Distribution and Conservation Threats of Softshell Turtles (*Nilssonia* spp.) in Morang District, Nepal

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Dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science in Zoology with special paper Ecology and Environment

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March 2025

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Date: 2081-12-20
2025-4-2

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March 2025

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February 2025

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Citation: Rai, B. (2025). *Distribution and conservation threats of softshell turtles (Nilssonia* spp.*) in Morang District, Nepal* (MSc dissertation). Central Department of Zoology, Tribhuvan University.

Declaration

I hereby declare that the work presented in this dissertation **"Distribution and conservation threats of softshell turtles *(Nilssonia* spp.*)* in Morang District, Nepal"** has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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Letter of approval

On the recommendation of supervisor "Laxman Khanal, PhD" this dissertation submitted by Bandana Rai entitled **"Distribution and conservation threats of softshell turtles *(Nilssonia* spp.*)* in Morang District, Nepal"** is approved for the examination in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.

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Certificate of acceptance

This dissertation work submitted by Bandana Rai entitled **"Distribution and conservation threats of softshell turtles *(Nilssonia* spp.) in Morang District, Nepal"** has been accepted as a partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

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Acknowledgments

I am incredibly grateful to my supervisor, Associate Professor Dr. Laxman Khanal of the Central Department of Zoology, for his consistent guidance, support, and supervision throughout this work. I would also like to express my appreciation to my senior, Ashmit Limbu, for assisting with the project design, supporting me during my fieldwork, helping with my thesis writing, and advising me on data interpretation and analysis.

I extend my sincere gratitude to Prof. Kumar Sapkota and the Central Department of Zoology for their support during my research. I am also thankful to all faculty members and staff of the Central Department of Zoology for their kind assistance.

I would like to express special thanks to Department of Forest and Soil Conservation for providing research permission.

I am deeply indebted to my sisters, Bardana Rai, Kopila Rai, and Sayusha Dhimal, for their invaluable help during my fieldwork. Additionally, I would like to express my gratitude to the locals of Morang district, who provided assistance and warmly supported me on many occasions during data collection.

Lastly, I extend my heartfelt appreciation to my family and friends for their unwavering support and encouragement throughout my research.

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Abstract

Softshell turtles (*Nilssonia* spp.) are freshwater turtles that act as natural scavengers and indicators of freshwater ecosystem health. Five species of softshell turtles are recorded across Southeast Asian countries, with three species, *Nilssonia nigricans*, *N. hurum* and *N. gangetica* being native to Nepal. This research aimed to assess the distribution and anthropogenic threats faced by *Nilssonia* spp. in Morang District of eastern lowland Nepal and propose potential conservation solutions. This study analyzed environmental and anthropogenic variables affecting distribution of the three turtle species in the eastern lowlands of Morang, Nepal, considering factors such as pH, dissolved oxygen (DO), habitat types (ponds, rivers, wetlands), water depth, connectivity, and the Human Disturbance Index (HDI). The variables are based on their documented relevance to aquatic ecosystems and turtle ecology. The results revealed that temperature (CI = –0.83 to 2.06, estimate = 0.4222, $p > 0.05$), pH (CI = –5.40 to 0.43, estimate = –1.8473, $p > 0.05$), river habitats (CI = –1.82 to 30.74, estimate = 6.7434, $p > 0.05$), wetlands (CI = –3.12 to 24.75, estimate = 4.7402, $p > 0.05$), and connectivity (CI = –23.74 to 1.5, estimate = –6.8630, $p > 0.05$) did not show significant effects on turtle occurrence. However, the HDI (CI = –13.13 to –2.80, estimate = –5.7479, $p < 0.05$)) had a significant negative influence on their distribution. The width of carapace from live turtle specimens was significantly smaller than that of the old carapaces indicating over harvesting of the species. Electrocution, habitat fragmentation and excessive exploitation of resources are the major threats to the softshell turtles in the study area. A questionnaire survey with pre-structured questions was done among the local inhabitants of the study area. Fishing, habitat modification and poisoning were identified as the major conservation threats to softshell turtles in the study area. This study identified human disturbance as a major conservation threat to the softshell turtles in Morang District and suggests for formulating species specific management and conservation strategies.

शोध सारांश

नरम खपेटा भएका कछुवाहरू (*Nilssonia* spp.) सफा पानीमा पाइने कछुवा हुन् जसले प्राकृतिक सफाइकर्ताको भूमिका खेल्छन् र सफा पानीको पारिस्थितिकी प्रणालिको स्वास्थ्यका सूचकका रूपमा काम गर्छन् । यी प्रजातिहरू दक्षिणपूर्वी एसियाका विभिन्न देशहरूमा पाइन्छन्, जस मध्य नेपालमा पाइने तीन प्रजातिहरू *Nilssonia nigricans, N. hurum,* र *N. gangetica* हुन् । यस अनुसन्धानले नेपालको पूर्वी तराई क्षेत्र मोरङ जिल्लामा *Nilssonia* spp. को वितरण र मानवजनित जोखिमहरूको मूल्यांकन गर्ने तथा सम्भावित संरक्षण समाधानहरू प्रस्ताव गर्ने लक्ष्य राखेको छ । यस अध्ययनले यी प्रजातिहरूको वितरणलाई प्रभाव पार्ने प्रमुख चरहरूलाई विश्लेषण गरेको छ, जसमा pH, घुलित अक्सिजन (Dissolved Oxygen), वासस्थानको प्रकारहरु (पोखरी, नदी, तथा सिमसार), पानीको गहिराइ, जडानशीलता (Connectivity), र मानव हस्तक्षेप सूचकांक (Human Disturbance Index) समावेश गरिएका छन् । यी चरहरू जलीय पारिस्थितिकी प्रणालि र कछुवाको पारिस्थितिकीमा देखिएको प्रमाणित महत्त्वको आधारमा चयन गरिएको हो । परिणामहरूले देखाएअनुसार तापक्रम (CI = -०.८३ देखि २.०६, अनुमान = ०.४२२२, p > ०.०५), pH (CI = -५.४० देखि ०.४३, अनुमान = -१.८४७३, p > ०.०५), नदी वासस्थान (CI = -१.८२ देखि ३०.७४, अनुमान = ६.७४३४, p > ०.०५), सिमसार (CI = -३.१२ देखि २४.७५, अनुमान = ४.७४०२, p > ०.०५), र जडानशीलता (CI = -२३.७४ देखि १.५, अनुमान = -६.८६३०, p > ०.०५) ले कछुवाहरूको उपस्थितिमा महत्वपूर्ण प्रभाव देखाएनन् तर, मानव हस्तक्षेप सूचकांक (HDI) ले तिनको वितरणमा उल्लेखनीय रूपमा नकारात्मक प्रभाव पारेको देखिएको छ । जीवित कछुवाका नमूनाहरूबाट प्राप्त क्यारापेसको चौडाइ पुरानो क्यारापेसको तुलनामा उल्लेखनीय रूपमा सानो थियो जसले प्रजातिको अत्यधिक दोहनलाई संकेत गर्दछ । यस अध्ययन क्षेत्रमा सफ्टशेल कछुवाहरूका लागि प्रमुख जोखिमहरूमा विद्युतीय प्रवाह, वासस्थानको गुणस्तरमा ह्रास, र स्रोतहरूको अत्यधिक दोहन रहेका छन् । अध्ययन क्षेत्रमा स्थानीय बासिन्दाहरू बीच पूर्व-संरचित प्रश्नहरू प्रयोग गरी प्रश्नावली सर्वेक्षण गरिएको थियो । उक्त सर्वेक्षण अनुसार, माछा मार्ने क्रियाकलाप, वासस्थानको गुणस्तरमा ह्रास, र विषादीकरण सफ्टशेल कछुवाहरूको संरक्षणका लागि मुख्य चुनौतीहरू हुन् । यस अनुसन्धानले व्यवस्थापन तथा संरक्षण रणनीति बनाउनका लागि केही महत्त्वपूर्ण पारिस्थितिक पक्षहरू थप्ने कार्य गरेको छ ।

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List of abbreviations

Abbreviated form	Details of abbreviations
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CR	Critically Endangered
DO	Dissolved Oxygen
EN	Endangered
GLM	Generalized Linear Model
GPS	Global Positioning System
HDI	Human Disturbance Index
IUCN	International Union for Conservation of Nature
QGIS	Quantum Geographic Information System
VIF	Variance Inflation Factor

1. Introduction

1.1 Background

In Nepal, there are 16 species of freshwater turtles under 10 genera and three families (Praschag et al., 2022; Rai et al., 2022). The genus *Nilssonia* comprises five recognized species: *N. formosa*, *N. gangetica*, *N. hurum*, *N. leithii*, and *N. nigricans* (Liebing et al., 2012). Of these, Indian softshell turtle (*N. gangetica*), Indian peacock softshell turtle (*N. hurum*), and black softshell turtle (*N. nigricans*) have been documented in Nepal. *N. gangetica* occurs in major river systems such as the Rapti and Narayani Rivers in Chitwan National Park, the Ghodaghodi Lake Area of Kailali District, and Koshi Tappu Wildlife Reserve (Aryal et al., 2010; Bista & Shah, 2010; Khatri et al., 2020; Pun et al., 2023). Similarly, *N. hurum* has been recorded in the Timai River, Betana Wetland of Morang and Jhapa District, and Ghodaghodi Lake Area (Bista & Shah, 2010; Kharel & Chhetry, 2012; Rai, 2022), while *N. nigricans* has been identified in the Betana Wetland (Praschag et al., 2022b). Due to overexploitation and habitat destruction, all three species of softshell turtle are facing conservation challenges and are listed as Critically Endangered (*N. nigricans*) (Praschag et al., 2021) and endangered (*N. gangetica* and *N. hurum*) in the IUCN Red List of Threatened Species (Ahmed et al., 2021; Das et al., 2021). Of the three soft shell turtles, *N. gangetica* and *N.nigricans* are identified as very large reaching up to 94 cm and 72 cm carapace length, respectively; and *N. hurum* has more dome carapace shape and have heavier anterior carapace margin (Praschag et al., 2021). These morphological significances will help in the identification of different *Nilssonia* species.

Besides in Southeast Asia two species of *Nilssonia,* Indian softshell turtle (*Nilssonia gangeticus*), Indian peacock softshell (*Nilssonia hurum*) are native to Pakistan. Numerous researchers have documented these turtle species in nearby regions of Khyber Pakhtunkhwa and Punjab province in Pakistan (Ara et al., 2021). This critically endangered species only exists in the pond at the Hazrat Bayazid Bostami shrine in Chittagong, Bangladesh. It is also found in drainage of Brahmaputra River which is located in Assam state of India (Hilton-Taylor, 2000).

This species of turtle is primarily aquatic, frequently found in ponds, rivers, and marshes; it avoids salty environments and prefers freshwater (Kar, 2022). It can be found in the Tarai region of Nepal in both lotic and lentic water bodies (Shah & Tiwari, 2004).

