Habitat Assessment of White-bellied Heron at Hararongchu site along Punatsangchu River Basin.

Project Final Report

A Project sponsored by Oriental Bird Club and The March Conservation Fund, on the advice of Mr. Ivan Samuels.

Oriental Bird Club

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Acronyms

CPUE: Catch Per Unit Effort

DBH: Diameter at Breast Height

DoFPS: Department of Forests & Park Services

DoL: Department of Livestock

EIA: Environment Impact Assessment

FA: Field Assistance

FAO: Food and Agriculture Organisation

FNCA: Forest and Nature Conservation Act

FO: Forest Officer

GPS: Global Positioning System

IBA: Important Bird Area

IUCN: International Union for Conservation of Nature

m.a.s.l: meter above sea level

MoAF: Ministry of Agriculture & Forest

MoEF: Ministry of Environment and Forest

MW: Megawatt

PHP: Punatsangchu Hydropower Project

RBA: Relative Basal Area

RSPN: Royal Society for the Protection of Nature

SPSS: Statistical Package for Social Sciences

WBH: White-bellied Heron

WCD: Wildlife Conservation Division

WMD: Watershed Management Division

Abstract

Habitat assessment of White-Bellied Heron was carried out in Hararongchu in Punatsangchu river basin. Study was done through questionnaires survey with local people living in WBH habitat vicinity and field survey in the two river stretch. The study was design to assess local people's perceptions and attitude towards WBH and WBH habitat conservation, Floristic compositions of the WBH habitat, present condition of Nesting and Foraging habitat, prey abundance and availability, threat assessment, and WBH abundance association with other environmental variables.

Local people's perception and attitude were overwhelmingly good for the conservation of the WBH. 99% of respondents have fair knowledge about WBH and their Habitat with 86% saying that population trend is decreasing. 47% believes such trend in population is due to disturbances and 49% believes it is attributes of habitat degradation. 99% saying the WBH habitat must be protected and other 1% is unsure of the idea.

The vegetation composition nature of the study area is xerophytic and it is made of pure chirpine forest with mean density of 4.75 trees per10 m^2. The WBH encounter rate in the river stretch was found to be 0.3 WBH/km.

Foraging habitat are characterized with average wetted width 64.5 meters and average depth of 42.70cm. Shallow river with mean flow of 0.93 m/sec were observed at feeding sites. Nest are made on steep slope of 53-67^0 in opposite side of river to human settlement on Chirpine tree of average height of 28.25 m height and average DBH of 202 cm. Nesting site is characterized by no or sparse understory growth.

Disturbances factors such as fishing and forest fire are frequent in the study sites. Other disturbances factors such as human activity, agricultural practices and vehicle movement are prevalent in the sites.

Fish as food for WBH was studied. Fish diversity and assemblage were studied. 10 species of fishes were recorded with Cyprinids being most dominant member in assemblage structure. Salmo trutta had highest biomass in the study sites.

WBH abundance in study sites are negatively associated with degree of disturbances level and positively associated with fast flowing and shallow water whereas WBH abundance is not influenced by fish biomass and other environment variables.

Background

White-bellied Heron (WBH) is scientifically known as *Ardea insignis*. There are 26 individuals residing regularly in the Punatshangchu river basin and its tributaries below 1,500 m.a.s.l. in Punakha, Wangdiphodrang, and Tsirang Districts in Bhutan (RSPN, 2011) and 28 individuals in total in the country. They are categorized as *Critically Endangered* species in 2007 by the International Union for Conservation of Nature (IUCN) red list (IUCN, 2008) owing to its total population estimates of 50-200 individuals in the world (BirdLife International, 2011) and also listed among top 100 Evolutionary Distinct and Globally Endangered species (EDGE, 2015). WBH is also the holder of world record of rarest heron on Earth in Guinness Book of World Records (Price & Goodman, 2015).

The existence of 28 WBH in Bhutan (RSPN, 2015) is an indication of Bhutan's long sustaining conservation efforts. However, when our country step the path of modern development it is also confronting conservation challenges increasingly.

The Punatsangchu River Basin is main habitat of *Adrea insignis* in Bhutan but it is under massive threat due to activities and plans to construct seventeen hydro-projects under Power System Master Plan (2003) of Bhutan. The installation of continuous hydropower project I and II along the Punatshangchu are quite devastating for the WBH's habitat. Due to accelerated development of large scale hydro-power projects in the Punatshangchu basin the habitat for the WBH is altered irreversibly (RSPN, 2011). This project certainly took away large area of the heron habitat along Punatshangchu.

Punatshangchu hydropower project (PHP) activities along the Punatshangchu have led to major land use change in the habitats of the heron exterminating vegetation that existed in the place. The disturbance from a large number of employees working increase access to the heron, heavy construction and road works significantly change the quality of foraging habitat for herons (RSPN, 2011). The increase in land use change and settlement of thousands of people working for the PHP along the river basin, increased disturbance to WBH and decreased the area of its habitat.

The Environment Impact Assessment (EIA) reported that the construction of 2560 megawatt Sankosh hydropower project in Punatsangchu river basin would require a land area of 7619 ha (Business Bhutan, 2013). It is assumed that the construction of 1200 megawatt Punatshangchu hydropower project I would require approximately 3500 ha of land. This will result in loss of existing vegetation, area occupied by WBH and habitat fragmentation.

Assessment of WBH habitat health remains important task in this critical time. The physical vegetation, food and its related variables, disturbances and threats to the WBH and its habitat remains questions and leaves large research gap. Local people's attitude and actions towards conservation of WBH and WBH habitat must be studied and understand if we are to safeguard WBH population and Habitat.

Problem Statement

The WBH is a critically endangered species with estimate of 200 mature individuals in the world. Many conservation works are being carried out to protect the WBH from extinction. But the conservation efforts are put into questions as little is known about their habitat: the single most important variable for the species survival. Habitat preferences and habitat health assessment must be carried out if we are to conserve the WBH. Global range of the WBH is restricted to Bhutan, India and Myanmar with report of 28 mature individual from Bhutan. Of 28 mature individual, 26 are reported from the Punatsangchu river basin making this river basin the most preferred habitat. But the good story is to be end for the WBH in Bhutan as this river basin is under massive multiple hydropower construction bringing tremendous disturbances to the habitat of the species and poising immediate threats to the species survival.

The habitat variables upon which the species dwell must be studied and documented scientifically. The physical structure of the habitat, food abundance and availability and threats must be assessed scientifically if we are to conserve the WBH from extinction from Bhutan. Therefore, Habitat Assessment of Critically Endangered White-bellied Heron in Hararongchu along Punatsangchu river basin must be carried out.

Objectives and Research Questions

***General Objectives*:**

- To assess the White-bellied Heron habitat in Hararongchu along Punatsangchu river basin.

***Specific Objectives*:**

- To study the physical characteristics of soil and chemical of water along with its floristic diversity.
- To study habitat selection, food abundance and availability in Hararongchu.

- To examine the potential threats and disturbances to the survival of the White-bellied Heron in Hararongchu.

Research Questions

- What is the physical condition of the bird habitat at the study area? How does the different physical environment condition affect the bird habitat preferences?
- What is the potential capacity of the area in providing food for the bird?
- What are the predators' abundance, potential threats from anthropogenic activities and disturbances to the habitat of the critically endangered White-bellied Heron in Hararongchu along Punatsangchu river basin?

Literature Review

A. General Background

The WBH known as the Imperial Heron, Great WBH or Gentle Giant (RSPN, 2013) is scientifically known as *Ardea insignis*. It is the second largest species of heron in the world exceeding its size only by the Goliath heron (*Ardea goliath*) (BirdLife International, 2011).The rareness of its population rated it as the rarest heron in the world in 2012 in the Guinness Book of World Records (Price & Goodman, 2015).

There are sixty five species of herons recognized in the world (Kushlan, 2007). It was assessed and found that nine species are currently under threat. Four populations of the herons are gone extinct in historic times. Habitat degradation is the main cause of threat to heron. In overall herons are an adaptable group of birds (Kuahlan, 2007) and most of them have been able to co-exist with human in their natural ranges.

The WBH is known from the eastern Himalayan foothills in Bhutan and north-east India to the hills of Bangladesh, north Myanmar and historically it occurred across west and central Myanmar (BirdLife International, 2001). It might have also occurred in south-east Tibet, China, but now it is extinct in Nepal. A complete population census has not been conducted globally for this species (BirdLife International, 2011). Occurring mainly on the south side of the Eastern Himalayas, the White-bellied Heron has a very large range, currently occurring as a resident there in three countries: Bhutan, India and Myanmar. However, WBH occurs at low density and the overall population is regarded as insufficient for future long-term

survival. There are large gaps in its known distribution, with the proviso that very extensive areas of apparently potential habitat have not been surveyed for the species (Price & Goodman, 2015).

The WBH's presumed range is covered by three biodiversity hotspots: Eastern Himalayas, Indo-Burma, and South-West China (Myers *et al*., 2000), two Global 200 Eco-regions: Terai-Duar savannah and grasslands and the Eastern Himalaya broadleaf and conifer forest (Olson &Dinerstein, 1998), 20 Important Bird Areas (BirdLife International, 2014) and the Himalaya global centre of plant biodiversity, possibly extending into the Indochina-China centre (Barthlott*et al*., 2005).

There are only about 200 known individuals of WBH population in the world (IUCN, 2008; BirdLife International, 2011). The WBH is protected by the law in Bhutan and it is listed as critically endangered by the 2012 IUCN Red List (RSPN, 2013). The IUCN Red List assigned it the highest risk category as critically endangered which means the natural population of a species has decreased or will decrease by 80% within three generations and the evidence available would show an extremely high risk of its extinction in the wild. The IUCN Species Survival Commission and the Zoological Society of London reported that the WBH was included among the world's 100 most threatened species in 2012 (Baillie & Butcher, 2012).

The conservation status and declining trend in the WBH population is well known among concerned individuals, both within its range countries and internationally. In its range countries, government and non-government organizations have been researching and supporting the WBH. In Bhutan, especially, over many years there have been systematic surveys of rivers for WBH, nest sites have been monitored, captive head-starting tried, and efforts made to provide supplementary feeding sites. In India, there are ongoing surveys and behavioural and ecological work on the WBH. In Myanmar, WBH have been included in many waterbird surveys in Kachin State. Surveys in China's Medog County, on the Tibet and Tengchong border have not yet revealed any verified recordings of WBH (Price & Goodman, 2015).

