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Socio-Environmental survey of an ecologically important forest edge hamlet in Buxa Tiger Reserve, West Bengal, India

Sayan Bhattacharya[1]*, Rimpa Maity[2], Gour Sarkar[2], Goutam Ghosh[2], Debasri Mukherjee[2], Chandrayee Mukhopadhyay[2]

[1.] School of Ecology and Environment Studies, Nalanda University, Rajgir, India.

[2.] Department of Environmental Studies, Rabindra Bharati University, Kolkata, India.

* Corresponding Author. Email: sayan.evs@gmail.com, sbhattacharya@nalandauniv.edu.in

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ABSTRACT Buxa Tiger Reserve (BTR) is located in *Alipurduar* Sub Division of West Bengal, India. It comprises of the entire forest area of the erstwhile Buxa Forest Division (Created in 1877 – 78) and some territory of the erstwhile neighboring Cooch Behar Forest Division. The Reserve lies between Latitudes 23°30′ N to 23°50′ N and Longitudes 89°25′ E to 89°55′ E. The total area of the reserve is 760.87 km^2 of which 385.02 km^2 has been constituted as the Buxa Sanctuary and National Park (Core zone of the BTR) and the balance 375.85 km^2 areas is treated as a buffer zone. It has 37 forest villages and 4 fixed demand holdings, 46 revenue villages and 34 tea gardens in and around it. The survey work was done in May, 2015 by visiting a forest edge village, *28 Mile*, in Buxa Tiger Reserve and the primary data were gathered through field survey and direct contact with common people and authorized centres of the region. Surveys on the demography, agriculture, livestock management, water management, education, culture, health, waste management, disaster management, transport, biodiversity, joint forest management activities, Non-timber forest product usage and human animal conflict were done in this area. In every phase of the survey work, photographic documentation was done. In spite of being positioned in a diverse and sensitive ecological zone, the village is not adequately managed. There is an urgent need for implementing sustainable management systems in the areas for the betterment of the socio-environmental structures. Some of the possible management strategies have been suggested for maintaining the social, environmental, economic and ecological balance of the region.

1. INTRODUCTION

The *Dooars* are the floodplains and foothills of the eastern Himalayas in North-East India around Bhutan and is one of the significant biodiversity zones of India. This region is divided by the Sankosh river into the Eastern and the Western *Dooars*, consisting of an area of 8,800 km² (3,400 sq m.). The Western *Dooars* is known as the Bengal *Dooars* and the Eastern *Dooars* as the Assam *Dooars* [1]. The *Dooars* region politically constitutes the plains of Darjeeling District, the whole of Jalpaiguri district and Alipurduar district and the upper region of Cooch Behar district in West Bengal and the districts of Dhubri, Kokrajhar, Barpeta, Goalpara and Bongaigaon in the state of Assam. The *Dooars* valley is specially noted for its wildlife sanctuaries, the most important of which are the *Gorumara* National Park (75 km from Siliguri), *Chapramari* wildlife sanctuary (68 km from Siliguri), *Buxa* Tiger Reserve (200 km from Siliguri) and *Jaldapara* Sanctuary (124 km from Siliguri).

Buxa Tiger Reserve (BTR) is situated in *Alipurduar* Sub Division of West Bengal, India. It comprises of the entire forest area of the erstwhile Buxa Forest Division (Created in 1877 – 78) and some territory of the erstwhile neighbouring Cooch Behar Forest Division [2]. The Reserve lies between Latitudes 23°30′ N to 23°50′ N and Longitudes 89°25′ E to 89°55′ E. The total area of the reserve is 760.87 km^2 of which 385.02 km^2 has been constituted as the Buxa Sanctuary and National Park and the rest 375.85 km^2 areas is considered as a buffer zone [3]. It has 37 forest villages and 4 fixed demand holdings, 46 revenue villages and 34 tea gardens in and around it. The entire Northern boundary runs along the territory of Bhutan. The nearest broad gauge railway

station is 1.5 Km. away and a section passes through the reserve. *Bagdogra* Airport near Siliguri is 175 Km. Away from the forest area. In BTR, Temperature varies from 15°C to 39°C and rainfall varies from 3570 mm to 5600 mm. The lowest point is 125 m. above mean sea level and highest point is 1750 m. above mean sea level [4]. Most of the rainfall is received during June to September. Pre-monsoon showers occur during May. Hail is rare. As the Reserve is located in the foothills of the outer Himalayas, it remain adequately humid throughout the year. Maximum relative humidity varies between 80% – 95%, seldom below 75% with a maximum in June to September and minimum in December to February [2]. BTR is administered by two Divisions – BTR (East) and BTR (West). There are fourteen territorial ranges in BTR. The habitat is primarily tropical moist deciduous forest dominated by *Sal* tree (*Shorea robusta)*. In addition, evergreen, semi-evergreen and riverine forest, scrub and grasslands are found, along with plantations of sal, teak (*Tectona grandis*), jarul (*Lagerstroemia reginae*), and mixed plantations of native trees [5]. BTR is located at the confluence of three major bio-geographic zones: The lower Gangetic plains, Central Himalayas and the Brahammaputra valley [6]. It consists of Himalayan formation of Darjeeling gneiss at an altitude of 1800 in., the Great Boundary Fault (Gondwans) lies just to the south of it, followed by the Shiwalik Hills. The highly drained bhabar track and ill-drained terai track lies to the south [2].

BTR is biologically very rich and supports a tiger population (*Panthera tigris*). BTR represents several elements of the biodiversity of north-east India and is one of the most biodiverse regions in the country [3]. About 60% of the total floral endemic species of north-east India are observed in BTR. The reserve also act as a carbon sink of the region. It has a network of many perennial and seasonal rivers, which are the water sources of wild animals and plants. This is an international corridor of elephant migration [3]. Figure 1 shows the Google map position of BTR and figure 2 shows the map of BTR including the roads, railway tracts, range offices, forest rest houses, rivers, international and state boundaries and tiger reserve boundaries.

Figure 1: Google map of Buxa Tiger Reserve.

