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HABITAT DESTRUCTION AND ITS PROBABLE IMPACT ON WILDLIFE IN MAHANANDA WILDLIFE SANCTUARY

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Forest fragmentation and habitat destructions are very common phenomena in the transitional areas of human settlements and wild environment. The spatial information in the temporal context is an important tool to assess the sensible areas of fragmented forest cover and habitat loss. In this study, Satellite data of last 30 years of time span used to generate Normalised Difference Vegetation Index (NDVI) which is a key indicator to assess the status of vegetation cover. This paper deals with the causes of habitat fragmentation and its adverse effect on Mahananda Wildlife Sanctuary (MWLS). Result is showing regressing rate of forest cover loss in present years as compare to past years along with creating more patches in the ecosystem. Some species needs more space for movement than others as a result of which they will migrate or die leaving the habitat intact with less diversity. Considering this fact the lower reaches of MWLS is in great danger.

Keywords: MWLS, Habitat, Biodiversity, Ecosystem, Edge Effect, Human Animal Conflict, NDVI

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INTRODUCTION

Habitat loss and fragmentation have been considered the major threats to biodiversity (Haddad et al., 2015), affecting a larger number of species than biological invasions, overexploitation, or pollution (Baillie et al., 2010; Collen et al., 2012; Corlett, 2016). However, because of the complexity and variability of the processes underlying land-use change across landscapes, the interdependence of habitat loss and fragmentation and other anthropogenic threats,

РАЗРУШЕНИЕ СРЕДЫ ОБИТАНИЯ И ЕГО ВЕРОЯТНОЕ ВОЗДЕЙСТВИЕ НА ДИКОЮ ПРИРОДУ В ЗАПОВЕДНИКЕ ДИКОЙ ПРИРОДЫ МАХАНАНДА

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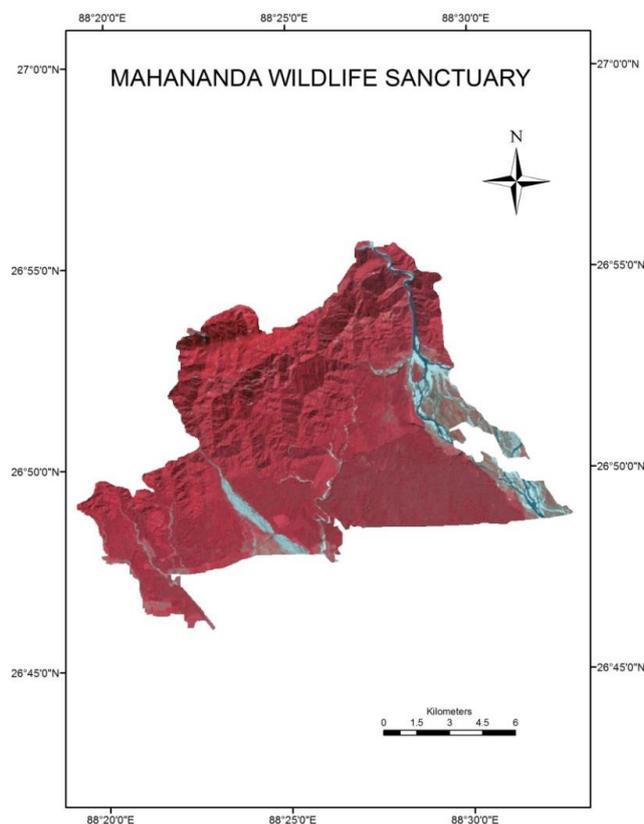
Фрагментация лесов и разрушение среды обитания - очень распространенные явления в переходных районах населенных пунктов и дикой природы. Пространственная информация во временном контексте является важным инструментом для оценки разумных областей фрагментированного лесного покрова и утраты среды обитания. В данном исследовании спутниковые данные за последние 30 лет использовались для формирования нормализованного разностного вегетационного индекса (NDVI), который является ключевым показателем для оценки состояния растительного покрова. В данной статье рассматриваются причины фрагментации среды обитания и ее неблагоприятное воздействие на заповедник дикой природы Махананда (MWLS). Результат показывает регрессию темпов потери лесного покрова в нынешние годы по сравнению с прошлыми годами наряду с созданием большего количества пятен в экосистеме. Некоторые виды нуждаются в большем пространстве для передвижения, чем другие, в результате чего они мигрируют или умирают, оставляя среду обитания нетронутой с меньшим разнообразием. Учитывая этот факт, низовья MWLS находятся в большой опасности.

Ключевые слова: заповедник дикой природы Махананда, среда обитания, биологическое разнообразие, экосистемы, краевой эффект, конфликт человечества и животных, индекс NDVI

and the variety of habitat requirements, dispersal abilities, and functional traits among species, estimates of the effects of habitat loss and fragmentation are variable across groups of species, types of landscapes, and types of native vegetation (e.g., Murphy and Romanuk, 2014; Newbold et al., 2014). Fragmentation changes intact forest to small patches of native vegetation, mutually isolated by a matrix of agricultural or other developed lands (Wilcove et al. 1991). It changes in structure, spatial relationships and function among ecosystem elements (Forman and Gordon 1986). Destruction of habitat is one of the major reasons behind the extinction of species. Typically, the loss of native vegetation occurs discontinuously and leads to the breakup of the original land cover into distinct patches, separated by a matrix of land converted to a variety of anthropogenic land-uses (Fahrig, 2003; Ewers and Didham, 2006).

