2.1. Biodiversity

2.1.1 International status

The most striking feature of the earth is the existence of life and its diversity. Topography, soil, climate and geographical location of a region, influence the vegetation diversity of the forest ecosystem **(Tilman, 2000)**. The biodiversity at landscape level in relevance to environmental context for northern Thailand and Sumatra, Indonesia was worked out by **Gillison and Liswanti (2004).**

Brown et al., (2006) observed the effects of an invasive tree community structure and diversity in a tropical forest in Puerto Rico and recorded potentially long-term changes in community structure, species composition. The tropical dry forests in Central America were examined by **Gillespie et al., (2000)** for their diversity, composition, and structure. Species richness and diversity of tropical forest were found frequently lower in mature forests than during regeneration phases as studies carried out by **Aide et al., (1996).**

The terrestrial environment provides evidence of functional importance of biodiversity to ecosystem processes, nutrient properties and ecosystem functioning **(Giller et al., 2004)**. The empirical studies of **Tilman et al., (2006)** support the hypothesis that ecosystems with high species diversity are more stable and resilient to environmental disturbances than those, which have low species diversity. **Stern et al., (2002)** studied the changes in composition and structure of a tropical dry forest in north western Costa Rica. Most tropical dry forests are less biologically diverse compared to tropical humid or wet forests, their threatened status and high endemism elevate their conservation value. As a result of rapid expansion of urban areas, due to increasing human settlements, the species composition of vegetation is getting changed **(Freeman et al., 2014). Gurevitch and Padilla (2004)** suggested that invasive species have been considered as the second largest threat to biodiversity globally after habitat destruction. Land-use changes, the resultant of increasing human population, has also been recognized as one of the major drivers of future changes in biodiversity **(Khamyong et al., 2003).** The conversion of tropical dry forest to agriculture and pasture still continues with an increasing rate in many parts of the tropics, and entails nearly total destruction of forest structure and composition, and disruption of ecosystem functions (**Maass et al., 1995)**. Degradation and conversion of dry forests are far more advanced than that of wet forests. According to **FAO (2001)** the deforestation has been variable in time and space and over the last 50 years it has shown an increasing trend. Tanzanian tropical forests were investigated for their species diversity, forest structure and species composition by **Huang (2003)** and it was disclosed that the restoration of species diversity occurs faster in the early and middle stages of the process of vegetation development. According to **Laloo et al., (2006)** the high rate of extinction of tropical species is aggravated by the conversion of forest land for agriculture, harvesting non timber forest products, extraction of mature trees and collection of fuel wood which threatens to erode the biodiversity seriously.

In present times the forest diversity is being lost because of rapid deforestation, fragmentation and degradation (**Kattan, 2002)**. **Collins et al., (1995)** argued that richness should be the highest at intermediate frequencies of disturbances when condition favours competitive species and those that tolerate disturbance. Thus, the intensity and frequency of disturbance are important determinants of plant diversity in a community.

2.1.2 National Status

India is one of the richest center for biodiversity in the world with 63.7 million ha of forest cover **(Anon, 1999).** The tropical forests of Mudumalai Wildlife Sanctuary, Western Ghats, India were investigated for their quantitative structure and composition by **Reddy et al., (2008). Devi and Yadava (2006)** studied floristic diversity assessment and vegetation analysis of tropical semi-evergreen forest of Manipur, North-East India and concluded that the diversity index of shrubs and herbs were found to be higher than the tree species. The diversity and population characteristics of woody species exposed to cultural disturbances in subtropical humid forests of Meghalaya were worked out by **Upadhaya et al., *(*2004)** and results revealed that the disturbance of mild intensity, to which these forests were exposed, enhanced species richness without altering tree population structure of the community. **Tripathi et al., *(*2004)** analyzed the community structure and species diversity of Saddle Peak forests of Andaman Island and concluded that size variation was more in foothill forest site showing the highest degree of asymmetry. The stand structure of a tropical dry deciduous forest in Badra Wild Life Sanctuary, Karnataka was studied by **Prakasha et al., (2008)** which supported the view that high species richness favours very good regeneration. The exploitation of natural resources by the local populations has resulted in depletion of the bio-diversity of forest communities

