

A Spatio-Temporal Assessment of Green Turtle Habitat at Hawkes Bay, Karachi through Geo-Informatics Techniques

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Abstract: Hawkes Bay site is one of the major favorable nesting sites for green turtles (*Chelonia mydas*) in Pakistan. Many environmental factors influence the nesting patterns of green turtles at this beach. The main objective of this study is to evaluate the importance of monitoring habitat of wildlife with the help of GIS and remote sensing. Seasonal influence on nesting pit density is quite noticeable on high resolution imageries. Pearson's correlation coefficient analysis was used to highlight the strong relation of temperature and nesting pits. As a result of this research monitoring of spatio-temporal variation and impacts of temperature rise on nesting grounds observed.

Keywords: Green turtle, Temperature, GIS Techniques, Satellite Imageries, Geographical Factors, Temporal Change and Risk Factors.

INTRODUCTION

Marine turtles are found across the world's major oceans, they generally prefer to live in warm tropical and temperate waters. Their movement range is from tropical to subtropical regions, Atlantic to Indo-Pacific Ocean [1]. Nesting site selection is an important part of the life cycle of marine turtles. Five important turtle species; green turtle (*Chelonia mydas*), olive ridley turtle (*Lepidochelys olivacea*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*) and leatherback turtle (*Dermochelys coriacea*) have been reported in the Indian Ocean [2]. Among these species, Green turtles also have a typical behavior for the selection of their nesting sites and always select ideal geographical sites which are environmentally more favorable [3]. This species is listed as under endangered in IUCN Red list [3-6]. Range of green turtle in world map [7] is shown in (Figure 1) depicting main nesting places around the globe.

The Pakistan coastline has significant major nesting beaches of the world marked by IUCN at number 16 [8] as shown in (Figure 2). Hawkes Bay beach of Karachi coast is one of the suitable nesting grounds of Green turtles (*Chelonia mydas*). It was firstly reported as turtle nesting beach in 1966 [8-11].

Green turtles (*Chelonia mydas*) nest on these beaches throughout the year, the peak nesting season start post-monsoon. The peak nesting season ranges from September to October [12, 13].

Evaluation of sea turtle population trends is usually based on the monitoring of seasonal nesting patterns. Although temporal variation depends on several ecological and climatic parameters, sometimes it reflects changes in the population status [14-18].

There are many factors influencing on the selection of appropriate nesting months by female turtles. Some environmental microhabitat indicators are involved in the nest site selection, like beach accessibility, beach elevation, anthropogenic activities, sand bar characteristics, moisture, tides, currents, temperature etc. [19, 20]. Temperature fluctuations act as a basic factor which affects the biological and behavioral science of turtles [21-26]. The recent climatic changes have significant bearing on the sex of the turtle hatchling around the globe. Nevertheless, this is underway in Karachi by the authors and will be communicated in the forthcoming publications.

Remotely sensed images have been previously used to monitor climatic changes globally. Pakistan has important climatic regions. A moderate climate exists along the coastal belt of Karachi, especially in post monsoon season, which is often quite favorable for turtles to lay their eggs [27]. Temperature varies from north to south (a coastline of 70 Km) of the Karachi approximately 1 to 2 °C daily. Mild winters 20 (°C) and warm 36 (°C) summers are typical (Figure 3). Monthly change in temperature puts impacts on wildlife habitat.

Some common threats are such as overcrowding at the beach, tourism, climate change, illegal encroachments of huts and recent oils spills are leading to the decline of the local green turtle population [11]. Most of them are man-made in beach development, pollution, disturbance of nesting pits and

