CHAPTER -I

INTRODUCTION AND REVIEW OF LITERATURE

Forests play a significant role in capturing carbon dioxide from the atmosphere through photosynthesis, converting it to forest biomass and releasing into atmosphere through plant respiration and decomposition. Therefore forests contribute positively to global carbon balance. Carbon sequestration in forest soil and vegetation has been used to achieve greenhouse gas reduction target. Thus forests play an important role in climate mitigation and adaptation as well as the need for forest dependent people and forest ecosystem to adapt to this challenge. Forests maintain high carbon stock by reducing deforestation and promoting the sustainable management of all types of forests. Sustainable forest management provides an effective framework for forest based climate mitigation and adaptation.

Forests store more carbon dioxide than the entire atmosphere and the role of forests is more critical (Stern 2006). Carbon sequestration is an important part of an overall carbon management strategy to help in reduction and to mitigate global CO₂ emission. The United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto protocol have an international agreement on incorporation of forestry activities to this major
environmental challenge (Ramachandran et al. 2007; Yadava 2010). Global Environmental Facility (GEF), Clean Development Mechanism (CDM) and Reduced Emission from Deforestation and Forest Degradation (REDD) provide funds to reduce emission of CO$_2$ through forestry in the developing countries. Recently IPCC (2006) has also emphasized in understanding the role of forests in carbon capture and storage under anthropogenic change. Therefore it is essential to emphasize the understanding of carbon cycle scenario, its impact and its efficiency on sequestration options in natural ecosystems.

Bamboo forest ecosystem is an important part of forest ecosystem and an important carbon source and carbon sink on the earth. In bamboo forest ecosystem, through the mechanism of photosynthesis, bamboos turn CO$_2$ into organic carbon and store it has their structure part of which will store in the litters or in forest soil. Considering the respiration of microbes and decomposition of organic matter, the net primary production of bamboo forest is the key issue. In the natural forests of the tropics, bamboo spreads gregariously where there is disturbance by logging and shifting cultivation activities and the bamboos are the fastest growing plants, reaching their full height in two to four months and that branching begins as soon as culms reach their full height. So bamboo is very vigorous and dynamic in growth. Due to its rapid biomass accumulation and effective fixation of solar energy and CO$_2$ bamboo can sequester carbon within a very short time.
But since bamboo is botanically a grass and not a tree, many carbon accounting documents fail to include bamboo, or don’t consider bamboo within forestry. Bamboo therefore doesn’t adequately fit under the terminology for a ‘forest’ in either the Kyoto Protocol or IPCC. If bamboo were to be adequately recognised within ‘forestry’, bamboo could potentially occupy an important position in climate change mitigation, adaptation and sustainable development (Lobovikov and Lou 2009). To make this happen, more insights are needed in the potential contribution of bamboo to mitigate the climate changes.

Bamboo is not only an ideal economic investment but also has enormous potential for alleviating many environmental problems facing the world today. Bamboo being the fastest growing plant and having high productivity removes more carbon from the atmosphere in any given period. Bamboo accumulates biomass quickly and often the opportunity to maintain and increase carbon stocks through carbon sequestration. Biomass production, carbon storage and rate of carbon sequestration has been done in various species of bamboo in India as well as in the world but biomass accumulation varies with environmental anthropogenic and topographical factors form species to species. But studies on bamboo biomass are scarce (Veblen et al. 1980; Taylor and Zisheng 1987; Othman 1994; Mendoza et al. 2005; Embaye et al. 2005; Yen et al. 2010).
In India bamboo occupies 12.8% (Bahadur and Verma 1980) of the total forest area of the country comprising 22 genera and 136 species of bamboo (Sharma 1987). The North East India is recognised as one of the reserves of bamboo in India. Out of 136 species of bamboo in India 89 bamboo species under 16 genera grow naturally or cultivated in tropical and subtropical region of North East India (NMBA 2008) and 53 bamboo species are reported from Manipur (Anonymous 2010).

However a number of studies has been carried out on the carbon captured and storage in the forests of different regions of the world (Brown and Lugo 1982; Dixon et al. 1994; Lal and Singh 2000; Cairns et al. 2003; Sierra et al. 2007; Metzker et al. 2011; Sheikh et al. 2011; Hoover et al. 2012; Tanget et al. 2012; Ngo et al. 2013; Zhang et al. 2013). There are number of report available on carbon stock and storage in the Indians forests (Haripriya 2000; Chhabra et al. 2002; Chaturvedi et al. 2011; Gairola et al. 2011; Mohanraj et al. 2011; Sharma et al. 2011 and Devagiri et al. 2013) but there is limited information on the carbon capture and storage in the forest ecosystems of North East India (Baishya et al. 2009; Yadava 2010; Borah et al. 2013; Thokchom and Yadava 2013 and Yadava and Thokchom 2013).

Recently bamboo forests have been receiving greater attention as it can accumulate a large biomass in a short period and having a high productive
potential in sequestering CO$_2$ from the atmosphere. Studies on carbon stock and rate of C sequestration in bamboo forest of different part of the world has been undertaken by several workers (Isagi et al. 1994; Li et al. 1998; Zhou and Jiang 2004; Li et al. 2003; Xiao et al. 2007; Lou et al. 2010; Yen et al. 2010; Düking et al. 2011; Song et al. 2011; Yen and Lee 2011; Zhou et al. 2011; Wang et al. 2013; Guicang et al. 2013). Only a few reports are available for the belowground carbon stock (Isagi 1994; Zhou and Jiang 2004; Li et al. 2003; Zhou et al. 2011; Wang et al. 2013). In India limited information is available on the carbon stock and sequestration in the bamboo forests in India (Tripathi and Singh 1996 and Das and Chaturvedi 2006) but few studies were conducted in North East India (Nath et al. 2008, 2009 and Nath and Das 2012).