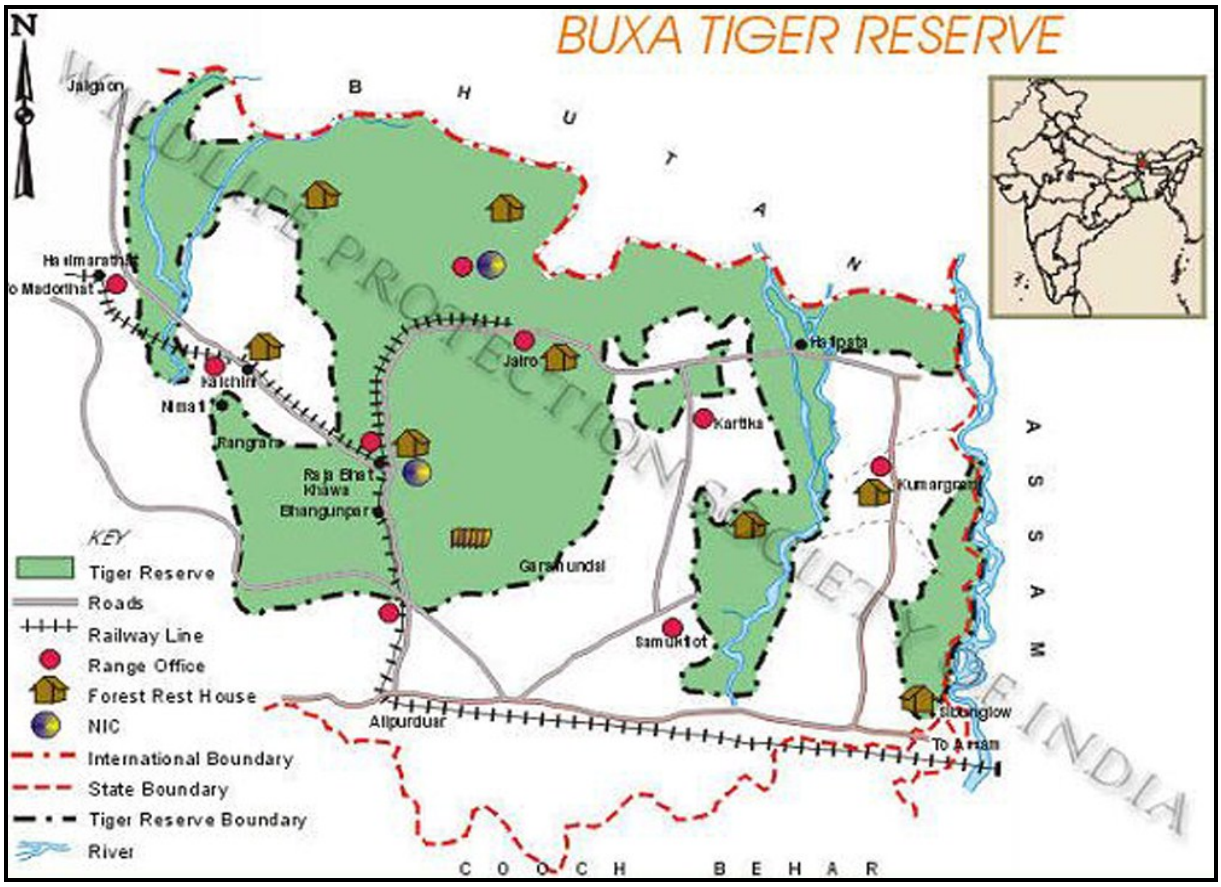

Figure 2: Buxa Tiger Reserve Map (Source: WPSI, India) [7].

2. OBJECTIVES OF THE RESEARCH WORK

The developmental perspectives depend on socioeconomic settings and environmental status of an area. The survey work was done in May, 2015 by visiting a forest edge village *28 Mile* in Buxa Tiger Reserve. The objectives of the study are:

1. To know about the local area, it's past and present and Socio-Economic structure.
2. To get acquainted with the geographical and social environment.
3. To know about the transportation & communication facilities of the village.
4. To know about the health and hygiene of the villagers and the medical facilities of the area.
5. To explore the water and waste management perspectives.
6. To explore the cultural and educational status of the area.
5. To explore the biodiversity status of the ecologically important area and to explore the human-biodiversity interactions.
6. To propose sustainable management policies for the betterment of socio-environmental condition of the area.

3. MATERIALS AND METHODS

The survey work was done in May, 2015 by visiting a forest edge village, *28 Mile* (established in 1927-28) in Buxa Tiger Reserve and the primary data were gathered through field survey and direct contact with common people and authorized centres of the region. Surveys on the demography, agriculture, livestock management, water management, education, culture, health, waste management, disaster management, transport, biodiversity, joint forest management activities, Non-timber forest product usage and human animal conflict were done in this area. Demographic information was collected from the village area and the *panchayat*. Census report was collected from the local *Panchayat* Office. Health and education information was collected from the local schools and local sub health centers. Information regarding the transport system was collected

from the local transport office and syndicate. Religious and social festival information was collected from the local people. Information on agricultural activities is collected from the local villagers. Information on environmental activities like using sustainable agricultural practices and waste management policies is collected through surveys in the villages. Human animal conflicts were studied in the village area, as the area is periodically disturbed by the encroachment of elephant, rhinoceros and leopard. Biodiversity of the region was documented by visiting the adjacent forest areas, accessing the database of West Bengal Forest Department Office and visiting the nature interpretation centre situated at Buxa Fort. Photographic documentation was done in every phase of the survey work.

4. RESULTS AND DISCUSSION

People:

Since 1999, 2,919 families of diverse ethnic groups are residing in the forest villages of BTR [3,8]. Of them, the Nepali and *Rabha* communities are the two most dominant ethnic groups. The human population of these villages is 95,049 (1991Census) [3]. Migrant Hindus, Muslims and *Rajbanshis* are the predominant ethnic groups in revenue villages of the reserve.

