Chapter I

Introduction
Chapter I-1

Problem Introduction
1.1.1. **International Scenario**: Protein is an essential component of the diet of human as well as animals. In developed countries, the majority of protein requirement is met from animal proteins however, in developing countries 80% of the protein requirement is met from plant sources. The recommended per capita per day demand is 56.2 g where as net availability per capita per day is 36.3 g. The supply of protein is therefore not adequate and 60% of the population suffers from malnutrition (Suchita, 1990).

The problem therefore, is how to solve this chronic protein deficiency. There could be two solutions- either to increase the area under pulses or to develop high yielding varieties, so as to get increased production of pulses per hectare. The first one is not possible as we have to increase the available area at the rate of 3.1 % per annum to meet such huge demands. If no extra land is available then the yield must be increased at a very high rate of 4.5 per cent per annum compelling the other areas to cover under pulses. But it is not possible as it will reduce the area under cereals, which are staple food of the people (Kusum and Swami, 1975). The second option is time consuming and research efforts have not been succeeded in the same proportion as they had succeeded in the case of rice and wheat. Among the various answers to this chronic and urgent problem, one of the most promising areas could be to look for non-conventional legumes. Non-conventional vegetables include those edible plants that grow in the wild or under semi-domesticated condition being grown casually as backyard crop, but in any case these form an important component of human food that come from sources other than organized cultivation (Handique, 2003).

There is at least 3000 edible plant species known to man. Out of which, merely 300 crops contribute to more than 90% of the world’s calorie intake, and only 120 crops are economically important on a national scale which implies that world’s food security rest on a slender base of 4% of known edible plants (Cooper et al., 1996). Therefore, from the point of view of meeting the challenges of food security it is necessary to widen the food base by establishing more and more new food crops.

Although many species and sub-species of legumes are known, only about a dozen of them are important as commercial food crops (Table 1.1.1). Beans and peas each account for about 25 % of the total production of legume crops. Chickpea and broad beans rank next in importance. Some of the legumes, however, are of only regional or local importance.

Leguminous plants are found throughout the world, but the greatest variety grows in the tropics and sub-tropics. Of the thousands of known legume species, less than 20 are used
Table: 1.1.1. Common legumes and their scientific Names

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Other Scientific Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Peanut, Ground-nut</td>
<td><em>Arachis hypogaea</em></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Red gram, Arhar</td>
<td><em>Cajanus cajan</em></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Pigeon pea, yellow <em>dhal</em>, congo pea</td>
<td><em>Cajanus indicus</em></td>
<td></td>
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<tr>
<td>4</td>
<td>Chickpea, Bengal gram, garbanzo</td>
<td><em>Cicer arietinum</em></td>
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<tr>
<td>5</td>
<td>Horse gram</td>
<td><em>Dolichos biflorus</em></td>
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<tr>
<td>6</td>
<td>Lentil, masur <em>dhal</em></td>
<td><em>Lens esculenta</em></td>
<td>a) <em>Lens culinaris</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b) <em>Ervum lens</em></td>
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<tr>
<td>7</td>
<td>Broad bean, Windsor bean</td>
<td><em>Faba vulgaris</em></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Soybean</td>
<td><em>Glycine max</em></td>
<td>a) <em>Glycine soja</em></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>b) <em>Glycine hispida</em></td>
</tr>
<tr>
<td>9</td>
<td>Lupin</td>
<td><em>Lupinus SPP</em></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Velvet bean</td>
<td><em>Mucana pruriens</em></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Mung bean, Green gram</td>
<td><em>Phaseolus aureus</em></td>
<td>a) <em>Phaseolus radiates</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>b) <em>Vigna radiate</em></td>
</tr>
<tr>
<td>12</td>
<td>Lima bean</td>
<td><em>Phaseolus lunatus</em></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Black gram, Urd, mungo bean</td>
<td><em>Phaseolus mungo</em></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Kidney bean, Navy bean, Pinto bean</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Haricot bean, Snap bean</td>
<td><em>Phaseolus vulgaris</em></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Pea</td>
<td><em>Pisum sativum</em></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Winged bean</td>
<td><em>Tetragonolobus purpureus</em></td>
<td></td>
</tr>
</tbody>
</table>

extensively to-day (Anon, 1979). Those in common use include peanut, soybean, pea, lentil, pigeon pea, chick pea, mung bean, kidney bean, cow pea, alfalfa, sweet clover, other clovers and vetches. The remaining species are little used as yet, and many of them are almost unknown to science. Legumes offer a variety of edible products in addition to seeds. Many immature pods are edible before the fibres are lignified and hardened. Legume seeds are second only to cereals as a source of human and animal food. Nutritionally they are 2-3 times richer in protein than cereals. As legumes contain more protein than almost any other plant product, sometimes as high as 60% (Chatterjee and Bhattacharya, 1986) cultivation and exploitation of lesser known legumes might be able to help eliminate protein malnutrition in the near future.

