Classification of The Key Functional Diversity of the Marshes of Southern Iraq Marshes

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Abstract. The term "marshes" refers to the wetlands that are almost of shallow water with relatively dense plant cover, mainly of prominent plants (such as Phragmites and Typha), or other submerged plants. The marshes of Southern Iraq (Ahwar) are of unique environmental and cultural features that rarely meet in similar habitats worldwide. They are the most distinctive wetlands in Southwest Asia and worldwide as well. In some times in the past, these wetlands used to cover more than 15,000 km², however, now it consists of less than this area. Functional diversity is fundamentally considered as a guide to comprehend the nature of ecosystem work. Despite the possession of the marshes of Southern Iraq for many major and minor functions, no study to determine the function diversity of this area was conducted. The present study aims to classify the major functions of the Iraqi marshlands, and then to develop a general framework to determine the extent of the decrease or increase in those functions as a result of the different influences. Also, the current study provides the criteria in preparing estimates for Iraqi marshes rehabilitation programs.

Keywords: Iraq, marsh, Functional diversity, Cultural and Natural Heritage.

Introduction: The marshes of Southern Iraq is located in the southern part of the Mesopotamia (Fig.1), on confluence of Tigris and Euphrates rivers. The marshes area has unique properties that rarely can be met worldwide, which makes it one of the most important wetlands on the global level [1]. The Iraqi marshes fall under category of wetlands; hence, the functional diversity of wetlands can be summarized in how wetlands can affect neighboring environments [2]. It is defined by [3] as a process or series of biological processes that take place within the wetlands. The functions of the wetlands vary from region to another, therefore, no wetland can perform all functions at a high level because many of these functions might not act normally within the different direction [4-6].
The geographical location and size of wetlands determine the nature of the functions they will perform [7]. Data on the environmental functional diversity helps to give economic evaluation of wetland resources and services of which contribute to the country's total national production [8-9]. Due to their vast areas and the richness and diversity in flora and fauna of the marshes in southern Iraq, this magnified their major and minor functions [10]. The physical, chemical and ecological properties of freshwater wetlands in general and the Mesopotamian marshes in particular can be classified into four key levels of functional diversity: Production function, regulation function, information function of habitat and biodiversity function [11-13].

The classification of the key functions

The classification of the key functions of the marshes in Southern Iraq are detailed below:

1. Production Function:

The ecosystem of wetlands, with all its components, plays a crucial role by conversion of solar energy to other types that result in production of useful materials for plants and animals [14]. Human societies, since the start of humankind, have used renewable resources in nature; these resources have a value known as "existence value" [15]. The function of production is determined by the amount of the wetlands’ natural resources; subsequently, the production function in wetlands is divided into several levels; the most important of which are:

1.1: Raw Materials:

Wetlands provide a suitable environment for animals to graze, produce wood for fuel, as well as raw materials for industries such as warehouse equipment like mats, trays, baskets. They also provide raw materials used in the paper industry [16]. The most common plant species in the marshes of Southern Iraq marshlands are reed *Phragmites australis* and reed mace *Typha domingensis* and they are considered as economic plants. A report by United Nations Environment Program (UNEP) in 2001 refers to the use of these plants in building houses by local people as an inherited Sumerian tradition. The plants of these marshes have been used as a raw material in local industries of paper production [17].
1.2: **Food Production Function:**

Wetlands are considered as the basic harbor of fish resources [16]. Fisheries of Iraqi marshes have an exceptional importance because they are one of the main economic foundations of the traditional culture of the marshlands. According to a study by [18], there are 14 economic importance fish species in the Iraqi marshes. Abd & Rubec (2009) [19], have identified four additional fish species of high economic importance. In 1990, the FAO estimated the fishing in Iraqi inland waters to reach 23,600 tons/yr, and more than 60%; that amount is originated from marshlands [1]. The amount of fish-catch in Iraq during the 1970s and 1980s was likely to be greater than that of the 1990s [20].

