Chapter 2

MATERIALS AND METHODS

2.1 THE POPULATION

The state of Sikkim is ethnically rich and appealing for anthropological research and other field of studies related to humans. Some knowledge of history is necessary before moving to the discussion of various ethnic populations residing in the state. The erstwhile kingdom of Sikkim joined Indian union through popular memorandum to become its 22nd state on 16 May 1975. Until then it was ruled by a righteous king, supported and nurtured by Tibetan Theocracy. In Sikkimese Bhutia language righteous king is known as Chogyal, which can be translated in *Dharma Raja* in Nepali and Hindi languages. The annexation of Sikkim on 16 May 1975 brought down the 300 year old Namgyal dynasty. The first king of the dynasty was Chogyal Phuntsog Namgyal. He was the descendent of Khe Bumsa, prince's son of Minyak kingdom of eastern Tibet, celebrated as having strength equals to 1 lakh warriors. This fame was conferred to him when he alone erected gigantic pillars in the chapel of a Sakya Monastery when the monks repeated efforts were not successful. He was invited to remain in Sakya where he married the hierarch's daughter. Eventually, he settled in Chumbi Valley and one of his sons Mipon Rab, later moved to Gangtok, Sikkim. Phuntsog was son of Mipon Rab and consecrated as the first Chogyal of Sikkim by three monks namely Gyalwa Lhatsun Chenpo, Gnadag Sempo Chenpo and Kathog Rigzing Chenpo in Yuksom in the year 1641. Simultaneously these monks inducted Ningmapa sect of Buddhism among the Sikkimese people, Lepchas and Limboos, including people who accompanied them during the trek to Sikkim (Gyamtso, 2011). However, religious influence upon Limboos was meagre.

The Bhutia people of Sikkim claim their affiliation to Namgyal dynasty. The author from the same community have emphasised that there could be cultural, traditional and lifestyle similarities with other Himalayan groups like Lopas, Menpas, Denpas, Sherpas who are also referred by generic term Bhutia actually like to be known as Sikkimese Bhutia (Gyamtso, 2011). They speak a dialect of Tibetan Language. So, Bhutias of Sikkim were ruling class of the state. A majority of them are still found in bureaucracy. The last Chogyal of Sikkim was Palden Thondup Namgyal.

The consecration of King Phunstog Namgyal is believed as the result of prophecy and boon of Thekong Tek, the Lepcha Patriarch to Khe Bumsa a generation ago in a place called Kabi Longtsok in North Sikkim. Simultaneously, Thekong Tek and his wife Nekung Nyal inter into a blood brotherhood treaty with Khey Bhumsa in the same place. According to which Lepcha and Bhutia should be considered as brothers and equal under new Buddhist monarchy (White 1909; Gyamtso, 2011). However, there are claims and believes about the existence of Lepcha kingdom and rivalry with before and after the establishment of Buddhist monarch (Chattopadhaya, 1990).

The Lepcha, which is also an East Asian population like Bhutia and Tibetan, is considered to be one of the prominent indigenous populations of the state. Their built is slightly smaller than Bhutia and Tibetan. They called themselves Rongpa or dweller of mountain ravine valley. There are speculations about their origin in the literature, one of which says they migrated through Assam and Burma. However, they do not subscribe to this view (White, 1909). They believe that they are the original inhabitants of the region. This view is also supported by the accounts of pioneers like Hooker (1854), White (1909) and Risley (1891). They have their own language, which has been praised for having names for all animals, insects and plants found in

Sikkim. This also reflects their close association with nature in the past. It is well known the Lepcha language is distinct from Tibetan and other Kiraties language of the vicinity. They were actually nature worshiper and later under the Buddhist ruler many of them converted first into Buddhist and other were converted to Christian by missionaries. Hence, there are animist Lepcha, Buddhist Lepcha and Christian Lepcha. Beside Sikkim, they are found in Kurseong, Darjeeling and Kalimpong districts of West Bengal, Southern Bhutan and Eastern Nepal bordering Sikkim. The means of subsistence in the past among the Lepcha were slash and burn shifting cultivation. Dzongu, in North Sikkim was their first permanent settlement in the record (White, 1909). At present, they practice all kind of possible agriculture and cattle farming in the villages. Young generation are engaged as bureaucrats and professionals in the government of Sikkim.

In 1889, the British appointed Sir J. C. White as the first political officer in Sikkim. White during his administration raised the revenue of Sikkim from ₹ 8000 per annum to ₹ 22,00,000 per annum with the introduction of terrace farming. People from nearby Nepal were encouraged to settle with purpose of terrace farming on the steep slopes where virtually farming was impossible (White, 1909). However, even during the consecration of Phuntsog Namgyal, presence of Manger people has been mentioned (Chattopadhaya, 1990). Further, forts belonging to Manger King were also reported from the place called Mangerjong and other places of Sikkim (Bhattacharyya-Panda, 2015). It is well documented the word Lepcha itself was first used by Nepali people to address their new kinfolks (White, 1909). Hence, presence of Nepali people in the erstwhile kingdom of Sikkim before 19th century cannot be denied. The fact can also be supported by geographical continuity with adjoining Himalayan country. However, most of the accounts on Sikkim and its people consider

Nepali as 19th century migrants, which has harm the image of Nepali speaking people of Sikkim and Darjeeling region.

The Anthropological Survey of India has identified twenty-five ethnic communities in Sikkim. These are classified into four ethnic stocks (Lepcha, Limboo, Bhutia and Nepali). While the first three are homogenous entities, the Nepali is composed of a number of castes and sub-castes. They constitute a major chunk of the population in Sikkim. Among them, Bhaun, Chettri, Kami, Damai, and Sarki are similar in physical features. They are Hindu by religion and society is structure according to Varna system. First two are higher castes and the later three are service castes. However, between the higher caste and service caste, other Himalayan tribes were fitted by the erstwhile king of Nepal during his regime, that structure still prevails in Sikkim and still dominates the day to day life among Sikkimese Nepali. These "caste-tribe" people are Rai, Dewan, Newar, Gurung, Tamang, Mangar, Sunwar, Bhujel, Thami, Thakuri etc with East Asian features. They are referred to as caste-tribe people because they have both caste and tribal characteristics. Interestingly there is no word for "tribe" in Sikkim and the word *jat* is widely used which translates into English word caste. The elements of caste were adopted by them from their higher caste Nepali neighbour and tribal characters were their own. As a result, belief system among them is neither Hindu proper nor animist in total. Most of them are strong shamanistic and follow oral tradition. The Gurungs and the Tamangs among them profess Buddhism. Many of the above mentioned Nepali caste and communities of Sikkim were converted to Christianity during the time of British. Still Hinduism is a major religion of the state of Sikkim numerically (Sikkim Human Development Report, 2014). In general people are very tolerant of each other beliefs and culture. Their day to day life is so closely interwoven to each other.

2.1.1 THE LIMBOO

Popularly known as Limbu or Subba, the Limboo is one of the original ethnic people of Sikkim and are referred as “Tsong” by the Bhutias. The Limboo population, according to Risley (1891), originated from the Tsang Province of Tibet from where they migrated to Sikkim via East Nepal. However, Subba (1999) was of the opinion that Limboos were the original inhabitants of a region called “Limbuwan”, which was composed of parts of West, South and a part of North Sikkim along with some districts of East Nepal. The Limboos exhibit East Asian features and are similar to that of the Lepchas and Rais. They have their own script called Sirijonga script and language called Limboo language. The Limboo language is a member of the eastern sub-group of Himalayan languages with complex pronominalizing features. It is one of the members of Tibeto Burman sub family (Kainla, 1992).

They are found in Sikkim, Nepal and West Bengal. In Sikkim, their major concentration is in West Sikkim. The total population of Limboo in Sikkim according to the census of India (2011) was 53,703, with more people residing in the rural area.

They were pastoralist in the past and practiced slash and burn cultivation, like other tribals of northeast India. Their past was constructed by Subba (2010), on the basis of occasional mentions of high altitude flora and fauna, including yak (*Bos frontalis*) in their oral tradition and allegory. Their preference to be called as Yakthungba, meaning ‘yak herders’ and possession of yak tail as auspicious household item were also considered. Further inferences were made based on the deities they worshiped, the rituals they performed, the places of worship, the materials used for all of these, and *kipat* system of communal land ownership. The practice of settled cultivation by them is about two centuries old (Subba 2010). The majority of

them own land and practice terrace farming and cattle rearing as a humble means of livelihood. Among the people residing in higher elevation, cardamom farming is more popular compared to traditional paddy farming. Many of them are engaged in government jobs, army and recently village based tourism industry.

The earliest mention of Limboo in Sikkim can be trace back to the "Lho-Men-Tsong-Sum" a tripartite treaty signed between the ministers of the king on one side and the leaders of Lepcha and Limboo on the other side (Subba, 1999), following the consecration of Phunstsog Namgyal in the year 1642. The main reason behind this agreement was to strengthen Namgyal rule and ensure co-operation among Lhopas (Bhutias), Menpas (Lepchas) and Tsongpas (Limboos) who inhabited Sikkim at that time (Kazi, 1983; Basnet, 1974). This suggests the presence of Limboos long before the establishment of Namgyal dynasty in Sikkim.

