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Research Paper

# Socio-environmental survey of a forest hamlet proximate to Neora Valley National Park in the Eastern Himalayas, India

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**Abstract**
The Eastern Himalayas have significant impact on the climate and biodiversity of the Indian Subcontinent. Many scattered hamlets are found in this zone and some of them are proximate to the forests enriched with endemic biodiversity. Icchey Gaon (27.1336°N, 88.5657°E; Altitude 5,600 feet) is a small village situated in Kalimpong district, India in the Eastern Himalayas. The village is one of the recently developed tourist destinations in the Eastern Himalayas. The survey work was done in April, 2017 by visiting Icchey Gaon village in Kalimpong, West Bengal. The survey work integrates the perspectives of human and social ecology, ecosystem services and sustainable development. Primary data were gathered through field survey and direct contact with common people and authorized centres of the region. Structured questionnaires and semi-structured interviews supplemented by field notes were arranged to collect data from the village areas in Icchey Gaon. Focuses were given on demography, agriculture, livestock management, traditional water management, education, culture, health, waste management, disaster management, biodiversity, joint forest management, ecosystem services and human animal conflict. Biodiversity of the region was documented by visiting the forest areas and the nature interpretation centre situated in Neora Valley National Park. Management strategies have been suggested for conserving the forest biodiversity and socio-economic condition of the hamlet. Extensive study is necessary in the Eastern Himalayas to explore the socio-ecological conditions in the context of climate change.

**Keywords**
Survey, Forest, Himalayas, Sustainable Development

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## 1. INTRODUCTION

The Eastern Himalayas are considered as the meeting ground of the Indo-Malayan, Palaearctic, and Sino-Japanese biogeographical realms with diverse ecological and altitudinal gradients and an equally diverse flora and fauna (ICIMOD, 2010). The Eastern Himalayan rivers and landscapes provide valuable ecosystem services such as soil retention, climate regulation, carbon sequestration etc. The welfare of millions of people downstream is inextricably linked with the natural resources of the Eastern Himalayas. Shaped by natural environment, the indigenous communities of Eastern Himalayas have rich blending of religious, cultural and local traditions. These communities of the Eastern Himalayas derive various ecosystem services from the forest resources. The services include provisioning (eg food, fodder); cultural (aesthetic, religious); supporting (soil formation and water cycle); and regulatory (erosion, climate) services (Chettri et al., 2007). The main challenge, however, lies in using the natural resources in a sustainable manner.

Many scattered hamlets are found in the Eastern Himalayas and most of them are proximate to the forests enriched with endemic biodiversity. Icchey Gaon (27.1336°N, 88.5657°E; Altitude 5,600 feet) is one of those hamlets, situated in Kalimpong district, India in the Eastern Himalayas (figure 1 and 2). Icchey Gaon was established in between 1955 and 1957 in Algarah Block of Kalimpong district, West Bengal. The hamlet is proximate to Neora Valley National Park, which is one of the significant forests of the Himalayas with high diversity of medicinal plants.

Icchey Gaon is one of the newest and attractive tourist destinations in the Eastern Himalayas. The village area is also a centre of Cinchona plantation since 19th century. The

adjacent areas of Icchey Gaon have extensive coverage of Cinchona plantation. The survey work was done in April, 2017 by visiting Icchey Gaon in Kalimpong, West Bengal, India. The study focuses on an interdisciplinary understanding on the physical and cultural environment of the forest and mountain areas.

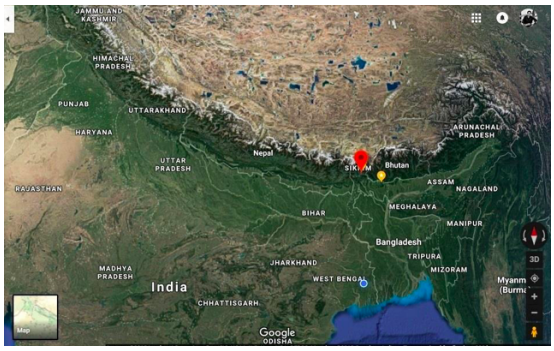


**Figure 1.** Icchey Gaon (27.1336°N, 88.5657°E; Altitude 5,600 feet) is one of those hamlets, situated in Kalimpong district, India in the Eastern Himalayas.

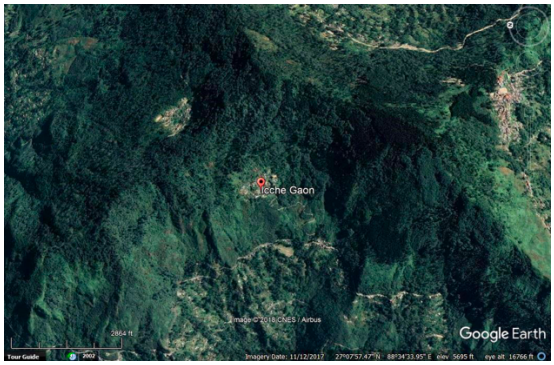


**Figure 2.** Icchey Gaon is situated proximate to Neora Valley National Park in the Eastern Himalayas.

## 2. METHODS

The survey work integrates the perspectives of human and social ecology, ecosystem services and sustainable development. Primary data were collected through field survey and direct contact with common people and authorized centres of the region. Structured questionnaires and semi-structured interviews supplemented by field notes were arranged to collect data from the village areas at Icchey Gaon. The length of each interview was about 40–50 minutes and was supplemented by field notes. The interviews were conducted in the local dialect (which comprised of mixture of Bengali and Hindi). Both qualitative and quantitative data were collected during the survey.

