

Exploring the Socio-Ecological Characteristics of Gahkuch Marshland: A Unique Wetlands Ecosystem in Hindukush Mountain Ranges

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Abstract: Gahkuch marshland spreading over 133.54 hectare amidst Hindukush mountain ranges in northern Pakistan is characterized by typical wetlands ecosystem, comprising of small lakes, streams, peat lands, bogs, marshy areas and riverain forests. The area abodes largest resident population of waterfowl in Gilgit- Baltistan, in addition to providing wintering and staging ground for a large number of migratory birds and other aquatic life. A detailed socio ecological study conducted during August to September, 2011 revealed that the area is rich in biodiversity, harboring eight large and three small mammal species, 35 species of birds, seven species of fish, eight species of trees and 18 species of medicinal and economic plants and seventeen families of benthic-macro invertebrates. Moreover, six physical, nineteen chemical and three biological parameters of water bodies were also determined. In addition to its ecological significance the area also supports livelihoods of about 10000 people by providing timber, fuel wood, grazing ground and fish resources. Anthropogenic pressures includes solid waste, influent and illegal hunting were key threats to wetlands and its resources. Wetlands management planning in collaboration with key stakeholders would be effective approach to protect important biodiversity and wetlands resources of the area.

Keywords: Gahkuch, Marshland, Wetlands, WWF, Benthic, Hindukush

1. Introduction

Wetlands are areas of marsh, fen, peat land 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 meters. (Ramsar Convention, 1971). It is difficult to clearly demarcate boundaries between wetlands and adjacent deep-water systems, especially when water levels fluctuate greatly and frequently between extremes (seasonal wetlands) (RCS, 2006). Wetlands are sensitive ecosystems providing habitats for a variety of plants species, birds, small mammals and other aquatic biota. The term “wetland” is mostly used to explain diverse habitats

where the land is wet for extensive period of the year or season but not essentially permanent waterlogged (Collins, 2005). ‘Wetland’ is a term used to define a variety of habitats in different climatic zones of the Globe. Ecologically, wetlands are transitional (ecotonal) systems between upland terrestrial and deep open water systems. They are characterized by aquatic vegetation (hydrophytes) (Mitsch and Gosselink, 2007). Wetlands are most important freshwater resources; fresh water forms the habitat of large number of species. These aquatic organisms and the ecosystem in which they live, represent a substantial sector of the Earth’s biological diversity (UNEP, 1994). Around 50% of the world’s wetlands have been lost in the past century alone due to urbanization, drainage for agriculture, and water system regulation (Shine and de Klemm, 1999).

High altitude wetlands, which include lakes, marshes, seeps, peat bogs etc, in the Himalayas have several characteristics that make them unique in terms of their biodiversity value. The plants and animals that occur in and around them are often endemic and highly adapted to their locations. (WWF, 2010). Alpine wetlands are critical ecosystems at risk from natural and manmade threats. In the Indian subcontinent, they are reservoirs of biodiversity, providing staging and breeding ground for migratory birds across Himalayas, and supporting many types of endemic wildlife. Human communities also inhabit the regions surrounding the high-altitude wetlands; they rely upon the ecosystem services (Srinivasan, 2002). High-altitude wetlands cover only approximately 3% of the total land area (Maltby and Immirzi, 1993). Alpine wetlands can store approximately 30% of the global terrestrial carbon (Gorham, 1991; Blodau, 2002). Pakistan supports an estimated 7,800,000 hectares (ha) of wetlands and in excess of 225 significant wetland resources are recorded by 2004, nineteen of these have been internationally recognized by the Ramsar Convention Bureau as being of global importance and about one-third of Pakistan bird species use wetlands for food, shelter, and (or) breeding (Ali, 2005). However, the birds that visit or breed in poorer quality habitats will not contribute to

a sustainable population through the years (Pulliam and Danielson 1991).

Gahkuch Marshland is one of such valued and critical wetland ecosystem, occurring at higher elevations but its socio ecological significance has never been documented. The current paper elaborates finding of a study conducted during August to September, 2011 to explore and record key socio ecological characteristics of Gahkuch Marshland.

2. Materials and Methods

2.1. Study Area

Gahkuch wetland complex located at 36° 10' 19.5" N, 73° 46' 25.3" E and at an elevation of 1899 m comprises of marshland, peats, riverain ecosystem along Ghizer River and more than a dozen lakes. The typical marshland spreading over 133.54 hectare is situated adjacent to Ghizer river in the district headquarter; Gahkuch and is owned by the Gilgit-Baltistan Forest & Wildlife Department and the local community, whereas, the upland cluster of three lake locally called Barosar, Chunosar and Photakesar covering some 427.24 sq km area are surrounded by lush green pastures abound in medicinal herbs.