With the passage of time, behaviours of the king towards the Lepcha and Limboo subjects changed and deteriorated. Such attitude towards Limboo may be due to cultural differences and revenue related issues, as a result they were also clubbed with Nepalis (Subba, 1999). Even after coming of democracy, they suffered a lot, with non-representation in the assembly. Of late, the Limboos have been accorded the status of Scheduled Tribe in the state. According to Article 366 of the Constitution of India, 'Scheduled Tribes' are those communities who are scheduled in accordance with Article 242 of this constitution. This article states that only those communities who have been declared as such by the President of India through an initial public notification or through a subsequent amending Act of Parliament will be considered as 'Scheduled Tribes'. The essential features for a community to be identified as a 'Scheduled Tribe' first laid down by the Lokur Committee, are indications of

primitive traits, distinctive culture, shyness of contact, geographical isolation, and backwardness.

Limboo people possess some Hindu and Buddhist characters in their culture, which could be the result of them being ruled by Gorkha Hindus in Nepal and Tibetan Buddhists in Sikkim. The Limboo profess Yumaism as their religion, where Yuma means grandmother and Tagera Ningwaphuma is their supreme goddess or grandmother, also known as Yuma Mang. The different forms of deity Tagera Ningwaphuma are Yuma Sam and Thoba Pa-Sam or Hangsam are transcendental forms in the earth (Subba, 2012). Risley (1981) has stated that Limboo religion is similar to Pon or Bon religion of pre-Buddhist Tibet. Later on, Subba (2010) has shown the conceptual evidence to show the similarity between pre-Buddhist religion of Pon and Limboo religious practices and concluded Limboo religion as animism. However, a different author, Subba (2012), is reluctant to accept Limboo religion as animistic religion and consider Yumaism as a monotheist religion. The previous author is anthropologist by training while the later is not. In the present day Sikkim any Limboo children can say their religion is Yumaism, which was not the case 20 years ago. No place of worship like temple or monastery were known among Limboos, although of late they have constructed one at Martam and other is coming up at Darap, West Sikkim. Their place of worship is called Mangkhim. In the village of Lingchom an open space with rising steps on two sides for people to sit during rituals ceremonies is another Mangkhim or sacred place considered by villagers. The Mangkhim look like small amphitheatre. It shows the Limboo are moving towards larger religious philosophy away from mere animism, irrespective of conflicting motives behind.

The different deities of Limboo mentions here are propitiate with blood sacrifice and offerings of alcohols and meats. Legends and philosophies surrounding these deities are found in *Mundum*. Socio-cultural activities of Limboo people are defined and guided by *Mundum.* It is oral tradition handed down the generations which is a collection of rich myths and beliefs. Recitation of *mundum* takes place in every ritual as it is powerful and mystical, through which shamans can contact with the supernatural being. The *Mundum* can even trace the origin of a single family back to the ancestral place. In the different stages of life, ritual and recitation of *mundum* is indispensible. Nowadays Limboos have started writing *Mundum* in the forms of books for preservation. Such as *phedangmas, Sambas* and *Yeba* are their religious specialists who preside over particular types of rituals and ceremonies. However, such specialities are on the verge of extinction, as result, any senior individuals with such knowledge are expected to preside over such events. This is possible because there is a tradition of debate between shamans and onlooker who are usually village elders (Subba, 1999).

Beside above mentioned deities of Yuma religion, they also hold high regards for Teyongsi Srijanga, pioneer Limboo poet and saint who advocated, preserved and revived Limboo language. Every household hangs the hand painted picture of Srijanga. Reverend Teyongsi Srijanga and his eight disciples killed by Buddhist monks in the bank of the river, *kolej khola* angst against his revival of culture, language and script among the Limboos. The birth anniversary of Teyongsi Srijanga is celebrated every year with cultural performances, poetry reading, story reading etc.

The Hindu festivals like Dashain and Tihar, which coincides with Durga Puja and Diwali elsewhere, use to celebrate by all ethnic communities of Sikkim excluding Bhutia and Lepcha. These festivals for caste people have religious significance and

for Limboos it is primarily a get-together and a social occasion. They have abandoned these festivals in North Bengal, Sikkim and Nepal since 1991. Subba (1999) finds no plausible reason for abandoning these festivals claiming as Hindu festivals. Some of the Limboo festivals listed by Dr B.L. Khamdhak in his blog (www.buddhilkhamdhak.blogspot.com/p/struggle-of-sikkimese-limboos-for.html) are *Kokfekwa Tongnam, Sisekpa Tongnam, Bolihang Tongnam, Tongsum Tongnam and Ingmang or Yokwa* few of which coincides with the Hindu festivals of Nepali caste (Assessed on 11-09-2017).

They are divided into Kasi gotra and Lhasa gotra, which are further divided into several clan/sept. The Limboos of Sikkim practice clan/sept exogamous marriage and marriages outside the tribe are not rare phenomena in Sikkim. Since the historical time, the Limboos have marital relationship with the Lepchas, the Rais and the Bhutias. However, marriage with other Himalayan caste and tribes can also be observed. Some commonly found clans of Limboos in Sikkim are Khamdhak, Kewa, Nebang, Lingden, Muringla, etc. Some clans like Youngmu, Sitling, Lucksom and Mangmu among Lepchas and Limboos are common. These clans are considered Lepcha if they are in Lepcha country and Limboo if they are in Limboo area (Subba, 2010). Shared cultural traits among the Kiratis and other Hindu Nepalis suggested the long co-existence of people together. Gotra system of lineage indicates influence of Hinduism and nothing to do with marriage as among Hindus (Subba, 1999). A majority have disregarded gotra as it is a Hindu concept. They live with parents of bridegroom event after marriage which is a patrilocal system of residence. The Limboo marriage is usually arranged marriages that take place in the house of the bridegroom. Nowadays elopement is more popular than the arranged marriage. The Limboo believe in physical chastity and do not cohabit before marriage. The study has

shown the absolute supremacy over the marriage and choice of spouse enjoy by Limboo women. They can even divorce their husbands and get married with other men. In such cases, the other man along with his wife has to come to the wife's previous husband for ceremonial exchange called *Jari* (Subba, 1999). Marriages among close relatives are strictly avoided.

Limboo descent is traced patrilineally and the rule of inheritance is male ultimogeniture with regard to immovable property and female equigeniture about movable properties. Immovable property means land and house, while moveable properties are cattle, gold/silver ornaments, brass or copper utensils, clothes, and so on (Subba, 1999).

The Limboo have a custom of adopting members of other clan or tribe which is followed by feast and rituals. However, they hardly allow caste Nepali to take such membership. They also have a system of bond-friendship with member of other ethnic community, which is established through rites performed by a Brahmin priest and called Mith-sino. Such bond-friendship also found among the other community of Sikkim. There is restriction on the marriage between the families of fictive kins for four generation. Yet, such kins have no property right (Subba, 1999).

The Dhan Nach or Yalang (paddy dance) performed by a group of male and female Limboo during the time of paddy harvesting. During the time when the use of oxen to thrash the rice grain was not known, they used to thrash rice grains by trampling over the dried paddy plants. It was a hard job and they had to spend day and night. So, throughout the process they used to sing while trampling over the paddy plants. This way of thrashing paddy turned into a dance while singing. Nowadays it

can be performed in any kind of ceremonies and festivals. In Sikkim, it is performed on the cultural festivals like *Bhanu jayanti*, *Panglabsol* and *Maghe Mela* etc.

Another popular dance of Limboos of Sikkim is Kelang or Chyabrung dance. This is a typical Limboo Drum made out of huge hollow trunk of a tree with processed leather on both sides. This dance is performed after the completion of new house to free it from various kind of insect that dwell on wooden pillars of the house, to wade off evil spirits, to save house from natural calamities such as wind, storm, earthquake and fire. This dance is also performed in the marriage ceremonies, for well coming revered guests and for other special occasions.

They are non-vegetarian in their food habits and alcoholic beverages constitute an integral part of their cuisine until recently. Rice is the staple crops and is the main source of energy. Other food products like fermented foods, maize, millets and roots also are rich in energy. They consume animal food excluding their totem animal, which is specific for different clans/septs. Consumption of alcoholic beverages was part and parcel of Limboo life, which is discredited by the younger generation and look down upon. Globalized food and beverages have also made ways into the life of this Himalayan folks. Snacks for guest, agriculture labour and family mostly consist of fizzy drinks (coca cola, pepsi), instant noodles and potato chips beside sugar tea. Otherwise it used to be, ripe squash and its roots, pumpkin, potato and other roots boiled etc.

The Limboo community of Sikkim can be considered as most successful in preserving their culture and ethnic identity compared to Lepcha and Bhutia. There are groups within Limboo community who are working towards social reforms and successful in bringing major changes. Major cultural changes are abandoning of

excess alcohols used and animal sacrifices in ritual and ceremonies followed by simplification of expensive and elaborative rituals. They are also checking consumption of alcohols and alcoholic beverage among the tribe members. Further impetus is provided by raising living cult of Yuma, which also teaches non-violence and love. Their members have to follow different sets of rituals and rites for all the events from birth to death, which emphasizes the use of milk and vegetables in place of alcohol and meat.