C storage in soil is the balance between the input of dead plant material and losses from decomposition and mineralization processes. Bamboo soil has an important implication in the manipulation of atmospheric CO$_2$. Soil is a mixture of various inorganic and organic chemical compounds and exhibits certain significant chemical properties. Soil pH largely controls plant nutrient availability and microbial reaction in the soil (Brady and Well 2008).

Forest soils can store large amounts of carbon that could be released to the atmosphere through deforestation and decomposition of organic matter (Houghton et al. 1983). Soil organic carbon (SOC) has been considered as an important factor for ensuring a stable ecosystem and sustainable development
The dynamics of SOC are important indications for soil quality, carbon (C) cycling (Bremer et al. 1995) and soil fertility. The soil inorganic carbon stock has the potential to help in the establishment of vegetation as well as sequestration of organic carbon in the soils (Bhattacharyya et al. 2004). The ratio of carbon to nitrogen of soil helps in determining the rate of decay and the rate at which nitrogen is made available to plants. An intense competition among microorganism for available soil nitrogen occurs when residues having a high C: N ratios are added to the soil (Brady and Well 2008). It is reported that greater the C: N ratio, lower would be the N control in the soil (Mishra 2011) and thus lower N availability to the plants. Lower C: N ratio shows nutrient rich soil (Arunachalam and Pandey 2003).

The physico-chemical characteristics were studied by several workers in different forest ecosystems (Kumar et al. 2011; Jehangiretal. 2012; Imora 2012; Joshi et al. 2013; Odewumietal. 2013;) and in Northeast India (Ramakrishnan and Toky 1981; Laishrametal. 2002; Barbhuiyaetal. 2004; Mishra 2011; Thapaetal. 2011). However limited studies have been done on the physico-chemical characteristics of bamboo soil (Chandrashekra 1996; Maillyetal. 1997; Arunachalam and Arunachalam 2002; Griscon and Ashton 2003; Embayeetal. 2005; Guo-Mo et al. 2006; Takahashi et al. 2007; Tripathiand Singh 2006 and Zhang et al. 2010).
A number of studies have been reported on the carbon stock and rate of sequestration in the soils of forest ecosystems (Ravindranath et al. 1997; Lal and Singh 2000; Chhabra et al. 2002; Ramachandran et al. 2007; Bhattacharya et al. 2010; Yadava 2010; Mohanraje et al. 2011; Sharma et al. 2011; Sheikh et al. 2011; Ullah and Amin 2012 and Choudhury et al. 2013). However, limited information is available on soil carbon stock in bamboo ecosystems (Isagi 1994; Tripathi and Singh 1996; Zhou and Jiang 2004; Nath et al. 2009; Dinakaran and Krishnaya 2010; Song et al. 2011; Yiping et al. 2010 and Zhou et al. 2011).

Soil respiration is also an important index of soil biological activity. It is a major component of the global fluxes of CO$_2$ (Schlesinger and Andrews, 2000) and an important component of CO$_2$ exchange between soil and the atmosphere. The response of soil respiration to climate change is likely to have a significant impact on the CO$_2$ sink strength of land ecosystem and on future atmospheric CO$_2$ concentration.

Soil respiration is a major process controlling the carbon budget of terrestrial ecosystems and increased carbon sequestration in an ecosystem may mitigate increasing atmospheric CO$_2$ concentration. The total global emission of CO$_2$ from soil is recognised as one of the largest fluxes in the global carbon cycle.
To date, many measurements of soil CO₂ efflux have been made in various ecosystems to estimate how much CO₂ is released from the soil and address the relationship between CO₂ efflux and environmental conditions.

Soil respiration varied in different ecosystems because of the influences of various environmental factors such as soil temperature (Peng et al. 2009; Fang and Moncrieff 2001), soil moisture (Dilusto et al. 2005; Moyano et al. 2013); nitrogen addition on soil (Tu et al. 2013); soil organic matter, roots, litter (Zhou et al. 2013); vegetation (Wang et al. 2011); topographic (Takahashi et al. 2011) and soil texture (Dilusto et al. 2005) on soil respiration. Among these factors, soil temperature and soil moisture play a very important role in speeding the rate of decomposition and mineralisation rate of organic matter by the activities of micro-organisms present in the soil and contribute to soil CO₂ efflux (Qi and Xu 2001 and Li et al. 2008).

In India, studies on the rate of soil respiration have been reported by several workers in different forest ecosystems (Singh and Gupta 1977; Rajvanshi and Gupta 1986; Laishram et al. 2002; Devi and Yadava 2008, 2009; Jha and Monapatra 2011 and Mohanty and Panda 2011). There is limited information on the carbon storage, rate of carbon sequestration and soil CO₂ flux in bamboo forests of North East India (Nath and Das 2011, 2012). However, there is no information on carbon pool in soil and vegetation and rate of carbon sequestration in bamboo forests of Manipur, North East
India. Therefore an attempt has been made to study the role of bamboo forests in carbon sequestration and its contribution at regional, national and global CO$_2$ level.

Thus the main objectives of the present study were to (i) assessment of soil and vegetation carbon pool and the rate of carbon sequestration, (ii) soil CO$_2$ flux in the bamboo forest ecosystem of Manipur and (iii) its interrelationship with biotic and abiotic factors of the environment.

The thesis is divided into eight chapters starting with chapter I-Introduction and review of literature; II-Description of the study sites and climate; III-Physico-chemical characteristics of soil; IV-Biomass and Net Productivity; V-Carbon Stock and Rate of Carbon Sequestration; VI-Soil Respiration; VII-General Discussion and Conclusion and VIII-Summary ending with references.