

Chapter - 3

**MATERIALS
AND
METHODS**

3.1. Study area

West Bengal is a State in the eastern region of India and lies between 20°31' and 27°10' North latitude and 85°50' and 89°52' East longitude, spreading over 88,752 sq. km. It shares boundaries with Nepal, Bhutan, Bangladesh (International boundaries) and also Assam, Sikkim, Jharkhand, Bihar and Orissa (State boundaries). The State comprises of 19 districts, from north to south these are: Darjeeling, Jalpaiguri, Cooch Behar, North Dinajpur, South Dinajpur, Malda, Murshidabad, Birbhum, Nadia, Burdwan, Bankura, Purulia, Hooghly, Howrah, Kolkata, East Midnapore, West Midnapore, North 24-Parganas, and South 24-Parganas. West Bengal is the only State consisting of high peaks of Himalaya in the northern extremes to coastal regions down south, with regions such as plateau and Gangetic delta intervening in between.

A large number of rivers flow through the State of West Bengal. The Ganges is the main river, which divides in West Bengal and flows as the Bhagirathi-Hooghly River. The Teesta, Torsa, Jaldhaka and Mahananda rivers are in the northern hilly region. Whereas, the drier western part has rivers like Damodar, Ajay, and Kangsabati. The Ganges delta and the Sunderbans area have numerous rivers and creeks.

The features of soils are best described in terms of climate and vegetation supported by it. It can be classified in six agro-ecological sub-regions (Anonymous 2004), these are: Warm Humid (mountain regions of Darjeeling), Warm to Hot Humid (foothills of Bhutan Himalaya, mainly the northern fringe of Jalpaiguri district), Hot Humid (level of Teesta Plains – Dooars, below the Bhutan Himalaya), Hot Moist Sub-Humid (Gangetic plain), Moist Sub-Humid (coastal regions), Hot Dry Sub-Humid Agro-Ecological Sub-Region (outlines of Chotta Nagpur plateau).

The climate of West Bengal varies with elevation of lands. The main seasons are summer, monsoon, a short autumn, and winter. During summer months (March-May) the average maximum temperature ranges between 35°-45°C. Due to Indian Ocean monsoon and winds from Bay of Bengal moderate to heavy rainfall is received during monsoon (June-September). During winter (December-February) the weather remains pleasant and minimum recorded temperature varies between 7°-15°C. However, the hills of Darjeeling experience a harsh winter, with occasional snowfall.

The major forest types of West Bengal can be classified under ten broad categories depending on temperature, altitude, vegetation, soil types, and other climatic factors (Champion and Seth 2005). These are as follows: Northern Tropical Wet Evergreen Forests (plains of North Bengal upto 150m altitude). Northern Sub-Tropical Semi Evergreen Forests (North Bengal), North India Moist Deciduous Forests (North Bengal – almost entire Dooars and Terai area), Littoral and Swamp Forests – the mangroves (the tidal mangrove forests of Ganga-Brahmaputra delta – the Sunderbans), Littoral and Swamp Forests – Tropical Seasonal (Malda and North and South Dinajpur), Northern Tropical Dry Deciduous Forests (Bankura, Purulia, Midnapore, Birbhum, Burdwan), Northern Sub-Tropical Broad-Leaved Wet Hill Forests (North Bengal hills 300-1650m altitude), Northern Montane Wet temperate Forests (North Bengal hills 1650-3000m altitude), East Himalayan Moist Temperate Forests (North Bengal hills 1500-1800m), and Sub-Alpine Forests (North Bengal hills 3000-3700m). Total recorded forest land in the State is 11,879 sq. km., of which 7,054 sq. km. is Reserve Forest, 3,772 sq. km. is Protected Forest and 1,053 sq. km. is Unclassed State Forest, thus constituting 13.38% of the geographical area of the State. West Bengal has a chain of six National Parks, 14 Wildlife Sanctuaries, two Tiger Reserves, and one Biosphere Reserve.

Rodgers *et al.* (2002) identified ten bio-geographic zones all over India based on distinct geo-physical and hydro-climatic conditions. Each zone has unique floral and faunal elements. These bio-geographic zones are again classified into total 26 provinces. The State of West Bengal can be clearly demarcated into four bio-geographic provinces (under four zones) (Fig. 3.1), namely –

1. **2C – Himalaya – Central Himalaya:** Darjeeling district (northern part)
2. **7B – Gangetic Plain – Lower Gangetic Plain:** Cooch Behar, Jalpaiguri, Darjeeling (southern-most part), North Dinajpur, South Dinajpur, Malda, Murshidabad, Nadia, Burdwan (eastern part), Bankura (eastern part), Birbhum (eastern part), North 24 Parganas (northern part), Howrah, Hooghly, South 24 Parganas (northern part), East Midnapore (northern part), and West Midnapore (north-eastern part) district.
3. **6B – Deccan Peninsula – Chotta Nagpur:** Birbhum (western part), Bankura (western part), Purulia, Burdwan (western part), and West Midnapore (western part) district.