B. Habitat Ecology:

B.1. Roosting Habitat:

RSPN reported that the roosting site was approximately 1 km (straight line) from the closest edge of the river, and approximately 200 m from the edge of open paddy fields that adjoined the river on slopes that ranged from 30 – 40 degrees. Roost trees were located in an open heavily grazed forest dominated by Chir Pine (*Pinus roxburghii*) and roost trees were clearly the tallest trees in the stand, located approximately 300 m from the top of a ridge. The three roost trees were 10, 14, and 16 m in height, and inter-roost tree distances ranged between 52 and 105 metres, with little or no mid-story or understory vegetation. The site is regularly grazed by cattle, and, based on local information and fire scars on trunks, is subject to fires of unknown frequency. Distances from roost trees to nearest over-story trees ranged between 8 and 14 m. Most birds were roosting near the ends of relatively large lateral branches between 8 and 10 m above ground level (RSPN, 2011; Price & Goodman, 2015). No other information is known to be available on roosting sites for WBH

B.2. Feeding Habitat:

In Myanmar observations of feeding have mainly been of WBH in rapids in clear, shallow waters, 12-30 cm deep, with some blue-green algae and with stone beds and sand bars (ThetZawNaing*et al.*, *n.d.*; King *et al.*, 2011). The most detailed analysis, based on observations, comes from Bhutan reported by RSPN that the rivers are 75 – 250 m in width, and up to 3 m in depth, though 0.1 - 2 m is much more common. Rapids vary between classes 1 – 3 with turbid, greenish blue water. The rivers varied between having 1 and 4 channels depending on location and stage, with multiple channels being much more common than single. Substrate was rounded cobbles, rocks and boulders of up to 1.5 m in size, river bars were usually composed of both rocks and sand, with logs and driftwood common. Islands were usually less than 300m long and less than 100m wide; vegetation on islands varied between none, tall grass and in some cases large (10m height) trees. Foraging herons were found far more commonly on braided sections of these rivers than on sections with only a single channel. River sections with foraging herons were approximately 200 m wide (range 150 – 200). Herons foraged most commonly either in shallow ponds that occurred within islands (32% of observations), or on edges of islands (82% of edges) (RSPN, 2011).

Cobble and gravel islands and multiple channels within the river therefore seemed to be strongly preferred by herons. This preference probably has several sources. First, when the river is divided into multiple channels, the strength of flow and depth in any channel is reduced. This satisfies the need for foraging in relatively shallow water – 86% of foraging observations were of herons in water that did not exceed the tarsometatarsal (TMT) joint. In addition, WBH seemed to prefer smooth water (69% of observations) and riffles (29%), and rarely ventured into main flow-ways or even the edges of major rapids. It seems likely that this preference is related both to the need for relatively shallow water, and the need for conditions that allow visual sighting of prey in water (Price & Goodman, 2015; RSPN, 2011). Smooth, shallow water was only available in ponds and pools contained within bars, and in backwaters and oxbows on the river edges.

Herons seemed to avoid mainstream river edges strongly, probably because river edges may allow the close approach of potential mammalian predators. Islands therefore probably offer the additional advantage of a clear field of view of potential predators, and large distances between herons and potential predators and disturbances. In sum, foraging habitat and microhabitat for herons seems to be related to multiple channels and associated islands, probably for reasons of preferred water depth, availability of prey to herons, and predator avoidance. There is only one assessment of the ranging behaviour of nesting WBH: RSPN have estimated that reproductive birds were foraging up to 5 km from the nest on small streams and along the Punatsangchu(RSPN, 2011).

WBH are able to feed in faster flowing water than many other birds that feed in a standing posture, thus, WBH prey species might overlap more with birds that are swimmers (e.g. cormorants and Oriental darters) than with other river-margin stalkers (other herons, storks etc.). The behaviour of WBH is different between Bhutan, India and Myanmar even in terms of timing of foraging. In Bhutan (with the exception of Lake Ada) and India (Manas), fast flowing rivers are occupied, in Myanmar, both fast and relatively slow-flowing rivers are used. In the HVWS, Myanmar, there is huge variation in water flows throughout the year, and WBH are seen on the same rivers throughout the year (Price & Goodman, 2015). While the consensus is that in India and Myanmar, WBH requires clear water for feeding, in Bhutan WBH has been seen feeding in turbid water made murky by hydropower infrastructure development (RSPN, 2011). In Lake Ada, Bhutan, green algae are prolific, with high fish numbers due to the provision of food for religious purposes; herons feed in the shallows here, possibly with larger than usual feeding efficiency, and on streams nearby; nearby cattle seem

no deterrent (RSPN, 2011). In Namdapha WBH have only been seen on rivers with broad banks, although they are frequently seen elsewhere in wide, fast-flowing rivers with boulders and cobbles; they also feed in lakes and in waterbodies in grasslands (Maheswaran, 2014). Such observations suggest WBH may have a wide range of feeding habitats as is common for herons (Price & Goodman, 2015). Some habitats may be sub-optimal, raising the questions of what is optimal habitat for feeding, and to what extent, and where does such habitat remain.

B.3. Nesting Habitat:

The species is known to breed and roost in Chir pine forest (Tordoff et al., 2006). Four nests located in Bhutan in 2003-2007 were solitary and located in large Chir pines on ridges or steep slopes at 500-1,500 m a.s.l, near the confluence of a small forest stream with a larger river (Pradhan, 2007; Pradhan *et al*., 2007). RSPN (2011) reported that WBH appeared to prefer areas with sparsely dispersed large, tall Chir Pines with no understory touching the tree, and a very sparse to non-existent shrub and small tree layer. Two nests on the Zawa Chu, they have measured a mean nearest Chir Pine tree distance of 15.5 and 19 m, respectively. Mean distance to the nearest 6 neighboring trees (>10 cm dbh) was 16.5 and 14.7 m, respectively. Nest trees were usually rooted on particularly steep parts of hillsides (42 –68^0 slope), and had an average diameter at breast height of 67cm and were 27 – 43 m tall. Nests were located on large (> 10 cm diameter) middle branches or crotches of the tree, rather than at the top. This may be because middle branches offered a more open aspect that helps with take-off and landing of these large birds. It may also be that middle heights are preferred because of the strong winds that are frequent in the afternoons in the Punatsangchu valley (RSPN, 2011).

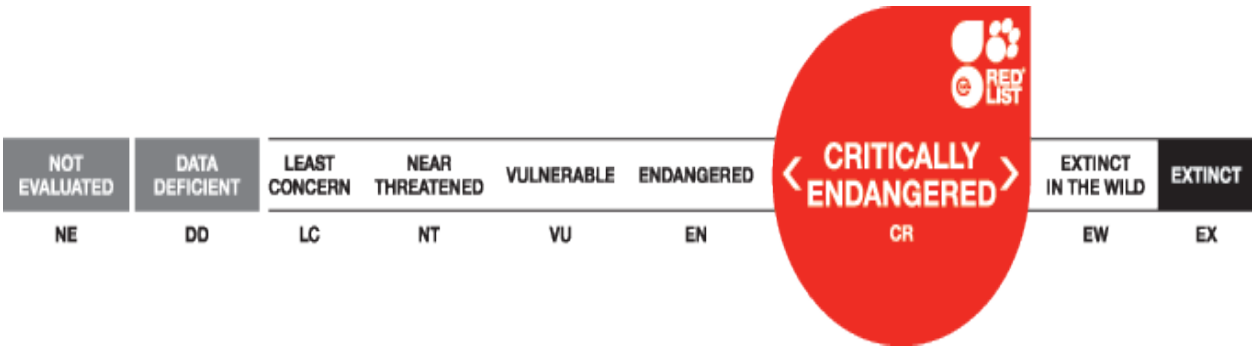
Nests were located 12.7–22 m from the base, and the closest branch to the base was at least 12 m from the ground. This suggests that WBH are attempting to nest well above the ground in large trees that are difficult for mammalian predators to climb. Nests along the Punatsangchu were 1.55 to 9 km away from each other (flight distance) though they could be along the same river or stream (RSPN, 2011).

In Namdapha, Assam, in 2014, a nest was located about 18 m above the ground on a *Terminalia myriocarpa* tree in riparian forest adjacent to the dry river bed, which was covered in tall grass and small shrubs. The nesting tree was visible from a long stretch of the meandering main river. Although there were many tall trees in the vicinity, the herons selected a tree of moderate height and constructed their nest on the outer branches, easily

accessible for birds of their size and affording a clear view of the river for several km to both east and west and also a clear view of the southern bank. The width of the river bed varies from 500 to 800 m (Mondal & Maheswaran, 2014). In contrast to the Bhutan situation, the WBH nests at 400 m a.s.l in Namdapha and below 200 m a.s.l in Myanmar. In the latter, nests are found in low elevation broadleaf forest (RSPN, 2011)

C. Conservation Status

The WBH was up-listed to Critically Endangered status in 2007, and currently remains there based on criteria CR C2a(i) (BirdLife International, 2013), due to population size estimated at fewer than 250 mature. Individuals with a continuing decline, observed, projected, or inferred, in numbers of mature individuals and no subpopulation estimated to contain more than 50 mature individuals. This decline is projected to intensify as more habitats is lost and degraded, with the possibility of direct exploitation and disturbance, especially when nesting (Price & Goodman, 2015) and they are listed as top 100 evolutionary distinct and globally endangered species (EDGE, 2015).



IUCN Red list scale for White Bellied Heron (Birdlife International, 2013)

D. Legal status in each range country

Bhutan: The Royal Government of Bhutan has recognized the significance of the WBH which is evident in the order issued by the Cabinet Secretariat in 2007: " Phochu is declared as White-bellied Heron Habitat vide the approval of the Cabinet Secretariat letter No COM/04/07/887 dated March 1, 2007 and 336th CCM Sessions which states: **a**. Banning all quarrying operations along Pho-chu namely at Gubjithang, Khawaraja and Samdingkhar and declaring the areas as the Protected habitat of White-bellied Heron. **b**. Enlisting WBH in Schedule I of the Nature and Forest Conservation Act 1995 through the National Assembly

(RSPN, 2011). Listing on Schedule 1 means that WBH is afforded the highest level of protection.

China: The WBH is not protected under any law within China. Its presence is not currently confirmed there (Price & Goodman, 2015).

India: In India the species is included in Schedule IV of the Indian Wildlife Protection Act (Price & Goodman, 2015).This means that the species is fully protected, but the penalties for contravention are much lower than for species on Schedules I-III.

Myanmar: The WBH is considered a completely protected species under the Protection of Wildlife and Conservation of Natural Areas Law (1994) (Price & Goodman, 2015).

E. Threats:

For over a century the white-bellied heron has been at risk due to deforestation because its preferred habitat is mature forest(IUCN Red List, 2011). It is also under threat from the fragmentation and degradation of its wetland habitats through pollution, over-exploitation of resources and the rapid growth of aquatic vegetation due to leaching of artificial fertilizers (Birdlife International, 2013). In addition, the white-bellied heron is vulnerable to disturbance and habitat degradation as a result of agricultural expansion, human settlements and poaching (Birdlife International, 2013), as well as overfishing (Hancock & Kushlan, 1984).

There is high nestling mortality in this species due to predation and the risks associated with forest fires (WWF Bhutan , 2015). As the white-bellied heron frequents fast-flowing rivers, it is also extremely susceptible to disturbance from transport routes, and from hydroelectric-power development, especially in Bhutan (Birdlife International, 2013).

The heron is a riverine species, favouring water bodies with shallow banks of sand or gravel. Adjacent subtropical forest is needed for breeding; White-bellied Herons select Chir pines to nest in. they have been recorded from the foothills of mountains, as well as lowland areas and at elevations up to 1,500 m.

Since ornithological records began in the Indian subcontinent, this heron generally appears to have been uncommon. Being large and solitary, its populations have presumably always been thinly distributed, and these constitutive factors have perhaps underlain its decline. While it probably suffers the suite of threats that apply to most waterbirds, namely habitat loss, disturbance, hunting and pollution, direct evidence is only available for the first two.

E.1. Small gene pool

The best guess for the population size of this species worldwide is less than 200 individual. Even if this population were panmictic, this tiny population size could easily result in deleterious effect of inbreeding. To make the matter worst, the population seems to be very discontinues in distribution (RSPN, 2013).