(Ramakrishnan, 2003). **Ram et al., (2004)** studied the plant diversity in six forest types of Uttaranchal, Central Himalaya, India and suggested that the anthropogenic disturbances, soil, water and climatic conditions play an important role in change, loss or maintenance of plant diversity of a region. **Sagar and Singh (2005)** studied the structure, diversity and regeneration of tropical dry deciduous forest of Northern India and concluded that these forests are strongly impacted by anthropogenic activities. In the past several decades, the dry deciduous forests covering most parts of central India are being converted into dry deciduous scrub, dry savanna and dry grasslands which are progressively species poor. **Kumar et al., (2006)** recently studied the tree species diversity and distribution patterns in tropical forests of Garo Hills, Meghalaya. They concluded that many tropical forests are under great anthropogenic pressure and require management intervention to maintain the overall biodiversity, productivity and sustainability. **Rasingam and Parathasarathy (2009)** studied the tree species diversity and population structure across major forest formations and disturbance categories in Little Andaman Island, India and recommended long-term monitoring of the species rich evergreen forests and the littoral forests which harbour the endemic tree *Manilkara littorallis* for biodiversity changes and forest dynamics. **Kharkwal and Rawat (2010)** recently studied the structure and composition of vegetation in subtropical forest of Kumaun, Himalaya. The function, distribution and occurrence of species in an ecosystem are affected by human interventions. Among human influence, commercial exploitation, agricultural requirements, forest fire and grazing pressure are the important sources of disturbance **(Singh & Singh, 1992)**. Various studies on tree species biodiversity, its loss and conservation in different forests of India have been carried out by several workers **(Kumar et al., 2004; Sharma et al., 2009; Anitha et al., 2007; Reddy et al., 2008; Nirmal Kumar et al., 2001, 2002 and 2010).**

2.1.3 Regional Status

Forest degradation is usually accompanied by species extinction, reduction in biodiversity and decrease in primary productivity. Consequently, there is a growing interest in quantifying habitat characteristics like forest structure, floristic composition and species richness in Indian forests. The forest structure, diversity and soil properties in a dry tropical forest of Udaipur, Rajasthan was worked out by **Nirmal Kumar et al., (2010)**. The effect of micro-environment and human disturbance on the diversity of woody species in the Sariska Tiger Project, Rajasthan was carried out by **Yadav and Gupta (2006)**. **Panchal and Pandey (2004)** analyzed vegetation of Rampara forest in Saurashtra region of Gujarat state of India. **Sinha and Ghial (1997)** inspected the ecological regeneration, biodiversity conservation and environmental restoration of the Thar Desert ecosystem in India.

2.2 Dry Matter Dynamics

2.2.1 International status

Dudley and Fownes (1992) and **Deans et al., (1996)** reported that the forest biomass studies have increased in the past several years as basic ecosystem data that are needed for the development of sound ecological land management and to predict the dynamics and productivity of the forests. Prior to, this biomass information in the world was rather limited in the tropical countries (**Neirynck et al., 1998; Bauhus et al., 2000). Brown (1997)** estimated biomass and biomass change of tropical forests of south and south East Asia. **Dinkelaker et al., (1995)** explained that much of the nutrient capital is present in the litter and surface soil layers and so roots proliferate there. The volume of soil that can be explored by a given root mass varies greatly between species and is related to branching patterns and specific root length.

Barrett and Gifford (1995) explained that in each environment nutrient concentrations vary between soil horizons, depending on the soil chemistry and may vary in time, depending on temperature and moisture. **Montagnini (2000)** studied the above-ground biomass, nutrient concentration of above-ground tree tissues, and soil nutrients in two young plantations of eight indigenous tree species grown in pure and mixed designs in a low fertility site in the humid lowlands of Costa Rica. **Santa Regina (2000)** studied the biomass estimation and nutrient pools in four plantations of *Quercus pyrenaica* in Salamanca, Spain and he concluded that the re-translocation of nutrients may satisfy a significant proportion of the demand for nutrients for the production of new biomass.

