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Current status and future prospects of Lhalu wetland on the Tibetan Plateau

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Keywords: urban wetland, biodiversity conservation, human settlement, ecological restoration

Abstract

Lhalu wetland, located in the northwest of Lhasa city, Tibet, is the highest and largest urban natural wetland in the world. Due to its specific climate and the unique plateau ecosystem, it is a hotspot of endemic and endangered species. Lhalu wetland is an important wetland for Lhasa city for its biodiversity and for enhancing human well-being. However, due to global warming, over-exploitation and the presence of non-native species, it has suffered serious ecosystem damage and biodiversity loss. To protect biodiversity and the functioning of the ecosystem, new measures are needed, and current measures should be better enforced. This study is important for biodiversity conservation and the management of Lhalu wetland in the Qinghai-Tibet plateau.

Profile

Protected area

Lhalu wetland

Mountain range

Himalaya, China

Introduction

Wetland ecosystems cover only 1.5% of the Earth's surface, but provide about 40% of the value of all ecosystem services in the world (Zedler 2003). However, globally, wetland areas have decreased rapidly (Davidson 2014), notably in China, where the last thirty years have seen their massive reduction (Mao et al. 2018). The Qinghai-Tibet plateau has the most densely distributed wetland areas in China (Xu et al. 2019). However, some wetlands have experienced degradation caused by multiple factors (Meng et al. 2017). This has been the case for Lhalu wetland, which is the highest and largest urban natural wetland in the world (Chen et al. 2018), where degradation has been rapid. In this study, for better protection of highland wetlands generally, we provide an overview of the status, threats and conservation recommendations for Lhalu wetland.

Study area

Lhalu Wetland (29°39'46.3"–29°41'05.5" N, 91°03'48.5"–91°06'51.4" E; average elevation 3645 m; total area 6.6 km^2) is located in the northwest of Lhasa city, the capital of Tibet, China (Figure 1). It is a swampy wetland of peat and reeds, located in a temperate, semi-arid, monsoon climate zone in the southern Tibetan Plateau. The average annual precipitation is 439.8 mm, and most rain falls between July and September. Temperatures are low, ranging from 16°C (extreme 30°C) in June or July, to –1.6°C (extreme –16.5°C) in January (average temperature 7.5°C). The principal rivers are the Lhasa and the Liusha, which are fed mainly by rainwater and alpine snow-melt.

Method

We gathered biodiversity information from diverse sources, searching for the combination of words *biodiversity* and *Lhalu wetland* in the Web of Science (ISI, http://www.isiknowledge.com) and the China National Knowledge Infrastructure (http://www.cnki.net). We also looked for biodiversity information in various Chinese publications, such as the *Comprehensive investigation report on Lhalu wetland nature reserve* (LEPA 2004). Threatened and endangered species were identified according to the red list categories of the International Union for Conservation of Nature (IUCN, www. iucnlist.org) and the China Species Red List (Wang & Xie 2004).

Biodiversity

In terms of flora, previous surveys indicated the presence of 85 vascular plant species belonging to 30 families distributed in the marsh. At the family level, Gramineae were the most dominant, with 20 species, followed by Cyperaceae, with 13. Other families contributed fewer than five species each (Li et al. 2008); some non-native species, such as *Amaranthus tricolor* and *Oxalis corymbose*, have invaded Lhalu wetland. The wetland supports rich and endemic animal resources: 62 bird species belonging to 24 families of 13 orders; 10 fish species belonging to 4 families of 3 orders; 4 amphibian species belonging to 2 families of 1 order; 255 species of protozoa belonging to 79 families of 5 orders. Seven bird species are identified as protected species in China, where there are two levels of protection. These are *Grus nigricollis* and *Gypaetus barbatus* (classified at the higher protection level), and *Milvus korschun*, *Accipiter nisus*, *Buteo buteo*, *Falco peregrinus* and *Falco tinnunculus* (classified at the second level of protection). *Anser indicus* and *Tadorna ferruginea* are listed as protected species in the Tibet Autonomous Region (Ba et al. 2009).