2. **Regulation Function:**

The marshes perform regulatory functions that constitute processes essential to ecosystems through bio-geochemical cycles and other biosphere processes [14]. These processes consist of direct benefits in maintaining ecological balance and species productivity. These regulating functions of marshes are of two kinds: hydrological and biological [14].

2.1: **Hydrological Functions:**

Maltby (2009) demonstrated the hydrological properties of wetlands that affect the soil and the nature of vegetation as well. Hydrological functions of wetlands were classified into several levels: flood control, water supply, water storage, and erosion control [21].

2.1.1 **Flood Control:**

One of the most common hydrological functions of wetlands is flood reduction. wetlands store water during rainy periods, and the stored water is released during dry periods. Iraqi Marshlands are characterized by their dry desert climate, where water levels decrease in summer season due to lack of rain and low water imports. The marsh areas in southern Iraq is somewhat larger in winter when water imports are available and surface water is stored at a depth of up to 4 meters in some occasions [13]. However, it seems that the function of flood control in Iraqi marshes is rare, especially considering the current water situation in Iraq, which does not predict the occurrence of floods in this region, especially with the increasing number of dams, which were established and the planned to be established on Tigris and the Euphrates [22-23].

2.1.2 **Water Supply:**

Wetlands perform functions such as water preservation and storage [12]. The majority of the Middle East countries are considered as arid or semi-arid, with an average annual rainfall of 166 mm [24-25]. About 75 billion cubic meters of water flow to Iraq from Tigris and the Euphrates. The marshes of Southern Iraq account for about 44% of the total inland waters of Iraq [26]. Therefore, the Mesopotamian marshlands are potential strategic reservoirs of the water supply used in agricultural, human, and industrial purposes before being discharged into the Persian Gulf [22-23].

2.1.3 **Water Storage:**

Water is usually infiltrating into soil cavities among soil grains, through small areas called small micropores spaces, and through networks of cracks, roots and channels known as macropore or larger cavities known as soil pipes [27]. Groundwater in the marshes of Southern Iraq area is of an air origin and is rarely of marine origin. The Iraqi groundwater originated through the penetration of rainwater and floods into the ground, where the nature of underground water storage in all Iraqi marshlands is semi-open area type. Groundwater flows according to the hydraulic gradient from high-pressure zones to low-pressure zones depending on the topography of the region [28]. The groundwater levels in the middle areas of the marshlands reach shallow depths that do not exceed one meter above sea level in some areas. The amount of water that can be extracted from a wells in the area is between 400 and 900...
m3s/day, however, groundwater is not used to fill the marshes because of their low quality which may cause economic and environmental damage [29].

2.1.4 Corrosion-reduction Function:

Without plant cover, the soil erosion rates increase. Many countries, especially those in tropical areas, lose large amounts of soil because of the erosion. Globally, eleven million square kilometers of land (equivalent to the United States of America and Mexico combined) are affected by the high erosion rates. Each year, about 75 billion tons of soil are believed to be eroded from earth ecosystems 13 to 40 times faster than the average required for soil creation. Wetlands and their plant cover play a major role in reducing dust storms. The marshes of Southern Iraq are characterized by their geographical location because they are surrounded by arid lands [30]; consequently, these marshes play major role in protecting the soil erosion. The functional role of the marshes of Southern Iraq was obvious when Saddam Hussein's regime committed the crime of draining the marshes during the 1990s. The dust storms increased and rising dust has became more obvious due to the drying of marshes and exposure of large areas of soils and the loss of plant-cover in those areas [31].

