Conserving Wetlands for Migratory Waterbirds in South Asia

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Abstract

Wetlands are highly productive ecosystems and provide many crucial services. Most waterbird species depend on wetlands throughout their life cycle. The Central Asian Flyway covers a large continental area of Eurasia bounded by the Arctic and Indian Oceans, connecting breeding grounds in Siberia and temperate Eurasia with nonbreeding grounds in West and South Asia. Species that breed in wetlands in the Arctic and northern latitudes of Central Asia migrate along different routes, stopping to rest and refuel in wetlands, grasslands and sometimes in deserts on the way to their nonbreeding grounds, where they spend the northern winter. Over 180 species of waterbirds use the Central Asian Flyway, among which are pelicans, ducks, geese, swans, cranes, waders (also called shorebirds), herons, storks and cormorants. Due to past and ongoing destruction, and degradation of coastal and inland wetlands, many of these species are now threatened with extinction. Strict habitat protection, adaptive management of both protected and unprotected areas (including managing water for wildlife) and, when necessary, restorations of wetlands are essential to maintaining functional wetland ecosystems and combating declines of wetland-dependent bird species. Most importantly, monitoring is crucial to guide effective management and conservation.

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6.1 Introduction

Wetlands come in many shapes and sizes. They can be located inland or on the coast and with salinity ranging from freshwater though brackish water (e.g. coastal marshes) to saline (e.g. salt marshes). They can be open bodies of water consisting of seasonally or permanently waterlogged soil, mangrove forests and intertidal mudflats (such as those of the Sundarbans shared by Bangladesh and India) or coralline islands and atolls (such as in the Maldives and Lakshadweep in India). Some wetlands, such as ponds, scattered through the extensive open, mixed forests of the Russian taiga, measuring only a few km^2 each, while the major flood plains of the Indus, Ganga and Brahmaputra rivers extend over hundreds of thousands km^2.

Wetlands provide provisioning, regulating, cultural and supporting ecosystem services to billions of people worldwide (Millennium Ecosystem Assessment 2005; McInnes 2013). Although many uses and values of wetlands are evident, wetlands have historically been regarded as wastelands and whenever possible turned into something more "useful" (Daryadel and Talaei 2014). As a result, wetlands have been drained and converted into agricultural land or commercial and residential developments all around the world. Due to these past and ongoing human demands on water and land, wetlands are one of the most threatened habitats in the world. In the last three centuries, global wetland loss is estimated to be 54–57%, but it might be as high as 87% (Davidson 2014). Intertidal wetlands have seen some of the greatest losses worldwide. For instance, the area of the Yellow Sea tidal flat ecosystem lost to reclamation in the last 50 years is 50–80%, which qualifies it as endangered according to the International Union for Conservation of Nature (IUCN) Red List of Ecosystems criteria (Murray et al. 2015).

One of the crucial ecosystem services of wetlands is supporting biodiversity. Given that wetlands are among the most threatened habitats, the species that depend on them are among the most threatened taxa. According to BirdLife International (2016), modification of inland wetlands and habitat conversion for agriculture are threatening over 100 species of birds in Asia and around 60 species in India. One of them, the pink-headed duck *Rhodonessa caryophyllacea* is possibly extinct, with the last definite observation in the wild in 1935 (Rahmani and Islam 2008).

Monitoring wetland condition and biodiversity is vital for conservation, restoration and management and often relies on the use of surrogate taxa. Waterbirds are commonly used as flagships of biodiversity and are the subject of major wetland conservation initiatives. As wetlands are usually highly productive, relatively small areas can support large concentrations of waterbirds. This dependence may be so strong that the population dynamics of waterbirds is often used as an indicator of wetland conservation status (Péron et al. 2013). For instance, in Australia,

waterbirds provide a useful indicator of river and wetland condition that can be monitored across large spatial scales (Kingsford and Auld 2003). Besides their role as bioindicators, waterbirds play a range of key functional roles in wetland ecosystems, among others serving as predators, insectivores, herbivores and vectors of seeds (Figuerola and Green 2002). As birds move among habitats, they also reallocate a considerable amount of nutrients, for instance, within agricultural fields and between agricultural areas and wetlands (Navedo et al. 2015). In some cases, humans have capitalized on these natural dynamics. For instance, in southern India, the guano of spot-billed pelican *Pelecanus philippensis* has traditionally been used to fertilize fields to increase crop yields (Kannan and Pandiyan 2013). Feeding on economically harmful species, waterbirds can provide an effective and free service to farmers by controlling pests or weeds. As over 350 bird species use rice fields for feeding in the Indian subcontinent (Sundar and Subramanya 2010), this service can be substantial. In China and Southeast Asia, ducks have been used since ancient times to reduce the number of crabs, locusts and weeds in rice paddies (Peng 1984; Suh 2014). Additionally, waterbirds provide a range of important provisioning (such as meat, feathers and eggs) and cultural services to both indigenous and westernized societies (Galbraith et al. 2014; Green and Elmberg 2014). Migratory and resident birds provide substantial recreational services, supporting bird watching, hunting and ecotourism (Bibby 2002). Waterbirds have also been used as sentinels of potential disease outbreaks (Green and Elmberg 2014).