Mahananda Wildlife Sanctuary is rich in variety of flora and fauna but currently facing the problem of habitat loss and fragmentation, which is considered to be the greatest threat to the species of an ecosystem. Construction of railways, roadways, continuous development of urban areas surrounding MWLS, increasing rate of deforestation, poaching, illegal logging, sedimentation of river Mahananda, Tista and their tributaries stimulating the loss of habitat by fragmenting it into small lands. Dominant species are generally considered as free from the risk of extinction as they are abundant in undisturbed and disturbed land fragments but the vulnerable species can't cope up with this habitat loss as they can't acclimatize with the change in environment easily. Research shows almost 20,000 to 30,000 species go extinct every year or 50 to 80 species every day all over the world (David Vallejo, 7th August 2018). So, it is considered to be the greatest threat to all the species of an ecosystem.

AREA OF STUDY



Map 1. Location of Mahananda Wildlife Sanctuary

Mahananda Wildlife Sanctuary (MWLS) is a part of Eastern Himalayan Region, situated at the west bank of river Tista having an elevation of 350 to 1500 m. from sea level. Geographical location is between $26^{\circ}55'33''$ N and $26^{\circ}47'54''$ N and longitude $88^{\circ}33'31''$ E and $88^{\circ}23'36''$ E, which comes under Dajiling district. The southern part is surrounded by less protected forest area, the Baikunthapur Reserve Forest, some fragmented landholdings and areas under private ownership, corresponding to different level of Govt. administration and monitoring. In 1949 it was declared as a protected area and notified as a Wildlife Sanctuary by Government of West Bengal in June 1976. "Major part of the sanctuary was brought under the administrative control of Wildlife

Division I, Darjeeling by Principal Chief Conservator of Forests in November 1995, all the notified blocks of MWLS have been placed under the direct management of Wildlife wing on Reorganization of Forest Directorate in September, 1995 (Anonymous 1996)” (Nature Environment and Wildlife Society, 2017). The total area has four ranges viz. East, West, North and South and divided into 33 forest blocks. These forest blocks are: Punding, Bandar Jhora, Jogijhora, Kuni, Choklong, Upper Champasari, Gulma, Silihhita, West Sevok, East Sevok, North Sevok, Jhenaikuri, Lower Ghoramara, Upper Ghoramara, Gola, Ruyem, Andera, Chawa, Samardanga, Lower Champasari, Singimari, Gulma, Mahanadi, Sukna (Part 1), Ringtone, Choklong, Mohorganj, Panchenai, Hatisar, Kyananuka, Adalpur, Chumta and Laltong.

Flora Type: This sanctuary can be divided into four forest type as per Govt. Report of West Bengal (1996), A) Undistributed Forest Tract, B) Distributed Forest Tract, C) Open Canopy Areas, D) Water Bodies. Some vegetation types are listed below, *Schima wallichii*, *Toona ciliate*, *Tetrameles nudiflora*, *Acrocarpus fraxinifolius*, *Magnolia champaca*, *Tectona grandis*, *Shorea robusta*, *Amoora rohituka*, *Dalbergia sissoo*, *Bombax ceiba*, *Lagerstroemia parviflora* etc.

Fauna Type: Some important mammal species are, *Panthera Pardus*, *Elephas Maximus*, *Bos Gaurus*, *Canis Aureus*, *Felis Chaus* etc. some birds like, *Eurystomus Orientalis*, *Coracias Benghalensis*, *Aviceda Leuphotes*, *Surniculus Lugubris*, *Clamator Jacobinus*, *Lanius Schach*, *Cacomantis Passerinus*, *Lanius Cristatus*, *Chrysococcyx Xanthorhynchus* etc.

Objectives:

1. To figure out the change in the forest cover pattern in present year (2020) as compares to last thirty years (1990).
2. What are the possible causes for the destruction of habitat and its fragmentation in MWLS.
3. How come fragmentation of habitat has some probable negative impact on wildlife.

MATERIALS AND METHODS

In order to achieve our objectives following steps were taken, starting from delineating study area, collecting data, data processing, mapping, change detection and analysis. Advance remote sensing and GIS Techniques has been used to reach our goals. Normalised Difference Vegetation Index (NDVI) has been used to focus on the changes that have been occurred in Mahananda wildlife sanctuary in the last 30 years. Climate data has been represented to show climatic variability over space and time in this region. These steps are mentioned below in detail. Simultaneously, Landsat 5 and Landsat 8 data has been collected from USGS Earth Explorer and analysed in the GIS platform to know the changing situation in MWLS. Meteorological data has been collected from India Meteorological department (IMD) for further computation. Several forest reports, newspaper record; census report has been used for better understanding, reading purpose, building concept and extract information.

Table 1. Landsat image dataset

Assessment year	Satellite	Path / Row	Spatial resolution (Mtr.)	Acquisition date
1990	Landsat 5	139/41	30	05-11-1990
2000	Landsat 5	139/41	30	15-10-2000
2010	Landsat 5	139/41	30	14-12-2010
2020	Landsat 8	139/41	30	02-09-2020

Image Pre-processing: Before using satellite imageries Radiometric Calibration, Atmospheric Correction, Sampling and DOS techniques has been applied in ENVI 5.2 to rectify errors, retrieve surface reflectance in order to obtain the real ground irradiance.