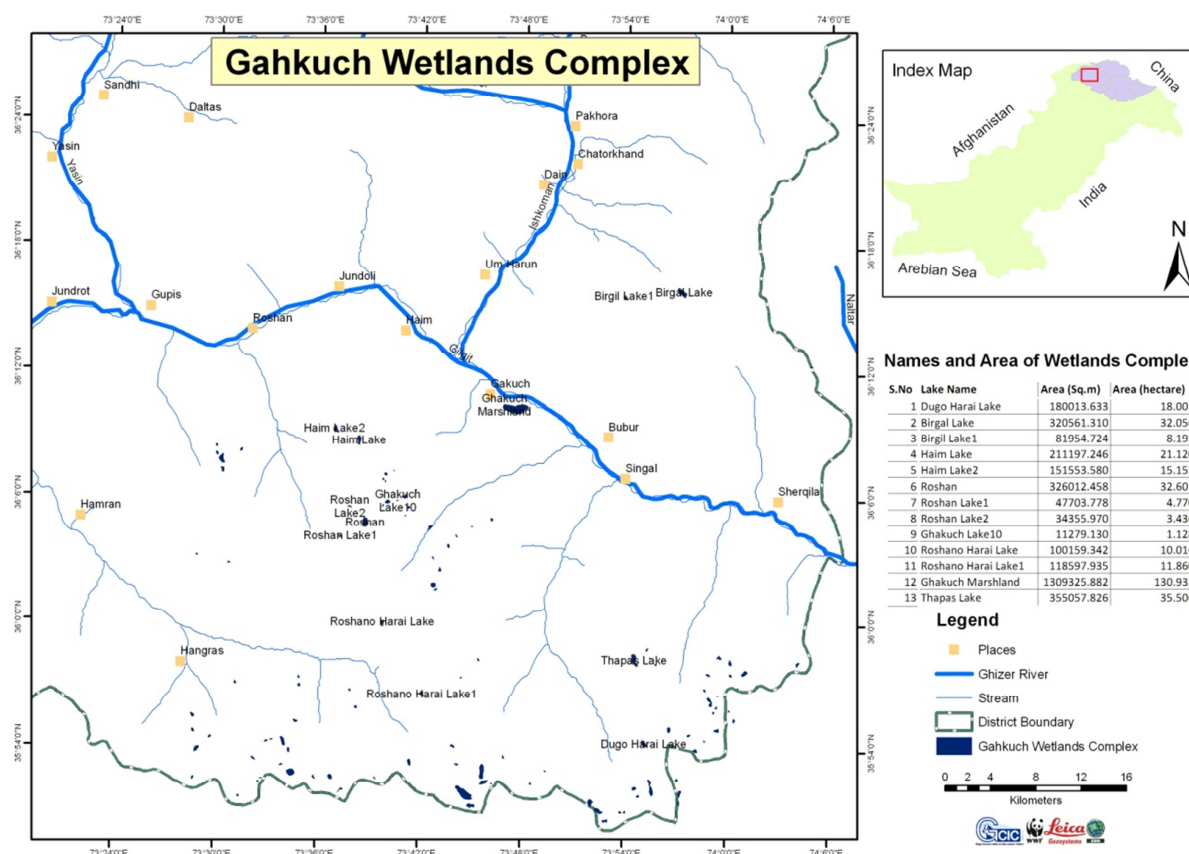


Figure 1. Map of the Study Area.

2.2. Methods

A random sampling procedure was followed to study the large mammals around the Gahkuch Marshland and in some

places transect methods were applied to estimate the population density of the large mammals while Transect method was also applied to study the small mammals of the areas. Techniques used during the studies are visual Sighting,

Odors, Spotlighting, Entry sites, Leftovers, Tracks and claw marks, Sherman Trap and also the information's gathered through interviews with local community resource persons.

Vegetation survey was under taken and collected plant specimens during their specific blooming season. Collected specimens were gathered with field information's and properly pressed with the help of plants presser. The ethno botanical information and traditional uses of plants were documented by interviewing local and filling of questionnaires from local experts both men and women. Species identified with help books and desk assessment was done to develop a check list of plants from Gahkuch Marshland. Equipment used during field survey were Garmin Global Positioning System (GPS), Columbia digital camera, plants pressers, blotting papers, note book, maps, pencils, plants pressers, polythene bags, Sesser and magnifying mirror, Bird's diversity was recorded through Direct and indirect counting methods. Direct observations include direct counts and specimen collection and indirect observations include information gathered from interviews and general discussions with the local community. Mist nets were used to capture the birds and nets were operated for all the 24 hours per day (beginning at local sunrise) during the study. All the birds caught were identified and blood samples were taken for DNA analysis. A 10x42 mm Olympus binocular, 20x45-60 mm Nikon telescope, Garmin Map 76 GPS receiver, note book, lead pencils, field guide, Birds of Pakistan by Grimmett *et. al* (2008). Pocket guide to the "Birds of Indian Subcontinent" by Richard Grimmett (2001) and "a field guide to the Birds of the Indian Subcontinent" by KrysKazmierczak (2000) were used in the field.

