

## Land use land cover change and its implication on water fowl diversity: A case study of Taudaha Lake, Kathmandu, Nepal

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### Abstract

The wetlands of Nepal are well known for unusually rich biodiversity. Taudaha is famous for winter migrant water fowls as far as from Siberian. The natural form of Taudaha has been neglected and it is surrounded by concrete homes instead of trees and paddy field. Land use change is often regarded as one of the main reasons for habitat degradation and subsequent decrease in migratory birds' population. This article aims to quantify the land use change scenario in and around the lake area using GIS tool. Google images from February 2004 and April 2022 were obtained from "Google Earth Pro" software and used to prepare the land use map by using "QGIS 3.12" software. The cultivated land covered about 73.42% of the total study area followed by settlement (8.61%), vegetation (8.02%) and the lake (9.95%) itself in 2004. But 18 years later, in the year 2022, Taudaha is gradually surrounded by urban areas. The cultivated land has been changed to be settlement areas. The cultivated land has decreased for construction of houses, hotels and resorts. Human activities in hotels and resorts near the lake area have caused distraction to migratory birds visiting the lake. This is causing degradation of habitat of the migratory bird species. Literatures showed the declining number of migratory bird species visiting the lake areas during winter.

**Keywords:** *Land use change, GIS, Migratory bird, Urbanization*

### Introduction

"Land-use change" is any way in which humans modify the natural landscape. Some of these changes are permanent destruction, such as urban expansion. Other changes, such as cropland abandonment and forest restoration, may attempt to repair previous damage. About three-quarters of the Earth's land surface has been altered by humans within the last millennium (Winkler et al., 2021). Land use change has affected almost a third (32%) of the global land area in just six decades (1960-2019) (Winkler et al., 2021).

Nepal has undergone significant land cover changes, with forests, wetlands, and permanent ice/snow decreasing while croplands, artificial surfaces, and bare lands increasing between 1990 and 2015. Factors such as climate changes, population growth, urbanization, and government policies have driven these changes, with higher intensities observed in the Eastern and Central Development Regions (Li et al., 2017). Spatiotemporal changes in land use/

land cover (LULC) in Nepal's Bagmati River Basin from 1988 to 2018, reveal significant increases in urban areas by 247.5%, barren land by 109.5%, and shrub land by 32.4%, while forest cover declined by 6.2%, cultivated land decreased by 4.1%, water bodies reduced by 30.3%, sand areas diminished by 29.2%, and grass cover declined by 10.6% (Risal et al., 2021).

As growing human populations place additional burdens on land due to increased needs for food, energy, natural resources, economic development, and space, pressure increases to convert natural habitats for other uses. Land use change reduces the size of habitats and ecosystems and therefore leads to biodiversity loss and loss of ecosystem services. The loss of ecosystem services leads to economic damage, which can be interpreted as the lost value of biodiversity and damage to human well-being and health (Galgani et al., 2021). Globally, the continuous intensification of industrialization and urbanization has led to a significant reduction in wetlands and land cover due to newly constructed

lands. Although cities account for less than 3% of the land area on Earth, the loss of native habitats resulting from urbanization has become an important cause of decreasing biodiversity (Galgani et al., 2021). Kathmandu Valley, Nepal is undergoing rapid urbanization and it can be categorized into urban, sub-urban and rural areas. A study showed that the species richness and diversity of birds declined from rural to urban areas and showed significant variation along urban–rural gradients (Katuwal, 2018).