RESULTS AND DISCUSSION

A. NDVI Analysis: Normalized Difference Vegetation Index (NDVI) is an indicator of 'greenness' as well as the indicator of vegetation health. Low value of NDVI is generally seen in lighter green patches whereas dark green shows high NDVI value. Lower the value, more poor vegetation health is whereas higher the value indicates improved vegetation quality. The formula for calculating NDVI is

$$NDVI = \frac{NIR - R}{NIR + R}$$

The value of NDVI ranges between -1 to +1, where the value of -1 indicates no vegetation and +1 indicates good healthy vegetation in the concerned area.

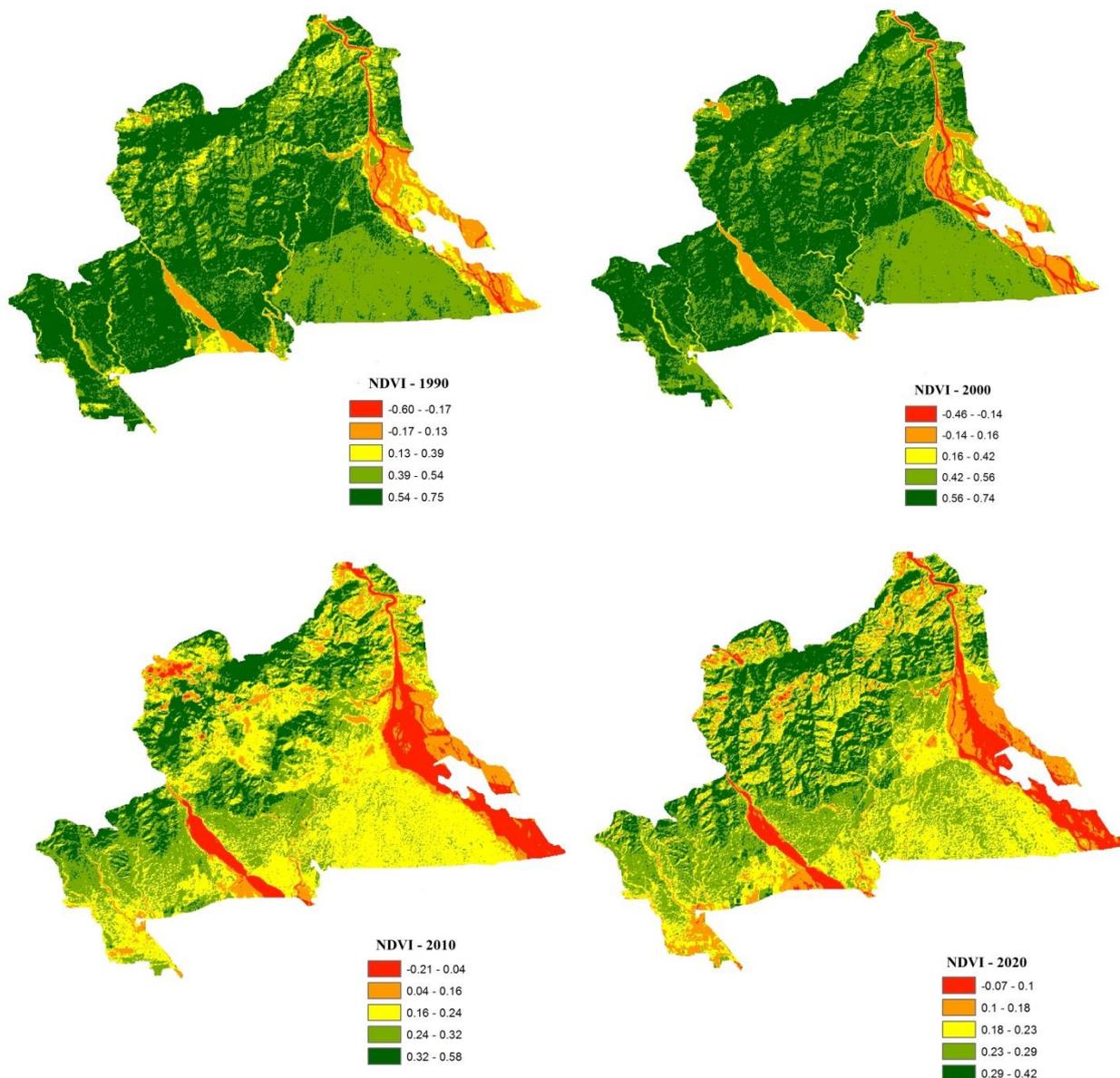
The value of NDVI ranges between positive one (+1) to negative one (-1). High positive value of NDVI indicates high and healthy vegetation cover in the area, whereas, low or negative value stands for less or no vegetation. Based on the results, we've classified the area into high vegetation cover to no vegetation cover. In 1990, the NDVI value of MWLS ranges between -0.6 to 0.75. The maximum negativity of NDVI observed in the river bed and surrounding areas, where the vegetation amount is low or absent. Similarly, the deep forest areas of the sanctuary show high NDVI value due to more protection and inaccessible due to elevation and slope of the area.