The facts and analysis discussed, made it is clear that they were successful in preserving their cultural practices such as religion, language and cultural traits even in presence of hegemonic monarch. Invent of modern education in Sikkim has the major impact in their society and overall development. Until recently may be due of modern education and modernisation youth among them were really confused about their religion and ethnic affiliation and culture. They were lately recognised as a tribal group by the constitution of India compared to Lepcha and Bhutia, can be regarded as positive result of them being educated. Diminishing agriculture land and agricultural practices are some problems faced by community are directly related to changing traditional food habits. The market economy has, even more, influence upon their food habits. All this may have bearing on their health and nutritional status.

2.2 THE AREA

As already noted, that Sikkim was ruled by righteous king till the date of its annexation with the Indian union. The state of Sikkim has an area of 7096 km^2 and located between 27°04'46" to 28°07'48" North latitudes and 88°00'58" to 88°55'25" East longitudes. It is surrounded by Tibet, a country under Chinese occupation, on the north and east, Bhutan on south-east, Nepal on west and districts of West Bengal

(Darjeeling and Kalimpong) on the south. This is depicted by the map given in Figure 2.1. The total population of the state is 6, 10,577 according to census of India (2011). The state is the 2nd smallest state of India only after Goa in size and population. The landlocked mountain state is connected to rest of India via a national highway NH 10 (earlier NH31 A), which passes from Darjeeling hills, ultimately leading to Siliguri, a bustling town and major business hub of the region on the foothill of Darjeeling District (see Figure 2.2). The national highway NH 10 becomes a lifeline and Siliguri town a major supply centre for all kind of commodities for life in Sikkim. As it is clear that only means of transport are roads in the state. Although there is helicopter service from Bagdogra to Gangtok the capital city.

Since the state of Sikkim is dependent on the Siliguri town for all necessary supplies supporting lives, to reach Siliguri one has to drive 3 to 6 hours on hilly roads on the bank of river Teesta. This connecting road falls under the newly formed Kalimpong district which was originally a part of Darjeeling district and share similar topography and climate. This passage to Siliguri also remains disrupted due to frequent landslides and agitation strike in the neighbouring Darjeeling in the past. There was concern for the direct and alternative mode of communication between Sikkim and other states of India. Initiative by the state government in this regard has been the construction of a fully operational airport in Pakyong, East Sikkim. As of now the other nearest airport is located in Bagdogra and the only railway connection to Sikkim is New Jalpaiguri station both in the periphery of Siliguri town.

This mountainous state is home to the world third highest peak Mt. Kanchandzonga (8,586m) situated partly in Sikkim and in Nepal on the western border. Sikkim is separated by the Singalila range from Nepal in the west and Chola range from Tibet in the north-east and Bhutan in the south-east. Teesta and

Rangit rivers form the borders with the Indian state of West Bengal in the south. The state has 10 mountain peaks that rise above 7,000 metres, 84 glaciers and 315 glacial lakes (including the Tsomgo, Gurudongmar and Khecheopalri). Its unique geographical position, high annual rainfall, varied topography, rich flora and fauna make it a biodiversity hotspot (Sikkim Human Development Report, 2014). The vegetation of Sikkim is broadly classified into tropical, sub-tropical, temperate and alpine types (Singh and Chauhan, 1998).

Teesta and Rangit are two major rivers of the state with its innumerable tributaries which flows southward makes drainage system of the state. In addition, there is great variation in elevation, ranging from 270 mm to 8580 mm from sea level. Seasons in Sikkim are winter, spring, autumn, summer and monsoon. The heavy rainfall is a phenomenon in Sikkim with the mean annual rainfall of 82 mm to 3494 mm. The combination of drainage systems, varied elevation of land mass and heavy rainfall makes the state prone to soil erosion and landslides. As a consequence some remote villages remain isolated during the monsoon. Soil type and composition of rock are also responsible for frequent landslides. The capital town of Gangtok and other places with similar altitude usually have the mean temperature ranging from 1°C to 25°C. In the lower altitude it ranges between 4°C and 35°C, in contrast the range for mean temperature never rises above 15° C and go down to freezing point in winter (Gazetteer of Sikkim, 2013).

Above 4500 species of angiosperms, 424 medicinal plants, 16 species of conifers, 480 species of ferns and allies, 527 species of orchids, 11 species of oaks, 144 species of mammals, 58 species of primulas, 23 species of bamboos, 574 species of birds, over 689 species of butterflies and moths are reported from the state (Rahman and Karuppaiyan, 2011). The forests are abundance in *Alnus nepalensis*

(Uttis), *Castanopsis* (Kattus), *Macaranga* (Malata), *Engelhardtia spicata* (Mahua), *Toona ciliate* (Tooni), *Machilus* (Kawla), *Cinnamomum* (Sinkoli), *Symplocos* (Kharane) etc. along with some shrubs *Rhododendrons*, *Juniper*, *Rosa* (Rose), *Barberries* (Paewu), *Rubus* (Aiselu), *Daphne* (Algeri), *Leucosceptrum* (Ghurpis). Some carnivores and herbivores of the state are Red fox, Tibetan fox, Tibetan wolf, Himalayan brown bear, Snow leopard, Pallas's cat, Tibetan gazelle, Tibetan Argali and Blue sheep etc (Lachungpa, 2009; Gazetteer of Sikkim, 2013).

The state of Sikkim is divided into four districts such as North, South, West and East. The districts are further divided into subdivisions and blocks. These are shown in Figure 2.3 and Figure 2.4. The villages under the present study fall under the Geyzing or Gyalshing Block, which is also a district, headquarter (Figure 2.4). The Gyalshing is situated at 27^{o} 17' 41.88" North latitude and 88^{o} 15' 12.31" East longitude. The names of the study villages are Langang, Tikjek, Lingchom, Darap, Singpheng and Nambu. These villages are situated at the altitude of 4831feet (Gyalshing) and above from the sea level. All the villages are connected to Gyalshing through metalled road. Houses or settlements of people are upto far above and down below the roads connecting one village to another. Hence, means of communication upto road is following narrow footpaths or village roads passing through farming fields and jungle on foot.

Figure 2.1: Location map of Sikkim showing rivers, districts, and sub-divisions surrounded by neighbouring countries and a state of India (Source: ENVIS Sikkim centre http://sikenvis.nic.in/Database/NaturalResources_790.aspx. Accessed on 27-10-2017).

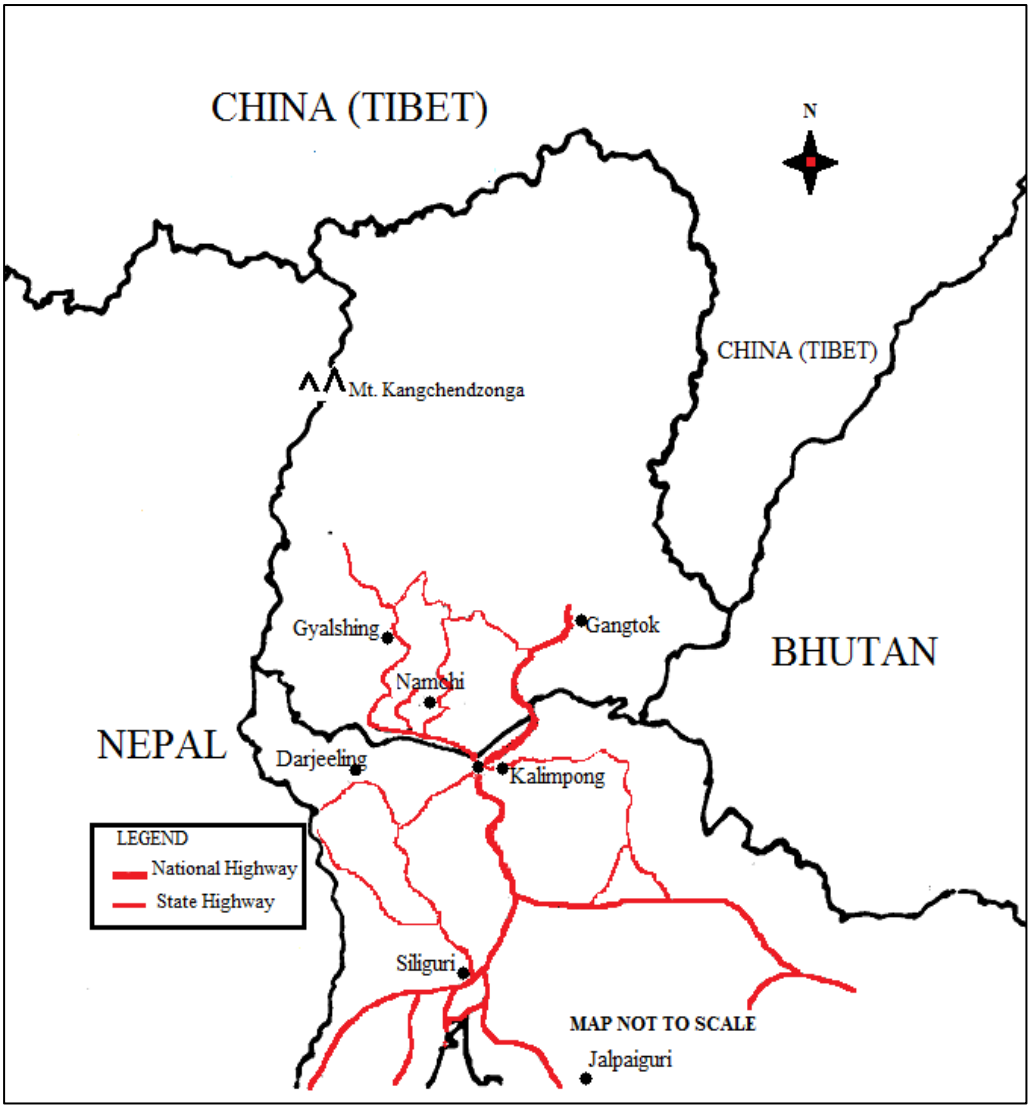

Figure 2.2: Map showing the National Highway 10 only connection to rest of the country and Siliguri, Subdivision of Darjeeling District.