28 mile village was established in 1927-28.The village has total area of 285 hectares. The village has 105 houses with 1190 inhabitants. Most of the houses in the village are made up of wood and the houses are constructed well above the ground by the help of wooden pillars to avoid elephant attacks. 93% of the population of this area consists of Nepali community, while only 7% of people belong to tribal community.

The villages, located in the remote and difficult to reach areas, suffer serious infrastructure and civic amenities deficiencies. The households do not have adequate toilet facilities within their houses and the drinking water is provided from the streams and rivers.

Agriculture and livestock:

People in Buxa *28 mile* village area are generally poor and make their living mainly by means of agriculture. Most of the cultivable crops are mainly used for consumption rather than earning money from the products. The people of Buxa usually practice organic farming, and for this purpose cow dung is mainly used as manure. Most of the houses in *28 mile* village area have cultivable lands adjacent to the houses and farming is done there. In Buxa, the common cultivable edible plants are potato, rice, bean, corn, ginger, squash, pumpkin, mustard, ryeshak etc. Pest attacks in potatoes are common and regular economic losses in potato cultivation. Canal irrigation and rain-fed irrigation are done in the agricultural fields. In earlier days honey was also produced which was an important source of earning. However, in recent times the practice has been reduced significantly.

The common livestock's at Buxa *28 mile* village area are local breeds of goat, cows, buffalo, chicken. Egg and milk are livestock products which are among the important economic source. Here livestock is as an emergency source of income, especially during rituals and festivals, or bearing the cost of medical treatment. Livestock encroachment in the forest areas are controlled by the villagers, mainly due to the risks of wildlife attacks.

Water Management:

The main water source of *28 mile* village in Buxa is *Buxa Jhora*, a natural stream situated 7 km. away from the village. Network of pipeline distributes the water in the villages and water is stored in small reservoirs in the village area. The water becomes wispy in rainy season. The main river in Buxa area is The Buxa River. For most of the seasons this river remains dry while in monsoon the river is filled up with rain water. Rainfall measurement shows that the month of July receives heavy rainfall while December receives least amount of rainfall. Continuous rainfall generally occurs in June to September period. Water crisis occurs during the period of March-April. No rainwater harvesting structure is found in the village for water conservation. However, our previous studies showed that numerous rainwater harvesting structures are generally found in

different mountain and forest hamlets of North Bengal like *Lava, Rishop, Tinchuley and Chatakpur* [9,10,11]. Figure 3 shows the reservoir situated in *28 mile* village for stream water storage.

Figure 3: Reservoir situated in *28 mile* village for stream water storage.

Waste Management:

In *28 mile* village in Buxa, the common waste materials generated are solid wastes, including plastic packets, paper boxes, plastic bottles, glass bottles, vegetable wastes etc. Solid wastes are usually collected in specific bins. Every house their own burning places where they used to burn all the solid wastes once in a week. The unburned materials are buried in the ground. However, burial of the wastes, mainly the hazardous ones, can affect the biodiversity of the area, and can affect the inhabitants as well [12]. Plastic and glass bottles are generally recycled by selling in the local markets after use. Some of the houses in *28 mile* village have separate sanitation system and toilets.

Education and culture:

There is only one primary school in Buxa (Buxa Forest Village Primary School, Bengal medium; figure 4). The classes are up to forth standard. Only two teachers are available in that school, while the number of students is 40 to 45. For higher studies, people of Buxa usually go to *Jayanti* secondary school and colleges in Alipurduar city.

In Buxa *28 mile* village, the main festivals are *Durga puja, Kali puja and Losar*. *Losar* is the Buddhist festival ("*Losar*" in Tibetan language means New Year), which is celebrated for 15 days, however, the main celebration occurs in the first three days. *Mahakal* festival is a popular local festival in Buxa, organized at the time of maize cultivation. *Van Mahautsav* was also celebrated by conducting programs like drama, essay, quiz, drawing, seminar etc.

An interpretation center is an establishment for dissemination of local knowledge of natural or culture heritage of a place. These centers are types of museums, associated with visitor centers or eco museums and located to sites of cultural, historical or natural importance. A Nature Interpretation Center is present in Buxa Fort area (figure 5), which can reflect the tradition, culture and rituals of the local villages. The interpretation center executes the history and tradition of the

Buxa Fort, the social, cultural and economic dimensions of the Buxa villages and about the local knowledge. Various objects of local importance are preserved in Buxa Nature Interpretation Center, such as- *Jajee* (Container for keeping Wine), *Chasum* (Utensil for making tea), *Churu* (Type of necklace used by Women), *Chebete* (Container to keep water during Puja), *Phup* (Used for writing purpose), *Chaka Timi* (For keep Supari), *Chempa* (Lamp / Diya), *Koma* (Part of dress of Women), *Doji* (Put on after wearing the dress), *Timi* (For keeping lime for paan/betel leaf), *Chanso* (Put on Brewing Wine), *Bakhu / Dobigulla* (Dukpa dress for males), *Kera / Dobigulla* (Dukpa dress for females) etc.

Figure 4: Buxa Forest Village Primary School, *28 mile* village.

Figure 5: Nature Interpretation Centre near Buxa Fort.

Health facilities:

There is no specific medicinal shop in Buxa area. Basic Medicines are available in local stationary shops. People used to go to *Kalchini* and *Santalbari* Sub Health Centers for treatment purposes. 4 nurses and 2 doctors are available in *Kalchini* and 1 nurse in *Santalbari* health centers. For emergency cases people used to go Alipurduar hospital, where operation and emergency treatment facilities are available.

Disasters:

Dooars of North Bengal are under rapid habitat destruction due to several anthropogenic pressures and developmental activities including hydro-electrical projects, road development, establishment of tea gardens, mining activities, landslides, forest fire etc [8]. These factors gradually have increased the fragility of the Himalayan Mountains, leading to an increase in the incidence of landslides in the region.