1.1.2. North East India Scenario: Due to topography and climatic conditions North-Eastern region of India is noted for its great diversity of edible plants. This is evidenced by the fact that about 40 % of the total flora of the country is said to be represented in the north eastern part of India, which means an approximate number of 6000 to 7000 species (Anon, 1984). Ordinarily, the flora of the districts in upper Gangetic plains or the plains of peninsular region of India has only about 600 to 700 species but in North-eastern India, so far 1000 to 1500 species have been recorded. Still very little is known regarding the rich vegetation of this region. The large variety of economic plants such as medicinal, aromatic, tree fodders, fruits, oilseed producing trees, legumes, spices, orchids and flowering plants grow here, wild in nature. Das et al., (2008) reported 70 wild edible plants belonging to 45 families of the flowering and non-flowering plants from Barak valley of Assam. Out of which some of the plants are used as edible green vegetables and edible fruits and for other purposes. They are in the opinion that the nutritional value of the identified wild edible plants be worked out so that their contribution to human health in terms of nutrition can be recommended for the benefit of the people at large. Ramachandran (2007) was of the opinion that the nutritional analysis of some potential underutilized plant species may lead to the discovery of a new food source which will strengthen the sustainable utilization of the wild bio-resources. 110 wild edible plants have also been reported by Kayang (2007) from Meghalaya state. According to him, the local markets at Shillong, Jowai, Nongpoh and Tura are full of wild vegetables and fruits. He opined that these resources are genetically important for future agricultural research. Another such report came from Barua et al., (2007). He reported 38 wild edible plants used by the inhabitants of Majuli Island and Darrang district of Assam. Such edible wild plants act as supplementary food during lean and the period under stress.
Development of agro-technique for such non-conventional plants and to bring them into large scale cultivation may prove to be rewarding (Barua et al., 2007).

1.1.3. In the State of Manipur Scenario: People of various ethnic groups dwelling in the hills and valley regions inhabit the state of Manipur. This region abounds in many varieties of plants growing in the hill terrains, marshy places and lakes. The native of this area still gather and consume wild food plants in their own traditional way (Arora, 1981; Singh et al., 1988). Out of the 800 species of wild edible plants consumed mostly by the tribal inhabitants of India, about 300 species occur in the north-eastern region alone (Singh and Arora, 1978). There are various reports about the use of such wild plants in Manipur. Singh and Singh (1985) reported 30 (thirty) edible wild plants. Singh et al., (1988) reported another 46 wild edible plants belonging to 30 families. Salam and Singh (1991) also reported 50 (fifty) non-conventional edible wild plants of Manipur. Singh et al., (2001) studied wild edible aquatic plants of Manipur and reported 31 plants, which are commonly used by the Manipuris as edible. Singh (2004) studied the spices and condiments of Manipur and described 71 plants, which are indigenous to Manipur.

1.1.4. Origin of the Problem: All the above mentioned reports showed only the information about the plant types, scientific names and mode of their utilization. It would be the prime necessity to study the nutritive values of such lesser known plants and to assess their suitability for large scale cultivation and consumption. As the legumes are more nutritious and at the same time as the pulses are deficient in the developing countries, priority may be given for the exploitation of these lesser known legume plants. Out of the hundreds of such plants, mention must be made of Parkia, winged bean and Mucuna species.

*Parkia roxburghii* G. Don (Common Name: Parkia or stink bean) is considered nutritious and relished by the people of this region (Photo Plate-1.1.1a & b). Various parts of the plant right from the inflorescence and tender pods to the matured seeds are edible. The flowers are taken in the form of salads, whereas pods are used in the preparation of salads, curries, chutneys or in frying items (Salam, 1996). This vegetable is available for use for over seven months (October to April) of the year and can thrive on varied agro-climatic conditions from hotter plains to the colder mountains up to 2000 msl (Meitei and Jayalakshmi, 2005). It can be grown as shed trees in tea farms, courtyard (Photo plate 1.1.2), road sides (Photo Plate-1.1.3) and gardens. It can also be grown as upper story crop in agro-forestry systems (Photo plate 1.1.4). It grows moderately fast and serves as a source of good timbers and fuel woods (Dhyani and Chouhan, 1990). The pods and seeds of this plant are considered a much valued...
**Photo Plate-1.1.1a:** *P. roxburghii* pods being sold in the market at Imphal Bazar.

**Photo Plate-1.1.1b:** A woman selling *P. roxburghii* pods at Bishenpur bazaar.

**Photo Plate-1.1.2:** *P. roxburghii* plant is also grown as a shade tree in the road side.
vegetable in Manipur, in some North-Eastern states and other South-East Asian countries i.e. Phillippines, Malyasia, Thailand, Java and Vietnam (Hopkins, 1994). In north-east India it is known differently in different regions/states. It is known as ‘Yongchak’ in Manipur, ‘Zongtai’ in Mizoram, ‘Aerolap’ in Garo hills, ‘Barri-phang’ in Cachar hills, ‘Unkampinching’ in Nagaland and ‘Khorial’ in Assam ( Sharma et al., 1993) whereas in South-East Asian countries, it is known as ‘U’pang’ in Phillippines, ‘Sator’ in Thailand, ‘Petai pare’ in Java, ‘Petai’ in Malaysia, and ‘Pete’ in Indonesia (Online : GRIN, USDA). It is a native of tropical Asia and grows luxuriantly in North-eastern region of Indian sub-continent, Myanmar, Thailand, Indonesia and Malaysia (Hopkins, 1983). It is very popular in southern Thailand, Myanmar, Malaysia and Indonesia and these are sold in bunches. They are best eaten when combined with other flavouring items such as shrimp or added to a Thai curry such as green curry of duck (Charmaine, 1998). But due to lack of knowledge about the plant or fear of toxicity, the same is not consumed by the people elsewhere in India.