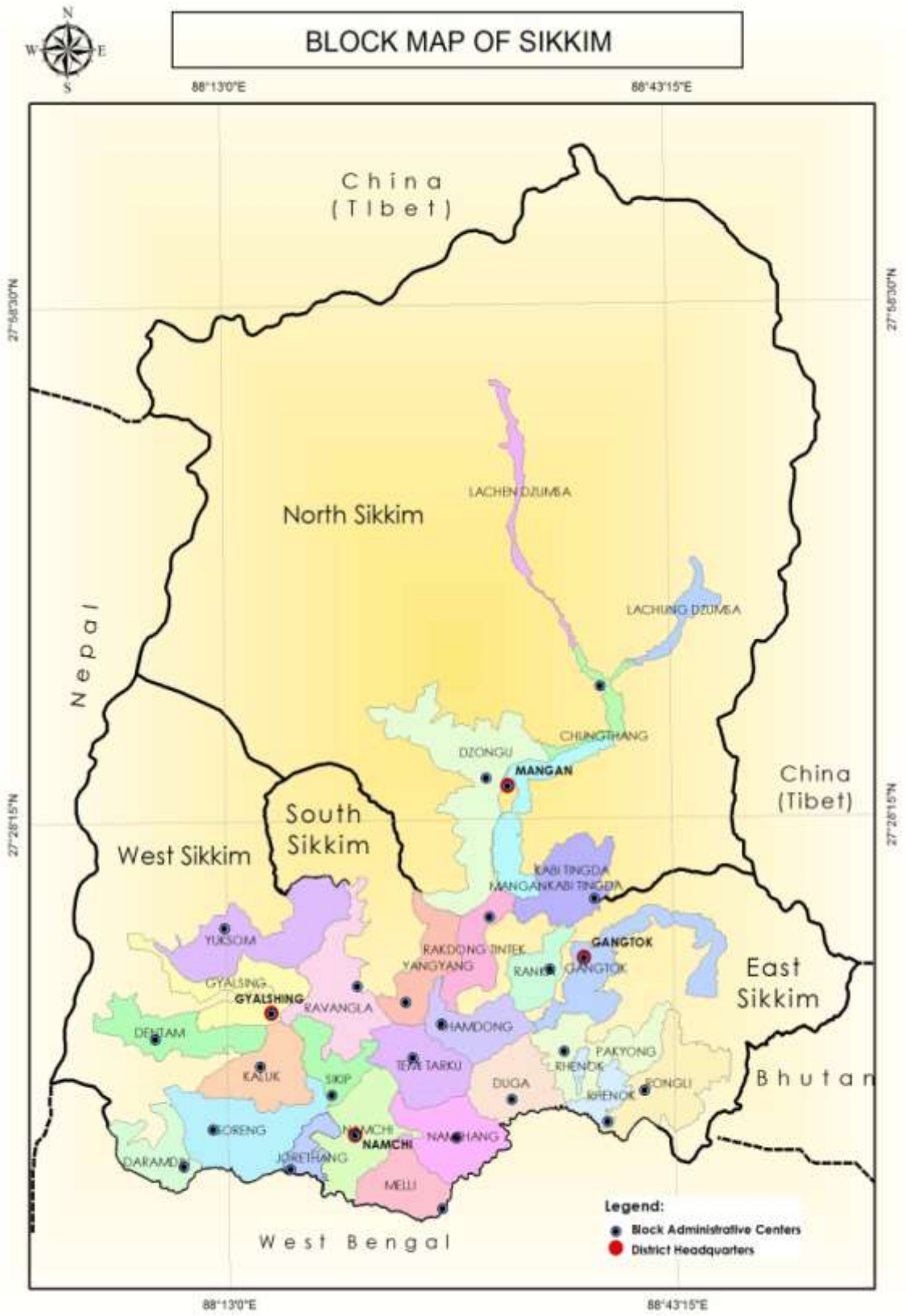

Figure 2.3: Block map of Sikkim with respective Block Administrative Centres (BACs) and District Headquarters (Source: Government of Sikkim Portal https://www.sikkim.gov.in/portal Accessed on 27-10-2017).

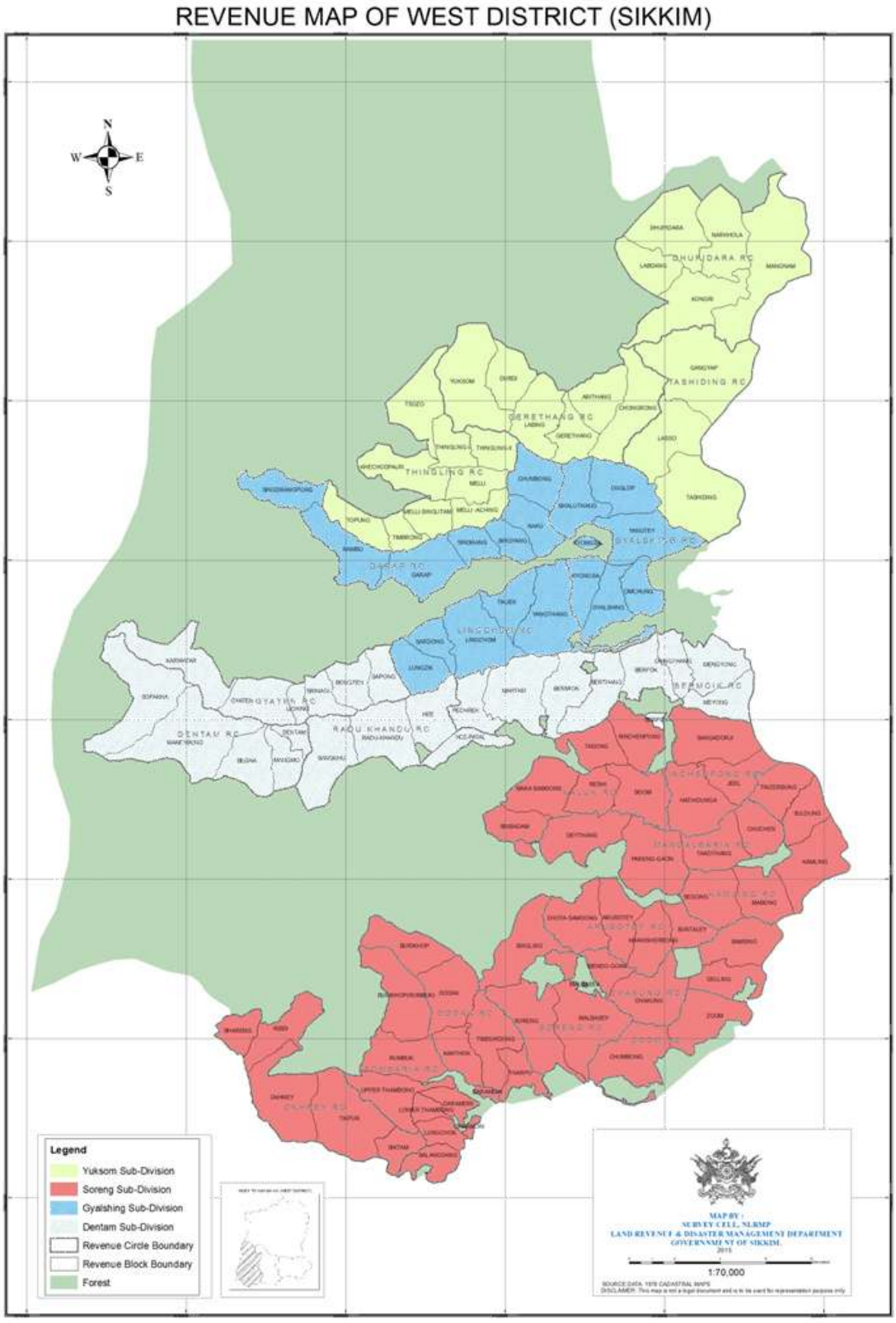

Figure 2.4: Map showing revenue blocks of West District of Sikkim including studied villages of the present study falling under Gyalshing Sub-division (Source: Government of Sikkim Portal https://www.sikkim.gov.in/portal Accessed on 27-10-2017).

