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Utilization of Geospatial Technology to Track Effects of Global Warming on Climate Changes in India

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Abstract

In order to track the global warming issues in India, "Satellite Remote Sensing" can be used effectively and the main reason for choosing this is that it gives climate associated variables with a massive regional coverage and global coverage. The survey has been effectively conducted through Ipsos and through this survey it can be stated that the global warming issue of India is increasing day by day. In addition, effective materials and methods have been highlighted and four models in this material part have been shown in a succinct manner. Uncertainty, poverty and the weak role of the local government are the major factors and these factors are increasing the climate risk issue.

Keywords

Satellite Remote Sensing, Climate Risk Issue, Global Warming Issue

1. Introduction

Geospatial Technology can be recognized as an emerging area of study that comprises "Geographic Information System (GIS)", "Global Positioning System (GPS)", and "Remote Sensing (RS)". In addition, this Geospatial Technology supports in enabling someone to obtain data that has been utilized to identify the risks of climate and utilize it for modeling, analyzing, visualizing and simulations. Geospatial data is utilized to monitor nitrogen and carbon content that are present in the environment. In this work, the way this Geospatial Technology has helped in tracking the impacts of global warming and the way this global warming is changing the climate of India has been shown in an effective manner.

2. Literature Review

2.1. Climate Change in India

In recent years, the Indian subcontinent has been prey to major heat waves, with some areas experiencing significantly high temperatures. The temperature in some parts of India has been recorded to be the highest in as the country continues to experience spring-less years. India has become hotter with each passing decade and "average mean temperature" between 2011 and 2020 exceeded the previous records by 3.1 degree Celsius [1]. In another survey conducted by Ipsos, 78% of Indians considered the likelihood of increasing "average global temperature" in 2020 to be highly likely [2]. Additionally, India's average temperature is projected to rise by approximately 4.4˚C by the end of the 21st century [3]. The heat stress across the Indus and IndoGangetic river basins is expected to be the highest, with an average 1˚C rise in the "Sea surface temperature" (SST) of the "tropical Indian Ocean" [3]. Accordingly, the Indian government is taking measures to cut down carbon emissions and achieve a "500 GW non-fossil capacity" target and a "net zero" target by 2070 [4].

2.2. Importance of Geospatial Technology in Evaluating Climate Change

"Geospatial technology" essentially enables the acquisition of earth data for simulations, visualisation, analysis and modelling. "Geospatial tools" [5] help scientists and governmental organisations to visualise climatic changes such as rising sea levels, changing patterns of weather and increasing public health risks. "Geospatial technology" plays a crucial role in improving global warming research by establishing meaningful connections between the public and climatic changes [5]. Through this procedure, the government is able to make the public more involved in climatic changes by making them aware of the current impacts of global warming.

Due to the emergence of "geospatial technology" in the market, it has become easier for organisations to generate valuable and reliable insights for resource managers as well as the general public as it is a rather inexpensive mode of detecting climate change [6]. In addition, scientists and researchers are increasingly using different geospatial tools to better visualise and manage carbon emissions by measuring the amount of carbon in the biomass [7] Among the various uses of "geospatial technology", satellite imagery is one of the most useful tools for assessing climate change. Satellite imagery helps in the better understanding of climate systems and allows researchers to monitor sea level changes, vegetation health, ocean pollution, weather patterns and emissions of greenhouse gases [8]. Accordingly, this technology can be helpful to the government in identifying hotspots and other factors responsible for increasing global temperature and locating the areas that are the most vulnerable to climate change.

2.3. Main Applications of Geospatial Technology

2.3.1. "Geographic Information System" (GIS)

GIS helps in assessing and visualizing location-specific issues in resource management, environmental and geospatial science by incorporating "heterogeneous spatial data" along with some other attributes to derive knowledge through different modelling approaches and "spatial analysis tools" [9]. GIS uses satellite images to monitor environmental changes, which makes it a vital geospatial tool in monitoring the distribution of natural resources across the globe.