The effective utilization of this lesser-known legume as a nutritious but low cost food for human consumption depends upon consumer acceptance. The knowledge of parkia is essentially inadequate and utilization of it for human consumption has not yet been realized to its full potential. Meitei and Singh (1990) classified \textit{P. roxburghii} into different plant types on the basis of \textit{P. roxburghii} growing pockets. As the classification was based on specific regions, it could not give detailed information about how many plant types/cultivars are available in Manipur and what are their distinguishing characters. They also studied the growing habitats, propagation techniques, manuring, yield and other post harvest processing techniques. Singh (2002) studied eight cultivars of \textit{P. roxburghii} collected from four different places of Manipur. He analyzed morphological characters of these cultivars and grouped them into four clusters. However on the basis of storage proteins and RAPD analysis, the cultivars were reported to be of the same genotype. Longvah and Deosthale (1998) also studied some non-specific cultivars of \textit{P. roxburghii} from north-eastern India and reported them to contain high amounts of protein, fats and essential amino acids. However, all the above studies failed to report about the very important information like different cultivars available in the state, mineral composition, different biochemical constituents, nutritive value, anti-nutritional factors and other toxic substances (if any). Researches leading to better understanding of the chemistry of parkia viz. protein, lipids, carbohydrates, minerals and toxic constituents, if any, should open up new avenues for large scale utilization of it. Keeping the above in mind, the present work was taken up with the following objectives:
Photo Plate 1.1.3: *Parkia roxburghii* plant grown as a court yard-tree in a house at Imphal.

Photo Plate 1.1.4: *Parkia roxburghii* plants are grown as upper storey crop with corn and ground nut in an agro-forestry system at Indonesia. (Source: Ervizal A. M. Zuhud: [http://www.iwf.or.id/Kedawungagroforestrv.pdf](http://www.iwf.or.id/Kedawungagroforestrv.pdf))
1.1.5. OBJECTIVES:

1.1.5.1. To study the environmental factors of the tree bean growing areas (Study sites) based on the agro-climatic zones

1.1.5.2. To study the morphological characters of different genotypes of *P. roxburghii* growing in different agro-climatic zones of Manipur

1.1.5.3. To analyze biochemically active constituents and minerals in different developmental stages of the pods of *P. roxburghii* cultivars

1.1.5.4. To study the palatability of the pods of *P. roxburghii* with respect to their physical appearance

1.1.5.5. To evaluate anti-nutritive and toxic substances (if any) in the edible parts of the *P. roxburghii* pods and to ascertain their toxicity against some lower organisms

1.1.5.6. To analyze the effects of processing and cooking methods on the various nutritive, anti-nutritive and toxic substances

1.1.5.7. To ascertain relationship between the environment of different agro-climatic zones on the quality of the pods

1.1.5.8. To study the genetic diversity among the selected *P. roxburghii* cultivars from different agro-climatic zones of Manipur and to find out suitable parents for further genetic improvement of the crop
Chapter I-2

Description of Study Site, Climate, Soil and Vegetation
1.2.1 North-east region: The immense variety of the climatic, edaphic and altitudinal variations in India have resulted in a great range of ecological habitats for which North-east India takes the pride of place. Lying between 22-30 degrees N latitude and 89-97 degree E longitude, and sprawling over 2,62,379 sq. km., North-east India represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biographic regions and a meeting place of the Himalayan mountains and Peninsular India. It was the part of the northward migrating ‘Deccan Peninsula’ that first touched the Asian landmass after the break up of Gondwanaland in the early tertiary period. North-east India is thus the geographical ‘gateway’ for much of India’s flora and fauna, and as a consequence, the region is one of the richest in biological values and variations. It is in this lowland-highland transition zone that the highest diversity of biomes or ecological communities can be found.

The forests in the region are extremely diverse in structure and composition and combine tropical and temperate forest types, alpine meadows and cold deserts. After the Andaman and Nicobar Islands and the Western Ghats, North-east India forms the main region of tropical forest in India, especially the species-rich tropical rain forests. The tropical semi-evergreen and moist deciduous forests in the lowlands of this region extend south and west into the subcontinent, and east into Southern China and Southeast Asia. The subtropical forests of the region follow the foothills of the Himalaya to the west. Himalayan temperate and sub-alpine zone forests extend from northern Pakistan and adjacent Afghanistan through North-east India to South-west China. Each of the eight states of the region, namely Arunachal Pradesh, Assam, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura can be proud of several endemics in flora as well as fauna. This region represents an important part of the Indo-Myanmar biodiversity hotspot, one of the 25 global biodiversity hotspots recognized currently (online In: http://www.wii.gov.in).

The North-eastern Hills region comprising the States of Manipur, Meghalaya, Nagaland, Sikkim, Tripura, Arunachal Pradesh and Mizoram is bounded by China in the North, Sinkiang province of China and Myanmar to the east, Myanmar and Bangladesh in the south and southern part of Nepal, and northern part of West Bengal and Bangladesh in the west. The region is bestowed with rich resources of soil and agro-climate making it one of the fertile regions of the country. The vast area of the hills interspersed with fertile valleys represents agro-climates of unique diversity ranging from extreme temperate to typical tropical, falling within altitude range of 0 to 5000 meters and above. Couple with this is the abundance of natural water sources well distributed annual precipitation and deep alluvial
loamy soils having pH 4.5 to 6.5 which combine to permit growing of wide variety of crops (Anon, 1984). In respect of horticulture, almost all types of fruits and vegetables grow in one or the other part thereby confirming the vast potential that the area possesses for the growth of horticultural crops.