E.2. Habitat loss

Its dependency on mature trees in association with wetlands links it to a habitat complex which is threatened throughout its range either by wetland destruction or by forest destruction. The remote swamplands of the Indian terai and duars have largely been drained and cleared to make way for agriculture and settlements (Hancock & Kushlan, 1984), with a resultant reduction in the area of habitat available to the species.

Furthermore, forests in West Bengal, Assam and Arunachal Pradesh are threatened by shifting cultivation, commercial logging, "monoculture forestry" and increased clearance for tea estates. The Rufous-necked Hornbill *Aceros nipalensis* had all but disappeared from the valleys of West Bengal by the 1920s as a result of deforestation and this threat doubtless contributed to the disappearance of the White-bellied Heron from the same region. In the early 1990s, Arunachal Pradesh apparently retained primary forest cover over 61% of its total area, but this proportion is diminishing rapidly as a result of slash-and-burn cultivation, a factor presumably accelerated by the doubling of the state's tribal population between 1970 and 1990 (Grimmett, Inskipp, & Inskipp, 1998).

Forest around Namdapha National Park is also disappearing rapidly because of cattle-grazing and wood-cutting, while within the park certain areas have been cleared by Chakma refugees who occupy nearby settlements and visit the park to collect wood and poach wildlife. Habitat alteration has probably been more severe in lowland areas. Wetlands in the Brahmaputra floodplain are threatened by "habitat alteration, extensive fishing, weeds growth, siltation and biotic interference" (Saikia & Bhattacharjee, 1990). Forests along the Mo Chu in Bhutan are being cleared, with potentially disastrous impacts on the small resident population there (Grimmett, Inskipp, & Inskipp, 1998).

In Myanmar, large scale habitat destruction seems to have had a devastating effect on the species (del Hoyo, Elliott, & Sargatal, 1992). In particular, large areas of previously ideal

habitat in the Irrawaddy, Chindwin and Sittang catchments have now been degraded and disturbed with the spread of human populations along much of these river systems.

In Bhutan, large scale habitat destruction mainly attribute to Hydropower construction which is described in hydropower effect section.

E.3. Disturbance

Based on flush distance, this species seems to be exceptionally sensitive to approach by humans (RSPN, 2011). RSPN (2011) concludes that, in general, human activity within 200 m is likely to cause a heron to fly away, and this should be the minimum distance for acceptable approach.

In the Punatsangchu area of Bhutan, the WBH population is thought to be affected by disturbance by bird watchers, mostly conservationists and tourists, who come to the area on a regular basis to take photographs and monitor the nesting site (Dorji, 2013).

E.4. Hunting

Although there have been no direct reports of persecution, it is nevertheless likely, given the high levels of hunting and trapping reported in north-east Indian states that it suffers pressure of this kind. Wetlands in the Brahmaputra floodplain, for example, are threatened by "extensive netting, trapping and shooting" of birds (Saikia & Bhattacharjee, 1990), a factor likely to impinge on the population of White bellied Herons visiting the area.

In Myanmar, White-bellied Herons are apparently quite tame, often allowing boats to approach closely, or flying past villages. Hancock and Kushlan (1984) concluded that "one characteristic of the species, perhaps stemming from its minimal contact with man, seems to be a fearlessness" (Hancock & Kushlan, 1984). However, judging by Baker's (1922–1930) assertion that it is "solitary and very wild and wary" in India, and the opinion that it was "very wary" in central and southern Myanmar, this characteristic is not universally displayed (Baker, 1930). Similarly, in West Bengal it was recorded only on the uninhabited side of rivers "with little chance of molestation" and it was generally very shy in both Assam and Arunachal Pradesh (Kushlan & Hancock, 2005).

Any temporal or geographical variation in wariness is doubtless a response to fluctuating levels of persecution. There is apparently little threat to the species in Bhutan at present, especially as hunting of birds is uncommon in the country (Pradhan, 2007). There is very

little direct information from Myanmar, but half a century ago the levels of hunting in most areas were thought to be very high, especially in many mountainous areas owing to the hunting lifestyles of hill-tribesmen. Pollution, although there are no direct reports of pollution affecting the species, the use of thiodan (a non-biodegradable pesticide) by fishermen in the rivers of Dibru-Saikhowa National Park must be a threat. This practice is quite possibly widespread in the Brahmaputra lowlands (Kushlan & Hancock, 2005).

E.5. Developmental Activities

Developmental activities form one of the most important functions that government must perform. With the existing level of developmental pace, the habitat and ecology of the White Bellied Heron is in jeopardy. Developmental activities such as road expansion, expansion of municipal, and most importantly construction of hydro-power project degrades the habitat and ecology of the bird. The former two literally reduces the space for the bird and their migration pattern. The hydro-power plant construction increases the water level, which makes the bird hard to find its food. This affects the birds life as they have to stay long near to the river bank for search of food which makes them more vulnerable to hunting themselves down as well as they have to leave their chick unguarded. This way makes the next generation survival rate to much lower level.

Bhutan plans to generate more than 10,000 MW by 2020. To reach this target, ten projects were identified, three of which are underway (and expected to be commissioned by 2018) and others have since been identified as potential sites (International Rivers, 2015). In Bhutan, hydroelectric power developments and road improvements have resulted in significant habitat degradation (Price & Goodman, 2015).

The effects of dam construction are complex and specific to each dam and river system. However, immediately upstream of any dam, river habitats will be lost through impoundment of water. Changes in sediment load are likely to impact the freshwater environment as well as the ability of the dam to function long-term. Fish that survive and thrive must be able to adjust to deeper, slower-moving water, with a different temperature profile and chemistry, including its oxygen content etc. Similarly, downstream, altered flow will impact the biotic community of the river, especially periphyton and macroinvertebrate assemblages. Dam construction will also impact fish populations by preventing migration and access to spawning and nursery grounds resulting in decline of the prey population for WBH (Price & Goodman, 2015). The transmission lines used for the power transmission appear to be

immediate threat to the survival of WBH. 3 individuals died of electrocution since 2008 (RSPN, 2015).

White-bellied Heron casualty statistics				
Sl. No	**Year**	**Location**	**No. of Death**	**Remarks**
1	2003	Taberongchu	1	Dead, floating on river bank
2	2008	Basochhu	1	Electrocuted on electric cable
3	2008	Nangzhina	1	Burnt by forest fire
4	2011	Phochhu	3	Predated
5	2012	Kamechhu	1	Electrocuted on electric cable
6	2013	Hararongchhu	1	Wing injured
7	2014	Hararongchhu	2	Unknown
8	2014	Kamechhu	1	Electrocuted on electric cable
9	2015	Burichhu	1	Chick fell off the nest

Figure: Casualty records in Bhutan (RSPN, 2015).

E.6. Fishing

In Bhutan, according to Pradhan *et al.* (2007), one of the main threats to the WBH is the intense level of fishing. In India, illegal fishing in Namdapha National Park may be placing increased strain on the WBH (Maheswaran, 2007). However, none of these suggestions has been objectively demonstrated and remain merely opinions. Amongst the many constraints and challenges for conservation of these birds, the practice of poachers setting fish traps, especially along the Pho Chu, Punatsangchu and below Burichu Sunkosh Confluence, in Bhutan, needs urgent attention (Pradhan, 2007). Whether the cause for concern is disturbance to WBH or unsustainable offtakes of fish or other impacts is not stated. Hararongchu, a tributary of Punatsangchu have good number of WBH residing in it, but there is intensive fishing. Fishing in this river is legal.

E.7. Forest Fire

Chir pine forest is both created and maintained by fire, and trees show evidence of repeated burn events. Coupled with the marked wet or dry season, apparent lightning regime and steep slopes, fires seem endemic to this ecotype even in the absence of human pyrogenic activities.

All nesting areas had strong evidence of fire history such as fire scars on trees, lack of woody debris on the ground, and lack of mid-story trees. All evidence suggests that frequent fires can typically consume nearly all of the ground cover and that flame heights are often as high as 15 metres in these forests. Fire intensity probably varies hugely with fuels, slope, and winds (RSPN, 2011). There is one report of WBH casualty due to fire incident.

Materials and Methodology

Study area

The study will be conducted at Hararongchu along Punatsangchhu river basin. The river basin covers four districts from the extreme north to the extreme south of Bhutan and consists of the major rivers Mochhu and Phochhu at its upper basin, having their sources in the north-eastern part of the Himalayas and merging with each other at Punakha. Its course in Bhutan has a length of about 250 km. The Punatsangchu River Basin has a total land area of 13263 km2 with a population of 162071 people living within the basin area. The annual precipitation varies from 400 to 600 mm in upstream region, 700 to 900 mm for midstream region and more than 2000 mm for downstream region. The highest rainfall occurs in monsoon season. The highest elevation of river basin is 6500m and lowest is 200m.The study site is described as low-altitude xerophytic forest in the dry deeper valley of Punatshangchu watershed (Grierson &Long, 1983; Wangda, 2003) where the forest is purely *Pinus roxburghii.*

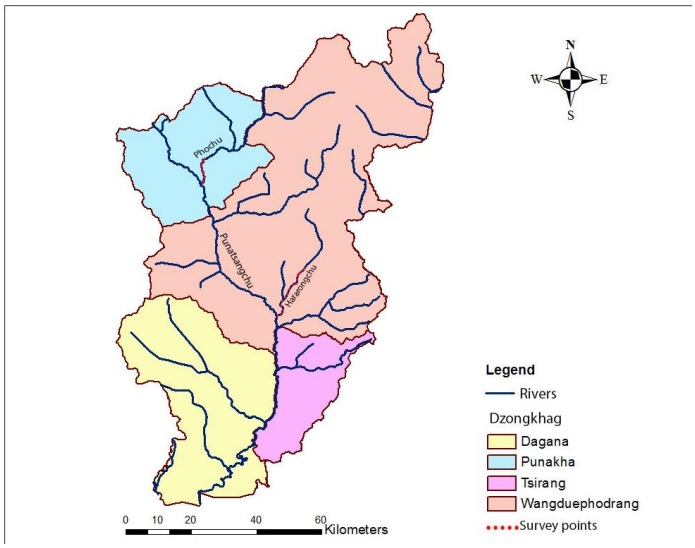


Figure: Study Area

Methodology

Habitat assessment of the WBH in Hararongchu along Punatsangchu river basin was assessed on basis of vegetation composition, prey availability and abundance, and threats and disturbances present in the WBH habitat. Transect in all habitats was randomly designated by using Geographical Information System (GIS) and the positions will be recorded by Global Positioning System (GPS). Perceptions of local people living in the WBH habitat vicinity was assessed through the technique of questionnaire survey.

Reconnaissance: Informal discussion with RSPN (National NGO currently working on conservation of WBH in the study country) were carried out before the start of the study work. All the information on the important habitat sites were acquired and study was done in accordance. Interview and questionnaires survey with locals people were done in the villages where WBH habitat falls in to find out local people's knowledge about the species, their habitat and perceptions on the conservation importance of the WBH habitat was taken to get the fair knowledge of the area in month of January.

Physical Environment: The physical environment parameters such as temperature, slope, aspect, elevation and topography were assessed in each study sites and recorded. Temperature of the each sample blocks was recorded using digital thermometer. The slope, aspect and topography were measured by using clinometer and compass, and elevation using GPS.

Vegetation: After consultation with RSPN, tree diversity was assessed based on tree suitability class for WBH nesting. For this, 10*10 m plots were laid in random location within the area to be assessed and tree species are recorded along with their DBH (Sutherland, Newton & Green, 2004). Dominant vegetation type was analyzed on three vegetation classes of Chirpine forest, broadleaf forest and mixed forest. The tree density per hectare for the study sites was calculated. Mean tree per plot were analysed using descriptive statistics in Excel.

