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# GIS Based Approach to Determine the Changes of Water Hyacinth (*Eichhornia crassipes*) Cover and Relation with Lesser Whistling Teal (*Dendrocygna javanica*) Assemblage at Santragachi Wetland, West Bengal

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ABSTRACT

The present investigation is conducted to study the year wise (2011 to 2018) changes of water hyacinth (*Eichhornia crassipes*) cover at Santragachi Lake a Wetland under National Wetland Conservation Programme of India. Further the relationship between water hyacinth cover and the most abundant migratory waterbirds of Satragachi, Lesser Whistling Teal (LWT; *Dendrocygna javanica*) is assessed because this bird species is prefer depending on water hyacinth mat for their roosting. The study comprises of eight satellite images procured from Google earth (2011 to 2018) to explore this relationship. A marked decline in the number of LWT at Santragachi wetland is observed in the year of 2017 and 2018. It is very interesting fact that from 2017-2018, the water hyacinth mat of this wetland is almost cleared before winter and the result of cluster analysis supports this fact. Significant positive correlation is also observed within LWT number and water hyacinth cover area ( $r = 0.7481$  at  $p < 0.05$ ) along with the total perimeter ( $r = 0.8648$  at  $p < 0.05$ ) of the water hyacinth islands at Santragachi wetland. However, open water area is also needed for diving, swimming, food searching for the LWT and other waterbirds. Therefore, more study is needed to optimize the clearing operations, focused on optimizing the shape and size of water hyacinth islands for proper management of the waterbirds habitat.

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## 1. Introduction

Increase in human population generates a huge amount of domestic and industrial wastewater, which discharge into the lake or river system, helping the invasive species to spread resulting in eutrophication and a steady decline of freshwater ecosystem. Furthermore, anthropogenic activities and extreme weather events may accelerate invasive species propagation. Taking into the account of invasive species, water hyacinth is rated as one of the hundred most harmful invasive species by IUCN <sup>[1]</sup>. The water hyacinth (*Eichhornia crassipes*) is fast growing, free-floating, stoloniferous, freshwater perennial plant indigenous to South America <sup>[2]</sup>. This plant which is introduced as an ornamental species more than a decade, has spread at least fifty country, including India and created serious socioeconomic and environmental problems to the people associated with aquatic ecosystem. It has estimated that under favorable environmental conditions, especially land surface temperature and nutrient content of aquatic ecosystem, 10 water hyacinth plants can reproduce 655,360 plants within 8 months and can cover almost 0.5 ha of the surface water <sup>[3]</sup>. Due to this reason water hyacinth also recognized as one of the top 10 worst weeds in the world <sup>[4 & 5]</sup>. Not only that this plant causes ecological alteration and consequently disrupts the nutrient cycle, food web structure, and invertebrate-fish assemblage in aquatic ecosystem <sup>[6]</sup>. Different studies have shown that the relationship of water hyacinth cover and zooplankton population is inversely proportional <sup>[4 & 7]</sup>. Water hyacinth form of a blanket like layer over aquatic ecosystem, which prevents sunlight into the hypolimnion part of the water body, reducing photosynthesis rate for the submerged aquatic plants <sup>[8]</sup>. This condition disrupts aquatic species diversity and create non-conductive, unproductive ecological conditions <sup>[9 & 10]</sup>. This inhabitable unproductive condition results hypoxia and create favorable condition different pests and diseases viz. filariasis, malaria, schistosomiasis, ancephalitis, and other water born disease <sup>[11 & 12]</sup>. Moreover, the rate of evapo-transpiration of water hyacinth is 2-8 times more than the evaporation from free water surface, resulting hydrological alteration due to heavy water loss from water body <sup>[13 & 14]</sup>. Furthermore, high rate of organic-matter production by water hyacinth accelerate the decomposition rate, results more CO<sub>2</sub> and CH<sub>4</sub> generation from water body <sup>[15 & 16]</sup>.