Hydro chemical and physical properties were tested from a total of five sampling sites selected in Gahkuch Marshland on the basis of topography, surface geology, break and human made structures. During survey, each site was marked using a GPS. To study the affect of water quality sampling bottle of 450ml was filled completely from each sampling site mentioned above for the determination of water quality and heavy metals contents. All the physical and chemical parameters of water samples were determined referring to the American Public Health Association (APHA).

For fish surveys recognized methods used included bank-side counts, trapping, cast netting, seine netting, gill netting, and electro-fishing. Bank-side counts are preferred on the banks of clear shallow streams. Trapping used for specific species using specific baits. Gill netting and seine netting was mainly done in Marshland (Survey guidelines for Australia's threatened fish, 2004). All the specimen data and the relevant auxiliary information were recorded in the data sheet specially designed for these studies.

Baseline information on aquatic invertebrates (benthic macro-invertebrates and zooplanktons) of Gahkuch Marshland was studied by collecting three samples from different braided channels of Ghizer River. The samples were collected by two persons (first person hold D-frame dip net facing second person that help to disturb substrate by kicks). A total of 20 kicks were taken over the length of

the stretch from all possible substrates. Four kicks were made at each transect. A total area of 3.1 m² was disturbed. After every 2 kicks, more often if necessary, the collected material was washed by running clean water through the net for two to three times. Then transferred to white enameled tray, thoroughly check all wooden debris for organism attachment and remove it from the sample. Then sample was transferred to preservation bottle having sufficient 5-10% formalin solution. External label was written with sampling locality, date of collection and collector name on external upper side of lid and lower bottom of sample container. An interior label written in pencil on waterproof paper was inserted as a backup. At last sampling bottle was placed inside an air tight ½ barrel hard plastic drum to avoid inhalation of formalin fumes and safe transportation during field operations.

To assess socio-economic conditions of local communities and understanding of extent of dependency on high altitude wetland, integrated management option for sustainable uses of natural resources a number of methodologies including group discussion, questionnaire survey and personal observation were employed during the study.

3. Results

3.1. Large Mammals and Small Mammals

A total of 8 species of mammals were recorded in the area. *Canis lupus* (Wolf), *Capra ibex* (Himalayan Ibex) and *Moschus chrysogaster* (Himalayan Musk Deer) were reported by the Wildlife staff and local peoples. Only one species of lagomorphs, *Lepus capensis* (Cape Hare) was seen. The fecal material of the *Vulpes vulpes* (Common Red Fox) was observed on different places of the area. The area is rich in large mammal species which adequate that the area is ecological rich in biodiversity. Three species of rodents, *Apodemousrusiges* (Himalayan Wood Mouse), *Mus musculus* (House Mouse) and *Rattusturkestanicus* (Turkistan Rat) and one insectivore, *Crocidurapullata* (Asiatic White-toothed Shrew) were recorded in the study sites.

3.2. Records of Trapped Small Mammals in the Study Sites

Trapping results at Gahkuch Marshland shows that the site is productive as three species of rodents i.e., *Apodemousrusiges*, *Mus musculus*, *Rattusturkestanicus* and *Crocidurapullata* (Asiatic White-toothed Shrew) were trapped in the study area. The overall trapping success remains 51.76%. The 10.41% traps were tripped due to unknown reason while the 20.25% traps were dislocated from their original trapping stations, which can be ascribed about the fluent movement of some mammals at night. In terms of relative abundance, 45.30 % of the total trapped specimens were Himalayan Wood Mouse, 31.10% was *Mus musculus* (House Mouse), 15.11% *Rattusturkestanicus* (Turkistan Rat) while the 8.49% was *Crocidurapullata* (Asiatic White-toothed Shrew).