According to **Specht and West (2003)** the conifers tend to have a higher proportion of leaf biomass than broadleaved trees. The similar work by **Chave et al., (2001)** also showed a major percentage of total nutrient content in the leaves of conifers compared to broad leaved trees although nutrient concentration in the leaves of conifers is lower than in broad leaved trees. Deciduous trees have a number of advantages over conifers on abandoned agricultural land, when young they usually grow faster than conifers, they also improve soil conditions, have better wood quality. It seems to be a general observation that nutrient contents in tree compartments vary with the species. **Nambiar et al., (2000)** pointed out that forest floor biomass plays a significance role in structure and function of forest ecosystems by acting as a nutrient reservoir for the intra-system processes and improves the infiltration rate and water holding capacity of soils. However, the biomass and productivity of tree species vary from place to place due to variation in climate, soil, temperature and rainfall **(Onyekwelu, 2006)**.

Kimaro et al., (2007) studied the nutrient use efficiency and biomass production of tree species for rotational woodlot systems in semi-arid Morogoro, Tanzania and suggested that nutrient use efficiency and biomass production criteria in tree selection for rotational woodlot system management minimized nutrient export through wood harvests while maintaining site productivity.

Mixed plantations may be composed of fast-growing species with relatively high yields, while also containing slower growing species that have higher economic value thus providing a diversified source of income **(Binkley et al., 1992; Montagnini et al., 1995)**. **Son and Kim, (1998)** studied the above-ground tree component biomass and leaf area and analyzed plant tissue, forest floor and soils for major nutrient elements (N, P, K, Ca and Mg) in a 15-year-old ginkgo *(Ginkgo biloba)* plantation in central Korea.

2.2.2 National Status

Many factors can influence the accuracy of biomass estimation in tropical forests and are known to vary with soil type, soil nutrients, climate disturbance regime, successional status, topographic position, landscape scale and human impacts **(Clark & Clark, 2000).** The biomass, net primary production and impact of bamboo plantation on soil redevelopment in a dry tropical region of Singrauli coal field, Madhya Pradesh were examined by **Singh and Singh (1999)**. They concluded that with increasing age of plantation, a greater proportion of soil C, N and P tend to be immobilized in soil microbial biomass. Net primary production and the soil redevelopment process exhibited a positive feed-back relationship.

Rana et al., (2001) studied the biomass production in seven year old plantations of *Casuarina equisetifolia* on sodic soil. **Swamy et al., (2003)** studied the growth, biomass, carbon storage and nutrient (N, P and K) variations in one to six year old chrono sequence plantations of *Gmelina arborea* in three degraded red lateritic sites in central India. **Kumar et al., (2005)** studied the above ground biomass production and nutrient uptake of thorny bamboo forest of the Kerala. They suggested that nutrient export through harvest (NPK) varied among the tissue types with the highest in live culms, followed by leaves, twigs and dead culms. According to **Lodhiyal and Lodhiyal (1997a, 2003a)** the rising demand of energy from renewable sources has generated new ideas and turned attention to woody biomass production system. **Mani and Parthasarathy (2007)** studied the above-ground biomass estimation in ten tropical dry evergreen forest sites of Peninsular India and they recommended that above ground biomass distribution and wood specific gravity will be useful to assess potential production of the tropical dry evergreen forest sites as well as find strategies for helping in the conservation plan.

2.2.3 Regional Status

Above ground biomass studies in Indian tropical forested area using multi frequency DLRESAR data were carried out by **Nizalapur et al., (2010)**. **Nirmal Kumar et al., (2009)** observed quantification of nutrient content in the aboveground biomass of teak plantation in a tropical dry deciduous forest of Udaipur, India

2.3 Nutrient dynamics

2.3.1 International status

The trees take up large quantities of nutrients from the soil system (**Valdespino et al., 2009).** Although much of the nutrient uptake is returned to the soil through litter fall, large amount of nutrients are also removed when trees are harvested **(Cleveland et al., 2006; John et al., 2007).** Nutrient accumulation and the pattern of distribution in different plants are affected by climate **(Jobbagy & Jackson, 2001)** and by the type and age of the species **(Ranger, 1996)**. According to **Foster and Gross (1998)** nutrient availability is a major factor influencing the distribution of plant species. Most plants from low nutrient sites have a low nutrient requirement **(Liu et al., 2001).**

Reich et al., (1992) suggested that on the basis of above-ground biomass production relative to N uptake, deciduous forests have lower Nutrient Use Efficiency (NUE) than evergreen forests. However, NUE did not differ with forest type across local N mineralization gradients in mixed-species sequences, and was poorly correlated with foliar life span across diverse ecosystems. **Bockheim and Leide (1991)** studied the foliar nutrient dynamics and nutrient-use efficiency of oak and pine on a low-fertility soil in Wisconsin. **Deans et al., (1999)** studied the nutrient and organic-matter accumulation in *Acacia senegal* in semiarid region of UK and suggested that soil improvement is linked to growth of deep-rooted trees and shrubs which recycle plant nutrients from depth and also build up soil organic matter. **Zheng et al., (2008)** indicated that the key to success of Mimosoid trees in dry/saline environments is more likely to be attributed to their deep roots.