However, besides various drawbacks of water hyacinth, it helps in pollution mitigation and acts as a bio-indicators of pollution. Water hyacinth efficiently remove mineral,

especially different heavy metals from the aquatic system and serving as biological sinks. Different research works has been done on the water hyacinth and these studies have shown that this plant not only remove the minerals but also reduces amounts of total suspended solids, dissolved solids dissolve organic carbon, redox potential, turbidity, salinity, coliform bacteria, different organic pollutants like dyes, phenols, aldehyde etc. and numerous inorganic chemicals from domestic and industrial wastewater. Moreover, properly managed water hyacinth cover plays a significant role for plankton, microinvertebrates and fish by providing shelter, habitat, feeding grounds and breeding grounds <sup>[9, 17 & 18]</sup>. Therefore, monitoring and management of water hyacinth cover is necessary at present time to control pollution or to mitigate pollution in freshwater ecosystem.

On the other hand, nowadays, advance technology like GIS, remote sensing is widely used in different applications viz. land use – land cover change, vegetation and forest cover change, disaster monitoring and hydrology changes <sup>[19-25]</sup>. The assessment of present and future scenario of water resources, river dynamics, wetland biogeography, climate change, agriculture productivity, flood mapping are very crucial for better understanding about spatial distribution of surface water <sup>[16 & 27]</sup>. For the extraction of surface water character and surface water cover, various image processing techniques have been applied in recent times. Moreover, to understand the spatial and temporal distribution of aquatic macrophytes GIS based study is a timely and cost-effective approach <sup>[28 & 29]</sup>. Pennatti et al. <sup>[30]</sup> has stated that constant coverage of satellite sensors deals spatial data for environmental monitoring, which is essential in detecting and evaluating the strengths of the control procedures in place. Also, the use of satellite imagery has verified to be a dependable primary data, which become frequently applied in ecological and environmental research <sup>[25]</sup>.

In the last couple of decades, despite a marked decline in the number of migratory waterbirds on the West Bengal wetlands, Santragachi jheel (Wetland under National Wetland Conservation Programme) near a crowded and noisy railway station, regularly supports 4000-5000 migratory waterbirds. Especially, the bird's density in Santragachi Jhill was decreased significantly in 2017-2018 than past and from 2017-2018, the water hyacinth mat of Santragachi Jhill were fully cleared before winter due to the National Green Tribunal Verdict, 2016. In the present study an attempt has been made to use satellite images to map the area of Santragachi Jhill covered by water hyacinth

during last 8 years (2011-2018) and to find out the effect of water hyacinth cover, if any, on the most abundant Lesser Whistling Teal (*Dendrocygna javanica*) colonization at Santragachi Jhill.

## 2. Materials and Methods

### 2.1 Study Area

Santragachi Lake is 8 km from the center of Calcutta City, in Howrah District, West Bengal, India (22°34'60"N, 88°17'60"E; at an elevation of 8 m). The area of this wetland is 12.8-ha.

### 2.2 Estimation of Density of Lesser Whistling Teal (LWT; *Dendrocygna Javanica*)

The study of LWT was conducted in Santragachi jheel, during the winter months of December-February for 8 consecutive years (2011-2018). A group of three trained observers recorded wintering waterbirds blind-folded over three specific time intervals (06:00-07:00, 12:00-13:00 and 17:00-18:00 hrs) of a day and averaged to obtain representative data [31] (Gibbons and Gregory, 2006). During each sampling time we traversed all the sides of the wetland where it was approachable. We surveyed each side by walking along a transect length of 1 km and counted all LWT seen within 50 m of transect using TruePlus 360 Laser range finder. All the LWT observed more than 50 m on both sides of the transect line were recorded as long as they were within 50 m perpendicular to transect. LWT which were flying or perching were also recorded separately along with those using the habitat directly. We also conducted random binocular-field counts of the populations of LWT to obtain a more-robust area-wise estimate [32-35]. A Nikon Fieldscope (25–75 x 82 ED), Bushnell Equinox Z (4.5 X 40) Night Vision and Nikon Action (10 X 50) binoculars were used for spotting the character details of the birds in sight.