Then, in the year 2000, there is no such significant change in the high vegetation cover areas, but a small change can be observed in the low vegetation cover areas show some indicative changes in the value because of some potential measures have been taken by the forest department of Govt. of West Bengal. In 2010, the NDVI value ranges from -0.21 to 0.58 indicates that, there is an improvement in the low vegetation cover areas, but simultaneously, the condition of the high vegetation areas are deteriorating because of interference of human activities, which not only causes the forest destruction but sometimes creates the conflict with the animals.

In 2020, the NDVI value ranges between -0.07 to 0.42, which signifies that the lower part of the MWLS and the river bed areas are improving from the low vegetation cover to moderate vegetation cover, because of the agricultural and pastoral activity carried out by the local forest villagers. But, there is a serious concern in the upper part of the sanctuary which needs more attention and care.

In general, it is clear, that there are no significant changes in the No Vegetation, Less Vegetation and Moderate Vegetation cover areas compare to total area of the MWLS, but changes can be observed in the High Vegetation and Very High Vegetation Cover areas.

So, 2020 is showing a progressive result which is beneficial for habitat restoration but only in the protected areas of the jungle, monitored under forest department. Basically the protected areas are experiencing some regrowth of vegetation but the private land holdings and unprotected areas are not facing startling change.



Map 2. Normalised Difference Vegetation Index of MWLS in different assessment years

Table 2. Decadal change in the NDVI based Forest Category

NDVI Category	Change Analysis			Quality of Vegetation*
	1990-2000	2000-2010	2010-2020	
A	7.34	14.61	3.35	NV
B	0.91	3.39	1.22	LV
C	0.93	-2.54	2.51	MV
D	6.79	12.62	-12.02	HV
E	-4.24	-8.34	8.45	VHV

* NV - No Vegetation, LV- Low Vegetation, MV- Moderate Vegetation, HV – High Vegetation, VHV- Very High Vegetation.

Table 3. NDVI based Forest Cover of MWLS

Year	Category	NDVI Range	Area (in ha)
1990	A	-0.60 to -0.17	188.1
	B	-0.17 to -0.13	1464.06
	C	-0.13 to 0.39	1498.53
	D	0.39 to 0.54	5276.7
	E	0.54 to 0.75	9424.1
2000	A	-0.46 to -0.14	201.9
	B	-0.14 to 0.16	1477.37
	C	0.16 to 0.42	1512.73
	D	0.42 to 0.56	5635.26
	E	0.56 to 0.74	9024.23
2010	A	-0.21 to -0.04	231.52
	B	-0.04 to 0.16	1527.48
	C	0.16 to 0.24	1474.31
	D	0.24 to 0.32	6346.35
	E	0.32 to 0.58	8271.83
2020	A	-0.07 to 0.1	239.27
	B	0.1 to 0.18	1546.23
	C	0.18 to 0.23	1511.37
	D	0.23 to 0.29	5583.59
	E	0.29 to 0.42	8971.02

Table 4. Percentage-wise change in the NDVI based Forest Category

Forest Vegetation Category	1990	2000	2010	2020
A	1.05	1.13	1.3	1.34
B	8.2	8.28	8.56	8.66
C	8.4	8.47	8.25	8.47
D	29.56	31.57	35.55	31.28
E	52.79	50.55	46.34	50.25

