Diversity of Waterbirds Along Bindu River of Tashi Chhoeling (Samtse), Bhutan

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Habitat of Waterbirds, Bindu river

Abstract

This study was conducted along the Bindu River under Tashi Chhoeling (Samtse) District in southwestern Bhutan from 1 January 2016 to 29 February 2016, with an objective to find document species composition, diversity, richness, evenness and relative abundance of waterbirds inhabiting along the Bindu River. Point count method was used to observe, identify, and record the birds. A total of 296 individual waterbirds belonging to 6 families and 12 species were recorded along the Bindu River during the study period. Bird species within the Muscicapidae family were the highest number of species sighted and also the highest number of individual waterbirds sighted. Plumbeous water redstart was the most abundant waterbird found along the Bindu River with a relative abundance of 34.80% and Gray wagtail is the least abundant with a relative abundance of 1.01%. Shannon's diversity index, Margalef's richness index, and Pielou's evenness index of waterbirds for the Bindu River was 1.94, 1.93, and 0.78 respectively.

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Keywords: Bindu River; Waterbirds; Muscicapidae; Relative Abundance; Diversity; Richness; Evenness.

Introduction

Bhutan is known to support 701 species of birds (UWICE 2015) out of which 106 species are waterbirds. Located in the eastern region of the Central Asian Flyway, Bhutan is an important waterbird habitat and provides the shortest transit corridor for migratory waterbirds of Bangladesh and parts of northeast India. Bhutan is also a key breeding area for many waterbirds such as ibisbill (*Ibidorhyncha struthersii)*, river lapwing (*Vanellus daucelii)*, ruddy shelduck (*Tadorna Ferruginea)*, great thick-knee (*Esacus recurvirostris)*, white-bellied heron (*Ardea insignis)*, and Pallas's fish eagle (*Haliaeetus leucoryphus)*. It is also a key wintering area of the vulnerable black-necked crane (*Grus Nigricollis)*. However, with Bhutan's economy gradually transcending from agriculture to hydropower, wetlands (especially rivers) are one of the most used and exploited habitats, threatening the survival of waterbirds. It is, therefore, necessary to study the waterbirds that are dependent on wetlands for survival and reproduction.

The diversity of waterbirds in lakes and rivers has been widely documented in other countries (Guptha & Sridharan 2011). However, in Bhutan, studies on waterbirds are limited, leading to a scarcity of information. Thus, this research was conducted to study species composition, diversity, richness, evenness, and relative abundance of waterbirds found along the Bindu River (figure 1). This is the first study of its kind in southern Bhutan. Since there is a plan to construct a hydropower plant in the Bindu River, impacts of the dam and the hydropower plant on waterbirds inhabiting the area need to be assessed. This could only be possible with prior data on the waterbirds population at the site (Bindu River).

