DISCUSSION

14.0. Discussions:

Forest resources have come under increasing pressure in recent years. Thus, their management and use, needs to be underpinned by information, and their properties at a number of levels. It is also essential to understand the accurate information on health status of forest and, in particular, where and how they have changed over a time (Franklin, 2001; Kleinn, et al, 2002). Today after completion of three decades since the launch of the first international satellite program designed for earth resources, monitoring forest assessment using satellite data provides three levels of information. Namely 1) the spatial extent of forest cover, which can be used to assess the spatial dynamics of forest cover 2) understanding of forest type and 3) retrieving of biophysical and biochemical properties of forests. Along with these components, it aids in forest tree inventory, phenology and tree damage assessment thereby understanding the forest as whole.

In the present work the information on forest on Dediapada forest, regarding various parameters like DBH, Height, site quality and tree damage, phenology and biomass, provided information about the state and dynamics of forests for strategic and management planning.

Tree inventory related to an understanding of different DBH, height crown cover and basal area have given a clear insight of the forest species of Dediapada forest. An effective plantation management requires such kind of information as it gives a clear idea of the divergence between actual and planted development. Although some DBH and height vs. age ground data models have been developed to forecast the plantation height and DBH, an implicit assumption of these models is that a plantation will grow exactly as forecasted whereas, during the planning period, the actual plantation growth may vary. Such kind of changes may be due to a number of factors like disease, fires, silvicultural treatments or competition from other invading species, etc. To understand precisely how such parameters are actually performing in terms of growth and yield, it is essential to provide a better method of monitoring these changes. Such correlation can be acquired both conventionally through a ground survey based and by non-conventional through remote sensing data. Both these techniques have yielded in understanding the significance of different parameters with each other

The variations of DBH were seen in the present study in five different villages. Higher values were exhibited by *Tectona* and *Madhuca,* suggesting their good health. This information is significant for understanding or acquiring the sustainable yield of that forest area and understanding the dynamics of the forest. (Lea et al, 1979; Day Jr., 1985; Conner and Day Jr., 1992). *Tectona grandis* and *Terminalia crenulata* in the Dediapada forest were found to be the tallest tree. The factors that play premium role on tree height growth are abundant, minor stress, and minimum competition for light. (King, 1991 and Waring and Schlesinger, 1985). The capacity of the tree to have a maximum height and the role of biophysical determinants of maximum height are poorly understood. Some models predict heights of up to 120m in the absence of mechanical damage (West et al, 1999, and Friend, 1993) but there are historical accounts of taller trees. Trees such as *Butea monosperma, Madhuca indica and Dalbergia sissoo* are medium height trees. Hypotheses suggest that tree height limitation focus on increasing water transport constraints in taller trees and the resulting reductions in leaf photosynthesis. The difference in tree height at various locations as seen in the present study suggest that for every species, the rate of height growth varies from place to place. Early foresters noticed that the maximum height a tree reaches, correlates with the speed at which it grew in height when it was young. The tree height increments is governed by two factors: the light reduction environment within the canopy, and a species- and site-specific empirical height function. The former property requires the definition of a (arbitrary) light reduction function within the canopy. This function describes the variation with age of the percentage of light reaching the ground from the top of the canopy and primarily controls the crown shape (Disney et al, 2006).

Reduction in Tree height can be attributed to stress or age as seen in *Butea* and *Madhuca.* Trees seem to have mechanisms that slow their growth as their age increases and prevent them from growing beyond a certain height. A similar case was seen in case of *Eucalyptus regans* in east of Melbourne, Australia, where the height of the tree increased by 2-3m every year, but at maturity the height of tree virtually ceased. (Ryan and Yoder 1997).

Crown cover and basal area interrelated to each other. The main functions of the crown of a tree is to display actively photosynthesizing leaves most efficiently to radiant energy and to provide for the renewal of the leaves and reduction in the value of crown cover leads to decline in tree growth. Large dense crowns like those of *Tectona* and *Butea* have been associated with vigorous growth rates, while trees with small, sparsely foliated crowns such as *Madhuca indica* are in a state of decline, showing little or no growth. Kramer (1966) showed that tree crowns affect growth and survival, while Hamilton (1969) illustrated the dependence of tree volume increment on crown dimensions.

