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Temporal analysis of Vegetation Health of Murti River Basin: An approach through Geospatial Technique

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Abstract:
Forests are important resources of our planet. They act as primary producers of food chain and hence act as the engine of the food chain of the world. However, the forests at present are undergoing changes due to modern lifestyle of man. Increasing population and rapid urban development has laid a significant impact on the vegetation. A large number of forests have been destroyed all over the world for the construction of cities, undertaking agriculture and for fulfilling of other needs and requirements. In simpler words, while undertaking different developmental activities, the issues of environment are hardly taken into consideration. Developmental activities all over the world has not only brought about a reduction in the areal coverage of vegetation, but also it has brought about a decline in vegetation health. An attempt has been made in this paper to analyse the vegetation health of Murti River basin of West Bengal on a temporal basis by performing NDVI analysis using LANDSAT images. The development of tourism industry has triggered large scale anthropogenic activities in the study area that have laid a considerable impact on the vegetation health of the study area. The study clearly revealed that the vegetation health of Murti River basin has undergone notable decline with time from the period of 2000 to 2020 and developmental activities owing to increasing tourism is considered to be the primary reason for such changes.

Keywords: *Urban development, Vegetation Health, NDVI, Increasing tourism.*

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I. INTRODUCTION

Forests which at present cover about 30% of the earth surface is of extreme importance to living world. Forests act as the starting point of the food chain through which our living world receives all its nutrition and energy. Forests maintain the balance of oxygen and carbon-di-oxide in the atmosphere and thus maintains a homeostatic equilibrium in the ecosystem. With the passage of time, the global population is rising rapidly and the present population of the world is about 7.8 billion in 2020 and is expected to undergo a growth of about 25% and reach the mark of 9.9 billion by 2050. In order to fulfil the increasing demand and needs of the population, different types of developmental activities have been undertaken. Urbanisation and industrialisation all over the world has triggered economic development. However, while undertaking all these developmental activities, the environmental issues have been totally ignored. Man have indiscriminately destroyed forests and converted them into agricultural lands. Forests have also been destroyed for the purpose of urbanisation which involved construction activities, expansion of roads and many others. Besides, increasing level of pollution have also laid significant effect on the vegetation. In simpler words, it can be said that all these developmental activities have not only brought about a significant decline in areal coverage of vegetation but also have laid considerable effect on the vegetation health as well. With the advent of Remote Sensing, it has become possible to analyse the health of the vegetation cover of an area. Apparently, an area may be covered with dense vegetation. But the quality of the vegetation can be determined by performing Normalised Difference Vegetation Index (NDVI). An attempt has been made in this paper to analyse the vegetation health of Murti River basin in West Bengal in the years 2000, 2010 and 2020 using LANDSAT Imageries.

II. II.METHODOLOGY

In order to accomplish the task, LANDSAT 5 TM and LANDSAT 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images were downloaded from USGS Earth Explorer for the years of 2000, 2010 and 2020. Software like ERDAS Imagine 2014 and ArcGIS 10.3 were used for the preparation of maps. Graphs were prepared using MS Excel. All the maps and graphs prepared were finally analysed and interpreted in order to arrive at the required results.

2.1 Database*:*

For performing the present research work, LANDSAT 5 Thematic Mapper and LANDSAT 8 OLI and Thermal Infrared Sensor (TIRS) images have been used. Landsat 5 TM satellite orbits around the earth in a sun-synchronous orbit at an altitude of 705 km and was launched from Vandenberg Air Force Base in California on 1st March 1984. Landsat 5 images consist of 7 bands with spatial resolution of 30 m for bands 1 to 5 and band 7 while band 6 is a thermal band with spatial resolution of 120 metres. Thermal band 6 is acquired at 120meter resolution. Delivered products are resampled at 30meter resolution. Landsat 8 OLI was launched from Vandenberg Air Force Base in California on 11th February, 2013. Landsat 8 OLI images consist of 9 bands with a spatial resolution of 30 metres for bands 1 to 7 while Band 8 is Panchromatic with spatial resolution of 15 metres. Thermal bands 10 and 11 are having a spatial resolution of 100 metres. Hence, TIRS bands i.e., thermal bands of 11 and 12 although acquired at 100 m resolution, the spatial resolution is resampled to 30 metres in delivered satellite data products. Details of satellite images are given in table 1 and 2.