1.2.2. Manipur: Manipur stretches between 23.83° to 25.68° N latitude and 93.03° to 94.78° E longitude situated in the extreme North-eastern border of India. It is bounded by Nagaland state on the north, Chin Hills of Myanmar on the east, Myanmar and Mizoram on the south and Cachar district of Assam on the west. The total geographical area of the state is 22,327 sq. km. (Anon, 2002) which is about 0.07% of the Indian landmass. The average altitude of the valley is 763 msl and that of the surrounding hills is about 1363 m above sea level (Shamungou, 2000). The average annual temperature ranges from 0.03 to 34.50°C with an average annual rainfall of 131 cm. It has a central valley of about 2232 sq. km. while the rest of the area is represented by the hilly terrain (Ranjana, 2010).

There are altogether nine districts in the state viz, Imphal West, Imphal East, Thoubal, Bishnupur, Ukhrul, Chandel, Tamenglong and Churachandpur districts. These districts are divided into 30 sub-divisions and 165 village councils. The four valley districts are known as Manipur valley region which cover an area of about 2500 sq. km. The Barak valley or Jiribam sub-division cover an area of about 250 sq. km. and is located beyond the western Manipur hills. Several small rivers drain the Manipur state and the drainage is from north to south.

1.2.3. Features of Manipur: The ridge-and-valley character of the eastern mountains is more pronounced in the Manipur hills extending from the Tuensang hills in the north to about 24° N parallel in the south. The eastern boundary runs along the frontier between India and Myanmar and western boundary abuts against the Cachar plains and hills. The central part is a large basin, 50 km long and 30 km broad, surrounded on all sides by high mountains. This appears to be the bed of an old lake a remnant of which occupies the southeast corner of the basin and is known as the Loktak Lake, 12 km long and 8 km broad. It has centripetal drainage, and is finally drained by the south flowing Manipur River. The hill ranges on either side of the valley run practically to the same height a little over 2500 m and have flat rolling tops. The Barak is the largest river in the Manipur hills. It rises from the Japvo peak and flows south-west for 180 km parallel to two ranges lying on either side, before turning its course first to north and then to the west through the Cachar plains of
Assam. The geographical feature of Manipur with an area of 22,327 sq. km may be divided into three well defined regions (Shamungou, 2000):

1.2.3.1. The Manipur Hill Area: It covers about 90% of the total area but accounts only 30% of the total population. The area stretches mainly from north to south with altitude ranging from 760 m to 3030 m.

1.2.3.2. The Manipur Valley Area: This area covers 8% of the total area but it accommodates 70% of the total population. It is elevated plain, oval in shape with an average altitude of 792.4 m.

1.2.3.3. The Jiribam Plain Area: This region covers about 277 sq. km which is 1% of the total geographical area of the state. This plain area lies beyond the Manipur western hill tracts.

1.2.4: Climate: In most of the areas rainfall is abundant. The valley of Manipur constituting about 2238 sq. km. (Shamungou, 2000) shows mosaic of colour pulsating in the forest to indicate seasons. While the temperature seldom dips lower than 5° C in winter, it rarely goes above 27° C on an average excepting hot summer days. The state blends well with other sister states in respect of rainfall. Average rainfall is around 1438 mm (Shamungou, 2000) and the major precipitation occurs from July to September but monsoon starts during May and extends up to October. Manipur experiences winter season from December to February, summer season from March to April, rainy season from May to September and season of retreating monsoon from October to November. Winter is marked by cold night and warm and windy days. The coldest period is in the month of January. The hot weather season starts with gradual increase in temperature with occasional thundershowers.

Monsoon type of rainfall prevails in Manipur. The rainy season is associated with heavy rainfall, widespread cloudiness, high humidity, variable surface winds, dull, sultry and oppressive weather with occasional flood. Rain heralds the onset of agricultural activities and rice is the major agricultural crop of the state. Highest rainfall is experienced in high hilly areas of Tamenglong district while the lowest is noticed in Churachandpur district. The season of retreating monsoon is marked by gradual decrease of rainfall, clearer sky, short morning fog and pleasant weather comprising bright and sunny days and cool and pleasant nights.
1.2.5. Soils: Topography in association with climate played a dominant role in the soil formation in the hilly regions. The soils of Manipur valley (entsisols) have developed from the transported material (alfisols) formed from shale and this is the reason why these soils are heavier in texture. Fertility status of the soils differed widely. Around 50% of the soils are deficient in available phosphorus. The reasons of low availability of phosphorus in these soils might be due to strongly acidic soil reaction and presence of considerable amount of exchangeable alluminium (Indira and Somorjit, 2010). The content of organic carbon was rated high in most of the soils of this state. The possible reasons for higher organic matter content may be attributed to thick forest vegetation, high rainfall and low decomposition rate prevalent in the state. The soil reaction varies strongly acidic to acidic in nature. Generally, the soils of higher altitudes that belonged to high rainfall areas are strongly acidic. The reasons for low pH may be assigned to the leaching of the bases from the exchange complex under the prevailing high rainfall and hilly topography of the region.