The area in which Buxa lies is proclaimed to be at seismic risk, in Zone V of the earthquake hazard conation [13]. Seismicity of this area loosens the hill sides, causing rock slides and siltation in the river beds. The present course of Buxa *jhora* shifted after the 1993 flood and is presently cutting into the base of the table-top mountain [13]. The major earthquake in 1897 at shilling has changed the course of many rivers. River erosion is a serious problem in this area. Excess volume of water in the huge riverbed increased friction and erosion of banks, frequent flooding are one of the major disasters faced by the Buxa villagers. Devastating floods have been reported in 1950, 1952, 1954, 1968 and 1993, causing massive damage to the habitat of the reserve [3]. The wildlife habitat has been destroyed several times due to recurrent floods in the flood-plains of these rivers. A massive landslide occured in the sub-Himalayan slopes due to a destructive flood in 1954, when all river basins were affected by rapid rise of river bed bank erosion. Another destructive flood occurs in 1993 causing maximum damage to the Buxa area (about 200 deaths, loss of habitats) [6]. Figure 6 shows the location of a village in BTR at the hillside, having risk of landslide.

Figure 6: Location of a village in Buxa Tiger Reserve at the hillside.

Economy:

Agriculture is one of the main economic sources of the inhabitants of *28 mile* village in Buxa. The people used to sell the agricultural and livestock products in the local markets of Alipurduar. Tourism is also an important source of income in this area. Hotel business, guiding tourists, renting of home stays for tourism purpose is also the sources of earning money. There are five stationary shops in the village area. Landless people engage themselves as agricultural and daily wage labourers at *panchayat* or Forest Department works, or in selling firewood and engagement in local crafts. Their income is also supplemented by selling of areca nuts and bamboos. Crop husbandry, animal husbandry, wild biodiversity and rural economy are subsystems of the integrated traditional resource management system.

As in all protected areas in India there is a strong relation between the people and the forests because the people living in and around the forests are considerably dependent on the forest resources for subsistence, commercial and cultural purposes. NTFPs collection is another important source of income for the villagers of *28 mile*. They use small timber for house construction; thatch for roof; edible roots and tubers, mushrooms, leaf litter and leaves, flowers and fruits as substitute of staple foods especially during lean seasons; medicinal herbs for healing etc [8].

Transport and connectivity:

A daily bus is operated by North Bengal Govt. in the village area. Private modes of transports are cycle, bike, car, auto and scooter. For tourism purpose car or trekking jeeps are mainly used. The reserve can be approached by road (30 km) from Cooch Behar. The nearest airport is at *Bagdogra* near *Siliguri*.

The network connectivity in this area is very poor and high tariff makes it more inaccessible. The mobile connection is very poor, only considerably high populated areas such as *Rajabhatkhaoa* has meager connectivity.

Biodiversity:

A. Floral Diversity:

Buxa Tiger Reserve is biologically very rich. It represents several elements of biodiversity of northeast India, one of the most biodiverse Indian regions. Eleven landscape elements were identified in Buxa, which include, 1) Semi-evergreen vegetation forest, 2) dense evergreen forest, 3) deciduous forest, 4) dry thorn forest, 5) mixed vegetation and plantations, 6) degraded forests, 7) tea gardens, 8) teak plantations, 9) flood plains of the different rivers present in the reserve, 10) water bodies and 11) cultivation/settlements [14]. More than 50% of the plant species of India are represented in northeast India; of these, 60% are endemic. Most of the floral endemic species of northeast India are encountered in Buxa Tiger Reserve. The present checklist identified 283 species of trees, 31 species of shrubs and herbs, 33 species of climbers, 150 species of orchids, 36 species of grasses and reeds, and 7 species each of cane and bamboo. The most common species found within the forest is Sal (*Shorea robusta*), which is one of the ecologically and economically important trees of BTR. The lofty Sal trees occur with their usual associates, viz. Champ (*Michelia champaca*), Chilaune (*Schima wallichii*), Chikrashi (*Chukrasia tabularis*), Bahera (*Terminalia beterica*), Sidha (*Lagerstroemia parviflora*), Toon (*Cedrella toona*), Laii (*Amoora wallichii*), Lausuni (*Amoora rohituka*), Lampati (*Duabanga sonneratioides*), Simul (*Bombax ceiba*) etc [15,16]. In areas adjoining the rivers Simul, Sirish (*Albizzia* sp.), Sissoo (*Dalbergia sissoo*) and Khair (*Acacia catechu*) are the most common species. The commonly found hill forest species are Katus (*Castenopsis indica*), Mandane (*Acrocarpus fraxinifolius*), Bhalukath (*Talauma hodgsoni*), Phalame (*Walsura tubulata*) associated with Kimbu (*Morus laevigata*), Panisaj (*Terminalia myriocarpa*), Gokul (*Ailanthus grandis*), etc. The savannah woodlands are also characterized by tropical trees of Kumbhi (*Careya arborea*), Tantari (*Dillenia pentagyna*), Jamun (*Syzygium cumini*), Palash (*Butea monosperma*) and Kul (*Zizyphus* sp.) [17].

B. Faunal Diversity:

The faunal diversity of BTR includes 230 species of birds, 73 species of mammals, 37 species of reptiles, 32 species of fishes, 4 species of amphibians and 353 species of identified entomofauna. The main carnivores of BTR are Indian Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Clouded Leopard (*Neofelis nebulosa*), Hog Badger (*Arctonyx collaris*), Jungle Cat (*Felis chaus*), Leopard Cat (*Felis benghalensis*), Sloth Bear (*Melursus ursinus*), Fishing Cat (*Felis viverrina*), Civet Cat (*Viverricula indica*), Hyaena (*Hyaena hyaena*), Jackal (*Canis aureus),* Wolf (*Canis lupus*), Mongoose (*Herpestes edwardsi*), Fox (*Vulpes benghalensis*), etc. The predominant herbivores of the reserve are Elephant (*Elephas maximus*), Gaur (*Bos gaurus*), Sambar (*Cervus unicolor*), Chital (*Axis axis*), Barking Deer (*Muntiacus muntjak*), Hog Deer (*Axis porcinus*), Wild Pig (*Sus scrofa cristatus*), Hispid Hare (*Caprolagus hispidus*), Giant Squirrels (*Ratufa indica, R. bicolor*), and Pangolins (*Manis crassicaudata*, *M. pentadactyla*). Endemic Indo-Malayan species such as Clouded Leopard, Chinese Pangolin, Reticulated Python (*Python reticulatus*), and Black-necked Crane (*Grus nigriocollis*) have been reported in BTR [2,16].