Food abundance and availability: The WBH feeds on fishes. Therefore, the density of fishes in the sample area in the study area was taken. Fish sampling was performed in selected stream/ river stretches using different types of fishing gears like gill net of varying sizes (16mm, 22mm, 28mm and 32mm), cast net, drag net and scoop net and hooks in different habitats like run, riffle and pool in 100 meters reach of all study sites based on the methods of Johnson and Arunachalam (2009). Different types of gill nets was deployed at

each sites for 2 hours and based on the catch recorded the relative abundance of fishes was estimated based as catch per unit effort (CPUE). In addition to that cast net was operated to estimate fish density and biomass in selected habitat. All collected fishes were identified to species level. After collection, fish were examined, counted and released in river after 2 hours to avoid double counting. Along with fish sampling a set of environmental variables and habitat variables was taken at each study site such as water temperature, air temperature, dissolved oxygen, conductivity, turbidity, TDS, pH, riparian cover, land use pattern, human disturbances and water depth, width of the stream for comparing fish abundance with site variables based on.

Information about the structure of assemblage was extracted by adopting different univariate indices, namely Shannon diversity index, Margalef's species richness index and Shannon evenness index. Margalef's species richness index was calculated using the equation R = (S-1)/ln N, where S is number of species, N is total number of individuals. The Shannon's diversity index was calculated using equation H'= $\sum$pi ln pi, where pi= ni/N; ni is number of individual of 'i'th species and N= $\sum$ni. Shannon evenness index was calculated by equation E= H'/ lnS, where S is the number of species. The indices were used to compare the species diversity, richness and evenness across the study sites based on Johnson et al (2012). Fish biomass was also calculated using Biomass equation B=N.M where N is number of individuals of each species and M is average mass of each species.

Potential threats and disturbances: The disturbing factors for the WBH were taken into account. Distance from WBH habitat to disturbance factors was recorded using Nikon prostaff rangefinder. Disturbance factors considered were road, foot path, bridges, agriculture land, settlement, transmission lines and cattle grazing. Developmental activities were also recorded along with their scale (1-3) and distance at which it is taking place from WBH habitat. Threats such as fire incidence and fishing intensity were recorded by direct observation and through questionnaires surveys. All these data are analysed in excel and presented in figures and tables.

WBH and Environment Associations: The WBH sightings and habitat variables with separated sites were submitted to Canonical Correspondence Analysis (CCA), which is a direct gradient ordination technique that extracts the best synthetic gradients form field data on biological communities and habitat features: it forms a linear combination of environmental variables that maximally separate the niche of the species (terBraak &

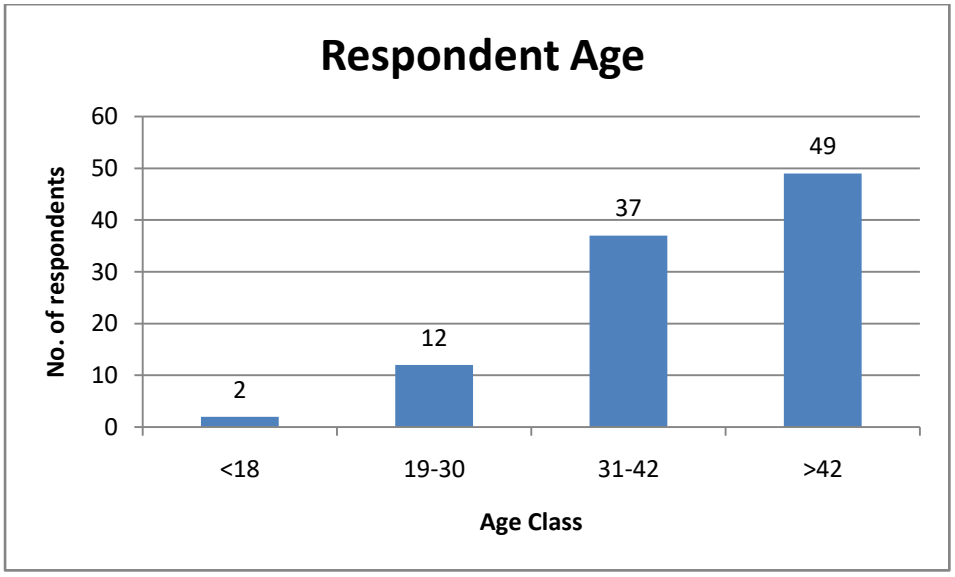
Verdonschot 1995). It is also a powerful exploratory tool for simplifying complex data sets and has the advantage over integrated analysis of both species and habitat data at each site (Taylor et al. 1993). In order to reduce the complexity of ordinance biplot, only five habitat variables (water depth, water temperature, flow, disturbances, fish biomass) were included in CCA and before analysing the raw data were transferred into $\log_{10}$ values. The resulting WBH abundance-habitat variables biplot is an ordination diagram in which species and sites are represented by points with respect to the supplied explanatory variables, represented by arrows. The arrows point in the direction of maximum variation in value of the corresponding variable. The arrow of a variables runs from the centre of the diagram to an arrow head, the coordinates of which are the correlation of the variable with axes (terBraak 1986; terBraak & Verdonschot 1995). The CCA was obtained with STATISTICA (version 7) programme.

Results and Discussions

Household survey

1. Demographic characteristics of respondents

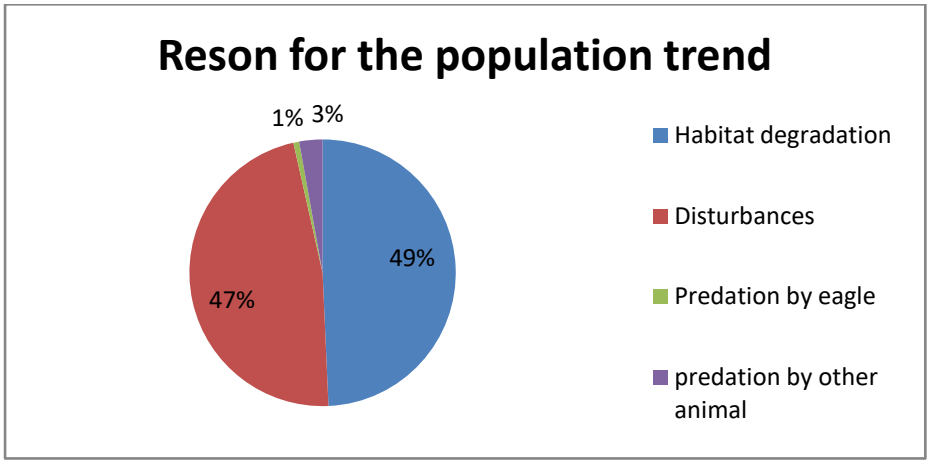
Out of 100 respondents, 59% were males (n=59) and 41% were female (n=41). The mean age of the respondents were 47.42 (SD=17.05, N=100). Majority of the respondents falls under age category of >42 years (49%).



2. Knowledge about WBH

The respondents when asked if they know about WBH, 99% (n=99) says they have knowledge about WBH. 4% of the respondent says they have seen WBH for the first time in

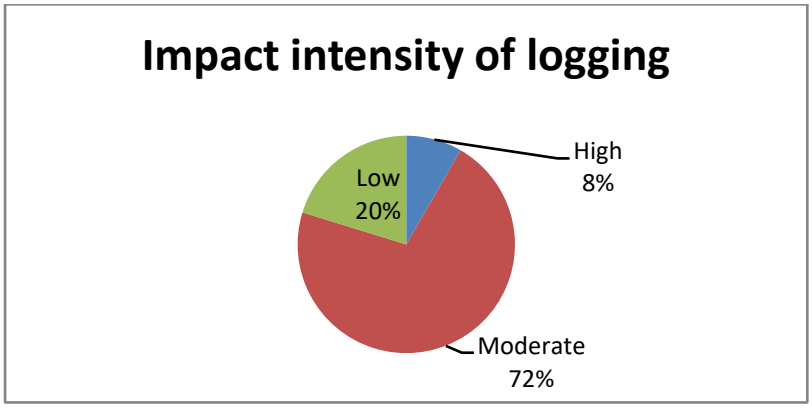
1-5 years ago, 26% for 5-10 years ago, 17% for last 10-20 years ago and 53% says they have seen more than 20 years ago. This indicates that the species is not a recent migrant to the study area. WBH in Hararongchu has been reported recently but local residents say WBH has been there in the river for very long time. 72% saw around 3-5 WBH when they first saw but when asked about the present population status 97% of respondents says they have seen only 1-3 mature WBH individuals. 86% feels WBH population trend is decreasing, 14% feels the trend is same but none says population is increasing.



The decreasing population trends mainly attributes due to habitat degradation and disturbances. 100% of respondents have seen WBH most in river feeding. Most sighting frequency occurs in early morning and evening.

3. Threats information

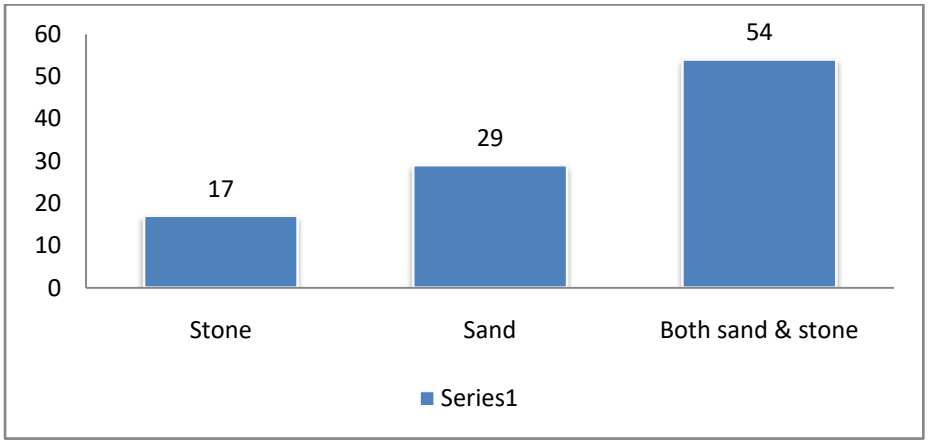
There is no logging in the WBH habitat in both the study area. Locals collect timber from other area. The study found that 93% of respondent agrees that logging have impact on WBH habitat. Majority of respondents (72%) feels though logging has impact on WBH habitat, intensity will be moderate.



72% respondent prefers alternative options in regards to logging with 63% of them preferring use of alternative area for logging, rest preferring alternative resources.