Freshwater turtles are facing serious threats for their existence worldwide. This similar condition occurs in Nepal. Their population is affected by many factors like change in climate, habitat destruction, urbanization, illegal trading for consumption, pet and pharmaceutical industries, human wildlife conflict, due to ethnomedicinal use and modifications near riverbanks or waterbodies (Ali et al., 2018). There is an evident gap in collection of authentic information about *Nilssonia* species in Morang District thus this research will provide science-based information about the distribution and conservation threats of the species. Threatened freshwater turtles have a narrow distribution range, small population size, and a high rate of population decline due to anthropogenic factors. The key abiotic factors shaping their distribution include water quality parameters such as pH, electrical conductivity, and dissolved oxygen, as well as climatic variables like temperature and precipitation (Khan et al., 2021; Mader et al., 2017). Biotic factors, such as the availability of prey and vegetation, also play a significant role in determining habitat suitability. In addition, anthropogenic activities, including habitat alteration, overexploitation, and pollution, severely impact turtle populations (Noureen et al., 2009; Roe & Georges, 2007). For example, sand mining along riverbanks, a common practice in Nepal, destroys nesting habitats and alters water quality, posing significant threats to turtle populations (Sarkar, 2017).

Morang District, characterized by its diverse wetlands, rivers, and floodplain ecosystems, provides critical habitats for softshell turtles. However, this region is also subject to intense anthropogenic pressures, including agricultural expansion, urbanization, and resource exploitation (Aryal et al., 2009). These activities not only degrade aquatic and terrestrial habitats but also threaten the survival of turtle species that rely on specific environmental conditions for nesting, feeding, and hibernation (Dudgeon et al., 2006; Stokeld et al., 2014). This study provides information on factors affecting distribution and conservation challenges in the Morang District.

1.2 Statement of the problem

To date, the only studies that have contributed to the research on turtle species in Nepal are those that discuss records of turtle species to Nepal (Bohara et al., 2024; Khadka &

Lamichhane, 2020; Praschag et al., 2022a), diversity and status including types of habitats that have been identified based on the turtle species existence at the exact moment of observation (Bista & Shah, 2010), distribution and conservation status (Aryal et al., 2010; Aryal, Prasad, et al., 2010; Nepali & Singh, 2018; Pun et al., 2023; Rai, 2003) and threats (Subba & Khanal, 2023). Despite these records, detailed investigations into the factors influencing the distribution of softshell turtles remain scarce in Nepal. To guarantee their distributional range, this type of monitoring should be repeated in other potential locations, and this paper might be useful as a guide for additional investigations.

1.3 Research objectives

1.3.1 General objective

The general objective of this study was to identify the factors influencing the distribution and conservation threats of softshell turtles (*Nilssonia* spp.) in Morang District.

1.3.2 Specific objectives

Specific objectives are:

i. To identify the factors influencing the distribution of softshell turtles (*Nilssonia* spp.) in Morang District.

ii. To identify the major conservation threats to softshell turtles in Morang District.

1.4 Significance of the study

This study aimed to identify and analyze the key biotic and abiotic factors affecting the occurrence of softshell turtles in the eastern lowland of Nepal. By integrating field surveys with biotic and abiotic factors, this research seeks to provide valuable insights into the ecological requirements of these species and the threats they face. Understanding the factors influencing their distribution is critical for effective conservation planning and management, particularly in regions such as Nepal, where these species are poorly studied.

2. Literature review

2.1 Distribution of *Nilssonia* species

According to IUCN red list among the five *Nilssonia* species of three species *N. gangetica*, *N. nigricans* and *N. hurum* are native in Nepal. *N. gangetica* occurs from the lowlands (perhaps 20 m) maybe up to 1,000 m above sea level (Ahmed et al., 2021). It inhabits mostly rivers, and large canals, preferably with turbid water, muddy bottom and some current. Lakes, oxbows, ponds and temporary waterbodies are used occasionally. The species is common throughout its range in the near places from Nepal like northeast India Bangladesh but 2011 Asian Turtle Red List Workshop in Singapore indicated that there is gradual decline in the in numbers, and size of *N. gangetica*. Overall population had likely more than halved (Ahmed et al., 2021). *Nilssonia gangetica* remains widespread and stable in temple ponds. The distribution of *N. gangetica* was recorded within Chitwan National park so far (Khadka & Lamichhane, 2020). The distribution records of *N. hurum* are reported in Chitwan National Park, Sukhlaphanta National Park, Sanischare Jhapa. This lowland species is found up to about 200m above sea level. The current population trend is decreasing (Das et al., 2021).

N. formosa is endemic to Myanmar and has been recorded from sea level to about 200 m above sea level (Horne et al., 2021). Similarly *N. nigricans* is recorded from Meghan Riverside, Karnaphuli River Bangladesh, several ponds of Assam and Tripura of Northeast India and was recorded for the first time in Betana Wetland, Morang (Praschag et al., 2022).The records shows that it's population trend is also decreasing (Praschag et al., 2021). *N. leithi* is native species to India and has disappeared from many places and is only found in (Kali River) Karnataka, Majira Wildlife Sanctuary and Siwaram Wildlife Sanctuary in Telegana.

Of these, Indian softshell turtle (*N. gangetica*), Indian peacock softshell turtle (*N. hurum*), and black softshell turtle (*N. nigricans*) have been documented in Nepal. *N. gangetica* occurs in major river systems such as the Rapti and Narayani Rivers in Chitwan National Park, the Ghodaghodi Lake Area of Kailali District, and Koshi Tappu Wildlife Reserve (Aryal et al., 2010; Bista & Shah, 2010; Khatri et al., 2020; Pun et al., 2023). Similarly, *N. hurum* has been recorded in the Timai River, Betana Wetland of Morang and Jhapa District, and Ghodaghodi Lake Area (Bista & Shah, 2010; Kharel & Chhetry, 2012; Rai, 2022), while *N. nigricans* has been identified in the Betana Wetland (Praschag et al., 2022b). Due to overexploitation and

habitat destruction, all three species of softshell turtle are facing conservation challenges and are listed as Critically Endangered (*N. nigricans*) (Praschag et al., 2021) and Endangered (*N. gangetica* and *N. hurum*) (Ahmed et al., 2021; Das et al., 2021) in the IUCN Red List of Threatened Species.

The understanding of wetland ecosystems allows conservation efforts to be more effective in preserving wetland habitats and species associated with them (Orsholm & Elenius, 2022). This study analyzed the critical factors affecting the occurrence of softshell turtles in eastern lowland of Nepal. A study on the bathymetric preferences of freshwater turtles in northern India revealed that deep pools, ranging from 3 to 18 feet, are favored microhabitats for species such as *N. hurum* and *N. gangetica* (Singh et al., 2021). This preference may be linked to the bottom-dwelling nature of softshell turtles (Mital, 2016). Conversely, turtles like the Indian flap shell turtle (*Lissemys punctata*) and Brown roofed turtle (*Pangshura smithii*) are rarely found in large river systems, typically preferring shallow waters with a maximum depth of 4 meters (Mital, 2016; Wahab et al., 2012). These turtles are often observed in ponds, among floating vegetation, or along riverbanks, classifying them as pelagic or surface-feeding species.

Several ecological factors explain the preference for deeper water bodies among turtles. Deeper habitats offer increased protection from predators, allowing turtles to retreat to less visible depths (Mital, 2016). They also provide more stable thermal conditions, crucial for the thermoregulation of ectothermic reptiles (Delatorre et al., 2020). Additionally, deeper waters support a richer diversity of benthic food resources, including mollusks and crustaceans, which are key dietary components for bottom-dwelling turtles like *Nilssonia* spp. (Singh et al., 2021). The larger volume of water in deeper habitats ensures better oxygen availability, essential for turtles that remain submerged for extended periods (Wahab et al., 2012). However, no significant relation has been observed in this study. It may be due to a survey that has been carried out in the water depth between 3.5 to 12.40 feet. Furthermore, deeper water bodies are less susceptible to seasonal drying, offering turtles a more reliable refuge (Mital, 2016). However, while shallow waters may dry up quickly, extremely deep waters can restrict basking and foraging opportunities (Mondal et al., 2016).

In Nepal, common disturbances in the area include water poisoning, electrocution, overfishing using gillnets and large nylon nets, and wetland encroachment for agricultural, economic, and recreational purposes. Similar challenges have been reported by other

researchers, including habitat destruction, water pollution, unsustainable fishing practices, and a high demand for turtle meat and medicinal use of their body parts (Ahmed et al., 2021; Das et al., 2021; Khan et al., 2016; Mital, 2016; Wahab et al., 2015). Additional threats to turtle survival include restricted movement, egg predation, overpopulation, a lack of nesting sites, and inadequate facilities for hatching and rearing (Kanungo et al., 2020; Praschag et al., 2021). Habitat type is essential for freshwater turtles as it directly influences their survival, reproduction, and overall ecology. Freshwater turtles rely on diverse aquatic ecosystems such as rivers, lakes, wetlands, and ponds that provide critical resources like food, basking sites, and suitable nesting (Buhlmann et al., 2009). These habitats are particularly important for thermoregulation, as turtles depend on the availability of sunlit areas and shaded waters to regulate their body temperature (Moll & Moll, 2004). The quality of freshwater habitats also determines nesting success, with turtles often requiring specific substrate types for laying eggs, as well as stable environmental conditions to ensure proper incubation (Markle et al., 2021; Massey et al., 2019; Van Huizen et al., 2024).

Furthermore, freshwater turtles are highly sensitive to habitat degradation caused by pollution, overfishing, wetland drainage, and agricultural expansion, which directly impacts their survival and reproductive rates (Gong et al., 2017; Haddad et al., 2015; Medková et al., 2017; Stanford et al., 2020). Complex habitats with submerged logs, aquatic vegetation, and riverbanks also provide shelter from predators and support juvenile turtles' survival (Ara et al., 2021; Das et al., 2021; Mital, 2016). Fragmentation or loss of these habitats disrupts migration routes between feeding, breeding, and overwintering sites, leading to population declines (Bárcenas-García et al., 2022; Gong et al., 2017; Tucker et al., 2012).

Habitats also play a crucial role in maintaining genetic diversity, as connectivity between populations reduces inbreeding and ensures resilience against environmental changes (Dresser et al., 2018; Hamer et al., 2016; Lowe & Allendorf, 2010; Marandel et al., 2018). With increasing threats from climate change, such as altered water levels and rising temperatures, intact and functional freshwater habitats are indispensable for the long-term survival of these species providing refugia (Finlayson, 2013; N. J. Mitchell & Janzen, 2010).

2.2 Conservational threats of *Nilssonia* species

Nilssonia spp. is being exploited for local consumption and regional and international trade within its range. As it is illegal to trade live specimen it has shifted trade to processed meat,

processed cartilaginous margin of the carapace (Horne et al., 2021). They are collected for food markets and in domestic pet trade. In addition water pollution and destruction of habitat fishing nets are the threat factors for this species (Das et al., 2021). They are highly exploited among the species as it is slow in breeding besides the human settlement near the river banks gold mining, illegal using fishing electric current and high boat traffic in the river (Horne et al., 2021). Similarly, *N. nigricans* is also under the same pressure of exploitation and has been documented to be declined by 20% per generation. Breeding depressing and fungal infection are the major causes of threats to this species (Praschag et al., 2021).

