CHAPTER-VII

GENERAL DISCUSSION AND CONCLUSION

The main objectives of present study were to estimate the biomass, soil 
\( \text{CO}_2 \) flux, carbon stock and rate of C-sequestration in bamboo ecosystem of Manipur, North East India. The bamboo forest is dominated by Schizostachyum per gracile.

The soil is clay loam in texture and acidic in nature. Soil colour is dark yellowish brown which indicate a well-drained soil and dark yellowish colour indicate the presence of high organic matter and iron oxide in the soil. The bulk density was found to be slightly higher in site I than in site II which may be due to the presence of high organic matter in the forest floor of forest site I.

The annual mean soil moisture increased with increase in the depth of soil in both the study sites. Soil Moisture and soil temperature was much higher in site I than that of site II which may be due to difference in the location of the stand and expose to the sunlight.

The soil organic carbon, total soil nitrogen and available soil phosphorus was found to be higher in the upper layer of 0-10cm soil layer and it decreases with the increase of soil depth in both the study sites which may be due to low
organic matter in lower layer. But reversed trend was observed in soil inorganic carbon with the increase of soil depth it increases. Seasonally maximum organic carbon, total soil nitrogen and available soil phosphorus was highest in rainy season followed by summer and winter season in both the study sites. The highest value in the rainy season may be due to a high temperature and moisture favouring the growth of microbes enhancing the decomposition of organic matter of plants and mineralization thus releasing nutrients to the soil. The lowest value in the winter season may be due to the low activity of microbes which hindered the process of decomposition. In case of soil inorganic carbon (SIC) it was minimum during the rainy season because of weathering and leaching of soil carbonates in the lower soil depth. The soil organic carbon, soil inorganic carbon, total soil carbon, total soil nitrogen and available soil phosphorus was recorded to be higher in study site I than in site II which may be due to higher culm density and biomass in site I which lead to high litter decomposition in the forest floor.

The aboveground biomass was recorded to be 118.96 and 165.24 Mg ha\(^{-1}\) and 101.93 and 146.84 Mg ha\(^{-1}\) in site I and II in 1\(^{st}\) and 2\(^{nd}\) year of the study period. Out of the total aboveground biomass, culm contributed the highest proportion followed by branch, leaf and litter across the two study sites. In both the study sites one year old culms contributed the highest biomass and then decreases with the increase of age class and similar finding was also reported by Nath et al. (2008) in village bamboo groove, Assam.
The belowground biomass of the bamboo forest of different age classes was 27.95 Mg ha\(^{-1}\) and 38.50 Mg ha\(^{-1}\) in site I for 2011 and 2012 respectively and 25.46 Mg ha\(^{-1}\) for 2011 and 35.69 Mg ha\(^{-1}\) for 2012 in site II. It shows that with the increase of age classes the belowground biomass also increased. Similar pattern was also reported for Bambusabambos in India (Shanmughavel and Franchis 1996).

The total biomass was recorded to be 146.91 Mg ha\(^{-1}\) and 203.52 Mg ha\(^{-1}\) in \(^{1}\)st year and \(^{2}\)nd year in site I respectively. In site II it was 127.39 Mg ha\(^{-1}\) and 182.53 Mg ha\(^{-1}\) in \(^{1}\)st year and \(^{2}\)nd year respectively. Out of total biomass aboveground parts contributed 81% and belowground contributed 19% in both the study sites.

The present estimates of the aboveground biomass and carbon stock were comparable with the data of Phyllostachyspubescens (Isagiet al. 1993 and 1997); Bambusaoldhamii (Mendoza et al. 2005); Yusania alpine (Embeyeet al. 2005); village bamboo grove (Nath et al. 2008 and 2009); Phyllosatakchysmakinoi (Yen et al. 2010) and Phyllostachyspubescens (Wang et al. 2013).

The annual total net productivity (TNP) were 62.43 Mg ha\(^{-1}\) in site I and 61.27 Mg ha\(^{-1}\) in site II. Out of the total annual TNP, 84.80% was contributed by the aboveground components and 15.20% by belowground components of the
bamboo ecosystem. The aboveground net productivity of bamboo sites of the present study is higher than the values reported for bamboo forest, bamboo plantation and village bamboo grove (Veblen et al. 1980; Singh and Singh 1999 and Nath et al. 2008).

The concentration of carbon in different components of aboveground and belowground biomass varied from 44.27 to 48.38% and 44.26 to 48.28% in Site I and II respectively. The carbon concentration of the different component was found in order of culm > rhizome > branch > and leaf across the two study sites.

The carbon stock in the aboveground biomass was recorded to be 55.59 Mg ha\(^{-1}\) in 2011 and 78.39 Mg ha\(^{-1}\) in 2012 in site I whereas in site II it was 47.93 Mg ha\(^{-1}\) in 2011 and 69.32 Mg ha\(^{-1}\) in 2012. The present data were comparable with the data reported for carbon stock in aboveground biomass in different bamboo forest ecosystems (Isagi 1994; Chen et al, 2009; Nath et al. 2009; Yen et al. 2010; Zhou et al. 2011 and Wang et al. 2013).

