The objective of the present study is, ***to correlate the aboveground biomass (AGB) and corresponding soil organic carbon content (SOC) across forest covers of Gujarat.*** All the results obtained from the study are discussed with relevant literature for supporting the observations. The conclusions of the study are derived from a holistic approach with pertinent supporting literature.

There is an increasing interest in estimating forests' biomass, as the world's forests play a major role in regulating nutrient and carbon cycles. Woomer et al. (2000) have reported that the presence and arrangement of woody biomass governs the approach to aboveground carbon measurement within an ecosystem. The present study followed a ground-based field data and its analysis approach to estimate AGB in Gujarat forests. Baseline carbon stock data (mainly from AGB and SOC) are key factors for proper implementation of global carbon cycle models. Keith et al. (2010) have reported that evaluating contributions of forest ecosystems to climate change mitigation requires well-calibrated carbon cycle models with quantified baseline carbon stocks. The potential impact of AGB on SOC stocks across natural and altered forest plots is very sketchy. Also, the influence of rainfall on the AGB and SOC and their relationship in tropical deciduous forests are poorly understood. The present study is an attempt to describe the relationship between AGB and SOC for an Indian tropical forest ecosystem. Further, an attempt has been made to understand how these parameters respond to varied rainfall (across RFZs 1–4) and soil properties. Estimation of AGB and SOC is very important because biomass production in forests is likely to increase as a consequence of elevated atmospheric CO_2 concentrations, rising temperatures, and shifting rainfall patterns. As AGB represents a major flux of carbon from vegetation to soil through litter decomposition, changes in litter inputs are likely to have wide-reaching consequences for soil carbon dynamics. Such disturbances to the carbon balance may be particularly important in the tropics because tropical forests store almost 30% of the global soil carbon, making them a critical component of the global carbon cycle (Sayer et al., 2007). Takahashi et al. (2007) have reported that soil carbon quantities are a result of the balance between carbon input to the soil (basically through plant litter) and the decomposition of organic carbon in the soil. In addition, improved understanding of carbon sequestration and AGB–SOC relationship across four RFZs having varied tree species and tree density across Gujarat will be helpful in conservation and management practices by the state forest department.

4.1. Vegetation covers across rainfall zones

The study area falls under semi arid to tropical dry and wet conditions (Koppen's classification system 1931). Numerous kinds of forest types are seen across study area including moist mixed deciduous forests, dry deciduous scrublands, and dry tropical riverine forests. Forests play an important role in regional and global carbon cycles because they store massive quantities of carbon in vegetation and soil. Photosynthesis and respiration are sources of atmospheric carbon when they are disturbed by human or natural causes, become atmospheric sinks during regrowth, and can be managed to sequester or conserve significant quantities of carbon on the land (Brown et al., 1999). In the present study, along with natural regeneration of the trees across the zones, several plantations of native and alien species was also noticed. Many of the laid down sample plots were located at a Sanctuary, National park, other protective areas, which having minimal human influence. LULC across all the zones were different. Prominent species utilised for extensive plantation are Teak, Bamboo, and *Prosopis*. Amongst these, Prosopis has taken attention as it is most widely spread (especially in RFZ – 1 and 2) and provides nearly 75% of the fuel-wood to the rural people in these regions of Gujarat (Forests and Environment Department unpublished records). Pande (2005) reported that plantation of target species in the blanks inside the forest created by disturbances improves the productivity, and balances the structure of forest ecosystem coming from invasion of species over a period of time. Vegetation covers of RFZ – 3 and 4 showed diverse vegetation that are covers with lesser plantations by federal government agencies. Plantations (specifically of broad leaved, economically important species) across disturbed regions of tropical forests of these RFZs (3 & 4) are assisting in the maintenance of both AGB and SOC levels. The understanding from the data is that the plantation activities are having a positive impact on these destabilized forest covers. It was reported earlier (Guo and Gifford, 2002) that as the age and size of stand trees increases, stability of the system becomes better. Paul et al. (2003) concluded that under plantation, as the stand develops, long-term soil carbon accumulates. Higher soil carbon values for old plantation plots across RFZs 3,4 from this study are in tune with these findings.