Among reptiles, tortoise, lizards, various kinds of Snakes such as King Cobra, Russel's viper, Black Krait, Banded Krait, Indian Python (*Python molurus*) and Reticulated Python (*Python reticulatus*), Chinese pangolin are found in this region. Gharial (*Gavialis gangeticus*) and Mugger (*Crocodilus palustris*) are reported in 6th Working Plan of Buxa Division (1965-66 to 1974-75), but these are not seen now-a-days [2,16,17].

Among the wetlands of BTR, *Narathali* is a significant one where 3 big shallow lakes harbour a good number of migratory ducks including Schedule-I species like whistling Teal as well as common Teal, Pintail, white eyed pocherd, shoveller etc. The swift streams of *Jayanti* & *Raidak* harbour Mergansers. The migratory birds appear during the end of Monsoon and fly away before summer. The migratory birds include the beautiful Ibis Bill, Pretty Minivets, Yellow Crested Sultan Tits, Streaked Spider Hunter which sucks nectar from *simul* flowers, Snipes, Wagtails, Leaf Warblers, Sandpipers. Endangered birds like Great pied Hornbill start nesting in *Pukhuri* area in *Phaskhawa* block of BTR during spring season [5,16,17].

Some of the endangered species found in the reserve are Indian Tiger (*Panthera tigris tigris*), Asian Elephant (*Elephas maximus*), Regal Python (*Python regius*), Chinese Pangolin (*Manis pentadactyla*), Hispid Hare (*Caprolagus hispidus*), Hog Deer (*Axis porcinus*), Slender-billed Vulture (*Gyps tenuirostris*) etc [2,16,17].

Buxa Tiger Reserve was one of the first reserves in the country to adapt census or enumeration of Tigers and co predators through scatDNA technique. The process started in 2007[2].

Buxa Tiger reserve is also enriched with butterfly diversity. Common Crow, Chocolate Albatross, Common Gull, Grass Yellow, Lemon Emigrant, Paris Peacock, Common Bluebottle, Common Beak, Lesser Zebra are some of the examples of butterfly species found here. We observed several butterfly species in the *28 mile* village and photographic documentation was done (figure 7-11). Figure 12 and 13 show the number of floral and faunal species in BTR.

Fig.7:Common Crow (*Euploea core*) in BTR.

Fig.8: Chocolate Albatross (*Appias lyncida*) in BTR.

Fig. 9: Common Gull (*Cepora nerissa*) in BTR.

Fig. 10: Grass Yellow (*Eurema hecabe*) in BTR.

Fig. 11: Chocolate Albatross (*Appias lyncida*) and Lemon Emigrant (*Catopsilia pomona*) in BTR.

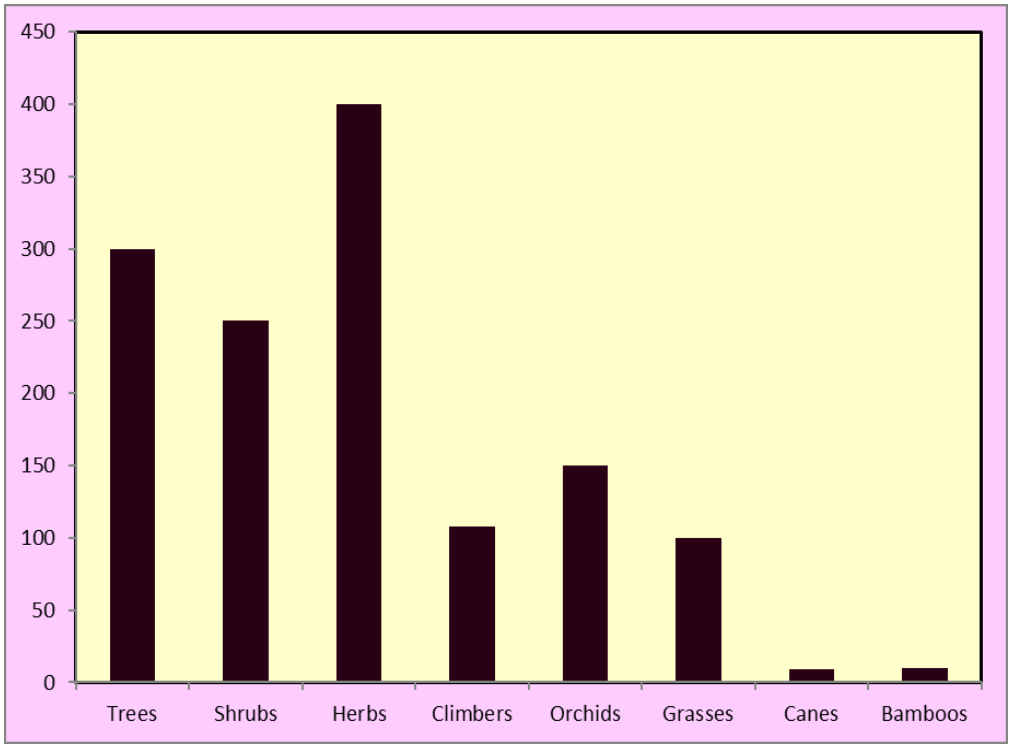

Figure 12: Number of floral species found in BTR (14,15,16).