In many villages of the Eastern Himalayas, families have traditionally delegated decision making rights to the head of the household regarding social and economic issues. Considering this fact, data was collected from the household heads of the families. Supplementary information was collected from the other members of the families. Structured questionnaires were used to identify socio-economic status of the households. Semi-structured interviews supplemented by field notes were used to study the dependence of villagers on ecosystem services. Focuses were given on demography, agriculture, livestock management, water management, education, culture, health, waste management, disaster management, transport, biodiversity, NTFP collection and human animal conflict. Demographic information was collected from the village area and from the local Panchayat. Health and education information was collected from the local schools and local sub health centers. Information regarding the transportation was collected from the local transport syndicate. Biodiversity of the forest areas was documented by visiting the adjacent forests and by accessing the database of West Bengal Forest Department. Information on cinchona plantation was collected from the cinchona plantation office situated at Munsong (5 km. from Icchey Gaon). Photographic documentation was done in every phase of the survey work (Bhattacharya and Ghosh, 2014; Bhattacharya, 2016).

## 3. RESULTS AND DISCUSSION

### 3.1 Population

There are 33 families at Icchey Gaon village with total population of 165 individuals. 53% of the population is male and 47% is female. Approximately 60% of the people are Buddhist and the rest are Hindus. The Buddhist community comprises of ethnic groups of Gurung and Tamang. The majority of Hindu population belongs to the ethnic group Sherpa, followed by Bhujel and Rai communities. Agriculture, tourism and business are the main occupations of the inhabitants. Among the 28 houses situated in the village, 12 houses offer homestays for the tourists.

The male members of the families are involved in tourism business, transportation and agricultural activities. The female members are engaged in the household works, hospitality of the tourists in the homestay and in agricultural activities.

**Table 1.** Population structure at Icchey Gaon village (Census 2011)

| Particulars | Total | Male | Female |
|---|---|---|---|
| Total number of houses | 33 | | |
| Population | 165 | 87 | 78 |
| Children (0-6 years) | 25 | 18 | 7 |
| Schedule caste | 0 | 0 | 0 |
| Schedule tribe | 96 | 49 | 47 |
| Literacy | 72.80% | 76.80% | 69% |

### 3.2 Agriculture and Livestock management

The Eastern Himalayas are the "centre of origin of cultivated plants", as original locations of over 50 important tropical and sub-tropical fruits, cereals, and rice (Hore, 2005). Out of approximately 800 species used for food in India, about 300 species are found in North East India (Rao and Murti, 1990).

In the hill areas of Icchey Gaon village, terrace cultivation or step cultivation is practiced. It is method of growing crops on sides of hills or mountains by planting on graduated terraces built into the slope. This labour-intensive method has been employed effectively to maximize arable land area in variable terrains and to reduce soil erosion and water loss (Bhattacharya and Ghosh, 2014). The common cultivable edible plants at Icchey Gaon village are green peas, maize, garlic, ginger, onion, mustard, tomato, raysak, potato, carrot, radish, round chilli, sugarcane, banana, cucumber, squash and large cardamom.

The inhabitants of Icchey Gaon practice organic farming. Organic compost is used as manure. Organic compost is mixed with jungle soil before application. Compost pits are constructed in the upper part of the village area (figure 3). They follow the methods of mixed farming and crop rotation in the agricultural fields. In the initial phase of the cycle, maize is cultivated, followed by the cultivation of mustard and potato.

Rainfed Irrigation system is practiced in the agricultural fields. Occasionally spring water is used for irrigation during the period of water crisis. Sparkling irrigation is done in large cardamom cultivation, mainly in the dry seasons. However, sparkling irritation is a recent initiative in this area. Previously, large cardamom cultivation was entirely dependent on rainfed irrigation.

Large cardamom is the main commercial plant cultivated at Icchey Gaon. The cultivated cardamom has about 12 local varieties and seven species of wild relatives readapted to different agro-climatic conditions of the Eastern Himalayan region. The crop was first domesticated by the indigenous Lepcha tribe and then by other communities Bhutias and Nepalis of Sikkim and was later passed on to the neighbouring Darjeeling district of India, parts of Bhutan and eastern Nepal (Sharma et al., 2000). Recently degeneration of cardamom is observed mainly due to the viral diseases such as chirkey and phurke. In Sikkim the cardamom yield has substantially reduced (Sharma, 2006). Disease control measures in the form of uprooting and drying of the infected plants and/or either burning or burying of infected plants are commonly practiced (Srinivasa, 2006). Large cardamom cultivation is practiced at Icchey Gaon village by using organic manures like cow dung, poultry wastes and goat dung. The farmers reported that the production of large cardamom has decreased in the recent years due to shortage of water and increase in temperature.

Most of the houses at Icchey Gaon have cultivable lands adjacent to the houses (figure 4). Agricultural production is one of the main economic sources of the people of this area. They use to sell the agricultural produce in the local markets. Large Cardamom is harvested and is supplied to the markets in Kalimpong and Siliguri.

The common livestock at Icchey Gaon are local breeds of cows, goats and pigs. Almost every household has small poultry farm with cow and goat shelters in their own backyard. Meat, eggs and milk are the main livestock products which are among the important economic sources. The waste generated by the livestock is converted into organic manure and is applied in the agricultural fields.

**Figure 3.** Compost pit at Icchey gaon

**Figure 4.** Organic farming at Icchey gaon

### 3.3 Water management

The main water source of Icchey Gaon is the water coming from the hills through natural water channels like "jhoras" (local springs). The local springs are situated in the forest area, 500 meter away from the village. The springs flow below the ground and natural filtration of water happens while passing through the soil layers. Water is collected in a well and subsequently deposited in the water tanks situated in the village (figure 5a and 5b). Network of pipelines distribute water from the water tanks (source tanks) to the houses. Previously there was only one source tank at Icchey Gaon; presently the village has three water tanks for water distribution.

The survey revealed that in the last few years the local stream water flow has been decreased during summer times and has negatively impacted water availability for domestic and irrigation use. March to May is the period of water crisis in Icchey Gaon, when people bring water from the local "jhoras". Even the home stays developed recently for tourism purpose suffer from water shortage during that period. The increasing number of tourists consequently has increased water consumption, which has considerable effect on water availability in the village.