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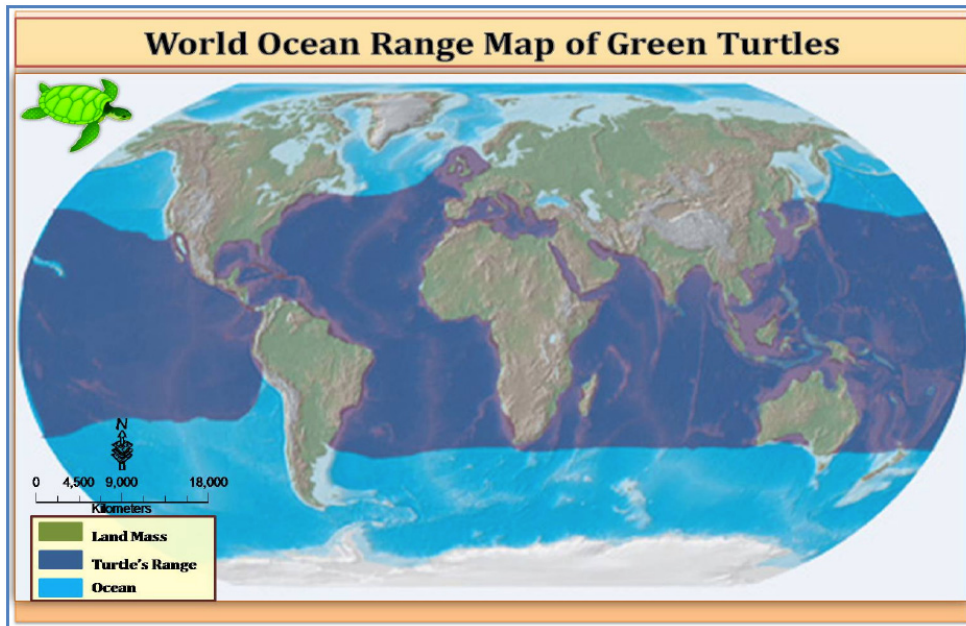


Figure 1: Green turtle's range map of the world, Source: askshamu.com/animal-info/info-books/sea turtle/habitat-&-distribution.

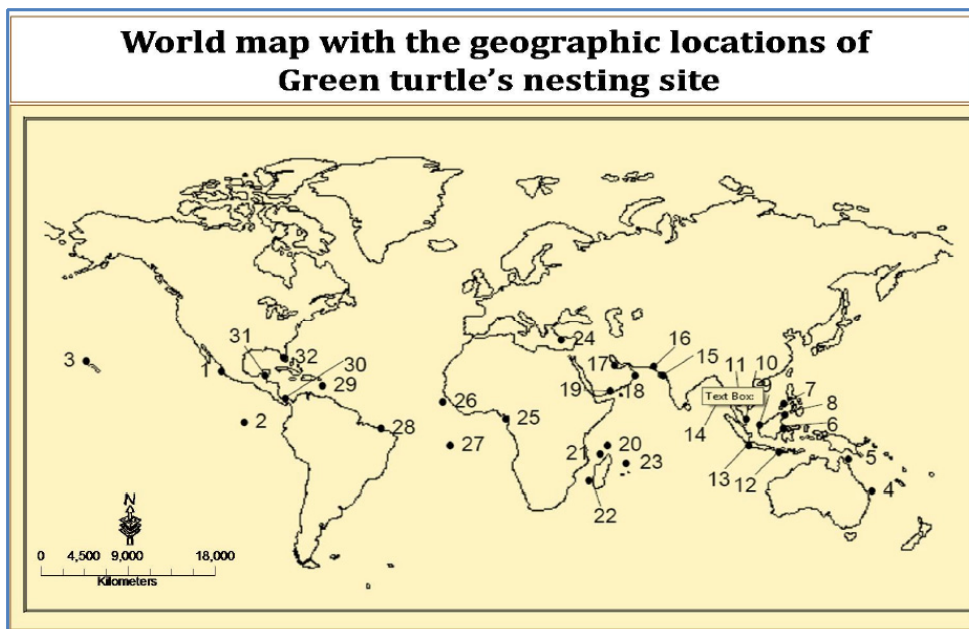


Figure 2: Green Turtle's nesting site map. Source: IUCN RED LIST 2004.

incidental catch by fishing nets are frequent. On the other hand, natural phenomena are also involved in degradation of nesting pits like high tides, beach erosion, sea surface temperature and climate change.