1.2.6. Natural Vegetation: The valley is well marked by the thick natural vegetation but faces rapid depletion due to increasing exploitation to meet the needs of the ever increasing demand and also lack of consciousness about the importance of conservation. The valley has mix vegetation with a large variety of forest trees (evergreen to deciduous) scattered throughout the region. Mixed open scrub and scattered trees covered the foot hills and the hillocks with Bombax malbaricum, Trapa bispinosa, Sagittaria sagittifolia, Zizania latifolia, Euryle ferox, Phoebe lanceolata. Riverine forest of mixed vegetation are found along the river banks, flood plain areas around the villages which contains Bambusa species, Mangifera indica, Ficus bengalens, Ficus religiosa etc. (Ranjana, 2010).

1.2.7. Horticulture: Manipur is the second largest state of pineapple producers in India. The main horticultural crops are Animus cosmasus, Musa paradisiaca, Carica papaya, Citrus lemon, Citrus maxima, Citrus reticulata, Psidium guajava, Mangifera indica. Cocus mucifera is mainly grown in Jiribam whereas Citrus reticulata and citrus lemon in Tamenglong, Jiribam and Churachandpur and Pyrus malus and plum in Ukhrul and Mao (Ranjana, 2010).

1.2.8. Forest: Forest represents the most important natural resource of Manipur covering an area of 15,154 Sq km (Annon, 1998) representing 67% of the total area of the state according to 1991 census. The major forest types in the hills and their percentage composition in 1990 and 1995 is given at table 1.2.1 (Anon, 1998).
Table 1.2.1: Percentage composition of major forest types in 1990 and 1995

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Forest Type</th>
<th>1990</th>
<th>1995</th>
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<tr>
<td></td>
<td></td>
<td>Area (Ha)</td>
<td>% of the total Forest area</td>
</tr>
<tr>
<td>1</td>
<td>Wet temperate forest</td>
<td>1,45,101.0</td>
<td>9.57</td>
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<tr>
<td>2</td>
<td>Pine Forest</td>
<td>2,44,277.0</td>
<td>16.12</td>
</tr>
<tr>
<td>3</td>
<td>Wet Hill Forest</td>
<td>6,59,059.0</td>
<td>43.49</td>
</tr>
<tr>
<td>4</td>
<td>Semi-evergreen Forest</td>
<td>64,489.0</td>
<td>4.26</td>
</tr>
<tr>
<td>5</td>
<td>Teak-gurjan forest</td>
<td>61,074.0</td>
<td>4.03</td>
</tr>
<tr>
<td>6</td>
<td>Bamboo brakes</td>
<td>3,26,800.0</td>
<td>21.56</td>
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<td>7</td>
<td>Grass brakes</td>
<td>14,600.0</td>
<td>0.97</td>
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<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>15,15,400.0</strong></td>
<td><strong>100.0</strong></td>
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</table>

Source: Anon (1998) Statistical Bulletin, Dept of Forest, Govt. of Manipur
1.2.9 Flora Diversity of Manipur: The first man who did the pioneer floristic exploration of Manipur was Watt (1889-1890). He was deputed as a botanist member to the boundary commission, which was set up (1881-82) by the then British government of India. Watt reported (1890) 143 plant species including 10 monocotyledonous plants. The second man who studied the flora of Manipur state including Nagaland was Clarke (1889). He reported 1,050 flowering plants and ferns under 114 families. Among the plants, he claimed 87 new species. He recorded 422 species from Manipur, the rest from Nagaland. A detailed study was made by Deb (1957-1961) and he reported 2192 plant species distributed over 213 family and 1021 genera ranging from Pteridophytes to angiosperms which include 8 new species to India and about 1500 species as new record from Manipur (Deb, 1958). Sukla and Baishya (1982) reported 43 species of flowering plants and 13 cryptograms on a short trip in some areas of the state. They reported Platearia wallichii from Manipur as a new report in India. Sinha (1987) reported 523 plant species under 363 genera as ethnobotanically important plant species. He also reported a new plant species called Isoetes debii. Singh (1987) described 607 plant species including 8 varieties under 2 new taxa namely Codonopsis manipurensis and Cymbidium manipurianum. Sinha (1996) reported 1200 species, out of which 430 species have been recorded as having local medicinal uses and 108 species as edible. Singh and Singh (1996) described 18 indigenous plants used in superstitions with reference to Meitei community. Singh et al., (1999) also reported 19 plant species belonging to 17 families used for the treatment of dog bites from Manipur.

1.2.10 Agro-climatic zones: The North Eastern hills region has been divided into three broad geographic zones namely Eastern Himalayan region, Purvanchal region and Meghalaya-Mikir region. The Eastern Himalayan covers Sikkim, Arunachal Pradesh excluding Tirap and part of Lohit district, while the Purvanchal zone comprises Nagaland, Manipur, Tripura, Mizoram and Tirap and Lohit districts of Arunachal Pradesh. The third zone of Meghalaya-Mikir region comprises Khasi, Jaintia and Garo hills of Meghalaya. The three broad regions show wide diversity of climate due to altitudinal, topographical, soil etc. variations contributing to the diversity in the agricultural activities of the people. Watt (1890) for the first time divided the forest of Manipur roughly into three zones namely- the western wall, the central undertaking wall and the eastern wall. Kaith (1936a & b) classified the forest into four major categories viz: Cashar border forest, Imphal valley forest, North-eastern Khasi pine forest and Burma (Myanmar) border forests. But a more lucid classification of zones with associated plant species was given by Deb (1960). According to him, the state was divided into four agro-climatic zones as follows:
Tropical climate-This zone comprised the valley and hills up to 900 m with annual rainfall varying from 157.48cm to 396.24 cm. Tamenglongmg, Jiri and Moreh are important regions. Three major plants associations namely *Tectona-Dipterocarpus* association, *Quercus-Laurus-Schima* association and *Laurus-melia-Bauhinia* association are recognized in this zone.