In Nepal, turtles face exploitation for various purposes, including bushmeat consumption, superstitions, decorative use, the pet trade, religious rituals, and medicinal practices. In the lowland regions, they are often killed as by catch when caught in nets, traps (Ali et al., 2018), or baited lines (Fratto et al., 2008) originally set for fishing. Freshwater turtle populations also suffer due to destructive and unsustainable fishing methods, such as the use of dynamite, electric shocks, and pesticides, which result in high mortality rates (Ewing, 1999; Noureen et al., 2009). The introduction of toxic chemicals into water bodies to enhance fish capture further threatens freshwater turtles (Saeed et al., 2011). These harmful activities disrupt crucial turtle behaviors, including nesting, hibernation, aestivation, and foraging, significantly endangering their survival.

Additionally, ethnic communities such as the Santhal, Rajbanshi, and Majhi utilize softshell turtle body parts for ethnomedicinal purposes (Kharel & Chhetry, 2012). Such human-driven activities are widespread in Nepal's lowlands and continue to pose severe challenges to turtle conservation efforts.

3. Materials and methods

3.1 Study area

Morang District is located in the eastern part of Nepal, bordering Jhapa to the east, Sunsari to the west, Panchthar and Dhankuta to the north, and Bihar, India, to the south. It covers an area of 1,855 km², with the lowest elevation at 60 meters and the highest at 2,410 meters above sea level (Subba et al., 2017). The district includes both the Tarai region and the southern slopes of the Mahabharat Hills, from which most of its rivers originate. In addition to these natural water sources, man-made ponds, canals, reservoirs, pools, and ditches are also present. This study examines *Nilssonia* species across the entire lowland waterbodies of Morang District (Sindaco & Razzetti, 2021).

This study was conducted across 70 locations in the lowland regions of the Tarai, within Morang district. These locations included 11 wetlands, 8 ponds, 5 canals, and 3 rivers. The wetlands included were Hasina (26°41'30.48" N, 87°18'53.78" E), situated in Sundar Haraicha Municipality at an elevation of approximately 120 m. Betana Wetland (26°39'33.71" N, 87°25'55.56" E), Sisauli Wetland (26°40'0" N, 87°25'20" E), Baghjhoda Wetland (26°40'43" N, 87°23'51" E),Amana Wetland (26°40'43" N, 87°23'51" E) of Belbari, Vallui Simar Kanepokhari (26°38'30" N, 87°30'33" E), Beteni Simsar (26°40'54" N, 87°36'34" E) & Lampatey Wetland (26°40'17" N, 87°34'37" E) of Urlabari, Jhaljhali Wetland,Dangihat (26°38'20" N, 87°27'59" E), Shree Shanti Bhulkhe Wetland (26°39'46.51" N, 87°33'45.57" E), located in Pathari Sanischare Municipality at an altitude of 143 m and Santoli Simsar (26°37'55.2"N, 87°31'45.0"E).
Similarly, the ponds include Sukuna, Radhanagar, Sunbarsipokhari, Kamalpokhari, Salakpur pond, Dhampalgadi pond, Sunjhoda and a pond in Naxal. Rivers like Lohandra,Singhiyaa and Dhadar khola were also studied.

The district is endowed with a variety of habitats, including tropical and subtropical forests, grasslands, and agricultural landscapes. Wetlands form a critical component of their ecology, supporting both biodiversity and local livelihoods. They also provide refuge for a variety of aquatic flora and fauna, including several threatened species (Adhikari & Chhetry, 2017; Baral, 2009; IUCN, 2004; Jha, 2009). However, water-related habitats account for only a small portion of 0.987% of the total area yet remain crucial as potential habitats for softshell turtles. Aquatic biodiversity in these regions faces significant threats from wetland habitat

degradation, overfishing with hooks and gillnets, and harmful practices such as poisoning and electrocution.

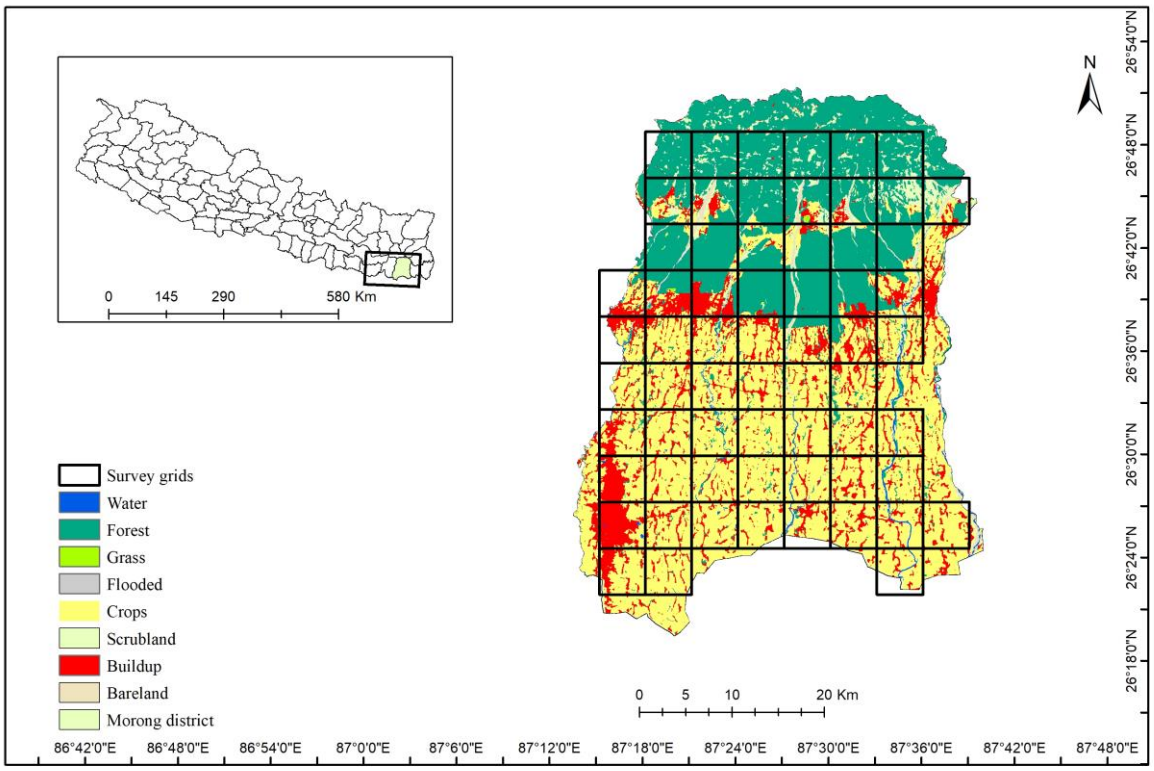

Figure 1. Map of the study area (Morang District) representing waterbodies, forest, grass, flooded area, agricultural land, scrubland and buildup.

3.2. Field survey

The water sources were geo-referenced during preliminary field surveys using Google Earth imagery, and 5×5 km grids were established to cover the total study area. In each grid, minimum two survey points were selected from wetlands, rivers, and ponds for assessment. Data was collected using both spatial and temporal replicates at each water source, with each sampling station surveyed at least three times to maximize the detection due to their very elusive nature (Mackenzie & Royle, 2005). Species encountered were identified using field guides and color photographs following Das (1985) and Shah & Tiwari (2004). Live individuals and shells were examined, photographed, and identified using the field guidebooks.

3.3. Data collection

The survey was conducted from October 2024 to January 2025 in different study sites within the grid and at least two representative survey points were selected from water bodies like wetlands, rivers and ponds. Both direct and indirect observation methods were used as a strategy for study of freshwater turtles. Visual inspections were carried out of turtles point count (Saeed,2015) of turtles was carried out and total of sampling points were established in the study area at the interval of 100m in each wetland and pond for systematic observation. The number of sampling points were varied according to the size of wetlands.

At each point, a 20×20m plot was established at the interval of 100 m, recording the presence/absence of turtle species and furthermore GPS location was recorded.

For effective survey observations from the banks, binocular was used in the large wetlands and rivers. Incidental sightings were also recorded as turtles have been sighted mostly during basking activity in winter which keeps them warm. The study areas were visited in much different timing mostly in early morning, afternoon and in evening (Kanwal & Khan, 2018).

Data was collected on water temperature variation, pH, water depth, food and feeding habits, breeding facilities, and other factors related to the conservation of *Nilssonia* species. Geographical locations were tracked using GPS. Dissolved oxygen (DO) and temperature of the water samples were measured using a Lutron PDO-520 (Lutron Electronics, accuracy ±0.4 mg/L). Water depth was recorded using a custom-made dipping probe consisting of a thread weighted with a metal at the end. A measuring tape was used to determine the size of the shells and live specimens found in the study area. Additionally, weight was recorded using an electronic digital hanging scale with an accuracy of 0.02 kg (0.05 lb), and the presence or absence of *Nilssonia* species was documented. Other environmental variables, such as the presence of invasive species, connectivity, and habitat type, were also recorded.

To calculate the Human Disturbance Index (HDI), five variables were categorized: 1) HM – habitat modification, 2) E – electrocution, 3) P – poisoning, 4) F – presence of fishing, and 5) T – traps and hooks. To prevent overestimating or underestimating the influence of individual variables, equal weights (0.2) were assigned to each. The HDI for each survey point was calculated using the formula: $HDI = (HM \times 0.2) + (E \times 0.2) + (P \times 0.2) + (F \times 0.2) + (T \times 0.2)$. The HDI values were then averaged based on replicates for each site (Fagerland & Hosmer, 2012). Structured Questionnaire was conducted after rapport for the documentation

of people's perception towards softshell turtles and their conservational threats. In each household, an adult individual (aged 16 years or older) was selected and asked about their willingness to participate in the interview. Prior to the interviews, participants were informed about the study's objectives and obtained their verbal consent. Data was gathered using the snowball sampling method due to the challenges of accessing fishing communities for research (Shuva, 2017). This approach relies on referrals, where initial participants help identify others who may be difficult to reach but possess relevant characteristics. As each respondent recommends new participants, the sample size expands progressively (Naderifar et al., 2017). The interviews were conducted in Nepali or local languages, with each interview taking 20–25 minutes to complete (Aryal et al., 2010b).