Differences seen in the mean annual precipitation (MAP) of RFZs 1–4 indicate the broad range of precipitation received by these RFZs annually. These differences showed a distinct demarcation on the diversity and distribution of forest tree cover across the four RFZs. The study area is rich in biodiversity. Trees observed showed significant diversity in habit, habitat and species diversity across the rainfall gradient. While some of the trees species found across the study area and are common to RFZs 1–4. A few tree species were successfully adapted to the varied rainfall found across all the RFZs while some of the species were found to be very specific to particular region. This added to the biodiversity and adaptability variability across the RFZs. Observations on the dominant trees across RFZ–1 and 2 showed their adaptability to water scarcity by having smaller leaves, open canopy, short stature with relatively slower growth. Greater representation by *Prosopis* in these zones indicate its suitability to grow better in these zones. Dominant trees of RFZ–3 and 4 are distinct in their habit having broad leaves, thick and wide spread canopy and robust growth. These tree forms are comparable with tree species reported earlier for semi arid and tropical dry forests with similar range of rainfall (Jha et al. 2010; Chaturvedi et al. 2011; Conti and Diaz 2013). Results of this study showed that the rainfall dynamics influenced plant diversity and density. Density and diversity of trees were lesser in RFZ–1 and the highest at RFZ–4 showing a linear relationship with MAP. More rainfall brings more diversity, as is evident at RFZ–4 with 6 times more diverse trees than of RFZ–1. Density of trees per unit area in forest ecosystem fairly influenced by rainfall received by unit area. Tree density found to be about two fold higher at RFZ–4 compared to RFZ–1 is evident. The density values of trees are in coherence with earlier reports (Chave et al. 2005; Patil et al. 2012) for areas with similar rainfall range. Density of the trees positively correlated with species diversity across RFZs reemphasizing the importance of diversity on the functioning of tropical systems. Tree density values in this study for the DBH class 9.7–12.8 cm for RFZs 1–3 are comparable with those reported by Chaturvedi et al. (2011), while RFZ–4 showed about three fold higher tree density values from those reported by Chaturvedi et al. (2011) for similar rainfall receiving tropical forests. Results of the present study showed that RFZ–1 with lesser rainfall was dominated by trees with lower DBH (3–10 cm) accounting for about 85% of total trees. The enumeration data of this study revealed that more than 60% of the trees at RFZ–4 are having high DBH (>10 cm). This suggests that there is potential influence of rainfall on tree growth as DBH values increased with an increase in MAP. These findings are comparable with Slik et al. (2010), who reported a positive correlation between DBH and MAP. These findings are significant as DBH of a tree is directly correlated to the volume and subsequently to the carbon stored in tree trunk. Chaturvedi et al. (2011) reported that most of the carbon (88-97%) resides in the old-growth (high DBH) trees, and therefore extra care is required to protect such trees in the tropical dry forest. Greater proportion of trees with lower DBH at RFZ–2 reiterates the importance of MAP on the growth and biomass accumulation of trees in semi arid to tropical dry conditions. DBH values across the four RFZs in this study match with the data reported earlier for Indian tropical forests with similar MAP (Chaturvedi et al. 2011; Patil et al. 2012). However, the range observed for DBH values (3.2–113.9) of RFZ–4 in this study was higher compared to the ones reported by Chave et al. (2005), who reported DBH values in the range of 5–34.7 cm for tropical dry forest of India with similar rainfall (1200 mm).