Table 1: Band Combination details of Landsat 5 TM

	Bands	**Wavelength (micrometres)**	**Resolution (Meters)**
Landsat 5 Thematic Mapper (TM)	Band 1- Blue	0.45-0.52	30
	Band 2- Green	0.52-0.60	30
	Band 3- Red	0.63-0.69	30
	Band 4- Near Infrared (NIR)	0.76-0.90	30
	Band 5- Shortwave Infrared (SWIR) 1	1.55-1.75	30
	Band 6- Thermal	10.40-12.50	120* (30)
	Band 7- Shortwave Infrared (SWIR) 2	2.08-2.35	30

(Chatterjee, 2020)

Table 2: Band Combination details of Landsat 8 OLI

	Bands	**Wavelength (micrometres)**	**Resolution (Meters)**
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	Band 1- Ultra Blue	0.435-0.451	30
	Band 2- Blue	0.452-0.512	30
	Band 3- Green	0.533-0.590	30
	Band 4- Red	0.636-0.673	30
	Band 5- Near Infrared (NIR)	0.851-0.879	30
	Band 6- Shortwave Infrared (SWIR) 1	1.566-1.651	30
	Band 7- Shortwave Infrared (SWIR) 2	2.107-2.294	30
	Band 8- Panchromatic	0.503-0.676	15
	Band 9- Cirrus	1.363-1.384	30
	Band 10- Thermal Infrared (TIRS) 1	10.60-11.19	100 * (30)
	Band 11- Thermal Infrared (TIRS) 2	11.50-12.51	100 * (30)

(Chatterjee, 2020)

Following satellite images have been used for the purpose of completion of the work and its details are given in table 3.

Table 3: Details of Satellite images referred

Acquisition date	**Sensor and Satellite**	**Reference System/path/row**
2000/31/10	Landsat 5 TM	UTM -45N/139/41
2010/11/05	Landsat 5 TM	UTM-45N/139/41
2020/11/07	Landsat 8 OLI and TIRS	UTM- 45N/139/41

(USGS, Earth Explorer)

2.2 Procedure of computing Normalized Difference Vegetation Index:

Normalised Differential Vegetation Index (NDVI) is a method of obtaining vegetation data using the Near Infrared band (NIR) and visible Red band (R). NDVI values always range from -1 to +1 (Roy and Basak, 2020). Very high NDVI values indicate healthy vegetation and negative values represent waterbodies, clouds etc. Green and healthy vegetation contains large amounts of chlorophyll. Such type of vegetation reflects more

NIR and green light as compared to other wavelengths (Chatterjee, 2020). More red and blue light is absorbed. The formula adopted for calculating NDVI is as followed:

$$NDVI = \frac{NIR - RED}{NIR + RED} \text{ (Equation 1)}$$

Let's explain it with an example.