3.4. Data analysis

A descriptive statistic was calculated to identify the location of the data of continuous variables around the mean. Presence absence of the *Nilssonia* spp. was used as a responsible variable and water PH, water temperature, DO, HDI, connectivity and invasive species was used as predictive variables. Before model run, a correlation test was performed to avoid multi-collinearity among the predictive variables. Multicollinearity was assessed using VIF and the predictor variable invasive species was excluded as the VIR value was 12.34 as severe multicollinearity may distort the results. Besides the other predictor variables such as water temperature, PH, HDI, habitat type and connectivity were used for GLM as the VIF<5. Generalized Linear Models (GLMs) with a logit link function were compared using binomial data to determine the full model. The plot was built without standardized data for interpretability using ggplot2 in R studio (R Core Team, 2023). All the questionnaire responses were organized in Microsoft Excel and then grouped and summarized similar open-ended answers. Descriptive statistics were calculated to describe the socio-demographic traits, knowledge, attitudes, and threats related to the softshell turtles. For measuring people's attitudes toward different statements, a five-point Likert scale were used: strongly agree, agree, neutral, disagree, and strongly disagree. Pearson's Chi-squared test was used to test the significance between different variables with the people's attitude towards softshell turtles. The Chi-Square ($\chi 2$) test was used to explore the relationship between socio-demographic factors, such as age, gender, and education level, and their influence on knowledge about conservation threats and their attitudes towards softshell turtles.

4. Results

4.1. Distribution of softshell turtles in Morang District

4.1.1 Spatial distribution of softshell turtles in Morang District

Out of 70 locations surveyed (Fig. 1), softshell turtles were detected at 12.85% of the sites (n = 9) (Fig. 2). Six of these records were identified as *N. gangetica*, two as *N. nigricans*, and ten as *N. hurum*.

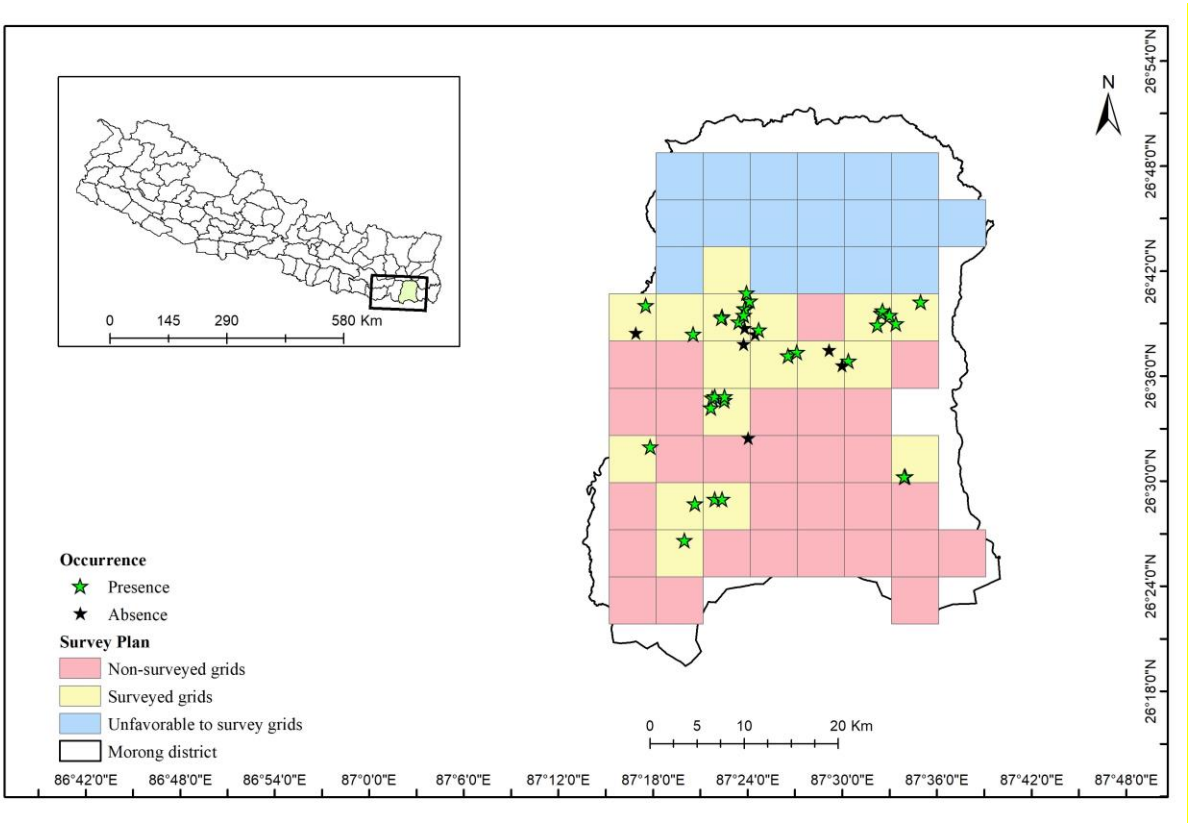

Figure 2. Map of the study area showing the distribution of *Nilssonia* spp. in lowland waterbodies of Morang District; black star represents the presence points where green mark represents the non- presence points.

Total 18 observations of softshell turtles were made from the nine sites, of which, 77.78% (n= 14) were from wetland, 11.11% (n=2) were from rivers and 11.11% (n=2) were from ponds.

4.1.2 Environmental factors affecting distribution of softshell turtles

The GLM revealed that the occurrence of softshell turtles (*N. hurum*, *N. gangetica*, and *N. nigricans*) was negatively affected by the Human Disturbance Index (HDI) (CI = –13.13 to –2.80, estimate = –5.7479, $p < 0.05$). In contrast, other predictive variables, such as temperature (CI = –0.83 to 2.06, estimate = 0.4222, $p > 0.05$), pH (CI = –5.40 to 0.43, estimate = –1.8473, $p > 0.05$), river proximity (CI = –1.82 to 30.74, estimate = 6.7434, $p > 0.05$), wetland presence (CI = –3.12 to 24.75, estimate = 4.7402, $p > 0.05$), and connectivity (CI = –23.74 to 1.5, estimate = –6.8630, $p > 0.05$) were not statistically significant in determining softshell turtle presence or absence.

Table 1. Relation of softshell turtles' distribution with the environmental and anthropogenic variables

	Estimated	**Std. Error**	**Z Value**	**Lower CI**	**Upper CI**	**Pr(>|z|)**
(Intercept)	–2.5352	4.1513	–0.611	–12.41	2.74	0.5414
Temp	0.4222	0.6473	0.652	-0.83	2.06	0.5142
HDI	–5.7479	2.2735	–2.528	–13.13	–2.80	0.0115*
PH	–1.8473	1.3445	–1.374	–5.40	0.43	0.1695
River	6.7434	9.7657	0.691	–1.82	30.74	0.4899
Wetland	4.7402	9.3274	0.508	–3.12	24.75	0.6113
Connectivity (Yes)	–6.8630	9.3915	–0.731	–23.74	1.5	0.4649

* Statistically significant

Given that the confidence interval included both positive and negative values, that was uncertain and weak correlation between temperature and turtle occurrence. Thus, water temperature is not statistically significant in identifying the presence or absence of softshell turtles.

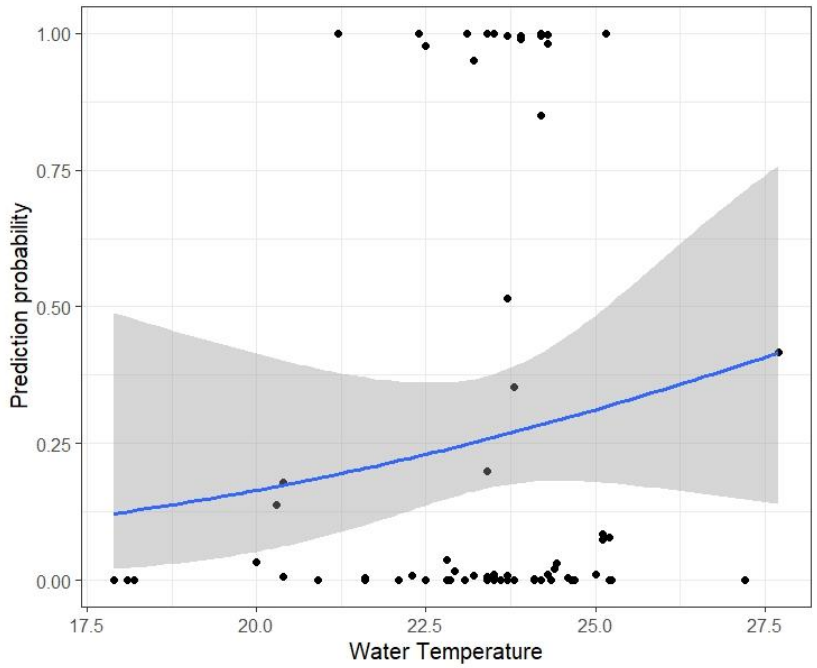

Figure 3. Relationship between water temperature and prediction probability of *Nilssonia* spp. occurrence.

Results revealed that when HDI surpasses moderate levels, the occurrence of softshell turtles declines significantly. At sites where the species was detected, the mean HDI was 0.31±0.15, reflecting moderate to high disturbance levels.

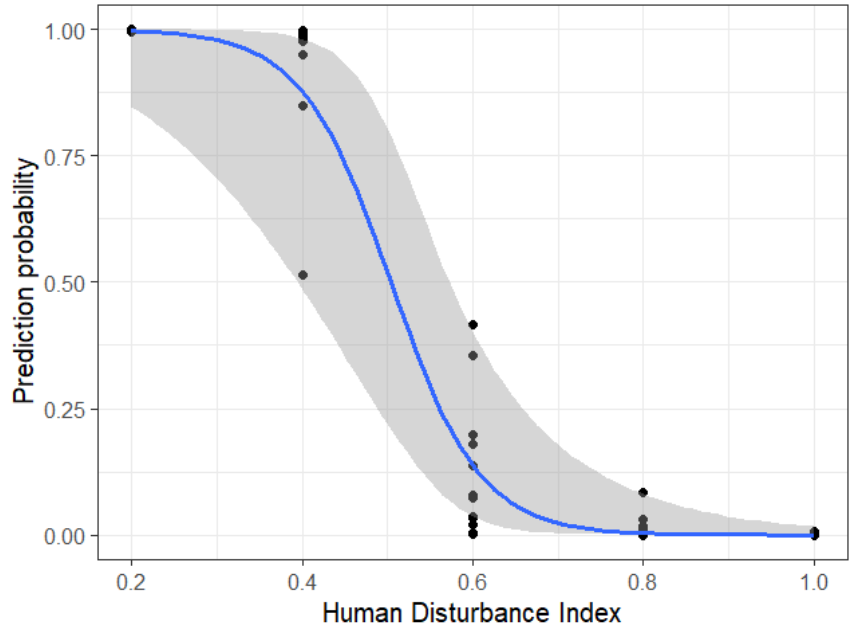

Figure 4. Relationship between Human Disturbance Index (HDI) and prediction probability of *Nilssonia* spp. occurrence.

The water pH did not have significant effect on the prediction probability of softshell turtles. The CI includes zero, indicating that this effect is not statistically significant even if pH had a negative estimate (implying that a lower pH would diminish turtle presence).