Birds, as a large and widely distributed group of animals, are sensitive to changes in habitats and human disturbance. They have high mobility and habitat selectivity and are therefore often selected as biological indicators of habitat and ecosystem changes (Xu et al., 2022). Species with a narrow range and specialized habitats such as wetland ecosystems are at higher risk. The Koshi Tappu Wildlife Reserve serves as a habitat for numerous species that are globally threatened. These species predominantly rely on swamp and marshes, forests, grasslands, and freshwater ecosystems as important habitats. Analyzing the changes over the past 34 years, it is evident that these ecosystems have undergone significant transformations, which are particularly crucial for globally important species. Among the ecosystems, the forested ecosystem has experienced the most substantial loss over the past 34 years, followed by wetland ecosystems like marshes/swamps and rivers/streams (Chettri et al., 2013). The study examining the transformations in Nepal's wetland areas, particularly the Ghodaghodi Lake Complex, using remote sensing, climate and population data analysis, reveals an increase in surrounding population, changes in land cover, temperature rise, and decreased rainfall, with anthropogenic pressure and climate variability identified as factors contributing to ecological degradation. (Lamsal et al., 2019)

Wetlands are among the most productive ecosystem in the world. The wetlands of Nepal are well known for unusually rich biodiversity. Taudaha Lake serves as a stopover site in Kathmandu for long-distance winter migratory water birds, with their arrival and

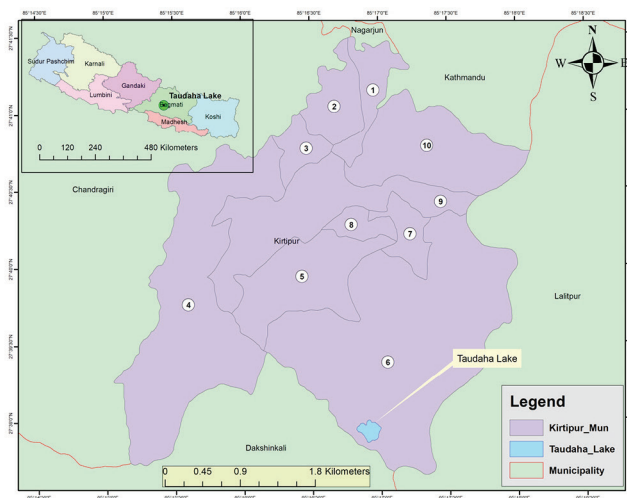
departure times influenced by the weather system, as decreasing temperatures from October attract the birds to the lake and increasing temperatures from March prompt their departure, with the highest population observed in January (Khatri et al, 2023). Water geese from Tibet, China, Korea, Mongolia and Central Asia migrate south across the mountains to spend the winter in Nepal. Some waterfowl such as Common Coot (*Fulica atra*), the Great Cormorant (*Phalacrocorax carbo*), the Common Teal (*Anas crecca*), the Eurasian Wigeon (*Anas penelope*), the Gadwall (*Anas strepera*) and the Mallard (*Anas platyrhynchos*) etc travel south through the Kathmandu Valley and live in Taudaha (Nepal, 2022) in winter. The natural form of Taudaha has been altered by concrete homes surrounding the lake instead of trees and Paddy field. A significant number of restaurants are opened and ever-increasing visitor population and their activities is deteriorating natural environment gradually around the Taudaha lake area.

A study from September 2007 to April 2008 recorded 40 species of birds out of which 21 were winter migrants, two were summer migrants and 17 were residents (Shah, 2016). Most recent bird count by BCN in Taudaha Lake in 2022 recorded 21 water birds of 19 species at Taudaha (Nepal, 2022). Water bird count at Taudaha has gone down in 2022 both in terms of the number of species and individuals (Nepal, 2022). There are plenty of researches about the lake, most of which deals about the water quality and biodiversity of the lake (Paudel et al., 2022; Shrestha B., 2022) but the information regarding land use change in and around the lake is very scarce. Land use change is often regarded as one of the main reasons for habitat degradation and subsequent decrease in migratory birds' population (Khatri et al, 2023; Nepal, 2022). The main objectives of the article are to map out the land use and land cover change in and around Taudaha Lake during the period of 2004 till 2022 using Google earth image, quantify the change in land use during this period and review the implication of urbanization on water fowl diversity in Taudaha Lake area.