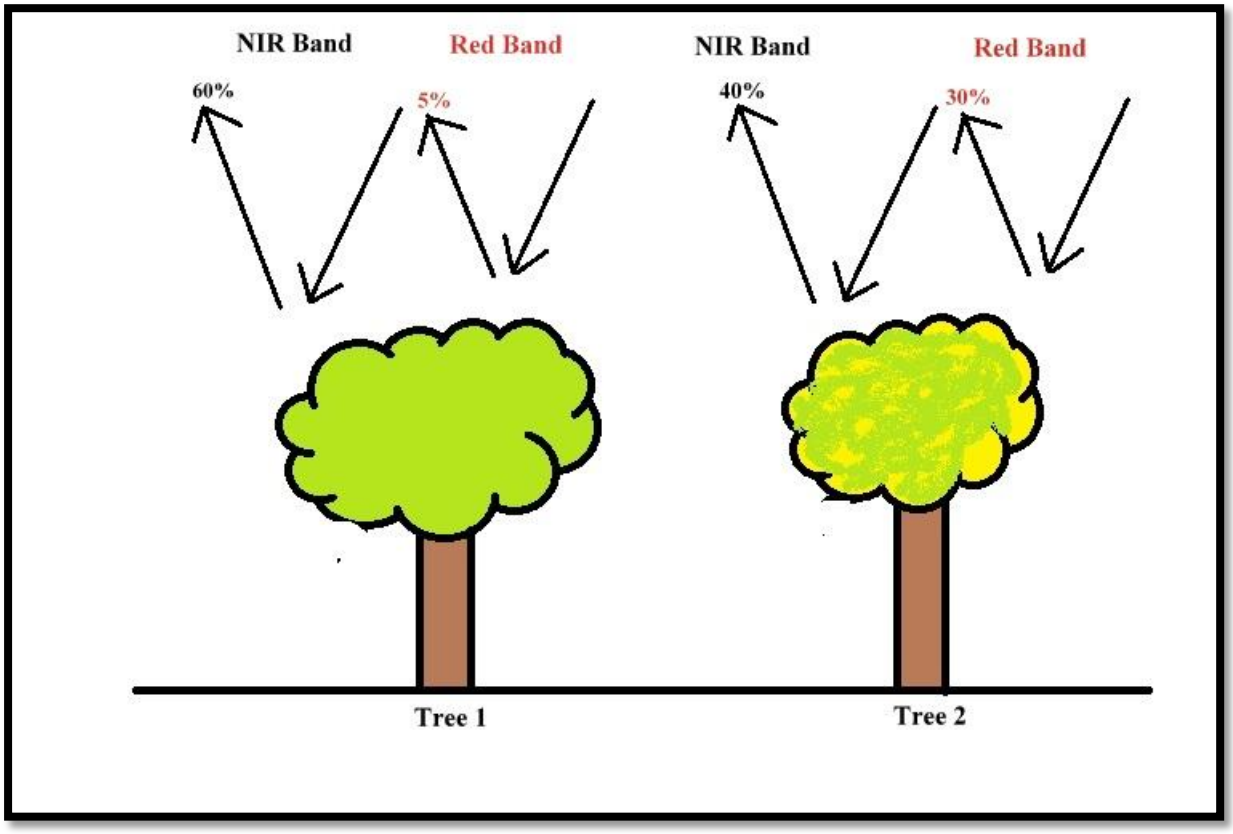

Figure 1: Variation of Reflectance (After Chatterjee, 2020)

In the figure 1 above, there are two trees namely Tree 1 and Tree 2. Tree 1 is healthy and has more chlorophyll. It reflects about 60% of NIR and absorbs the rest 40%. It reflects 5% of red band and absorbs 95%. On the contrary, Tree 2 is stressed with less chlorophyll content. It reflects about 40% of NIR and absorbs the rest 60%. It reflects 30% of red band and absorbs 70%. Now if we apply the equation 1 in case of two trees the following values will be obtained:

Tree 1:

NDVI= (0.6-0.05)/ (0.6+0.05) = **0.84.**

Tree 2:

NDVI= (0.4-0.3)/ (0.4+0.3) = **0.14.**

Hence, it is seen from the above example that Tree 1 has higher NDVI value than Tree 2 and thus it can be concluded that Tree 1 is healthy while Tree 2 is Stressed. In simpler terms, higher NDVI values will indicate healthy vegetation (Chatterjee, 2020)

NDVI values ranging from 0.3 to 0.6 are considered to be stressed vegetation while NDVI values having value of more than 0.6 are considered to be healthy vegetation (Bhatta, 2020). In the paper, NDVI values ranging from 0.3 to 0.4 are categorised as Highly Stressed Vegetation; values ranging from 0.4 to 0.5 are considered as Moderately Stressed Vegetation; values ranging from 0.5 to 0.6 are considered as Less Stressed Vegetation and NDVI values exceeding 0.6 are categorised as Healthy Vegetation.

2.3 A brief idea about the Study Area:

Murti River have its origin in the Neora valley national park. A large portion of the Murti River flows through the Dooars region and finally joins the river Jaldhaka. Murti river enters the plain at Samsing and flows through the Gorumara forest. After joining Jaldhaka, it enters Bangladesh near Mathabhanga and finally confluences with the Brahmaputra River. In this study, the part of the Murti basin which covers the Dooars region is taken into account. The total area of the basin taken for study is about 140 square kilometres. Its latitudinal extension is from 26°46´14´´N to 27°3´54´´N while its longitudinal extension is from 88°46´26´´E to 88°52´3´´E (Figure 2). The basin area is flanked by the Chapramari forest in its left and Gorumara forest in its right. Gorumara forest became a national park in the year 1994 while Chapramari is an extension of the Gorumara national park actually divided by the Murti river. These two forests are the habitat of wild animals like elephants, bisons, Indian rhinoceros, leopard and several species of colourful birds. Owing to its natural beauty and tranquillity of the forest environment, it has turned to be one of the most popular tourist spots that attracts tourists not only from different parts of West Bengal and India but also from different parts of the world.