3.3. Taxonomic Records with Conservation Status

The conservation status of mammalian fauna in Gahkuch marshland is determined by referring to IUCN red list (2010), Out of 8 mammalian species of the area *Moschuschrysogaster* (Himalayan Musk Deer) are listed on CITES appendix 1 and are classified as Endangered, while the other 7 species are included as Least Concerned. Three species i.e., *Moschuschrysogaster* (Himalayan Musk Deer),

Canis lupus (Wolf), are rare in the area. *Vulpes vulpes* (Common Red Fox), *Lepus capensis* (Cape Hare), *Apodemusrusiges* (Himalayan Wood Mouse), *Mus musculus* (House Mouse) and *Rattusturkistanicus* (Turkistan Rat) are common in the area while the *Crocidurapullata* (Asiatic White-toothed Shrew) are less common as compared to the other small mammals of the area which are described in Table. 1.

Table 1. Taxonomic records and conservation status of the mammals in the study site.

Sr. #	Zoological Name	Order	Family	CITES	IUCN (Red list 2010)	Local status
1	<i>Canis lupus</i>	carnivora	Canidae	Least Concern	3.1	Rare
2	<i>Vulpes vulpes</i>	carnivora	Canidae	Least Concern	stable	Common
3	<i>Moschuschrysogaster</i>	Artiodactyla	Moschidae	Endangered	3.1	Endangered
4	<i>Lepus capensis</i>	Legomorpha	Leporidae	Least Concern	2.3	Common
5	<i>Apodemusrusiges</i>	Rodentia	Muridae	Least Concern	2.3	Common
6	<i>Rattusturkistanicus</i>	Rodentia	Muridae	Least Concern	2.3	Common
7	<i>Mus musculus</i>	Rodentia	Muridae	Least Concern	2.3	Common
8	<i>Crocidurapullata</i>	Insectivora	Soricidae	Least Concern	2.3	Common

3.4. Common Flora of the Area

The area falls in dry temperate zone, receiving no monsoon rains. It represents small patches of mixed, Blue pine, Spruce, Juniper, Salix and Birch forests. However, in community owned portion, Willow and Poplar have been planted to meet timber and firewood needs. Major floral species identified were as follow in Table. 2.

Table 2. List of Tree identified during field survey.

S. #	Common Name	Botanical Name.	Family
1	Willow	<i>Salix tetrasperma</i>	Salicaceae
2	Juniper	<i>Juniperus macropoda</i>	Coniferae
4	Poplar	<i>Populus alba</i>	salicaceae
5	Walnut	<i>Juglans regia</i>	Juglanceae
6	Russian olive	<i>Elgeanus angustifolia</i>	Elgeaniceae
7	Mulberry	<i>Morus alba</i>	Moraceae
8	Birch	<i>Betula utilis</i>	Cupuliferate

3.5. Avi Fauna

The recent study revealed 35 birds' species of 11 orders in the Gahkuch Marshland from which 11 were resident species 9 were summer migrants while 8 were winter visitor species. Migratory waterfowl were recorded in the study area were common pintail, Nothren shoveler, Common Teal, Eurasian Wigeon and Gadwal. Gahkuch Marshland, typical wetland in Gilgit-Baltistan is important in term of migratory waterfowl because it provides staging ground for migratory birds while

at the same time also harboring a sound population of resident. Mostly birds prefer this area because of food, shelter and nest. Identified birds in Gahkuch Marshland is given below in Table. 3.

3.6. Fish Fauna

Seven species of fishes have been recorded from the River Ghizer and in the marshland (Table 4). The fish *Salmo truttafario* is an exotic fish and introduced in the Gilgit-Baltistan in 1916 by the British representative. It is common in the water bodies of Gilgit-Baltistan, especially in the lakes and streams. The brown trout is confined to crystal clear cold waters of high altitude lakes and streams. They generally avoid entering into main rivers due to high turbidity generally prevailing in these rivers. It is one of the major source of protein for the masses and is mainly caught by rod and line but netting by cast net is also practiced which is a major threat for this species. Different teams from the area come with their tents and ration on specific trout spots and they catch fish for many days for commercial purposes.

The species *Schizothorax plagiostomus* and *Racomalabiata* are also commercially important fishes and major part of the fish food for the local people. The population of *Racomalabiata* is, however, low in the area probably due to its food competition with the more successful fish *Schizothorax plagiostomus*. The loaches *Triplophysa microps*, *Triplophysa tenuicauda*, and *Triplophysa yasinensis* are small fish but an important component of the ecosystem as they are major food items for the brown trout. The species *Triplophysa microps*, *Triplophysa tenuicauda* are mainly found in the small waters of springs while the species *Triplophysa yasinensis* is common in the river. All the loaches

are endemic in the upper reaches of the Indus drainage. is distributed up till Khalti Lake in the river Gilgit. *Glyptosternumreticulatum* is the only cat fish in the area and

Table 3. Birds List.