4. **8B - Coasts - East Coast:** North 24 Parganas (southern part), South 24 Parganas (southern part), and East Midnapore (south-eastern and southern parts) district.

Therefore, the flora and fauna of West Bengal possesses the combined features of Central Himalaya, Chotta Nagpur, Lower Gangetic Plains and East Coast.

3.2. General methodology

Systematic field surveys were carried out from 2008 to 2012 in different districts of West Bengal for physical observation and/ or photographic documentation. From the four bio-geographic zones a total of 29 survey sites were selected on random-basis taking into account the logistic support and other infrastructural facilities. The survey sites are listed in Table 3.1 and also represented on the map of West Bengal (Fig. 3.2, 3.3). For diversity related studies random sampling methods were followed and relatively equal manpower was spent per site. Notes on ecological adaptations of each butterfly species were also taken. To study the seasonal patterns of diversity, abundance and habitat associations of butterfly communities more systematically, Gorumara National Park which is relatively smaller in size was selected as model survey site. The butterflies were observed in the National Park from January 2010 to December 2011. Transects were laid in three different habitats namely forest, grassland and bamboo. Monthly visits were undertaken to each transects between 07:00 h to 11:00 h on bright sunny days (Borkar and Komarpant 2004, Ramesh *et al.* 2010, Murugesan and Muthusamy 2011) and butterflies were recorded following 'Pollard Walk' method (Pollard 1977, Pollard and Yates 1993). Standard literature was used for field identification of butterflies. No live or dead specimens were collected from any of the Protected Areas. However, some rare and small butterflies which are difficult to identify were caught using butterfly net and closely observed after placing them in clear glass bottle. Then they were released in the same habitat from where they were caught. Enough precautions were taken, so that, by no means the entire procedure can cause any damage to the target specimens. Photographs of both upper and underside of the respective specimen were also taken for further references. Canon EOS 40D DSLR camera (Canon Inc., Japan) along with Canon EF 100 mm F2.8 USM Macro lens (Canon Inc., Japan) were used for photography purposes. Conservation

status of each butterfly was calculated based on abundance figure or sighting records (Rajasekhar 1995). Butterfly species diversity along the habitats was estimated through Shannon diversity index (Shannon and Wiener 1949). Shannon evenness (Magurran 1988) and Simpson's dominance index (Simpson 1949) were also estimated. The diversity indices of the butterfly abundance of each habitat were analyzed separately using BioDiversity Pro software (McAleece *et al.* 1997). Three-way factorial ANOVA was performed following Zar (1999) using the SPSS version 10 (Kinnear and Gray 2000) to comment on the variation with respect to the habitats and sampling seasons. The life-cycle parameters of two important butterfly species were studied in the laboratory following Atluri *et al.* (2002, 2004a, 2004b, 2010) and Ramana *et al.* (2004). Freshly laid eggs were collected from the field to study the life cycles and the duration of early stages. First they were placed in Petri dishes and then kept in clear containers. Rearing was done at $30\pm 2^{\circ}\text{C}$ of room temperature having $80\pm 10\%$ relative humidity. The larvae were supplied with weighed quantity of fresh leaves on daily basis. Larval instars were determined on the basis of moulting. Length and weight of each larva and the amount of egested fecal matters were recorded daily. Larval performance in terms of food utilization (indices like - Consumption Rate, Growth Rate, Approximate Digestibility, Efficiency of Conversion of Digested food to biomass, and Efficiency of Conversion of Ingested food to biomass) were calculated following Waldbauer (1968) and Scriber and Slansky (1981). Threats related data were generated through interviewing local people, forest guards, wildlife guides and farmers. Personal field observations were then compared with the existing literature and conclusions have been made.