OBJECTIVE

The main objective this study is to implement GIS and Remote Sensing techniques to evaluate the nesting patterns of pits of green turtle, with respect to spatio-temporal change and environment indicators. High resolution satellite imageries of GeoEye were

used to locate the nesting pits and quantify the monthly trends. Vector and raster based seasonal analysis with temperature was used to determine temperature relationships. This study may provide technical assistance for future studies and management of green turtle habitat.

Study Area

Karachi coast has its own unique ecological and geographical importance. It is 250km long. Sandspit

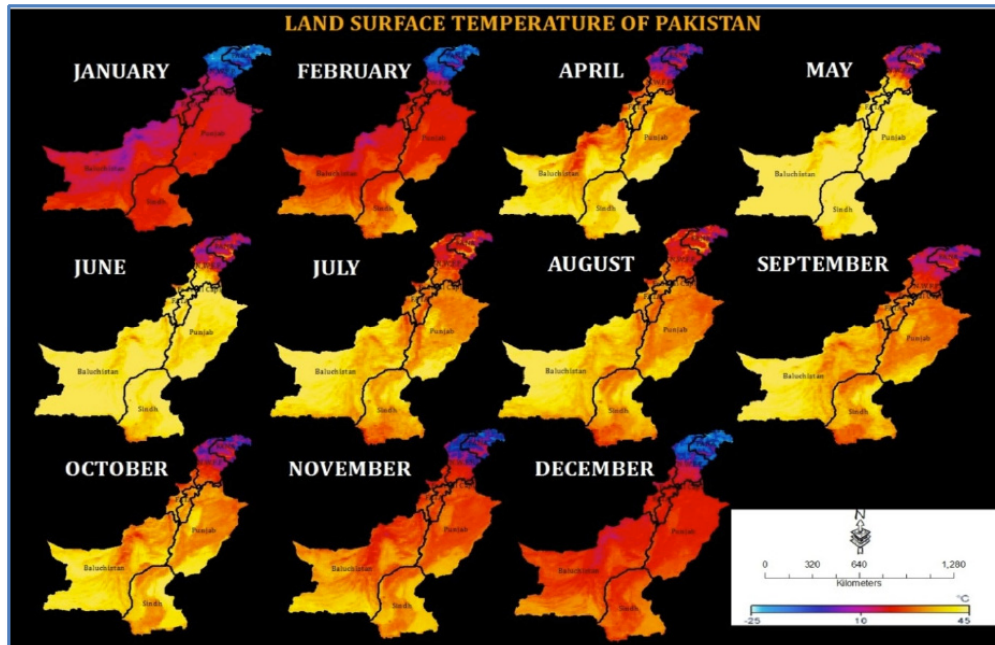


Figure 3: Land Surface temperature map of Pakistan, Source: neo.gsfc.nasa.gov.