2.3 NATURE OF SAMPLING AND SAMPLE SIZE

The individuals are selected using a multistage sampling method. West district of Sikkim has the high concentration of Limboo population, which is also explicit on the account of its proximity with east Nepal or erstwhile Limbuwan (Limboo kingdom). In the process, senior resourceful people were consulted for advice on the Limboo dominated villages. Through this process, 15 villages were listed and further it is reduced to 6 village base on the distance from the main urban centre Gyalshing. The six villages are Langang, Tikjek, Linghom, Darap, Singpheng, and Nambu. The villages were selected based on the predominance of Limboo individuals. The populations of the villages were confirmed by utilizing voter-list available online and some collected by meeting with panchayats. The data was collected during the period from January 2014 to April 2016 from above mentioned six villages. The villages named Langang, Tikjek and Linghom are within 9 km from Gyalshing, a district town and other villages like Darap, Singpheng and Nambu are 20 km away from the town towards north uphill. In Figure 2.4, the studied villages are shown in blue colour.

From the Limboo dominated villages, only Limboo individual willing to take part in the study were approached. Adults belonging to the Limboo community were identified by utilizing their surnames, physical features and language. The anthropometric, demographic, socio-economic and lifestyle related information were collected and recorded by visiting them at their homes and sometime all the individuals of a neighbourhood were call up on a neighbour's house. Opinion of the senior and respected persons of village was also taken into consideration. The non-Limboo individuals were simply excluded from the study.

After verification of the initial information related to ethnicity and age, 1080 Limboo individuals (males: 530; females: 550) were approached for taking part in the study. None of the women were pregnant or lactating. The objectives of the present study were then explained them prior to data collection. Of these 1080 individuals, 76 of them (7.04%) refused to take any further part in the study. Later on, 7 individuals were found to be a fitness freak and 5 individuals were not available to provide their SES information of including the date of birth. Hence, the final sample comprised of 992 adult Limboo individuals (males: 496; females: 496) aged 18 years to 64 years. Age of the individuals was collected from available official records like birth certificates, and in some cases, voter cards and Aadhaar cards were utilised. A bearer of voter cards in India is an eligible individual citizen who can cast his/her vote in elections thereby ensures participation in making of government. Similarly, Aadhaar is a recently initiated scheme which uses fingerprints and retina as unique identification marks and used for identification purpose. Informed consent was taken from each Limboo individual prior to collection of the data.

2.4 PROCEDURES OF DATA COLLECTION

In order to achieve the objective of the present study, standard procedures of data collection were taken into consideration to obtain data from the field situation. The data collection procedures are briefly described below. The study has been conducted in accordance with ethical guidelines about human experiments as laid down in Helsinki Declaration (Touitou et al., 2004).

2.4.1 DEMOGRAPHIC, SOCIO-ECONOMIC AND LIFE STYLE FACTORS

The demographic, socio-economic and lifestyle variables taken in this study has important bearings on the different stages of human life. It also influences the

nutritional status and the diseases out comes directly and indirectly. To obtain the demographic, socio-economic and lifestyle related data of the Limboo individuals, a questionnaire was structured and tested. The data on demographic, socio-economic and life-style related factors were collected using this structured and tested schedule (Annexure I) for the present field simultaneously with the anthropometric measurements.

2.4.1.1 Demographic variables

The explanatory variables that summarize the demographic behaviour of a population are considered as demographic variables. The demographics variables examined in the present study were age, sex, marital status, family size. Usually, individual can be identified as male and female and a third gender or transgender based on their biological endowment. In the present study biological sex was considered for the study and accordingly it was recorded.

Researches in the different fields have already identified differences in the physical, mental and social maturity among the human beings. However, the general tendency is physical, mental and social maturity is considered parallel with chronological maturity or age of an individual and difference as a deviation. Different age groups have different nutritional requirements. On the other hand different age groups have dependency and responsibility to one another. Unavailability or excess of nutrients according to age to an individual can impact the diseases out come. As already mention age was collected by asking the date of birth, if known, otherwise by asking about ‘the age completed on the last birthday’. In some cases official documents like birth certificates, voter cards and Aadhaar card were also utilised.

Individuals were categorised into three age categories for further analysis viz. 18-29 years; 30-49 years and 50-64 years.

The information on marital status was obtained by asking the person whether he or she is married. Marriage is the most important aspect of human life and has a positive bearing on individuals as it fulfils the biological and social needs. Though, it brings responsibilities and predisposed individuals to various kinds of stress and depression which is widely regarded as the by-products of modern lifestyle and culture. Usually, information comes out on simple conversations, yet, whether the person is married or not was confirm by asking the individual.

The numbers of family members or individuals sharing a common kitchen as a family constitute family size in the present study. They are mutually dependent upon one another by some social obligations. They share common resource or means of procuring such resources as result family also forms a basic economic unit of a society. It has a huge influence on social accessibility and economic attainment which in turn has bearings on nutritional status as well. It has edge over family type, which is hindered by impractical definition like nuclear family, joint and extended family at least in the present study. For the ease of analysis, the family type in the present study is defined as small and large with 0 – 4 members and above 5 members respectively. This information was obtained directly by asking the respondent.

2.4.1.2 Socio-economic variables

The variables which reflect the social and economic status of any population or group are known as socio-economic variables. These variables are also important for understanding the impact of nutritional status on health. The socio-economic

variables utilized in the present study were education, occupation, family monthly income, and land holding pattern.

The socio-economic characteristic like educational status, in general, is used as the degree of familiarity with culture and receptivity to new ideas and information on the part of individuals. At the same time, in this modern world, its importance is itself evident. In this sense, educational status has direct bearings on nutritional status and overall health of an individual. Those individuals who can read and write at least one vernacular language of the reason were considered literate. People with formal education were inquired about years of life spend on school and higher education institute.

Occupation gives measures of economic development attained by individuals and families as in the case of comparing societies. It also indicates the social position of individuals and families. The occupation category for the present study is based on the nature of the jobs, which is broadly classified into the manual occupation, non-manual occupation and the remaining as others. The manual occupation mostly consists of non-salaried jobs involving manual labour. In contrast the non-manual occupation category is consists of salaried jobs which involve less physical endurance. Category termed as ‘others’ consists of students and few unemployed individuals.

In the cash based market economy education and occupational status may not adequately highlight the economic attainment of a family and individuals. Families may have secondary sources of income which add to their purchasing power. The family monthly income helps us to understand their living standard. This parameter was calculated by adding the yearly incomes from all the sources as most of the

responded were farmers and they sold their agricultural products once in a year. This yearly sum was divided by 12 to get family monthly income. For people with government service, their monthly salary was considered as family monthly income. Both the methods were combined to derive family monthly income of families with one or two family member with salaried jobs.

Table 2.1: Kuppuswami socio-economic scale proposed by Mishra and Singh (2003) updated for year 2015

Sl. No.	Education	Score
1	Professional or Honours	7
2	Graduate or post graduate	6
3	Intermediate or post high school diploma	5
4	High school certificate	4
5	Middle school certificate	3
6	Primary school certificate	2
7	Illiterate	1
	Occupation	
1	Professional	10
2	Semi-professional	6
3	Clerical, shop owner and farmer	5
4	Skilled worker	4
5	Semi-skilled worker	3
6	Unskilled worker	2
7	Unemployment	1
	(C) Income per month in Rupee	
1	≥ 40,315	12
2	20,158 – 40, 314	10
3	15,118 – 20,157	6
4	10,079 – 15,117	4
5	6,047 – 10,078	3
6	2,036 – 6,046	2
7	≤ 2,035	1
	Socio-economic status	Total score
1	Upper (I)	26-29
2	Upper-middle (II)	16-25
3	Lower-middle (III) (Middle)	11-15
4	Upper lower (Lower)	10-5
5	Lower	< 5

The information on land holding pattern was taken as the additional parameter for understanding their living standard and economic status. Ownership of land which is a natural resource can give individuals and families extra viability. This was recorded by asking each individual about the amount of their land. This was further confirmed by land deeds certificates issued by the government of Sikkim.

In addition, the Socio-economic Status (SES) of the population under study was also assessed utilizing the modified scale of Kuppuswami proposed by Mishra and Singh (2003). The scale was updated for the year 2015 using real time calculator available online from www.scaleupdate.weebly.com (Accessed on 2016-05-10) which is developed by Dr R. Sharma (Sharma, 2012). The calculator has been utilised by different studies (Reddy et al., 2014; Thakur et al., 2014; Bhansali, 2015). The updated Kuppuswamy socio-economic scale is presented in Table 2.1. This scale utilises the level of education, occupation and monthly income of the individual to identify his or her socio-economic status.

2.4.1.3 Life style variables

The lifestyle variables have added influences on nutritional status of an individual or population. The variables recorded in the present study were sources of drinking water, toilet facility and house type.

Until recently most of the houses in Sikkim were Assam-type cottages. Nowadays concrete buildings are the norms. In the present study, mud plastered houses and wooden houses were considered as “kacha” house, Assam-type houses with cement plastered wall were taken as “semi-pakka” house and concrete building were taken as “pakka” house. All the kacha and semi-pakka houses in the study area were found with metal sheet roofs.