According to **Parrotta (1999)** nutrient availability is a major factor influencing the distribution of plant species. **Laclau et al., (2005)** suggested that plants growing on nutritionally deficient sites minimize nutrient loss by re-translocating a greater fraction of N and P from senescing leaves. According to **Palma et al., (2000)** seasonal variations in nutrient concentration and return are related to climatic fluctuations and/or changes in plant phenology, which in turn can affect later processes, such as decomposition, mineralization, and immobilization. **Laclau et al., (2003)** studied nutrient dynamics in *Eucalyptus* plantation at Congo, a small pool of nutrients circulating quickly in the ecosystem and made it possible to produce high amount of biomass in poor soil. According to **Kobe et al., (2005)** the evergreen and deciduous species share common functional relationships between senesced and green-leaf nutrient concentrations and simply occupy different ranges of the relationship.

Owusu et al., (2006) studied the nutrient cycling in primary, secondary forests and Cocoa plantation in the Africa. They suggested that nutrient cycling was better in the primary forest followed by the secondary forest and cocoa plantation. **Villella et al., (2006)** stud

ied the forest structure and nutrient cycling in a seasonally dry Brazilian Atlantic forest. An understanding of nutrient cycling processes is fundamental to the management of natural and disturbed vegetation growing on tropical soils of low fertility. **Ma et al., (2007)** recently evaluated the nutrient cycling and distribution in different-aged plantations of Chinese fir (*Cunninghamia lanceolata*) in southern China and they concluded that the evidence of productivity changes in successive rotations in tropical plantations is limited and often difficult to interpret due to confounding factors. The nutrient status of managed and natural forest fragments of *Fagus sylvatica* in Southern Europe was worked out by **Merino et al., (2008).** They recommended that nutrient status is related to the intensity of harvesting. Although the causes are uncertain, this negative effect may be due to a reduction in forest floor thickness, which implies the loss of preferred rooting space for trees.

Turner and Lambert (2008) worked on nutrient cycling in age sequences of two *Eucalyptus* plantation species in New South Wales Australia and they concluded that Calcium is a key nutrient and there is a risk of significant depletion of this nutrient especially in forests of smooth-barked species. **Inagaki et al., (2010)** examined nutrient dynamics through fine litter fall in three plantations in Sabah, Malaysia, in relation to nutrient supply to surface soil. The fine roots are the most significant component contributing to the forest ecosystem below-ground C fluxes, since up to 75% of the annual net primary production can be allocated into fine roots **(Majdi et al., 2005)**. Fine root biomass and fine root production have been estimated to vary between biomes **(Leuschner & Hertel 2003)**. The nutrient flows and stocks are important steps in the development of sustainable land use systems, especially on low-fertility soils of the humid tropics was studied by **Hartemink (2003).**

Sinsabaugh et al., (2005) examined soil microbial activity in a *Liquidambar styraciflua* plantation unresponsive to CO_2-driven increases in primary production and they concluded that the indirect response of soil micro biota triggers to the changes in plant physiology. **Okpara et al., (2005)** studied the role of soil organic matter in the retention of plant nutrients and emphasized the need for management strategies to maintain adequate levels of soil organic matter. **Witt et al., (2000)** found that the maintenance requirements for microbial biomass equal the total carbon input under steady or near steady-state conditions in terrestrial ecosystems. **Smith and Bradford (2003)** reported that the biomass of soil fauna of earth is nearly twenty times more than the biomass of human beings living on earth.