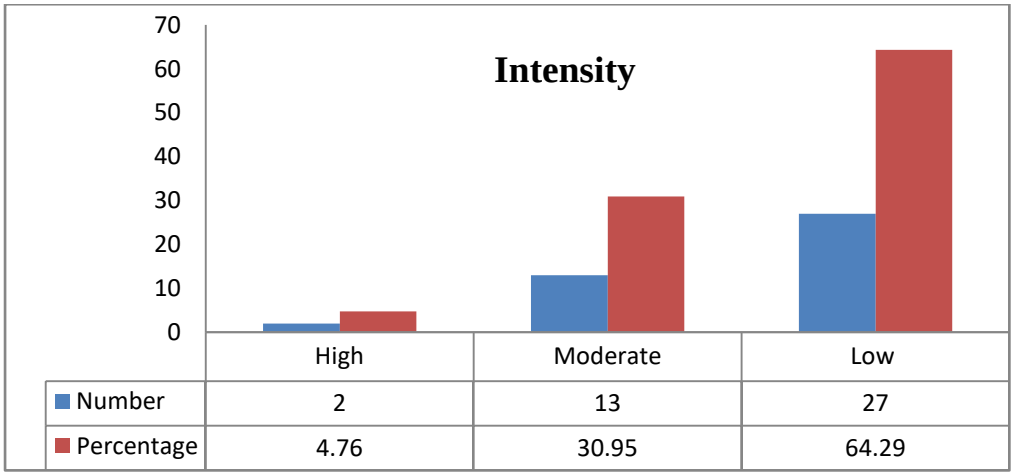
Fire is another major threat to the WBH habitat in particular to nesting sites. The study found out that 100% respondents report occurrence of wildfire in last 2-3 year in the WBH habitat. Respondent finds the impact of wildfire to WBH habitat imminent with 100% agreeing the impact of wildfire to be high on WBH habitat. However, RSPN (2011) reports that frequent ground fires in chirpine forest (WBH prefers low density chirpine forest to make nest) are probably beneficial to creating nesting habitat but needed to provide protection against catastrophic fires. In 2008, one WBH was burnt by forest fire (RSPN, 2011), making fire a threats to the species survival. 100% respondents says there is need to stop wildfire in WBH habitat with 47% finds fire control by regulation, 40% by awareness and 13 by community forest management group. This study reveals that there is need of government regulation and public awareness to stop forest fire in the study area as the forest fire occurrence in the important bird area is very frequent.

Foraging habitat degradation attributes to river bed alteration. Collection of various river materials alters the foraging habitat. Major cause to foraging habitat degradation in the river basin is hydropower but collection in domestic purpose in small quantity also seems threats to WBH habitat. With 81% collecting river material from the heron foraging habitat both direct and indirect threats are poised.17% collects stone, 29% collects sand, and 54% collects both sand and stone.



The study finds that people's perception that river material collection does not cause much destruction to WBH habitat with 58% respondent saying no impact to WBH habitat. Of

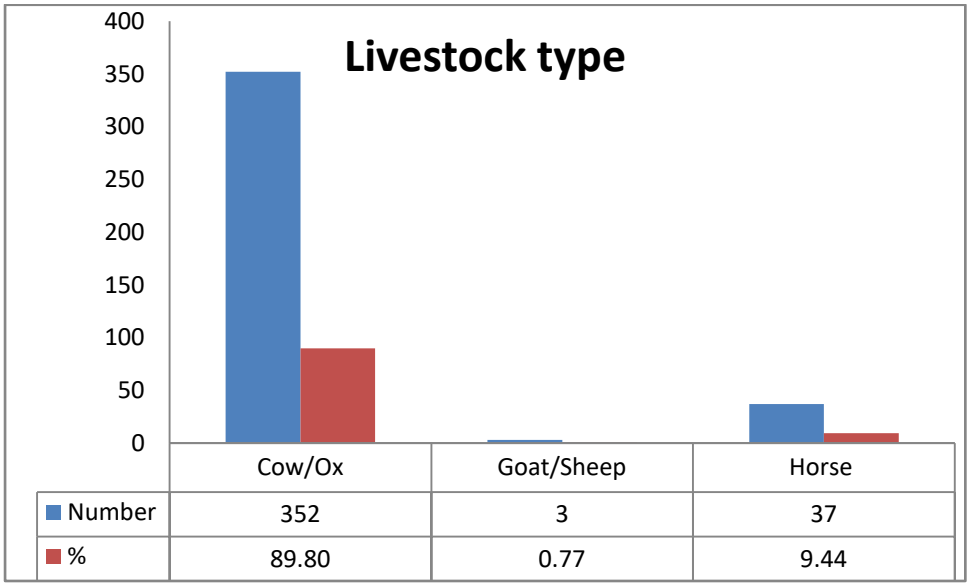
42 respondents who think river material collection degrades habitat, 4.76% asserts the impact is high, 30.95 % medium impact and 64.29% express the impact is low.



	High	Moderate	Low
Number	2	13	27
Percentage	4.76	30.95	64.29

When options were offered for the respondents other than collecting from the heron habitat, 50% agrees, 31% disagrees and 19% are not sure. An option preferred is collection of riverbed material from alternative area. Though majority of respondents collects riverbed material from the heron habitat, threats are not very serious as the quantity of collection is negligible and mode of collection and transportation of these materials from the heron habitat are all manual.

Livestock by themselves and relatively low densities doesn't appear to the threats to the heron (RSPN, 2011). 91% respondents have grazing livestock. 100% respondent asserts that livestock never disturbs and heron habitat is never degraded by livestock.



	Cow/Ox	Goat/Sheep	Horse
Number	352	3	37
%	89.80	0.77	9.44

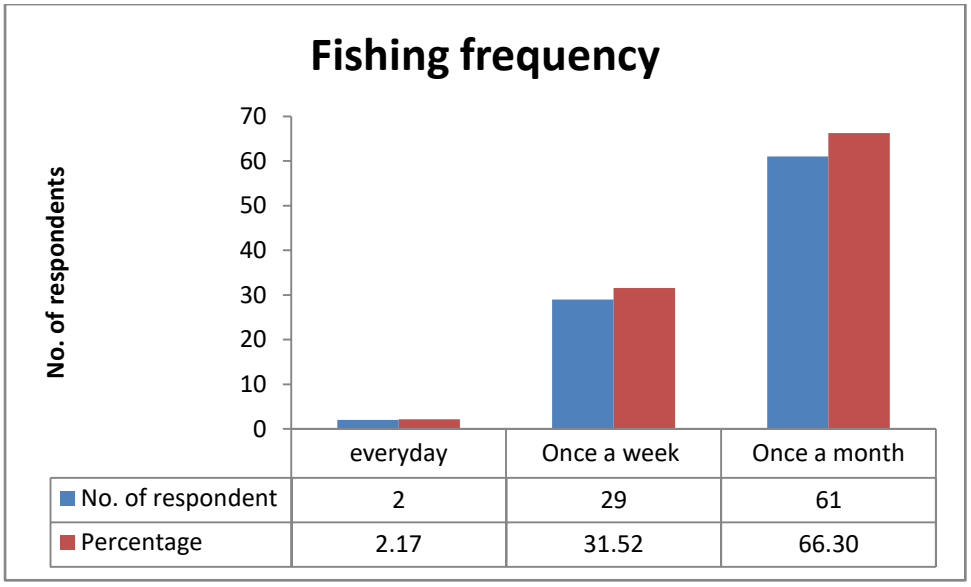
Water pollution can occur in many forms, and for wildlife may include increased exposure to disease agents, increasing trophic status through nutrient enrichment, altered community composition, decreased oxygen, increased turbidity, and exposure to toxins and endocrine disruption. Since WBH depends on fish for food, the will be strongly affected by anything that affects their prey resources.

Type of Chemicals	% respondent	Avg. quantity (g)	Avg. area (Acre)	Frequency/yr
Fertilizer	79%	6725.69	2.33	1
Weedicide	67%	489.33	2.33	1
Pesticide	52%	362.11	2.33	1
Herbicide	21%	98.62	2.33	1

Table: List of chemicals used by farmers

There is use of all four chemicals for agriculture purposes. The chances of these chemicals entering the river system and causing alteration to demography and community composition of fishes are very high as the agriculture land is very near to the river system some having less than 400 meters distance. Excess sedimentation from agriculture land use practices can affect suitability for fish spawning and fish survival. These chemicals can affect development and sex of fishes through endocrine disruption, to the extent that population declines can result. Water quality could be important threats to WBH.

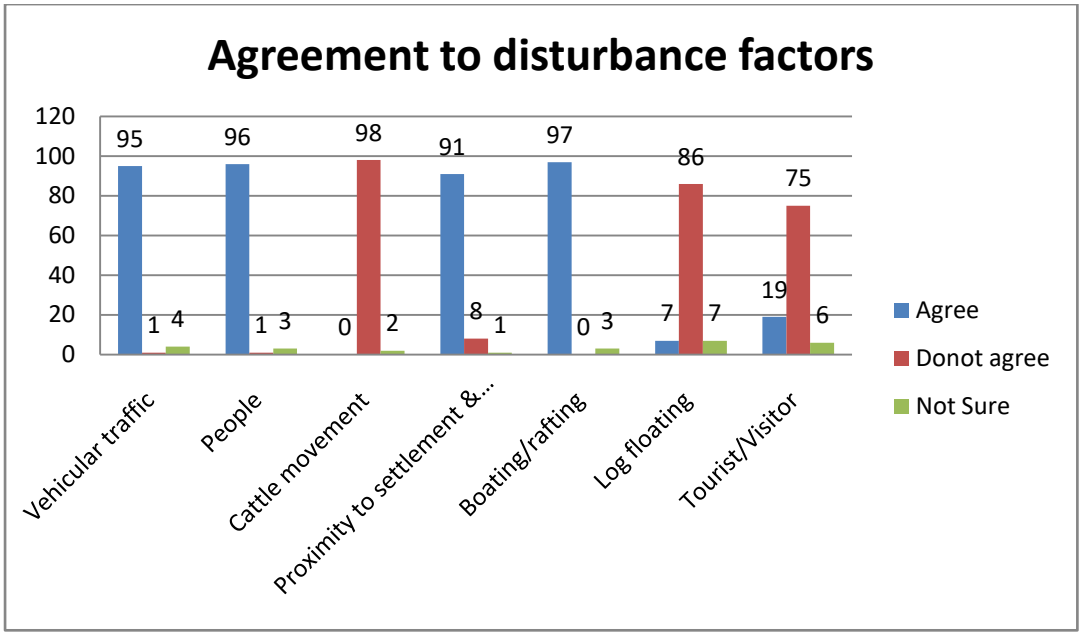
Human fishing pressure is almost impossible to quantify since most of it is illegal. In Hararongchu, even though fishing is legal, quantification of fishing is very difficult as the fishing is random and no proper records are to be found. RSPN (2011) reported that illegal fishing is frequent, widespread, and in some cases very intensive. The very low capture rates of herons documented during winter (RSPN, 2011), and the tendency for mountain rivers to have low productivity of fishes, both suggest that human fishing pressure could substantially alter the foraging ecology of WBH and poise great threat to the species survival in these critical habitat. 98% respondents believe that there is illegal or legal fishing in the study sites. Fishing frequency was assessed in the study resulting 66.30% local residents fishing from the WBH habitat river at least once every month, 31.52% atleast once in a week and 2.17% fishing everyday from the river.



Fishing day time causes extra disturbances to WBH as fisher man comes in direct contact in WBH feeding habitat causing extra stress to WBH. Hararongchu site has been legalized by the Royal Government of Bhutan to the local resident for fishing as the socio-economic condition of region is poor. These local prefers fishing at daytime giving direct interference to the species at the feeding site. Some of the feeding site appears to have more fishes preferred by both fisherman and WBH creating a conflict and making WBH more vulnerable.

90% of the respondent expressed that fishing has no impact on WBH and its habitat but 10% says otherwise. Of 10 respondents who argues that fishing in WBH habitat has impact on WBH, 94.6% says impact intensity is high and 5.4% says intensity is medium. 10 respondent says fishing must stop in the WBH habitat of which 50.6% finding strong regulation regarding fishing would be best way to stop illegal fishing, 42.2 % preferring advocacy and 7.2% preferring community management as means to stop illegal fishing from WBH habitat, and 90 respondents saying otherwise.