Through the help of GIS, the national government can incorporate and document satellite images to monitor the distribution of vegetation and prevent deforestation. For instance, GIS can be used with GPRS to map images localities and assess the distribution of forest land, which can further assist governmental organisations to allocate adequate tree planting funds to areas of need in order to restore the environmental balance [10]. Additionally, GIS tools can be helpful in generating insights into the water usage of localities and tracking the flow of water [9]. Consequently, the government can leverage water usage data to address water scarcity issues in different parts of the nation.

2.3.2. "Remote Sensing" (RS)

Remote Sensing monitors an area's physical characteristics by measuring its radiations emitted and reflected from an aircraft or satellite with the help of special cameras that gather remote images through sensors [11]. For instance, satellite cameras provide images of the earth's surface and capture temperature changes in oceans. The following are some common applications of remote sensing in analysing the earth's surface:

1) Allowing rangers to gain a larger view of affected forest lands by mapping forest fire areas from space.

2) Keeping track of clouds to facilitate better weather predictions [12].

3) Capturing volcanic eruptions from above and looking out for imminent dust storms.

4) Tracking and monitoring the growth of cities, changes in vegetation patterns and farmlands [12].

2.3.3. "Global Positioning System" (GPS)

The GPS used to monitor and control navigation in aviation and naval ships due to its series of network systems that allow mapping of locations. Mainly operated and monitored by the "Department of Defense" (DoD), a total of 31 GPS satellites currently orbit the earth [13]. The GPS satellites help determine accurate locations of different places on Earth along with detailed weather conditions of different localities. GPS is a useful Geospatial tool to measure climate change as it uses satellite constellations to constantly monitor the earth and predict environmental changes [14]. Meteorologists have identified the incorporation of GPS measurements to be highly relevant in determining the atmospheric water content, which further determines more accurate weather forecasts in the modern era. In addition, GPS measurements provide enhanced estimates of vertical measurements from the earth's surface and thus present unique opportunities for assessing ocean tides and making predictions [14].

2.4. Contribution of "Satellite Remote Sensing" in Climate Change

"Satellite remote sensing" can be considered as a suitable approach to monitor land cover along with its changes over timing over a spatial scale's varieties [15]. Climate analysis and monitoring can be considered as a necessary task in terms of improving the understanding of climate change and climate dynamics. The main reasons that "Satellite Remote Sensing" is becoming necessary have been shown below:

Assimilation of the data of satellites has vastly increased the analysis data's quality.

"Remote sensing" provides several climate related variables with a vast regional coverage and the global coverage.

2.5. Utilization of "Geospatial Technologies" for Environmental Effects Assessment in India

As per the by Ipsos on making some predictions about global issues in the year of 2020, 78% of Indians have thought that the "average global temperatures" would increase in upcoming years. In addition, 17% of the people who have given their responses were more skeptical regarding global warming in the year of 2020 [16]. Modern "geospatial technologies or tools" give certain applications for effectively detecting climate change. In terms of tracking the global warming and climate change issues, GIS, GPS and RS technologies have been utilized in India for drought monitoring, atmosphere monitoring, coastal and ocean monitoring including flood monitoring [16]. Remote sensing, GPS and GIS techniques would be beneficial for executing environmental assessment and monitoring with respect to:

- "Dispersion of pollutants" in India.
- Preparation of comprehensive thematic mapping for decision makers, planners along with environmentalists.

2.6. Application of Geospatial Technology in India

The Indian government is prioritising the need for advanced intelligence to assess better climate controls. According to the "Indian Geospatial Report", the current geospatial economy in India is valued at 38,972 crores Indian Rupees and employs nearly 4.7 lakh individuals [17].

In the Indian market, geospatial technology and information currently hold a vital position in all industries to enhance the economy. Businesses, as well as the government, are heavily relying on the geospatial sector to improve lifestyle and customer services through quality planning and citizen engagement. According to recent data, the total geospatial market in 2021 was estimated at nearly INR 14,050 crores, which in turn has been forecasted to be INR 23,200 crores by 2025 [17].

Currently "Urban Development", "Utilities" and "Defense and Intelligence" industry are using geospatial technology [17]. The three industries together accounted for 37.98% of the overall geospatial market, with "Defense and Intelligence" accounting for 14.05%, "Urban Development" accounting for 12.93%, and "Utilities" accounting for 11% [17]. As a result, the geospatial market has a huge potential in the Indian economy in the near future.