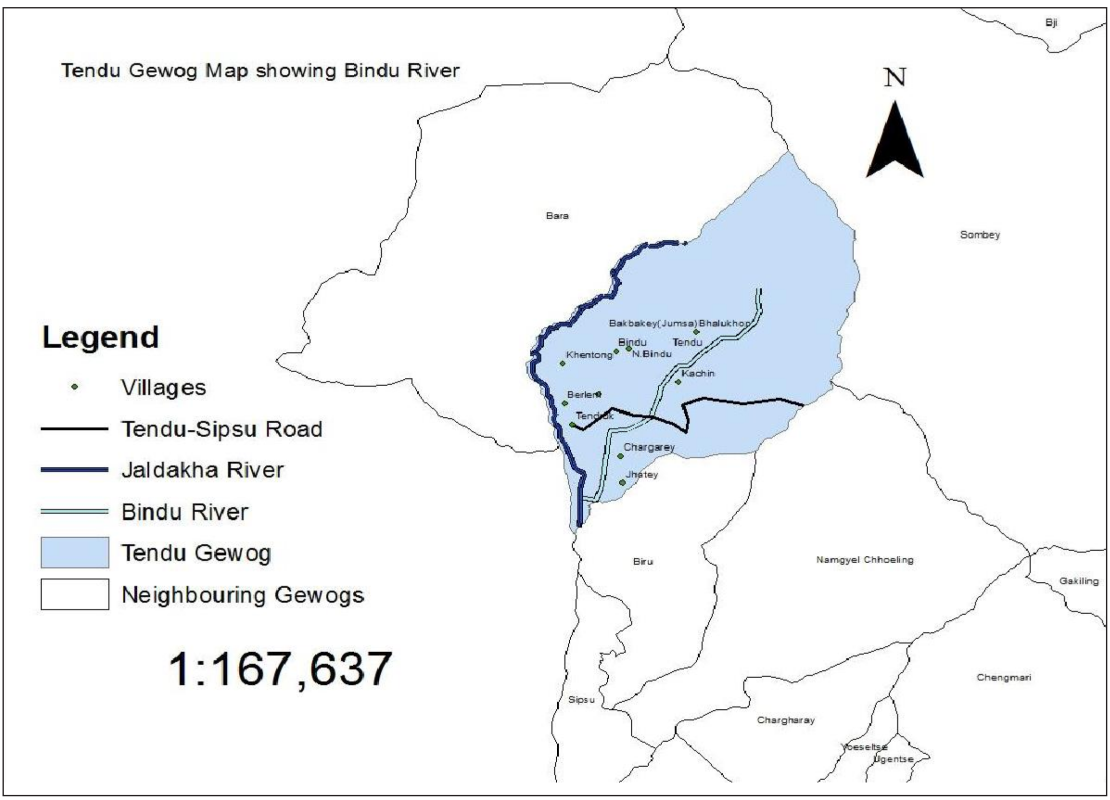

Figure 1: Map of Bindu River (Bindu River, Tendruk Block)

River flow is a major driver of morphological structure and community dynamics in the riverine-floodplain ecosystems and flow disturbances result in spatial and phonological mismatches of aquatic prey, a situation to which waterbirds are sensitive (Royan, Hannah, Reynolds, Noble & Sadler, 2013). The alteration of flow regimes is one of the most serious threats to the environment, populations of riverine ecosystems (Figarski & Kajtoch, 2015), and hydropower plants. Dams are one of the main agents causing alterations in flow regimes of rivers.

Humans regulated watercourses to improve transportation, water supply, flood control, agriculture, and power generation. Such anthropogenic alterations of riverine ecosystems change the established pattern of natural hydrologic dynamics and create new artificial conditions to which native species may be poorly adapted (Naiman, Magnuson, McKnight, Stanford & Karr, 1995). Construction of dams for hydroelectric projects (HEP) causes fragmentation of riparian ecosystems and isolates plants and animal populations. HEP constructions can restrict gene flow, erode genetic and functional diversity, and expose the plants and animals that use the aquatic and riparian ecosystems to severe environmental changes (Lopes, Vale, Prado-Jr., Schiavini & Oleveria, 2014).

Due to water resource developments, freshwater biotas are declining in diversity, abundance, and range, more than in other realms. A study by Kingsford, Bino, and Porter (2017) on waterbird abundance trends was conducted over 32 years (1983-2014) at three spatial scales in two similarly sized large river basins. With contrasting levels of water resource development in Australia (Murray-Darloing basin with 240 dams and lake Eyre basin with one dam), the study found significant long-term declines in the total abundance of functional groups and individual