4.2. Above-ground biomass and rainfall variability

Tropical forests dominate the terrestrial biospheric carbon cycle due to their large pools and fluxes (Chhabra and Dadhwal, 2004). Above-ground biomass (AGB) is a key component to understand carbon cycle across tropical forest ecosystems. Several studies have estimated AGB by field survey compiled with volumetric/biomass equations (Chaturvedi et al., 2011; Gairola et al., 2011), while some studies have done it by using Remote Sensing data (Bijalwan et al., 2010; Chhabra and Dadhwal, 2004). AGB estimates in the present study were obtained by tree species specific volume based allometric equations by using biophysical data and wood specific gravities for individual trees. From one of the two commonly followed approaches (volume based allometric equations, and Remote Sensing based models), the growing stock volume based approach gives more reliable carbon pool estimates as they are based on large field surveys (Chhabra and Dadhwal, 2004). Estimates of the AGB of trees are most commonly obtained through the use of allometric biomass equations which relate one or more measured variables (e.g. tree diameter) to total AGB (Ciais et al., 2011). AGB values recorded in this study coincide with the ones reported for tropical dry forests in India (Chhabra and Dadhwal 2004; Bijalwan et al. 2010; Chaturvedi et al. 2011). AGB data in this study also matches with the remotely sensed values reported by Saatchi et al. (2011) in their benchmark map of forest carbon stocks in tropical regions across three continents. In this study, values of AGB across RFZ–4 is getting matched for one of the districts falling in the same rainfall zone reported by Patil et al. (2012) who compiled the AGB values from remote sensing and ground based data for similar DBH range and density values. AGB values for Indian temperate forests (Gairola et al., 2011) are quite high compared to the values in this study. The AGB values in this study fall in the range of global data (Haberl et al., 2007; Saatchi et al., 2011) reported for tropical forests. Mean AGB values for districts across RFZs 1–4 coincide with previously reported data for Indian tropics (Chhabra, 2002). Bijalwan et al. (2010) reported slightly higher AGB values than those of RFZ–3 and lower than those estimated at RFZ–4 for similar rainfall receiving tropical forests in India. The AGB values fall in the range of global data sets reported for tropical forests with similar rainfall (Saatchi et al. 2011; Feldpausch et al. 2012). Becknell et al. (2012) reported two to three folds higher AGB values for higher rainfall receiving tropical forests than those reported in this study. The dry deciduous forests has a significant higher average than the moist forest, though one should expect it to be vice versa. The FAO reported reference values for potential biomass density in those ecological zones with 450 Mg ha^{-1} for moist forest and 250 Mg ha^{-1} for dry forest across Asia. Values from the present study for dry deciduous covers are comparable with this report.

AGB values in this study were found to be largely influenced by tree density, diversity biophysical parameters, and annual rainfall. Bijalwan et al. (2010) reported higher AGB values for more diverse mixed forests than single species plots. Higher AGB recorded at more diverse RFZ–3,4 than less diverse and even single species plots from RFZ–1,2 supports this findings. Variations seen in vegetation cover across RFZs showed a direct impact on AGB values. It was reported earlier that tree species with their differences in canopy spread, height, and GBH influence AGB (Pande 2005; Chaturvedi et al. 2011; Feldpausch et al. 2012). Chave et al. (2005) reported that the most important predictors (in decreasing order of importance) of AGB of a tree are, its trunk diameter, wood specific gravity, total height, and forest type (dry, moist, or wet). AGB values recorded in this study (across RFZs) were affected similarly with the trees' characteristics (height, DBH) reaffirming the inferences of earlier studies. Contribution of trees to total AGB in all the plots was much higher (~95%) as compared to that of herbs and shrubs together (~5%). Similar values had been reported earlier for trees (>93%) and shrubs & herbs (<7%) in tropical deciduous forests (Pande 2005). The AGB at RFZ–4 was about 40 times the AGB recorded for the RFZ–1. Becknell et al. (2012) reported that over 50% of the variation in AGB could be explained by a single climatic variable, MAP, in seasonally dry tropical forests. Similar conclusion can be drawn from the data set of this study. Logarithmic trend line between MAP and AGB showed an increase in AGB values with an increase in MAP. Increase in MAP has differed impact across RFZs 1–4. The impact is higher at RFZ–1 and 2 as compared to RFZ–3 and 4. It can be inferred that identical increase in MAP has higher positive impact on AGB at RFZ–1 as compared to RFZ–4. Rainfall is the climatic variable clearly affecting forests' productivity and nutrient cycling (Condit et al. 2013). It was reported (Slik et al. 2010) that climate (rainfall and rainfall seasonality), can have a profound impact on AGB. The data set in this study indicates that rainfall has significant influence on AGB, coinciding with these findings and with the inferences of recent studies (Chave et al. 2003; Schmidt et al. 2011; Yang et al. 2014).