Montane subtropical climate- This climate zone included those areas laying between 900-1800 m with an annual rainfall of about 220 cm. Chakpikarong, Chandel, Sugunu, Nongmaijing, Koubrou, Laimaton etc. are included in this zone. Important plant associations of the type viz; *Pinus-Quercus* association, *Sauraja-Phoebe-Beilschmieda* association and *Quercus-Enquelhardtia-Schima-Vaccinium* association are known in this zone.

Montane temperate climate-This zone included high altitude areas ranging from 1800 to 2400m where annual precipitation is high and the mean minimum temperature lies around 3°C. The climate is characterized by a severe winter accompanied by snow and frost. *Quercus-Magnolia-Acer* is an important association in this zone. Such plant association is common in the Mao and Koubru hill ranges.

Sub-alpine climate-this zone included Siroi, Koubrou, Somara and other hill ranges above 2400 m. The *Rhododendron-Betula* association is common in this zone.

However, the above classification suffers a lot of discrepancies. On the data available on various aspects of climate, topography, soil etc. and on the basis of the crops and livestock species being maintained in various zones of the North-eastern region, ICAR in its report (Anon, 1984) classified the region into six agro-climatic zones (Figure 1.2.1, inset) out of which Manipur falls under the following four distinct agro-climatic zones (Figure 1.2.1).

**1.2.11. Temperate Sub-Alpine Zone (Figure 1.2.2):** Its altitude ranges from 1500-3500 m above sea level. Average annual rainfall is around 2000. Average maximum and minimum temperatures are 27°C and 3°C (Figure 1.2.3). The areas under this zone include Mao and Maram areas of Senapati district, Ukhrul and adjoining areas of Ukhrul district. pH of the region at Ukhrul ranges from 3.8 to 5.7, organic carbon 1.44 to 5.1% and available phosphorus from 4.3 to 9.42 mg/kg (Figure 1.2.8a-c). Among the exchangeable bases, potassium (K), calcium (Ca) and magnesium (Mg) ranges from 0.24 to 2.82, 1.05 to 11.15 and 1.49 to 7.49 meq/100g, respectively (1.2.9a-c). The soils have high humus and nitrogen content but are highly acidic and subject to severe erosion every year. The slopes of this zone
Figure 1.2.1: Agro-climatic Zones of North East Region (inset) and Manipur.
Figure 1.2.2: Temperate Sub-alpine Zone.
Figure 1.2.3: (A) Temperature, (B) Relative humidity and (C) Rainfall in Temperate Sub-alpine Zone as recorded at Senapati during the years 2008 and 2009. (Source: Statistical Abstract, Manipur 2009, Dept. of Statistics, Govt. of Manipur).
are covered mainly with evergreen plants such as devdar, pines and firs with a rich collection of epiphytic and terrestrial orchids of all descriptions.

1.2.12. Sub-Tropical Hill Zone (Figure 1.2.4): In this zone average altitude ranges from 1000-1500 m above sea level. Average annual rainfall around 1600 mm. Average maximum and minimum temperatures around 30°C and 12°C. Soils of this region are generally loamy silt containing low to moderate organic matter. The pH of the region as recorded at churachandpur ranges from 3.8 to 5.7, organic carbon from 1.52 to 2.68% and available phosphorus from 4.54-15.81mg/kg (Figure 1.2.8a-c) while K, Ca and mg ranged from 0.46 to 1.18, 1.22 to 6.41 and 1.24 to 3.86 meq/100g respectively (Figure 1.2.9a-c). Moisture retaining capacity of the soils is generally low.

1.2.13. Sub-Tropical Plain Zone (Figure 1.2.5): This is the smallest agro-climatic zone in geographical area comprising mainly of Imphal valley. Altitude ranges from 400-1000 m above sea level having typical sub-tropical climate of warm summers and cool winters. The Imphal valley is surrounded by hills with winter temperature coming down to 5°C, the average maximum temperature remaining around 32°C during summer. Average temperature, relative humidity and rainfall of the region during 2008 and 2009 were given at figure 1.2.6. The soils of the valley are mostly alluvial, highly retentive, difficult to work when wet, forming deep and wide cracks when dry. Average annual rainfall is around 1375 mm. The pH of the region as recorded at Bishenpur ranges from 5 to 6, organic carbon from 0.12 to 3.42% and available phosphorus from 3.9-10.5mg/kg (Figure 1.2.8a-c), while K, Ca and Mg ranged from 0.18 to 1.05, 2.6 to 12.1 and 1.7 to 4.6 meq/100g, respectively (Figure 1.2.9a-c).