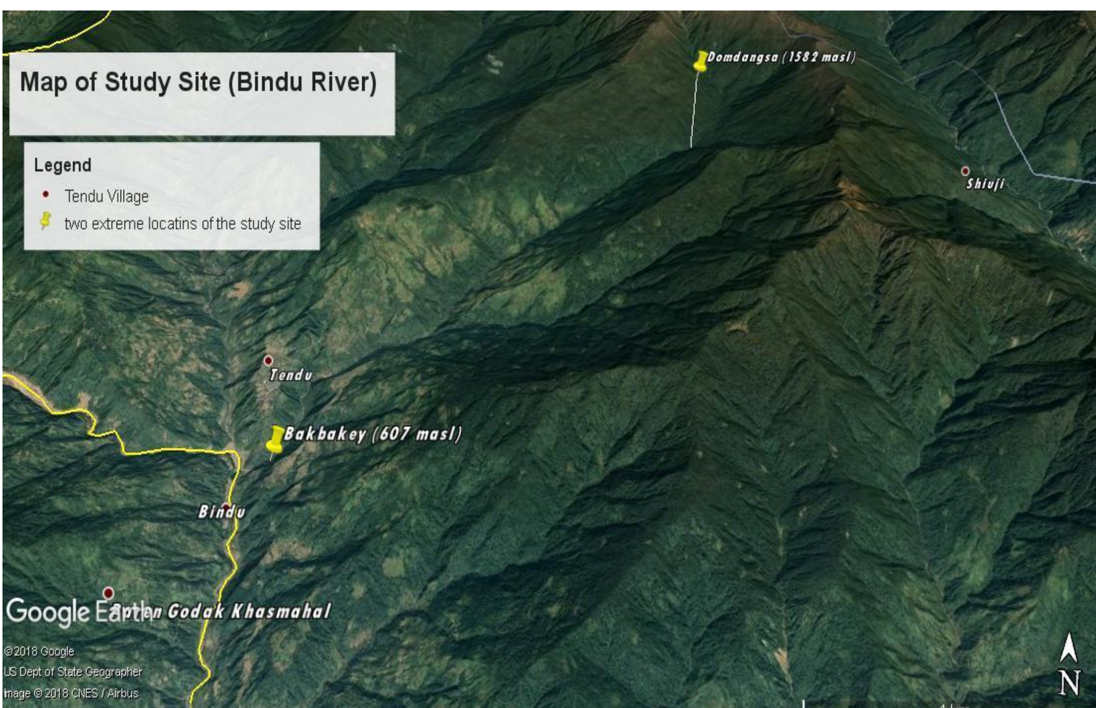

Figure 2: Google earth map of the Bindu River

species of waterbirds in Murray-Darling basin. However, no evidence of declines in waterbirds was found in the Lake Eyre basin.

Aquatic and riparian habitats support not only river-dwelling biota such as macroinvertebrates and fish but also waterbirds, the top predators in the aquatic food web. Zeng, Lu, Li, and Guo (2017) found that water depths have direct comparable negative impacts on waterbirds and fish, and river landscape heterogeneity directly and positively affected waterbird and fish populations. It was additionally suggested that rational planning and sustainable operation of dams in that maintaining in-stream habitat availability and heterogeneity would benefit the whole riverine ecosystem.

For the purpose of this Study, the term waterbirds refer to birds that depend on the freshwater wetland (either wholly or partially) to fulfill various activities such as foraging, breeding, roosting, loafing, moulting, and is considered synonymous with waterfowl.

Methods

Study Area

This Study was conducted along the Bindu River, from Domdangsa (also known as Balukhop), at coordinates 27°10'19.79"N, 88°56'34.21"E to Bindu Dam (also known as Bakbakey) at 27° 6'25.99"N, 88°52'17.87"E, covering a distance of 1500m. The segment of Bindu River covered under this Study stretches from an elevation of 607 meters above sea level (masl) to 1582masl. The Bindu River is a small river which follows through the middle of Tendruk Gewog (administrative block) and joins the Jaldakha River at Bindu Dam, located on the international border between Tendruk Gewog and Jolong, Darjeeling (India).

The survey transects, or the Bindu River is relatively pristine with no human interventions within the legal river buffer of 100 feet (Forest & Nature Conservation Act of Bhutan, 1995). Although, the Bindu River is dammed at its junction with Jaldakha River on the international border between Bhutan and India, the plots (point count stations) were located outside the 100 feet of the Dam. There is one village, with five houses including cowshed and farmhouses, located on the segment of the Bindu River but it is located well outside the legal buffer. However, the Bindu River will soon be dammed and a hydropower plant (*Druk Bindu Hydroelectric Power Project*) of an estimated 36 megawatts (MW) capacity will be constructed. Works on the detailed project report (DPR) had already begun in June 2016. The DPR for the upper phase of 18 MW has completed and the DPR for the lower phase of 8 MW was expected to be completed by the end of 2017 (www.kuenselonline.com, Sept. 14, 2017).