Availability of drinking water was also assessed of household visits and recorded accordingly. In Sikkim there are two sources of drinking water, one is government supply and other is managed by individual households or group of households from source directly using rubber pipes in their own expenses. The common sources are springs and small streams. Hence, the terms “supply” and “piped” has been used respectively in the present study.

Households in Sikkim are equipped with commode toilets or at least proper pit toilets. Information recorded for this study is the presence of commode and pit toilets. Pit toilets are relatively unhygienic. Except for concrete building most of the houses have toilets outside the home within premises and clearly visible.

2.5 ANTHROPOMETRIC MEASUREMENTS

Aims, objectives and procedures of the present study were explained to individual participants before obtaining the anthropometric measurements. Subsequently a verbal consent was taken and then only measurements were recorded. Participants were healthy and not suffering from any diseases at the time of measurements. People with any kind of physical deformity and abnormality were not included in the study.

2.5.1 PROCEDURES OF TAKING MEASUREMENTS

Anthropometric measurements of stature, weight, arm span, arm length and mid-upper arm circumference (MUAC) were recorded following the standard procedures as outlined by Weiner and Lourie (1981). Similarly, waist circumference (WC) and hip circumference (HC) were recorded following the guidelines of WHO stepwise approach to surveillance (WHO, 2008) and recommended by WHO (2008). The measurement of neck circumference (NC) was recorded following Ben-Noun et

al. (2001). Standing height, arm span, arm length and sitting height were measured using a standard anthropometer to the nearest 0.10 cm. Specially for measuring arm length and sitting height, 1st and 2nd segments of anthropometer (rod compass) were used. All the measurements were recorded in minimum clothes and bare feet on the left side of the subject. All the circumferences were measured using flexible nylon tape.

The skinfolds (BSF, TSF, SSF and SISF) were measured following Weiner and Lourie (1981) using a Holtain skinfold calliper on the left side of each individual to nearest to 0.2 mm. The skinfold calliper is designed to exert a pressure of 10 mm^2 during measurements. Precaution was taken to only include a double layer of skin and adipose tissue beneath but not muscles. The calliper was applied at the right angle to the fold. The reading was taken 2 seconds after the release of the trigger to exert full pressure.

In measuring obese subjects, firm pressure of the thumb and index finger were used to reduce excessive movement of the indicator. For difficult to raise skinfolds thickness, the caliper was forced to the muscle level and then slightly withdrawn when the fold is controlled by the grasp. Measurement was taken to the nearest 0.1mm. The three measures were taken on each individual and the mode value was considered.

The detail procedures of each measurement are briefly described below:

2.5.1.1 Height

Standing height was measured with the anthropometer rod (GPM type, Galaxy Informatics, New Delhi) to the nearest 0.10 cm. The adult subjects were made to

stand on a flat surface with both heels together. The head was kept stretched upward to the fullest extent in the Frankfurt horizontal plane. The horizontal arm of the anthropometer was brought down lightly to touch the vertex in the mid-sagittal plane of the subject.

2.5.1.2 Weight

Body weight of the individuals was recorded using a portable digital weighing machine. The individuals were instructed to remove their slipper or shoes and extra clothes before stepping into the measuring scale. They were also instructed to place their foot properly on the scale and stand still facing forward until asked to step off with hands hanging on the sides. Body weight was recorded to the nearest 0.1kg.

2.5.1.3 Sitting height (SH)

To measure SH the participants were instructed to sit on a table with legs hanging from the edge of the table with hands resting on thighs in a cross. The body posture should be erect with ear-eye plane. Then SH was recorded from the surface of table to vertex with the anthropometer positioned on back of the participants parallel to spinal cord.

2.5.1.4 MUAC

The MUAC was measured on the left arm of each individual with arms hanging relaxed and palm of hand facing forward. It was measured midway between the tip of the acromion and the olecranon process. The measurement points were marked by a marker and the measurement was recorded without compressing the tissue. The subjects were asked to stand erect throughout the process.

2.5.1.5 Neck circumference (NC)

The neck circumference was measured in the midway of the neck, between the midcervical spine and the midanterior neck, to within 1 mm, with flexible nylon tape. In men with a laryngeal prominence (Adam's apple), it was measured just below the prominence (Ben-Noun et al. 2001).

2.5.1.6 Waist Circumference (WC)

The waist circumference was measured at the midpoint between lower margin of last palpable rib and the top of the iliac crest while the subject is in standing position. The measurement was recorded at the end of normal expiration with arms relaxed on the sides. The measurement was taken with the help of a flexible nylon tape to nearest 1 mm. The measurement of female participants was measured and recorded by a female investigator in a separate room. The measurement was conducted on light clothing.

2.5.1.7 Hip Circumference (HC)

This measurement was taken immediately after the waist circumference. The hip circumference was measured as maximum circumference or elevation of the buttocks with the individuals standing straight with the heels touching and arms relaxed on the sides. The measurement was taken using flexible nylon tape to nearest 1mm. The measurement on female participants was measured and recorded by a female investigator in a separate room. The measurement was conducted on light clothing.

2.5.1.8 Arm span

Arm span measurement was taken from the tip of the middle finger of one arm to the tip of middle finger of another arm (dactylion to dactylion) with arm outstretched at right angles to the body, on a level concrete floor. In the process participants was standing straight with heels closed to each other.

2.5.1.9 Arm length

Left arm length (LAL) was taken from the tip of the humerus (acromion) bone to tip of the middle finger (dactylion) of left arm while the subject was standing erect in the Frankfort plane with arms hanging down wards lateral to the body and heels closed to each others. Same steps were repeated for right arm length (RAL).

2.5.1.10 Biceps Skinfold (BSF)

The participants were asked to stand straight and relaxed with arms hanging on sides. The midpoint of the acromion process and the olecranon process was measured and marked. The marked was extended to encircle around the arm and another point was marked 1cm. above the circular line on the anterior surface of the biceps muscle for BSF measurement.

The skin and the subcutaneous tissue fold was picked approximately 2 cms above the circular line with the help of thumb and index finger and then the jaw of the caliper was placed in the marked point. The measurement was recorded as mentioned above.

2.5.1.11 Tricep skinfold (TSF)

The participants were asked to stand straight with arms relaxed and hanging on sides. The left hand of the participant was marked in the midpoint between the acromion and the olecranon processes in the posterior surface of the tricep muscle. The skin and the subcutaneous tissue fold was picked 1 cm above the marked point with the help of thumb and index finger and then caliper was applied to the pinch at the marked point. The measurement was recorded as mention before.

2.5.1.12 Sub-scapular Skinfold (SSF)

The participant was asked to stand straight with arms hanging on sides and relaxed. The inferior angle of the scapula was located by palpating the posterior spine of the scapula with fingertips and marked. The skin and subcutaneous tissue fold was picked obliquely just below the inferior angle of the scapula. The caliper was applied 1 cm away from the left thumb and index finger on the marked point.

2.5.1.13 Suprailiac Skinfold (SISF)

The participant was asked to stand straight with arms relaxed and hanging on sides. The suprailiac skinfold was marked about 1 cm above and 2 cm medial to the anterio-superior iliac crest. The skin and subcutaneous tissue fold were lifted accordingly to measure suprailiac skinfold.

2.5.2 TECHNICAL ERROR OF MEASUREMENT

To achieve intra-observer precision, three widely used precision estimates were calculated: the technical error of measurement (TEM), the relative technical error of measurement (rTEM) and the coefficient of reliability (R) (Ulijaszek and Kerr, 1999; Goto and Mascie-Taylor, 2007). For the calculation of intra-observer

TEM of height, weight, armspan, arm length, MUAC, NC, WC, HC, BSF, TSF, SSF and SISF were recorded from 30 adult male and female Limboo individuals. Anthropometric measurement is conducted by the male investigator for male participants and by a female investigator for female participants.

TEM was calculated as the square root of the squared difference between two corresponding measurements divided by twice the sample size (Ulijaszek and Kerr, 1999; Goto and Mascie-Taylor, 2007). The relative technical error of measurement (rTEM) was calculated by dividing the TEM for the given variable by the mean for that variable and multiplying the result by 100. The coefficient of reliability or R was calculated using the following equation: $R = 1 - \left[\frac{TEM^2}{SD^2}\right]$, where SD is the standard deviation of all measurements.

Table 2.2: Intra-observer technical error of measurement (TEM) for the male investigator (n=30).

Measurement	TEM	rTEM (%)	R
Height (cm)	0.2384	0.1508	0.9975
Weight (kg)	0.4111	0.7312	0.9972
Armspan (cm)	0.3717	0.2315	0.9962
LAL (cm)	0.3638	0.5434	0.9793
RAL (cm)	0.3730	0.5530	0.9959
MUAC (cm)	0.3274	2.3951	0.9813
NC (cm)	0.2299	0.6492	0.9876
WC (cm)	0.3435	0.4263	0.9974
HC (cm)	0.3490	0.4176	0.9992
SH (cm)	0.2696	0.3173	0.9986
TSF (mm)	0.2121	3.0878	0.9929
BSF (mm)	0.1879	4.8908	0.9802
SSF (mm)	0.2556	2.2382	0.9972
SISF (mm)	0.2359	2.7856	0.9964

Table 2.3: Intra-observer technical error of measurement (TEM) for the female investigator (n=30).