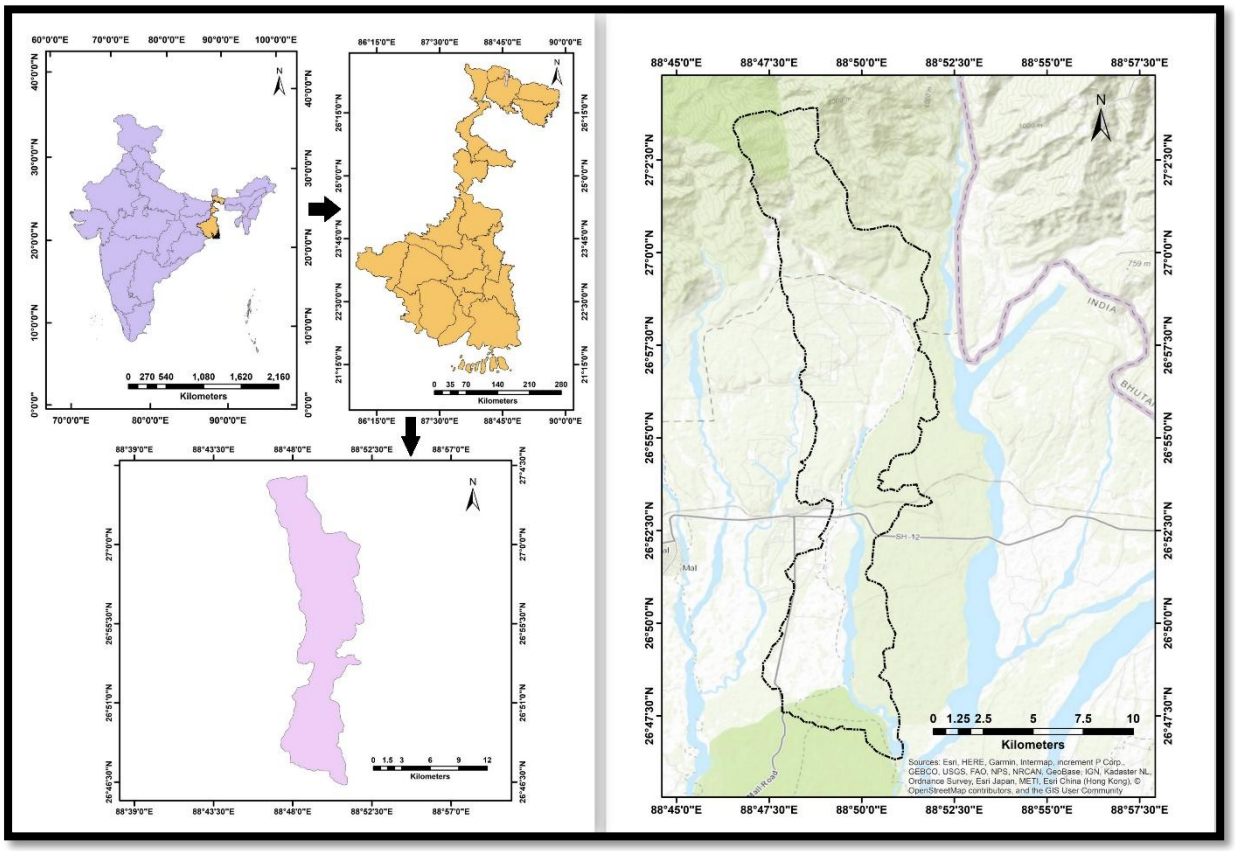

Figure 2: Location map of the Study Area

III. RESULTS AND DISCUSSIONS

3.1 Analysis of vegetation health of Murti River Basin:

Temporal analysis of vegetation health of Murti River basin was performed using Landsat 5 TM and Landsat 8 OLI images for the years of 2000, 2010 and 2020. The study revealed that in 2000, the maximum value of NDVI was 0.787234 (Figure 3A). Since the value is more than 0.6, hence it can be said that the vegetation was healthy. In the year 2010, the maximum value of NDVI turned out to be 0.77305 (Figure 3B). In this case also, this value exceeded the threshold value of 0.6 and the vegetation can be designated as healthy vegetation. However, in 2020, the maximum value of NDVI have undergone a mass decline and reached to 0.54077 (Figure 3C). Since this value ranges between 0.3 to 0.6, the vegetation can be designated as stressed vegetation.