Waterbird Surveys

Waterbirds were surveyed using fixed-radius (30 meters radius) point counts stations (hereafter as PCS). At every PCS, 10 minutes point count was conducted to observe, identify, and record the waterbirds. Only two PCS were covered in a day. Only waterbirds which were physically seen were observed and recorded for this Study. I observed and counted waterbirds within one-hour durations in the morning (0700 hours – 0800 hours) and in the evening (1630 hours – 1730 hours). Data on waterbirds were collected for each PCS, both in the morning and evening to enhance data quality, and increase the chances of detecting waterbirds that use different extremes of the day. Observations on waterbirds were done irrespective of weather conditions. Counting, observing, and identification of waterbirds were done by walking along the river and stopping every 300m to scan the area with Bushneel binocular (7x35) to identify waterbirds found within 30m radial distances. Considering the standing position of the observer located at the center of

PCS, the distances of 300m between PCS were maintained to minimize the chances of double counting of the same waterbirds (Rajpar & Zakaria, 2010, Aynalem & Bekele, 2008 as cited by Girma, Mamo, Mengesha, Verma & Asfaw, 2017). Waterbirds were observed within 30 meters radius only because the upper segment of the river was rugged and narrow, affecting visibility beyond 30m. Whenever unfamiliar species of waterbirds were seen, detailed notes were taken and sketches were drawn and used as identification guide to identify the species when observations are completed.

PCS were located along the river course alternatively. Locating PCS on the alternate side of the river was done to avoid covering more area on one side of the river where the PCS center is located, and to reduce the bias of the observer standing on one side of the river due to convenience. This was also done to cover the waterbirds using different aspects of the riparian habitats.

The whole survey was conducted under two rounds with the aim to have more replications and gain increased precision and obtain reliable data (Petit *et al*., 1995; Smith *et al*., 1993 as cited by Rajpar & Zakaria, 2010). The first round was conducted from 1 January to 30 January, and the second round from 31 January to 29 February. Two PCS from the lowest and highest elevation were visited alternatively with the aim to cover both early and late arrivals and departures of migratory waterbirds. Two PCS were visited on the first day from the highest elevation (Domdangsa) moving downwards, and two PCS were visited on the second day from the lowest elevation (Bakbakey) moving upwards. The remaining PCS were visited alternatively following the same process, finally culminating at the midpoint of the Bindu River segment covered during this Study. The same procedure was followed for both rounds of data collection.

Data Analysis

1. Measurement of diversity

The diversity of aquatic waterbirds was determined by Shannon's diversity index

Shannon's diversity index () =

Where:

S = total no. of species in the sample

Pi = proportion of individuals belonging to an i^{th} species in a plot or an area

1n = natural logarithm

2. Measurement of relative abundance

Relative abundance (RA) was determined by the formula;

RA = n/N X 100

Where:

n = the number of particular species

N = the total observation detected for all species.

3. Measurement of species richness

Margalef's richness index (Mg) was used as a simple measure of species richness (Margalef, 1963).

Mg = (S – 1) / In N

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

4. Measurement of evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966).

J = / In S

 = Shannon diversity index

S = total number of species in the sample

5. Data Analysis

The data collected from the Bindu River were compiled and analyzed using Microsoft Excel, 2007.