2.2: Biological Functions:

2.2.1: Primary Productivity:

Primary productivity is the process of converting the solar energy to chemical energy by plants. It is an essential tool for the dynamics in ecosystems, and thus can be considered as a determinant of many ecosystem functions. In general, freshwater marshes associated with rivers are highly productive ecosystems [32], and the Iraqi marshes do not differ from this hypothesis. They increase in the primary productivity within the environment of the Iraqi Marshlands is due to weak water currents, leading to increased growth of aquatic plants and algae [13]. The Iraqi Marshland Restoration Program (IMRP) reported that the initial productivity of phytoplankton in the marshes of Southern Iraq ranged from (1.1-12.5 g/m3/h at surface and 9.37-37.5 g/m3/h [33]. Emergent plants in the marshes of Southern Iraq are habitats for many organisms. Decomposing these plants creates organic pathways, which are key to energy cycle in these regions. These plants play an important role in reducing the speed of water currents, thus, facilitating the deposition of suspended particles in the water. In an integrative role, submerged plants absorb nutrients and particulate which are deposited in the water to increase photosynthesis to include whole water body. Phragmites australis is the most common aquatic plant in the marshes of Southern Iraq, followed by the Schoenoplectus litoralis, and thirdly Typha domingensis [34].

2.2.2: The Function of Carbon Sequestration:

Wetland ecosystems regulate carbon sequestration from the atmosphere, which helps in reducing the damage caused by global warming. Plants absorb CO2 during their growth process and then store it in underground plant biomass as sediments. Quantitative contribution of the micro-organisms affects the biogeochemical processes of wetlands and then on the flows of carbon and other nutrient flow [35]. Carbon dioxide emissions are resulting from plant respiration and soil activities, while methane emissions are produced only from soil activity, however, the total CO2 and CH4 emissions improve ecosystems, assuming that the presence rates of these gases affect the process of global warming. Carbon flow and greenhouse gases production in wetlands are affected by water salinity [36]. There is a general decline in methane flows with increased salinity in freshwater and saline swamps. This decrease is due to large quantities of sulfate which deter methane generation and lead to lower methane emissions for the upper layers. Al- Hammar Marsh (one of the Southern marshes’ components) is the saltiest among Iraqi marshes, and the carbon cycle dominates the cycles of other elements [13]. Abed et. al. (2017) have demonstrated the direct and subsequent effects of some of the climate change factors on the marshes of Southern Iraq, and the results have shown that are of considerable subsequences on the short and long terms.
2.2.3: Improving the Water Quality:

Wetlands are used as natural filters to improve water quality by reducing the suspended material [14]. Jin et al. (2006) stated that the use of aquatic plants improves water quality, restores water bodies, and controls pollution. The emerged plants have the ability to remove soluble inorganic nutrients (Ammonium, Nitrite, Nitrate and Phosphate) and heavy metal by absorption or direct introduction of water column through the stems of these plants, while their roots remove these materials from the bottom. Algae, floating and submerged plants, remove pollutants directly from water column. The marshlands of Southern Iraq play the role as a natural refinery to free Tigris and the Euphrates from waste and contaminants, while Dalmaj lake and marshes do the same function for the following Main Outfall Drain trunk that passes through this wetland. This property of the marshes is due to passing of the slow flow of water through the thick plants such as the Reed (P. australis) and Reedmace (T. domingensis), which work on filtering the water of some contaminants and reduce pollution of water flowing to the Arabian Gulf [20].

The studies that dealt with the treatment of water by aquatic plants in the marshes of Southern Iraq are very few. Aziza et al., (2006) considered the Reed and Reedmace as good vital evidence and environmental treatments because of their ability to accumulate trace elements such as copper, lead and zinc. Awad & Abdulshahib (2007) studied mercury concentrations in Al-Amara and Al-Basra marshes and Shatt Al-Arab in 13 species of aquatic plants, water column and precipitation. The highest concentration was in P. Potamogeton pectinatus in Al-Huweiseh marshes. Mercury concentrations were higher in aquatic plants than in precipitation and water. Sooknah (2000) demonstrated that the reduction of organic substances is carried out by bio-oxidation process by the bacteria that were found on the thin capillaries of biofilms, and were formed on the stems and roots of aquatic plants.