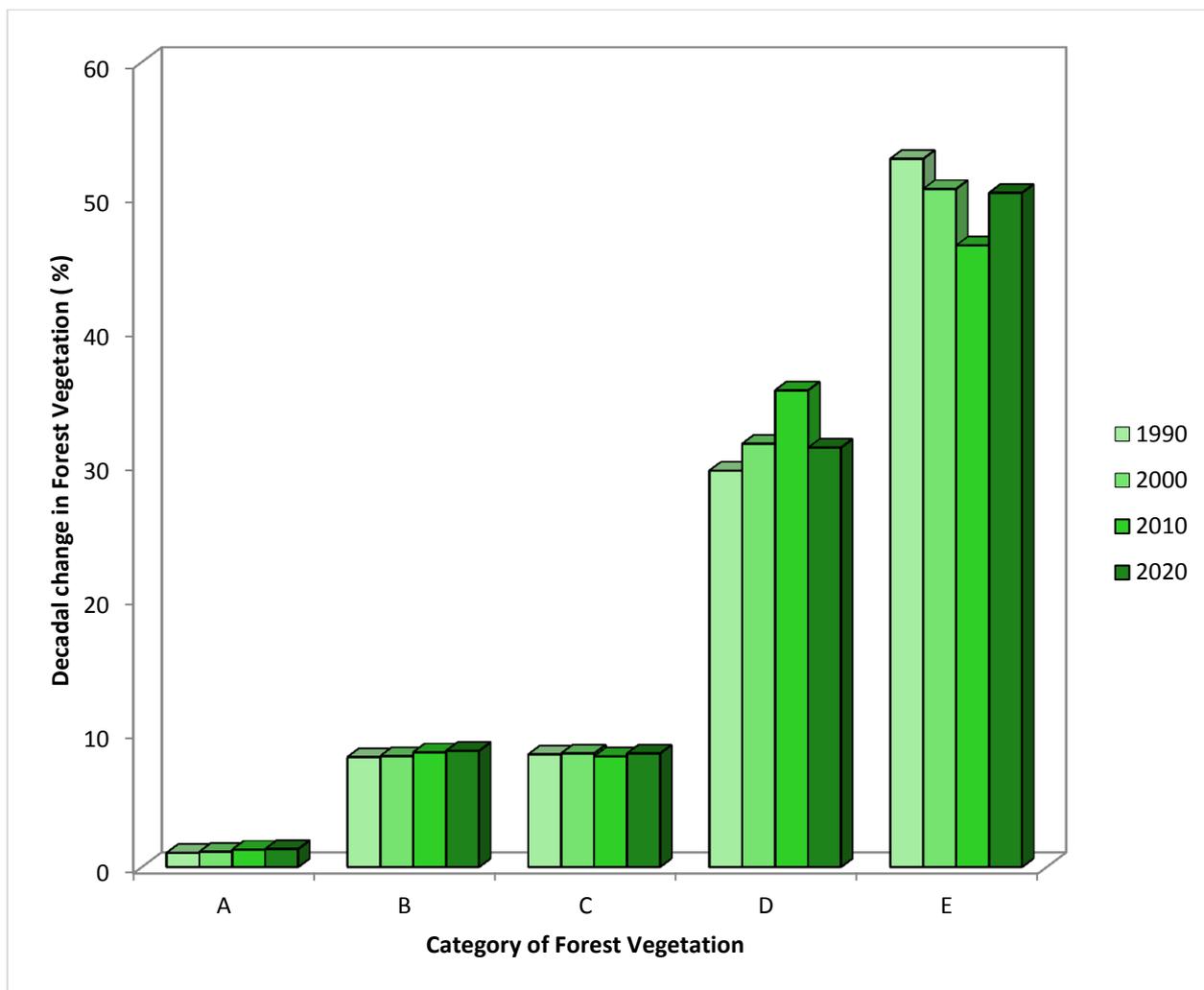


Fig. 1. Decadal change in forest cover over thirty years

B. Other Probable Factors:

I. Climate Change: Climate is the key factor which determines the animal plant distribution in an area and also the formation of different type of soil. Climate is chaotic in nature and very difficult to predict but it has direct impact on vegetation both positive and negative. As per the report published by FAO (1990), stated that,

1. Slight increase in diurnal temperature just for few hours also could lead to the damage of some vegetation and can cause pollen sterility.
2. Increased temperature could cause pests and diseases to increase their range.
3. Excessive precipitation and cloud cover could result in destruction of some vegetation, in some particular regions.

Here temperature and rainfall data of Darjiling district over last hundred years has been computed, which shows a high variability and drastic change in the pattern of rainfall and temperature. The given graph is clearly justifying our statement.

Both rainfall and temperature has been plotted to show the change of climatic parameters over hundred years which results a drastic change in their pattern. Temperature (Figure 2) data clearly shows the increasing trend of it, whereas rainfall (Figure 3) dataset is showing a downfall (since 1950) with high range of variability. Declining rainfall and increase in temperature continuously is not a good sign for any region.

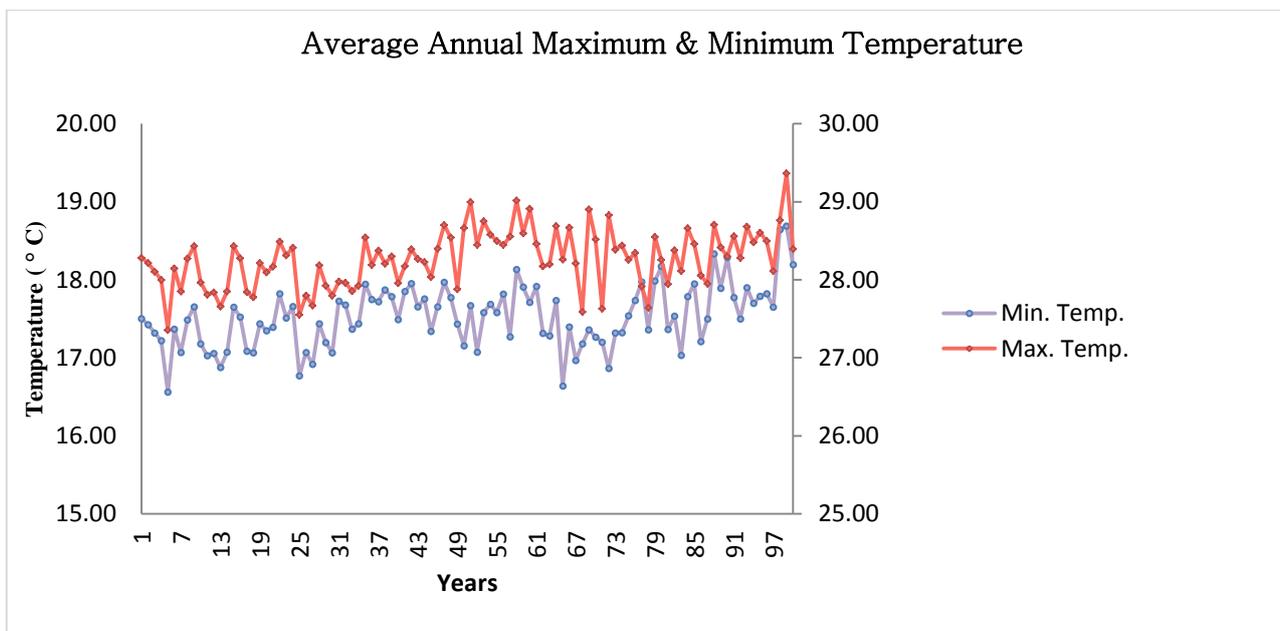


Fig. 2. Variation of average annual maximum & minimum temperature of Darjiling District