Results

Species Composition and Diversity of Waterbirds

A total of 296 individual waterbirds belonging to 6 families and 12 species were recorded along the Bindu River (table 1 and 2). Waterbirds belonging to families Muscicapidae, Turdide, Cerylidae, Cinclidae, Motacillade, and Phalacrocoracidae were recorded. Out of the six families recorded, Muscicapidae family had the highest number of species (n = 7) and the highest number of individual waterbirds (N = 254). The rest of the families had one species each with the Turdidae family having 21 individual waterbirds. The lowest number of individual waterbirds was found for Motacillidae family (N = 3). Waterbirds species recorded from the Bindu River were Plumbeous Water Redstart, Little Forktail, White-capped Water Redstart, Salty-backed Forktail, Blue-whistling Thrush, Spotted Forktail, Black-backed Forktail, Brown Dipper, Little Cormorant, White-crowned Forktail, and Gray Wagtail. The Shannon's diversity index, Margalef's richness index and Pielou's evenness index for Bindu River was 1.94, 1.93, and 0.78 respectively.

Relative Abundance of Waterbirds

Plumbeous Water Redstart was the most abundant waterbird found along Bindu River with a relative abundance (RA) of 34.80%, followed by Little Forktail and White-capped Water Redstart with RAs of 16.89% and 16.55% respectively. Gray Wagtail is the least abundant waterbirds species found with a RA of 1.01%, followed by White-crowned Forktail and Little Cormorant with RAs of 1.35% and 1.69% respectively (Table 3).

Table 1: Different families and species of waterbirds found along Bindu River in 2016

Sl. No.	Waterbird Species	Zoological name	Family	No. of waterbirds
1	Plumbeous Water Redstart	*Rhyacornis fuliginosus*	Muscicapidae	103
2	Little Forktail	*Enicurus scouleri*	Muscicapidae	50
3	White-capped Water Redstart	*Chaimarrornis leucicephalus*	Muscicapidae	49
4	Salty-backed Forktail	*Enicurus schistaceus*	Muscicapidae	28
5	Blue Whistling Thrush	*Myophonus caeruleus*	Turdidae	21
6	Spotted Forktail	*Enicurus maculates*	Muscicapidae	14
7	Crested Kingfisher	*Megaceryle lugubris*	Cerylidae	8
8	Black-backed Forktail	*Enicurus immaculatus*	Muscicapidae	6
9	Brown Dipper	*Cinclus pallasii*	Cinclidae	5
10	Little cormorant	*Phalacrocorax niger*	Phalacrocoracidae	5
11	White-crowned Forktail	*Enicurus leschenaultia*	Muscicapidae	4
12	Gray Wagtail	*Motacilla cinerea*	Motacillidae	3
				296

Table 2: Number of species and number of waterbirds recorded for different families

Sl. No.	Family	No. of species (n)	No. of individual waterbirds (N)
1	Muscicapidae	7	254
2	Cerylidae	1	8
3	Cinclidae	1	5
4	Motacillidae	1	3

5	Phalacrocoracidae	1	5
6	Turdidae	1	21
	Total	**12**	**296**

Table 3: Relative abundance of different species of waterbirds along the Bindu River (2016)

Zoological name	**Family**	**Relative Abundance %**
Rhyacornis fuliginosus	Muscicapidae	34.80
Enicurus scouleri	Muscicapidae	16.89
Chaimarrornis leucicephalus	Muscicapidae	16.55
Enicurus schistaceus	Muscicapidae	9.46
Myophonus caeruleus	Turdidae	7.09
Enicurus maculatus	Muscicapidae	4.73
Megaceryle lugubris	Cerylidae	2.70
Enicurus immaculatus	Muscicapidae	2.03
Cinclus pallasii	Cinclidae	1.69
Phalacrocorax niger	Phalacrocoracidae	1.69
Enicurus leschenaulti	Muscicapidae	1.35
Motacilla cinerea	Passeridae	1.01