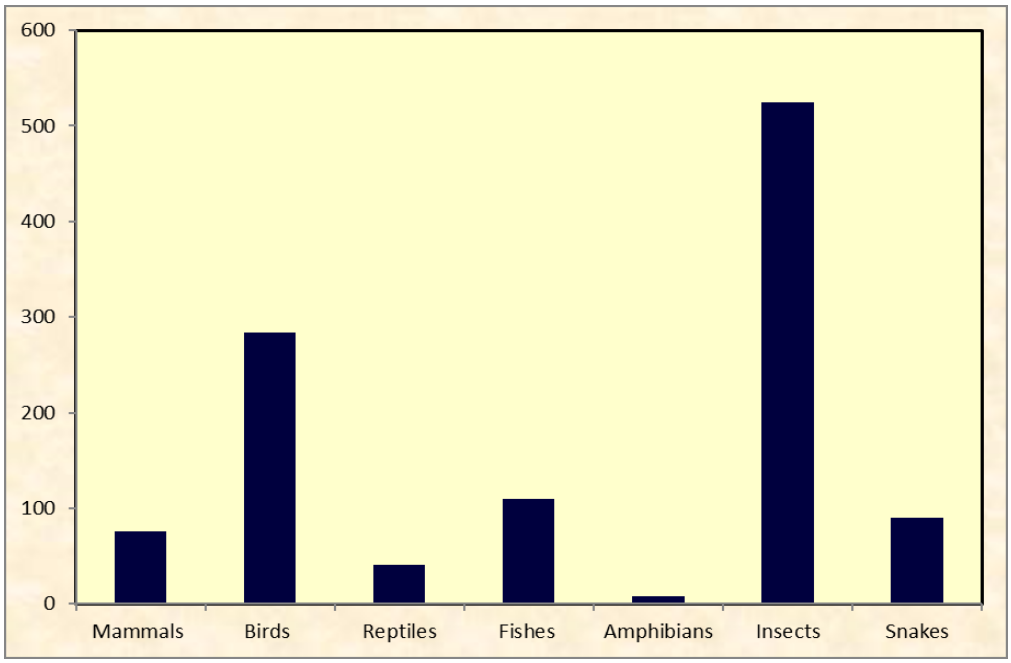

Figure 13: Number of faunal species found in BTR (14,15,16).

Human wildlife conflicts:

Human and wildlife conflict is in limelight in recent times as it causes a major threat to survival of many wild animal species in different ecological zones. Human-Wildlife Conflict (HWC) occurs when wildlife requirements overlap with those of human populations, creating costs both to residents and wild animals [18]. Man-animal conflict has been in existence for as long as human existence, and wild animals and people have shared the same landscapes and resources [19]. Direct contact with wildlife occurs in both urban and rural areas, but it is generally more common inside and around Protected Areas. With increasing population and pressure on forest areas, human-wildlife interaction and resultant conflict is also increasing [20]. *Dooars* area of North Bengal is immensely rich in biodiversity, and has diverse fauna which live in close proximity to human beings. Communities living in and around Protected Areas are not included as primary stakeholders. In many instances, these communities are highly marginalized and living in difficult circumstances.

BTR forest with periphery of 330 km. is surrounded by numerous tea gardens and cultivated land of villages. Over the decades there have been large scale changes in the landscape outside the forests by way of intensive cultivation, growth of human habitations in villages and towns and in tea gardens [2]. Many of the tea gardens in these areas are important corridors of wildlife. The tea gardens and revenue villages situated on the periphery witness highest intensity of human wildlife conflict, especially of elephant depredation. Since, elephants have wide home ranges, typically between 100 and 1000 km^2, a fragmented habitat or obstruction to traditional migration path is bound to bring many human-elephant conflicts resulting in damage to agricultural crops, property, household and injury and mortality to both humans and elephants [4]. Cultivated crops are easy source of forage for elephants which is nutritious and healthy too. Crop damage is positively correlated with migration patterns of elephants [4]. In Buxa Tiger Reserve, elephants damaged 4.6% of the cultivated area during 2001 and 3.4% during 2002 [14]. The proportion of cultivated crops damaged by elephant in Buxa Tiger Reserve is more than double the proportion damaged by elephants in a southern Indian population [14].

28 mile Forest village in Buxa Tiger Reserve is a part of the Buxa forest and an important area of elephant corridor. In 2002, 7.9% of the cultivated area of *28 mile* village was damaged by elephants [14]. In *28 mile* Forest village, the man animal conflict is mainly centered on the attacks of elephants in the agricultural fields. Besides, there are examples of the attacks of wild pigs and wild dogs on human population, agricultural fields and livestock. Leopard attacks on humans are very rare, but they used to kill the livestock in the villages. The village people of *28 mile* used to

protect the crop fields from elephant attacks by burning woods in the night time, burning firecrackers, beating drums and metal cans etc. Several watch towers are constructed in the *28 mile* village to monitor the encroachment of the elephants in the agricultural fields with communications (ex. whistles) to alert other farmers. Crop fields are protected by fences made up of thorny bushes, which are the initial resistant that can be used to hinder the entry of elephant in the agricultural fields. Search lights are used in the night time to resist the attacks of wild animals [4]. Figure 14 shows the position of elephant watch tower in 28 mile village in BTR.

Figure 14: Elephant watch tower in *28 mile* village in Buxa Tiger Reserve.

Joint forest Management:

Joint Forest Management (JFM) is the official and popular term in India for partnerships in forest management involving both the state forest departments and local communities. The policies and objectives of Joint Forest Management are detailed in the Indian comprehensive National Forest Policy of 1988 and the Joint Forest Management Guidelines of 1990 of the Government of India [21]. Villagers agree to assist in the safeguarding of forest resources through protection from fire, grazing, and illegal harvesting in exchange for which they receive non-timber forest products, eco development works and a share of the revenue from the sale of timber products.

The creation of the Buxa Tiger Reserve (figure 15) in 1983 resulted in a ban on fodder collection and cattle grazing, threatening the very survival of the inhabitants residing in and around the BTR [22]. Restrictions on resource use, often leads to conflicts among park managers and villagers. To reduce pressures and conflicts, the India Eco-Development Project (IEDP) was launched by the Forest Department, West Bengal, with assistance from the World Bank and the Global Environment Facility in 1996. The project addresses the issues regarding participatory management of PAs through a strategy of eco-development. It deals with reducing negative interactions of local people with biodiversity and increasing their collaboration in conservation. It aims at involving local people by supporting sustainable alternative income-generating activities with mutual understanding on controlled grazing, stall feeding, fodder regeneration outside forest areas etc. [23]. Forest Department provides employment opportunities to the people in various forestry works as Plantation Watchers**,** Fire Watchers**,** Eco Guides**,** Anti Depredation Helpers etc.