2.3.2 National Status

The productivity and nutrient cycling in Poplar (*Populus deltoids*) stands in central Himalaya, India was worked out by **Lodhiyal et al., 1994)** and they concluded that uptake of nutrients was found to be much greater in deciduous plantations than in evergreen plantations. **Mishra et al., (1994)** studied the distribution of organic matter and nutrients in different components of two *Acacia* species and subsequent nitrogen enrichment in lateritic soil. The high NUE is largely the result of higher soil nutrient availability, increased nutrient concentrations and amount of litter nutrient returned through litter fall to the soil. The variation in biomass and net primary productivity in short rotation high density Central Himalayan Poplar (*Populus deltoids*) plantations was worked by **Lodhiyal and Lodhiyal (1997**b**)** and they explained that the quantity of tree biomass per unit area of land constitutes the primary data needed to understand the flow of materials and water through forest ecosystems.

Sundaravalli and Paliwal (2002) studied the effect of *Albizzia lebbeck* plantation on the nutrient cycling in a semiarid grazing land in Madurai and they concluded that the effects of trees on the nutrient dynamics of grassland are limited. According to **Lodhiyal et al., (2002b) and Bargali et al., (1992b),** the survival of tree species and the rate of nutrient uptake depend upon the availability of water. They pointed out that trees take up large quantities of nutrients from the soil system, although much of the nutrient uptake is returned to the soil through litter fall and large amount of nutrients are also removed when trees are harvested. Nutrient distribution in the vegetation and soil compartments provide useful information on nutrient budgeting of the ecosystem **(Shanmughavel, 1995; Shanmughavel & Francis, 2001; Swamy et al., 2003). Bhattacharya et al., (2001, 2005)** measured the microbial biomass and enzyme activities in submerged rice soil amended with municipal solid waste compost and decomposed cow manure.

The effect of human-induced disturbance on fine roots and soil microbial biomass C, N and P dynamics in a tropical rainforest ecosystem of northeast India was worked out by **Dixit et al., (2008).** They disclosed that the soil microbial biomass and its activities are dependent on the quality, quantity and turnover of detrital organic matter in the forest floor. The Microbial Biomass (MB)-C, N and P in disturbed dry tropical forest soils of Vindhayan Plateau, India was carried out by **Singh et al., (2010)** and they revealed that the deforestation and land use practices (conversion of forest into savanna and grassland) caused the alterations in soil properties, which as a consequence, led to reduction in soil nutrients and MB-C, MB-N and MB-P in the soil of disturbed sites (grassland and savanna) compared to undisturbed forest ecosystems. **Deb et al., (2008)** carried out vegetation, soil and microbial biomass analysis of traditional agro forest and tropical forest in the foothills of Indian Eastern Himalaya. The Seasonal dynamics in soil microbial biomass C, N and P in a mixed-oak forest ecosystem of Manipur, North-East India was examined by **Devi and Yadava (2006).** They concluded that the contribution of microbial C, N and P to total soil organic C, total N and P indicates that microbial biomass is immobilized more in forest stand I in comparison to forest stand II.

2.3.3 Regional status

Yadav et al., (2011) evaluated the soil biological properties under different tree based traditional agro forestry systems in a semi-arid region of Rajasthan, India. They concluded that significant temporal variations in soil organic carbon, extractable P, NO_3-N and NH_4-N in an arid soil. The nutrient dynamics studies of the mangrove forest, Valmeshwar, near Narmada Estuary; West Coast of Gujarat were worked out by **Nirmal Kumar et al., (2011)** for *Avicennia marina.*

2.4 Litter decomposition

2.4.1 International status

The litter fall is a fundamental process in nutrient cycling and it means the transfer of organic matter and mineral elements from vegetation to the soil surface **(Rapp et al., 1999). Wang et al., (2007)** reported that the decomposition of litter is primarily driven by microbial activities and by environmental factors such as temperature and precipitation, as well as litter quality. As decomposer, microbes require nutrients from either litter material or surrounding soils to maintain their life activities. Soil nutrient availability has long been suggested as one of the controlling factors affecting the rate of litter decomposition **(Finzi et al., 2001). Berg and Matzner (1997)** found a positive response to N in the initial decomposition phase but a negative response in the later stages of decomposition. **Kwabiah et al., (1999)** suggested that responses of plant litter decomposition to soil nutrients were determined by litter quality. Litter decomposition rates are controlled by environmental conditions, the chemical composition of the litter, and by soil organisms (**Zheng et al., 1997; Sullivan et al., 1999).** However, soil chemistry and physical conditions can also influence the rate of litter decomposition **(Moretto et al., 2001)**. The decomposition of leaf litter is also an integral and significant part of biochemical nutrient cycling and food webs, this refers to both the physical and chemical breakdown of litter and the mineralization of nutrients **(Loranger et al., 2002)**.