Discussion

The Bindu River is relatively pristine with no major human interventions like the construction of dams and diverting of the river. It is home to a wide diversity of waterbirds. Studies on waterbirds were conducted in three other rivers in Bhutan (Figure 3), viz., Pachhu in Paro (Western Bhutan) with Shannon's diversity index (H') of 2.96 and 11 species of waterbirds (Wangdi, 2013), Nyeera Amachhu in Trashigang (Eastern Bhutan) with H' of 1.83 and 10 species of waterbirds (Dorji, 2015), and Puna Tsangchhu in Punakha (West Central Bhutan) with H' of 2.07 and 31 species of waterbirds (Kiorala, 2013). The Bindu River provides habitat for 12 waterbirds species. The highest number of species (n=7), along with the highest number of individual waterbirds (N=296) recorded for the Muscicapidae family were sighted at this location. This could be attributed to the Bindu River being small and fast flowing, where species of Muscicapidae family like Plumbeous water redstart, Little forktail, and White-capped water redstart are found widespread (Tyler & Ormerod 1993). Plumbeous water redstart is the most abundant waterbird found along Bindu River with a relative abundance of 34.80%, supporting research findings which state that Plumbeous water redstart is the most widespread species found along fast-flowing rivers and streams. It is also a common altitudinal migrant, migrating between 350masl to 4270masl (Tyler & Ormerod 1993; Inskipp et al. 2004). Some waterbirds found along the Bindu River, like the Little forktail (Enicurus scouleri) and Brown dipper (Cinclus pallasii) are highly aquatic waterbirds (Buckton & Ormerod, 2008). Entailing that these waterbirds are sensitive to habitat alteration, and that they are considered to be indicators of habitat quality (Sorace et al., 2002, Strom et al., 2002, Henny et al., 2005 cited by Chiu et al., 2009).

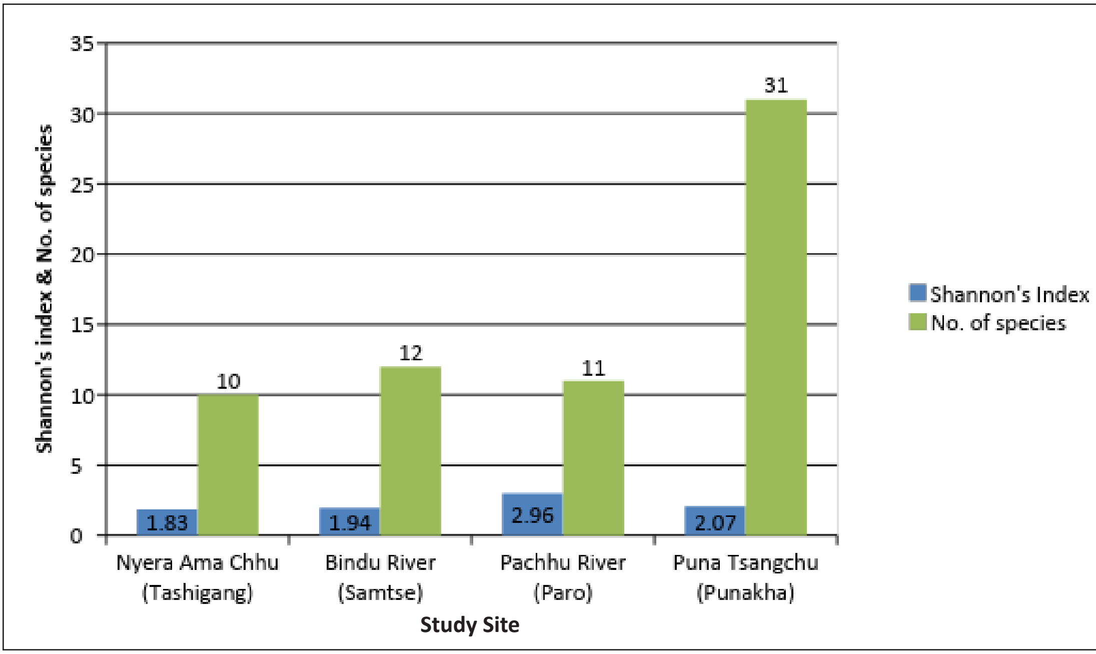

Figure 3: Diversity of waterbirds (Shannon's Diversity Index) in different rivers studied