T. crenulata had the maximum crown cover as seen in Mathasar indicating high growth rate, whereas, trees such as such as *T.grandis* and *D.sisoo* are either in their declining state or in young plantation.

Young plantation is typically manifested in smaller sized trees, lower height and DBH, and unfinished crown closure, compared to the older plantations. Tree height DBH and crown closure increase with age. As the tree crowns expand, they provide a greater light intercepting and reflecting face. Full interception occurs when the crown of all trees touches each other. It is commonly observed that an inverse relationship exists between tree canopy and their associated understorey ground coverage in terms of surface exposure.

The proportion of surface of exposed area to satellite sensored contributes to the canopy reflectance which is ultimately reflected in pixel value. Based on this concept it can be hypothesized that there can exist a quantitative relationship between different tree parameters like height DBH, tree canopy closure as measured on the ground and reflectance values as estimated from the satellite images. Consequently remotely sensed data can help in determining these parameters. In this study relationship between different tree parameters like DBH-height and DBH-crown cover has been retrieved developed both conventionally and non-conventionally. A relationship in the form of a regression equation has also been derived from these derived variables.

The development of simple and accurate height–diameter models, based on easily obtainable tree and stand characteristics, is a common precursor to using inventory and sample plot data to calculate volume and other stand attributes. A number of height–diameter equations have been developed using only DBH as the predictor variable for estimating total height (e.g., Curtis, 1967; Wykoff et al, 1982; Larsen and Hann, 1987; Wang and Hann, 1988; Huang, Titus et al,, 1992; Zhang, 1997; Peng, 1999; Fang and Bailey, 1998; Fekedulengn et al., 1999; Jayaraman and Zakrzewski, 2001; Robinson and Wykoff, 2004). A linear line was observed among all the species between DBH and tree height, indicating tree with broader tree trunk has a tall height. However, the relation between the diameter of a tree and its height varies among stands (Calama and Montero, 2004) and depends on the growing environment and stand, also the relationship between DBH and crown cover resulted in a simple linear regression. Linear regression was found in all the species between DBH and crown cover. In case of *Dalbergia sisoo* the linear regression was found to be highly correlated with R^2= 0.93. Four other species (Figure-4a-4e) also showed a linear regression with R^2>0.5. The coefficients of determination (R2) from these equations were found to be 0.5; meaning that they are statistically significant models and can be used for the future biophysical property determination. Similar studies were also carried out using different tree species (for example Bragg, 2001; Bechtold, 2003), and a strong relationship between DBH and crown diameter was noted. This relationship is of adaptive significance to the trees because the canopy size also contributes immensely to a trees total weight. Thus, huge trunks enable trees to support wide canopies (Horn, 1976).

A relationship between non-conventionally derived tree parameters and remotely sensed data has also been established in the present study. The correlation between the reflectance values in various Thematic Mapper (T.M.) bands and forest at different developmental stages is well known from the early plantation development stage (Coleman et al., 1990; Fiorella and Ripple, 1993) to the older forest stands (Poso et al., 1987; Cohen and Spies, 1992). Pierce et al. (1992) and Franklin et al. (1992) used T.M. data to separate different forest cover types. Gemmell (1995) investigated the utility of Landsat T.M. data to estimate coniferous timber volume for a mountainous mixed conifer species. Where both forest polygons and ground data were used to estimate timber volumes. It was reported that sampling T.M. imagery in small areas (0.25 ha) was unsuitable for specifying the relationship between T.M. data and the forest information.

Oldai , 2005 suggested that the visible region of the spectrum (0.4 to 0.7 µm; T.M. bands 1, 2, and 3) showed a narrower range of reflectance due to the higher absorption of the plant leaves, where the energy is required for photosynthesis, than the near and middle-infrared (T.M. bands 4, 5, and 7). This region of the spectrum may not be suitable for estimating canopy closure, DBH and height, using contrast reflectance between the overstory and the understory shrubs and herbs. A good correlation can be observed in the present research work when different structural parameter such as DBH, height, crown cover, and basal area were correlated and regressed with the Landsat ETM band 5 data.