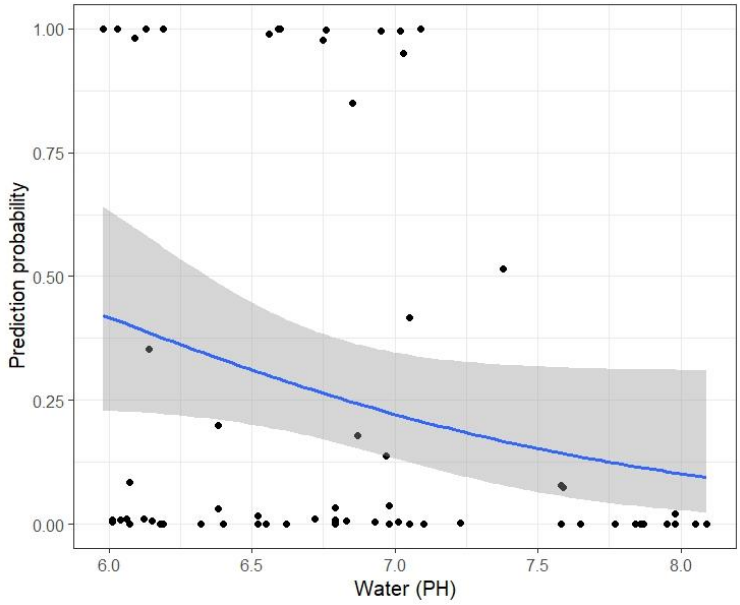

Figure 5. Relationship between water PH and prediction probability of *Nilssonia* spp. occurrence.

The water depth (Figure 6) and dissolved oxygen (Figure 7) did not have significant effect on the prediction probability of softshell turtles. Although the large CI indicates that this effect is not definitive, the positive estimate implies that higher depth of water and higher dissolved oxygen are better predictors of softshell turtles.

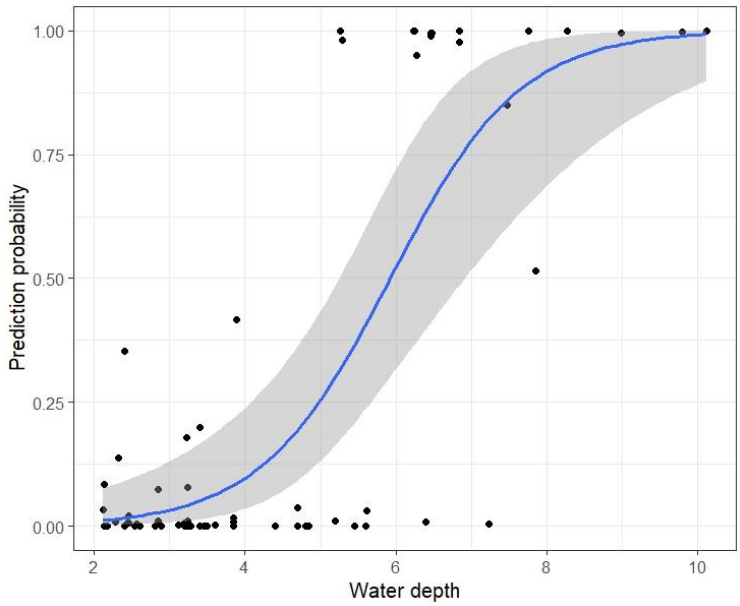

Figure 6. Relationship between water depth and prediction probability of *Nilssonia* spp. occurrence.

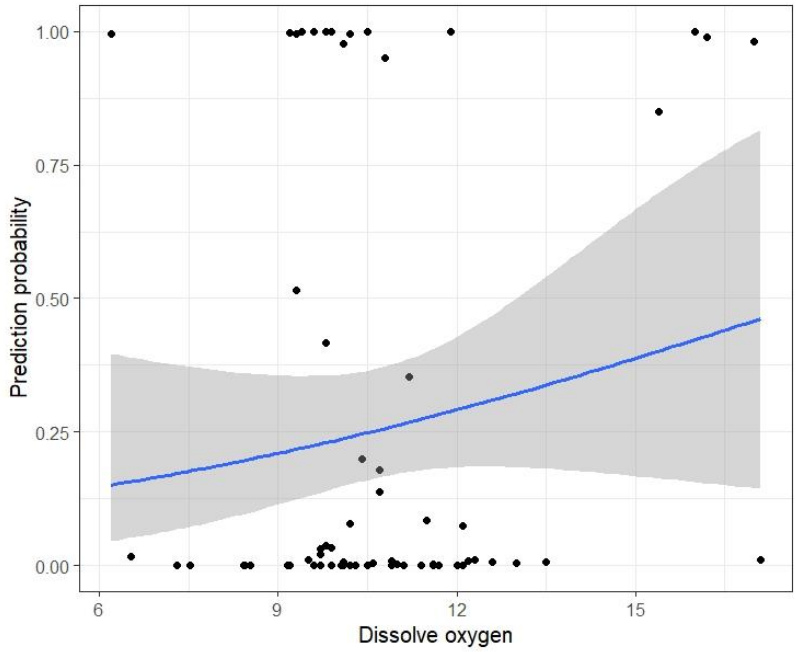

Figure 7. Relationship between water temperature and prediction probability of *Nilssonia* spp. occurrence.

Although not statistically significant, the negative estimate implies that fragmentation may be detrimental to softshell turtles.

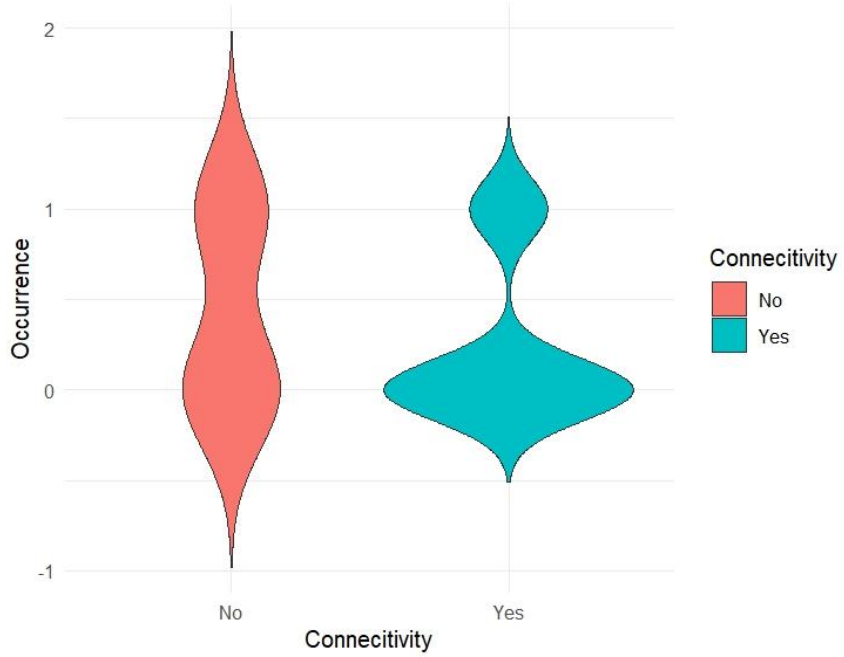

Figure 8. Relationship between and prediction probability of *Nilssonia* spp. occurrence.

4.2 Conservation threats to softshell turtles

4.2.1 Carapace morphometrics as an indicator of overharvesting

Besides live specimen records of softshell turtles in the study area, an additional eight carapaces were recorded from the local households. The average mean of the carapace length of live specimen was 13.55±4.62 and that of the old carapace specimen was 15±4.27 (Figure 9). The comparison of the length of carapace of live specimen and dead softshell turtles was done using Kruskal-Wallis test which reveals chi-squared=2.6706, df= 1, p-value= 0.1022. As the p-value (0.1022) exceeds 0.05, the outcome is not considered statistically significant.

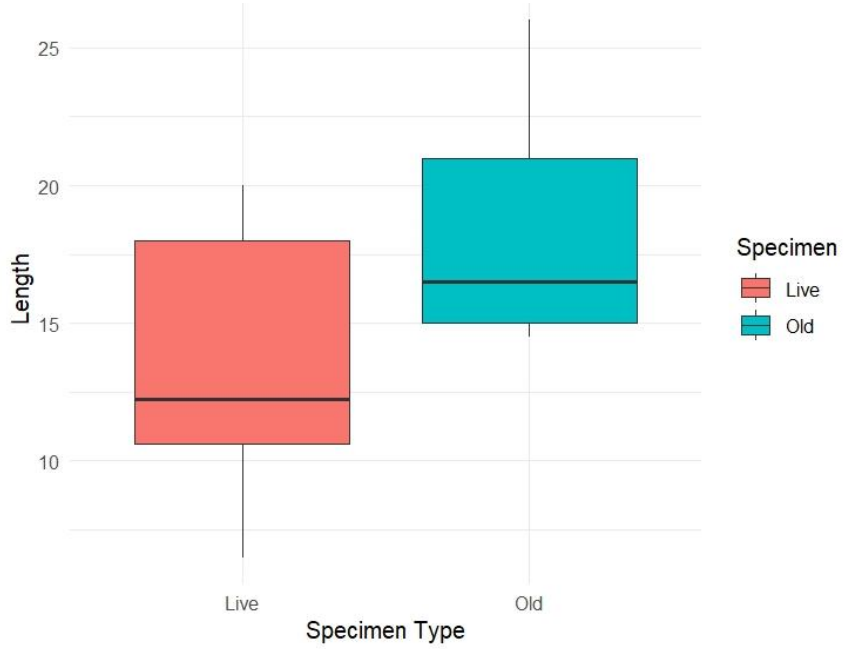

Figure 9. Scatter plot showing the relationship between the lengths of the carapaces of living and dead softshell turtles.

The carapace breadth of the dead specimen is 12.5 with a standard deviation of 3.61, while the mean of the live specimen is 10.45 with a standard deviation of 3.89. The Kruskal-Wallis test was used to compare the carapace widths of the living and dead softshell turtles; the results show chi-squared = 4.2659, df = 1, and p-value = 0.03859. This indicates that there is enough data to imply that there are notable differences in the carapace width between softshell turtles that are alive and those that are deceased.