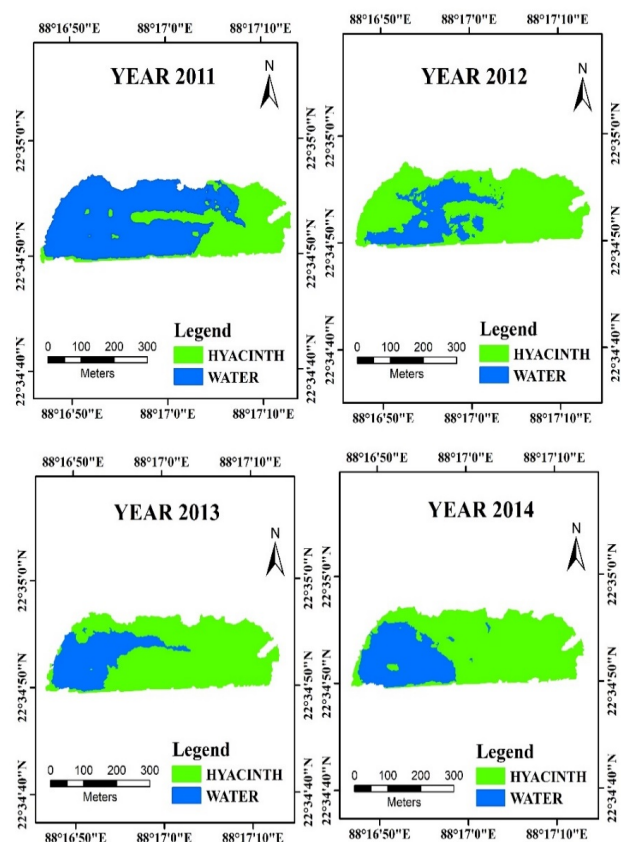
### 2.3 Preparation of Water Hyacinth Cover Maps

The images of Google Earth were used to execute the study. Software used in the change detection of this study ERDAS imagine were used for referencing Arc GIS 9.1 software were used for digitization in the water hyacinth change detection study.

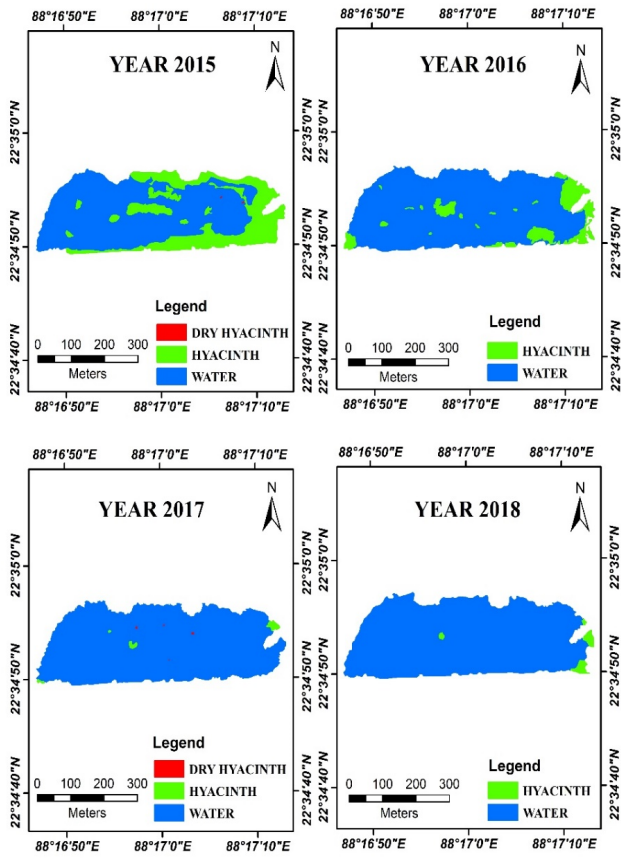
## 3. Result and Discussion

The result of this study delineates the areal changes of Santragachi Lake during 2011 to 2018 (Figure 1 and