Amongst these, *Prosopis* is one of the widely spread (especially in RFZ–1 and 2) species and contributes significantly to the AGB of RFZ–1. *Prosopis* is currently considered as an invasive species for a major part of RFZ–1 and 2. The scanty MAP of RFZ–1 is not conducive for the growth of native species. Easy establishment of *Prosopis* in RFZ–1 would positively augment AGB of these areas. Plantation of target species in the blanks inside the forest created by disturbances improves the productivity, and balances the structure of forest ecosystem due to invasion of local species in due course of time (Pande, 2005). Observations indicate that systemically planted trees showed higher density but lower AGB than those with higher DBH with less dense naturally growing sites. It is seen from the results of this study that plantations did increase the AGB values compared to non-planted area with similar DBH range. This is similar to the findings of Kauffman et al. (2009) and Pande (2005) across the tropics. Relatively higher MAP of RFZ–2 is suitable for some of the native species. Vast differences were observed in the AGB values of RFZ–2 plots dominated by *Prosopis* or native species indicated the negative impact of this invasive species at RFZ–2. Effective management of *Prosopis* would ensure the better distribution and establishment of other species. Yang et al. (2010) raised concerns about sustainable soil productivity due to forest management practices of larch plantations. A similar inference can be made for the spread of *Prosopis* at RFZ–2. Vegetation covers of RFZ–3 and 4 showed species that are naturally diverse and others altered by plantations. MAP of these zones supported larger diversity and better growth of the trees. This resulted in larger AGB values of these plots.

4.3. Soil Properties

4.3.1. Physical properties of soil

According to Shi et al. (2009), soil properties may vary greatly depending on soil types, topography, climate, vegetation and anthropogenic activities. In the present study, soil properties (physical, chemical and biological) varied (except soil pH) significantly at various depths and between four RFZs. It indicates that across RFZs different vegetal covers have an impact on soil properties. Higher AGB values of RFZ–4 can be attributed to this feature because of its better water holding capacity, soil biological activity and nutrient supply. Soil pH values at different depths of soils across RFZs are comparable with earlier studies in tropical forests (Moraes et al., 1996; Johnson and Wedin, 1997; Paudel and Sah, 2003). Soil pH values at different depths does not show significant differences. An earlier study (Laik et al., 2009) also did not find any significant change in pH values at two different depths of different plantations supporting observation of this study. Soil pH values observed at different depths are more or less similar to earlier studies (Balagobalan et al., 1991; Shukla, 2009; Keel, 1975; Cheng et al., 2004). Particle size distribution is a fundamental physical property of soils (Skaggs et al., 2001). Soil system consists of two different fractions; they are 1) coarse-earth fraction (>2 mm in size) such as gravels, cobbles, boulders and other fragments of a soil and 2) the fine-earth fraction such as sand (>0.05-2 mm), silt (>0.002-0.05 mm) and clay (<0.002 mm) (Carlile et al., 2001; Lesikar, et al., 2005). Variations have been found in soil texture across the RFZs at different depths. It was observed that sand fraction in soil significantly influences SOC values across the RFZs. Lower rainfall districts are comprised of high fraction of sand particles across RFZs 1,2. Higher rainfall regions of RFZs 3,4 are rich in silt and clay. Sand fraction values of this study match with those reported by Chaturvedi et al. (2011) (up to 25 cm from surface). Higher silt and clay fractions with proportional sand fractions would enhance water holding capacity of the soil, which is reflective in AGB values. Here drainage of water in deeper layers is slower. Fraction of sand has an impact on SOC values. A few sites with high AGB & high sand fraction showed very low SOC. Some part of soil carbon may lose its physical protection after land use changes from forest and pasture to plantation.