Pit toilets were constructed by each household for maintaining sanitation and hygiene standards. However, these pit toilets do not follow the guidelines provided by the World Health Organisation (WHO, 2013) and may have considerable effects on adjacent water streams and groundwater sources. Wastewater from the households is directly discharged on the ground; no drainage system has been developed in the village for wastewater discharge.

**Figure 5.** Water from local springs are collected in storage well and subsequently supplied to the village tanks

### 3.4 Waste Management

At Icchey Gaon, the common household wastes generated are plastic packets, paper boxes, plastic bottles, glass bottles, vegetable wastes etc. Vegetable wastes are used as cattle feed and for preparation of organic manure. Solid wastes are collected in bins (figure 6) for disposal. Every family burn all the solid wastes once a week, or bury the waste under the ground. Burial of bottles and plastic packets may have serious effects on the local ecosystems and biodiversity. There is no waste management system developed for carrying, segregating, transporting and processing of the waste materials. Sometimes plastic and glass bottles are recycled by selling in the local markets after use. Local villagers are concerned about the increase in waste generation because of recent development in tourism at Icchey Gaon.

The inhabitants of Icchey Gaon collect the fuel wood from the forest area. Usually the rotten and low quality woods are used for burning purpose. They use to store the wood in the storehouses after collecting from the forests (figure 7).

### 3.5 Economy

**Tourism**: The tourism business has been flourished in Icchey Gaon in the last 5 years, initiated in 2012. The spectacular view of the Himalayan ranges, forest and biodiversity

**Figure 6.** Plastic waste collection in paper box

**Figure 7.** Forest wood is collected in the storehouse

are attracting tourists from different parts of India. Icchey Gaon is attracting large number of tourists in recent times and the villagers have started developing home stays for the tourists. At present there are 12 home stays at Icchey Gaon. Local people are in support of tourism initiatives and considering it as an attractive option of earning money. Number of tourist remain maximum from October to December, followed by an above average tourist inflow from March to May and lowest inflow in the rainy season (June-September). Some of the villagers regularly visit the travel fairs in the cities, where they promote ecotourism facilities at Icchey Gaon.

The information about Icchey Gaon for the tourists are mainly available from the website of the village, touring agencies and operators, daily newspapers and travel magazines. The villagers are also using social networking sites like Facebook and WhatsApp for connecting people. The web-based promotion of this less known destination along with the positive vibe in print media had been quite useful for attracting tourists and making direct contacts between tourists and community based service providers. At the community level, socially cohesive bonds have been observed among the inhabitants of Icchey Gaon, which could be a strong regulating factor in community based ecotourism development.

Interesting, a shift in occupational status in response to

tourism was recorded during the survey. There is a considerable decline in livestock management with development of tourism activity. The villagers who started the tourism business sold the livestock for generating business capital. There is also a decline in maize cultivation at Icchey Gaon. According to the villagers, the decline in maize cultivation is because of development in tourism activities, which are more profitable than agricultural practices and livestock management.

**Cultivation of large cardamom**: Agriculture and tourism are the main economic sources of the inhabitants of Icchey Gaon. The people use to sell the agricultural and livestock products in the local markets. One of the major economic backbones of Icchey Gaon is the production of Large Cardamom (Amomum subulatum), which are regularly produced and supplied to different places (figure 8). The major portion of household income comes from selling the cardamom which is a high value crop compared to other farm produces. It is a less labour intensive and non-nutrient exhaustive systems compared to other cultivations. However, the post harvest methods and storage are still traditional in Darjeeling and Kalimpong hills, resulting in poor quality products with low market price (Sharma et al., 2009). Sometimes the farmers store their products of one or more years for one time income when the market rate raises high. Large cardamom plantation area is declining in several places of Eastern Himalayas due to natural calamities such as draught, hailstorm, snowfall in plantations at higher agroecological zones, widespread occurrence of fungal diseases and viral diseases. The prime reason of cardamom plantation and agronomic yield decline is due to the infestation by viral diseases viz. Chirkey and Phurkey (Sharma et al., 2009). This is one of the reasons for production decrease sharply by about 30% in during 2005-2007. The above mentioned constraints and problems of diseases are seen in almost all cardamom growing areas of Sikkim and Darjeeling hills of West Bengal. The villagers of Icchey Gaon experienced decrease in rainfall, unpredictable monsoons and disease outbreaks in large cardamom cultivation resulting in significant drop in production during 2005-2007. In recent times, the production has increased again in the region.

**Cinchona plantation**: The adjacent areas of Icchey Gaon have extensive coverage of Cinchona plantation (figure 9). The cinchona plantation office is situated at Munsong, a small village situated 5 km. away from Icchey Gaon. The Directorate of Cinchona and Other Medicinal Plants started functioning since 1862, right from foot hills to an altitude of 1800 meter in the hilly terrain of Darjeeling district. The Cinchona cultivation in Bengal Presidency initiated under the direction of Dr. Thomas Anderson, the then Superintendent of the Royal Botanical Garden, Calcutta. Dr. Anderson started his experimental trials for cultivation of Cinchona in Darjeeling hills of Bengal and ultimately selected Mungpoo Hills in 1862 for commercial cultivation. The successful establishment of Cinchona plantation at Mangpoo was made by Dr. Anderson in 1864. Subsequently Munsong plantation started in 1901, Rongo in 1938, Latpanchor in 1943 and Ambotia in 1977.

Initially there was only Directorate of Cinchona, later the Directorate of Medicinal Plants was created in the early 1950 and these two Directorates were ultimately amalgamated to a single Directorate in 1968. The initial objective of the Directorate was to grow different species of Cinchona trees to produce the life saving Anti-Malaria drug Quinine from the bark. Later on the activities of the Directorate expanded and the cultivation of Cephaelis ipecacuanha, Dioscorea composite, large Cardamom, Rubber, Mulberry, Turmeric, Taxus bacata, Broom stick, Citronella, Vetiver, Lemongrass, Artemisia annua, Mandarin Orange etc. started. Government Cinchona Plantation at Munsong was established in the year 1901. The area is situated 23 km. north of Kalimpong and on the border with Sikkim. The total area under Govt. Cinchona Plantation at Munsong is 9,361.80 acres. There are five divisions in the Munsong Plantation viz. (i) Sangseer (ii) Burmaik (iii) Munsong (iv) Kashyem and (v) Rangpoo. The Munsong Plantation is famous plantation of cinchona with high alkaloid content. The main features of cinchona plantation at Munsong are given in Table 2.