6.2 The Central Asian Flyway and Its Waterbirds

Migratory animals connect distant countries as they cover immense distances through their annual movements. This mobility makes their conservation particularly challenging, especially when the same individuals have to cope with various pressures at breeding, stopover (or staging) and nonbreeding sites. Members of the orders Anseriformes (ducks, geese and swans), Pelecaniformes (pelicans, herons, egrets, ibises and spoonbills), Gruiformes (cranes and rails), Charadriiformes (waders, gulls and terns), Ciconiiformes (storks) and Suliformes (cormorants and darters) migrate between wetlands in the northern breeding areas and southern nonbreeding areas and in doing so regularly cross the borders of two or more countries. The routes that these birds take are known as flyways, which are defined as "the entire range of a migratory bird species (or groups of related species or distinct populations of a single species), through which it moves on an annual basis from the breeding grounds to non-breeding areas, including intermediate resting and feeding places, as well as the area within which the birds migrate" (Boere and Stroud 2006). In the subtropical and tropical regions, where the cold season may not be very pronounced, herons, storks, ibises and other waterbirds may move locally, within or across national boundaries, largely in response to the availability of water. Complex migratory systems lead to a complex conservation problem, and as species have different ecological needs and varying patterns, a species-specific network of protected and properly managed sites is necessary to support all stages (breeding, stopover

Fig. 6.1 The Central Asian Flyway is one of the nine global waterbird flyways, covering a large continental area of Eurasia between the Arctic and Indian Oceans and the associated inland chains connecting breeding grounds in Russia to the southernmost nonbreeding grounds in West and South Asia, encompassing 30 countries of North, Central and South Asia and Transcaucasia

and nonbreeding) of their migration cycle. Thus, all long-distance, short-distance and nomadic species depend on a large network of wetlands throughout their range to complete their annual cycle.

The Central Asian Flyway (CAF) is one of the nine global waterbird flyways. It covers a large continental area of Eurasia bound by the Arctic and Indian Oceans and the associated inland mountain chains (Fig. 6.1). This flyway comprises of several important migration routes of waterbirds, most of which extend from the northernmost breeding grounds in Siberia to the southernmost nonbreeding grounds in West and South Asia, the Maldives and the British Indian Ocean Territory. The CAF Action Plan for the Conservation of Migratory Waterbirds and their Habitats (CMS 2006) encompasses about 30 countries of North Asia (the part of the Russian Federation from the Ural Mountains east to around the Kolyma River), Central Asia (Afghanistan, western parts of China, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Turkmenistan and Uzbekistan), Southwest Asia (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, the United Arab Emirates and Yemen), Transcaucasia (Armenia, Azerbaijan and Georgia) and South Asia (Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka and the British Indian Ocean Territory). This is the shortest of the major flyways, lying largely north of the equator. At least 279 waterbird populations of 182 species inhabit this flyway, including long- and medium-distance migrant wader, duck and goose populations that breed in the central Siberian Arctic, boreal Russia and the Central Asian steppe, as well as short-distance migrants and residents that breed south of the Hindu Kush – Himalayan mountain chain.

Under current population delimitations, there is considerable overlap between migratory populations of the CAF and both the West Asian-East African Flyway and the East Asian-Australasian Flyway (Iverson et al. 2011). Staging areas where long- and medium-distance migrants stop during migration to rest and refuel are

poorly known, but are believed to be inland freshwater and saline wetlands in Central Asian countries.

The breeding ranges of the critically endangered Slender-billed Curlew *Numenius tenuirostris* and the near threatened Asian Dowitcher *Limnodromus semipalmatus* are largely restricted to the region although their nonbreeding ranges overlap with adjoining flyways (Mundkur 2005). Some examples among threatened waders that occur in the CAF and other flyways include the critically endangered Spoon-billed Sandpiper *Calidris pygmaea*, Spotted Greenshank *Tringa guttifer* and Great Knot *Calidris tenuirostris* (both endangered), Eurasian Curlew *Numenius arquata* (near threatened) and Black-tailed Godwit *Limosa limosa* (near threatened). All of these waders depend on intertidal mudflats and are threatened by habitat loss and degradation (Chowdhury et al. 2011).

Cranes are among the most threatened group globally, and Central Asian cranes are no exception (Harris and Mirande 2013). Of the two populations of the critically endangered Siberian Crane *Leucogeranus leucogeranus*, the central population that used to spend the nonbreeding period in Bharatpur in India has not been recorded for the last decade (Rahmani and Islam 2008), while the western population that used to migrate to Iran is now down to one individual (Tavakoli 2014). It appears that these populations have been pushed to the brink of extinction by the loss and degradation of wetlands that were indispensable for the birds either as stopover sites during migration or as nonbreeding areas (Meine and Archibald 1996). These wetlands have been lost by diversion of water for human use, agricultural development, the development of oil fields and other human utilization. Illegal shooting of birds during migration might also have contributed to their demise (Meine and Archibald 1996), and for the western population, hunting on passage and during the nonbreeding period is still hindering recovery of the population (BirdLife International 2016). Similarly, Central Asian ducks and geese are negatively affected by loss of wetland habitats and hunting. One example is the Lesser White-fronted Goose *Anser erythropus* that used to be a common species only a century ago, but became globally threatened with extinction and is currently listed as vulnerable (Jones et al. 2008). Among storks, the Greater Adjutant *Leptoptilos dubius* used to be widespread and common across south and mainland Southeast Asia, but its number has drastically declined, and the species now qualifies as endangered. Breeding success has been extremely poor in Assam and many breeding sites have been abandoned (BirdLife International 2016).