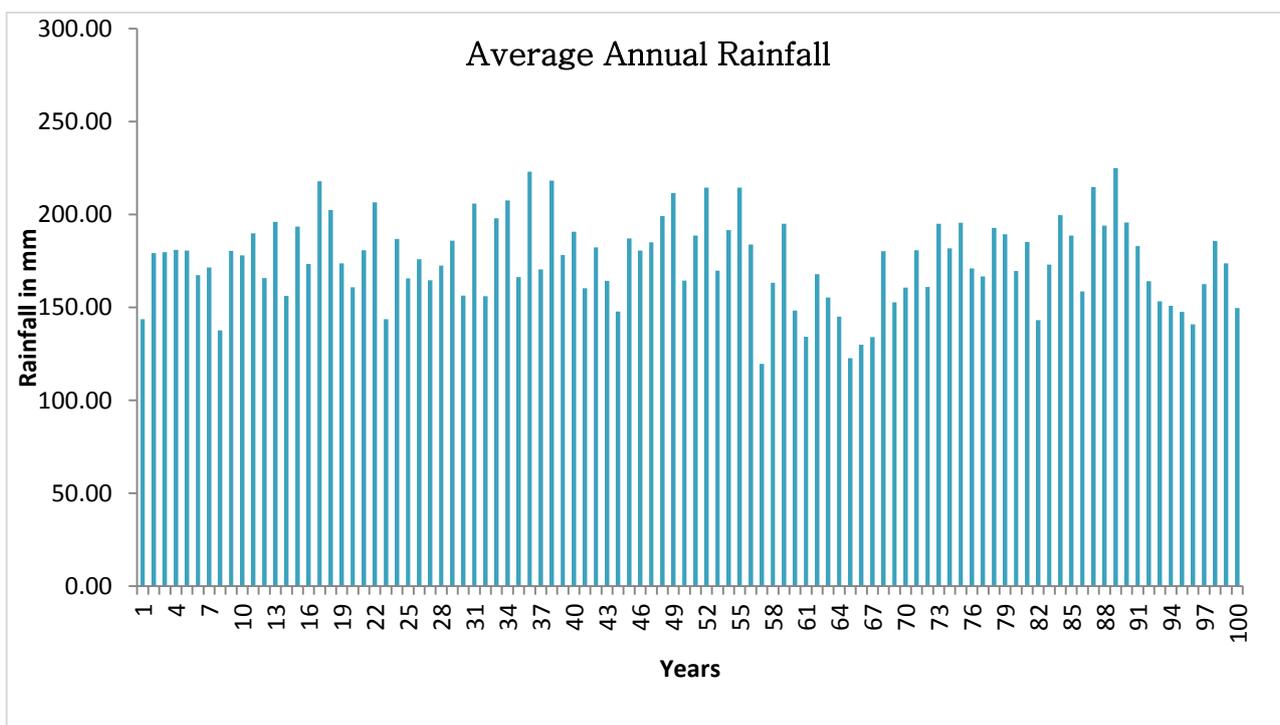


Fig. 3. Variation of average annual rainfall of Darjiling District

II. Edge Effect: Edge effect has a close connection with the fragmentation of habitat. Edge effect is the situation which creates between two natural habitats in the same ecosystem. This transition zone is largely controlled by the light, temperature, humidity and wind of that particular habitat (Schelhas and Greenberg, 1996). Edge effect serves as ‘energy traps’ since they are the points where materials, nutrients and organisms flow across ecosystems, and there is increased cycling of materials and nutrients at the edges. More habitat fragmentation means it will increase the number of edges which will have a negative impact on ecosystem. It has direct impact on the species which ranges within 300 feet from its boundary. Again edge breaks the continuity between