Figure 2). In the year 2011, Santragachi wetland comprises 12.89 ha area. The study has found that the water hyacinth patch was 4.59 ha (36.15% of total area) and the open water area was 8.23 ha (63.84% of total area) in the year 2011. The total area, which comprises Santragachi Lake from the year 2012 to 2018 were 13.49 ha, 13.61 ha, 13.61 ha, 12.58 ha, 12.7 ha, 13.2 ha and 13.49 ha respectively. In the year 2012, the lake subsumes 3.77 ha area as open water (27.94% of total area) and 10.31 ha area as the patch of hyacinth (72.05% of total area). The open water in the year 2013 was 3.54 ha (26% of total area) and the patch of hyacinth covers 10.07 ha (73.9% of total area). In the year 2014, the area of open water was 4.08 ha (30% of total area) and the area of hyacinth was 9.53 ha (70 % of total area). The area of open water, from the year 2015 to 2018 were 8.5 ha (67.56% of total area), 11.37 ha (89.52% of total area), 13.06 ha (98.9% of total area) and 13.23 ha (98% of total area) respectively. The area of hyacinth patches were 4 ha (31.7% of total area), 1.33 ha (10.47% of total area), 0.14 ha (1.06 % of total area) and 0.26 ha (1.06% of total area) from 2015 to 2018 respectively (Figure 1 & Figure 2).



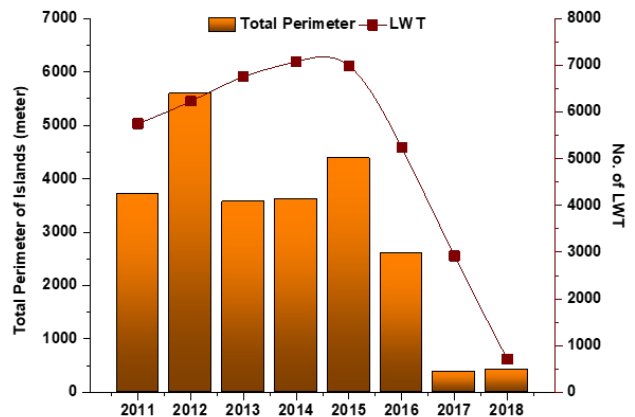
**Figure 1.** GIS based change detection of water hyacinth cover at Santragachi wetland during 2011-2014.



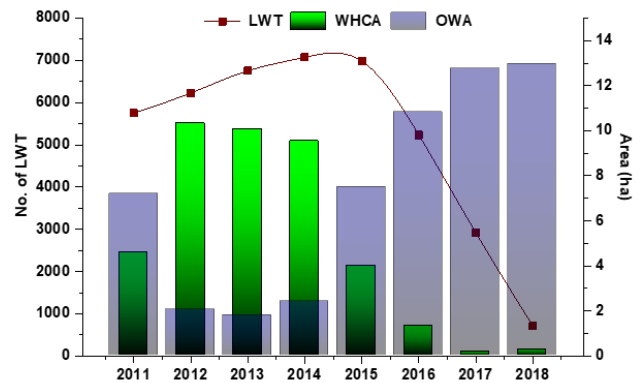
**Figure 2.** GIS based change detection of water hyacinth cover at Santragachi wetland during 2015-2018.

On the other hand the number of LWT was estimated 5232 – 7074 from 2011 to 2016. But after that a sharp decrease of LWT number was observed in 2017 and 2018. In 2017 the number of LWT was 2920 and in 2018 it was 707 only. It was depicted from Figure 3 and Figure 4 that the total perimeter of water hyacinth islands/ patches and water hyacinth cover in 2017-2018 was also decreased. From the cluster analysis it has been shown that 2017 and 2018 were distantly cluster with rest of the six years (Figure 5). Actually the water hyacinth mat of *Santragachi Jhill* were almost cleared in 2017-2018 before winter due to the National Green Tribunal Verdict, 2016. Thus the decline of LWT number in 2017-2018 was may be due to the decrease of water hyacinth cover area (WHCA) and perimeter. Actually, floating water hyacinth mat surely provided habitat and cover for aquatic invertebrates and fish that ensured a prey base for many bird species. It is the additional foraging habitat for large wading birds, such as the Egrets, Herons and Coots. Great diversity of aquatic macro- and micro-invertebrates are found along the edges of water hyacinth mats and fish could benefit from highly fragmented mats of water hyacinth. Point to be noted that in the present study our concern LWT fully