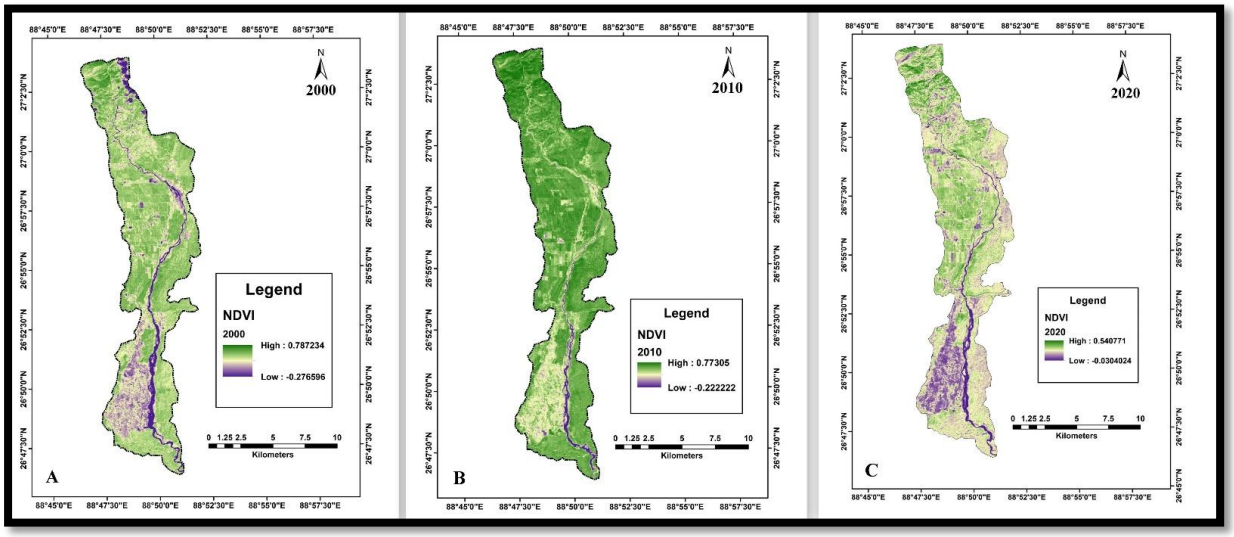

Figure 3: NDVI Scenario of Murti River Basin in 2000,2010 and 2020.

If the NDVI values are analysed on a temporal basis, it is seen that NDVI values have undergone significant decline with time which in turn indicates the decline in healthiness of vegetation. The maximum value of NDVI has declined from 0.787234 in 2000 to 0.77305 in 2010 and finally to 0.54077 in 2020 (Figure 3). Since NDVI values ranging from 0.3 to 0.6 are considered to be Stressed Vegetation while NDVI values more than 0.6 are considered as healthy vegetation, the maximum values of NDVI for the years 2000, 2010 and 2020 clearly indicate that there has been a decline in vegetation health with time 9 (Figure 4). Vegetation was healthy in the years of 2000 and 2010 while it became stressed in the year 2020. Increase in developmental activities due to development of tourism industry can be attributed as the reason for such decline of vegetation health.