2.2.4: Food Chains:

"Food web is a map that describes which kinds of organisms in a community eat other kinds". Food studies in estuaries are often driven by the desire to understand the nutrition sources that support fisheries production, and the relations between species in the food network can be represented hierarchically. The order of species starts from the bottom (bottom level of the food network) to the highest producers, and the category of producers mostly consists of living beings including green plants and algae, as well as blue bacteria. Originally, changes in each food level are an opposite response to the next nutrient level; in other words, the effect of the higher level at the lower level. Thus, the reduction of carnivorous predators allows the increase of animals with herbivores and so on. Competition within a single food level is a type of indirect food interaction known as a negative effect of one species on the rate of population growth or the abundance of another [42]. Batzer et al., (2004) demonstrated that food webs in wetlands are mainly dependent on aquatic plants and organic detritus, therefore, animal communities without predators do not suffer from shortage of food sources due to the abundance of these foods in wetlands. Aquatic plants, macro benthic algae, and phytoplankton are the main base in the marshes of Southern Iraq as primary producers [44]. Aquatic plants, macro benthic algae, and phytoplankton are consumed by animals of larger herbivores, birds, large and small invertebrates and first-class herbivorous fish (primary consumers). The marshes in southern Iraq are known for the largest group of detritivores fish [32]. Algae, diatoms and aquatic plants appear to be of great importance in these marshes. Nine fish species in these areas feed on algae, diatoms and aquatic plants, while six species of fish feed on diatoms only [45]. Mohamed et al. (2012) have illustrated the nature of the food web of fish in Al-Chabayish Marsh in the south of Iraq, during the period 2005-2006, Fig. (2).
3. Habitat Function and Biodiversity:

Parker (1989) defined the habitat as "part of the physical environment in which plants and animals live". Instinctively, living organisms require environments in which they find sufficient food, water, shelter, to breed and escape from potential predators. The vital role played by wetlands in maintaining the overall health of the ecosystem has become clearer over the past three decades. They provide wide spectrum of living environments for different species of flora, fauna, and biodiversity. Several definitions of the term ‘biodiversity’ have led to significant confusion in its meaning. Biodiversity can simply be defined as "number of taxa within a defined geographic range". It is agreed that each organism varies in its interaction with other organism and effects within the overall performance of the ecosystem, whether they are dominant in the community or not. The loss of any of these organisms will lead to environmental disturbance [47].

The marshes in southern Iraq have an outstanding biological diversity. The marshes are among the 200 global ecoregions. They have been identified as endemic birds' area [48], in addition, it includes a Ramsar site. Salim and Porter (2015) have described the global, regional and local importance of these marshes to the birds with details. The environmental functions of these wetlands are very important for the interactive relationships among the organisms and with the marsh dwellers as well. The surrounding areas and wetlands around the key marshes of Southern Iraq are also of considerable importance [10]. The four components of the marshes of Southern Iraq (Huweiza, Central Marshes, East Hammar, and West Hammar) were inscribed as the natural components of ‘Ahwar’ World Heritage property [49]. Dalmaj wetlands are also of high environmental importance for harboring considerable number of threatened taxa in addition to its being wintering and stop-over site for quite large numbers of birds, mainly Waterbirds [37, 50-54].

4. Information Function

Ancient human often used rivers and lakes as habitats. Wetlands provide drinking water and food (such as fish and birds), as well as, pastures and transport [55]. Wetlands have witnessed civilizations and constituted an important part of peoples’ cultural heritage, including the mythology, arts and religion [56]. Accordingly, wetlands are an essential source of information. The information function can be classified into many levels:
4.1 Cultural Heritage:

The word of Mesopotamia in originally is a Greek word which refers to the land between two rivers [57]. Also, is refers to the cultural heritage of the marshlands, and which they were mentioned in the Holy Scriptures by name Garden of Eden. The Mesopotamian marshes are the land from which Abraham emerged. The Mesopotamian marshes are the land from which Abraham emerged and before that it was a haven for Sumerians 5000 years ago [58]. The Sumerians were they were the first who grew up the urban civilization. In addition, they are the first to invented writing [59-61]. For their outstanding universal values (including cultural and natural), the marshes of Southern Iraq and three of the surrounding cultural sites (Uruk, Ur, and Erido) they have been inscribed on the World Heritage list at 2016 [49].