Measurement	TEM	rTEM (%)	R
Height (cm)	0.2342	0.1560	0.9971
Weight (kg)	0.7888	0.3371	0.9998
Armspan (cm)	0.4187	0.2732	0.9940
RAL (cm)	0.5241	0.8060	0.9685
LAL (cm)	0.5252	0.8110	0.9615
MUAC (cm)	0.6434	2.5193	0.9645
NC (cm)	0.1708	0.5455	0.9957
WC (cm)	0.5295	0.6340	0.9994
HC (cm)	0.3875	0.4176	0.9992
SH (cm)	0.3243	0.3968	0.9995
TSF (mm)	0.2338	2.0390	0.9961
BSF (mm)	0.2129	3.7093	0.9926
SSF (mm)	0.2323	1.8102	0.9982
SISF (mm)	0.2033	1.9265	0.9984

Since the R values are above the cut off value of 0.95 as proposed by Ulijaszek and Kerr (1999), the measurements recorded by both investigators (male and female) are reliable and reproducible. Subsequently all the measurements in the present study were recorded by both of them (male for the male subjects and female for the female subjects).

2.5.3 ASSESSMENT OF NUTRITIONAL STATUS

The nutritional status of the 992 adult Limboo individuals (males: 496; females: 496), in the age of 18 years to 64 years was assessed using standard anthropometric indicators and body composition indicators. These are described as follows:

2.5.3.1 Body Mass Index (BMI)

BMI is a suitable indicator to estimate the intensity of under-nutrition or CED and over-nutrition (overweight and obesity) of an individual or a population. BMI has been calculated using the following standard equation of WHO (1995):

$$BMI(kgm^{-2}) = \frac{Weight\ (kg)}{Height^2\ (m^{2)}}$$

Nutritional status has been assessed using the internationally accepted BMI cut-off points as suggested by WHO (WHO, 1995) and Asian cut-offs recommended by WHO (2000). For the screening of undernutrition, CED grades of BMI were used (WHO, 1995). The cut-off point value of <18.50 kg/m^2 for underweight was retained in recommended Asian cut-offs as well. New points for public health action for Asian adults are 23 kg/m^2 or higher considered as at risk. In addition to Obese I and II were formulated at 25 kg/m^2 and 30 kg/m^2 respectively. BMI is a well established proxy for undernutrition and high adiposity (James et al., 1988; Gibson, 1990; Ferro-Luzzi et al., 1992; Sengupta et al., 2014; Mondal et al., 2017). The classification of CED according to BMI as suggested by the WHO Expert Committee (WHO, 1995) and Asian cut-offs (WHO, 2000) are presented in Table 2.4 and Table 2.5 respectively.

Table 2.4: Cut-off points for assessing nutritional status of adult individuals as recommended by WHO (1995)

Category	BMI value (kg/m^2)
CED Grade III	< 16.00
CED Grade II	16.00 – 16.99
CED Grade I	< 17.00 – 18.49
Normal	18.50 – 24.99
Overweight	≥ 25.00 – 29.99
Obese	≥ 30.00

Table 2.5: Specific Asian cut-off points recommended by WHO (2000)

Category	BMI value (kg/m^2)
Underweight	< 18.50
Normal	18.50 – 22.99
Overweight	≥ 23.00
At risk	≥ 23.00 – 24.99
Obese I	25.00 – 29.99
Obese II	≥ 30.00

Table 2.6: Classification of CED based on BMI for adult individuals as recommended by WHO (1995)

Prevalence of CED	BMI value (kg/m^2)
Low prevalence	Warning sign: 5-9% of population with BMI < 18.50
Medium prevalence	Poor situation: 10-19% of population with BMI < 18.50
High prevalence	Serious situation: 20-39% of population with BMI < 18.50
Very high prevalence	Critical situation: > 40% of population with BMI < 18.50

2.5.3.2 Mid Upper arm circumference (MUAC)

Nutritional status was also evaluated in the present study using the internationally accepted cut-off points of MUAC. The individual values of MUAC found below 23 cm and below 22 cm were characterized as under-nutrition among the males and females respectively (James et al., 1994). These cut-offs value was recommended as a useful indicator of protein energy starvation (Harries et al. 1984; WHO 1995).

2.5.3.3 Waist Circumference (WC)

The cut-offs for WC given by International Diabetes Federation (Alberti et al., 2007) is 80 cm and 90 cm for female and male respectively and also recommended by WHO (2008) has been utilised to identify the individuals at risk of adiposity related morbidity. This criteria is used by WHO (2000) and WHO/FAO (2003) and

specifically recommended for Asians (WHO, 2008). In India, it is adopted by NNMB (2009) for its national surveys.

2.5.3.4 Waist-Hip Ratio (WHR)

The WHR has been calculated using the measurements of WC and HC using the following equation:

$$WHR = \frac{Waist\ Circumference\ (cm)}{Hip\ Circumference\ (cm)}$$

A high WHR was defined as >0.9 in males and >0.8 in females by Web *et al.* (2002) and Huxley *et al.* (2008) and recommended by WHO (2008). These cut-offs are used to assess the amount of higher regional adiposity among the individuals studied.

2.5.3.5 Waist-Height Ratio (WHtR)

The WHtR was calculated from the measurements of WC and height using the following equation:

$$WHtR = \frac{Waist\ Circumference\ (cm)}{Height\ (cm)}$$

A cut-off value of 0.5 was proposed by Hsieh and Muto (2004) to assess higher level of adiposity for both sexes. This cut-off has also been validated on the Kayastha population of North Bengal, India (Sarkar et al., 2009) and also recommended by WHO (2000). The present study has used this cut-off to assess adiposity among the Limboo individuals.

2.5.3.6 Cormic Index (CRI)

Cormic Index is also known as the index of body shape is calculated as ratio of sitting height to height. It is usually studied to observed ethnic differences and for correction of influence of long leg in relation to trunk in the BMI of an individual and population (WHO, 1995; Norgan, 1995).

$$CRI = \frac{Sitting\ Height}{Standing\ Height}$$

2.5.3.7 Conicity index (CI)

CI was also worked out in the present study to assess body composition following the equation of Valdez et al. (1993). Mostly this index is studied in association with cardiovascular diseases and other indicators of adiposity. Cut-offs points used for the Conicity index are 1.25 for males and 1.18 for females above which cardiovascular diseases and related risk increases. The formula to calculate CI is given below:

$$CI = \frac{Waist\ Circumference\ (m)}{0.109\sqrt{\frac{Weight\ (kg)}{Height\ (m)}}}$$

2.5.3.8 Neck Circumference (NC)

The NC has been put forth by Ben-Noun et al. (2001) as a culture free measure of adiposity of upper trunk which may well correlated with BMI and the related morbidity. In the present study it was used to compare with other established measures of adiposity such as BMI, WC, WHtR, WHR and BAI and CI.

2.5.3.9 Body Adiposity Index (BAI)

BAI was proposed by Bergman et al. (2011) to overcome the limitations of BMI in accessing PBF. The formula put forth by Bergman et al. (2011) is utilised to calculate BAI which is shown below.

$$BAI = \frac{Hip\ circumference\ (cm)}{Height\ (m)^{1.5}} - 18$$

Further, it has been utilised to compare with adiposity indicators like BMI, WHtR, WHR, WC, and NC based on the PBF derived from skinfolds.

2.5.4 ASSESSMENT OF BODY COMPOSITION

2.5.4.1 Upper Arm Composition

Combination of MUAC and TSF is useful for the assessment upper arm composition as suggested by Frisancho (1974, 1981, and 1989). The given method of upper arm composition is recommended by WHO (1995) and also corroborated by Singh and Mehta (2009). It enhances the utility of MUAC and TSF. In the present study the upper arm composition of the individuals was evaluated using the equations of Total Upper Arm Area (TUA), Upper Arm Muscle Area (UMA), Upper Arm Fat Area (UFA) and Arm Fat Index (AFI) which is given below:

$$TUA\ cm^2 = \frac{(MUAC)^2}{4\pi}$$

$$UMA\ cm^2 = \frac{\{MUAC - (TSF \times \pi)\}^2}{(4 \times \pi)}$$

$$UFA\ cm^2 = TUA - UMA$$

$$AFI = \frac{UFA}{TUA} \times 100$$

The standard equations of Frisancho (1989) were also utilized to assess the corrected Bone Free Muscle Area (BFMA) among the Limboo male and female individuals. The equations are as follows:

$$BFMA_{MALE}cm^2 = (UMA - 10.0)$$

$$BFMA_{FEMALE}cm^2 = (UMA - 6.5)$$

2.5.4.2 Body Density (BD) Assessment

In order to assess PBF utilizing skinfold thickness (e.g., BSF, TSF, SSF, SISF) calculation of body density is a mandatory step. Sex specific standard equations of Durnin and Womersely (1974) were utilized for the purpose. These equations assumed a logarithmic relationship between obesity or higher level of adiposity and sum of BSF, TSF, SSF and SISF skinfolds among the individuals. These equations have been validated in different Indian populations by Chakrabarty and Bharati (2010), Kaur and Talwar (2011), Chowdhury and Roy (2016), Banik et al. (2016), Ghosh and Bose (2018). The equations of Durnin and Womersely (1974) utilized to assess the body density is given below:

$$Male\ body\ density = 1.1765 - 0.0744 \times \log_{10}(BSF + TSF + SSF + SISF)$$

$$Female\ body\ density = 1.1567 - 0.0717 \times \log_{10}(BSF + TSF + SSF + SISF)$$