**Figure 8.** Large cardamom cultivation at Icchey Gaon

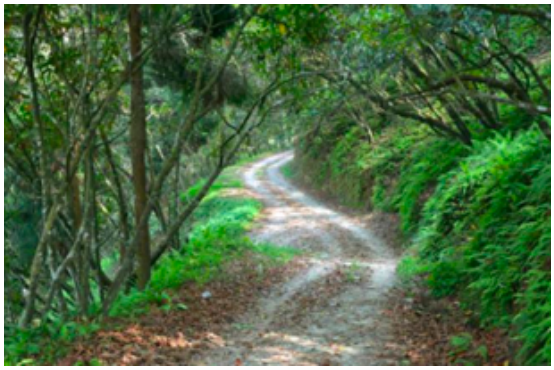

**Figure 9.** Cinchona plantation near village area

**Table 2.** Cinchona plantation at Munsong: General features (WBFPIH, 2018)

| Altitude | 1200-5800 feet MSL |
|---|---|
| Temperature (Max/Min°C) | 35/05 |
| Average rainfall | 5000 mm. Per annum |
| Agricultural scenario | Mostly wild plantation; Cinchona, Ipecac, rubber and large cardamom forming the major plantation. |
| Climate | Temperate, Sub-humid |
| Water resources | Natural springs and jhoras, pipe irrigation, rainfed |
| Soil | Organic matter more than optimum; Major, secondary and trace elements are low to medium; pH acidic; Application of lime in the soil; jungle soil and cowdung are used as fertilizer. |
| Number of workers | 1188 |
| Total area | 9361.8 acres |

### 3.6 Transportation

There are 10 private cars at Icchey Gaon which connects the area with Kalimpong town. The cars are generally available in the morning on sharing basis for going to Kalimpong town and Siliguri city. With the growth of tourism in Icchey Gaon, cars are available for going to different parts of North Bengal and Sikkim. No bus is available in Icchey Gaon; car is the only mode of transport. Bus service can be available from Kalimpong town, which is 18 km. away from Icchey Gaon.

### 3.7 Education, culture and health

There is a primary school upto 4$^{th}$ standard at Icchey Gaon with 4 teachers and approximately 5-6 students. There is also a high school situated at Ramdhura, which is around 5 km. from Icchey Gaon. For availing higher education in colleges and universities, the inhabitants of Icchey Gaon usually visit Kalimpong (18 km.) and Siliguri (90 km.).

Icchey Gaon has lower literacy rate compared to West Bengal. In 2011, literacy rate of Icchey Gaon was 72.86 % compared to 76.26 % of West Bengal. In the village community, male literacy stands at 76.81% while female literacy rate was 69.01%.

There is no hospital facility at Icchey Gaon. A primary health centre is situated at Munsong (5 km. from the village), where 1 doctor and 2 nurses are available for minor treatment. No operation facility is available in that health centre. For major treatments and operations, the inhabitants of Icchey Gaon visit the hospitals in Kalimpong town and Siliguri city. Basic medicines can be found in the local grocery shops of Icchey Gaon; there is no medicine shop found in the village area. The villagers are highly dependent on the local medicinal plants for treatment.

At Icchey Gaon, local food products are completely based on agricultural products and livestock products. Gundruk is considered to be the most popular local food in Icchey Gaon. Gundruk is fermented leafy green vegetable and one of the national dishes in Nepal (Swain, 2014). Gundruk is an important source of minerals particularly during the off-season when the diet consists of mostly starchy tubers and maize which tend to be low in minerals. Sinki is a preserved vegetable, similar to Gundruk, is prepared from radish tap roots. Sinki is generally consumed in the forms of soup and pickle made by the local inhabitants of Icchey Gaon. The other traditional foods and drinks are round chilli pickle, Khapsey (Deep fried Tibetan pastry eaten and offered during Losar festival), Chhaang (Nepalese and Tibetan alcoholic beverage made from barley, millet or rice).

The Buddhists population celebrates festivals like Buddha Purnima and Losar in Icchey Gaon. Losar is the Buddhist festival ("Losar" in Tibetan language means New Year), which is celebrated for 15 days; the main celebration occurs in the first three days (29$^{th}$-31$^{st}$ December). The Hindus celebrate festivals like Dussehra, Diwali, Makar Sankranti and Bhai tika.

### 3.8 Ecosystem services

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 (Das, 2005). NTFPs collection is a traditional practice of the villagers of Icchey Gaon. They collect small size timbers from the forest area for house construction and firewood as household fuel. The villagers also collect local bamboo species (Muli Bamboo, Melocanna sp.) and use them in roof construction. Sometimes they collect edible roots and tubers, mushrooms, fiddlehead ferns (ningro) and kafal fruits as substitute of

 

staple foods especially during lean seasons. Most of the villagers cultivate medicinal plants in the farmlands adjacent to their houses. Aloe vera is widely cultivated at Icchey Gaon. Other local medicinal plants for cultivation include Banmara (Eupatorium cannabinum), Tite pati (Artemisia vulgaris), Okhar (Juglans regia), Lali gurans (Rhododendron arboretum), Chirauto (Swertia chirata), Bhumi Champa (Kaempferia rotunda) etc. The villagers cultivate the medicinal plants for personal uses. During the survey work, some of the inhabitants mentioned that the ancestors of the villagers were far more knowledgeable about the medicinal plant resources of the forest areas. The present generations are less aware about the medicinal plant varieties because of availing medical facilities from the health centres and hospitals.