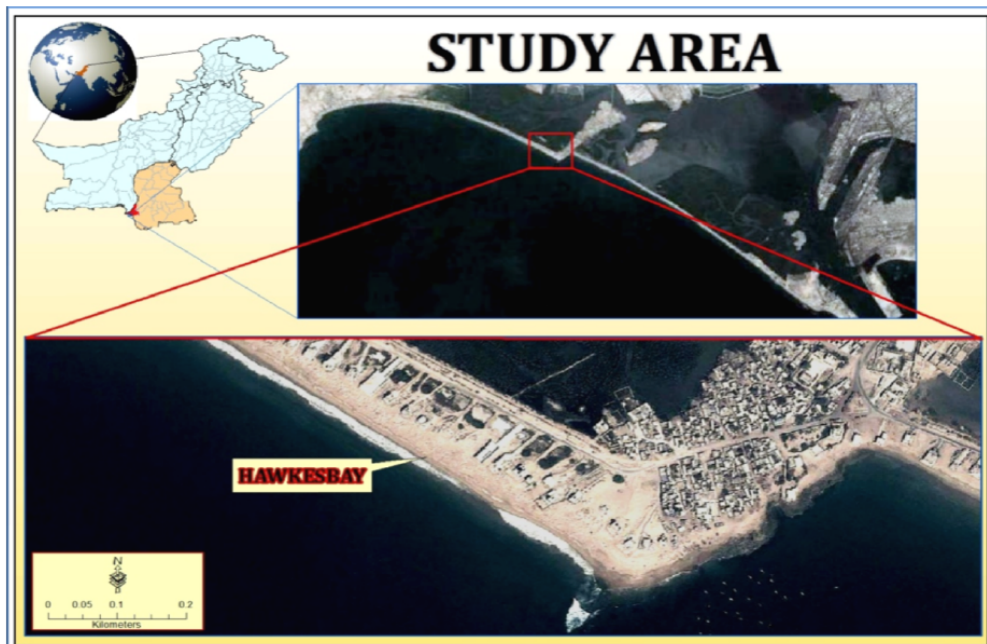


Figure 4: Study area (Hawkesbay) map, Source: Author.

and Hawkes Bay are sandy beaches of this coast. The shoreline of 0.7km of Hawkes Bay Beach is considered for this study; it is locally called as turtle beach. Geographically it is located at $24^{\circ}50'35.38''\text{N}$, $66^{\circ}53'53.70''\text{E}$. This site is environmentally quite special for its feature characteristics. Sandy profile and rocky outcrop made a perfect combination of ecosystem for green turtles to lay their eggs here (Figure 4).

MATERIALS AND METHODS

Data Collection and Processing

The primary data were collected through two types of satellite imagery. Monthly GeoEye images of 61cm resolution were obtained from 2005-2013 (month of March is not included due to data unavailability) of study area for seasonal vector layers development, while low resolution data source is MODIS 250m which

is collected to show the land surface temperature of the location. Development of study area and digitization used ERDAS Imagine (Leica) and ArcGIS 10.1 software. Published data (mainly maps and project reports) were also gathered from governmental and non-governmental organization, books and reports.

Statistical Method

For this study Pearson's Correlation coefficient (r) has been used to determine the relationship between number of nesting pits and temperature. Correlation depicts the relationship between two quantitative continuous variables. Pearson's Correlation coefficient (r) is a measure of strength of the association between two variables. Pearson's correlation coefficient (r) for continuous (interval level) data ranges from -1 to +1. Positive correlation indicates that both variables increase or decrease together, whereas negative correlation indicates that as one variable increases, so the other decreases, and vice versa [28]. This work is performed with the help of Statistical Package for Social Sciences (SPSSv. 18).

RESULTS AND DISCUSSION

Adult Female Green turtles use the Hawkes Bay Beach to nests. This site is under the pressure drastic changes. Most of them are man-made and some are climatic, these are affectively participating on the turtle's nesting activity. Large number of the nesting pits were formed in post monsoon months, while in pre monsoon months nesting process was not noticed or negligible.

Pits density were highest in the month of January, 344 numbers of nesting pits were recorded above the dry line of the study area. While in February 135 nesting pits are marked in an area of 0.7km. Comparatively, in other months in pre-monsoon (April, May, June) period no significant value of pits observed (Figure 5).

There are some natural explanations for the low and zero values of nesting pits in the monsoon months of July and August. The high tide line in months of July and August indicated that there was no dry sand available; it is thus an unfavorable condition for egg laying process.

The bulk of pits (397) were found in the month of October suggesting that climate may have a considerable influence. The high nesting months of November and December were also endorsing the mild climate favorability. As a result of this seasonal monitoring, the nesting patterns of green turtles are easily understood, as depicted in (Figure 6).

The effect of temperature on nesting ground is shown in following graph (Figure 7). The maximum temperature in May was 36.8 °C and 26 °C was the minimum in month of January. The mean value of temperature for higher nesting is 32.5 °C and mean number of nesting pits were 133. These values explained the temperature of this site decreases the density of nesting pits increases. The correlation between the nesting pits and temperature may provide reasons of the monthly variation in nesting pits occurred.