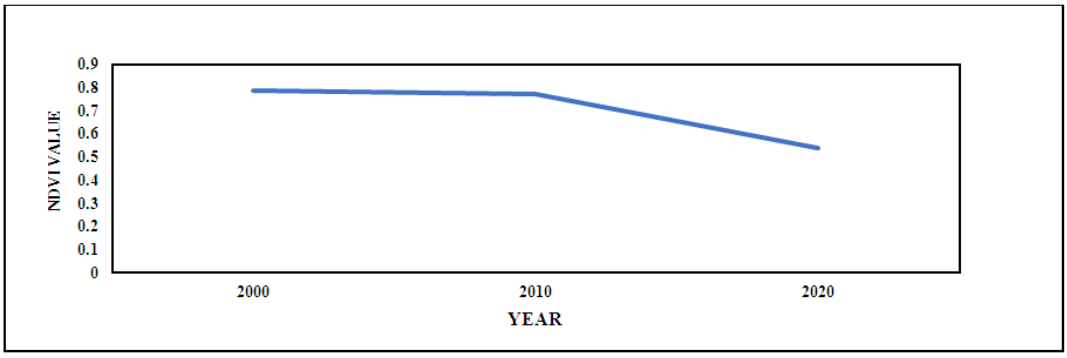

Figure 4: Declining trend of vegetation health of Murti River Basin

3.2 NDVI Classification of Vegetation of Murti Basin in the years 2000, 2010 and 2020:

For the proper understanding of the vegetation status of Murti River basin, NDVI classification has been performed. NDVI values ranging from 0.3 to 0.4 are categorised as Highly Stressed Vegetation; values ranging from 0.4 to 0.5 are considered as Moderately Stressed Vegetation; values ranging from 0.5 to 0.6 are considered as Less Stressed Vegetation and NDVI values exceeding 0.6 are categorised as Healthy Vegetation. In the year 2000 out of the total area of 144 square kilometre, highly stressed vegetation occupied about 9.4 square kilometre accounting for about 6.53% of the total area (Table 4). In the year 2010, area under highly stressed vegetation increased to about 11.42 square kilometre accounting for about 7.93% of the total area of the basin (Table 4). But a meteoric rise in area under highly stressed vegetation was noticed in the year 2020 where it increased to about 88.05 square kilometre accounting for 61.15% of the total area (Table 4). Area under moderately stressed vegetation also have undergone significant changes within the years selected for study. Area under moderately stressed vegetation was 18.9 square kilometre in 2000 accounting for about 13.13% of total area of the basin and it increased to 19.37 square kilometre in 2010 accounting for about 13.45% of total area and declined to 11.02 square kilometre in 2020 accounting for about 7.65% of the total area (Table 4). Area under less stressed vegetation also have undergone notable changes within the years selected for study. Area under less stressed vegetation was 52.32 square kilometre in 2000 accounting for about 36.33% of total area of

the basin and it increased to 68.6 square kilometre in 2010 accounting for about 47.63% of total area and became almost nil reaching the negligible value of 0.04 square kilometre in 2020 accounting for about 0.02% of the total area (Table 4). A continuous declining trend can be seen in case healthy vegetation in the study area whereby area under healthy vegetation in the year 2000 was 56.43 square kilometre accounting for 39.19% which declined to 37.71 square kilometre accounting for about 26.18% of the total area of the basin and in the year 2020, existence of no healthy vegetation has been found in the study area (Table 4). It can also be seen that in 2000 and 2010, most of the healthy vegetation and less stressed vegetation can be seen in the northern parts of the basin (Figure 5A and 5B). Moderately Stressed Vegetation and Highly Stressed Vegetation can be seen in pockets all over the basin especially in the south west part in the left bank of the Murti River (Figure 5A and 5B). However, in 2020, most of the vegetation of the basin have become highly stressed (Figure 5C). Some moderately stressed vegetation can be seen in upper portion of the basin (Figure 5C). Very few pockets of less stressed vegetation can also be seen in the northern part of the basin (Figure 5C).