Honey production is also an important source of earning. The inhabitants use to make artificial wooden structures in which bees take shelter and store honey. They periodically collect the honey and supply it to market. Analysis of semi-structured interviews in the study area indicated the dependence of people on forest ecosystems through the provision of ecosystem services.

### 3.9 Disasters

Kalimpong is under rapid habitat destruction due to unplanned developmental activities like hydro-electrical projects, construction of roads, establishment of tea gardens, and mining activities. These factors have an incremental effect on the fragility of the Himalayan ecosystems. (Bhattacharya, 2016). At Icchey Gaon, road side small landslides are very common. The inhabitants also reported about the thunderstorm hazards in the village. Besides, the area is also earthquake prone and falls under seismic zone IV; small earthquake incidences are common at Icchey Gaon. Minor effects were noticed at Icchey Gaon during the disastrous earthquake in Nepal in 2015. The houses made of concrete experienced more damage than the wooden houses. The villagers had very limited means to cope with natural disasters due to remote location and hilly terrain.

### 3.10 Biodiversity

Icchey Gaon is situated approximately 12 km. away from Neora Valley National Park (NVNP), which is located in the Eastern Himalayas as a global "biodiversity hotspot" (figure 10). This area is included in one of the 25 Global Hotspots (Myers et al., 2000), the Global 200 forest ecoregions (Olson and Dinerstein, 1998), two endemic bird areas (Stattersfield et al. 1998) and several centres for plant diversity. NVNP has wide range of environment gradients and climatic conditions, supporting a unique and ecologically important undisturbed patch of late succession forest. The park has a wide altitudinal variation (183–3,170 meters) and climatic conditions (tropical/sub-tropical in its lower range and temperate in its higher range). The climatic condition varies between tropical/subtropical in its lower range to temperate in its upper range (Mallik, 2010). In spite of being located in the Oriental Region, this park has some floral and faunal similarities with the Palaearctic Region of the adjacent zoogeographic zone. NVNP has been placed in the biogeographic zone 2 (Mallik, 2010). Moreover, it has characteristics of all the three sub-regions: Himalayan Montane System, Indian Peninsular sub-region and Malayan sub-region. The forest has total area of 88 $km^2$; located between latitudes . NVNP along with its adjoining forests of Kalimpong Forest Division is also an important ecological corridor in Eastern Himalayas for movement of long-ranging animals to and from other contiguous protected areas in North Bengal (Mallik, 2010). The forest has rich variety of habitats, as the area comprises the catchment and watershed of the Neora River. Four habitat types are recognized in NVNP: i) Subtropical Mixed Broadleaf Forest; ii) Lower Temperate Evergreen Forest; iii) Upper Temperate Mixed Broadleaf Forest; and iv) Rhododendron Forest (Mallik, 2010). It was notified as a protected area in April 1986 and was gazetted in December 1992.

The forest contains approximately 680 species of angiosperms, 23 species of pteridophytes, 276 species of insects, 38 species of other invertebrates, 308 species of birds and 33 species of mammals (Mallik, 2010). Approximately 20 % of the total species found in Neora Valley are extremely rare and many of those face the threats of extinction. Human settlements of late around this protected area have altered the biodiversity by means of habitat degradation.

**Floral diversity**: The lower altitudinal zone or foothills (500 to 1,700m) of Neora Valley display characteristic subtropical vegetation. The dominant tall tree species (10-30m) include Duabanga grandiflora, Michelia champaca, Terminalia alata, Schima wallichii, Castonopsis indica, Ficus subincisa etc. The undergrowth vegetation includes *Pandanus nepalensis, Maesa indica, Garuga pinnata* and *Holmskioldia sanguinea.* The common herbs found in NVNP are *Ageratum conyzoides, Oxalis corniculata, Urnea lobata, Eranthemum pulchellum* etc. Above this zone, a small sub temperate zone is situated (1,700-1,900m) which is characterised by species like *Ostodes paniculata, Ficus oligodon, Syzygium claviflorum, Ehretia serrata, Morinda angustifolia* etc. The ecological zones situated between 1,900 and 3,150 meters receive comparatively high rainfall and have higher humidity than the tropical area, hence have rich vegetation with wide ranging biodiversity. The 15-25 meters high trees form a dense, closed canopy with plants like *Michelia dolorosa, Magnolia campbellii, Alnus nepalensis, Rhododendron arboreum, Acer thomsonii, Juniperus pseudosabina, Abies densa, Pinus roxburghii, Cryptomeria japonica* etc (Fig. 13 ). The common climbers are *Thunbergia lutea, Clematis nepalensis, Lonicera macrantha* etc. The rich undergrowth is comprised of species like *Rubus paniculata, Viburnum erubescens, Astilbe rivularis, Strobilanthus thomsonii, Hedychium coccinium etc. Herbaceous flora is represented by Primula listeri, Swertia dulata, Rumex nepalensis, Poly-*

 

*gonum orientale* etc. Except in the very high altitude areas (above 3000 meters) the trees and shrubs are festooned with thick growths of epiphytic flora such as *bryophytes, pteridophytes, and angiosperms.* Heterophytic angiosperms like *Viscum, Loranthus, Balanophora, Aeginetia indica*, and many others are also abundant. The bryophyte diversity includes *Funaria sp., Hookeria sp., Asterella sp.* etc. High diversity of orchids are found among which species of *Acampe, Aerides, Bulbophyllum, Calanthe, Dendrobium, Eria,Thunia* etc. are noticeable (Mallik, 2010; Das, 2010).

Neora Valley is enriched with Rhododendron diversity. Several species of Rhododendron like *Rhododendron arboreum, R. falconeri, R. barbatum, R. dalhousiae, R. grande, R. triflorum* etc. are found in the forest area. Wild flowers available in the forest are Touch Me Not (*Mimosa putica*), Railway Glory (*Ipomoea cairica*), English Primrose (*Primula vulgaris*), Wild Musk Melon (*Cucumismelo*) etc (Das, 2010).