Once this river is dammed and water is diverted through tunnels, the habitat along the river are prone to change. Dams, diversions, and river management reduce flooding of wetlands, altering their ecology and causing poor health or death of aquatic biota (Kingsford, 2001). Around hydroelectric plant reservoirs, fragments have been found to end up with very distinct environmental conditions when compared to those existing before the dam installations (Lopes, Vale, Prado-Jr., Schiavini & Oleveria, 2014). Dams for hydropower plant will raise the water level above the dam to a certain distance due to backflow, which will negatively affect the diversity of wading waterbirds. Additionally, it will impact shore waterbirds, especially those that cannot forage in deep waters due to their morphological limitations. An annual depth range of approximately 0.3m to 1.3m conceptually provides maximum habitat area for both diving and non-diving waterbirds. (Robertson & Massenbauer, n.d). A study conducted in Lowbidgee floodplain in Murrumbidgee River in southeastern Australia indicated that in 19 years (1983–2001), the collective waterbird population estimated during annual aerial surveys collapsed by 90%, from an average of 139,939 (1983–1986) to 14,170 (1998–2001). This was due to water resource development like damming for hydrological plants and water diversion for irrigation (Kingsford & Thomas, n.d). By diverting the water through tunnels, the segment of the river channel between the dam and the outlet will remain dry or with less water, which will interrupt the ecological flow and alter or fragment the habitat, creating unfavourable habitat for the waterbirds. Alteration or fragmentation of river habitat due to damming and channeling water through the tunnel will have adverse effects on the waterbirds currently found in the area. The effects, whether positive or negative, could be ascertained if the same research is conducted after the construction and commissioning of the hydropower plant on the Bindu River.

Conclusion

Bindu River is a small-sized river but it provides habitat for 12 different species of aquatic waterbirds and a total of 296 individual waterbirds were recorded within 1500m (Bindu Damsite to Domdangsa). Riparian ecosystems have a complex relationship with economic development and are continuously overexploited for economic development. Hence, such economic activities within the riparian ecosystems are often linked to biodiversity loss. Waterbirds discharge important ecosystem services and are dependent on wetlands and rivers for their survival and reproduction. This research data on waterbirds along the Bindu River is, therefore, very important as soon the habitats along the river will be altered due to the construction of a hydro-power plant on the Bindu River.

This Study was conducted in the winter for a two-month period only. More work has to be done for longer periods to produce a comprehensive report on waterbirds found along the Bindu River. The similar study must also be conducted after the completion of the Druk Bindu Hydropower plant to see how hydropower plants and dams affect waterbird diversity.

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Literature Cited

Tyler, S. J and S.J. Ormerod. 1993. The ecology of river waterbirds in Nepal. Forktail 9: 59-82.

Daniels, R. J. R. 1991. Practical methods for studying water bird vegetation associations in the forests of the Western Ghats. Proceedings of workshop on "medicinal plants conservation areas of tropical forest" held on 26-29 April, 1991 at Kemmangundi, Chickmagalur pp. 21-28.

Cummings, J. and D. Smith. 2000. The line-intercept method: A tool for introductory plant ecology laboratories: Tested studies for laboratory teaching 22: 234-246

Kingsford, R. T. 2001. Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia. *Austral Ecology. https://doi.org/10.1046/j.1442-9993.2000.01036.X.*

Inskipp, C., R. Grimmett and T. Inskipp. 2004. Waterbirds of Bhutan. Timeless Books. India

M.N. Rajpar and M. Zakaria, 2010. Density and Diversity of Water birds and Terrestrial Waterbirds at Paya Indah Wetland Reserve, Selangor Peninsular Malaysia. Journal of Biological Sciences, 10:658:666.DOI: 10.3923/jbs.2010.658.666 URL: https://scialert.net/abstract/?doi=jbs.2010.658.666

Guptha, M. B. and N. Sridharan. 2011. Status of major wetlands and wetland waterbirdsin Kanyakumari, Coimbatores, Thanjavur, Tiruvarur, and Trichy Districts in Tamilnadu, India. World journal of Zoology 6(3): 235-242.

