2014. This value was calculated by evaluating the focal services (as identified by 30 residents of the CM in face-to-face interviews) provided by the CM (trading of fish, water buffalo milk, fodder and harvested plants). If the surveyed area is representative of the larger National Park, then the whole of the National Park could provide 3.05 Million USD across a 6 month period. Given that the average income per individual in Iraq in 2014 was 6720 USD (World Bank data - <https://data.worldbank.org/country/iraq>), then the CM study would have provided an average salary for 256 people (or the salary of 906 people if the study area is representative of the wider NP).

The results showed monthly variation in local economic activities and associated ESs in the CM. Water buffalo were identified by questionnaires as the most important animals for local people in the CM with 2,500 buffalo recorded in the CM and 17,000 water buffalo heads recorded across the entire CM area and surrounding villages and cities in Thi – Qar province by the Ministry of Agriculture (Chibayish city branch). Water buffalo are very sensitive to changes in water temperature and that controls the residency of local people inside the CM (28, 22). Buffalo avoid entering the cool water in winter and local people provide fodder directly to the animals in their yards. Thus, the amount of buffalo milk increases in winter and trading milk and fodder becomes the dominant economic activity during winter and spring. Fish trading and fishing activities are lower in winter and spring than in other seasons as fishing is prohibited in spring. Six fish species were recorded as the most

dominant species used for trading and food, which is interesting as 28 freshwater fish species were described in Iraq from 1843 – 2011 (29). The *Tilapia zilli* fish species was introduced to the CM 2010 and is considered as an invasive (15) and our results indicate it is the most traded fish species. The other non-native fish species, *Silurus triostegus* is not consumed by local people due to religious reasons, hence, it is used mainly in trading. *Cyprinus Carpio* is the most palatable fish species for the local people, but it is expensive. Thus, *Liza abo*, which is the cheapest fish species is consumed largely by the local population. Changing the historical hydrology of the CM and the introduction of invasive species has negatively impacted the native fish species *Barbus Sharpeyi* and *Barbus xanthopterus* (30) and probably contributed to their disappearance from the study area. Although the two non-native fish species *Tilapia zilli* and *Silurus triostegus* have negatively affected the ecology of native fish species, they provide economic support for the local people inside the CM (7). Economic activity relating to harvested plants is important to the CM's local people, who use plants for building houses, hand crafts, water buffalo fodder, and as a main source of income. The results showed that spring is the peak of plant trading activity in the CM. Moreover, transect one is the most used for plant harvesting.

Despite the current challenges that face the CM owing to issues of water scarcity (reductions in water quantity provided by rivers over recent years. For example, the estimated annual average of Euphrates River flow is 30 km³/year (951m³/sec) before 1990, while it dropped to 4.4 km³ (230m³), a 90% reduction in 2011 (21)), the site continues to provide valuable services to the local people. There are clear monthly differences in trading at the area of study, with local people relying mostly on milk

trading in winter, milk and plant trading in spring and fish trading activity in summer and autumn.

Using a modified version of the TESSA toolkit has provided greater understanding of the ESs provided by the CM and has highlighted the crucial role of nature in supporting sustainable well-being for humans living in close proximity to the CM. In addition, the results can be used to enhance local policy and aid management plans of the NP. Currently no data available on how the estimated value for the CM's ESs relates to the value of other economic activities in the area. However, it is important to bear in mind that the estimated value of the ESs provided by the CM most likely underestimates the true value of the services provided. This was due to the fact that the surveys carried out for only a part of the year and, in part, because we could not include some potentially important economic activities in the valuation. The focal activities that were not included are:

- i) Trading of economically important birds. Although we monitored the main market at Chibayish City during the survey, the economic value has not added to the overall estimation because the authors think giving a precise value for the trading of birds requires further intensive and targeted surveys.
- ii) Using plants for house construction, hand crafts and as fodder for water buffalo.
- iii) Eco-tourism, which has increased dramatically in the CM from inside and outside Iraq now visit the area during winter and spring especially in the last two years (Ministry of Environment (31). This activity could support and enhance local income; however, uncontrolled tourism could have negative impacts on the CM's ecosystem and wildlife.
- iv) Using motorboats for transportation inside the CM as an additional source of local income.
- v) The value of the CM for carbon storage and thus the potential of high GHG release if land-use changes