3. Materials and Method

3.1. "Remote Sensing Data"

The goal of this study is to study is to apply unmanned aerial systems data in synergy with geospatial technology to track the effects of global warming on climate changes in India. To realize this objective, unmanned aerial system (AUS) data extracted through field spectroradiometry for accurate radiometric analysis on Sentinel-2 (S2) and Landsat-8 (L8) imagery was used. The research hypothesis is that the imagery obtained by multispectral unmanned aerial system (UAS) sensors are perfectly calibrated with accurate data from drone file measurement. The process data are used to close on the scale gap between conventional in-situ measurement and satellite imagery measurements. With Landsat-8 and Sentinel-2, data sampling can be spread over large area, including inaccessible areas, areas with massive land cover and risky locations in less time while providing high radiometric quality. The Sentinel-2 and Landsat-8 efficiency was enhanced by utilizing multiple-date satellite data on shoreline mapping around region of focus (research region).

The reflectance of measurement data was empirically matched to multispectral data collected by an UAS through radiometric references spread across wider spectral range. In order to compare the accuracy of the CorRad-MiraMon method and the radiometrically adjusted Santel-2 and Landsat-8 official versions (Sen2Cor-SNAP and 6S-LaSRC, respectively) using pseudo-invariant areas like reflectance references (PIA-MiraMon). Drone data was recomputed to satellite grids I n the third stage of analysis, the matching bands of Landsat-8, Sentinel-2 and UAS were radiometrically corrected by combining the CorRad-MiraMon method (UAS-MiraMon) with UAS data as reflectance references. It is necessary to mention in this section that, for the year of "2019 Landsat OLI 30-meter spatial resolution (WIR-1, SWIR-2) was utilized [18]. The field of the Island has been utilized as an effective indicator for this shoreline change.

Naïve Bayes was used in algorithm classifier to classify data in correct category. Object-based image analysis was applied to group drone images based on resolution and pixels. OBIA was resourceful in this research as it enhanced digitization of mapping results.

3.2. "Socio Economic Data"

The geographic coordinates within India comes between n 8˚4'N to 37˚6'N latitude along with 68˚7'E to 97˚25'E longitude whose total mass have been estimated as "3,287,263 square kilometers" [19]. It can be stated that, with the help of direct interviews the household's "socio economic survey" has been conducted in the research area from the year of 2019 to 2020. In terms of conducting this survey "random cluster sampling" has been utilized. It has been found that 1023 households from the 41 Mouzas have been surveyed, utilizing systematic sampling and covering nearly 2.1% of overall population [18]. The four unique logistic models effectively have been utilized to analyze the interdependence among the main variables.

The log model has been shown below:

$$\Pi = \exp\left(B_0 + B_1X_1 + \cdots + B_kX_k\right)/1 + \exp\left(B_0 + B_1X_1 + \cdots + B_kX_k\right)$$

(Source: [18])

4. Result and Discussion

4.1. "Remote Sensing Data Analysis"

There has some significant change in this Sagar block's shoreline and this has been highlighted through the changes in the field of the Ghoramara Islands and Sagar. It highlights that during the time of 2009 along with 2019, the corresponding shoreline field of this Sagar Island has diminished effectively [20]. The particular mouzas are Bakimnagar, Chemguri, Narharipur, Chakfuldubi, Chandipur, Shikarpur, Ramkrishnapur, Gobindabapur (**Figures 1-3**).

4.2. "Socio-Economic Data Analysis"

Reduction or uncertainty in livestock yield and crop, poverty including a weaker contribution of the local government in giving appropriate infrastructure, had the main factors that are increasing the risks associated with climate [21]. The connection between the crucial variables analyzed by the four different models towards testing hypotheses has been highlighted below (**Figure 4**).