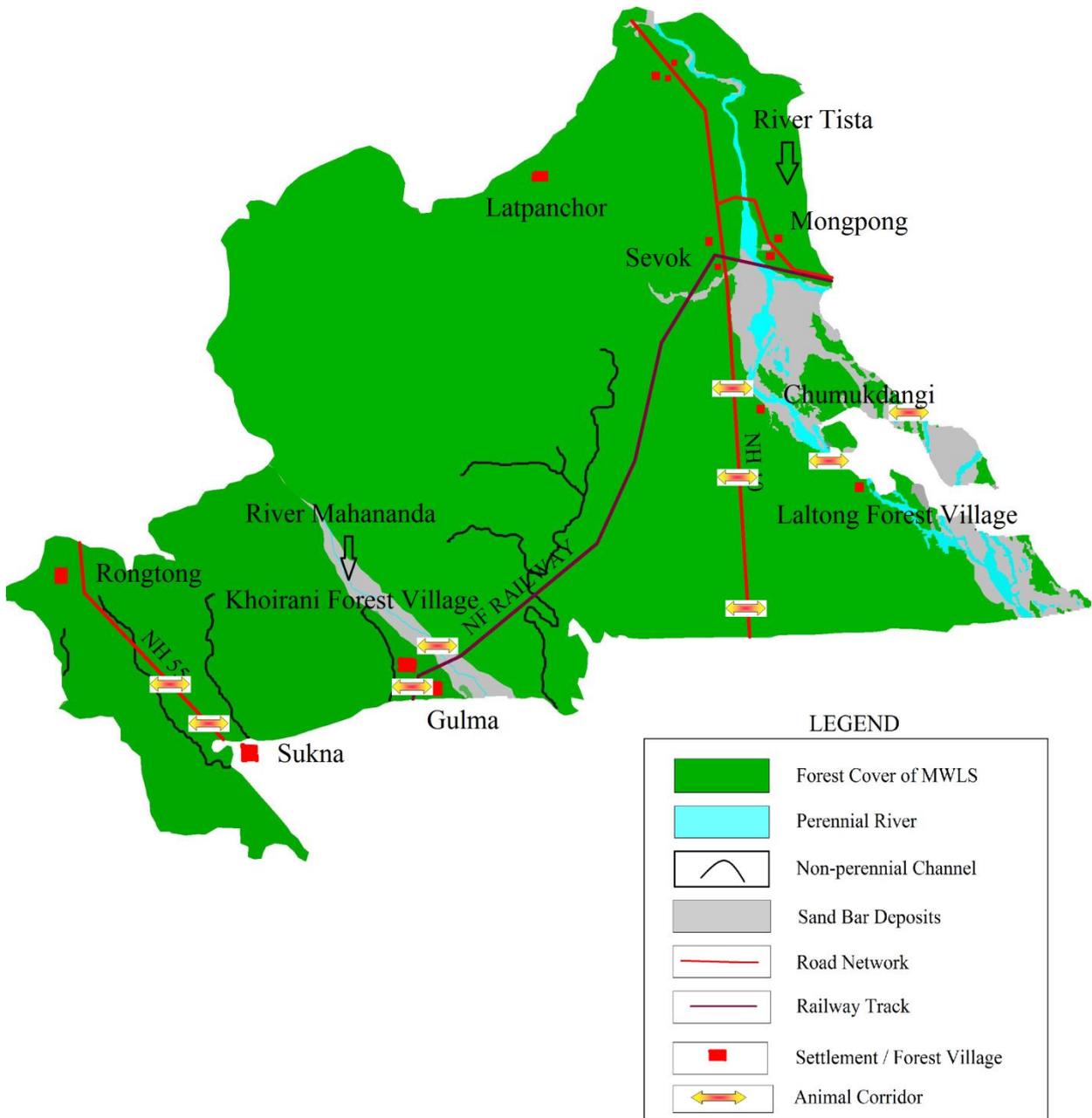
two habitats which breaks forest area into small patches. Certain species can't survive in small habitats such as migratory birds like winter visitor *Lanius Cristatus*, *Lanius Schach*, *Cacomantis Passerinus* etc. summer visitor like *Clamator Jacobinus*, *Surniculus Lugubris*, *Chrysococcyx Xanthorhynchus* etc. comes down to MWLS. Additionally, fragmentation breaks habitat continuity, reducing reproductive success, genetic exchange and therefore reducing genetic diversity in species, whereas fragmentation and edge effect jointly contributes 30% of extinction (David Vallejo, 7th August 2018).

In MWLS both aquatic and terrestrial ecosystem can be found in various parts of this region, which gives birth to the process of edge effect bisecting two different habitats in a same ecosystem. On the other hand, habitat fragmentation is increasing day by day creating more edges in this MWLS. So, there is a possibility that it has adverse effect on forest ecosystem of this area. This is based on our assumption, result is not tested scientifically.

III. Wetland Depletion and High Siltation on Rivers: Forest report (1990) shows the presence of wetland and Sukna Lake in MWLS. But due to changing course of river Mahananda (near Gulma), it captured those wetlands and now there is no existence of such wetland in that area. Unfortunately because of high siltation there is no water flow throughout the year but sometimes in rainy season river flows like a thread. This problem of siltation is very common in whole North Bengal, especially for small rivers who has small amount of discharge. These small channels deposits huge amount load they carry from hills which is more than their transport capacity and competency in the foothill region with declining altitude. In case of Tista, siltation is also there but presence of high volume of water and its depth doesn't affect much. These sand beds are creating some sort of barrier in between forest land resulting habitat fragmentation. Siltation stops the regrowth of grassland and water scarcity inside the forest will be prominent. Currently unscientific way to collect sand and boulder from rivers is the new threat to wildlife by hampering rivers' natural flow.

IV. Increasing Population: Census report of Darjiling district, in 2010 recorded 1,118,860 total population whereas in 2011, it is 1,846,823, which shows how rapidly population is increasing. With positive growth of population demand for land and other resources will automatically increase. The settlement in the surrounding area of MWLS and in the forest villages has been increased. Uprising population is creating more pressure on limited forest resources as a result of which human encroachment of forest land is increasing day by day reducing the forest area by logging, deforestation etc. Human animal conflict is very certain in case of sharing forest resources with wild animals.

V. Construction of Transport Network: Transport networks within the forest land breaks the continuity of forest causing habitat fragmentation. There are multiple human induced foot tracks throughout the jungle which are not imprinted on the map. In the western part of MWLS, NH55 (towards Darjiling town) is passing through the jungle. In the eastern part of MWLS, NH 10A (towards Sikkim) is running through the core area of the forest. Presence of Sevoke railway (NF) in the extreme corner of sanctuary is causing injury and death to wild animals (several deaths of elephants and monkeys in railway tracks) had been reported in newspapers.