Other than tree structural parameters, species diversity is also important component. Species diversity is subject to constant change and human induced modifications. The understanding of diversity, therefore becomes imperative for understanding (1) the number of species that occur in an area or sample, (2) the number of individual organisms that are present, and (3) the distribution of these organisms among the different species. This component was assessed conventionally and non conventionally. In the conventional methods four indices were analyzed such as Shannon-Wiener, Margalef, McIntosh and Brillouin.

Various indices put different weight on the importance of these components because they were originally developed to examine widely differing concepts, some of which do not apply directly to the problems of the study area (Huston, 1994). In the present work four different indices such as Shannon-Weiner, Margalef Mc-Intosh, and Brillouin were used to assess the diversity index of Dediapada forest.. Diversity indices generated gave the idea of species composition and its distribution in this forest community. Debate on the advantages and disadvantages of various diversity indices has continued over the last three decades (Hurlbert, 1971). The advantages of these indices over other indices are categorized in two, the first depends on information theory where diversity (or information) of a natural system is treated similar to information in a code or message (Zaghloul, 2008). Shannon-Wiener and Brillouin indices are classified under this category. The second category depends on the species dominance measures where it weighs towards abundance of the common species and so the total species richness is down weighted relative to evenness, McIntosh is included in this category. The Shannon-Wiener Index was applied to biological systems. It is the most preferred index among the other diversity indices. The index values are usually between 0.0 – 5.0. Index in this forest ranged between 0 to 1.5. The values above 3.0 indicate that the structure of the habitat is stable and balanced. In the present, the index was below 1.5 indicating the habitat to unstable and unbalanced. The values below 1.0 indicate that there is degradation of habitat structure as seen Chopdi, Chuli, Ralda and Khatam, the level of degradation is very high in these villages. Sagai and Gangapur are on the verge of degradation, with little input these forests can be revived back to their original state. The Margalef index has no limit value and it shows a variation depending upon the number of species. In the Dediapada forest, it ranged between 0 to 1.95. Thus, it can be used for comparison between the sites. This index shows variation depending on number of species, so that the number of individuals is less important for calculation. It has a different purpose of usage from other indices. However, it showed similar results with the other indices calculated in this study. The McIntosh in the present study indicated that tree species in these villages were homogeneously distributed. The Brillouin Index ranged between 0 to 1.1. It was sensitive to the abundance of rare species. (Hayat and Kudus, 2010) and exhibited the presence of unique species.

These species diversity indices showed a significant degree of negative Kurtosis and Skewness. Negative Skewness indicates a distribution with an asymmetric tail extending toward values that are more negative. Negative kurtosis indicates a relatively flat distribution. Negative kurtosis exhibits peakedness, which means very frequent small changes and less frequent, very large changes. Shannon-Weiner Index (H) was highly negatively skewed when compared to all other indices with its Kurtosis values to be slightly lesser than McIntosh (MI) and Brillouin (B). This indicated frequent and minor changes in this attribute when compared to other indices. The coefficient of variation (CV) for H was slightly lower than B. These CV for Margalef (Ma) and MI were still on the high side. In general, the better the variability of the index, the poor is its conformity with the total population or its statistical performance with regard to normality, therefore a compromise seems to lay in the middle of two indices, H & B, with variability around 54%. The present study has highlighted the H index most suitable for this area.

The assessment of forest biodiversity has recently become a priority area for forest research. Several measures of species diversity among communities have been recommended to assess biodiversity through environmental gradients. Although tropical ecologists have put forward a number of hypotheses to explain this species diversity, testing these hypotheses has been hampered by the lack of field studies with sufficiently large long-term data sets. Evaluation of this is potentially an enormous task, and any methods that can be adopted to reduce the amount of time spent collecting data are therefore of interest. Remote sensing represents such method although it has been under-utilized in studies of forest biodiversity. In the present study, utility of satellite data along with GIS tool has aided significantly in understanding and extrapolating the diversity information on a larger scale. The species diversity values, of this forest in Dediapada were overlaid on the NDVI and the village map provided the specific understanding of the diversity in these areas The Shannon index is based on the proportional abundances of species. It takes both evenness and species richness into account. No assumptions are made about the shape of the underlying species abundance, so it is referred to as a non-parametric index. Values of this index when were incorporated to generate species diversity map using the Kriging tool in GIS, aided in extrapolating the understanding of this index in other areas other than the sampling points. Spatially distributed data behave more like random variables, however, and regionalized variable theory provides a set of stochastic methods for analyzing them. Kriging is the method of interpolation deriving from the regionalized variable theory. It depends on expressing spatial variation of the property in terms of the variogram, and it minimizes the prediction errors, which are themselves, estimated. (Oliver and Webster, 1990) The accuracy and the statistical results together gave a precise idea regarding the distribution of the H index in the Dediapada forest. Inclusion of more ground truth points in the areas where the values were more skewed can help in increasing the accuracy of the results.