Order	Families	Species	Common Name	Occurrence	IUCN 2012 Red list	Status
Anseriformes	Anatidae	<i>Anascrecca</i>	common teal	winter visitor	LC	Abundant
		<i>Anasstrepera</i>	Gadwall	winter visitor	LC	Common
		<i>Anasacuta</i>	NorhtrenPintatail	winter visitor	LC	Abundant
		<i>Anasclypleata</i>	NothrenShoveler	winter visitor	LC	Abundant
		<i>Anas Penelope</i>	Eurasian Wigeon	winter visitor	LC	Abundant
Ciconiformes	Accipitridae	<i>Hieraaetus pennatus</i>	Booted Eagle	Resident	LC	Rare
		<i>Accipiter nisus</i>	Eurasian Sparrow Hawk	winter visitor	LC	Frequent
Ciconiformes	Falconidae	<i>Falco tinnunculus</i>	Eurasian Kestrel	Resident	LC	Common
		<i>Falco subbuteo</i>	Northern Hobby	summer breeding	LC	Frequent
Galliformes	Phasianidae	<i>Alectoris Chakur</i>	Chakur	Resident	LC	Common
Gruiformes	Rallidae	<i>Fulicaatra</i>	Common coot	Resident	LC	Abundant
		<i>Gallinulachloropus</i>	common Morhen	Resident	LC	Abundant
Gruiformes	Gruidae	<i>Anthropoidesvirgo</i>	Demoiselle Crane	Migrant	LC	Frequent
Columbiformes	Columbidae	<i>Streptopeliaorientalis</i>	Oriental Turtle Dove	Summer Visitor	LC	Common
		<i>Columba livia</i>	Rock Pigeon	Resident	LC	Abundant
Apodiformes	Apodidae	<i>Apus apus</i>	Common swift	summer breeding	LC	Abundant
Upupiformes	Upupidae	<i>Upupaepops</i>	Hoopoe	summer breeding	LC	Common
Piciformes	Picidae	<i>Picussquamatus</i>	Scaly-bellied Woodpecker	Resident	LC	Common
passeriformes	Motacilidae	<i>Motacillaflava</i>	Yellow Wagtail	Migrant	LC	Common
		<i>Motacilla alba personata</i>	White Wagtail	summer breeding	LC	Common
passeriformes	Cinlidae	<i>Cincluspallasii</i>	Brown Dipper	Resident	LC	Common
passeriformes	Troglodytidae	<i>Troglodytes troglodytes</i>	Winter wren	Resident	LC	Common
passeriformes	Alaudidae	<i>Alaudaarvensis</i>	Common Skylark	Migrant	LC	Common
		<i>Galeridacristata</i>	Horned Lark	Resident	LC	Common
		<i>Alaudagulgula</i>	Oriental skylark	summer breeding	LC	Common
		<i>Calandrellabrachydactyla</i>	Greater Short toed Lark	Migrant	LC	Abundant
		<i>Prunellastrophia</i>	Rufous-breasted Accentor	summer breeding	LC	Frequent
passeriformes	Prunellidae	<i>Prunellafulvescens</i>	Brown Accentor	Resident	LC	Common
		<i>Prunellarubeculoides</i>	Robin Accentor	summer breeding	LC	Frequent
		<i>Phoenicurusphoenicurus</i>	Black Redstart	Migrant	LC	Common
passeriformes	Turdidae	<i>Phoenicurusphoenicurus</i>	Common Redstart	Migrant	LC	Common
		<i>Luscinia pectoralis</i>	Himalayan Ruby throat	summer breeding	LC	Common
		<i>Lusciniasvecica</i>	Blue Throat	winter visitor	LC	Frequent
		<i>Tarsigercyanurus</i>	Orange-flanked Bush Robin	summer breeding	LC	Frequent
		<i>Phoenicurus frontalis</i>	Blue fronted Redstart	summer breeding	LC	Frequent

Table 4. Fish Fauna of Ghizer River in the Gahkuch Marshland Areas.