6.3 Waterbird Habitat in South Asia

South Asia has a high diversity of natural freshwater and brackish wetland habitats ranging from high-altitude bogs and lakes, marshes and riverine wetlands to brackish salt flats, as well as coastal mudflats, mangroves, coral reefs and atolls. These, along with rice fields and other artificial wetlands, provide suitable breeding habitat for many resident species and local migrants. They also serve as feeding or resting areas for birds that breed further north in temperate and arctic Asia and only spend

the nonbreeding period in the region. Some migratory waterbirds, such as Bar-headed Goose *Anser indicus*, Ruddy Shelduck *Tadorna ferruginea*, Brown-headed Gull *Larus brunnicephalus* and Common Tern *Sterna hirundo*, use high-altitude wetlands as breeding grounds and migrate into plains and coastal areas during the nonbreeding period.

Across the region, several major river systems, like the Indus, Ganga, Brahmaputra, Narmada, Cauvery, Irrawaddy, etc., have extensive floodplains and associated temporary lakes, beels and marshes that provide a range of habitats for millions of migratory and resident ducks, geese and other waterbirds. Most of these river systems have been transformed over the years through the construction of barrages and dams along with the creation of extensive canal systems that are used for irrigating rice, wheat and other crop fields and to provide water supply to urban and rural communities. Several of these areas are also important for waterbirds, although intensive pesticide use may be detrimental to the survival and productivity of the birds. In addition, the extensive network of small ponds and tanks across southern India and Sri Lanka provides valuable habitat for a large number of waterbirds. The seasonal and highly productive shallow saline wetlands of the Great Rann of Kachchh that is shared by India and Pakistan and the Little Rann of Kachchh and brackish Sambhar Lake in India support large numbers of waterbirds (BirdLife International 2016).

A variety of intertidal wetlands on the extensive coastline between Pakistan and Myanmar provide important habitat to migratory waders, gulls and terns and other coastal waterbird species. Some areas of international importance include the Indus Delta in Pakistan; the gulfs of Kachchh, Khambhat and Mannar; Chilika and Pulicat lagoons; Mahanadi and other major estuaries and associated mangrove forests of India; coastal lagoons and estuaries in Sri Lanka; the mudflats of the Sundarbans shared by India and Bangladesh; and deltas, mangroves and intertidal mudflats found on islands and along the coast of Bangladesh and Myanmar. The islands and atolls in Lakshadweep, the Maldives and the British Indian Ocean Territory provide habitat for a number of migratory wader, gull and tern species.

6.4 Migration Routes

The main migration routes of waterbirds to South Asia are dictated by the chain of mountains from the Hindu Kush in the west to the Himalayas across the north and east that serve as a physical barrier for many species. These mountains force many birds to choose a route over the lowlands in the west and east or between mountain passes. For instance, ruddy shelducks avoid flying at very high altitudes and cross over the Sikkim region between Nepal and Bhutan that provides a narrow corridor of slightly lower mountains (Newman et al. 2012; Palm et al. 2015). However, satellite telemetry studies have demonstrated that some geese (e.g. bar-headed goose (Kalra et al. 2011; Bishop et al. 2015)) and crane species (e.g. common crane *Grus grus* (Meine and Archibald 1996) and demoiselle crane *Anthropoides virgo* (Kanai et al. 2000)) are well adapted to fly across the Himalayas, capable of travelling at and above 5000 m.

6.5 State of Knowledge on Waterbirds

Sparked by the rich avian diversity, there has been an interest to study the distribution, breeding and ecology of waterbirds since the time of the British rule in the region. Nowadays, in most countries research activities are conducted by universities, research institutions, non-governmental organizations and individuals. In India, the Bombay Natural History Society, established in 1883, has the largest collection of bird specimens in the region and a long history of bird research. The study of migratory waterbirds routes in the South Asian region was pioneered in India in the late 1950s as part of a regional initiative in collaboration with the World Health Organization to investigate the possible role of birds in the dissemination of diseases linked with arthropod-borne viruses (Balachandran 1998). These studies have continued in India, particularly during 1980–1990, when research on the ecology of important wetlands [Keoladeo National Park (KNP) in Bharatpur, Rajasthan state in North West India and Point Calimere Sanctuary (PCS) on the coast of Tamil Nadu and a few other field stations] provided valuable information on the migratory habitat use of waterbirds, as well as more detailed ecological studies on the Siberian crane and several wader species. Large-scale bird-marking activities across the country allowed for identification of the breeding grounds and migration routes of the common teal *Anas crecca* (Ambedkar and Daniel 1990) and a range of other species (Rahmani and Islam 2008).

The use of satellite telemetry in migration studies started in the early 1990s, when two bar-headed geese were tracked north to China from Bharatpur (Javed et al. 2000) and common cranes were tracked from Bharatpur to Kazakhstan (Higuchi et al. 1994). The spread of highly pathogenic avian influenza H5N1 strain to bar-headed geese and other waterbirds in 2005 in China led to extensive research into the migratory routes and strategies of a number of waterbird species in Asia. Bar-headed goose, ruddy shelduck, northern pintail *Anas acuta*, northern shoveler *Spatula clypeata*, Pallas's gull *Larus ichthyaetus* and other species have been tracked from India, Bangladesh and Nepal, as well as from their breeding grounds, particularly in Mongolia and China (Muzaffar et al. 2008; Pawar et al. 2009; Iverson et al. 2011; Newman et al. 2012). This, complemented by large-scale colour marking of birds at breeding and nonbreeding grounds, has further improved our knowledge of movements and connectivity (Kasambe et al. 2008). Improved standardizations of techniques for capture and marking have been crucial in obtaining reliable data (Balachandran 2002; FAO 2007).