Another component of forest is the tree phenology. It is very important specifically in the recent years of climate change. Climate influences major vegetation types at the same time vegetative phenology acts as indicators of climate. The attempt to understand such relation in these studies has shown, that a high percentage of tree species showed shifting in flowering, fruiting, and leaf flush during a span of 16 years. The climatic component like rainfall and temperature are on the higher side when compared to 1992. This ensures the role of these two components in fluctuation in phenological stages.

Tropical trees are expected to respond variously to changes in rainfall and temperature because they differ widely with respect to adaptations to seasonal drought and cues for bud break of vegetative and flower buds (Singh and Kushwaha, 2005b). This component was also studied both conventionally and non-conventionally.

Conventionally shifting of phenology in the four trees such as *Albizzia lebbeck*, *Boswellia serrata* , *Butea monosperma* and *Tectona grandis* of Dediapada forest can be very well seen from the present work. Several studies have shown significant variation (advanced or delayed) in onset dates of flowering and fruiting responses in tree species as a result of climatic change. In 1971, Walter stated that the amount and the annual distribution of rainfall, forms an indicator in deciduous, semi-deciduous and evergreen tropical, because seasonal variation in tree water status constitutes a major determinant of tropical tree phenology. Severe water stress enhances the abscission of old leaves and prevents the expansion of new shoots and leaves. The leaf flush was found to be less in 2007 compared to 1992 which may be due to increase in duration and severity of the dry season that results in trees leafless for progressively longer periods. Inversely, the duration of deciduousness among trees in a landscape should be considered as an indicator of the duration of severe drought. Probably the climate change impact can be better assessed at the level of functional types based on the duration of deciduousness and the timing of onset of the reproductive phase (first-visible-flower). The need for functional types has been emphasized to evaluate and predict the nature of vegetation responses to future global change (Box, 1996).

Non-conventionally the phenology was assessed with microwave backscatter information. Radar backscatter sensitivity to canopy condition is a function of sensor frequency and polarization, as well as forest cover type and phenology. The Dediapada forest showed variation in backscatter with changes in the phenological pattern in different season. These results indicated that even a slight change in the flowering, fruiting or in leaf flush correspondingly, changes the backscatter value. When more number of tree species are in any of the phenophase then the backscatter also tends to increase mainly in the HH and VV polarization. Variations of the radar signal are mainly caused by changes of the dielectric properties of the scattering surface and by changes of the scattering mechanism as introduced by changes of surface roughness and contributions by volume scattering. The main reasons for these variations are changes of soil moisture and the growth of vegetation. Vegetative growth and increased surface soil moisture increased the backscatter from the surface. An increase in the backscatter signal therefore indicates growing conditions.

Satellite microwave remote sensing has been used for landscape- to global-scale assessments of a variety of biophysical parameters including soil moisture [e.g., Magagi and Kerr, 1997; Wagner et al., 1999a; Wagner and Scipal, 2000], and vegetation dynamics [e.g., Frison and Mougin, 1996; Hardin and Jackson, 2003]. Radar sensitivity to these parameters arises from the strong dependence of radar backscatter to surface dielectric properties, which are strongly dependent upon the liquid water content of the forest. Shorter microwave wavelengths such as the C-band of Radarsat-2 are particularly sensitive to the vegetation canopy structure and moisture. Because of the similar characteristic sizes of leaves and branches, which increases the radar backscatter response to these canopy constituents [Ulaby et al., 1982; Elachi, 1987] Thus, it can be said that the with increase in percentage of flowering, fruiting or leaf flush, backscatter value also increases.