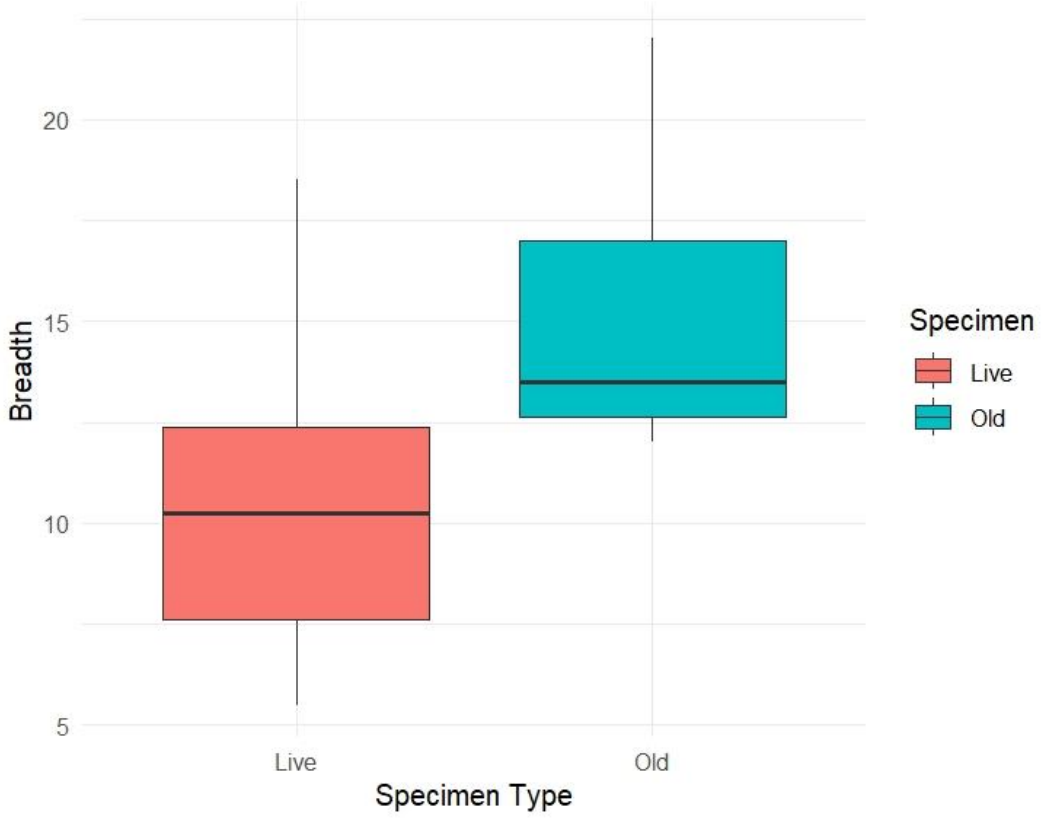

Figure 10. Relationship between the breadths of the carapaces of living and dead softshell turtles.

4.2.2 Identification of conservation threats based on questionnaire survey

4.2.2.1 Demographic profile of respondents

Among the total respondents, (57%, n=57) were male, and (43%, n=43) were female. The respondents' ages ranged from 17 to 81 years. The highest percentage of respondents, 47% (n=47), belonged to the middle-aged group (40–59 years), followed by young adults (17–39 years) at (36%, n=36) and older adults (≥60 years) at (17%, n=17). Regarding education, 77% (n=77) of the respondents had not received formal education, (2%, n=2) had completed primary education, (17%, n=17) had completed secondary education, (4%, n=4) had completed higher secondary education. The respondents belonged to different ethnic groups: (62%, n=62) were Janajati, (10%, n=10) were Brahmin, (8%, n = 8) were Chettri, and 15%, n=15 was Madhesi and 5% n=5 belonged to Dalit community. The main occupation of the respondents was agriculture (71%, n=71), followed by laborer (12%, n=12), fisherman (5%,

n=5), wetland management members (5%, n=5), student 42%, n=4) and government officials were (3%, n=3).

Table 2. Demographic profile of the surveyed people

Socio demographic status	Category	Total	Percentage (%)
Gender	Male	57	57
	Female	43	43
Age	Young adult (16-39)	36	36
	Mid adult (40-59)	47	47
	Old age (>60)	17	17
Education	Illiterate	77	77
	Primary	2	2
	Secondary	17	17
	Higher secondary	4	4
Ethnicity	Brahmin	10	10
	Chettri	8	8
	Janajati	62	62
	Madhesi	15	15
	Dalit	5	5
Occupation	Agriculture	71	71
	Laborer	12	12
	Fisherman	5	5
	Wetland management	5	5
	Student	4	4
	Government officials	3	3

4.2.2.2 People's knowledge of conservation and their attitudes towards softshell turtles

One of the major conservation threats to turtles is their killing for food and ethnomedicine. The survey revealed that 63% of respondents identified fishing in rivers, ponds, and wetlands as the primary cause of turtle deaths. Additionally, 19% reported that habitat modification has led to turtle mortality, as heavy machinery is used to dig ponds and wetlands, while tractors in agricultural fields inadvertently kill turtles during their feeding activities. Furthermore, 13% of respondents attributed turtle deaths to poisoning, citing the rise of commercial farming near rivers, where reliance on synthetic fertilizers, pesticides, and chemicals has increased. Lastly, 5% of respondents stated that electrocution also contributed to turtle fatalities (Figure 4).

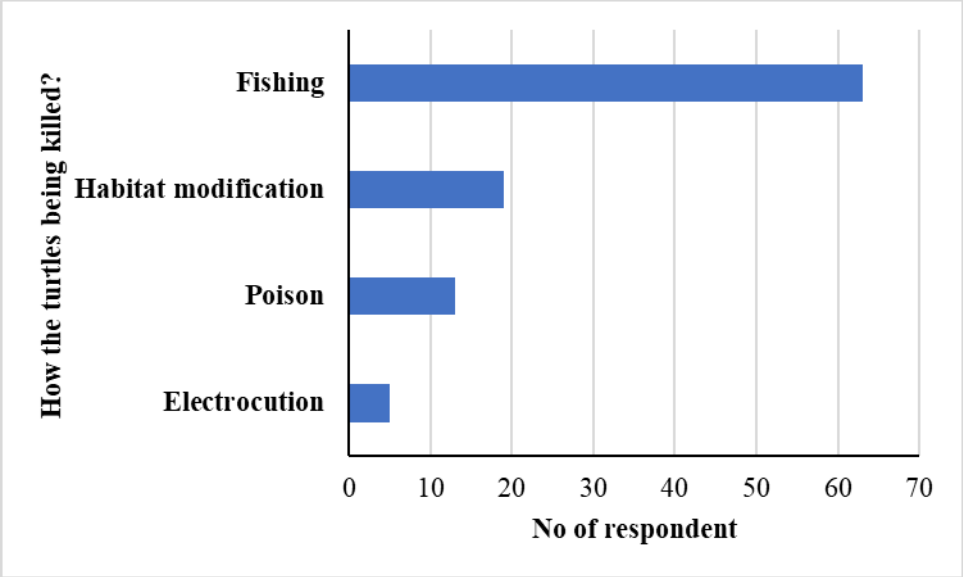

Figure 4. Major threats to softshell turtles in Morang, Nepal: Fishing is the leading cause of mortality, followed by habitat modification, poisoning, and electrocution.

From the survey, 49% of respondents strongly acknowledged the cultural significance of turtles, while another 49% agreed, and only 2% remained neutral ($\chi^2 = 10$, df = 8, p = 0.265). Regarding the ecological role of softshell turtles in maintaining freshwater ecosystems, 30% agreed, while a significant 63% were neutral or unaware, and 7% disagreed ($\chi^2 = 18$, df = 12, p = 0.1157). Additionally, 29% of respondents believed that local communities benefit economically from softshell turtles. When asked about their use in ethnomedicine, 54% strongly agreed and 45% agreed that their carapace, eggs, and body parts are commonly utilized by various ethnic groups ($\chi^2 = 10$, df = 8, p = 0.265). Concerns about declining turtle populations were also evident ($\chi^2 = 15$, df = 12, p = 0.2414), with 58% strongly believing in their decline and 18% agreeing, based on the number of softshell turtles they had encountered. Furthermore, 35% of respondents stated that turtles are being killed by humans in the surveyed area, while 18% strongly agreed ($\chi^2 = 15$, df = 12, p = 0.2414). Regarding illegal trade, 18% strongly agreed and 36% agreed that it contributes to population decline ($\chi^2 = 8$, df = 6, p = 0.2381). Similarly, 32% strongly agreed that softshell turtles are fully exploited, while 55% attributed the decline to human activities and habitat destruction ($\chi^2 = 20$, df = 16, p = 0.2202). When asked about the willingness towards conservation, 45% showed willingness to participate in conservation activities for protecting softshell turtles and 79% strongly agreed to save turtle in their locality ($\chi^2 = 15$, df = 12, p = 0.2414) (Figure 5).

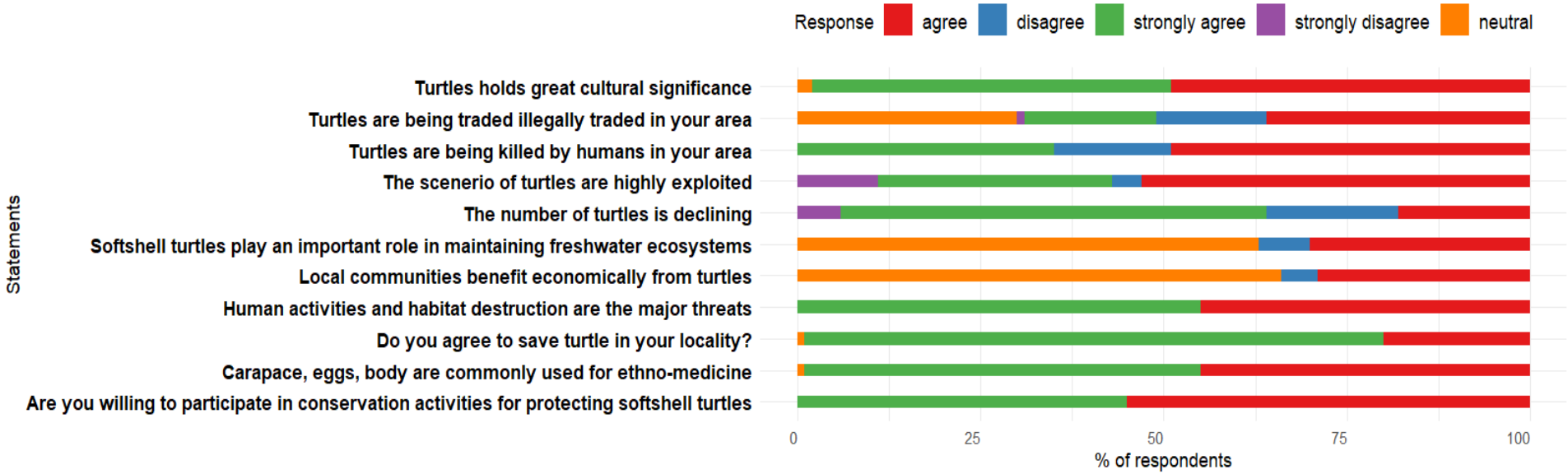

Figure 5. Likert chart showing the local people's attitude towards softshell turtle and its conservation threats.

To evaluate the relationship between respondents' attitudes and other softshell turtle-related factors, the Pearson's Chi-squared test was used. Among the turtle attitude categories no significant different was observed as most of the responses were inconclusive. Although there is insufficient confidence to reach a solid conclusion, the data may indicate a trend.

4.2.2.3 Knowledge on conservation status and approaches for softshell turtles

The conservation agreement by demographic analysis examines the percentage of respondents who agree or disagree with tortoise conservation across different demographic groups. The significance of each factor was measured using a p-value from Pearson's Chi-squared test. Occupation was the only factor significantly influencing awareness of the species' conservation status ($\chi^2 = 33.192$, df = 15, p = 0.004416), while age, gender, ethnicity, and education had no significant effect. Among 100 respondents, 44% (n = 44) of males and 35% (n = 35) of females strongly supported the conservation of softshell turtles. The survey revealed that 46% of local residents strongly disagreed with the effectiveness of government regulations and policies, while only 3% of those working in wetland areas supported them. On the other hand, 52% of respondents strongly believed that community-based conservation programs could help protect softshell turtles.