Among the medicinal plants found in the Neora Valley forest, Chinese Pepper (*Litsea Citrata*) is used as Antidepressant, antiseptic, Insecticide, helpful in heart diseases and bronchitis; Manjistha (*Rubia cordifolia*) is used to detoxify blood and to dissolve obstructions in blood flow; Herbaceous Woodlander (*Smilacina oleracea*) root extract is used for curing fractures; Chirayata (*Swertia chirata*) is used as drug for intermittent fevers, skin diseases and bronchial asthma; Indian snakeroot/Sarpagandha (*Rouwolfia serpentine*) is used as drug for high blood pressure and schizophrenia; Ground pines/creeping cedar (*Lycopodium sp.*) is used for treatment of disorders of the locomotor system, skin, liver and bile, kidneys and urinary tract infections; Himalayan ginseng (*Panax pseudoginseng*) has antibacterial, antiinflammatory, antiseptic and hypoglycaemic properties; Shilapushpa (*Didymocarpus pedicellata*) prevents the formation of urinary stones and has antimicrobial property. Jaributi valley of Upper Neora is famous for producing the most important medicinal plants (Mallik, 2010).

**Faunal diversity**: There are 276 species of insects and 38 species of other invertebrates (molluscs, arthropods and annelids), including 6 species of leeches are found in NVNP (Singhal, 1998). The Neora Valley is richly blessed with a medley of beautiful butterflies like Common Grass Yellow (*Eurema hecabe*), Blue Mormon (*Papilio polymnestor*), Pale Grass Blue (*Pseudozizeeria maha*), Himalayan Five ring (*Ypthima sakra*), Yellow Orange Tip (*Ixias pyrene*), Indian Tortoise Shell (*Aglais cashmirensis*), Painted Lady (*Cynthia cardui*), Golden Sapphire *(Heliophorus brahma*), Bath White (*Pontia daplidice*), Tiger Brown (*Orinoma damaris*), Punchinello (*Zemeros flegyas*) (figure 12) etc.

The Neora River runs for about 57.6 km. from north to south and is drained by 9 major streams and 16 subsidiary streams. This part of the Eastern Himalaya has a greater diversity of coldwater fishes than the other parts of the Himalayas. The fish species found in the Neora River are Balsohani (Nangra punctata), Goni (*Labeo gonius*), Hara (*Hara jordoni*), Lohari (*Garra annandalei*), Bumble bee (*Laguvia shawi*) etc (Das, 2010).

Amphibians found in NVNP are Common Tree Frog (*Polypedates teraiensis*), Himalayan Frog (*Bufo himalayanus*), Himalayan Bull Frog (*Paa leibigii*), Twin Spotted Tree Frog (*Rhacophorus bipunctatus*) etc (Das, 2010).

Twelve species of lizards and 47 species of snakes have been identified in this park. Reptiles like Flat-backed Mountain Lizard (*Japalura planidorsata*), Indian Garden Lizard (*Calotes versicolor*), Asian Glass Lizard (*Ophisaurus gracilis*), Flat Tailed Gecko (*Hemidactylus garnoti*), Spectacled Cobra (*Naja naja*), Common Wolf Snake (*Lycodon aulicus*), King Cobra (*Ophiophagus hannah*), Indian Rat Snake (*Ptyas mucosa*) etc. are found in the NVNP (Das, 2010).

The semi-evergreen forests between 1,600 m. and 2,700 m. of Neora Valley are home to several rare species of birds and are considered as one of the most attractive places of ornithological study. Among approximately 300 bird species found in Neora Valley, 7 are globally threatened and 2 are near threatened, 12 species belong to the Red Data Book list (Mallik, 2010). The Red Data Book enlisted species are Greater Spotted Eagle (*Aquila clanga*), Blue Fronted Robin (*Cinclidum frontale*), Long-tailed Shrike (figure 11), Broad-billed Warbler (*Tickellia hodgsoni*), Lesser Kestrel (Falco naumanni) etc. Other major species of birds include Black Eagle (*Ictinaetus malayensis*), White Tailed Robin (Myiomela leucura), Great Tit (Parus major), Green-backed Tit (P*arus monticolous*) (figure 13), Eurasian Tree Sparrow (Passer montanus), Ashy Wood Pigeon (Columba pulchricollis), Brown Parrotbill (*Paradoxornis unicolor*), Chestnut Thrush (*Turdus rubrocanus*), Black-throated Sunbird (*Aethopyga saturata*), Hill Myna (*Gracula religiosa*), Goldcrest (*Regulus regulus*) etc (Mallik, 2010; Das, 2010).

Neora Valley provides shelter and protection to various species of mammals included in Red Data Book of IUCN and appendices of CITES (Convention on International Trade in Endangered Species of wild flora and fauna). Red Panda (*Ailurus fulgens*), Gaur (*Bos gaurus*), Asiatic Black Bear (*Ursus thibetanus*), wild boar (*Sus scrofa cristatus*), Tiger (*Panthera tigris*), Leopard (*Panthera paardus*), Clouded Leopard (*Neofelis nebulosa macrosceloides*), Red Fox (*Vulpes vulpes*), Barking Deer (*Muntiacus muntjak*), Himalayan Palm Civet (*Paguma larvata*), Marbled Cat (*Pardofelis marmorata*), Leopard Cat (*Prionailurus bengalensis horsfieldi*), Asiatic Wild Dog (*Cuon alpines*), Malayan giant squirrel (*Ratufa bicolor*), Indian pangolin (*Manis crassicaudata*), Chinese pangolin (*Manis pentadactyla aurita*), Malayan giant squirrel (*Ratufa bicolour*), Hodgson's flying squirrel (*Petaurista magnificus*), are significant mammals of Neora Valley. Discovery of tiger Panthera tigris tigris in 1998 prompted the forest department to include NVNP as a sensitive wildlife zone. (Mallik, 2010; Das, 2010).