The decomposition of leaf litter of four tree species in a sub-tropical evergreen broad-leaved forest, Japan was carried out by **Alhamd et al., (2004)**. It has been proved that the decay rate of newly shed litter is controlled by several major factors, i.e. litter quality **(Ribeiro et al., 2002),** site conditions including microbial community **(Liu et al., 2001)** or plant type **(Moretto et al., 2001)**. **Bayala et al., (2005)** evaluated the nutrient release from decomposing leaf mulches of *Vitellaria paradoxa* and *Parkia biglobosa* under semi-arid conditions in West Africa and they revealed that the pattern of leaf litter mass loss was verified by combining litter species or by using just one genus and few comparisons have been made about differences in mass-loss pattern among groups of foliar litter species along a broad climate gradient. **Bationo et al., (2007)** studied the soil organic carbon dynamics, functions and management in agro-ecosystems of West Africa. **Moore et al., (2006)** calculated the pattern of Carbon, Nitrogen and Phosphorous dynamics in decomposing foliar litter in Canadian forests. Long-term studies have indicated that the factors that best correlate with rates of early decay are often not the same as those that relate to long-term decay **(Yang & Janssen, 2002).** The different species have different nutrient release patterns, which are related to quality, season, and environmental factors was examined by **Sangha et al., (2006)**. **Dent et al., (2006)** observed that rates of litter decomposition responded to both the litter quality and its decomposition environment and the most nutrient rich litter decomposed most quickly in all environments. However, increased water availability and high soil fertility in the alluvial forest habitat resulted in the fastest rates of litter decomposition. Similarly **Villela and Proctor (2002)** also suggested that the variation in water availability can affect nutrient cycling via increased litter fall during wet periods and decreased decomposition rates during dry periods.

2.4.2 National Status

The tropical environment and the climatic seasonality characterized by alternating wet and dry periods play a vital role in regulating the rates of litter decomposition by changing the population of microbial community on decomposing organic matter **(Tripathi & Singh, 1992). Arunachalam et al., (1998)** worked on decomposition dynamics and N and P mineralization patterns of leaf litter in humid subtropical region of India. They emphasized that tree and shrub leaf litter decomposition varied depending on species and type of soil. The litter fall, leaf litter decomposition and N and P release were studied in four tree species (*Dalbergia sissoo*, *Azadirachta indica*, *Pongamia pinnata and Shorea robusta*) planted on a mine spoil habitat at Singrauli, Madhya Pradesh, India by **Singh et al., (1999)** which provided the guidelines about the suitable species to be planted and their possible impact on the reestablishment of nutrient cycling. The leaf litter production, litter decomposition, litter chemistry, influence on soil biological activity and other aspects of soil fertility were examined by **Parrotta (1993). Pande et al., (2002)** evaluated litter production and nutrient return in tropical dry deciduous teak forests of Satpura Plateau in Central India and observed higher leaf fall, nutrient concentration and higher nutrient return to the forest floor. **Pragasan and Parthasarathy (2005)** studied the litter production in tropical dry evergreen forests of Coromandel Coast, South India in relation to season, plant life forms and physiognomic groups. **Singh and Kashyap (2007)** evaluated the seasonal variations in soil N-mineralization and nitrification of dry tropical forest and savanna ecosystems in Vindhyan region, India. They reported soil moisture as the important factor controlling N-mineralization and nitrification at sites. The leaf litter decomposition of dominant tree species of Namdapha National Park, Arunachal Pradesh, North-East India was carried out by **Barbhuiya et al., (2008)**. They recommended that early decomposition is regulated by nutrient concentrations (especially N and P) whereas the late-stage decay is regulated by lignin concentration.