depends on water hyacinth mat for their roosting. The significant positive correlation ( $r = 0.7481$  at  $p < 0.05$ ) between LWT and WHCA also corroborates with this water hyacinth dependent roosting behavior of LWT (Table 1). Furthermore, the number of patches and total perimeter were also important because LWT mostly used periphery of the water hyacinth cover for roosting. Significant positive correlation ( $r = 0.8648$  at  $p < 0.05$ ) also found between LWT and total perimeter of water hyacinth islands. In contrast, dense water hyacinth blanket over a large surface area would physically prevent waterbird to access to prey and, thereby, negatively impacted waterbird density with the increasing water hyacinth cover. The concern LWT is a diving duck and collect food from the deep water. So, area of open water is also very important for LWT. Therefore, more study is needed to find out the optimum water hyacinth cover area, open water area and number of islands for proper management of the LWT and other wintering waterbirds habitat.

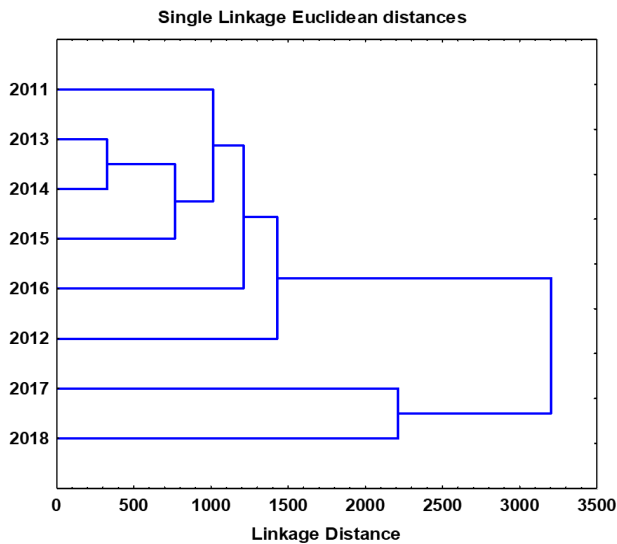


**Figure 3.** Changes of Lesser Whistling Teal (LWT) number in accordance with the total perimeter at Santragachi Wetland



**Figure 4.** Changes of Lesser Whistling Teal (LWT) number in accordance with water hyacinth cover area (WHCA) and open water area (OWA) at Santragachi Wetland





**Figure 5.** Hierarchical cluster analysis (single linkage Euclidean distances) of eight years depending on Lesser Whistling Teal number, open water area, water hyacinth cover area and total perimeter of islands

**Table 1.** Correlations within Lesser Whistling Teal (LWT) number and open water area (OWA), water hyacinth cover area (WHCA), and total perimeter of islands (TP) of Santragachi wetland (Bold red color face correlations are significant at  $p < 0.05$ ).

	LWT		
OWA	-0.8099	OWA	
WHCA	0.7481	-0.9943	WHCA
TP	0.8648	-0.8226	0.7838

#### 4. Conclusions

Major findings of this work are that scientific weed management is one of the most important prerequisites for increased richness and abundance of migratory waterfowls. There are numerous wetlands of varying sizes in West Bengal, from north to south. Most of these land bound wetlands in the river plains attract varieties of migratory birds those depend on lentic freshwater bodies for feeding and resting, especially during the winter season. Usually many of these wetlands are weed choked in the natural retrogressive fate of lentic situations. Optimal clearing of weeds, especially the floating weeds, well ahead of the wintering season for migratory waterfowl congregation, would be most important conservation criterion to attract these creatures to their feeding grounds because foraging guild structure and niche characteristics of waterbirds depends on it [36 & 37]. This work has worked out the basic

premise to optimize the clearing operations, focused on optimizing the shape and size of the islands of floating weeds and pointed out the importance of vegetation as direct or indirect food sources.

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