4.3.2. Biological properties of soil

Across the RFZs, MBC was significantly higher at 0–5 cm as compared to 20–25 cm, as fresh litter inputs into the top layer have large quantities of easily decomposable organic matter, priming microbial activity. Schmidt et al. (2011) reported that microbial activity may be reduced by suboptimal environmental conditions, energy scarcity, lesser availability of organic matter because of its sparse density or association with reactive mineral surfaces. Similarly, results of this study indicated easy availability of organic matter in the form of litter on top layers of soil, and the decreasing availability of the same in deeper layers of soil have a negative impact on microbial growth and existence. Lower MBC values seen at RFZ–1 and 2 and the linear correlation of MBC to SOC can be attributed to the factor reported by Moorhead and Sinsabaugh (2006) that soils may sequester more carbon either by slower decay rates or by larger organic (litter) inputs.. AGB and MBC did not show any correlation either at 0–5 cm or up to 25 cm depth ($R^2<0.3$) across RFZs. This indicates that soil microbial activity is more affected by SOC rather than AGB in these tropical forest covers. This is in similar line with the earlier study that reported availability of carbon has been assumed to be the most common limiting factor for microbial growth in soil (Demoling et al. 2007). Similarly, in this study, higher MBC values of RFZ–3 and 4 (as compared to RFZ–1 and 2) are attributed to their litter diversity (through tree species richness) and higher SOC values. This indicates about how LULC, vegetation dynamics influence the functional microbial activities in the soil. It was reported earlier (Yang et al. 2010) that plantation area supports lesser MBC as compared to natural secondary forests. Results of the present study coming from RFZ–1 and 2 are in congruence with these findings.

4.4. Soil organic carbon

Soil organic carbon (SOC) content up to 25 cm depth from top layer is in accordance with the earlier reports (Jobbágy and Jackson 2000; Chhabra and Dadhwal 2004; Pande 2005; Fontaine et al. 2007; Chaturvedi et al. 2011) for tropical forests. SOC in top layer of soil (0–5 cm) are comparable to earlier published data (Dinakaran et al., 2008; Assad et al., 2014). SOC values for 0–25 cm depth in this study are higher across RFZs 3–4 and lower across RFZs 1–2 than the published data (Yang et al., 2010; Usuga et al., 2010; Shung et al., 2010) for tropical forests with similar rainfall. Higher SOC content in the top layer (0–5 cm) across the RFZs reflects the fact that, these top soils contain high organic matter content associated with large carbon stocks in the soil profile, where the highest carbon volume is accumulated in the system (Usuga et al., 2010). Russell et al. (2007) found the effects of different types of tree species on SOC in the surface layer of tropical moist forest, which is also seen in the present study, as highly diversed plots of RFZs 3–4 showed more SOC than the lesser diverse RFZs 1–2, adding to the fact that diversity positively affects the carbon sequestration across tropics. SOC stock in any forest ecosystems is controlled by physical, chemical and biological properties of soils. SOC stock with a depth interval of 5 cm showed how SOC movement across the soil system differs through the RFZs and different vegetation compositions. A steep fall in the SOC content was observed at 15 cm and at subsequent depths (20 and 25 cm) the decrease was much lesser. This is an indication of higher biological activity associated with top layers reflecting greater degradability of SOC at these depths. Values were significantly different across RFZs 1–4. In a similar manner, Giardina and Ryan (2000) reported significant differences in SOC decomposition across different vegetation covers due to substrate availability. In this study variations in tree diversity and density, along with rainfall variation brought in different substrates with variable chemistry and decomposability leading to SOC dynamics across RFZs.

As the largest pool of terrestrial organic carbon, soils interact strongly with atmospheric composition, climate, and land cover change (Jobbagy and Jackson, 2000). SOC should be described by quantifiable environmental characteristics governing stabilization (Schmidt et al., 2011). In their analysis, Jobbágy and Jackson (2000) mentioned that the effect of vegetation type was more important than the direct effects of precipitation. Clearly, however, correlation analysis between AGB–SOC and the variation in SOC values across rainfall gradient (RFZs 1–4) show both vegetation type and precipitation have an important role in the regulation of SOC in tropical soils. Similarly in a previous study, Chaturvedi et al. (2011) reported a positive relationship between AGB and SOC. Schmidt et al. (2011) reported that water availability is an important factor for soil carbon stocks through its direct correlation with tree growth and its biomass. Higher SOC values in RFZ-4 and lower SOC in RFZ-1 of the present study support this report. In contrast to this study, Yang et al. (2011) reported that effects of climatic factors on carbon inputs and outputs to mineral soil could lead to the weak associations between the rate of soil carbon pool changes and climatic variables. Interestingly, observations from the present study show that SOC is getting increased from RFZ–1 to 4 for the plots with similar range of AGB across RFZ 1–4, which is indication of effect of rainfall on SOC. SOC content increases with precipitation (up to shallow layer in soil) and clay content (deeper layers in soil) (Jobbagy and Jackson, 2000). Results of this study showed similar pattern. Higher values of SOC in RFZ – 1 & 2 (exceptional cases) in deeper layers could be attributed to previous rich vegetation.