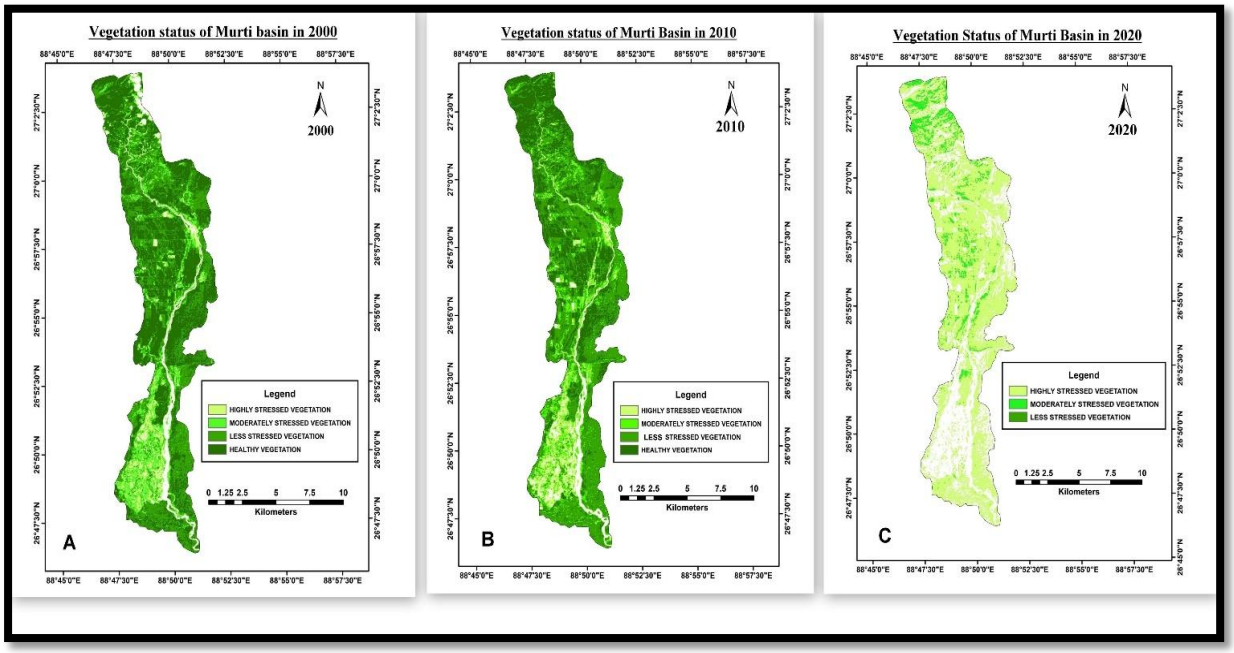

Figure 5: Trend of vegetation health status of Murti River Basin

Table 4: Areal coverage of different vegetation health (in square kilometre)

Vegetation type	2000	2010	2020
Highly Stressed vegetation	9.4	11.42	88.05
Moderately Stressed vegetation	18.9	19.37	11.02
Less Stressed vegetation	52.32	68.6	0.04
Healthy vegetation	56.43	37.71	0

Hence, from the above discussions the following key points have become clear.

➢ Highly Stressed Vegetation has exhibited a continuously increasing trend in areal coverage from the period of 2000-2020 (Figure 5). Increase in developmental activities due to large scale popularity of tourism industry is the main reason. A large number of vegetation has been destroyed for the construction of hotels and resorts. A considerable portion of vegetation is also destroyed for the purpose of expansion of roads. Increase in vehicular pollution due to increase in influx of tourists owing to popularisation of tourism is also responsible for increase in areal coverage of highly stressed vegetation over time.

➢ Moderately stressed vegetation has exhibited a rising trend in areal coverage in the first decade between 2000-2010 (Figure 5). However, the areal coverage of moderately stressed vegetation has declined in the second decade of 2010-2020 (Figure 5). Such a decline is due to the fact that a part of the moderately stressed vegetation has entered into the category of highly stressed vegetation.

➢ In the first decade of 2000-2010, areal coverage under less stressed vegetation have exhibited a rise (Figure 5) . However, a large-scale decline in areal coverage of stressed vegetation has been noticed in the second decade of 2010-2020 (Figure 5). This rapid decline is owing to the fact that a large part of vegetation which was less stressed in 2010 has turned into highly stressed vegetation in 2020.

➢ Healthy vegetation has exhibited a continuously declining trend from 2000 to 2020 (Figure 5). Developmental activities due to increasing popularity of tourism is considered to be the main reason responsible for such declining trend in areal coverage of healthy vegetation.

➢ It can be seen from the above discussions that area under highly stressed vegetation exhibited a rising trend in the two decades of 2000-2020 while area under healthy vegetation exhibited a declining trend during the same time period (Figure 5). Hence, it can be concluded that vegetation health of Murti River basin is declining with time (Doski *et al*,.2013).