Tree inventory which further aided in tree damage assessment is a major feature for understanding the forest health status, because the tree damage increase in the prescribed annual cut has a negative effect on sustainable forest management. A growing amount of salvage cutting operations requires that the focus be placed on the forest health status and the quantity of tree damage. The primary task for forest management should be, to locate stands of poorer health in order to maintain their vitality and naturalness at an optimal level by applying timely measures (Pernar et a. 2007b). It is essential to inspect and determine what factors may be affecting tree health or vigor, including pest infestation, disease infection, change in environmental conditions, construction impacts, and soil- or water-related problems; provide specific action steps to improve and invigorate tree health. In the present work, visual interpretation of tree health assessment was carried out. The assessment is based on tree characteristics, which serve as good indicators of overall tree health, twelve different parameters were assessed to understand the health status of individual tree. It was seen the *Tectona grandis* was found to be best in Gangapur because of good environmental condition. In some areas, health of *Tectona* was in medium to poor, which suggested that the trees must be in stress condition due to either disease infestation or poor physiology. *Butea monosperma* and *Dalbergia sissoo* also showed health status from medium to poor; their condition was the result of poor branch attachment, leaf diseases or cut stems and weak stem. These are mainly due to a certain amount of insect activity, disease, mortality, damages, and decay in normal and healthy forest system, leading to death of the individual and provide critical habitat for wildlife.

The second level of forest assessment with respect to biophysical and biochemical properties. These properties indicate resource quality and resource management information. The biophysical variables like leaf area index and biochemical content like chlorophyll affects forest function light interception and nutrition cycle (Bonan, 1993). They vary both spatially and temporally across forest areas and are difficult and expensive to measure. They are, however, the key spatial; variables required to drive forest ecosystem stimulation models at a range of spatial scales and so considerable effort has been expended in developing remote sensing techniques to map these variables over extensive forest areas (Running et al 1989, Song and woodcock,2002).

These parameters when derived conventionally and non-conventionally in this study exhibited a good correlation between the ground based and spatially derived variables. A seasonal variation observed in the chlorophyll content seems to be quite classical. Strong increase during the first phase of the growing season is followed by stability and a strong decrease in cut-back season. Sun leaves tend to always have larger chlorophyll concentration than shaded leaves. Indicating that the leaves position towards the sun have maximum chlorophyll content as oppose to those which are in shaded condition. Exception can occur in tree species where the influence of the growing season and environmental condition is more than the position of the sun. This can be seen in the present study, where the *Tectona grandis* and *Terminalia crenulata* had more chlorophyll content in the growing season. Leaf total chlorophyll content was more in Monsoon season as the conditions were favorable for the tree growth. Under stress-inducing conditions, reductions in total chlorophyll concentration (Chl; chlorophyll a + chlorophyll b), can occur . Stress decreased total chlorophyll content of the plant by increasing the activity of the chlorophyll degrading enzyme: cholorophyllase (Rao & Rao, 1981), inducing the destruction of the chloroplast structure and the instability of pigment protein complexes (Singh & Dubey, 1995).

The leaf area index also controls many biological and physiological properties in the plant. The leaf exposed to full sunlight may differ in growth from those growing in shade. Adaptation of plants can be associated with morphological, physiological and ultra-structural changes in leaves (Lichtenthaler 1985). Rao and Singh (1985) suggested that leaf structure undergoes ontogenic progression, which are at the same time sensitive to environmental changes, leading to large changes in leaf area. In the present study, reduction of leaf area was observed as the stress level increased during summer. Plant exposed to stress environment generally has the reduced leaf area. Leaf area may be reduced due to drought, through inhibiting leaf initiation (Kozlowski, 1982 and Ibrahim, 1995) or decreasing leaf size (Ibrahim et al., 1997, 1998) or accelerating leaf senescence and consequently leaf shedding (Begg, 1980) or more than one of them.