Forest department allows timber and woods for the construction of houses at fixed intervals. The villagers did not make any complain against restrictions. They, rather showed, concern for the forest.

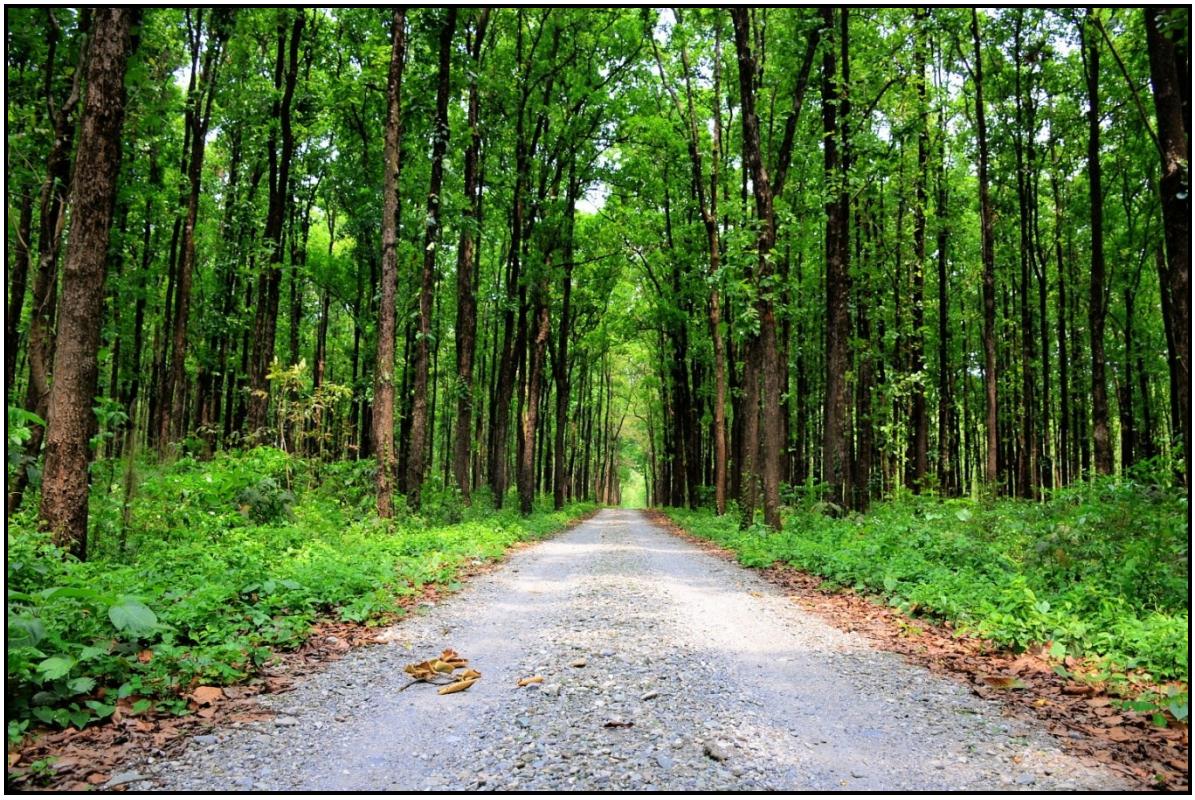

Figure 15: Forest area of Buxa Tiger Reserve.

5. SUSTAINABLE MANAGEMENT POLICY RECOMMENDATIONS

Several hamlets of *Dooars* have become the emerging tourist spots of West Bengal for pleasure trips, biological and geographical excursions and medical research works. In spite of getting so much attention in the recent time, the areas are not adequately developed. There is an urgent need for implementing sustainable management systems in the areas for the betterment of the socio-environmental structures. We observed several environmental, social and economic problems in *28 Mile* Forest village, which should be addressed for sustainable management of the village area. Some of the management strategies applicable for this area are mentioned below:

A. For reducing the water crisis in *28 Mile* Forest village in April-May season, micro scale rainwater harvesting structures should be constructed in the houses. Filtering systems should be provided to the local inhabitants so that they can use the rainwater for drinking purpose after purification.

B. Adequate health services should be provided to the local inhabitants of *28 Mile* Forest village. Local Sub Health centres with doctors, nurses and basic medical facilities should be established in these areas. Availability of operation theatre in the nearby hospitals should be arranged.

C. Local training centres should be established for teaching the local people about the importance of biodiversity resources of *28 Mile* Forest village. The initiatives of the local people can effectively protect the natural assets of the areas. Implementation of successful joint forest management programme and relate them with the local economy can improve the socio-biological conditions. Proper study is necessary to enumerate different NTFPs and to estimate the average production. It is

also very crucial to understand the phyto-sociological relationship of different floral species in the vegetation for the conservation of different important floristic elements.

D. Portfolio of tourism products should be developed by utilizing its unique ecological assets. As these areas are considered as tourist attractions, development of handicrafts made from the forest bioresources could be beneficial for the economic development of the local communities.

E. West Bengal is considered as the cultural capital of India. The specific components of cultural tourism can be implemented in these areas, including fairs and tourism festivals, arts and crafts tourism and village tourism.

F. Tourism carrying capacity is defined as the maximum number of people that may visit the tourist destination without causing destruction of the physical, economic and socio cultural environment and an unacceptable decrease in the quality of visitors' satisfaction. The carrying capacity assessment and sustainability of tourism in the circuits identified is an important component of the ecotourism study as it will form the basis for resource allocation and future development [24]. The balance between ecotourism development and carrying capacity could develop the social, cultural and economic status of the local villages.

G. There is lack of gross knowledge among villagers on the advantages of afforestation in the forest and hill areas. Specific training and awareness efforts from the Forest Department should be given to educate people on the effects of deforestation, with special focus on the long term effects of deforestation on climatic conditions. Focus should be given on areas critically important to floral and faunal habitat, water catchments and areas important with social and cultural values. A better understanding of corridor management can reduce the incidences of elephant encroachment and attacks.