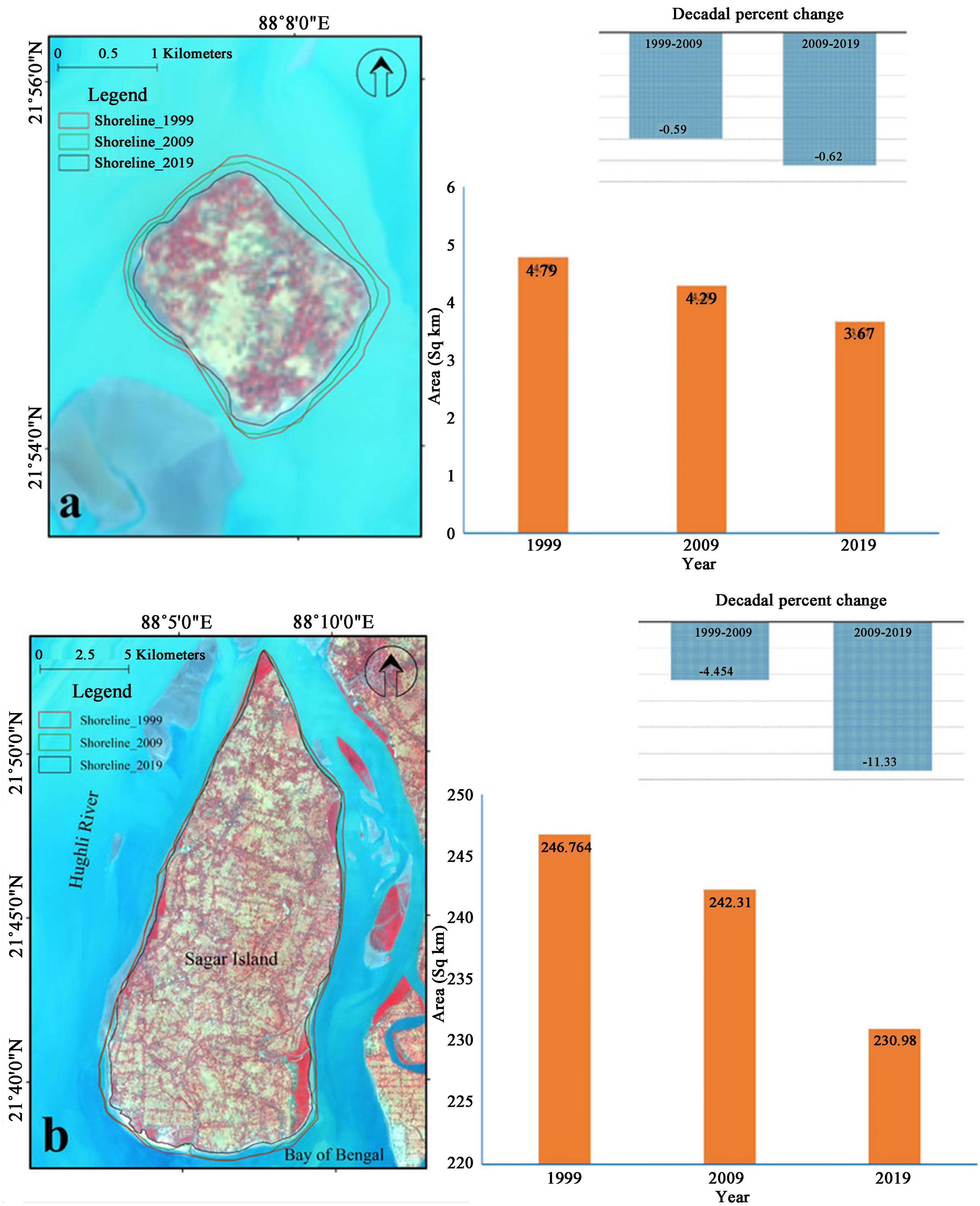
Model 1, the below **Table 2** has examined the interconnection within land loss with productivity loss, migration, including "loss of livelihood" (**Table 1**).

The values of these "corresponding coefficients" are 15.39, −1.45 and 12.05 respectively (**Table 2**). The regression analysis highlights an effective association among productivity loss and land loss, resulting in "loss of livelihood" in the Sagar Island [22].

Model 2, this below table highlights a "logistic regression" of IM on land loss including other variables such as "agricultural productivity loss" and "loss of livelihood"

Model 3, the below table attempts to search the connection among the "loss of livelihood" and "land loss" where IM including changes in productivity are known as the control variables (**Table 3**) [23].