## Materials and Methods

### Study Area

Taudaha Lake is situated in Kirtipur Municipality-6, Kathmandu district, Bagmati province, Nepal. Geographically it lies at  $27^{\circ} 38' 72.55''\text{N}$  and  $85^{\circ} 16' 54.8''\text{E}$  with altitude of 1291 m on the way to Dakshinkali Temple about 7 km South from Balkhu of Kathmandu. The area of the lake is about 4.6 ha with maximum depth of 6.8 m. The Lake is mainly fed by rainfall and irrigation canals coming from the nearby paddy fields. The climatic condition of Taudaha Lake resembles with the Kathmandu city. The average annual temperature varies from  $10^{\circ}\text{C}$  to  $26^{\circ}\text{C}$ . The lake shows subtropical climate with three distinct seasons as summer, rainy and winter. Kathmandu Valley was once a huge lake. It is believed that the Taudaha Lake is formed when the stagnant water in the valley was released out through Chobhar gorge. Taudaha is about 210 meters long and 180 meters wide. In Newari language, 'Tah Dah' means 'big pond'. Later, it is considered to be 'Taudaha' by aberration of 'Tah Dah'. It is also one of the most important religious places in Kirtipur. It is believed that the Taudaha is home to Karkotak Naag and people celebrate Nagpanchami in the name of Karkat Nag Raja and Nag Rani, once a year. Figure 1a and 1b presents the Location map of Taudaha Lake and a photograph of the Taudaha Lake taken in January 2022 respectively.



**Figure 1a:** Location Map of Taudaha Lake

## Methodology

### Land use change mapping

This research is mainly based on the analysis of Google imagery using GIS tools. Google images from 1<sup>st</sup> January 2004 and 3<sup>rd</sup> November 2022 were obtained from "Google Earth Pro" software and used to prepare the land use map by using "QGIS 3.12" software. A polygon has been created by enclosing the four points having following geographic coordinates [ $27^{\circ} 39' 2.78\text{N}$ ,  $85^{\circ} 16' 40.00\text{E}$ ], [ $27^{\circ} 39' 5.31\text{N}$ ,  $85^{\circ} 17' 12.56\text{E}$ ], [ $27^{\circ} 38' 41.92\text{N}$ ,  $85^{\circ} 16' 41.54\text{E}$ ] and [ $27^{\circ} 38' 44.38\text{N}$ ,  $85^{\circ} 17' 13.36\text{E}$ ] in both images for this study. Figure 2a and 2b shows the Google Imagery of the study area in the year 2004 and 2022. The polygon is created such that the lake lies on the center of the polygon. The area of the polygon is 46.43 hectare. The images were georeferenced and screen digitized using "QGIS 3.12" software in order to create the features and assigned the respective land cover attribute to the respective features. The features are categorized in four classes as Settlement, Agricultural, Vegetation and Lake. Lastly the area covered by these four features are calculated for both years and a comparison is made to draw the conclusion. Methodology adopted for Land use change mapping in this study is presented in figure 3.



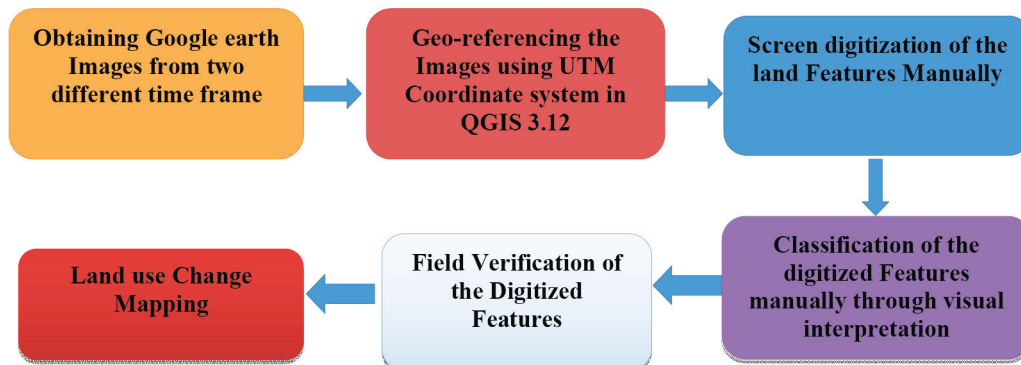
**Figure 1b:** Photograph of the Taudaha Lake taken in January, 2022