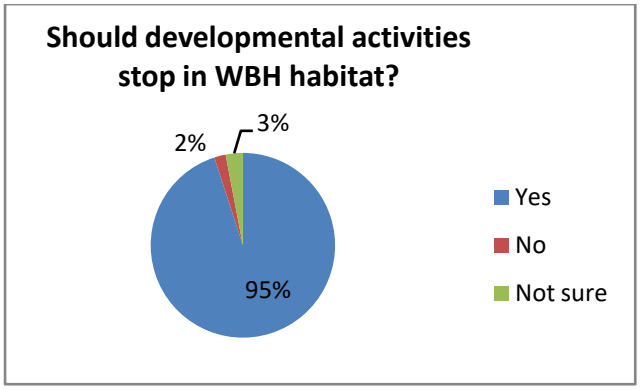
The respondent gives different opinions to different disturbance factors for WBH when we asked if following factors are present in the WHB habitat. Boating/rafting (97%) in the river appears to be serious disturbance factors to the species followed by people and vehicular traffic. 98% finds cattle movement no disturbances at all.

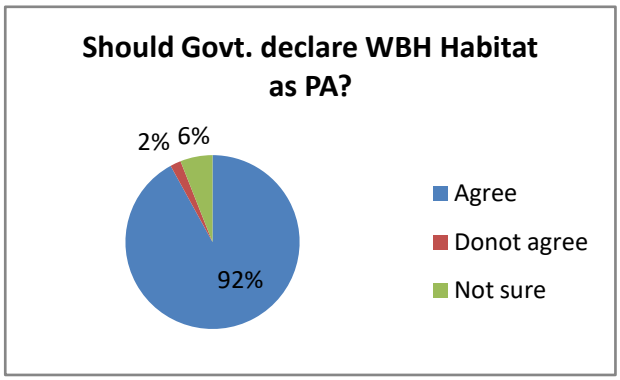


Respondents have mix feeling about the tourist/visitor causing disturbances with 75% saying it does not cause disturbances but 19% feels it causes disturbances, otherwise respondents have almost similar perception about each cited disturbances factors.

Local residents reports that no major developmental is going on as of now. Developmental activities poise both direct threats as well as indirect threats. The species gets disturbed due to noise from the activities sites, heavy vehicular movement, and huge number of human being involved. Indirectly developmental activities may degrade their habitat causing long lasting paramount negative affect.

The study tested the respondent's attitude towards conservation of WBH and its habitat. This attitude is one of the principle factors if we are to protect the WBH habitat and conserve the species eventually as the locals residents are the one who literally lives in and around the WBH and its habitat. 95% respondents agrees to statement that developmental activities should be minimized in WBH habitat with 3% not sure of the idea and 2% against the idea.

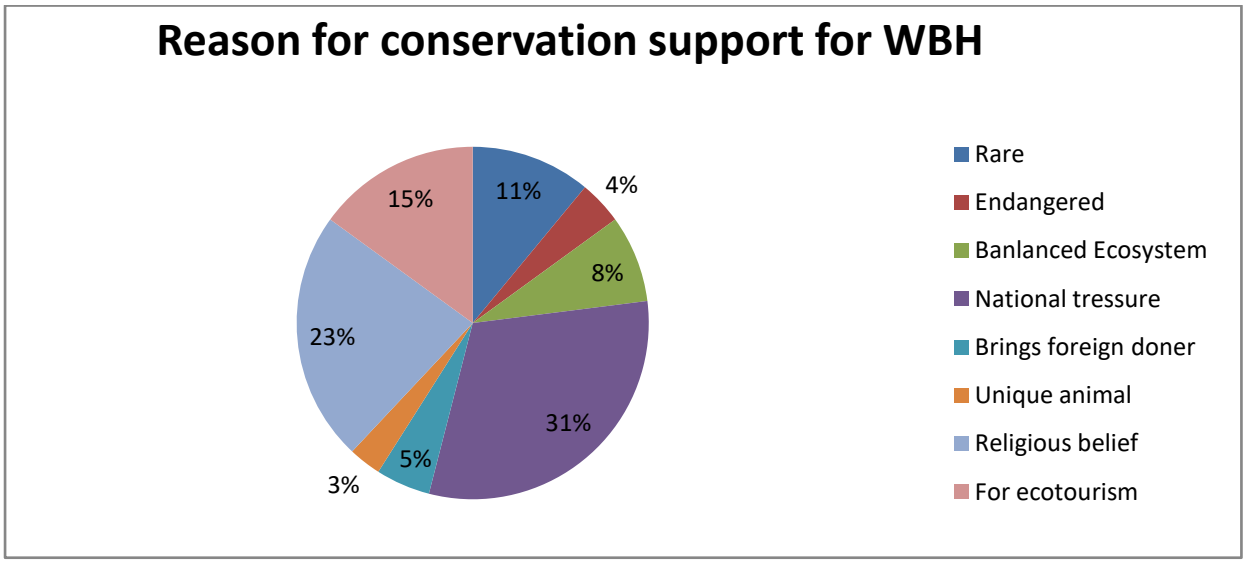




92% wants express that Government should declare WBH habitat as protected area but 2% does not agree with this opinion and 6% is not sure if it is a smart move.

The study found that 94% respondents agrees that WBH has social value with ecotourism (98%) being most cited advantage of WBH in the study area. Cultural value (93%) of WBH has slightly lower support from respondents than social value with value being belief (50%) and respect for other living being (50%). The reason for this result could be all the respondents were Buddhist by religion and they have strong belief and respect for other living creatures.

99% of the respondent agrees that the critically endangered WBH must be conserved and the rest 1% is not sure of the idea.

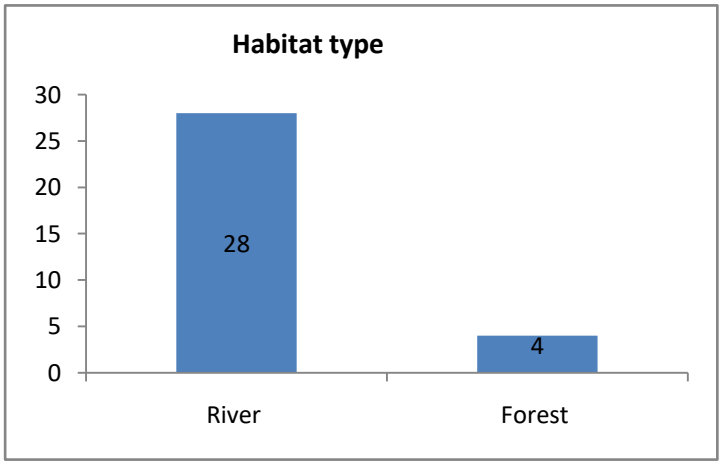


With the reason cited for the support of WBH conservation, local resident's perception and attitude about the WBH seems very positive. Frequent awareness campaign

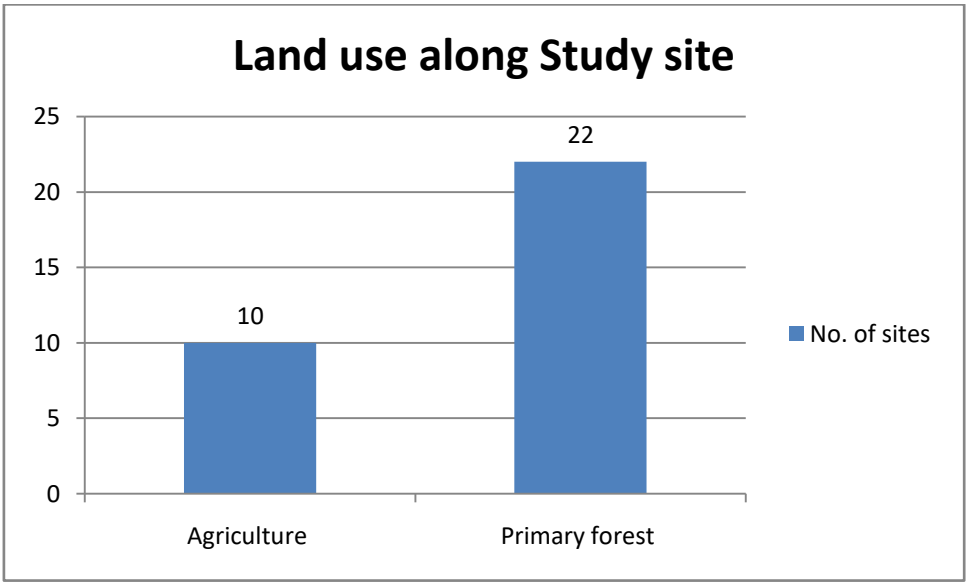
conducted by various agencies seems working and more frequent such campaign seems needed for effective conservation of WBH.

Habitat assessment

32 sampling plots were laid. 10 km stretch was taken along the river and WBH encounter rate was found out to be 0.3 WBH/km. 28 out of 32 plots were river and 4 were forest. The river habitat is used as foraging habitat and forest were used for nesting habitat. The study could not locate roosting habitat for the WBH as new roosting is yet to be found and the known roosting habitat is already abandoned.



Land use around the habitat are 10 sites are agriculture and 22 sampling plots were found be to primary forest.



1. **Floristic characteristics of WBH habitat**

For this purpose tree diversity and density was carried out in the study sites. After consultation with RSPN, the study was done only for the tree diversity and density. Other understory vegetation does not affect much to the nesting habitat whereas as feeding habitat needs open and wide area (RSPN, 2011). As long as WBH is concern, they prefer to nest in sparse pure chirpine forest.

2. **Tree diversity**

The study found only *Pinus roxburghii* in the sampling plot. All study sites are made of pure chirpine forest.

3. **Tree density**

The overall tree density per hectare was estimated to be 5430 trees/ha in Hararongchu along Punatsangchu river basin.

It is very important to maintain the right tree density especially the *Pinus roxburghii*(Chir pine) because WBH were known to breed and roost on it. Nest of WBH discovered in Bhutan in 2003 – 2007 were solitary and located in large Chir pine on ridges (Pradhan, 2007). The forest must be maintained to relatively low densities as the heron seems to prefer for nesting.

4. **Feeding Habitat**

The survey demonstrated that WBH is foraging on the low reaches of Hararongchu. The Hararongchu flows through forested land on both sides of river with agriculture land nearby on one side. Foraging habitats are of mean width of 64.5 meters (SD=51.76) and mean depth of 42.70 cm (SD=9.62). Heron seems prefer to forage in shallow river irrespective of width. Mean flow rate at the feeding site is 0.93 m/s (SD=0.04) with water turbidity in all the sites at 0 JTU. The rivers varied with 1 to 4 channels. More channeled river site is may be chosen by WBH as the river is relatively shallow. Substrates were mostly cobble followed by boulders and gobbles. River bars are mostly composed of rock and sand, with logs and driftwood.