The coefficient's values of the standard deviance and land loss are 1.165 and 1.1691 and it is good enough to state that these are interconnected. The values of this AIC and log-likelihood of this model are 45.714 and 2.375 respectively [24].



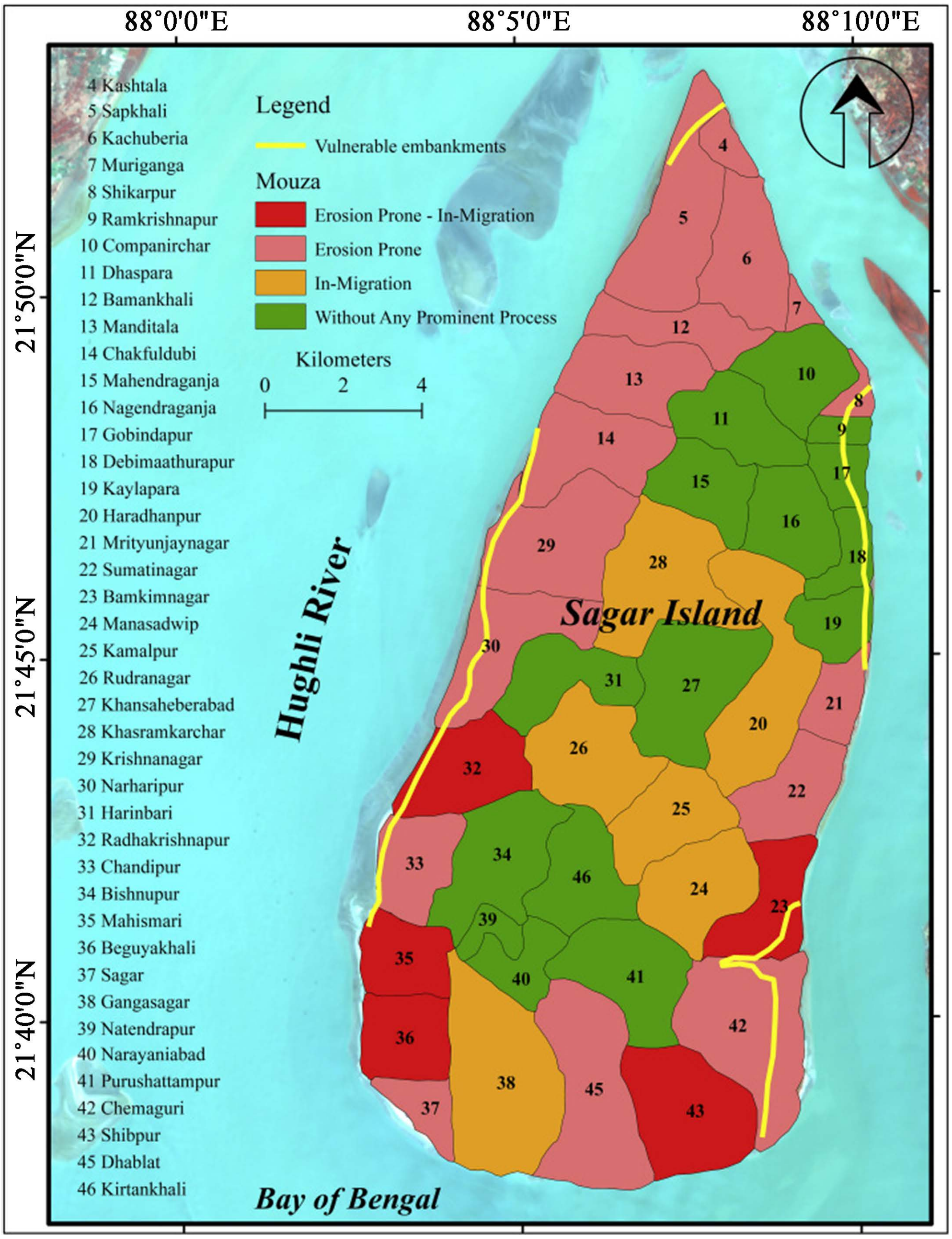
(Source: [20]).