Kiorala, T.P. 2013. waterbirds composition, diversity, distribution, abundance and disturbance along the Puna Tsangchhu Mochhu and Phochhu river during winter. A dissertation submitted in partial fulfilment of the requirements of the B.Sc Forestry program. College of Natural Resources, Lobesa, Punakha, Bhutan.

Lopes, S.F., Vale, V.S., Prado-Jr. J.A., Schiavini, I and Oliveira, P.E. 2014. Landscape changes and habitat fragmentation associated with hydroelectric plants reservoirs: insights and perspectives from a Central Brazilian case history. *Biosci.J., Uberlandia*, 30: 1205-1212

Dorji, T. 2015. Waterbirds diversity and their habitat use along Nyera Amachhu and its tributary in Thrimshing, Trashigang. A dissertation submitted in partial fulfillment of the requirements of the B.Sc Forestry program. College of Natural Resources, Lobesa, Punakha, Bhutan.

Figarski, T and Kajtoch. L.. 2015. Alterations of riverine ecosystems adversely affect bird assemblages. Hydrobiologia. (744): 287-296. https://doi.org/10.1007/s10750-014-2084-1.

Menon, M., D.M. Prashanti, V. Nangopalan and R. Mohanaraj. 2015. Species diversity and functional assemblages of waterbirds fauna along riverine habitats of Tiruchirappalli, India. Environmental management of river basin ecosystem pp 729-748.

Girma, Z., Mamo, Y., Mengesha, G., Verma, A. and Asfaw, T. 2017. Seasonal abundance and habitat use of waterbirds species in and around Wondo Genet Forest, South Central Ethiopia. EcolVol 7(10): 3397-3405. DOI: 10.1002/ece3.2926

Kingsford, R.T., Bino, G. and Porter, J.L. 2017. Continental impacts of water development on waterbirds, contrasting two Australian river basins: Global implications for sustainable water use. https://doi.org/10.1111/gcb.13743

Robertson, D. and Massenbauer, T. n.d. Applying Hydrological Thresholds To Wetland Management For Waterbirds, Using Bathymetric Surveys And GIS. Department of Conservation and land management, Western Australia. E-Mail: davidrob@calm.wa.gov.au.

Royan, A., Hannah, D.M., Reynolds, S.J., Noble, D.G. and Sadler, J.P. 2013. Avian community responses to variability in hydrology. PloS ONE. 8(12): e83221. https://doi.org/10.1371/journal.pone.0083221.

Tena, A. G., A. Saura and L. Britons. 2007. Effects of forest composition and structure on waterbirds species richness in a Mediterranean context: Implications for forest ecosystem management. Forest ecology and management 242:470-476.

Traut, A. H. and Hosteler, M.E. 2003. Urban lakes and waterbirds: effects of shoreline development on avain distribution. Elsevier (Landscape and urban planning). 69(2004): 69-85

Traut, A. H. 2003. Urban lakes and waterbirds: Effects of the development on distribution and behavior. A thesis presented to the graduate school of the University of Florida in partial fulfilment of the requirements for the degree of masters in science. University of Florida.

Ugyen Wangchuck Institute Conservation and Environmental Research. 2015. 701 waterbirds species in Bhutan. Available from http://www.uwice.gov.bt/read_fullnews.php?nid=201512161 (Assessed October 6, 2017).

Wangdi, T. 2013. Community structure of winter waterbirds along Pachhu River. A dissertation submitted in partial fulfillment of the requirements of the B.Sc. Forestry Program. College of Natural Resources, Lobesa, Punakha, Bhutan.

Zeng, Q., Lu, C., Li, G. and Guo, Z.B. 2017. Impacts of dam on winter in waterbirds habitat use. https://doi.org/10.1017/S0376892917000406.

Kingsford, R.T. and Thomas, R.F. n.d. Destruction of Wetlands and waterbirds Populations by Dams and Irrigation on the Murrumbidgee River in Arid Australia. NSW Department of Environment and Conservation. 43 Bridge Street, Hurstville, NSW 2220, Australia.

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