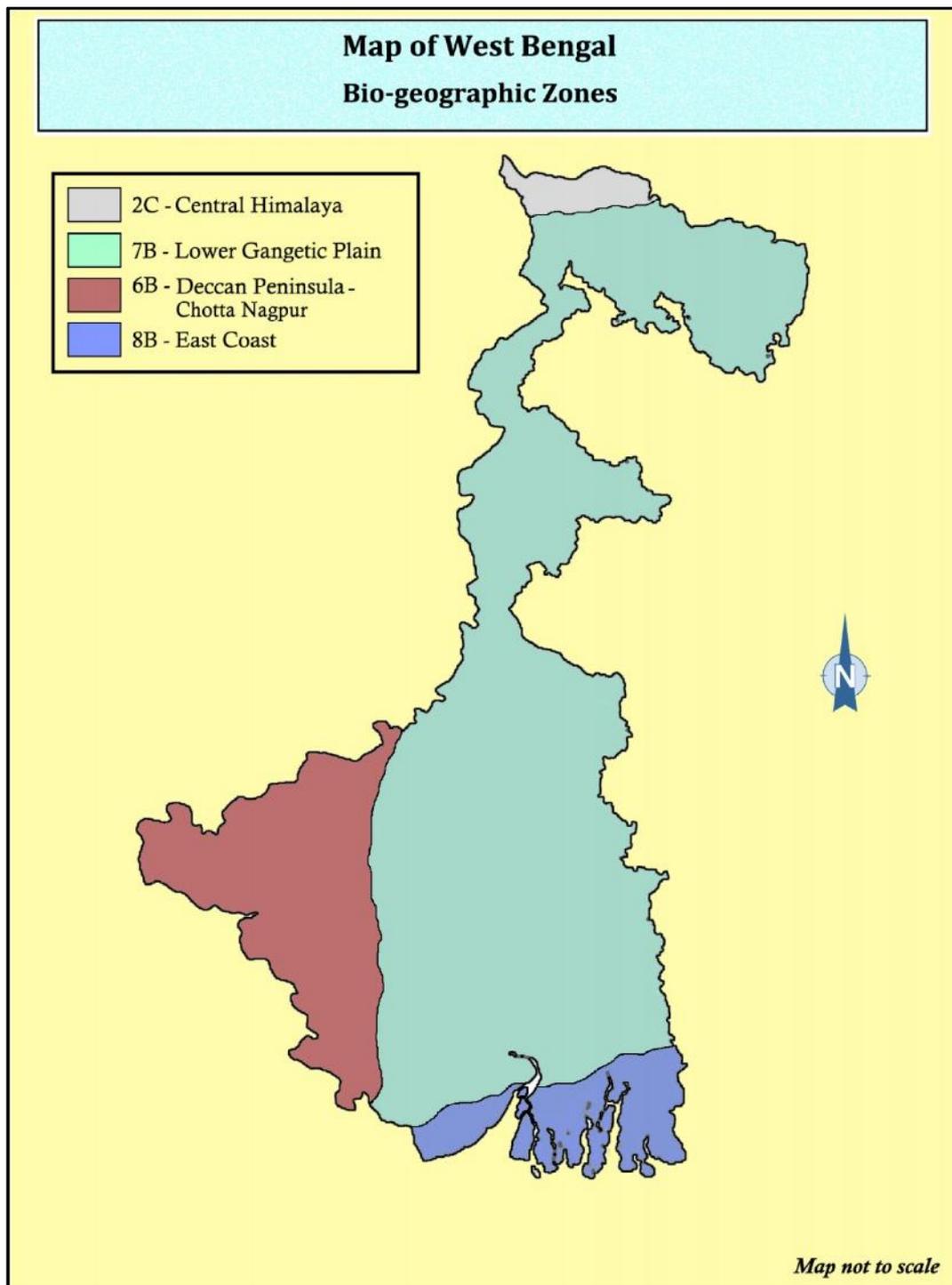


Figure 3.1. Map showing Bio-geographic zones of the State West Bengal

Table 3.1. List of sites where surveys were conducted

Districts	Area Surveyed
Darjeeling	Singalila National Park Samsing Suntaleykhola Pedong
Cooch Behar	Chilapata Reserve Forest
Jalpaiguri	Buxa Tiger Reserve Chalsa Gorumara National Park
Murshidabad	Berhampore
Nadia	Bethuadahari Wildlife Sanctuary
North 24 Parganas	Bibhutibhusan Wildlife Sanctuary
Hooghly	Dankuni
Howrah	A.J.C. Bose Botanical Garden, Shibpur Joypur Domjur
South 24 Parganas	Cintamani Kar Bird Sanctuary Bakkhali Sagar Island Bali Island
Kolkata	East Kolkata Wetland (Nalban) Alipore Zoological Garden, Kolkata Taraknath Palit Siksha Prangan (Ballygunge Sc. College Campus)
Burdwan	Belun (Katwa) Maithan
Birbhum	Ballavpur Wildlife Sanctuary
Bankura	Indrabeel
Purulia	Garpanchokot
West Midnapore	Jhargram
East Midnapore	Digha

3.3. Identification

Identification of butterflies was done mostly in the field using standard literature – Watson (1891), Evans (1932), Talbot (1939, 1947), Wynter-Blyth (1957), Corbet and Pendlebury (1992), D'Abbrera (1982, 1985, 1986), Haribal (1992), Larsen (2004), Smith (1994, 2006), and Kehimkar (2008) and a comprehensive list was prepared.