2.5.4.3 Assessment of Percentage Body Fat (PBF)

After the calculation of body density, the standard equation of Siri (1956) was used to assess PBF for both male and female individuals of the present study. Indian studies have utilized Siri's equation in order to estimate the body fat content in

different ethnic populations (Chakrabarty and Bharati, 2010; Kaur and Talwar, 2011; Chowdhury and Roy, 2016; Banik et al., 2016; Ghosh and Bose, 2018).

$$PBF = \left(\frac{4.95}{Body\ density} - 4.50\right) \times 100$$

2.5.4.4 Assessment of Fat mass (FM) and Fat free mass (FFM)

The body mass consists of both fat mass (FM) and fat free mass (FFM). The standard equations of Van Itallie et al. (1990) and Eckhardt et al. (2003) have been utilized to assess the amount of FM and FFM among the Limboo individuals. Several researchers have utilized these equations to assess the FM and FFM among different Indian populations (Chakrabarty and Bharati, 2010; Kaur and Talwar, 2011; Chowdhury and Roy, 2016; Banik et al., 2016; Ghosh and Bose, 2018). The equations are as follows:

$$Fat\ Mass\ (kg) = \left(\frac{PBF}{100}\right) \times Weight\ (kg)$$

$$Fat\ Free\ Mass\ (kg) = Weight\ (kg) - \ FM\ (kg)$$

2.5.4.5 Assessment of Fat mass index (FMI) and Fat free mass index (FFMI)

The indices of fat mass index (FMI) and fat free mass index (FFMI) were calculated from the equations of Van Itallie et al. (1990). The indices are given below:

$$Fat\ Mass\ Index\ (kgm^{-2}) = \frac{FM}{Height^2\ (m^2)}$$

$$Fat\ Free\ Mass\ Index\ (kgm^{-2}) = \frac{FFM}{Height^2\ (m^2)}$$

The proposed classification for FMI and FFMI for Caucasian men by Kyle et al. (2003), modified by Khongsdier (2005) for males of the Northeast, India was used in the present study. The cut-offs of FFMI was 15.1, 15.1-18.0 and 18.0 kg/m^2 for low, normal and high FFMI, respectively. Similarly, FMI was 2.9, 2.9-5.0 and 5.0 kg/m^2 was categorised as low, normal and high, respectively (Khongsdier, 2005). As Khongsdier (2005) has not presented the cut-offs for women, the cut-offs of FMI given by Liu et al. (2013) for Chinese men (7.00) and women (7.90) were utilised further in the present study.

2.5.4.6 Assessment of status of body fatness

The percentage body fat classifications of Nieman (1995) and Muth (2009) were used to determine the fitness level among the individuals of the present study. The detail of their classification is presented in the Table 2.7 and 2.8. Classification given by Muth (2009) was sex specific and classification of Nieman (1995) was general.

2.5.4.7 Assessment of related risk factor with PBF

There is no recommended cut-offs to assess the risk level of PBF (WHO, 1995; Lavie et al., 2009). The often used cut-offs points of PBF for male and female are 25% and 35%, respectively. Increasing use of these cut-offs point for PBF was purported from the unavailability of a reliable cut-offs. On the other hand the increasing use of these cut-offs is generating evidence in favour of these PBF cut-offs per se (Deurenberg, 2002; Lavie et al. 2010) etc. Another widely used cut-offs points of PBF are 25% for male and 30% female individuals which are utilized in the present study (Dudeja et al. 2001; Zeng et al. 2012).

Table 2.7: Classification of Percentage Body Fat (PBF) given by Nieman (1995)

Body weight status	Fat %
Lean	< 13%
Optimal fat	13-23%
Fat	24-32 %
Over fat	>33%

Table 2.8: Sex specific cut-off values for assessment of related risk factor with PBF after Muth (2009).

Classification	Male %	Female %
Essential fat/Underweight	2-5	10-13
Normal	6-17	14-24
Acceptable/ Overweight	18-24	25-31
Obese/Morbid	25	32

2.6 STATISTICAL ANALYSIS

The data obtained in the present study were statistically analyzed using statistical constants and relevant statistical tests. The statistical analyses were performed utilizing the Statistical Package for Social Sciences (IBM SPSS; version 20). A p-value of <0.05 and <0.01 was considered to be statistically significant.

The anthropometric variables recorded have been described using descriptive statistics (mean ± standard deviation). Some variables were log transformed owing to normal distribution. Sex differences and age specific differences within sexes in the anthropometric variables were analysed using one-way analysis of variance (ANOVA). The Pearson correlation coefficient analysis was done to understand the association between the anthropometric variables. Linear regression analysis was done to assess the dependency of the sex, age and BMI on the anthropometric variables.

Chi-square (χ^2) analysis was utilized to assess sex differences in socio-economic, demographic and life style related factors (population size, education, occupation, family monthly income, family size, marital status, drinking water facility, toilet facility, landholding pattern, house type, and socio-economic status). Further, χ^2 analysis was also done to assess the sex differences and difference within sex in the prevalence of undernutrition and overnutrition based on various anthropometric indices taken in the study. The Fisher's exact test was utilised for a cell/category with less than 5 individuals. This correction term adds to the accuracy of the χ^2 analysis when the numbers of classes are small. The χ^2 analysis was also utilized to assess sex differences in nutritional indices related to fatness, body composition, overnutrition and regional adiposity measurements between male and female individuals. The differences in BMI, WHR, WHtR with respect to the different socio-economic, demographic and lifestyle related variables were also assessed using χ^2 analysis.

The logistic regression models were fitted to estimate the odds of being affected by undernutrition and overnutrition in case of BMI, WC, WHR, WHtR and CI among the Limboo individuals. Multinomial logistic regression was used to compare being affected by underweight, overweight and obesity against normal weight. Similarly, binary logistic regression analysis was conducted to compare the chances of being affected by high WC, WHR, WHtR and CI. The model with the calculation of Wald χ^2-square, corresponding adjusted odds (ORs) and 95% confidence interval (CIs) was used to examine possible differences between the individuals in the category of under-nutrition or overnutrition. The predictor variables or independent variables were socio-economic, demographic and life style related factors such as sex, age, marital status, education, occupation, income, socio-

economic status (based on Kuppuswamy Scale), family size, land holding, house type, drinking water and hygienic toilet. The multinomial regression model allows controlling effects of these variables to create dependency in selective variables. Therefore, individuals affected by undernutrition and overnutrition were categorized into different levels by using different sex specific cut-offs points for BMI (WHO, 1995), WC (WHO 2008), WHR (WHO, 2008), WHtR (Hsieh and Muto, 2004) and C-Index (Valdez et al., 1993). Cases of undernutrition, overweight and obesity were coded as 3, 4, 5 and normal cases were coded as 0 for BMI respectively. The parameters of central obesity such as WC, WHR, WHtR and C-Index were coded as 0 for the cases below the cut-offs and coded as 1 those above the given cut-offs. These dummy variables were entered in the regression model as response variables. Similarly, the predictor variables were coded separately and entered in the regression model as a set of dummy variables. The variables used as predictors for the multinomial regression model includes sex (male; female), age (18-29 years; 30-49 years;50-64 years), marital status (unmarried; married), education (illiterate; upto 8^{th} grade; $\geq 9^{th}$ grade), occupation (non-manual; manual; others), income ($\leq$ ₹4999/=; ₹5000/= - ₹9999/=; $\geq$ ₹10000/=), Socio-economic status based on Kuppuswamy Scale (upper lower; lower middle; upper middle), family size (large; small), land holding ($\geq$ 1 acre; 0-0.99 acre), house type (semi-pakka; pakka; kacha), drinking water (piped from spring; supply) and hygienic toilet (pit; commode). The words in the brackets are categories of the each variable and coded keeping in view that SPSS automatically assigned last or higher number as reference so that first category of each of these variables gets set as the reference category for the logistic regression models.

Receiver operating curve (ROC) analysis was utilised to compare the available indices of adiposity. Best indices were identified based on area under curve (ROC-

AUC). The same analysis was utilised to define appropriate cut-offs for different variables of obesity and fatness including body composition variables taken in the present study. The cut-off points were defined at the equal sensitivity and specificity of ROC-AUC using highest value of Youden Index (J). The J is equal to sensitivity + specificity. The skinfolds derived PBF with cut-offs of 25% (male) and 30% (female), and the BMI (WHO 2000) classifications were utilized as a reference for ROC-AUC.