4.5. Litter decomposition analysis

4.5.1. Changes in litter quality and decomposition rate

As observed in this study, alteration in vegetation cover leads to differences in the leaf litter quality and their decomposition rates. Variations in the characteristics of leaf materials recorded in this study influenced decomposition rates. It was found that SLA acts as an important leaf trait affects litter decomposition, a plant's economic strategy can be understood from these SLA values. Cornwell et al. (2008) reported that leaf 'economic' traits lead influential 'afterlives', affecting the rate of decomposition, which is a key component of the global carbon cycle. In this study, higher SLA values were associated with herbs and lower ones with trees. A positive correlation seen between SLA and *k* values in this study revealed its importance in leaf litter decomposition, confirming the importance of SLA to litter decomposition was reported earlier (Cornelissen 1999; Santiago 2007). Recently Salinas et al. (2011) reported that species type influences the decomposition rate, most probably through its influence on leaf quality and morphology. A similar conclusion can be drawn from the results of this study. It has been found that differences in vegetation characteristics (leaf longevity, proportion of non structural carbohydrates, LCI and SLA) influenced the *k* values of litter in the short term. Over the study period, most of the leaf material showed decomposition up to 80 % within 270 days. Understanding generated from this is that LCI determines the quantity of undecomposed / slowly decomposing litter added to the soil. This will have a positive impact on steady state carbon storage in the soil.

Litter chemistry strongly influences litter mass loss (Pe´rez-Harguindeguy et al. 2000; Moorhead and Sinsabaugh 2006; Zhang et al. 2008; Austin and Ballare 2010; Mahaney 2010), that is also evident in the results of this study. Of the three chemical constituents measured, nonstructural carbohydrates degraded faster followed by holocellulose and lignin. Mass loss observed across the different species is exponential at initial stage and linear later. This is correlated with changes occurring to litter chemistry during decomposition. Moorhead and Sinsabaugh (2006) proposed a guild based decomposition model. This model describes three microbial guilds in the context of decomposition: 1) a guild of opportunist microorganisms grow quickly having high affinity for soluble substrates, 2) a guild of decomposer specialists grow more slowly having affinity for holocellulose substrates, and 3) a guild of miners grow very slowly and is specialized for degrading lignin. Higher *k* values of non-structural carbohydrates, relatively smaller *k* values of structural carbohydrates, initial increase and subsequent decrease in MBC values recorded in the litter decomposition study support this model.

Amongst the 10 species selected, the species with lower LCI decomposed faster and other species with higher LCI values decomposed at slower rate. LCI can serve as an indicator in evaluating the impact of changes in vegetation cover on current litter decomposition. *k* values of a species kept at two different depths of a site did not differ significantly indicating that in these ecosystems, soil biological activity has nearly the same impact on litter decomposition at least up to 25 cm depth.