The taxonomy at sub-family level used largely follows that of the '*GloBIS*' (Global Butterfly Information System), a web-based universally accepted taxonomic framework for butterflies' worldwide (Haeuser *et al.* 2005). Braby (2005), Wahlberg *et al.* (2003), Evans (1949) and Cantlie (1963) were consulted for finer classification of Pieridae, Nymphalidae, Hesperidae and Lycaenidae respectively. Anonymous (2007a) was followed to determine protected status as per the Wild Life (Protection) Act, 1972 of India.

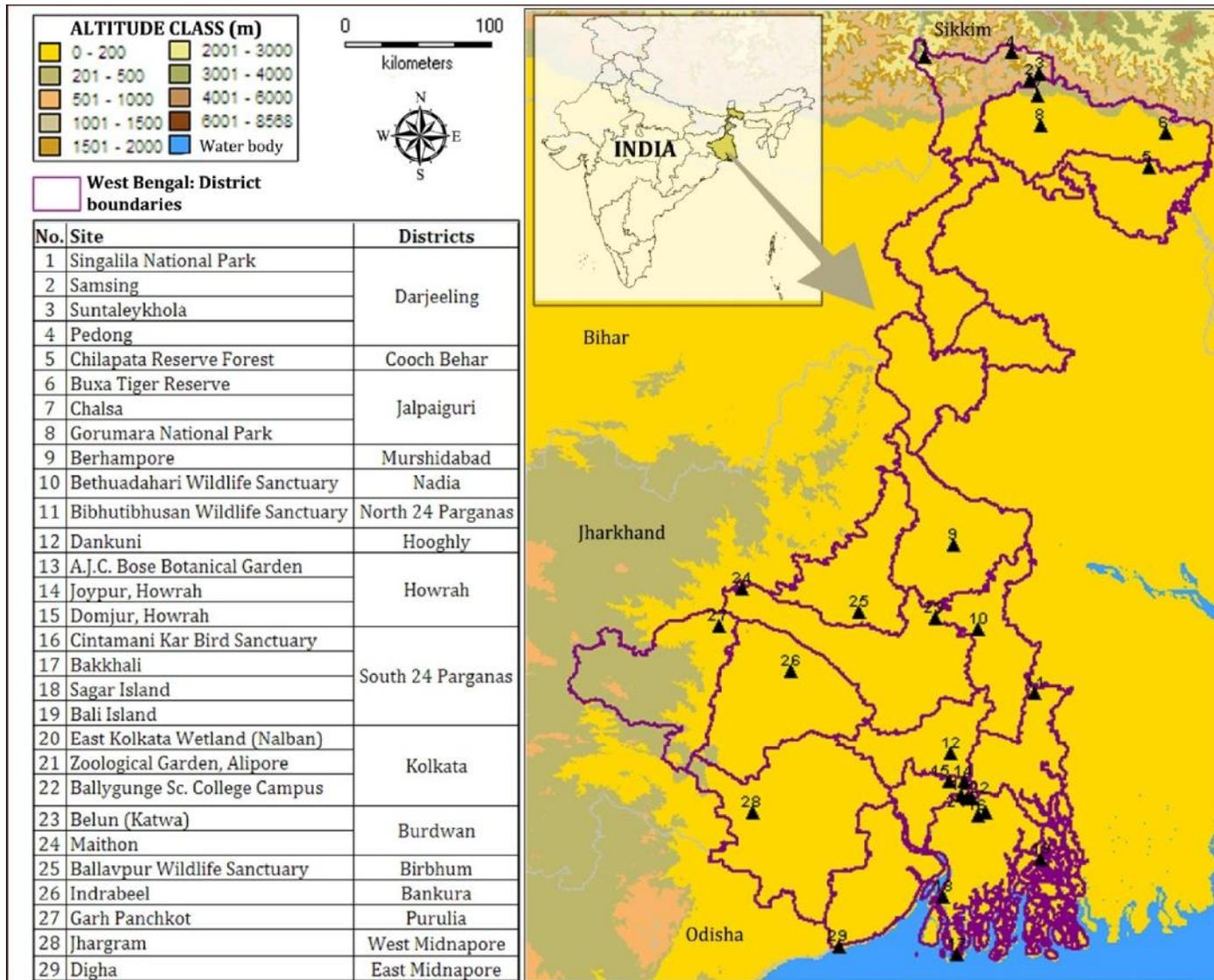


Figure 3.2. Map showing survey sites in respect of altitudinal gradients of West Bengal