**Figure 2a:** Google Imagery of Taudaha Lake and its surrounding area in the year 2004



**Figure 2b:** Google Imagery of Taudaha Lake and its surrounding area in the year 2022



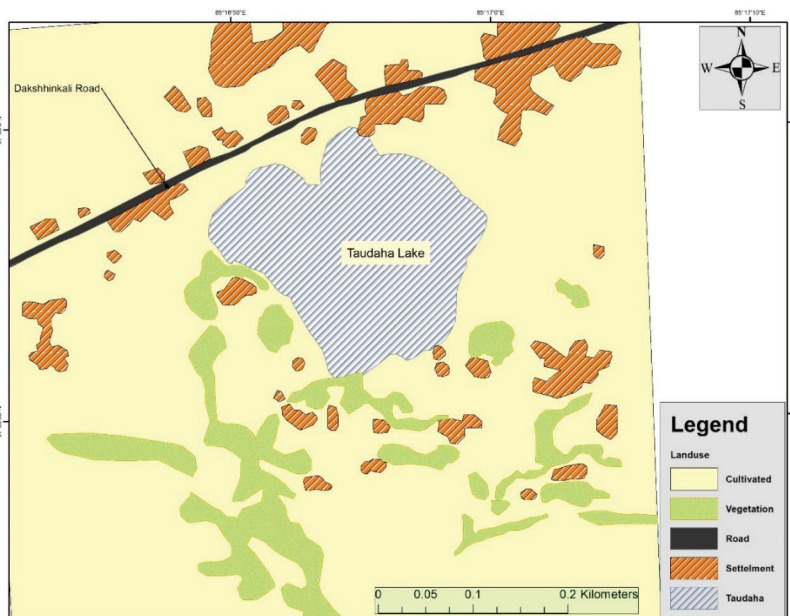
**Figure 3:** Methodology adopted for Land use change mapping

**Impact of land use change on water fowls**

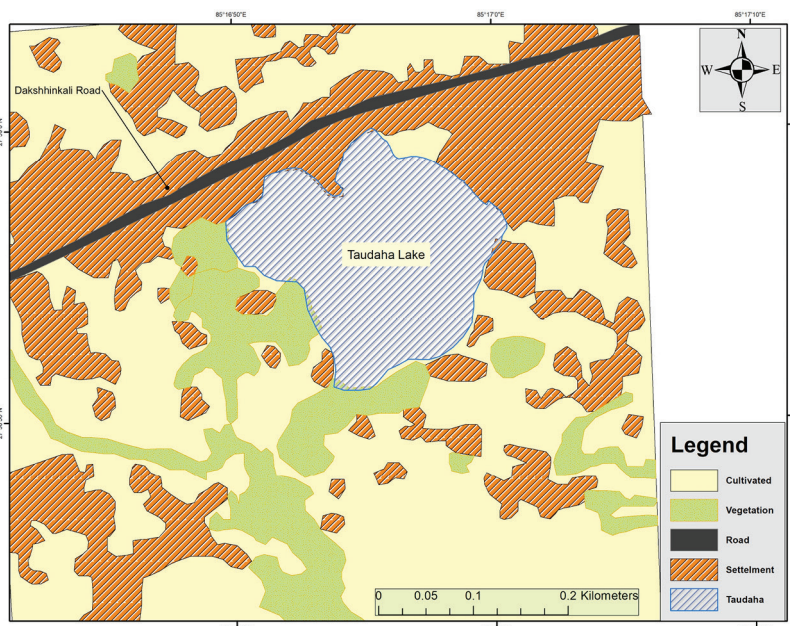
To study the land use change and its implication on wetland, various scientific papers related to land use change and wetland were reviewed and analyzed qualitatively in the paper.