**Figure 10.** NVNP near Icchey Gaon village

**Figure 11.** Long tailed shrike at Icchey Gaon

**Figure 12.** Punchinello butterfly in NVNP

**Figure 13.** Green backed tit in NVNP

### 3.11 Human Animal Conflicts

Human-Wildlife Conflict (HWC) occurs when wildlife requirements overlap with those of human populations, creating costs both to residents and wild animals (WPC, 2003). With increasing population and pressure on forest areas, human-wildlife interaction and resultant conflict is also increasing (Zubri and Switzer, 2001). Sikkim and Darjeeling, being a part of a global biodiversity hotspot (Myers et al., 2000), has diverse fauna which live in close proximity to human beings. In many instances, these communities are highly marginalized and live in difficult circumstances. Periodical wildlife attacks in the forest edge hamlets of the Eastern Himalayas affect the socio-economic structures of the local settlements.

Regular incidences of leopard attacks were reported by the villagers at Icchey Gaon. According to the local villagers, previously there were frequent incidences of leopard attacks because of the livestock grazing practices. After the cultivation of large cardamom started, the grazing activity had been restricted, consequently incidences of leopard attacks on the livestock decreased. The closed fences in the village area also reduced the leopard attacks on the livestock. During August and September every year, there are incidences of wild bear attacks in the maize field at Icchey Gaon. The agricultural fields are being attacked by porcupines, rabbits, deer, wild cats and monkeys. Porcupines usually attack the maize fields. Fences are used in the agricultural field for protecting the plants from wildlife attacks. Snake bites are rare in the village area.

## 4. SUSTAINABLE MANAGEMENT POLICIES

Icchey Gaon village area has become the emerging ecotourism destination of West Bengal for pleasure trips, trekking, nature camps, biological and geographical excursions and medical research works. There is an urgent need for developing and implementing sustainable policies for protecting forest ecosystems and biodiversity, socio-environmental structure of the local hamlets and ethno-cultural conservation. The focal areas for conservation and management are as follows:

**Water resource Management**: Rain water harvesting structures along the hill slopes can be developed for water crisis mitigation. Micro scale rainwater harvesting structures can be constructed in the village houses. Household filter systems can be provided to the local inhabitants for using the collected rainwater for drinking purpose. Water storage and micro-irrigation equipment business can be developed by this group for the use of local villagers. However, the recognition of the group by financial services providers such as banks, local government, and establishment of proper training facilities remain major challenges in this context

(Sandhu and Sandhu, 2014).

**Food security and agricultural development**: Enhancing the ecosystem services can lead to improvement of food and nutrition security. This can be achieved by deploying cost effective protocols such as crop rotation with legumes to fix atmospheric nitrogen in soil instead of nitrogenous fertilizers, enhancing functional agriculture biodiversity for managing insect pests instead of pesticides (Wratten, 2013).

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. Encouraging and supporting the farmers towards Organic farming in Icchey Gaon village can stabilize both ecology and economy. Creation of community seed banks and preservation of germplasm of the indigenous varieties would ensure availability of the food resources in the future. However, impact of climate change on these varieties must be identified to develop measures to fortify them against adverse impacts when they are growing. Integrated pest management (IPM) systems could be implemented by scientists from the Agricultural, Horticulture, and Plant Pathologists (Sandhu and Sandhu, 2014).

**Health and Sanitation management**: Adequate health services should be provided to the local inhabitants of Icchey Gaon. Local Sub Health centres with doctors, nurses and basic medical facilities should be established in these areas. Telemedicine facilities can be established in the hill villages like Icchey Gaon. This is especially important for enabling people in remote areas to consult specialists and then seek right suggestion for treatment. The specialists in the private hospitals and retired specialists from government hospitals can be engaged for this service.

Pit toilets should be re-designed by using appropriate technology under the specifications provided by the WHO, which consequently could reduce the extent of groundwater and stream water pollution (WHO, 2013). Local youth can be trained in technical skills required for constructing and managing pit toilets and understanding how right technology can minimize impacts on surrounding ecosystems. However, the key challenges are training of local entrepreneurs in the technology and the financial assistance to learn technical skills and start small scale business (Sandhu and Sandhu, 2014).

**Energy management**: For cooking purpose, use of energy efficient and smokeless cook stoves can be promoted to increase efficient fuel usage and reduction in cooking time, lowering pollution from using fuel wood (Barnes et al., 1993; Pandey et al., 1990). Pellet fuel required for these cook stoves can be made from the biomass waste from agricultural activities. It can prevent unsustainable harvest of wood and fuelwood from the forest. Implementation of biogas plant in Icchey Gaon can also reduce the pressure on fuel wood. Large scale installation of solar panels in these areas would be beneficial for having sustainable use of energy.

**Biodiversity conservation**: There is lack of gross knowledge among villagers on the advantages of afforestation in the hill areas. Specific training and awareness efforts from the Forest Department have to be undertaken to educate people on the drawbacks of deforestation and the long term effects it has on the climatic conditions. Ecological restoration should be done by restoring the damaged, degraded and areas destructed by landslides. Focus should be given on areas critically important to floral and faunal habitat, water catchments and areas important with social and cultural values. Community-based forest management systems can also help to increase carbon stock.

Like any other protected area in India, the forest areas of Icchey Gaon, especially Neora Valley National Park suffer from illegal cattle grazing, firewood collection, encroachment on the fringes and poaching. However, due to inaccessibility and difficult terrain, the biotic pressures are still not very acute. More intense survey works and management practices should be done for mitigating the anthropogenic threats.

The factors responsible for the depletion of medicinal plant diversity are: a. Increasing demand of herbal products. b. Shrinking of natural habitat of medicinal plants due to population pressure and other developmental activities. c. Indiscriminate and over exploitation from natural sources. d. Less efforts for commercial scale cultivation. e. Forest fire. f. Illegal trading of banned high value medicinal plants, especially in Neora Valley. g. Overgrazing of livestock. h. Cutting of medicinal trees for fuel, timber, etc., and lopping of leaves for fodder and cattle bedding. i. Change in climate and weather pattern. Sustainable management planning of medicinal plant conservation could be implemented after considering the factors responsible for the depletion of medicinal plant resources.