Non-conventional technique such as NDVI used to assess these parameters which have been worked by several workers. (Carlson and Ripley, 1997; Sembiring et al., 1998) Higher NDVI values indicated an increase in vegetation growth per unit area and vice versa. The positive values represent different types of vegetation classes, whereas near zero and negative values indicate non-vegetation classes, such as water, and barren land. Increasing positive NDVI values indicated increasing amounts of green vegetation. Thick and healthy vegetation has a low red-light reflectance and high near-infrared reflectance, and hence, high NDVI values. NDVI values near zero and decreasing negative values indicate non-vegetated features such as barren surfaces (rock and soil) and water. Basically, when the index is below 0, it is the detection of clouds when it is between 0 and 0.1 it represents rocks, senescent vegetation or soil; when it is between 0.1 and 0.4 it is indicative of sparse vegetation and when it is above 0.4 it implies the presence of high vegetation

Conventionally derived parameter such biophysical and biochemical parameters have proved to be useful in establishing the relationship between and non-conventionally derived biophysical parameter such as NDVI and NDMI. Basically forest parameter has no direct physical relationship with the remote sensed data signal, but they may be correlated through indirect relationships with LAI, biomass or canopy cover (Danson and Curran, 1993). For example, a large number of studies have found relationships between forest stand variables and a range of remote sensed data with mixed success. In the present study positive correlation has been derived between biophysical and biochemical parameters. In plants, there are mainly there are two main optical domains influencing the optical properties of vegetation, namely the visible region (400 to 700nm) which has a strong chlorophyll absorption and the near infrared region that has a strong reflectance (700 to 1000nm). The differential reflection of green vegetation in the visible and near infrared portions of the spectrum provides an innovative method for monitoring vegetation from space. However the NDVI is thought to be a suitable indicator of relative biomass and vegetation health (Boone et al. 2000).

The biomass that is the other important biophysical parameter. Optical remote sensing technologies, theoretically, have limited capability to predict forest biomass since the recorded spectral responses in the optical images are mainly related to the interaction between the sun radiance and forest stand canopies. Thus, the correlation between forest biomass and spectral responses or vegetation indices is usually poor, especially in the mature forests where spectral responses become saturated and lose sensitivity to trunk and branch biomass. However, the obtained correlation was found to be good for in the present study. The regression equation was used to generate biomass map. Changes in biomass can be easily interpreted from the generated map. It is seen that the areas where higher biomass values were present has increased in 2005, suggesting new plantation in that area. In the absence of encroachment and cutback, tree death, is the only way biomass can decrease in a plot and in such circumstances a negative rate cannot be used to assess changes in growth. (McMahon, 2010)

Limitations of optical data in biomass estimation can be overcome using attractive technology microwave remote sensing in frequent cloud cover. Previous workers have shown the ability of estimation of biomass using backscatter value.

The AGB estimation using C band data has achieved good results in vegetation covers with lower biomass. The main scattering component of the C band, are the leaves and small branches. For the present study the Microwave data such as the C-band of ENVISAT-ASAR and Radarsat-2 were utilized. This C band, which has an intermediate wavelength, shows greater penetration of the radiation into the canopy which enables further sources of scattering to be active and so there is some volumetric scattering. It can be said that in the present study canopy scattering and some volume scattering was present. As the typical sources of scattering at C band are secondary branches and leaves (Ranson and Sun 1994, Leckie and Ranson 1998), the penetration of crown thickness by the radiation is normally not exceeded (Le Toan et al. 1992). Recent studies indicate that the backscatter response to forest biomass depends on stand-to-stand differences in stand structure (tree height, diameter, and stocking density) and on species-related differences in growth form and branching pattern (Dobson et al., 1995; Imhoff, 1995). Lack of control over these variables is one cause of weak backscatter-biomass regressions and apparent "saturation" of the regression curves at low biomass levels. which can be seen in the present study area, where the backscattering occurs at a lower biomass value.

The important problem in using relationship between the backscatter in different polarization and biomass is the saturation level of different wavelengths and polarizations. The biomass map generated from Envisat ASAR data using the Multiple linear regression model also showed saturation at high biomass level. The saturation levels depend on the wavelengths (i.e. different bands, such as C, L, P), polarization (such as HV and VV), and the characteristics of vegetation stand structure and ground conditions.