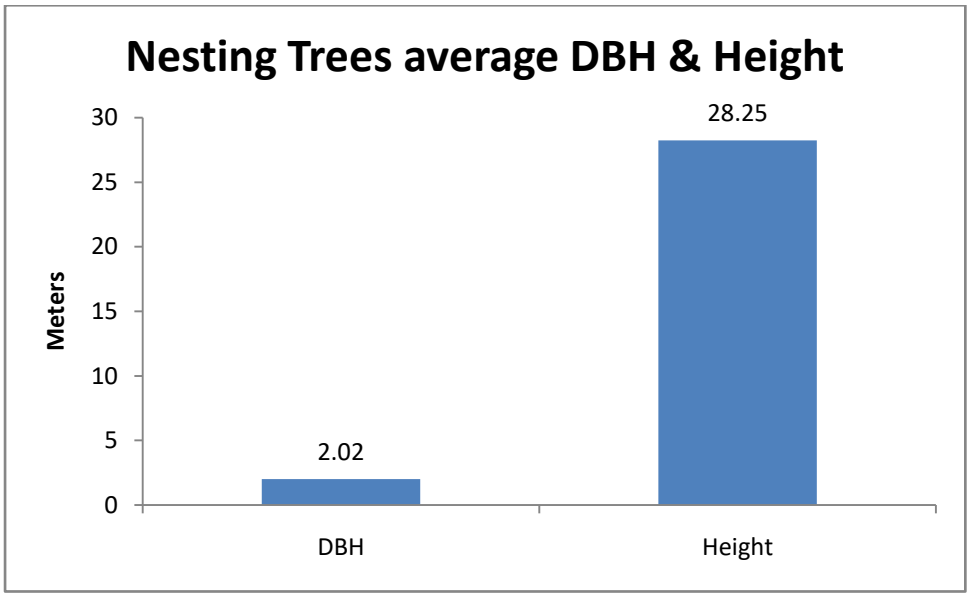
RSPN (2011) reported that Heron avoids river edges strongly while foraging, probably because river edges may allow the close approach of potential mammalian predators. Looking into all the observation and reports, foraging habitat of WBH seems to be

related to multiple channels, relatively shallow water, availability of prey to heron and predator avoidance.

5. Nesting Habitat

Nesting habitat of the WBH based on four nest observed during the survey prefers very steep slope of 53-67^0 facing in east aspect. These steep slope seems to be selected due availability of large trees with open space in front. It may for the reason of steep slope makes it more difficult for predator to access the nest as footing is treacherous. RPSN (2011) says it may also be that there is a relationship between slope and understory that is mediated by fire.

All the nests were made on tall Chirpine trees. Reason for choosing such tall trees may be as such trees offers advantage such as their strength and mass offers a stale platform for nesting as the area where WBH nest experiences high wind during the nesting season. Chirpine also offers large lateral branches for nesting. The nesting tree has average height of 28.25 m (SD=5.11) and mean DBH of 202 cm (SD=2.20). These features makes nest safe from most of the predators as climbing of main stem of 2.02 meters DBH will be very difficult. Together with no or very less understory trees or vegetation, this offers predators no way to reach the nest and predate on the nest. There is very sparse understory and low density of large trees. The mean distance of nest to 5 nearest trees is 9.66 meters (SD=5.40). These features seem to provide two important purposes to WBH. First, the open canopy is much need for the WBH to fly through without much danger and second, lack of understory leaves potential nest predators few or no to access to nest.



All the nests were located near to the river on the steep slope of adjacent hill. The mean distance of nest from river is 79.25 meters (SD=36.15). Making nest at this close to river is attributed to easy forage in the river during hatchling time. At this time protection of chick is also needed as well as feeding them. Lesser distance from feeding site can reduce time of leaving the chicks unguarded. Yet the nest of the WBH is far away from human interference. All the nests were found on the opposite side of the mountain where human settlement. It was recorded that there is no than 250 meters between nesting sites and human related features. However, RSPN (2011) reports that perceptions of being inaccessible is probably important than straight line distance for heron.

Distance of nest to different features in meters				
River	**Road**	**Settlement**	**Foothills**	**Transmission line**
119	>250	>250	215	>250
39	>250	>250	39	>250
60	>250	>250	58	>250
99	>250	>250	20.5	>250

Table: Different features in meters from nest.

Threat assessments

There is no evidence of logging in the study area sites. Though logging seem to have long potential impacts on WBH directly through disturbances at close proximity to nesting or foraging habitat, or indirectly changing the nature of nesting and to lesser extent, foraging habitat. As of now, there is no need to tackle this issue as logging seems absent from the WBH habitat.

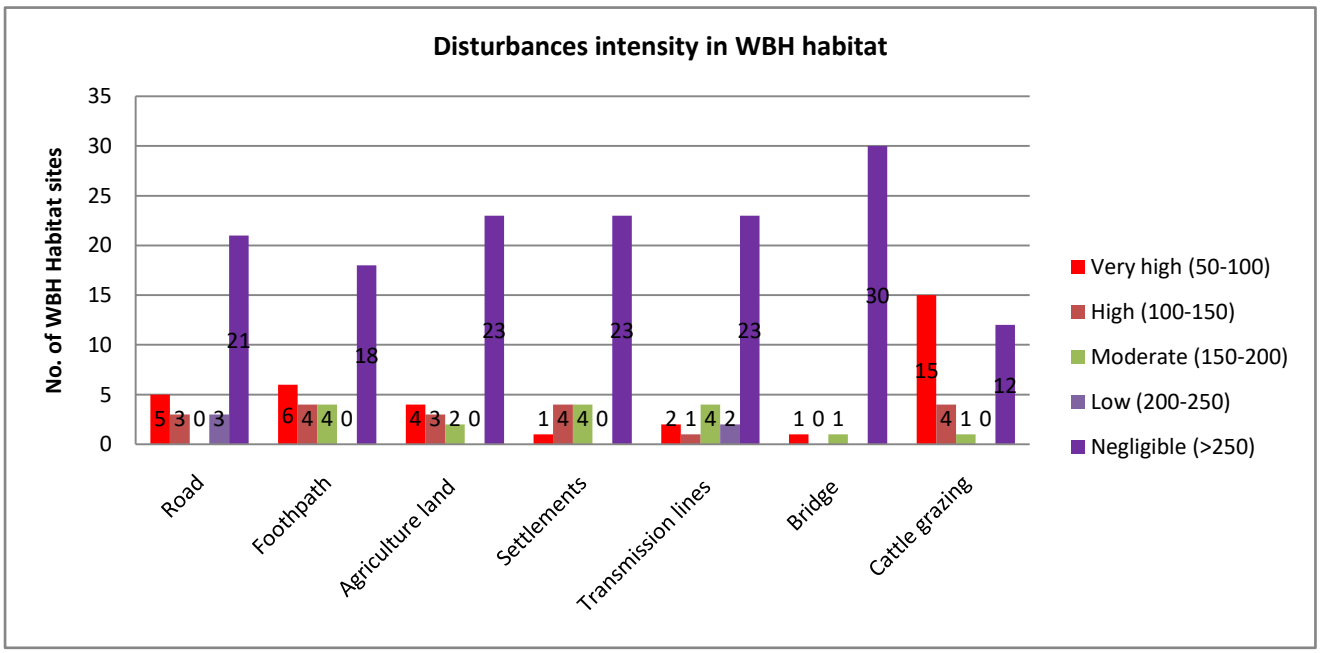
All the sampling points in the study sites have fire occurrence records with evidence of fire scar in each sampling point. Fires threatened nests directly and in that sense fires area potential problem for reproduction. This could be particular reason for low hatching success in Bhutan. Individuals also gets burned up during wildfire causing survival rate of WBH to drop down. Fire too has beneficial aspects for WBH too as it clears underbrush and samplings and promotes a low density of matures trees that WBH finds attractive to nest on. In this regards frequent ground fire may be beneficial to creating nesting habitat and providing protection against catastrophic fires. These frequent fires could be the reason why there is

only Chirpine trees in the sampling plots as other species are prone to fire and Chirpine being fire resistant species.

Though 81% respondent collects riverbed materials from the WBH habitat, the intensity is not high enough to notice in the field during survey. There is no sign of riverbed material collection. Reason for not being able to notice riverbed material collection due to least activity of such in the WBH habitat site as Hararongchu site has very least development activities. Collections as well as mode of transportation are both done manually resulting in least disturbances to the habitat.

Disturbances factors are present in the study sites. Factors considered as disturbances are presence of road, footpath, bridges, agriculture land, settlement, transmission line and cattle grazing. Presence of these disturbances is measured in meters and according classified into intensity as per the findings from RSPN. Intensity level varies in a way that 50-100: very high, 100-150: high, 150-200: moderate, 200-250: low, and >250 m: negligible. RSPN recommends a minimum distance of 200 meters with exception of cattle as unattended cattle causes minimal disturbances than other factors.

Though cattle presence in the study sites in distance less than 100 are categorized as very high as like other disturbance factors, it the intensity is not so high as like other factors. Nonetheless, cattle cause some disturbances to the species.



Hararongchu WBH habitat along Punatsangchu river basin has less disturbances factors but in heron feeding sites, there is lots of legal fishing activities going, poising threat to the WBH physically with human presence as well as competing indirectly for fish (Food).

The nest of the WBH has minimal disturbances effect. All the disturbing factors are more than 250 meters away from the nest site and opposite side of the river from the nest location. Moreover, nest location being on steep slopes encounters less other mammals in the area.

Food abundance and availability:

Name of species	Sampling plots							
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8
Amblycepsmangois	0	0	0	0	3	4	0	2
Bariliusbendelisis	0	0	0	0	18	1	5	0
Crosssocheiluslattius	0	0	0	0	14	2	0	0
Garraannandalei	0	0	0	0	9	13	0	13
Glyptothoraxcavia	0	0	0	0	8	7	1	6
Neolissochilushexagonolepsis	15	13	11	12	16	13	8	10
Oreinusmolesworthi	23	18	19	21	14	18	11	8
Salmotrutta	24	17	18	25	16	4	11	19
Schizothoraxprogastus	0	6	8	6	11	5	8	12
Schizothoraxrichardsonii	7	5	8	9	13	7	5	17

Table: list of fish species recorded from study sites.

Study site	Sampling plots							
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8
Taxa	4	5	5	5	10	10	7	8
Individuals	69	59	64	73	122	74	49	87
Cyprinidae abundance	45	42	46	48	95	59	37	60
Cyprinidaepercentage(%)	65.22	71.19	71.88	65.75	77.87	79.73	75.51	68.97
Shannon indx	1.30	1.50	1.54	1.49	2.23	2.05	1.81	1.95
Margalef	0.71	0.98	0.96	0.93	1.87	2.09	1.54	1.57
Equitability	0.94	0.93	0.96	0.92	0.97	0.89	0.93	0.94

Table: Variation in species abundance, cyprinid abundance, Margalef's richness index and Shannon index in study area.

During the study a total of 10 species of primary fresh water fishes belonging to 4 families and 9 genera were recorded from the study sites. The Shannon diversity index, Shannon evenness index and Margalef richness index were shown in table.

In the assemblage part, Cyprinidae family was dominant (65.22% - 79.73%) with 7 out of 10 species recorded from the study sites belong to it. Cripnids *Neolissochilus*

hexagonolepsis, *Oreinus molesworthi*, *Schizothorax richardsonii* were represented in all study area. The maximum number of Cyprinids was recorded from plot 5 with species such as *Schizothorax richardsonii*, *Schizothorax progastus*, *Oreinus molesworthi*, *Neolissochilus hexagonolepsis*, *Garra annandalei*, *Crosssocheilus lattius* and *Barilius bendelisis.* Low cyprinid population was observed in plot 7 in Hararongchu followed by Plot 2 and Plot 1.

Shannon diversity index showed high value in Plot 5 followed by Plot 6 and Plot 8. The evenness index of the species distribution was uniformly similar in all the study sites.