Biopiracy is a major problem in Eastern Himalayas which can considerably affect the endemic plant diversity in the areas. Neora valley national park is considered to be one of the richest medicinal plant diversity zones of India. Initiatives should be taken at Icchey Gaon for promoting medicinal resources and giving economic support to build up private nurseries where several varieties of important plant species can be preserved. Local training centres should be established for teaching the local people about the importance of natural resources of Icchey Gaon. The initiatives of the local people can effectively protect the natural assets of those areas. In the silviculture units, the plant varieties should be increased and more modern methods of conversation should be implemented associated with gene banks and extensive databases.

**Disaster Management**: Due to many anthropogenic activities, the land of Darjeeling is prone to landslide every year. Vegetative control measure of soil conservations should be adopted to protect further damage of land at and around the Icchey Gaon forest areas.

Promotion and implementation of vermicomposting techniques in this area can maintain the soil structure, agricul-

tural productivity and waste reduction (WWF, 2009). Technology supported by finance to develop low cost earthquake proof and energy saving housing would be beneficial.

The effects of climate change are more severe in the Himalayas compared to the other regions (IPCC, 2007). 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 (Singh et al., 2011). The Himalayan region, including the Tibetan Plateau, has shown consistent warming trends during the past 100 years (Yao, 2006). Likewise, among the administrative units, Darjeeling was the most vulnerable compared to Sikkim, eastern Nepal and western Bhutan. The major crops grown in Darjeeling district such as rice, wheat, pulses, and oil seeds are likely to experience decrease in production due to rise in temperature Bhattacharya and Ghosh (2014).

During the survey work, the villagers reported that previously there were incidences of snowfall in winter (January and February) at Icchey Gaon, however, in the last ten years, there has been no snowfall during the winter. The villagers also reported that the temperature has been increased considerably in the village area and the rainfall has become unpredictable. Extensive studies on the effects of climate change on Icchey Gaon can be done. Monitoring the climate change by establishing stations to meet long-term climatic data from Eastern Himalaya is the need of the hour.

**Pollution and waste management**: The number of vehicles is increasing in the ecotourism destinations of the Eastern Himalayas like Icchey Gaon. The vehicles should be monitored regularly for mitigating the vehicular pollution in the forest areas. Installation of the modern devices in the vehicles for pollution control should be done and routine checking system should be implemented.

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 mountain hamlets. Proper management of solid wastes through the methods of collection, storage, transportation, recycling and disposal should be implemented in the Eastern Himalayan hamlets.

**Economic development**: There remains the need for clearer understanding of resource flows to and from mountain areas. This will lead to increased income to mountain communities and a fairer distribution of earnings from natural resources exploitation and services provided. A number of innovative mechanisms, allowing a greater share of the proceeds from mountain-based economic activities to reach mountain people have to be continuously thought of and evolved. Creation of markets for channelizing the local products and establishment of distribution systems with strong communication could uplift the local economy of the village area.

**Tourism management**: The specific components of cultural tourism can be implemented in these areas including Fairs and Festivals Tourism, Arts and Crafts Tourism and Village Tourism. Portfolio of tourism products should be developed by utilizing its unique ecological assets. As these areas are the attraction for tourists, development of handicrafts made from the forest bioresources could be beneficial for the socio-economic development of the local communities.

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. The carrying capacity assessment should be done for Icchey Gaon, based on the inflow of tourists and their activities.

**Research initiatives**: More mountain-specific investment programs and greater mobilization of financial resources for mountain development and conservation programs will be required. In some cases this may mean formulating and financing programs which are focused exclusively on mountain areas. There are signs of greater willingness on the part of government to increase investment levels in mountain areas, which historically have been neglected.

National and International cooperation and grants should be enhanced for the conservation of Neora Valley National Park 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 Neora Valley National Park in international platforms.

## 5. CONCLUSIONS

The Eastern Himalayas, with a wide spectrum of ecological zones, is shared by Nepal, Bhutan, India, China and Myanmar. Many critical eco-regions and critical transboundary conservation complexes are of global importance. The area surrounding Mount Kangchenjunga is one of the richest landscapes of the "biodiversity hotspots" and one of the world's most critical centers of biodiversity (ICIMOD, 2010; Sharma and Chettri, 2005). Due to its strategic location between Nepal, India, Bhutan and China, it is an important area for biodiversity conservation and needs transboundary cooperation to make conservation efforts effective (Sharma and Chettri, 2005).

The present work is the first ever socio-environmental study done at Icchey Gaon village till date. Extensive investigations at other hill areas of Eastern Himalayas should be done so that the places could be highlighted for conservation in future. Our previous research papers highlighted the socio-environmental perspectives of some of the hamlets situated in the Eastern Himalayas Bhattacharya and Ghosh (2014);

Bhattacharya et al. (2015); Bhattacharya (2016, 2017); Bhattacharya et al. (2016). Integrating the scientific and social approaches together can lead to a holistic and sustainable management perspective. This survey work and sustainable proposals can be followed in other ecologically sensitive forest edge hamlets of Eastern Himalayas for biodiversity and traditional ecological knowledge conservation. The major challenge for the ecologists and environmental scientists in the Eastern Himalayas is to ensure the modernization of the native cultural values by a careful, step-by step transformation. The aim should be to provide lasting, synergistic benefits for the local people, their economy and culture in rural and semi-urban landscapes. The people of the Eastern Himalayan hamlets like Icchey Gaon are gradually realizing the value of protected areas and their role in management and are willing to engage in major decision making. Bringing local communities into protected area management will have significantly positive impact on long-term biodiversity conservation in the transboundary Himalayan landscapes.

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