Figure 1. Percent decadal field changes in Sagar Islands and Ghoramara.

	Sagar Island			Ghoramara Island		
	Year					
Area (Sqkm)	1999	2009	2019	1999	2009	2019
	246.76	242.31	230.98	4.79	4.29	3.67

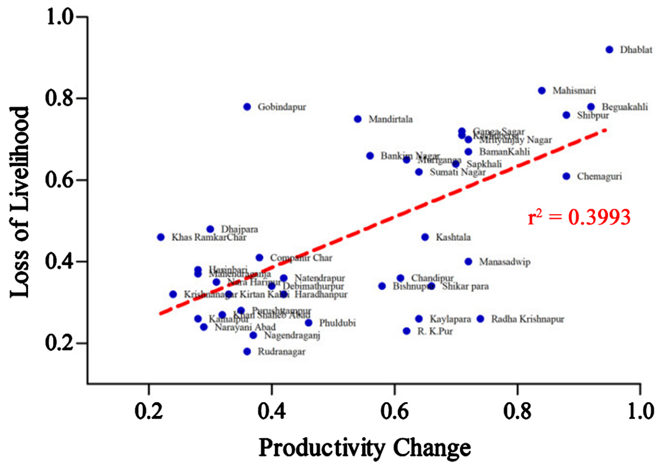
(Source: [20]).

Figure 2. Yearly changes in Sagar Island.



(Source: [20]).

Figure 3. Mauzas of this Sagar Island.



(Source: [21]).

Figure 4. Regression plotting.

Table 1. Model 1's logistic regression.

Coefficient	Estimate	Standard Error	Z Value	P value	Akike Information Criterion (AIC)
Intercept	−0.92481	1.04605	−0.884	0.377	45.714
Ind. Migration	1.16911	1.00316	1.165	0.244	
Productivity Change	0.05081	0.76255	0.067	0.947	
Loss of Livelihood	0.84670	2.20901	0.383	0.702	

(Source: [22]).

Table 2. Model 2's logistic regression.

Coefficient	Estimate	Standard Error	Z Value	P value	Akike Information Criterion (AIC)
Intercept	−2.6006	1.4286	−1.820	0.0687	53.868
Ind. Migration	−0.5751	1.2764	−0.451	0.6523	
Productivity Change	0.5888	2.6737	0.220	0.8257	
Loss of Livelihood	2.6808	2.4451	1.096	0.2729	

(Source: [22]).

Table 3. Model 3's logistic regression.

Coefficient	Estimate	Standard Error	Z Value	P value
Intercept	−0.92481	1.04605	−0.884	
Ind. Migration	1.16911	1.00316	0.244	45.714
Productivity Change	0.05081	0.76255	0.947	
Loss of Livelihood	0.84670	2.20901	0.702	

(Source: [24]).

Table 4. Model 4's logistic regression.

Coefficient	Estimate	Standard Error	Z Value	P value	Akike Information Criterion (AIC)
Intercept	−0.6664	0.9731	−0.685	0.493	52.147
Ind. Migration	1.0328	1.1168	0.925	0.355	
Productivity Change	0.2637	0.7544	0.350	0.727	
Loss of Livelihood	1.0057	2.3995	0.419	0.675	

(Source: [25]).

Model 4, the below table highlights regression analysis highlighting productivity change, control variables and land loss (**Table 4**).

The values of this coefficient of crucial variable land loss are 0.925 and 1.0328 and these are highlighting that productivity decrease is more proportional to inundation and erosion. The testing variables have affected "loss of livelihood" and "migration" [25].

5. Conclusion

Throughout this article analysis, it has been shown that proper utilization of Geospatial Technology has helped in tracking the impacts of global warming on the climate of India. This "Geospatial Technology" can be considered an increasing field of study that involves GPS, GIS and Remote Sensing. It has been shown in the study that, Geospatial tools are helpful in highlighting the weather changing patterns, sea level risks, and increasing risk towards human health. In this study, it has been shown that a survey has been conducted by Ipsos and this survey has highlighted that India is facing issues of global warming.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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