Additionally, 56% of people were unaware that *Nilssonia* species are endangered and listed on the IUCN Red List, while one-fourth of the surveyed individuals were either neutral or uninformed. Nearly half (48%) of respondents did not know that *Nilssonia* species are legally protected, 29% were neutral, and only 22% of residents living near wetlands were aware of their protected status. Furthermore, 80% of the individuals surveyed had never seen *Nilssonia* species in the area, with only 20% reporting any encounters with them.

5. Discussion

5.1. Factors affecting distribution of softshell turtles

Although the number and coverage of research have always been small, attempts have been made at various points in time to explain the distribution and occurrences of species. Conservation efforts can more successfully preserve wetland habitats and the species that are connected with them (Orsholm & Elenius, 2022).Turtles' a preference for deeper bodies of water can be explained by a number of biological reasons. Turtles can hide in less obvious depths in deeper settings because they are more protected from predators (Mital, 2016). This statistical analysis suggests that while environmental factors like temperature, wetlands, and rivers play a role in *Nilssonia* distribution, human impact (HDI) is a significant threat to their survival in Morang District.

Our study highlights that increasing human-induced disturbances, as reflected by the HDI, result in a decreased likelihood of encountering softshell turtles. The mean HDI across all survey sites was 0.68 ± 0.27, signifying a high degree of anthropogenic pressure on the habitats of softshell turtles in eastern Nepal. Common disturbances in the area include water poisoning, electrocution, overfishing using gillnets and large nylon nets, and wetland encroachment for agricultural, economic, and recreational purposes. Similar challenges have been reported by other researchers, including habitat destruction, water pollution, unsustainable fishing practices, and a high demand for turtle meat and medicinal use of their body parts and their use in different rituals(Ahmed et al., 2021; Das et al., 2021; Khan et al., 2016; Mital, 2016; Wahab et al., 2015). Additional threats to turtle survival include restricted movement, egg predation, over pollution, a lack of nesting sites, and inadequate facilities for hatching and rearing (Kanungo et al., 2020; Praschag et al., 2021).As the wetlands are modified using machines and concrete walls are constructed around the water resources.

The HDI was incorporated to quantify the impact of anthropogenic pressures on turtles distribution within the different habitats of lowland region of Morang district. HDI reflects land-use changes, urbanization, and agricultural activities, which degrade water quality, destroy nesting sites, and alter habitat connectivity (Sarkar, 2017; Stokeld et al., 2014). As the Tarai's population grows and human settlements encroach on wetland areas, people opt to take use of the resources, especially turtles (Aryal et al., 2009; Jha, 2009). Turtles are killed when they are accidentally captured using nets, traps (Ali et al., 2018) and baits (Fratto et al.,

2008) intended to capture fish. Freshwater turtle species are also negatively impacted by a range of destructive and unsustainable methods, such as dynamite explosion, electric shocks, and pesticide (water poisoning) to catch the greatest number of fish, which leads to a high mortality rate (Noureen et al., 2009). The number of freshwater turtles has suffered as a result of the introduction of harmful chemicals into the water to enhance fish capture. (Saeed et al., 2011).

Our findings show that when HDI surpasses moderate levels, the occurrence of softshell turtles declines significantly. At sites where the species was detected, the mean HDI was 0.31 ± 0.15, reflecting moderate to high disturbance levels. Notably, much of the surveyed region is already nearing the species' tolerance threshold. These findings emphasize the substantial negative impact of human activities on turtle habitats and stress the urgent need for targeted conservation measures.

The surveyed area reveals almost all the species of turtles are found to be dependent on wetland. Hence, the conservation of the wetland ecosystem should be prioritized. The highest species recorded was in wetlands where any kind of modification was not done and near by areas where the turtle came out due to overflow of water or in search of foods similar to the data of past work. Thus, the distribution of the turtles shows correlation with the anthropogenic activities and also commercial fish harvesting in wetlands which disrupts the existence of certain environments for essential functions like nesting, hibernation, aestivation, searching for food, adult residence, and terrestrial distribution are closely linked with the presence or absence of certain herptile species.

The promotion of wetland areas, ponds and riverside as ecotourism site has increased human activities, which in turn may deteriorate water quality and the turtles migrate towards less disturbed area which might not be the best for surviving. The commercial harvesting of the fish done without scientific regulation has threatened the distribution of the softshell turtle species in the lowland waterbodies of Morang district. There is need of balance between economic benefits and biodiversity conservation which can be done through sustainable and scientific fisheries management for the survival of the softshell turtles.

5.2. Conservation threats of the softshell turtle

This study focused particularly on three species of softshell turtles found in Nepal, namely *N. gangetica* (EN), *N. hurum* (EN), and *N. nigricans* (CR). Globally, the populations of these species are declining due to threats such as biological resource exploitation (overfishing and harvesting), natural system modifications (e.g., dam construction and other ecosystem alterations), water pollution, human intrusions and disturbances (e.g., recreational activities), invasive species, and diseases (Ahmed et al., 2021; Das et al., 2021; Praschag et al., 2021). In addition to these threats, turtles in the lowlands of Nepal face challenges from practices such as ethnomedicinal uses, poaching for pets and bushmeat, poisoning, and electrocution.

Overharvesting of the softshell turtles is threatening its population in Morang District. The mean of carapace breadth of dead specimens was larger than that of live specimens which reveals that there is shrinkage of turtle population. Similar evidences of overharvesting based on carapace morphometrics has been presented in several species of turtles (Stanford et al., 2020). Such a difference in carapace size could be due to the lack of food availability or the exploitation of the turtles which has imposed conservation threats to the softshell turtles. The lower average carapace breadth in live specimens might indicate that fewer large turtles remain in the population, which can lead to a demographic shift toward smaller individuals over time. Given that larger turtles frequently have higher reproductive potential, a drop in larger individuals can interfere with breeding success. A weaker population structure and decreased genetic diversity could result from this trend, making the species more susceptible to changes in its environment. In order to promote healthy population growth, conservation measures should prioritize lowering exploitation, enhancing habitat quality, and guaranteeing food supply.

In order to address these challenges effectively, several conservation strategies are necessary: reduce the people dependency on river and wetlands by creating alternative food sources; enforcing policies and laws more efficiently; establish connectivity between rivers and ponds; ensuring clean and healthy environments for turtle by restoring degraded habitats; on-site education and raising awareness to local communities; and engaging local communities to ensure active participation in the conservation process. The combined measures are necessary for ensuring the health and sustainability of species populations. The establishment of Turtle Rescue and Conservation Centers and the implementation of a semi-in-situ conservation model in eastern lowland Nepal (Rai, 2017) have proven beneficial, although they are not

sufficient. Expanding the number of such conservation centers would greatly enhance the reach and impact of conservation efforts, providing comprehensive care to many more turtles. It is equally important that conservation initiatives also involve the participation of local communities. Education and involvement in these matters may raise stewardship values in them and substantially lessen the exploitation of turtles for food, medicines, and the illegal pet trade (Aryal & Paudel, 2024). Moreover, there are some policies and laws for the conservation of turtles i.e., the National Parks and Wildlife Conservation Act (1973) and Biodiversity Act (2002), which provide a legal framework for the protection of all wildlife, including turtles However, stricter enforcement and policy improvements at both regional and national levels are needed to address ongoing threats effectively as many people are unaware of it as per our questionnaire survey. It is also crucial to consider the cultural rights of ethnic communities. Developing a conservation framework that balances the needs of turtles with the rights and traditions of local ethnic communities will be essential for achieving long-term success.

6. Conclusions and recommendations

6.1. Conclusions

This study underscores the critical importance of understanding wetland ecosystems and factors affecting the distribution of freshwater turtles, highlighting the need for effective management strategies. Among the environmental variables analyzed, human disturbance index had a significant negative influence on the occurrence of softshell turtles in Morang District. Significant difference in carapace width between the live specimens and old carapaces suggested for the overharvesting of the turtles in the study area. Anthropogenic pressures pose significant threats to turtle habitats, with higher human disturbance index levels linked to decreased turtle populations. Additionally, habitat degradation, overfishing, wetland encroachment, pollution, and unsustainable fishing practices have severely affected softshell turtle populations in the study area. To address these challenges, conservation strategies must include habitat restoration, stricter enforcement of policies, and community engagement. Balancing the cultural rights of local indigenous people with conservation efforts is essential for achieving sustainable coexistence between local communities and these endangered species.

This study emphasizes how crucial it is to comprehend wetland ecosystems and habitat preferences to protect freshwater turtles, underscoring the necessity of efficient management techniques as the highest number of species observed is in the wetland and the areas near it. In addition, HDI plays very crucial role in the occurrence of the species so, habitat restoration, reducing the amount of overfishing and completely banning the electrocution is necessary to conserve the species and its habitat. The conservation status and ecological significance of the softshell turtles are not well known to many locals. Their opinions on conservation vary depending on their occupation, age, gender, and level of education. The ineffectiveness of government regulations and policies remains a major concern in the region. Awareness campaigns should be launched in order to safeguard the turtle population, and habitat conservation should be prioritized. However, the study shows that community-based conservation programs should help to protect the species.

6.2. Recommendations

Based on the results of the study, the following recommendations can be made:

1. Softshell turtles are facing conservation challenges due to overharvesting. So, conservation initiatives should be taken immediately.
2. The study supports the occurrence of softshell turtles and their occurrence was higher in lower human disturbance. So, wetland habitat needs to be protected.

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Appendices

Appendix 1. Questionnaire survey form for *Nilssonia spss.* and their conservation threats.

Distribution and conservation threats of shoftshell turtle Nilssonia spss in Morang district,Nepal

Namaste, my name is Bandana Rai. I am a student. Currently, I am doing my thesis for Master's degree, Central Department of Zoology, Tribhuvan University. I'm curious how people feel about shoftshell turtles.Your participation is completely voluntary, and you are free to choose not to answer any questions. I want to ask you some question regarding the species in your area? Your identity and any information you choose to share will be kept completely private. 20-30minutes will pass. Let's get started.