The people who live in the Iraqi marshes are known by name (Marsh Arabs or Ma’dan), they descendants of sideburn communities of Sumerians [62]. The famous reed guesthouse (Mudheef) typifies, which is one of the most ancient cultures inherited from the ancient Sumerians to the present marsh dwellers. It is a place for a gathering place individuals the tribe. Also, it is used to receive guests or foreign travelers passing through the area. As well as it used as a place to hold meetings and conflict resolution. All members of the village participate in its construction, in the same old Sumerian style surviving 5000 years (Fig.3).

4.2 Scientific Research:

Wetlands are a source of information about aquatic organisms, bird species, habitats, ecosystem functions, and natural biological processes and relationships between them [63]. The marshes of Southern Iraq, along with Dalmaj wetlands, have been fertile ground from various study aspects, cultural, historical water biological, and still much new facts are being discovered, such as recording new species [54; 64]. The taxonomic studies of the biota in the Mesopotamia region such as microorganisms [65-66] plants [67-68] fishes [69], birds [70-73], mammals [74-75 and reptiles [76-78]. These pieces of works have provided better understanding on the current knowledge of these wetlands.

On the other hand, it is also worthy to mention that within the current scientific coverage of the marshes of Southern Iraq, and among the recent research efforts, a research paper was published that include unreal results on the endangered Basra Reed Warbler that these wetlands form the key breeding habitat for this species on the global level; therefore, a group of key scientists and international experts have refer to the wrong information in this research paper to the claimed methodology that the researcher did not use in the field at all [79-80] The authors of this paper, [81] have replied with their defend; however, the argument was very weak and has only added more confusion to their work. In addition, there were some research papers that have been published on these wetlands that were not made by specialized experts; for this reason, it would be crucial to select those papers that are based on true, yet solid, methodologies when researching on the marshes of Southern Iraq.
Figure 3: Left, The Al-Mmudheef in Southern Iraq 2015. Photos by the author. In the Right, Al-Mudheef 3,000 year ago. (UNEP, 2001)

4.3 Entertainment and Aesthetic Features:
Wetlands are unique landscapes that do not exist in other environment types, and offer opportunities for recreational activities such as camping, fishing and bird watching [14]. Scott & Evans (1994) presented a general primary list of elements of the landscape (which form) the marsh scene - of fresh, permanent freshwater lakes with dense growth of submerged aquatic plants and narrow lanes within the large promontory plants of reed and papyrus and the sloping mud banks Many sources, which are taken from travel books and reports that have dealt with many Iraqi Marshlands testify to their beauty and uniqueness [82-83]. Based on intensive fieldwork, Salim, et. al. (2009) have demonstrated the presence of large flocks of Waterbirds in the marshes of Southern Iraq that creates additional beauty to the mars’ landscape. There is also a reference to the Mesopotamian marshes in Sumerian literature [83]. Among what has been written about the marshes of Southern Iraq, Wilfred Thesiger, (1954) described his first experience of visiting the marshes in the 1950s as follows: "Memories of that first visit to the Marshes have never left me: firelight on a half-turned face, the crying of geese, duck flight in to feed, a boy's voice singing somewhere in the dark, canoes moving in procession down a waterway, the setting sun seen in crimson through the smoke of burning reed beds, narrow waterways that wound still deeper into the Marshes”

Conclusion
1- The marsh in southern Iraq area has unique properties that rarely be found in any other spot worldwide which makes it one of the most important wetlands on the global level.

2- The functional diversity of the Mesopotamian marshes classified into four major levels: Production function, Regulation Function, Habitat Function and Biodiversity and Information Function.

3- The need to conduct further studies, as well as showing of the size of the changes that have occurred on these functions in light of climate change and establish reliable, yet updated, database capable of providing the required advice for the concerned authorities to ensure effective protection and development of these areas.

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