Map 3. Fragmented habitat of Mahananda Wildlife Sanctuary

Impact: 1. The change in forest cover and loss of native vegetation species over time will lead to the situation of habitat homogenization which can be functional, genetical or taxonomical leads to a condition of losing ‘beta diversity’.

2. A degrading habitat may remain intact but as it will reduce its perimeter. The required area for species will decline gradually, as a result of which species will extinct or migrate or die leaving the habitat with less biodiversity and isolated population.

3. With time human animal conflict will increase. The census is showing a progressing report of increasing leopard and elephant population and especially these two needs a larger area for access. But with time as the forest area is reducing those animals will come to the human occupied land in search for food and MWLS had already faced this problem before. The problem will be critical for forest villagers as they are already sharing land with the wild. Each year they face the

problem of damaging crops, hunting domestic animals, destruction of household and crops by elephant and leopard.

4. Animal behaviour depends on their environment. Same animal can behave completely different in a city environment compared to a forest environment. So, with the changing environment in the ecosystem will affect the animal populations' behaviour. This problem will be minor for small animals like Songbirds, Squirrels but it will create severe problem for larger animals like Elephant, Leopard, and Bison etc. who needs a larger territory for movement. Animal always conserve energy and never works hard until it is mandatory to ensure survival. It shows that their behaviour is responsive to the relative abundance or scarcity of whatever resources they need.

5 Some research work already showed that with the increase of human movement in the forest changes the lifestyle of residing animals. Like animals become nocturnal, changes their feeding time, hunting time, wake up time, sleeping time etc. to avoid interaction with humans. But those same animals behave differently deep inside the forest without disturbance. In the lower segment of the MWLS, interference of human is maximum as compare to upper section of the forest. Forest villages are situated on that region along with some private landholdings and with time numbers are going upward, which may change the lifestyle of animals.

6. Climate change basically has negative impact on animal nature and also on the migratory species. Already research showed a negative impact of global heating in the life of Polar bears, Leatherback Turtles, monarch butterflies, Puffins etc. all over the world. In MWLS, with increasing temperature and decreasing precipitation over hundred years may affect the wildlife as well as the forest vegetation cover. Animals can respond to this climate change by migrating, adapting or dying. Intensity and frequency of forest fire, severe storms may increase resulting destruction of larger section of forest.

7. Food (sometimes water), Nesting, Safety, Mating partner in a forest, are the primary need of an animal. Scarcity in any one of this will impact their life greatly. Research showed that with changing habitat and resources animal tries to adjust with the environment by changing food habit, amount of food they eat, which make them sick and weak.

8. With the increase of temperature and human encroachment of forest land and frequent human interference in wildlife can turn a passive animal into aggressive one.

SUGGESTION

We've gone through the different measures to habitat restoration and what are the initiatives have been taken by the forest department for this region and some of our suggestions are listed below which will be applicable particularly for MWLS. There are a few things still we can do to save MWLS from this crisis i.e.

1. Plantation is mandatory in MWLS to keep the habitat intact but incorporating local people on that activity is needed so that they can take care of those plants afterwards. If we want to protect wildlife then we have to preserve their natural habitat and community participation in that case can be the most effective way.

2. In MWLS, some forest villages are there and people of these villages are daily labourers, tea garden workers and basically depend on the forest resources for their daily needs. If some community development programme can be arranged to make them economically stable then the pressure on forest area will automatically decrease.

3. Human will always have impact on its surroundings, but we all can be little more careful and empathetic to reduce that negative impact on the habitat on behalf of other species' need.

4. Human animal conflict is a major problem in MWLS, mainly the forest villagers encounter this kind of problems as they are sharing same resource with the wildlife. Bio-fencing, protecting animal corridors and staying out from those regions, beehive fencing, buffer zone crops

etc. can be a great measure to protect the wildlife without harming or polluting the natural environment.

5. Ultimately awareness and knowledge is very important among the local people and forest villagers. They are the key to our success if we want to save MWLS. Treating animals in right way, informing forest department when animals are caught in locality, caring for plants and wildlife etc. needs to be done. Simultaneously overgrazing, cutting down trees to build home and make furniture, killing wild animals for meat, torturing innocent animals etc. should be strictly prohibited by the local people. Periodic arrangement to educate the mass to understand the importance of forest assets to human life and how both are depending on each other, how important is species' diversity (both flora and fauna), the concept of habitat fragmentation, degradation of biodiversity etc. can be done. Several seminars, focus group discussion, meeting with local people or awareness camps can be arranged to ensure that the message is reaching out to the grass root level.

6. Agreement within communities that includes forest villagers, private landowners and government officials to build a MoU to prevent deforestation, creation of new green space and allowing enough movement space of wild habitats and encouragement of "Biodiversity Conservation by Indigenous People" can effectively help to save MWLS.

7. River Tista, Mahananda and their tributaries are considered as the lifeline of this sanctuary. Currently unscientific boulder and sand quarrying and excessive siltation are causing fragmentation of the natural habitat. So, govt. should take immediate action to pause this activity, so that river can maintain its natural flow. If quarrying is needed then it can be shifted to the lower reach of the river in a scientific manner.

8. Govt. has to take initiative for the betterment of people living there as they are the ultimate protector of the MWLS. Even they can help to prevent illegal logging and poaching as well. Proper education and economically stable life will ensure the safeguard of forest area. Development in the forest villages and the surrounding area is very essential but in a sustainable manner.

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