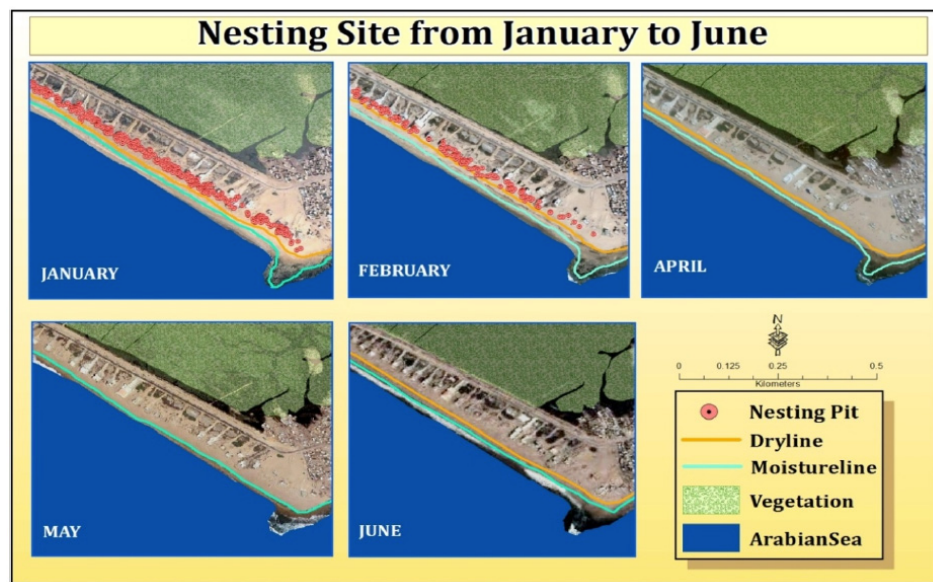


Figure 5: Nesting site from January-June. Source: Author.

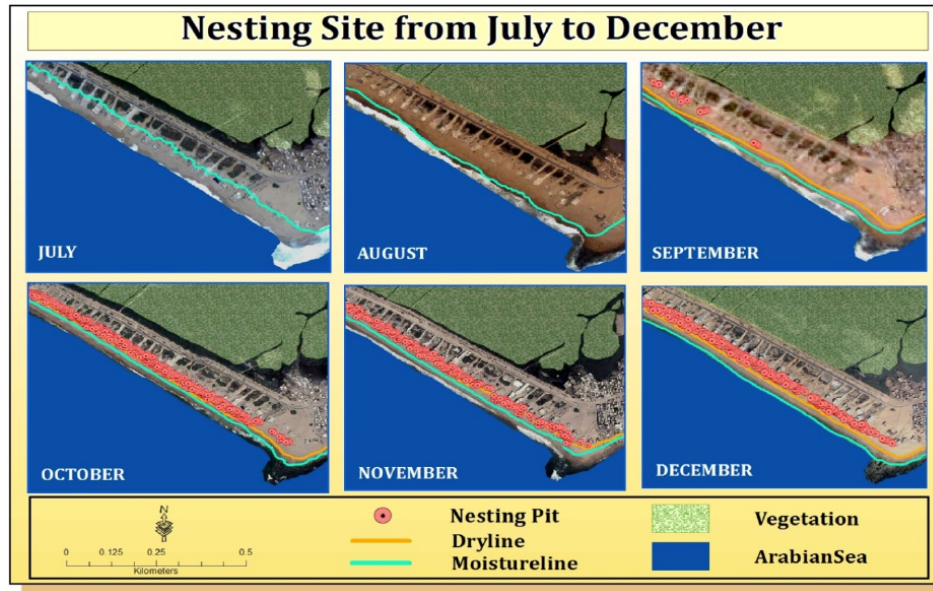


Figure 6: Map of nesting site from July to December. Source: Author.