S. No.	Fish Species	Common Name	Food Habit	Status in the area	IUCN Status	Distribution status
1	<i>Salmo truttafario</i>	Brown trout	Carnivore	Common	LC	Exotic
2	<i>Racomalabiata</i>	KunarSnowtrout	Omnivore	Rare	Data deficient	Wide
3	<i>Schizothoraxplagiostomus</i>	Golden snow trout	Omnivore	Common	Vulnerable	Wide
4	<i>Triplophysamicrops</i>	Leh loach	Carnivore	Rare	LC	Endemic to upper Indus drainage
5	<i>Triplophysatenuicauda</i>	Short tailed loach	Carnivore	Rare	Data deficient	Endemic to upper Indus drainage
6	<i>Triplophysayasinensis</i>	Yasin loach	Carnivore	Common	Data deficient	Endemic to upper Indus drainage
7	<i>Glyptosternumreticulatum</i>	Turkestan catfish	Carnivore	Common	LC	Wide

3.7. Aquatic Invertebrates

There is no published information regarding the invertebrates of Gahkuch Marshland. Present baseline survey was conducted to investigate the first hand knowledge of Benthic Macro-invertebrates fauna. Twenty taxa (Seventeen families and eleven generas) of Benthic-macro invertebrates

were identified from 1198 individuals at Gahkuch Wetland Complex (see Table 5 and Figure 2). The number of individuals from S₁, S₂ and S₃ were 585, 208 and 405 respectively. The most abundant taxa at S₁ were Tanypodinae (Chironomidae) 210 individuals followed by *Baetis* sp. 158 individuals and Chironomidae 123 individuals. Nine taxa including *Mesonemoura* sp., *Hydropsyche* sp., Psychomyiidae, *Omphiogomphus* sp., *Probezziasp.*,

Tabanidae, Hydrophilidae, Naididae and Tubificidae were not recorded from S₁. Sampling station S₂ was found abundant with Chironomidae 52 individuals followed by *Baetis* sp. 36 individuals and Tanypodinae (Chironomidae) 31 individuals. Following six taxa were not recorded at S₂, *Epeorus* sp., *Lepidostoma* sp., Simuliidae, *Culex* sp., Elmidae and Hydracarina (Arachnida). Sampling station S₃ was again dominated by Chironomidae 147 individuals followed by Tanypodinae 94 individuals and *Baetis* sp. 84 individuals. Five taxa including, *Mesonemoura* sp., *Epeorus* sp., *Probezzia* sp., Elmidae and Psychomyiidae were not recorded from S₃. Organism's pollution tolerance was taken from HKHbios (Hindukush Himalayan score Bioassessment) scoring list. Extremely pollution sensitive organisms richness were maximum at sampling station S₂, e.g., *Mesonemoura* sp. and *Rhithrogena* sp. Extremely pollution tolerant taxa were *Bezzia* sp. and *Probezzia* sp. among them first one was

found at all sampling sites while later in S₂ only.

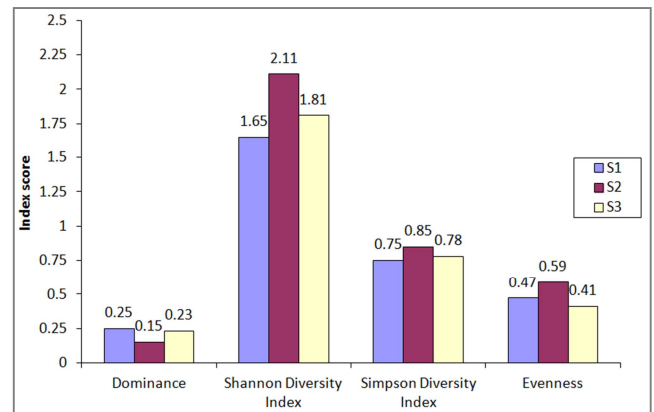


Figure 2. Diversity indices of Benthic Macro-invertebrates at Gahkuch marsh land.

Table 5. Benthic.

S. No.	Taxa (Family/ Class)	Genus	S ₁	S ₂	S ₃	Functional feeding groups	Pollution Tolerance (Based on HKH bios scoring list)
1	Nemouridae	<i>Mesonemoura</i> sp.	-	4	-	Shredders	9
2	Heptageniidae	<i>Rhithrogena</i> sp.	14	23	8	Scrapers	9
3		<i>Epeorus</i> sp.	8	-	-	Scrapers	8
4	Baetidae	<i>Baetis</i> sp.	158	36	84	Collector gatherers	-
5	Hydropsychidae	<i>Hydropsyche</i> sp.	-	6	3	Collector filterers	7
6	Psychomyiidae	-	-	1	-	Collector gatherers/ Scrappers	7
7	Gomphidae	<i>Omphiogomphus</i> sp.	-	3	5	Predators	-
8	Lepidostomatidae	<i>Lepidostoma</i> sp.	5	-	8	Shredders	8
9	Chironomidae	-	123	52	147	Unknown	-
10		Tanypodinae	210	31	94	Predators	-
11	Ceratopogonidae	<i>Bezzia</i> sp.	16	5	10	Predators	2
12		<i>Probezzia</i> sp.	-	1	-	Predators	2
13	Simuliidae	-	27	-	15	Collector filterers	7
14	Tabanidae	-	-	2	2	Collector gatherers / Predators	6
15	Culicidae	<i>Culex</i> sp.	8	-	3	Collector filterers	-
16	Elmidae	-	4	-	-	Scrappers / Collector gatherers	8
17	Hydrophilidae	-	-	3	2	Unknown	6
18	Naididae	-	-	25	10	Collector gatherers	3
19	Tubificidae	-	-	16	9	Collector gatherers	1
20	Hydracarina (Arachnida)	-	12	-	5	Predators	-
No. of Individuals			585	208	405	Total No. of Individuals= 1198	
Number of taxa			11	14	15		