Site	**Sampling plots**								**Total**
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	
Amblycepsmangois	0	0	0	0	246	276	0	144	**666**
Bariliusbendelisis	0	0	0	0	1776.06	106	495	0	**2377.06**
Crosssocheiluslattius	0	0	0	0	1092	124	0	0	**1216**
Garraannandalei	0	0	0	0	918	1599.00	0	1412.84	**3929.84**
Glyptothoraxcavia	0	0	0	0	1338.40	1484	230	1013.4	**4065.8**
Neolissochilushexagonolepsis	3480	3276	2221.01	1308	7232	7033	3328	4110	**31988.01**
Oreinusmolesworthi	8303	5370.66	3811.21	4128.39	5894	7398	3619	3220.8	**41745.06**
Salmotrutta	14400	9231.00	7205.58	8816.75	7280	1284	3861	7381.88	**59460.21**
Schizothoraxprogastus	0	2166	3739.52	2700	4637.16	1705	3608	5364	**23919.68**
Schizothoraxrichardsonii	6300	3250.00	6888.87	6017.68	7293	4557	2155	9655.66	**46117.21**
Total	**32483**	**23293.66**	**23866.19**	**22970.82**	**37706.62**	**25566**	**17296**	**32302.58**	**215484.9**

Table: Biomass in grams of each species in each sampling site in two study area.

Salmo trutta (59460.21) has highest biomass in the study sites followed by *Schizothorax richardsonii* (46117.21) and *Oreinus molesworthi* (41745.06). And site wise Plot 5 (37706.62) has highest biomass followed by Plot 1 (32483) and Plot 8(32302.58). The total biomass from all the study sites was 215484.9 grams.

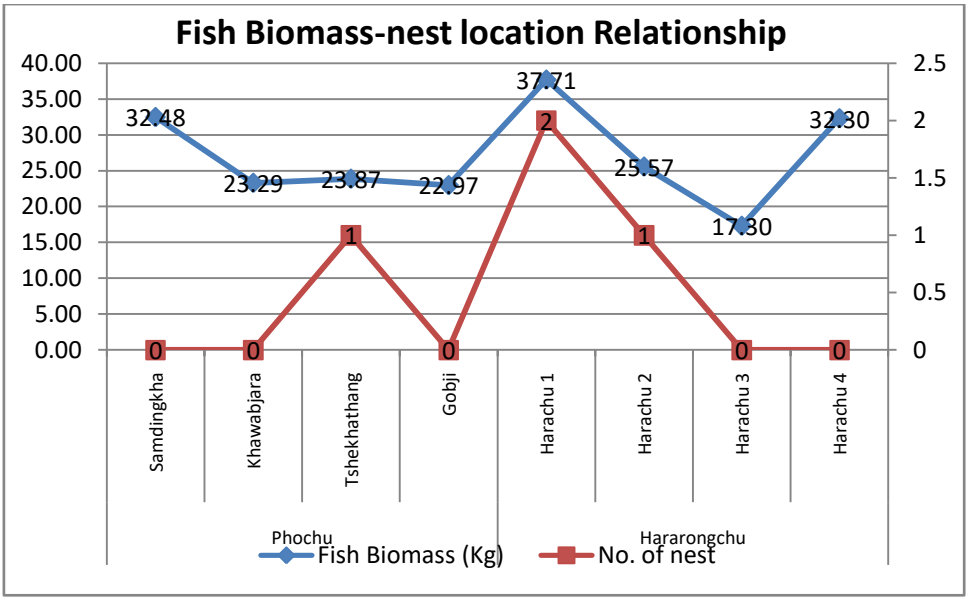


Figure: Graph showing relationship between fish biomass and nest location.

The nest location does not have any relationship with fish biomass. Regression analysis value gives, r^2=0.24 (p value= 0.22), p > 0.05 showing there is no significant relationship.

All captures by WBH were fish and no invertebrates or anurans were recorded (RSPN, 2011). Based on a reported midpoint of bill sizes of 152 mm, RSPN (2011) reported that captured fish ranged in size from an estimated 7.7 to 30.8 cm in length. Often observations were made WBH capturing fishes bigger than their beak size. Despite repeated sampling, RSPN (2011) found only two species large enough to be captured, *Salmo trutta* and *Schizothorax richardsonii*. But the current study found out that including these two species reported by RSPN (2011), 10 species of fish large enough to be prey of the WBH was found. The observation made by RSPN (2011) has some similarities with the current study, current study finding *Salmo trutta* and *Schizothorax richardsonii* top most abundant in terms of biomass. Chances of capturing these two species by WBH may be higher than other species due to their abundance in biomass.

WBH abundance- Habitat variable association:

The WBH sightings and site scores biplot based on CCA of the habitat variables displayed 38.46% of weighted variance in the left set and 100% in weighted variations in the right set and class total of WBH sightings with respect to the habitat variables. The eight values of axis 1 and 2 accounted 0.87 and 0.29 respectively. The biplot of the WBH sightings and site score produced from CCA show the distribution of WBH and sites in ordination

space (Figure). In this plot, 8 sites and 5 habitat variables have been depicted to provide insight into their composition and distribution. The results indicated that WBH presence was highly influenced by the degree of disturbance level. In addition to that the habitat variables such as Depth and Flow are the most important habitat variables for WBH. The results of CCA indicated that the WBH frequently used sites such as Plot 2, Plot 3, Plot 4 and Plot 6 (site 2, 3, 5 & 6 in Figure) were associated with fast flowing habitat with shallow region of the river, whereas WBH abundance was not influenced by fish biomass and other habitat variables.

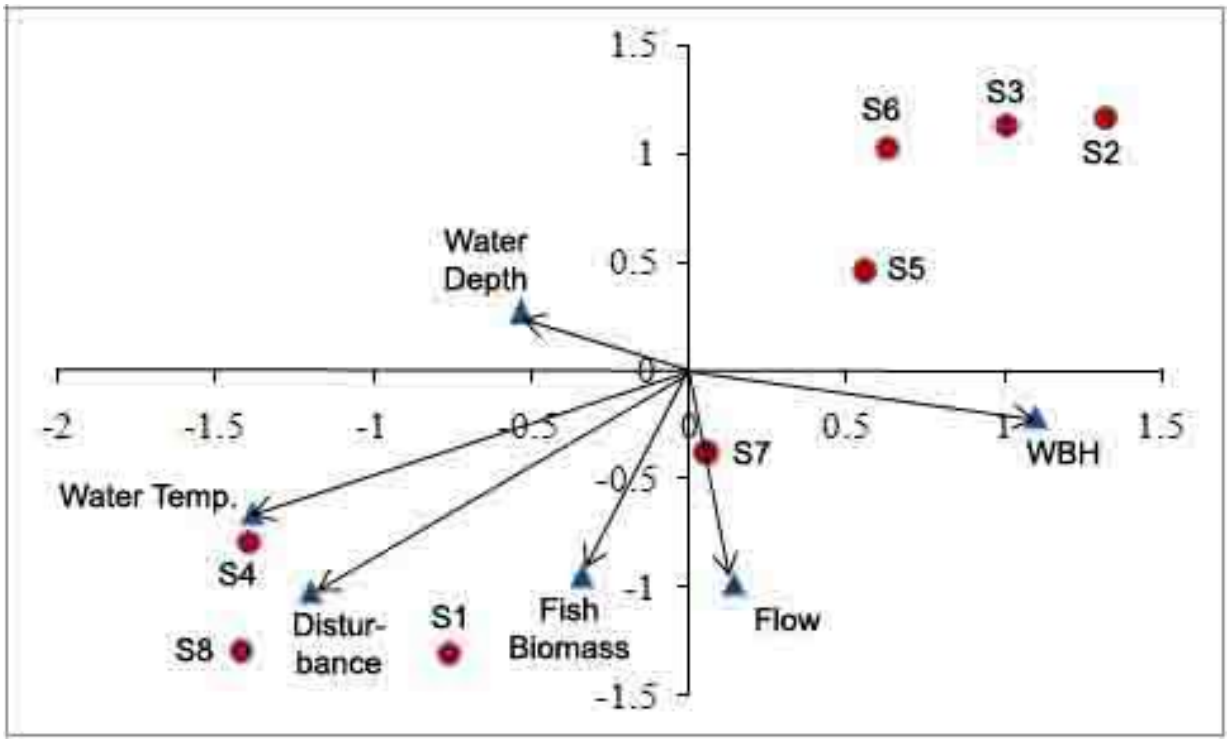


Figure: Canonical Correspondence Analysis (CCA) biplot depicting distribution of WBH along environmental variables in 8 study sites in Hararongchu along Punatsangchu river basin. [Site labels: S1-Plot 1, S2-Plot 2, S3-Plot 3, S4-Plot 4, S5-Plot 5, S6-Plot 5, S7-Plot 7 and S8-Plot 8.]

As per the result from CCA analysis, disturbances heavily influence WBH habitat selection negatively. WBH seems to avoid where higher degree of disturbances are present. Disturbances considered for the study are human activities, agriculture land, vehicle movement, transmission lines and fishing intensity. RSPN (2011) reported that WBH are intolerant to human or related activities within 100 meters. Habitat association of WBH is fast flowing river with shallow depth. This may be due to visibility of prey in the river. WBH feeding technique is mostly sit-and-wait and visual cues are very important. Choosing of fast

flowing and shallow region of the rivers may be attributed to this behaviour of WBH. Biomass of fishes and other environmental variables does not seem to affect WBH abundance in the sites. This may be due to not so significant difference in fish biomass in all the sites (mean=26953.61 g, SD=6641.8). Other environmental variables which do not affect WBH abundance are variables such as water temperature, conductivity, dissolved oxygen, total dissolved solids, pH, river width and altitude. All these variables are similar in all the study sites.

Conclusion

White-bellied Heron is Critically Endangered and rarest heron on the Earth (IUCN, 20018; Price & Goodman, 2015). Therefore all scientific conservation measures have to be implemented sooner. Knowing habitat about the species and conservation measures initiated based on this study will ensure long time survival of the species. For this reason, the current study entitled Habitat Assessment of White-bellied Heron along Punatsangchu river basin was taken.

Foraging and nesting habitat was studied in detailed in this study. Heron habitat are found to be made of pure chirpine forest with no or sparse understory. Study found out that nesting habitats are chosen on steep slope opposite river side of human settlement nearby to the feeding sites.Foraging habitats were found to be in low reaches of streams with multiple channels preferred. Foraging habitat is strongly liked with shallow water irrespective of width. Disturbances incidence such as forest fire and fishing is very commonly observed in field as well as acquired by interview with local people.

WBH abundance and degree of disturbance level are highly associated negatively. WBH abundance is also associated with shallow and fast flowing water irrespective of depth. Fish biomass and other environment variables does not seem to affect WBH abundance.

The overall encounter rate in both the study sites is found to be 0.3 WBH/km.

The local people's perception and attitude are also equally important to conserve the species. The respondents have fair knowledge about the WBH and reasons for their population decline pointing disturbances and habitat degradation to be two main causes. Their attitudes for the conservation of the species in their area are pretty impressive with most respondent agreeing with the need of conservation. But constant awareness education is needed as there is constant conflict between WBH and locals in terms various disturbances and threat posed by locals to WBH.

Yet, there are many attributes of WBH habitat not being able to study during this study time due to time constrains. The resource utilization pattern is one of the main study future researcher must focus on to reduce pressure of bird finding its prey. Understanding ecological process critical to prey availability for WBH is also another attributes researcher must focus on. The immediate research need is to understand their foraging ecology.

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