Current degradation status of Lhalu wetland

For a long time, Lhalu wetland was considered wasteland by local residents (Yeh 2009). The area of the wetland decreased sharply in the years 1950–2000 (Table 1). It then remained constant until 2005, thanks to the creation of the Lhalu National Nature Reserve. Although the total area of Lhalu wetland has not decreased any further in the last ten years, the wetland ecosystem has become degraded. Firstly, the water levels in the wetland continued to fall. In the 1950s, the wetland was entirely covered by standing water thanks to the continuous flow of the Liusha river throughout the year. Now, the proportion of water-covered area to total area has significantly decreased (Li 2005). Some areas of wetland ecosystem have converted to meadow and eventually to sandy land (Zhang et al. 2013). Secondly, the plant community structure, species composition and diversity of Lhalu wetland have changed dramatically in the past seventy years. The height of the grasses has decreased from 2 m to less than 1 m in the past seventy years, and the yield of grass fell from 12 690 kg / ha in the 1960s to 945 kg / ha in the 2000s, and now to 63 kg / ha (Chen et al. 2018). Forty years ago, the typical vegetation was reed (*Phragmites australis*); in the 2000s, the area was dominated by *Carex spp.*, *Kobresia spp.*, and *Juncus spp.* (Laduo et al. 2009). The number of plant species increased significantly from 53 in 1985 (mostly hydrophytes, such as *Hippuris vulgaris* and *Potamogeton distinctus*) to 85 in 2008 (mostly mesophytes, such as species of Gramineae and Cyperaceae).

Threats to Lhalu wetland

Global warming

The Qinghai-Tibet Plateau is one of the most sensitive regions to global warming (Lu & Liu 2010). Over the past sixty years, the annual average temperature of Lhalu wetland has increased gradually (Tang et al. 2019). Especially since 1995, there have been significant increases in Lhasa city in the winter temperature and the annual average temperature (Zhao et al. 2015). The highest recorded summer temperature was in excess of 30°C in 2019, far exceeding the hottest temperature record of 25°C in 2009. Higher temperatures lead to increased evapotranspiration, and the water level of Lhalu wetland has generally been decreasing since the 1960s (Hua et al. 2007).

Table 1 – Changes in the city (Lhasa) and Lhalu wetland areas in the past sixty years

Year	Area of Lhasa (km²)	Area of Lhalu wetland (km²)
1951	3.16	12
1952–1959	4.26	11.2
1960–1969	14.43	10.5
1970–1979	21.90	10.5
1981–1989	43.40	9.6
1990–2000	54	6.2
2001–2010	62.88	6.6
2011–2019	77.9	6.6

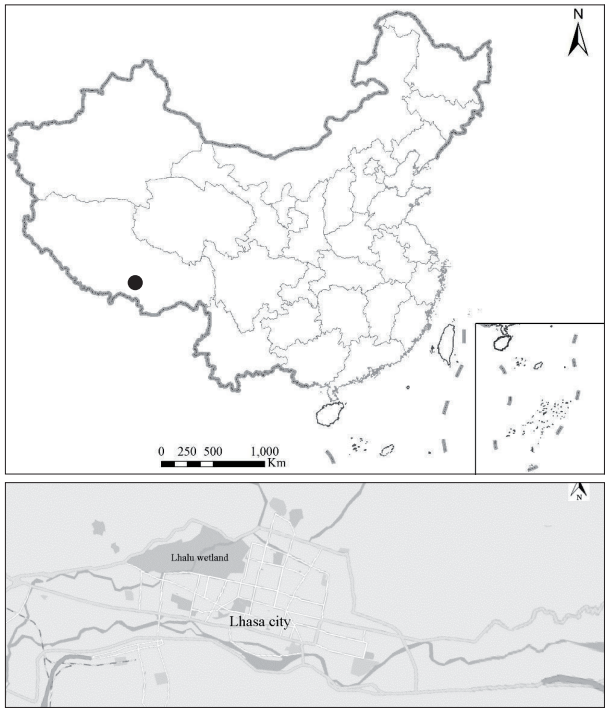

Figure 1 – Lhasa city and Lhalu wetland.