The diversity indices of benthic macro-invertebrates (BMIs) of Gahkuch Wetland Complex were displayed. The dominance index score 0.25 was detected higher at S₁. It was attained due to the increase of relative abundance of single taxon Tanypodinae 35.9% of the total count, consequently other taxon were poorly represented. For that reason, the diversity indices including Shannon Weiner and Simpson score were lower due to higher dominance score of sampling station S₁. These results were a sign of less equitable distribution of BMIs taxa at S₁ and S₃. At sampling station S₂ the dominance index score 0.15 was two times less than the other sampling stations. The taxa relative abundance is relatively evenly distributed at S₂, therefore, diversity indices Shannon Weiner, Simpson and Evenness score of S₂ were

higher than the S₁ and S₃. It showed that sampling station S₂ was more equitable in distribution of taxa as compared to S₁ and S₃.

Macro-invertebrates, number of individuals, relative abundance (values inside parenthesis) functional feeding groups and pollution tolerance values at Gahkuch Wetland Complex. (Very sensitive taxa are those taxa given HKHbios score of 10 & 9 extremely tolerant taxa are those taxa given a HKH bios score of 1 & 2)

Many species of benthic macro-invertebrates are diagnostic of certain kinds of habitats and their water quality, commonly known as indicator organisms. These organisms become numerically dominant only under a specific set of environmental conditions. The Ephemeroptera (mayflies),

Nemouridae (stoneflies), Trichoptera (caddisflies) and Diptera (true flies) are commonly, or perhaps always, the four orders used as indicator organisms in environmental impact assessments. For this reason, more emphasis is placed on these orders than on other orders of insects. The highly pollution sensitive taxa *Mesonemoura* sp. and *Rhithrogena* sp. were found at S₂. Therefore, above mentioned organisms would respond by first disappearing after further environmental degradation or perturbation at sampling station S₂.

The overall conclusions revealed that

- Among benthic macro-invertebrates Tanypodinae (35.9% of total count) was dominant at sampling station S₁. Chironomidae were dominant at S₂ and S₃, while share 25% and 36.3% of total count respectively
- Organism's pollution tolerance was taken from HKHbios (Hindukush Himalayan score Bioassessment)

scoring list. Extremely sensitive organisms include *Mesonemoura* sp. (Nemouridae: Plecoptera) and *Rhithrogena* sp. (Heptageniidae: Ephemeroptera). Extremely pollution tolerant taxa were belonging to family Ceratopogonidae including *Bezzia* sp. and *Probezzia* sp.

3.8. Water Quality

3.8.1. Physical Properties

The values of all physical properties have been shown in Table 6. All physical properties of marshland water at five different points were found to be normal in normal range suggested by USEPA, WHO and Pak EPA. Difference in values of physical properties due to distance, geographic location, biological and chemical activities in and around marshland.

Table 6. Physical parameters of water at Gahkuch Marsh Land Lake.

Physical Parameters	Units	Site-I	Site-II	Site-III	Site IV	Site V	Standard Value
1 Temp Air	°C	17.5	16.8	17.2	16.6	16.5	40.0
2 Temp Water	°C	12.0	11.4	12.3	12.9	10.0	35.0
3 pH		07	07	07	07	07	6.2-7.5
4 Color	TCU	36	22	32	28	35	50.0
5 Odor		No	No	No	No	No	Un-objectionable
6 Turbidity	NTU	14.0	13.2	14.3	13.2	14.2	25.0

3.8.2. Chemical Parameters

The values of all chemical properties were found to be normal as suggested by USEPA, WHO and Pak EPA. There were no Zn and Manganese was found. Differences in values and chemical properties of Marshland was due to location. Results are shown in Table. 7.

Table 7. Chemical Properties of five Different Sites.