The carbon stock in below ground biomass was 13.30 Mg ha\(^{-1}\) and 18.28 Mg ha\(^{-1}\) in 2011 and 2012 respectively in site I whereas in site II it was estimated to be 12.09 Mg ha\(^{-1}\) and 16.96 Mg ha\(^{-1}\) in 2011 and 2012 respectively and are comparable to the data reported by Isagi(1994) on Phyllostachysbambusoides stands in Japan and less than reported by Tripathi and Singh (1996) on Dendrocalamus strictus in Uttar Pradesh.
Soil organic carbon (SOC) stock varied from 16.76 to 20.76 Mg ha\(^{-1}\) in forest site I across the soil depths and in forest site II it ranged from 14.36 to 19.88 Mg ha\(^{-1}\). Soil inorganic carbon (SIC) stock ranged from 4.77 Mg ha\(^{-1}\) (0-10 cm soil depth) to 6.79 Mg ha\(^{-1}\) (20-30 cm soil depth) in site I and 4.09 Mg ha\(^{-1}\) (0-10 cm soil depth) to 6.01 Mg ha\(^{-1}\) (20-30 cm soil depth) in site II. The soil organic carbon stock decreases with the increase of soil depth in both the study sites and similar trend were also reported by Zhou and Jiang (2004) on Phyllostachys pubescens bamboo forest and Nath et al. (2009) on village bamboo groove, Assam. Reversed trend was observed in soil inorganic carbon stock with the increase in soil depth, the SIC stock increases and similar trend was also observed by Bhalla and Gupta (2013). The SOC was found to be highest in the months of August and lowest in the month of January in both the study sites. This may be due to high rate of decomposition during the rainy season but reversed trend was observed in SIC as it was minimum during raining season as the weathering and leaching of carbonates present in the soil. However the SOC stock was higher than that of SIC in different soil depths in different months throughout the year.

The total carbon stock in vegetation and soil system was 148.83 Mg ha\(^{-1}\) and 131.55 Mg ha\(^{-1}\) in site I and site II respectively. Out of the total carbon in the vegetation/soil system 44.57 to 45.14% occurred in aboveground biomass, 10.58 to 11.05% in belowground, 1.94 to 2.14% in litter and the
percentage of carbon sequestered in soil was 49.13 to 49.84% across the study sites. Thus carbon storage is slightly higher in vegetation components than that of soil across the forest sites.

The total annual carbon sequestration was found to be 27.41 Mg ha\(^{-1}\) yr\(^{-1}\) and 26.54 Mg ha\(^{-1}\) yr\(^{-1}\) in site I and site II respectively. Out of the total carbon sequestered, aboveground components contributed 81.75% and belowground contributed 18.25%. Thus it shows that the aboveground components of bamboo vegetation sequestered more carbon than the belowground parts.

The data of the present study on aboveground C-sequestration were comparable with *Bambusabambos* (Das and Chaturvedi 2006) and village bamboo grove (Nath et al. 2008).

The total biomass, net production, carbon stock and rate of carbon sequestration was recorded to be higher in study site I than in site II which may be due to the higher culm density, and the total leaf area implying greater capture of solar radiation and hence more photosynthetic production as well as litter production leading to increase in total biomass accumulation which lead to an increase in carbon stock and rate of carbon sequestration.

In both the study sites, the biomass and carbon stock was comparatively higher in 2\(^{nd}\) year of study due to selective cutting of culm every year which
resulted in the growth of new culms and this attribute to the higher net productivity.

The rate of soil respiration was recorded to be maximum in rainy season and minimum in winter season in both study sites. During the rainy season the microbial activity increased owing to congenial environmental condition i.e. was very high due to high temperature and moisture which leads to the faster decomposition of litter and organic matter present in the soil thereby contributing to the high rate of emission of CO$_2$ from the soil. In winter season the growth of micro-organisms may be slow due to cool and dry period and thus affecting CO$_2$ emission.

The rate of soil respiration was higher in study site I than in site II which may due to high temperature, moisture and litter on forest floor in site I which may promote the growth of micro-organisms and rate of decomposition leading to enhance emission of CO$_2$ from soil.

The significant positive co-relation between rate of soil respiration and soil temperature, soil moisture and soil organic carbon which indicate that the rate of soil respiration is controlled by various factors and was in the order of soil temperature > soil moisture > soil organic carbon in the bamboo ecosystem of Manipur, North-east India.

Thus the bamboo forest can play a vital role in the reduction of atmosphere CO$_2$ and in mitigation of climate change owing to its high
productive potential in short span of life as compared to tree forest ecosystem. In conclusion the data generated on carbon stock, sequestration and soil CO$_2$ flux in the present study will be utilised in the preparation of carbon budget, carbon cycling and carbon credit of bamboo forest ecosystems of Manipur in particular and North East India in general.