**Results and Discussion**

Figure 4a and 4b present the Land use map of Taudaha Lake and its surrounding area in the year 2004 and 2022 respectively and the result has been presented in table 1. The total area considered under this study is 46.43 ha. In the year 2004, Taudaha Lake is mostly surrounded by cultivated land, mostly paddy field. The cultivated land covered about 73.42% of the total study area followed by Settlement (8.61%), Vegetation (8.02%) and the lake (9.95%) itself in 2004. But 18 years later, in the year 2022, the Taudaha is gradually surrounded by urban areas. The cultivated land has been changed to be settlement areas. The area of the cultivated land decreased by 25.58% while the settlement area increased by 22.48% during that period. Vegetation cover around the Taudaha Lake is found to be increased by 3.02%. The reason behind this is that some cultivated areas are turned uncultivated and some are changed into private park/resort for commercial purposes. In 2004, the settlement areas were mainly



**Figure 4a:** Landuse map of Taudaha Lake and its surrounding area in the year 2004



**Figure 4b:** Landuse map of Taudaha Lake and its surrounding area in the year 2022

**Table 1:** Land use Change of Taudaha Lake and its surrounding area

Landuse	2004		2022		% Change
	Area (Ha)	%	Area (Ha)	%	
Cultivated	34.09	73.42	22.21	47.84	-25.58
Vegetation	3.72	8.02	5.12	11.03	3.02
Settlement	4.00	8.61	14.43	31.09	22.48
Taudaha	4.62	9.95	4.66	10.04	0.09
<b>Grand Total</b>	<b>46.43</b>	<b>100.00</b>	<b>46.43</b>	<b>100.00</b>	

concentrated along the Dakshinkali Highway on the northern side but currently the lake is surrounded by settlements from all sides of the Lake.

Taudaha lake is recognized as popular destination for migratory water fowls such as the Common Coot (*Fulica atra*), the Great Cormorant (*Phalacrocorax carbo*), the Common Teal (*Anas crecca*), the Eurasian Wigeon (*Anas penelope*), the Gadwall (*Anas strepera*) and the Mallard (*Anas platyrhynchos*). The Bar-headed Goose (*Anser indicus*), the Ruddy Shelduck (*Tadorna ferruginea*), the Spot-billed Duck (*Anas poecilorhyncha*), the Northern Shoveler (*Anas clypeata*), the Northern Pintal (*Anas acuta*), the Common Pochard (*Aythya ferina*), the Red-crested Pochard (*Rhodonessa rufina*), the Tufted Duck (*Aythya fuligula*), the Furruginous pochard (*Aythya nyroca*), the Black-headed Gull (*Chroicocephalus ridibundus*), and the Lesser Black-backed Gull (*Larus fuscus*) have also been reported over the years in Taudaha Lake, especially in winter (Shah., 2016; Nepal, 2022). Urbanization and rapid development activities near the lakeside and Taudaha beautification process are attributed to the continuous decline in the number of water birds visiting the Taudaha Lake area in winter (Nepal, 2022; Shrestha, 2022). For instance, in 2007 the census reported 40 species (Shah., 2016), 28 species in 2014, 23 species in 2015, 21 species in 2016, 23 species in 2017, 20 species in 2018, 23 species

in 2019, 17 species in 2020 and 2021 respectively (Nepal, 2022).

Khatri et al., (2023) also reported 10 migratory water bird species observed at Taudaha Lake in 2020 which is lower compared to previous years. The total population of water birds recorded was found to be 210 which is almost 120% lower than the count in 2007/8 and 30% lower than in 2014-15. Previously abundant water bird species like Gadwall, Common Teal, and Mallard have experienced a rapid decline in their populations. Moreover, Falcated Duck (*Mareca falcatae*), Tufted Duck (*Aythya fuligula*), and Garganey (*Spatula querquedula*) have not been sighted at the lake since 2003, 2008, and 2011, respectively. This absence could be attributed to increased disturbances caused by people, such as playing loud music, ongoing concrete construction activities, insufficient vegetation in and around the lake, and changes in land use near the lake's periphery (Khatri et al., 2023). Figure 5a shows Migratory birds (Great Cormorant) resting on a tree located in the middle of Taudaha lake and figure 5b shows the ever growing urban areas along the bank of the Lake.