S.No	Parameters	Units	Site-I	Site-II	Site-III	Site IV	Site V	Standard Value
1.	DO	mg/l	4.12	4.38	4.21	4.78	4.23	3.000
2.	Alkalinity	mg/l	276	354	245	231	329	-
3.	Carbonates	mg/l	53	43	64	52	64	-
4.	Bicarbonates	mg/l	312	276	265	312	218	-
5.	Hardness	mg/l	321	307	343	210	286	500.0
6.	Ca	mg/l	123	118	154	132	128	200.0
7.	Mg	mg/l	165	189	127	165	194	500.0
8.	Chloride	mg/l	176	189	212	354	276	600.0
9.	Chlorine	mg/l	5.6	3.9	5.8	5.0	5.3	1.0
10	Electrical Conductivity	µs/cm	298	287	265	276	215	-
11	Flouride	mg/l	2.12	1.87	1.43	1.98	1.32	1.5
12	Manganese	mg/l	ND	ND	ND	ND	ND	0.5
13	Nitrate	mg/l	14	13	15	17	13	45.0
14	Nitrite	mg/l	0.03	0.06	0.04	0.03	0.02	0.010
15	Salinity	mg/l	ND	ND	ND	ND	ND	1000.0
16	Sulphate	mg/l	132	187	232	165	243	400.0
17	Sulphide	mg/l	3.32	3.11	2.43	3.21	2.54	-
18	TDS	mg/l	123	132	143	132	127	1500.0
19	Zn	mg/l	ND	ND	ND	ND	ND	15.0

3.8.3. Biological Parameters

The value of biological parameters has been shown in table 8. The higher value of ammonia was found at site IV i.e. 0.007mg/l followed by site III i.e. 0.005mg/l. The lower value was found at site V i.e. 0.002mg/l. The higher value of BOD was found at site III i.e. 3.231mg/l followed by site I i.e. 3.213mg/l. The higher value of COD were found at sites V i.e. 3.413mg/l followed by site III i.e. 3.321mg/l. The significantly lower value was found at site II i.e. 2.213mg/l. The values were found to be in normal range as suggested by US EPA, WHO and Pak EPA. According to Pakistan NEQS, the maximum limit of COD for municipal and industrial effluents is 150mg/l for inland waters.

Table 8. Biological parameters of water at Gahkuch Marsh Land.

S.No	Parameters	Units	Site-I	Site-II	Site-III	Site IV	Site V	Standard value
1	Ammonia	mg/l	0.004	0.003	0.005	0.007	0.002	0.500
2	BOD	mg/l	3.213	3.141	3.231	3.222	2.132	6.0
3	COD	mg/l	2.654	2.213	3.312	3.221	3.413	10.0

3.8.4. Socio Economic

There are total 600 households in Gahkuch Bala with a population of 5400 individuals, while in Gahkuch Paen is comprised of 500 households with population of 4500 individuals. Natural forest of Gahkuch Nallah is government protected, but some concession on fuel wood collection and grazing right are granted to local community to fulfill their domestic requirement.

Major land use in the area is subsistence farming and

livestock rearing. It is clear that farming is major form of local land use. But still traditional agriculture is being techniques practiced in upper Gahkuch and adjust areas. The alluvium traces and fens mostly used growing for fruits trees and fodder cultivation, but during study it was revealed that average crop production per household wheat is 456 kg, maize 36 kg and 804 kg potatoes respectively. Gahkuch Paeen falls under double cropping zone while Gahkuch Bala is single cropping zone. Mostly the villager's prefer potatoes and wheat than maize and barley.

Livestock is integral part of the livelihoods in the study area, livestock contributing inputs such as farm and manure. In Gahkuch valley 65% people have livestock, of whom 35% sale livestock products in markets and rest utilized for domestic purposes. Average livestock population per household was 11.4 including cows, goats and sheep respectively. Livestock population in upper Gahkuch is higher than lower Gahkuch. Goats and sheep mostly grazed in Gahkuch Nullah without a proper grazing system.

Socio-economic study in the area revealed that community is dependent on natural resources e.g. forest, wildlife, agriculture, water, wetlands and pastures because lack of opportunities for jobs, and alternate source of energy.

4. Conclusion

The baseline socio ecological studies revealed that Gahkuch Marshland is one of the significant wetland providing habitats for small and large mammals, migratory birds, fish species and other aquatic life and floral species. But the area is facing serious natural and manmade threats including illegal hunting, fishing and poaching of wildlife, solid waste and water pollution, deforestation, lack of awareness, poverty, institutional and policy, Climate change impacts (floods, sedimentation, turbidity, loss of habitat) and ill managed tourism are common threats for the marshland. Dependency of agro pastoral community on wetland resources is high due to lack of alternate source of energy, poverty and awareness. The conservation and protection of the area needs wetlands conservation planning and management through collaborative approaches

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