2.5 Carbon sequestration

2.5.1 International status

Forests store substantial amounts of carbon. The amount stored, however, changes over a time period as forests grow and die. Land use changes and forestry practices alter the level and rates of carbon storage, while "leakage" (shifting production) may offset some of the increases in forest carbon sequestration **(Ramseur & Gorte, 2009).** The clearing of tropical forests also destroys globally important carbon sinks that are currently sequestering CO_2 from the atmosphere and are critical to future climate stabilization **(Stephens et al., 2007)**. **De Fries et al., (2005)** concluded that forests represent tremendous reservoirs of carbon (C). Over half of the world's terrestrial organic soil and vegetation are currently resident in forests with one half of this in boreal forests alone. The estimation of carbon stocks in different above ground parts, root biomass is typically estimated to be 20% of the aboveground forest carbon stocks (**Mokany et al., 2006; Ramankutty et al., 2007**). Similarly, dead wood or litter carbon stocks (down trees, standing dead, broken branches, leaves, etc) generally assume to be equivalent to approximately 10-20% of the aboveground forest carbon estimate in mature forests (**Delaney et al., 1998; Achard et al., 2002**).

MacKinnon and Vold (1998) suggested that management of lower productivity forests for timber can lead to increases in total C storage (ecosystem plus wood products) in systems. **Gibbs et al., (2007)** suggested that the reducing carbon emissions from deforestation and degradation in developing countries are of central importance in efforts to combat climate change. The conversion of old boreal forests to young plantations or managed forests also generally contributes CO_2 to the atmosphere **(Roshetko et al., 2002)**. Although the magnitude of this contribution depends on a range of factors, including the silvicultural system and rotation length used (**Chave et al., 2005)**. **Kurz et al., (1997)** studied the humid tropics maximum potential in carbon sequestration achieved by focusing on increasing aboveground biomass in woody vegetation rather than as soil carbon, given the smaller pool size of soil organic matter and short mean residence time.

2.5.2 National Status

Ravindranath et al., (2001) worked on sustainable biomass production and carbon sequestration in India. As per studies of Indian Institute of Science, Bangalore and model based projection of carbon stocks in India's forests and tree cover, estimates increase in carbon stocks as contained in the country's forests from 8.79 Gt C in 2005 to 9.75 Gt C in 2030. **Kaul et al., (2010)** evaluated carbon storage versus fossil fuel substitution, a climate change mitigation option for two different land use categories based on short and long rotation forestry in India. **Kaul et al., (2009, 2010)** worked on net carbon flux caused by deforestation and afforestation in India over the period from 1982 to 2002, separately for two time periods, 1982–1992 (PI) and 1992–2002 (PII), using the IPCC 2006 guidelines for greenhouse gas inventories. A dynamic growth model (CO_2FIX) was also used for estimating the carbon sequestration potential of Sal (*Shorea robusta* Gaertn. f.), Eucalyptus (*Eucalyptus tereticornis* Sm.), Poplar (*Populus deltoides* Marsh), and teak (*Tectona grandis* L.) forests in India. **Jana et al., (2009)** examined carbon sequestration rate and aboveground biomass carbon potential of four young species. They concluded that the results were lower than the previous works done by different scientists, may be due to consideration of one tree from each species, very young ages plant, only aboveground biomass carbon considered, chosen similar agro-climatic areas for study or similar soil characteristics. A Strategy for Sustainable Carbon Sequestration using Vetiver (*Vetiveria zizanioides* L.), a quantitative assessment over India was worked out by **Singh et al., (2011)**. They pointed out that plantation of Vetiver as an inter-crop in short rotation forest plantations and in agro-forestry systems can provide significant lift to the rural economy without any adverse effect on the eco-system. Based on a number of estimates it is suggested that utilization of waste and degraded lands and social forestry systems for Vetiver plantations can provide multiple benefits including significant carbon sequestration in India. According to **Lal, (2004)** the carbon sink capacity of the world's agricultural and degraded soils is said to be 50–66 percent of the historic carbon loss from soils. The rate of soil organic carbon sequestration with adoption of recommended technologies depends on soil texture and structure, rainfall, temperature, farming system, and soil management.

2.5.3 Regional status

Carbon sequestration potential of the soil of Gir forest, Gujarat was worked out by **Patil et al., (2010)** and they revealed that the higher amount of carbon sequestration occurs in surface layer of the soil. **Kiran and Kinnary (2011)** studied the carbon sequestration of urban trees on roadsides of Vadodara city and suggested need for more roadside plantation to retrieve the 88% effect of emitted carbon.