Parajuli, (2022) pointed out that the majority of the species found in the wetland of Hetauda were discovered to be at risk due to the loss and deterioration of their natural habitats. The main



**Figure 5a:** Migratory birds (Great Cormorant) resting on a tree located in the middle of Taudaha lake in January 2022.



**Figure 5b:** Recently opened hotel and resorts on western side of the Lake along Dakshinkali highway.

concerns identified in the research include the fragmentation and degradation of habitats, as well as pollution and sewage stemming from industrial zones and urban regions. Effect of urbanization on wetland bird was studied in seven river wetlands around Chaohu Lake, China with satellite remote sensing image data from the same period. It was found that the water bird diversity index declined exponentially with increases in the intensity of urbanization. The changes in the land use patterns around river wetlands associated with urbanization resulted in the loss of food resources and habitats (Xu et al., 2022).

Now a days bathing and washing in the Taudaha lake has been banned. Similarly it is restricted to dispose sewage into the Lake. Recent research on the hydrochemistry and water quality of Taudaha Lake demonstrates that the water is suitable for supporting aquatic life as well as domestic and irrigation purposes. The slightly alkaline pH and moderate dissolved oxygen (DO) level suggest that the lake water has been minimally affected by organic pollutants originating from human activities (Paudel et al., 2022). Hence it can be concluded that lake water is not a root cause of declining migratory bird population in the Lake.

There were no hotels and resorts along the bank of Taudaha lake and the tourist activities were also nil. Currently there are more than 15 hotels and restaurants surrounding the lake from all sides. The lake is now one of the hotspots for tourists in Kathmandu valley and Tourist activities have been increased drastically. Nearby hotels often play loud music and sounds for their entertainment in the restaurants. The use of colorful lights on the trees in which birds' shelter has forced some birds like cormorants take refuge in nearby network towers. The line of restaurants and use of powerful sound equipment around Taudaha Lake may causes ear damage, an increase in stress response, changes in forage or call responses, and even a flight reaction (Nepal, 2022). Noise pollution can alter bird communities by forcing some birds to abandon the area (Tang, 2022). Artificial light itself can have countless negative influences on different aspects of birds, such as sleep, digestive

efficiency, and circadian rhythm. Light pollution not only affects the physiology of urban birds but also poses a significant threat to migratory birds, as the challenges of migration make them more vulnerable to its effects, leading to disrupted migration patterns, attraction to artificial lights, and abandonment of resource-rich areas, ultimately impacting the success of their journeys. (Tang, 2022). The number and concentration of migratory species decrease as built infrastructure expands. Certain birds, like the Eurasian blackbird and house sparrow, exhibit a decline in their migratory patterns because urban areas provide sufficient food resources to sustain them during the winter season. Resident species have the tendency to occupy high-quality nesting locations in cities prior to the arrival of migratory species. This leads to the exclusion of migrants from urban areas through competitive interactions (Patankar, et al., 2021).

## Conclusion

It can be concluded from this research that the Taudaha lake and its surrounding area is experiencing rapid urbanization. The cultivated land is decreasing day by day for construction of houses, hotels and resorts. Human activities in hotels and resorts near the Lake area are the cause of distraction to migratory birds visiting the lake. This is causing degradation of habitat of the migratory bird species. Various measures, such as acoustic barriers and tree planting can be implemented to mitigate noise pollution and promote environmental sustainability. The concerned authority should implement strict regulation to control the excessive human interventions in and around the lake in order to preserve Taudaha lake as a natural habitat for migratory bird.

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