Breeding, moulting, staging and nonbreeding locations, as well as distances travelled by migratory birds and variation in migration behaviour, have been identified through analyses of stable isotope ratio in feathers (Bridge et al. 2014) and attaching small geolocators to birds (Bridge et al. 2013), although these techniques are still to be widely used in South Asia.

A recent publication *Waterbirds of India* (Gopi and Hussain 2014) provides a valuable synthesis of state of knowledge and ecology of a variety of waterbirds and their conservation needs. The *Handbook on Indian Wetland Birds and their*

Conservation (Kumar et al. 2005) provides a useful overview of the status of migratory and resident waterbirds in India.

6.6 Status and Monitoring of Waterbirds

Monitoring of waterbirds across the region has been undertaken through a number of programmes, most notably the Asian Waterbird Census (AWC). This census was initiated in 1987 in India, Pakistan and Sri Lanka under the name of Asian Waterfowl Census (van der Van 1987) and was later extended to other parts of South Asia, Southeast and East Asia and Australasia, coordinated by Wetlands International (Li et al. 2009). This volunteer-based programme made it possible to collect data on the distribution and abundance of waterbird species across the region, identify important wetlands and promote waterbird and wetland conservation. In the states of Andhra Pradesh and Kerala in south India, the programme has been undertaken diligently over the last decades, enabling more detailed data analyses that provided new knowledge about the distribution and changes in abundance of waterbirds (Pittie and Taher 2004; Nameer et al. 2014). The major aim of MigrantWatch, another citizen science programme initiated in 2007, is to gather information on the migration of birds, including waterbirds across the Indian subcontinent. It has generated useful data on the timing of migration of species (MigrantWatch Team 2013). Nevertheless, detailed information on the bulk of migratory waterbird distribution, abundance, and resource use is rudimentary at best (Urfi et al. 2005; Namgail et al. 2011) and provides opportunities for future research (Gopi 2014). There are severe knowledge gaps in other countries of the region too.

The annual Asian Waterbird Census and other national and local waterbird monitoring programmes provide data to feed into periodical updates of the estimates and trends of waterbird populations summarized in the Waterbird Population Estimates (Li et al. 2009). This information is crucial to prioritize conservation actions, including the designation of Ramsar sites. However, compared to other flyways, up-to-date information of the status and trends of waterbirds in the CAF is limited (Mundkur 2005). In the most recent (fifth) edition of the Waterbird Population Estimates (Wetlands International 2012), most population status and trends for this flyway are of high uncertainty, and much of the available information for migratory bird populations found in South Asian countries is at least 10–15 years old. Lack of information is not only a problem for migratory species; the current status and trends of many resident populations are also poorly known. As shown below for a subset of birds (Asian migratory ducks and geese), not only rare, but also common species are declining (such as Baikal Teal *Sibirionetta formosa*), and our uncertainty across the range of population sizes is substantial. Population size estimates range widely both for species with large population sizes but also for the ones on the brink of extinction, such as the Baer's Pochard *Aythya baeri* and Scaly-sided Merganser *Mergus squamatus*, and for species with intermediate population size, such as Lesser White-fronted Goose or Swan Goose *Anser cygnoid* (Fig. 6.2).

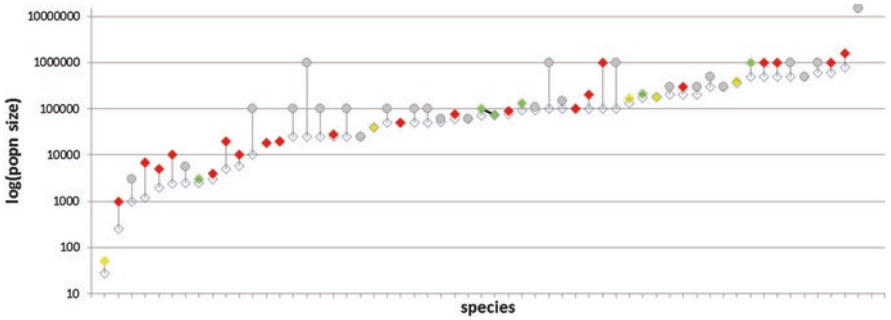

Fig. 6.2 An example to show population trends and numbers for Asian migratory ducks and geese based on the Waterbird Population Estimates 5th Edition (Wetlands International 2012). *Red dots* indicate declining, *yellow* stable and *green* increasing species. The length of the lines connecting minimum and maximum population estimates for a given species represents uncertainty about population size. *Grey dots* indicate no knowledge about population trends

It appears that in this flyway, very few migratory waterbird populations are increasing, while more (possibly around three to four times as many) are declining. This is reflected in the IUCN assessment of these species; currently many of them are globally threatened or near threatened. In fact, the highest numbers of threatened inland-breeding waterbirds in the world are in Eastern Asia, India and Kazakhstan (Williamson et al. 2013). Some of these threatened species exclusively or largely occur in this flyway, such as Sociable Lapwing *Vanellus gregarius*, which is critically endangered, and Black-necked Crane *Grus nigricollis* and Indian Skimmer *Rynchops albicollis*, both of which qualify as vulnerable (BirdLife International 2016). Other largely flyway-endemic waterbirds (Bar-headed Goose, Ibisbill *Ibidorhyncha struthersii* and Brown-headed Gull) still considered as of least concern, are facing many threats (Mundkur 2005; BirdLife International 2016).