The communities in Buxa do not seem to be adequately informed of the implications of the new Acts/rules of biodiversity. Their access to the biodiversity, according to them, is unrestricted. Similarly the government officials, concerned with the implementation of bio-diversity Act and Rules are also not clear about the implications and follow this as a bureaucratic process. The policy framework and the stakeholders need to be compatible with each other in relating to the issues and potentials of biodiversity and in appreciating the long term implications of the policy framework viz-a-viz the community and their rights.

H. Organic farming is one of the several approaches found to meet the objectives of sustainable agriculture. Organic farming is a production system that sustains the health of soils, ecosystem and the people. Organic farming works in harmony with the nature rather than against it. It relies on ecological processes adapted to local conditions, rather than the use of inputs with adverse effects in the long run. Encouraging and supporting the farmers towards organic farming in *28 Mile* Forest village should be done by government initiatives.

I. The effects of climate change are more devastating in the Himalayas compared to the other regions [25]. The annual and seasonal temperature trends in the Kanchenjunga landscape indicate an increase at the rate 0.01 – 0.015 °C/year, with higher altitudes experiencing greater warming [26]. Likewise, among the administrative units, Darjeeling was the most vulnerable compared to Sikkim, eastern Nepal and western Bhutan. Extensive studies on the effects of climate change on *28 Mile* Forest village and adjoining areas of BTR should be done, as it represents one of the richest biodiversity zones of India.

J. The adjoining forest areas of *28 Mile* Forest village suffer from illegal cattle grazing, firewood collection, encroachment on the fringes and poaching. More intense survey works and management practices should be done for mitigating the anthropogenic threats in BTR.

K. Natural habitats were converted to *Teak* and *Jarul* (monoculture) plantations in many areas of the reserve like *Sankosh, Kumargram, Bholka, Rydak, Dima, Rajabhatkhawa, Santrabari, Bhutri, Bharnabari,* and *Gudamdabri* blocks as well as in National Park areas during the sixth and the seventh Working Plan period before formation of BTR. *Teak* (*Tectona grandis*) and *Jarul* (*Lagerstroemia speciosa*) plantations occupy 34% of total plantation of the Tiger Reserve, which is not congenial for wild animals. Natural carrying capacity of the habitat is reduced considerably on account of such adverse changes [16].

L. A number of PWD roads, including a National Highway, NH 31C, pass through the BTR. The meter gauge railway line from *Damanpur* to *Hasimara*, which has been graduated to broad gauge railway line, passes through the Reserve. The number of vehicles and trains during night has increased by many times. Consequently, wild animal death cases due to accidents have also increased. Railway and road construction in BTR area should be inspected thoroughly after proper study on the corridor networks and their management strategies [16].

M. Separate waste collection and disposal system should be operated by the government for safeguarding the sensitive ecosystems of the areas. Effective management design should be done for plastic wastes generated in these areas.

N. The vehicles used in the areas should be monitored regularly so that the vehicular pollution could be checked in the areas. Installation of the modern devices in the vehicles for pollution control should be done and routine checking system should be implemented.

O. To reduce the pressure on the forest and the drudgery to which women are subjected due to use of smoke producing "*chullas*", an alternative fuel policy should be evolved and implemented. Large scale installation of solar panels in these areas would be beneficial [11]. Biogas is a cheap, pollution free alternative energy source. It can also reduce the annual emission of CO_2 from households. One biogas plant can save approximately 2 tons of fuel wood, 0.8 tons of agricultural wastes and 50 litres of kerosene per household per person. Implementation of biogas plant *28 Mile* Forest village areas can reduce the pressure on fuel wood and can safeguard the forest resources.

P. Extraction of boulders from river beds has been resumed recently near *Santrabari* in BTR. The ban on boulder extraction from river beds had raised the river beds, to levels higher than the adjoining road, thus increasing risks of floods and river bank erosion. The resumption of extraction, on a restricted scale can be a favourable initiative.

Q. Over the years, the incidences of cattle grazing in the villages of BTR have exponentially multiplied. A study placed the number of cattle grazing in the forest every day at about 150,000 cattle graze in the forest every day. Excluding some blanks and steep slopes, the intensity of grazing is 2.5 cattle per ha. The number of households increased by about 66% from 1970 to 1999 [22]. With the increase in households, cattle numbers have also increased rapidly. Reduction in cattle grazing in the forest areas can increase the soil stability, can reduce erosion and can balance the ecosystems.

R. National and International cooperation and grants should be enhanced for the conservation of Buxa Tiger reserve and its village communities. Research grants should be raised for exploring the social and biological status of the area. Training programmes, seminars and workshops should be organized for highlighting the conditions of Buxa Tiger Reserve.

6. CONCLUSIONS

In spite of being positioned in a diverse and sensitive ecological zone, the *28 mile* village in Buxa is not adequately managed. The forest communities, who are residing for years and sustain livelihood from forest resources, are getting more vulnerable and marginalized. To reduce the threat faced by villagers especially in a protected area like BTR, there should be some area-specific policy involving legal changes to deal with the land scarce area circumscribed by national parks and sanctuaries as well as rivers that originate from hills causing severe damage and erosion of forest lands. More functional participation and cooperation of the local people can create trust and confidence and can reduce conflicts with forest authority which can further help to preserve bioresources. Attention should also be given to marginalized tribals who are the worst sufferers during relocation. Active coordination between the revenue and forest departments in dealing with this kind of situation is extremely important.

It is unquestionable that the hill and forest areas of India have major contributions in maintaining climatic and ecological balance in the country. For a long time, these areas have not received their due emphasis on development issues. The present work is the first ever socio-environmental study done at 28 mile village of Buxa Tiger Reserve so far. Extensive investigations at other forest areas of North Bengal should be done so that the places could be highlighted for conservation in future.

Photographs: All the photographic documentation is done by Dr. Sayan Bhattacharya. Nikon D5100 Digital SLR and Nikkor 18-140 mm. VR lens were used for capturing the images.

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