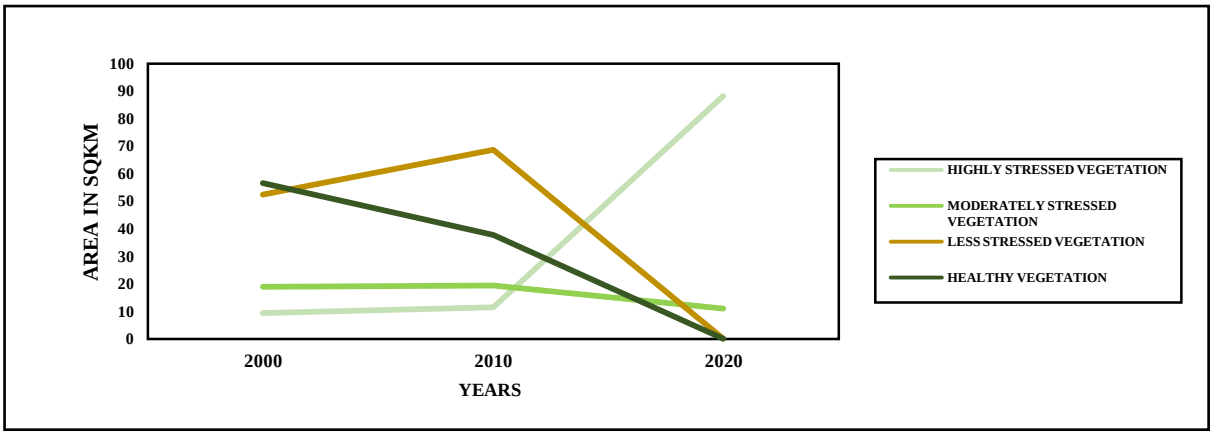

Figure 5: Trend of areal coverage of vegetation health status of Murti River Basin

3.3 Prediction of NDVI Scenario of Murti River Basin up to the year 2040:

It can be already seen that the NDVI values are exhibiting a declining trend. NDVI values have gone down from 0.787234 in 2000 to 0.77305 in 2010 and finally to 0.54077 in 2020 (Figure 6). A prediction of trend of NDVI values have been performed up to the year 2040 and the results turned out to be alarming. If the NDVI values continue to decline at the current trend, it will reach the value of 0.44571 in 2030 and finally to 0.33113 in 2040 (Figure 6). Hence, it can be said that by 2040, most of the vegetation of the Murti River basin will enter into the category of highly stressed vegetation.

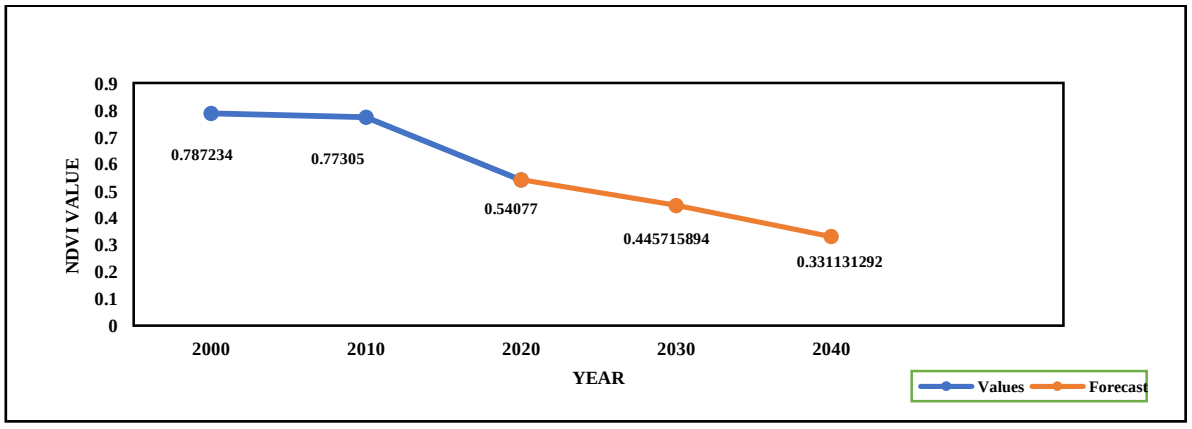

Figure 6: NDVI prediction of Murti River Basin up to the year 2040

IV.CONCLUSION

There is no doubt of the fact that development is the most important requirement for a developing nation like India. All developmental activities that are taking place must be encouraged. However, the environmental issues must also be given much emphasis. Since Murti River basin consists of many places that are popular tourist spots and attracts tourists from different parts of West Bengal, India as well as abroad, strategies adopted for the development of tourism industry must be undertaken as tourism act as the backbone of the economy of the people keeping in mind the fact that environmental dimensions are not underestimated (Roy S, 2020). All developmental activities must be done in such a balanced way so that it does not harm the vegetation of the study area. There is also an urgent need to determine the tourism carrying capacity of the region and conduction of Environmental Impact Assessment before undertaking any big developmental project (Shimu *et al*,.2019). Level of pollution must also be controlled and afforestation programmes must be undertaken. The forest department along with local NGO's must come forward to solve the issue.

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