6.7 Threats to Wetlands and Waterbirds

Major threats to migratory waterbirds in the CAF are loss and degradation of wetlands, exposure to pollutants and pesticides, invasive species, hunting and disease (CMS 2006; BirdLife International 2016). With the rapid rate of development in the South Asian region over the last decades, wetlands are under increasing threat from a wide range of large- and small-scale changes in landscapes, including changes to traditional agricultural and forestry practices. By converting and degrading wetlands, humans have made previously suitable habitats unsuitable for many organisms, including migratory waterbirds. Loss and degradation of wetlands are primarily caused by human activities, such as wetland reclamation, agriculture, pollution, land development, transportation corridors and energy production (Sutherland et al. 2012). In some countries, there is still an agricultural policy in place that encourages wetland drainage and the expansion of row-crop agriculture into grasslands (Hagy et al. 2014).

Many wetlands have suffered irrevocable changes through trophic cascades, triggered by the addition or removal of top predators and involving reciprocal changes in the relative populations of predator and prey through a food chain, which often results in dramatic changes in ecosystem structure and nutrient cycling (Estes et al. 2011). For example, in addition to the increase of fisheries in the Yangtze (Chen et al. 2011), the river's floodplain shows signs of local collapse of submerged macrophytes (Fox et al. 2011). There is a decrease in submerged vegetation, particularly tuber-producing *Vallisneria*, caused by introduction of intensive aquaculture. Changes in lake hydrology following construction of the Three Gorges Dam may also have adversely affected submerged vegetation productivity along the Yangtze River (Zhang et al. 2011), leading to a decline in the food source of the vulnerable swan goose that spends the nonbreeding season at Shengjin Lake.

Wind farms placed near wetlands have been reported to cause avian mortalities and to disrupt feeding and breeding behaviour of waterbirds and other species (Kumar et al. 2012; Prinsen et al. 2012). In addition, human development also accelerates effects of climate change, including increased occurrence of droughts or other natural disasters, such as earthquakes and tsunamis (Daryadel and Talaei 2014). Increasing pressures, particularly in the coastal areas due to recent, ongoing and planned urbanization, industrialization and port facilities across the region (e.g. along Gulfs of Kachchh and Khambhat in Gujarat, Uran in Maharashtra, Pulicat Lake in Andhra Pradesh in India and Sonadia Island in Cox's Bazaar in Bangladesh), as well as climate change-related effects, are negatively impacting intertidal mudflats and associated mangrove wetlands and coral reefs (Mathew et al. 2010; Prerna et al. 2015), resulting in reduction of the suitable habitats for migratory waterbirds, including the critically endangered Spoon-billed Sandpiper (Chowdhury et al. 2011).

Another major source of habitat degradation is pollution. Urban and industrial wastewater, agricultural activities, combustion of fossil fuels, mining and smelting, processing and manufacturing industries and solid waste disposal are major anthropogenic sources of pollution that affect the flora and fauna of wetlands. Some pollutants, such as mercury, bioaccumulate and biomagnify, meaning that the toxicant is increasingly accumulated in the tissues through the trophic levels and the effects on organisms are greater higher up the food chain, for example, in fish-eating birds (Eagles-Smith and Ackerman 2014). Reclaimed and cultivated wetlands have also been shown to contain considerable amounts of heavy metals (Ghabour et al. 2013). Animals congregate in wetlands to find water, food and shelter; therefore deleterious accumulations of persistent organic pollutants in small areas can potentially have broader effects on wildlife populations (Tran et al. 2014). Birds that feed in agricultural areas are often exposed to pesticides. Even though acutely toxic organophosphates are being phased out in many parts of the world, they are still used in some countries. Legal and illegal uses of organophosphates have resulted in poisonings, especially when birds consume treated seeds (Pain et al. 2004). Pesticide use in open rubbish dumps in India has led to several mortalities of greater adjutant (Lowe et al. 2000).

Increased nutrient input causes eutrophication and encourages nutrient-loving invasive alien plants (Kaushik and Gupta 2014). Compared to other habitat types, wetlands are disproportionally invaded by alien species: even though they only

Fig. 6.3 Pollution is common in many wetlands – here a Wood Sandpiper *Tringa glareola* is resting on a pile of plastic in an urban lake in Coimbatore, India (Photo by Judit Szabo)

cover 6% of the surface of the Earth, they host 24% of the most invasive species on the planet (Zedler and Kercher 2004). One of the most problematic species is water hyacinth *Eichhornia crassipes*, native to the Amazon basin, which now affects innumerable wetlands in over 50 countries, including in South Asia. This fast-growing invader restricts open water, impacts water flow, blocks sunlight from native aquatic plants and starves fish of oxygen (Lowe et al. 2000) and has negatively affected important waterbird habitats (Fig. 6.3).