4.6. Above-ground biomass (AGB) and Soil organic carbon (SOC)

AGB of unit area in the forest determines the quantity of carbon input to the soils of tropical ecosystems. This carbon input to the soil could vary depending upon the types of vegetal cover and climatic factors such as rainfall. SOC values have been analysed by the rainfall received, AGB and soil characteristics of the studied plots across the four RFZs. AGB and SOC have an inherent relationship, specifically in forest covers. Recently Chaturvedi et al. (2011) reported a positive relationship between AGB and SOC in tropical forest. Results from the present study indicate similar pattern. Higher AGB and SOC values in RFZ-4 and lower AGB and SOC values in RFZ-1 supports findings of Schmidt et al. (2011), who reported that water availability is an important factor for soil carbon stocks, through its direct correlation with biomass. In contrast to this study, Yang et al. (2011) reported that effects of climatic factors on carbon inputs and outputs to mineral soil could lead to the weak associations between the rate of soil carbon pool changes and climatic variables. Interestingly, for similar AGB across RFZ – 1 to 4, SOC tend to increase which can be explained as preferable decomposition activities with increase in water content. Variations in the vegetation present, density and diversity of species, their biophysical features (especially of canopy spread and foliage), soil moisture, soil texture, MBC showed a significant impact on the addition of litter, rate of decomposition, and SOC across the RFZs. According to Schmidt et al. (2011), spatial heterogeneity of biota, environmental conditions and organic matter have dominant influence on carbon turnover. The results show that impact of rainfall was distinct on the AGB and SOC values of RFZ–1 and 2 as compared to that of RFZ–3 and 4. Previous studies reported that soil carbon gets influenced by AGB, litter quality (Pe´rez-Harguindeguy et al. 2000; Moorhead and Sinsabaugh 2006; Zhang et al. 2008; Austin and Ballare 2010; Mahaney 2010; Mehta et al. 2013), soil quality, microbial activity (Moorhead and Sinsabaugh 2006; Schmidt et al. 2011), climatic conditions, and land-use and land-cover changes (Jobbágy and Jackson 2000; Post and Kwon 2000; Schmidt et al. 2011; Yang et al. 2011). Observations coming from the generated data in this study confirm these findings for tropical forests of India. It was observed that SOC values tend to increase with high rate at an initial increase in AGB which means a rapid increase in SOC with little increase in AGB values. After a point of equilibrium in ecosystem established the AGB and SOC is linear with very low rate which means even with very higher values of AGB, the SOC values does not increase after certain point, which might be depends on the ecosystem functionality. The logarithmic relationship of SOC–AGB revealed that in all the RFZs, the increase in SOC slows down with higher AGB, implying a tighter link of AGB to SOC in low AGB, dry regions of the study area. The point at which such saturation occurs is different for each zone indicating the impact of MAP on AGB and consequently on SOC. The rate of carbon pool changes both in vegetation and soil, declines with stand age and approaches an equilibrium state during the later stage of stand development (Yang et al., 2011). Ravindranath et al. (2008) reported that India is one of the few countries in the world, particularly among the tropical countries, where carbon stock in forests has stabilised or is projected to increase. Quantity of SOC per unit amount of AGB recorded was much higher in RFZ–1 and 2 as compared to RFZ–3 and 4. It is attributed to the quality of litter and soil properties (such as soil texture, MBC, moisture) and rate of decomposition.

Plantations (specifically of broad leaved, economically important species) across disturbed areas of these RFZs are assisting in the maintenance of both AGB and SOC levels. AGB and SOC relationship may vary with the land-use/land-cover (LU/LC) change (afforestation, deforestation). Several studies have estimated the contribution of afforestation to the global carbon cycle at both regional (Niu and Duiker, 2006; Potter et al., 2007; Kula, 2010) and global scales (Benitez et al., 2007; Olschewski and Benıtez, 2010). From the field observations made during this study, it seems that plantation activities have an impact on AGB and SOC. This requires further research, more focused on plots with known history of deforestation and plantation activities. As the age and size of stand trees increases, AGB of the system improves and subsequently ameliorates organic carbon of the soils beneath. It was reported earlier (Guo and Gifford 2002) that when native forest is cleared for plantation forestry, soil carbon stocks are unaffected by broad leaf plantations in low rainfall areas but decline when rainfall exceeds 1500 mm yr^{-1}. In a similar manner Paul et al. (2003) concluded that under plantation, as the stand develops, long-term soil carbon accumulates. Higher AGB and SOC seen in the plots with plantation activities in RFZs 1–4 support these views. The projected SOC values recorded in the present study (up to 100 cm depth) are comparable with published reports (Jobbágy and Jackson 2000, 2001; Dinakaran and Krishnayya 2008, 2011; Yang et al. 2011). These estimates come from the differences in the SOC values of top layer and bottom layer (25 cm). Any change in land-use and land-cover will alter SOC values of the top layer and this effect can get reflected in the estimates made up to 100 cm. Inference has been made that any periodic changes (such as selective logging, plantation) in land-use and land-cover of these forest covers can be accounted better in landscape projection models for carbon by using these calculations.