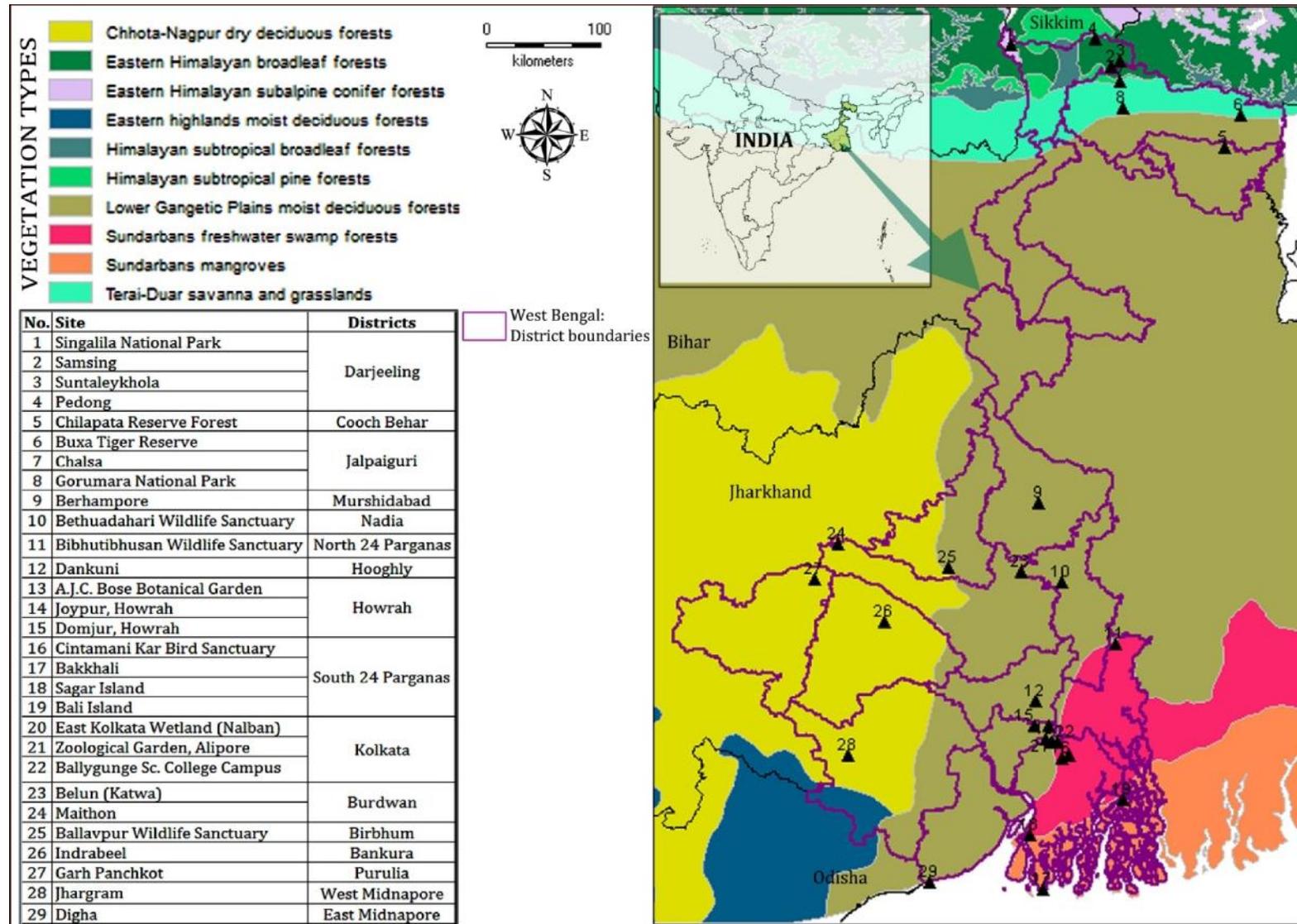


Figure 3.3. Map showing survey sites in respect of vegetation patterns of West Bengal