In some regions, waterbirds are also frequently hunted for subsistence, as well as sport and the primary source of protein for humans (Kanstrup 2006). Although killing migratory waterbirds is officially banned in Bhutan, India and Nepal with legal provisions for hunting selected species in Afghanistan, Iran and Pakistan, illegal take of waterbirds is still a problem in many countries of the CAF, for instance, in Afghanistan (Ostrowski et al. 2008), India (Ahmed 1996; Ahmed and Rahmani 2002; Lahkar et al. 2013; Ramachandran 2014) and Iran (Tayefeh et al. 2011). Hunting decreases the population viability by killing birds directly, but it also causes substantial disturbance to the individuals not injured or killed. During breeding season, human disturbance increases nest trampling, jeopardizing successful breeding (Crossland et al. 2014).

Urban expansion also increases unauthorized access by people and feral animals to sensitive wetland areas, causing disturbance (Antos et al. 2007). Increasing anthropogenic disturbance and predation has been negatively affecting bar-headed geese breeding on the Mongolian Plateau (Batbayar et al. 2014).

Similar to other birds, waterbirds carry a range of viral, bacterial and fungal organisms, some of them manifesting in disease (Gogu-Bogdan et al. 2014; McCoy et al. 2016). Avian influenza has been an issue of increased regional and global concern, especially over the last decade, particularly since a large number of bar-headed geese and other waterbirds were affected by highly pathogenic avian influenza (H5N1) in 2005 in Qinghai Lake, China (Chen et al. 2005). Low-pathogenic forms of the avian influenza virus are often isolated from ducks, geese, swans, waders and gulls (FAO 2007). These low-pathogenic forms can sometimes mutate into highly pathogenic forms in poultry that can cause fatalities not only in domestic poultry but

also in wild birds and humans. Even though highly pathogenic avian influenza (H5N1) has not been detected at the major wetland complexes in central or southern parts of Central Asia where many birds congregate and agriculture is most extensive (Iverson et al. 2011), it has been detected, or believed to have caused mortality of migratory waterbirds in India, Bangladesh, Nepal and Pakistan, as well as in Southeast and East Asia (Cappelle et al. 2014). The large scale and intensification of poultry production, including domestic ducks in wetlands in South Asia, facilitate transmission of low-pathogenic forms of the virus between wild and domestic birds and spillover of the highly pathogenic virus from domestic birds back to the wild. Routine and regular surveillance of wild birds can help in monitoring virus movements (Parvin et al. 2014; Hoque et al. 2015). In order to protect wild birds from the virus and minimize spillover and spillback, the poultry industry and relevant authorities need to enforce more stringent biosecurity measures at domestic poultry facilities.

6.8 Conservation and International Cooperation

Highly mobile organisms, such as waterbirds, have a complex migratory system, and therefore they pose a significant and complex conservation challenge. Typically, these species have population dynamics that require the use of multiple wetlands, but this aspect of their life history has often been ignored in planning for their conservation (Haig et al. 1998).

One way of conserving highly mobile species is protecting and managing the habitat they use during their annual cycle (Runge et al. 2014). In response to the increasing loss and degradation of wetlands, to prevent their further destruction, the Ramsar Convention on Wetlands was established in 1971 (Ramsar Convention Secretariat 2013). The Convention recognizes that wetlands need to be sustainably managed due to their important economic, cultural, scientific, biodiversity and recreational values. Key areas are designated and managed by the countries as Wetlands of International Importance ("Ramsar sites"). A wetland can qualify under various criteria of international importance (Ramsar Convention Secretariat 2013). Of these criteria, the ones most frequently used to identify sites important for waterbirds are Criterion 5 (sites that regularly support 20,000 or more waterbirds) or Criterion 6 (sites that regularly support 1% of the individuals in a population of one species or subspecies of waterbird). Additionally, Criterion 4 allows for the recognition of internationally important sites based upon the movement of significant numbers of birds through a site during migration (serving a critical staging function), while Criterion 2 can be used to identify sites regularly used by globally threatened species.

Under the criteria developed by BirdLife International, wetlands can also be recognized as Important Bird and Biodiversity Areas (IBAs) if they support significant numbers of globally threatened species, hold restricted-range species or have a high proportion (more than 1%) of a biogeographic population of a congregatory waterbird species or more than 20,000 waterbirds (BirdLife International 2016). Some of

Table 6.1 Summary of important sites for which waterbird counts have been provided by participants of the Asian Waterbird Census 1987–2007

Country	AWC sites	Ramsar sites	IBAs	Protected areas	Sites with >20,000 waterbirds	Number of sites meeting >1% criterion
Bangladesh	199	2	7	7	13	67
Bhutan	15	0	6	1	0	3
India	3,296	18	126	112	100	458
Maldives	2	0	0	0	0	0
Nepal	30	4	7	5	1	5
Pakistan	534	17	29	18	56	124
Sri Lanka	160	2	21	17	14	53

Source: Li et al. (2009)

the important wetlands in South Asia have already been designated as protected areas under national legislation and as Ramsar sites, while a large number are still not designated or adequately managed, although many have been identified as IBAs (Table 6.1).

It is particularly important to identify and protect "bottleneck" sites, areas where very high proportions of a population stop over or pass through. These include the main staging areas for common and demoiselle cranes, pelicans, ducks and geese in the mountain passes in the Hindu Kush; the lower section of the Himalayas between Nepal and Bhutan, through which a large number of waterbirds including bar-headed geese pass; and the eastern Himalayas (Choudhury 2000). Conservation of such key areas is essential if we wish to maintain the migration and the continued existence of these species. However, identification of important sites is often difficult, because characteristics of the bird species (cryptic, non-flocking or occurs in habitats difficult to count) or the site (found in areas that are difficult and expensive to access) limit collection of information and therefore data availability.

The Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention) with its Programme of Work on Migratory Birds and Flyways 2014–2023 (UNEP/CMS Secretariat 2014) and the Central Asian Flyway Action Plan (CMS 2006) provide a powerful basis for international cooperation for the conservation of migratory waterbirds and wetlands in the flyway. This Action Plan, adopted in New Delhi in 2005, aims to better protect waterbirds and their habitats in the CAF, based on sound ecological knowledge and by enhancing regional environmental cooperation among the CAF states. It calls for a wide range of actions at both flyway and national levels, including improved legislation for species, regulations on hunting, habitat management, training, education and awareness and species monitoring. In addition, it calls for establishment of a network of internationally important sites. Besides the CAF Action Plan that provides an overall framework for conservation action, recognizing the special needs of threatened species, a number of flyway-level conservation action plans have been developed. These plans prioritize research and conservation for Siberian crane (UNEP/CMS/ICF 2011), Eurasian Spoonbill

Platalea leucorodia (Triplet et al. 2008), Spoon-billed Sandpiper (Zöckler et al. 2010), Lesser Flamingo *Phoeniconaias minor* (Childress et al. 2008), White-headed Duck *Oxyura leucocephala* (Hughes et al. 2006), Ferruginous Duck *Aythya nyroca* (Robinson and Hughes 2006) and Sociable Lapwing (Sheldon et al. 2012). Proper implementation of these plans should achieve improvement in the status of these threatened species and also improve conditions for other waterbirds.

Along the CAF, the current network of protected areas and managed sites provides inadequate coverage for threatened and nonthreatened waterbirds (Williamson et al. 2013). The Western/Central Asian Site Network established under the CMS in 2007 (UNEP/CMS/ICF 2011) provides a framework for conservation of some of the important sites, although there is an urgent need to enhance the geographic coverage of the network to include many additional important sites in the whole of the South Asian region and the rest of the CAF and to improve their management. In addition to these conventions, the Convention on Biological Diversity (CBD), to which all countries in the region are signatories, provides a global mandate for the conservation of all biodiversity, including waterbirds (Secretariat of the Convention on Biological Diversity 2010) and should be more effectively used as a tool to promote international cooperation and conservation action for waterbirds and their wetland habitats.

6.9 Raising Awareness

It is important to involve local communities in conservation and encourage the wise use of wetlands (Bosselmann et al. 2008), balancing the needs of people and wild species. Raising awareness on the importance of wetland habitats and the threats to them is vital for their protection and continued existence. Involving local communities in coordinated training and large-scale monitoring can enhance people's awareness of wetlands and wetland birds. It is also important to enhance public knowledge of the situation and involvement in solutions, as well as to gain support from local and multinational organizations in order to support enactment and implementation of international protection measures (Szabo et al. 2016).

Many awareness-raising efforts, such as the annually held World Wetlands Day in February (promoted by the Ramsar Convention) and World Migratory Bird Day in May (promoted by the Convention on Migratory Species and the African-Eurasian Waterbird Agreement), are being actively observed by governments, NGOs assisted by local groups and communities in the region. These and other activities, such as the annual Flamingo Watch organized by the Bombay Natural History Society in India, raise awareness and local interest in migratory waterbirds and their conservation (Anonymous 2013). There is a need to increase such activities to educate and engage a wider audience in conservation actions.

Strategically located visitor centres can play a pivotal role in public education and awareness about wetlands and waterbirds (Do et al. 2015), and the region has a large number of centres operating at many national parks and sanctuaries, such as the KNP in Bharatpur, India. However, maintaining buffer zones between tourists

and sensitive areas is very important to protect birds from human and other disturbances (Weston et al. 2009) particularly during times when birds are breeding and are the most vulnerable.

With increasing affluence in the region and the availability of high-quality equipment, there is a growing interest in bird photography. While photographing waterbirds can increase awareness and engagement with conservation, there is also the growing pressure from photographers as they can disturb feeding and resting birds, possibly negatively impacting their survival, migration and breeding potential. Similarly, wetland tourism can provide positive opportunities, but also pressures (Fernando et al. 2013), and there is a need to guide the development of these activities to ensure their impacts on waterbirds and wetlands are minimized.

6.10 Management Actions

For management to be effective, we need to understand what species use the habitat and how these interact to form ecosystems, the natural processes that sustain them and the threats to these processes (Chatterjee et al. 2008). Management of wetlands requires coordinated multisectoral planning and implementation to realize the needs of biodiversity conservation and local people (Mundkur 2005).

Habitat management is commonly used to maintain and enhance the value of seminatural habitats where natural processes no longer create suitable conditions for the desired species. Habitat restoration and creation are increasingly being used to expand ecologically important habitats in order to mitigate the impacts of human development. Modification of past management techniques and introduction of new ones can provide additional benefits. In wetlands, such techniques include the manipulation of water levels or the water quality, i.e. nutrient levels that are too high or too low, pH, pesticide residues or salinity (Ausden 2008). Other management actions for waterbirds can include the control of invasive alien plant or animal species or the temporary exclusion of grazing animals.

Creating a diverse and heterogeneous complex of wetlands will support more waterbird species than a single lake of the same total surface area (Sebastian-Gonzales and Green 2014). Tidal freshwater wetlands (Beauchard et al. 2013), as well as floodplains (Bartha et al. 2014) have been successfully restored. However, restoration might take a long time, for instance, in the case of salt marshes, it was estimated that 20 years was necessary to fully restore all ecological functions (Warren et al. 2002).