Questionnaire survey
Questionnaire Number…… Date……
Name……..
Age……. Gender……. Religion…… Education....…
Occupation…… Ward…… Municipality……
Latitude/longitude……

Rate the following statements using the scale:

(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

1.There are records of the presence of *Nilssonia* species in my area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

2.Softshell turtles are commonly found in rivers, wetlands, and ponds in this district.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

3.Turtles hold great cultural importance.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

4.Turtles are worshiped as gods.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

5. Softshell turtles play an important role in maintaining freshwater ecosystems.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

6. Local communities benefit economically from turtles.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

7. Carapace, eggs, body are commonly used for food or medicine.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

8. Turtles are becoming less in number in my area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

9. Turtles are being killed by humans in my area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

10. Turtles are being traded illegally in my area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

11. The parts of turtle that are illegally traded are…

Body,Carapace,Egg

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

12. I am aware that freshwater turtles are endangered and under threat, according to the IUCN Red List.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

13.I am aware that turtles are legally protected species.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

14.Turtles are being fully exploited in my area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

15. Human activities and habitat destruction are the major threats to freshwater turtles.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

16. Turtles should be conserved in my area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

17. Conservation efforts (awareness programs, protected areas, etc.) are effectively helping to protect turtles in my region.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

18.Community-based conservation programs can help protect softshell turtles.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

19.Government regulations and policies for turtle conservation are effective in this area.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

20.I am willing to participate in conservation activities for protecting softshell turtles.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Appendix 2. Correlation test among the environmental and anthropogenic variables

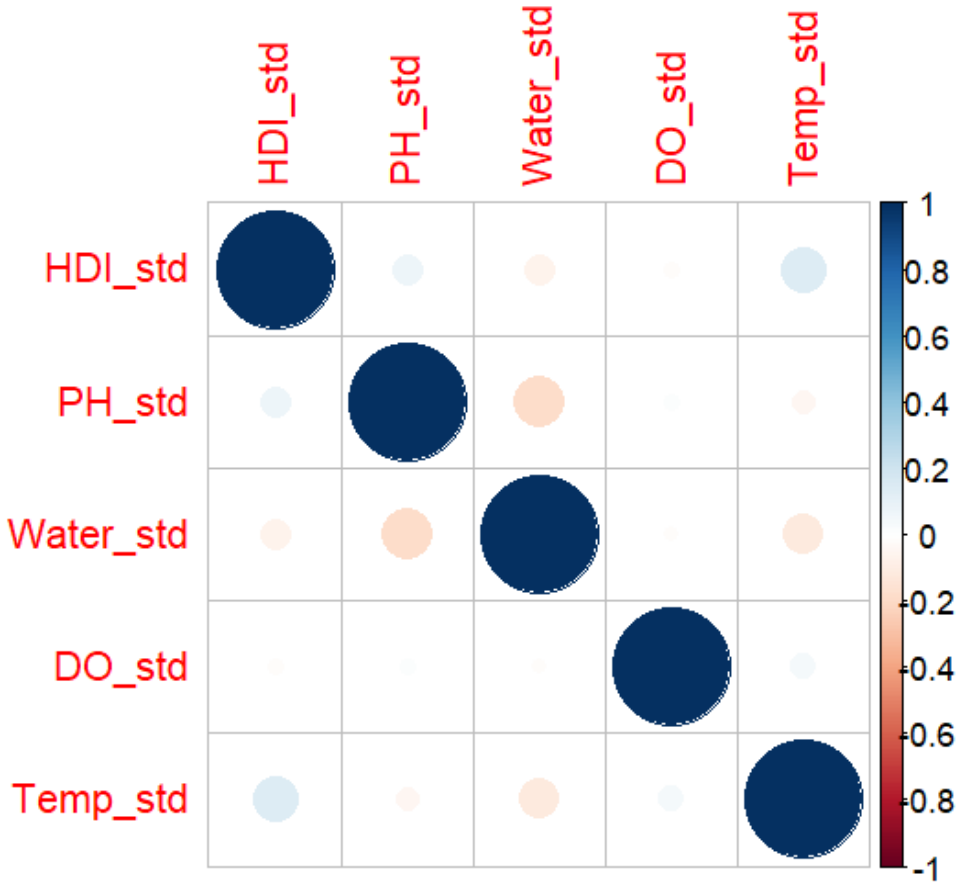

Figure 6. Multicollinearity test of all environmental and anthropogenic variables

Appendix 3. Pictures of live species and carapaces found

Photograph 1. Live specimens of the freshly captured softshell turtles in the field or by the people. A – *N. hurum* in Simpane; B- *Nilssonia* in Betana; C- *N. nigricans* in Simpane; D- *N. nigricans* in Sisauli; E- *N. hurum* near Hasina Simsar; F- *Nilssonia* from Sisauli.

Photograph 2. Carapace of turtle (left) and old carapace (right) were documented during the fieldwork near Vallui wetland, Kanepokhari.

Photograph 3. Carapace of turtle documented during the fieldwork near Hasina Wetland used by a "Shaman" or "Spiritual Healer" for the rituals

Photograph 4. Softshell turtle captured nearby irrigation canal in Borabandh and kept as a pet in a bucket documented during field survey

Appendix 4. Permission from Department of Forest and Soil Conservation

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
वन तथा भू-संरक्षण विभाग

फोन नं. ४-२२७५७४
४-२२०३०३
फ्याक्स: ४-२२७३७४

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लख गर्नुहोला।
बबरमहल, काठमाडौं, नेपाल

प्राप्त पत्र संख्या र मिति:-
पत्र संख्या:- ०८१।८२
च. नं.:- २४१

मिति: २०८१/०५/३१

विषय: अनुसन्धान अनुमति सम्बन्धमा ।

श्री वन्दना राई,
भोजपुर, नेपाल ।

प्रस्तुत विषयमा Tribhuvan University, Central Department of Zoology, Ecology and Environment मा M. Sc. मा अध्ययनरत तपाईले "Distribution and Conservation Threats of Softshell Turtle (*Nilssonnia spp.*) in Morang District, Nepal" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०८१/०५/२७ गते यस विभागमा दिनु भएको निवेदन प्रपोजल प्राप्त भयो। सो सम्बन्धमा कारवाही हुँदा उक्त अध्ययन अनुसन्धानबाट Distribution and Conservation Threats of Softshell Turtle लगायतका विषयमा जानकारी प्राप्त हुने भएकोले प्रपोजलमा उल्लेखित Methodology (Field Survey, Visual Inspection and Questionnaire Survey) अनुसार तपसिलको शर्तहरुको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि मन् २०२४-०९-१५ देखि २०२४-११-३० सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ ।

शर्तहरु

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्टिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरुको पूर्ण पालना गर्नुपर्नेछ ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।
३. नमूना सङ्कलन गर्न पाईने छैन ।
४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरु गोप्य राख्नु पर्नेछ अनाधिकृत रुपमा त्यस्ता सूचनाहरु कसैलाई पनि उपलब्ध गराउन पाइने छैन ।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतिय) यस विभागमा अनिवार्य रुपमा बुझाउनु पर्नेछ ।
६. तोकिएका शर्तहरुको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ ।

२१।५।८१
२।३१

(सुरेन्द्र प्रसाद अधिकारी)
वन अधिकृत

बोधार्थ

श्री डिभिजन वन कार्यालय, मोरङ्ग। : आवश्यक सहयोग तथा अनुगमनको लागि अनुरोध छ ।

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
वन तथा भू-संरक्षण विभाग

फोन नं.: ५३२७५७४

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प्राप्त पत्र संख्या र मितिः-
पत्र संख्याः- ०८१/०८२
च. नं.:-२४८

मितिः २०८१।०९।०३

विषयः अध्ययन अनुसन्धान अनुमतिको म्याद थप सम्बन्धमा ।

श्री वन्दना राई,
भोजपुर, नेपाल ।

प्रस्तुत विषयमा Tribhuvan University, Central Department of Zoology, Ecology and Environment मा M. Sc. मा अध्ययनरत तपाईले "Distribution and Conservation Threats of Softshell Turtle (*Nilssonnia spp.*) in Morang District, Nepal" विषयमा यस विभागको प.सं. २०८१।०८२ च.नं. २९१ मिति २०८१।०५।३१ को पत्रबाट अध्ययन अनुसन्धान गर्न अनुमति प्रदान गरिएकोमा उक्त अध्ययन अनुसन्धान कार्य तोकिएको समयभित्र सम्पन्न गर्न नसकिएको भनी म्याद थप गर्न अनुरोध भई आएको हुँदा यस विभागको मिति २०८१।०५।३१ को अनुमति पत्रमा उल्लेखित शर्तहरुको अधिनमा रही अध्ययन अनुसन्धान गर्न अनुसन्धानको म्याद १३ डिसेम्बर, २०२४ देखि ३१ अगष्ट, २०२५ सम्म थप गरिएको व्यहोरा निर्देशानुसार अनुरोध छ । ८

(सवनम पाठक)
वन अधिकृत

वोधार्थ
श्री डिभिजन वन कार्यालय, मोरङ्ग: प्रत्यक्ष निगरानीमा उल्लेखित कार्य गर्न आवश्यक सहयोग गर्नु हुन ।

Appendix 5: Permission from Betana Wetland Community Forest Users Group, Morang

रुख रापौं वन जोगाऔं दर्ता नं.: MOR/DE/58/04

श्री बेतना सिमसार सामुदायिक वन उपभोक्ता समूह

बेलबारी नगरपालिका, मोरङ

स्थापित :- २०७२

पत्र संख्या.- ०८१/०८२ चलानी नम्बर :- १९ मिति- २०८१/०६/१४

"जहाँ जल त्यहाँ जिवन"

श्री वन्दना राई
बेलबारी-२

विषय :- अध्ययन अनुमति सम्बन्धमा ।

प्रस्तुत विषयमा मिति २०८१/०६/१४ गते प्राप्त पत्र अनुसार वन तथा भू-संरक्षण विभागको मिति २०८१/०५/३१ को पत्र संख्या ०८१/०८२ चलान नं. २९१ को अनुसन्धान अनुमति अनुसार Tribhuwan University Central Department of Zoology, Ecology and Environment मा M.Sc. अध्ययनरत छात्रालाई थेसिसको तयारीको लागि "Distribution and conservation Threats of Softshell Turtle (Nilssonnia spp.) in Morang District, Nepal" विषयमा अध्ययन अनुसन्धान अनुमतिको लागि तपशिलको शर्तहरुको अधिनमा रही २०८१/१२/१४ सम्मको लागि अध्ययन अनुसन्धान गर्नुहुनको लागि अनुमति प्रदान गर्दछु ।

शर्तहरु

१) अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन वियमावली २०७९, राष्ट्रिय निकुन्ज तथा वन्यजन्तु संरक्षण ऐन २०२९ र नियमावली २०३०को मातहतको नियमावलीहरुको पुर्ण पालना गर्नुपर्नेछ ।
२) अनुसन्धान कार्य डिभिजन वन तथा सव डिभिजन वन कार्यलयसँगको सहकार्यमा गर्नुपर्नेछ ।
३) नमुना सङ्कलन गर्न पाईने छैन ।
४) अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सुचनाहरु गोप्य राख्नु पर्नेछ ।
५) अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति प्रतिवेदन यस समितिमा अनिवार्य बुझाउनु पर्नेछ ।
६) तोकीएका शर्तहरुको पालाना नगरिएमा समितिले कुनै पनि समयमा अनुमति रद्द गर्न सक्नेछ ।

.....अध्यक्ष...
(शम्भु भट्टराई)
अध्यक्ष
वेतना सिमसार सा.व.उ.स.

"जहाँ वन त्यहाँ व्यवस्थापन,जहाँ बाँझो त्यहाँ वृक्षारोपण"