1.2.14. Mild Tropical Hill Zone (Figure 1.2.7): This zone represents a significant deviation from the zones already described falling within the altitudinal range of 200 to 800m with an annual average rainfall of 1400 mm, maximum temperature of 30°C and the minimum of 12°C. Rains start in May but maximum precipitation is received during July to September. Summers are hot and humid. The soils are similar to that found in sub-tropical hill zones ranging from sandy loam to clayey loam and acidic in reaction with high aluminium and iron content. pH of the region at Tamenglong ranges from 4.0 to 4.8, organic carbon 1.48 to 3.12% and available phosphorus from 2.49 to 8.19 mg/kg (Figure 1.2.8a-c). Among the exchangeable bases, potassium (K), calcium (Ca) and magnesium (Mg) ranges from 0.26 to 1.26, 2.85 to 5.15 and 1.01 to 3.26 meq/100g respectively (1.2.9a-c). The natural flora of the
Figure 1.2.5: Sub-tropical Plain Zone
Figure 1.2.6: (A) Temperature, (B) Relative humidity and (C) Rainfall in Sub-Tropical Plain Zone recorded at Lamphelpat during the years 2008 and 2009. (Source: Statistical Abstract, Manipur 2009, Dept. of Statistics, Govt. of Manipur).
Figure 1.2.7: Mild Tropical Hill Zone
Figure 1.2.8: (A) Soil pH, (B) Organic carbon and (C) Available Phosphorus at specific sites under different agro-climatic zones of Manipur (Source: Kailash Kumar et al., 1994).

Figure 1.2.9: (A) Exchangeable Potassium, (B) Exchangeable Calcium and (C) Exchangeable Magnesium in specific sites under different Agro-climatic Zones of Manipur (Source: Kailash Kumar et al., 1994).
zone may be divided into 3 broad groups- evergreen, deciduous and swamp out of which bamboo is the commonest (*Dendrocalamus hamiltonii*).
Chapter I-3

Botanical features, Systemic Position and Distinguishing Characters of Parkia roxburghii, G. Don
1.3.1. Botanical features: The genus Parkia is known to have 40 species widely distributed in tropical parts of the world, out of which 3 species occur in India (Willis, 1982). It is commonly known as “Tree bean” and belongs to the family leguminosae, sub-family mimosacae. It commonly grows in every house yard, jhums and forest in Mizoram, Nagaland, Manipur, Meghalaya and in the forest of cachar, North cachar hills and Sibsagar district of Assam (Kanjilal et. al., 1938). In Manipur it is found to grow luxuriantly in the valley as well as in altitudes as high as Maram (2000 msl). The other related species grown are P. intermedia Hassk and P. speciosa Hort. ex hassk (Sharma et. al., 1993).

1.3.2. The Tree: Tree bean is a perennial woody plant with spreading branches having white to brown or light gray bark with white spots. Its height at maturity varies approximately from 20-60 ft. or even more and spreads around 20-50 ft (Photo Plate-1.3.3:1-9). The inflorescence emerges during the months of June-July (Photo Plate-1.3.1.). The axillary bud does not develop fully but persist till the secondary bud develops and forms new shoots of the subsequent season. Flowering starts by the last week of July (Photo Plate-1.3.3:2-3). Setting of fruit starts after 10/15 days of flowering (Photo Plate-1.3.3:6-7).

1.3.3. Pods: Pods remain suspended on long heads (Photo Plate-1.3.3:8). The length of stalk, pod length, pod width, pod thickness, pod weight and number of seeds per pod are variable according to the pod and ranges from 4.5 to 15.0 cm, 17 to 40cm, 2.4 to 4.6cm, 0.3 to 0.7cm, 20 to 125 g and 10 to 25 seeds, respectively. The main botanical features of the plant are given below:

1.3.4. Leaves: Leaves are compound bipinnates i.e. the mid-rib produces secondary axes which bear the leaflets. There are around 500 to 3500 leaflets in a single leaf. The leaf has obtuse apex, smooth and free from hairs. (Photo Plate –1.3.1) Leaves are arranged in spiral or haphazard alternate fashion. It has 1/3 phyllotaxy i.e. the 4\textsuperscript{th} leaf stands over the first one.

1.3.5. Inflorescence: The inflorescence arises terminally. The main axis of the inflorescence does not terminate in a flower instead it continues to grow giving flower heads in also petal succession i.e. racemose inflorescence (Photo Plate-1.3.1). The axis or receptacle is suppressed almost like a butt bearing flowers on it hence it may be sub-grouped under the “Head” or “Capitulum” of the racemose inflorescence (Photo Plate –1.3.3:4).

1.3.6. Bracts: 4(four) foliacious bracts are present. They are free to each other. They protect the head when it is tender (Photo Plate-1.3.2). As the head develops, the growth of the bract ceases and falls before flowering (Photo Plate –1.3.3:1-2).
Photo Plate-1.3.1: Inflorescence of *P. roxburghii* with leaves showing the acropetal order of emergence of heads/capitulum.

Photo Plate-1.3.2: Magnified view of a young head of *P. roxburghii* showing bracts covering the head/capitulum.
Photo Plate 1.3.3. (1-9): Photo showing various parts of P. roxburghii plant (1= inflorescence; 2- 3= flower initiation; 4=full blooming ‘head’; 5= different flowers on the ‘head’; 6-7= fruit initiation; 8= matured pod and 9= plant with pods)
1.3.7. Involucre: As the head develops, 4 to 5 rounds of scaly bracts are seen around the head, just at the junction between the head and the axis. This may be termed as involucre and is a characteristic of the composite family.