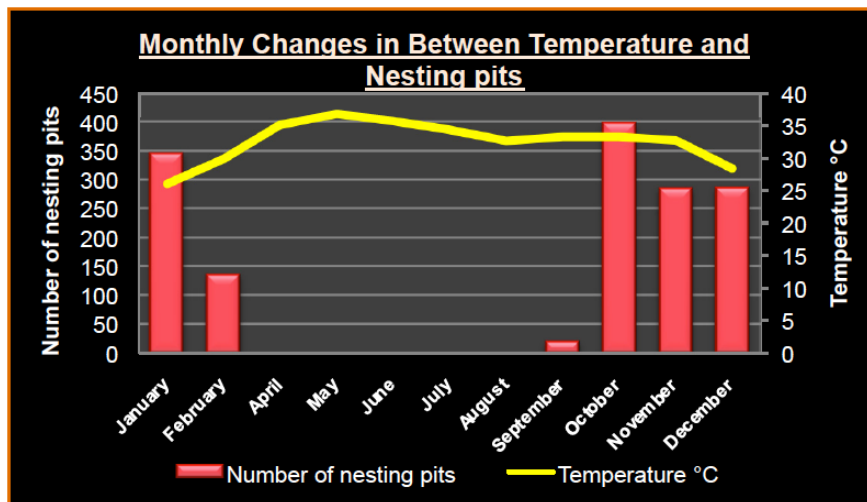


Figure 7: Month wise Change in temperature and nesting pits, Source: Author.

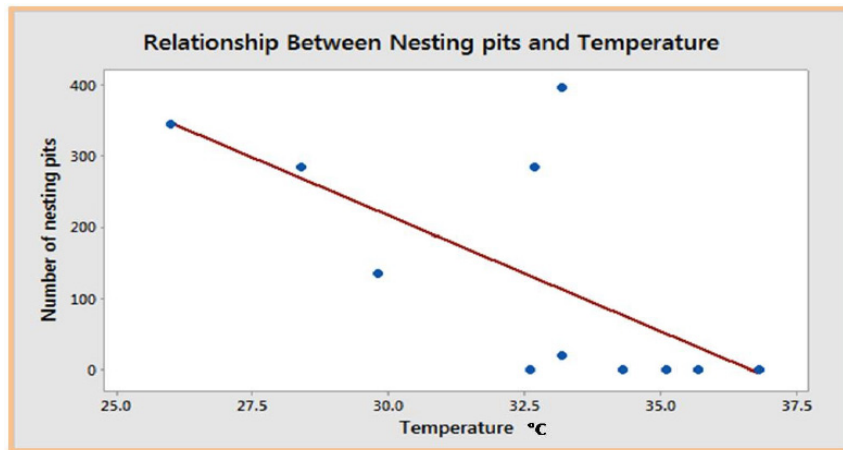


Figure 8: Correlation Coefficient, Source: Author.

The number of nesting pits was used as dependent while temperature taken as independent variable. The scatter plot of variables shows the negative linear correlation in between both variables; because the points are tend to lie near a downward sloping line. The significant value $p = 0.05$, which indicates the moderate degree of association between variables ($r = -0.657^*$). Most of the points lie near the line shows the strong relation in between temperature and nesting pits. The increase in temperature is associated with a decrease in the number of nesting pits (Figure 8).

CONCLUSION

It is concluded that the GIS and remote sensing techniques may help in monitoring of the green turtle (*Chelonia mydas*) nesting behavior. It has been also revealed that the Spatio-temporal change on nesting sites was easily observed with the help of satellite images. The seasonal density of nesting pits was dependent on climate indicators. This has also been confirmed that the nesting density is high in winter as compared to summer seasons. Correlation analysis determined the relationship of nesting pits with surface temperature. Also through this study, the variables were identified which limits the existing spatial distribution of the nesting grounds. Temperature affects the nesting behavior of green turtle. High temperatures may cause harm to the nests [30]. Development of GIS enhances the effect of climate change knowledge about the conservation of green turtles.

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