Human disturbance

Human disturbance is the most important cause of degradation of Lhalu wetland. Before the 1960s, the wetland supported high biodiversity, with dozens of different species per square kilometre. From 1964, drainage canals and roads were built in the wetland, and in the 1970s farms and infrastructure built around the wetland caused the peat gradually to degrade. In the mid-1980s, stones and gravel blocked the incoming water and quicksand from the Niangergou and Duodigou rivers, causing desertification in the north of the wetland at a rate of 1 to 1.5 acres per year. In the 1990s, the construction of the main canal greatly changed the hydrological conditions of the wetland. Because the canal can only be drained and not irrigated, 70% of the water in Lhalu wetland was discharged directly into the River Lhasa. In 2000, over 5 000 farm animals were being raised in the wetland, at one point reaching 7 000, and more than 1 000 farmers were cutting hay there. Finally, since 2000, a further large area of Lhalu wetland has become seriously desertified and natural vegetation has been reduced significantly (Zong et al. 2005).

Non-native species

Non-native species are one of the main threats for aquatic biodiversity (Mack et al. 2000). China is now the country with highest number of non-native aquatic species in the world, and consequently has suffered great ecological and economic damage (Xiong et al. 2015, 2017; Wang et al. 2016). Despite that, the num-

ber of non-native species in Tibet is lower than in other administrative regions (Bai et al. 2013). Recently, many non-native aquatic species were introduced into the Qinghai-Tibet Plateau (Chen & Chen 2010; Liu et al. 2015; Xiong et al. 2015; Sui et al. 2016). Some, such as *Rana catesbeiana*, *Trachemys scripta elegans*, *Pseudorasbora parva*, *Carassius auratus*, *Misgurnus anguillicaudatus*, *Silurus asotus*, *Cyprinus carpio*, *Micropercops swinhonis* and *Paramisgurnus dabryanus*, have established dense populations in Lhalu wetland, where the populations of many native species, such as *Ptychobarbus dipogon*, *Schizopygopsis younghusbandi* and *Triplophysa orientalis*, have declined sharply due to the invasion of these non-native species (Liu et al. 2015).

Measures and prospects for ecological restoration

Restoring hydrology and vegetation is the first priority in the ecological restoration of wetlands (Cui et al. 2009). In order to restore water levels in Lhalu wetland, the north canal was built in the 2000s. Now, the north canal is the main water supply channel of the wetland, where the water remains 0.5–1.5 m deep throughout the year. The number of hydrophytes has recovered to 30 species, which are now found in 95% of the total area of wetland (figures for 2019). The restoration of the area's hydrology has benefited the restoration of the vegetation.

After the establishment of the Lhalu wetland National Natural Reserve, human interference decreased greatly. In 2000, the Lhasa Municipal Government issued the Administrative Measures for the Lhalu Wetland Nature Reserve, compiled the *General Plan for the Lalulu Wetland Nature Reserve*, and established the Lhalu Wetland Reserve Management Station. In the 2000s, a fence of about 11km long was constructed around the wetland. Thereafter, livestock grazing, peat exploitation, hunting and other human activities were banned in Lhalu wetland. Now, biodiversity in the wetland has rebounded sharply, with many endemic and protected species returning to the area.

Ecological monitoring is an important tool for the protection of endangered species and wetland restoration (Martin et al. 2007). Now, new technology and methods, such as remote sensing, automatic cameras and environmental DNA, are widely used for monitoring and protecting endangered species in the wetland (Klemas 2013). This ecological monitoring helps to improve the recovery of protected species, as well as to control the invasion of non-native species.

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