For some species, artificial wetlands are believed to partly compensate for the loss of natural wetlands (Márquez-Ferrando et al. 2014). For instance, saltpans are very important for migratory waders in India (Pandiyan et al. 2014). According to a study in Spain, larger species used saltpans during the northern winter and southward migration, while smaller species were still dependent on mudflats for feeding (Dias et al. 2014). When found close to natural habitats, even aquaculture ponds were able to provide alternative roosting and supplemental foraging habitat (Choi et al. 2014). Other studies found that alternative habitats were not satisfying the needs of waterbirds (Bellio et al. 2009), reinforcing that artificial wetlands provide

only secondary habitat, while most species are dependent on natural wetlands (Li et al. 2013). Therefore maintaining natural wetlands is of great importance for the conservation of many bird species.

The monitoring of wildlife populations is essential if they, and the sites on which they depend, are to be managed and conserved effectively. Monitoring is also required to assess the fulfilment of objectives of the Ramsar Convention and the Convention on Migratory Species. However, as both time and resources available for conservation are finite, we need to prioritize actions and design monitoring schemes accordingly to identify sites or species for which conservation actions are most needed. For large-scale national monitoring schemes, it is necessary to collect and analyse count data at a range of spatial scales, relating population changes to established thresholds for conservation action (Greenwood et al. 1994).

Monitoring waterbird populations is also important in order to evaluate the success of restoration activities. For instance, breeding colonial waterbirds have been used as indicators to evaluate the success of adaptive management of river flows (Kingsford and Auld 2003). In the case of the Kissimmee River Restoration Project, egret, heron, duck and other waterbird species were integral components of the floodplain ecosystem before the river channel got straightened and deepened. However, after channelization these species have declined substantially. Restoration was expected to attract wading birds and waterfowl by reintroducing naturally fluctuating water levels, seasonal hydroperiods and historic vegetation communities (Cheek et al. 2014). The authors found that evaluating wetland restoration success by monitoring wading birds and waterfowl relative to historical conditions was a practical means to measure the return of ecological integrity to a system. However, this process relied on the availability of historical (reference) data. Cheek et al. (2014) advise that choosing species for monitoring that are of great interest to the public can be beneficial for communicating restoration goals and measures of success. However, restoration expectation targets should be formulated with multi-year running averages appropriate to the study site and study species to help buffer against climatic or other stochastic events that can significantly affect monitoring data across years and seasons.

The size and footprint of the human population keeps increasing. Humans compete for resources not only among themselves, but also with other living organisms. This is currently one of the biggest challenges for conservation. As climate change is expected to affect the distribution and availability of suitable wetland habitats, these sites need to be created for the future as well as for the present (Bellisario et al. 2014). However, protection and management do work, for example, waterbird species richness and abundance increased more rapidly in Ramsar wetlands than in non-designated wetlands (Kleijn et al. 2014). In addition, over 70% of threatened migratory ducks and geese are recorded in Ramsar sites; however, only 10% of threatened non-migratory ducks and geese are protected at the same level (Green 1996). The situation has not improved much in the last 20 years; looking at all 1,451 migratory bird species, currently only 9% of them are adequately covered by protected areas across all stages of their annual cycle (Runge et al. 2015).

6.11 Conclusions and Recommendations

The management of coastal and inland wetlands of southern Asia is of crucial importance for conservation of waterbirds of the Central Asian Flyway, especially as many of these species are rapidly declining in number and are already globally threatened. A wide range of actions are needed to enable their conservation and to restore populations. It is crucial to step up actions to identify species and sites at greatest risk and to collect, analyse and regularly share information to support their conservation and management. We need to strengthen the existing protected area network through designation and management of currently unprotected critically important sites. The protection and adequate management of these key breeding, stopover and nonbreeding sites can provide a functional ecological network for the conservation of threatened migratory waterbird species in the long term. These wetland habitats will need to be adaptively managed under the overarching influence of climate change and a rapidly growing human population that uses more and more resources. This will require greater efforts to mainstream and integrate priorities for waterbird and wetland management into national and local human development plans and programmes.

We need to increase monitoring efforts to learn about the status and trends of waterbird populations through strengthening national monitoring programmes. Monitoring data can provide the basis to assess the effectiveness of implementation of wetland management and restoration actions. Law enforcement needs to be strengthened as illegal harvest of waterbirds is a common practice in many countries where hunting is banned outside the legal hunting period and inside protected areas. It is necessary to monitor other direct and indirect threats to waterbirds and wetlands and to build local capacity to undertake the monitoring.

Raising awareness among the general public, government and corporate sectors and decision makers about the amazing beauty and value of waterbirds and wetlands is essential. Gaining wider and stronger interest from these stakeholders is crucial to provide the long-term basis and increase the support needed for species conservation and wetland management.

Conservation of migratory species is a matter of international concern, and its success is completely dependent on the development and implementation of conservation actions and enhanced cooperation between countries. Implementation of existing government commitments to international conservation frameworks (under Ramsar, CMS, CBD and others) is urgently needed to strengthen ongoing programmes and initiatives and to initiate new ones. Such efforts will need to be strongly supported by the public and corporate sectors to ensure the survival of migratory waterbirds and their wetland habitats in the Central Asian Flyway.

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