1.3.8. Bracteol: At the base of every individual flower there is a very thin membranous structure called bracteol. When the head is young, it covers the individual flowers thereby imparting its brown greenish colour to the head. With the development of individual flowers, it pushes the bracteols aside and blooms.

1.3.9. Flowers: There are approximately 3000 to 4000 individual flowers in a head. As the individual flowers emerge on the head, three different types of flowers are noticed (Photo Plate-1.3.4.).

1.3.9.1. Flower -1: These flowers spread just after the stalk bordering the whorle of involucre and spread 1.0 cm to 1.5 cm around the head (Photo Plate-1.3.3:5a). They are approximately 500 to 600 in number. The main characteristics of the individual whorles are given below –

1.3.9.2. Calyx: 5 (five) sepals, petaloid, gamosepalous, zygomorphic and persist with the flower. The top portion is thicker and extremely hairy. It has embricate aestivation.

1.3.9.3. Corolla: 5 (five) petals, membranous, slender, polysepalous and zygomorphic. The petals attached to the tubular structure of the stamens somewhere about 2-2.5 mm above the calyx.

1.3.9.4. Androecium: There are 10 (ten) slender, whitish, about 19-22 mm long filaments. They are devoid of anthers staminode. The fused one another at the base and forms a tubular structure called staminal tube the tubular structure is around 5-8 mm in length after which the stamens are separated – monadelphous. Due to the extra ordinarily long whitish filaments, it gives a sort of attraction to the insects thereby facilitating the fertilization of the other flowers.

1.3.9.5. Gynoecium: Superior highly reduced. Flower as whole is sterile due to the absence of anthers and non development of ovary.

1.3.9.6. Flower -2: The flower-2 starts just after the flower-1 and extends upto a length of approximately 10-13 mm around the head. Normally, this portion cannot be seen from a distance as it is almost covered by the extraordinarily long filaments of the flower-1. These
Photo plate 1.3.4: Photo showing position of different flowers on the head of *Parkia roxburghii*.
flowers are also sessile and around 300-400 in number. They are about 1.5 to 2 mm shorter than the other flowers hence it gives a sort of constriction to the head (Photo Plate-1.3.3:5b). The characteristics of the individual whorles are given below –

1.3.9.7. Calyx: Same as flower –1(1.3.9.2).

1.3.9.8. Corolla: Same as flower –1(1.3.9.3).

1.3.9.9. Androecium: The number of stamens is the same with the flower-1. But in this case, the stamens are very short (6 mm). They are closely packed inside the petals and only the anthers are seen from outside. The anther is two lobed and has two chambers or loculi called the pollen sacs. The pollen grains/microspores are poorly developed. The ventral portion of the anther has a longitudinal groove running along the whole length of the anther. The filament attached to the anther from the dorsal side (dorsifixed) at the end of the connective tissue on which the two anther lobes are united. The connective tissue is brown in colour. The anther is stouter as with the flower. The filament is white, thick and tubular.

1.3.9.10. Gynoecium: Superior, highly reduced. These flowers also can not bear fruits due to non-development of anther and ovary.

1.3.9.11. Flower –3: The existence of flower stalk is found in this case and has a length of around 1 to 2 mm. It starts just after the flower –2 and covers all the bulging portion of the head. They are about 2400-2800 in number and thus far exceed other flowers in population (Photo Plate-1.3.3:5c). The characteristics of the individual whorles are given below –

1.3.9.12. Calyx: Same as flower –1(1.3.9.2).

1.3.9.13. Corolla: Same as flower –1(1.3.9.3).

1.3.9.14. Androecium: There are 10 (ten) stamens, with a length of 10-12 mm including the 4-6 mm tubular structure. The filaments are slender and brownish in colour. The anther lobes are thin and pollen grains are fully developed. Other features are same as with flower –2.

1.3.9.15. Gynoecium: Fully developed and has a length of around 8 to 12 mm. Out of this, the length of ovary is only 5 to 6 mm. The ovary is simple and has marginal placentation. It has a single stigma.

These flowers have fully developed anthers as well as gynoecium i.e. they are hermaphrodite and can bear fruits. Arrangement of the three types of flowers on a typical P. roxburghii
‘head’ leading to fruiting is shown at photo plate 1.3.4. The complete flower may be represented by the following floral formula –

\[ \Theta K_5 C_5 A_{10} G_1 \]

1.3.10. Seeds: Depending on the shape and size of the pod, number of seeds and size also varies. Seeds elliptical in outline and placed horizontally across the width of the pod. Testa of the dry seed is very hard and dark brown in colour. Seeding habit differs from pod to pod. Sometimes it is placed uniformly nearer to one side whereas in some other pods, it is placed in zig-zag fashion. However, in majority of the pods, seeds are placed centrally equidistant from both the sides.

1.3.11. Systemic Position: Out of the five species of Parkia, *Parkia roxburghii* is the most widely distributed plant in the Indo-pacific region. The other species which have limited distribution are *Parkia filicoidea* Welw. Ex Oliver; *Parkia speciosa* Hassk; *Parkia clappertoniana* Keay and *Parkia bicolor* A. Chev (Online In: GRIN, USDA). Due to its wide distribution, it has also been accessioned under different names (Synonyms) which are *Inga timoriana* DC.; *Parkia biglobosa* Auct. non (Jacq); *Parkia javanica* (Lam.) Merr. and *Parkia timoriana* (DC.) Merr. (Anon, 1981). According to Hopkins, (1983) its systemic position is placed as under:

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