Ultimately, although the CM site is facing challenges from changes to the hydrology of the Euphrates River, uncontrolled use of ESs, changes in water quality and the disappearance of some important native fish species, the site still supports much biodiversity (32), as well as providing the local people with valuable ESs. Iraq currently faces significant decreases in its cropland area, (which includes marshlands) by approximately 30,000 ha/year (33). Thus, to support, protect, and improve ESs provided by the CM, the local authorities and government should account for the extrinsic and intrinsic value of the natural services from the CM and take serious steps to enhance water quantity and quality inside the CM. Moreover, the value of the ESs provided should be added and embedded within

the national budget. Finally, we recommend carrying out long-term surveys by repeating methodology of this study for at least one year and expanding the study area to include all NP areas, which could provide a more accurate estimation of the ESs provided by the CM. Identification of plausible alternative states and application of appropriate methods to assess relevant services under current vs. alternative states are also strongly recommended steps for better decision making. Iraq has 220 Key Biodiversity Areas (15) and repeating our methodology to value ESs inside all KBAs could provide a clear image of nature's value to the Iraqi economy.

Disclosure

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Competing Interest

The authors declare that they have no competing interests.

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Conflicts of Interest: None.

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تقييم خدمات النظم الايكولوجية في الاهوار الوسطى جنوبي العراق

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الخلاصة:

توفر النظم الطبيعية خدمات للبشر تتضمن الغذاء والمياه العذبة والتنظيم المناخي والمنافع الاجتماعية الاقتصادية الأخرى. تعد أهوار بلاد ما بين النهرين من أكبر الأراضي الرطبة في الشرق الأوسط وهي توفر منافع متنوعة على مستوى النظم الطبيعية وخدماتها. وعلى الرغم من أهميتها فإن خدمات النظم الطبيعية في الأهوار تعطي قيمة اقتصادية واطئة لا تعكس مقدار أهميتها في التحليلات الاقتصادية والقرارات الوطنية. الدراسة الحالية هي محاولة أصيلة لتقديم هذه الدراسة في الأهوار الوسطى التي تمثل المحمية الوطنية الأولى في العراق كأول نموذج لخدمات النظم الطبيعية في البلد. تبنت هذه الدراسة تحليل TESSA كطريقة عمل معتمدة عالمياً لتحديد القيمة الطبيعية الحياتية والاقتصادية لهذه الخدمات وذلك على مستوى الموقع. جمعت البيانات الخاصة بتجارة الأسماك والنباتات وحليب وعلف الجاموس لفترة 6 أشهر من المراقبة للنشاطات الاقتصادية المحلية. بلغت القيمة الكلية لخدمات النظم الطبيعية لمنطقة الدراسة في الأهوار الوسطى (40000 هكتار) ما مقداره 86007823 دولار أميركي خلال مدة الدراسة في عام 2014. بلغت مساهمة تجارة النباتات ضمن القيمة الكلية مبلغ 8607825 دولار وتجارة الأسماك 55133480 دولار وتجارة حليب الجاموس 16730370 دولار وتجارة علف الجاموس 5480400 دولار. معدل الدخل للفرد في العراق كان 6720 دولار في سنة 2014 حسب إحصاءات البنك الدولي واستناداً إلى ذلك فإن خدمات النظم الطبيعية في الأهوار الوسطى تساهم بتوفير دخل حسب المعدل المذكور إلى 256 فرداً. توفر نتائج الدراسة الحالية فهماً أوسع لمساهمة الأهوار الوسطى في خدمات النظم الطبيعية كما تسلط الضوء على الدور الحيوي للطبيعة في دعم ديمومة مستوى الحياة الجيدة للبشر الذين يقطنون في منطقة الدراسة. فضلاً عن ذلك يمكن استخدام النتائج لتعزيز السياسات المحلية وتقديم العون لخطط الإدارة للمحمية الوطنية وكذلك يمكن أن تساعد في تقييم الفقدان والضرر الناتج عن تأثيرات تغير المناخ.

الكلمات المفتاحية: خدمات النظم الطبيعية، الأهوار الوسطى، بلاد ما بين النهرين، تغير المناخ، صون الطبيعة