Along with biomass other biophysical parameter is the relative water content which is a useful indicator of the state of water balance of a plant, essentially because it expresses the absolute amount of water, which the plant requires to reach artificial full saturation (González and González-Vilar, 2001). Unlike the vegetation stress indices, RWC does take into consideration the quantity of water in the plant. However, two different species may have the same RWC as is seen in *Tectona*, *Dalbergia* and *Butea*. The rate of RWC in plants with high resistance against water stress is higher than others. In other words, a plant having higher yields under stress should have high RWC. Under the water deficit, the cell membrane is subjected to changes such as an increase in penetrability and decrease in sustainability (Blokhina et al., 2003). Blackman et al., 1995 in his microscopic investigations of dehydrated cells revealed damages, including cleavage in the membrane and sedimentation of cytoplasm content. Water deficit can destroy the chlorophyll and prevent making it (Montagu and Woo, 1999; Nilsen and Orcutt, 1996). Mensah et al. 2006 found that subjecting Sesame plants to drought stress caused leaf chlorophyll was increased and then remained unchanged. The maximum reduction of 20% in RWC can be seen during stress condition *i.e.* in non-healthy trees of *Butea monosperma,* in the monsoon season. Overall, from the results of this study, it can be concluded that water stress (excess water and water deficit) significantly decreases leaf chlorophyll concentrations.

Correlation of RWC parameter with non-conventionally derived NDMI showed that retrieval of such parameter from satellite data can prove beneficial in deriving the plant moisture. NDMI contrasts the near-infrared (NIR) band 4, which is sensitive to the reflectance of leaf chlorophyll content to the mid-infrared (SWIR) band 5, which is sensitive to the absorbance of leaf moisture. Vegetation Moisture is related to forest health as seen in some areas of Dediapada Taluka. The lower level of moisture content as seen in the present study indicates trees under stress condition

Several remote sensing measures of vegetation moisture based on water absorption have been proposed, including indices based on near infrared (NIR) absorption (Gao, 1996) and shortwave infrared (SWIR) absorption (Hardisky et al., 1983; Ceccato et al., 2002). Sims and Gamon (2003) compared the abilities of water indices based on NIR and SWIR wavelengths to estimate the vegetation water content of common vegetation species in Southern California. They found an index based on a 1200 nm water absorption feature which was the best predictor of canopy water content and was less sensitive to atmospheric water vapor absorption. In the term NDMI the word "moisture" is conventional and is retained for lack of a better term (Cohen et al. 1995, Wilson and Sader 2002). A universally accepted term seems to be lacking because the biophysical interpretation of the indices that use the Middle infra-red (MIR) bands is more problematic than those that use near-infrared (NIR) and red bands. The MIR wavelengths are highly absorbed by leaf and soil water (Hunt and Rock 1989). Hunt et al. (1987) found that the reflectance of TM band 5 (SWIR) for dry leaves was almost equal to reflectance of TM band 4 (NIR), suggesting the difference between TM band 4 and 5 should equal the water absorbance for a fresh leaf. The lower level of moisture content as seen in the present study in the vegetation indicates trees under stress condition which is related to the relative water content. The stressed plants showed low RWC and NDMI were also low. Similarly healthy tree species showed good RWC and with high NDMI.

This relationship will help in Identifying healthy tree species from the NDMI map in homogenous pixel.

The biochemical and biophysical parameter proved to be useful in determining the tree health status. In addition to this disturbance and degradation should also be monitored which can be done through forest cover mapping.

This mapping can be achieved by optical and microwave data. Optical data of 1997 and 2005 showed serve reduction. Open forest also reduced during this period. Such studies have been carried out by several workers (Woodwell et al., 1987; Green and Sussman, 1990; Houghton et al., 2000, Rede, 2009). Depletion of forest cover in this area is mainly due to agriculture pratices. The adoption of improved varieties and the development in irrigation led to the encroachment of agriculture in the forest ecosystem. Increase of other classes are mainly due to the development of Narmada dam

To overcome some of the difficulties of optical sensors, SAR sensors are also used in mapping forest of this area.

The increase utility of this sensor is recommended by the studies that reported to well suited to forest cover, particularly, through the acquisition of multitemporal data sets (Suzuki and Shimada, 1992; de Groof et al., 1992; Kuntz and Siegert, 1999; Quegan et al., 2000; Rosenqvist et al., 2000; Balzter et al., 2002; Sgrenzaroli et al., 2002). The present dataset was acquired for June 2011 Radarsat-2. The supervised classification of microwave radarsat-2 data gave distinct separation of the class, river, dense forest, and the open forest. Due to different scattering mechanism of the trees in the forest and Radarsat-2 being C-band data, thereforesurface scattering can be seen. This is the reason why there is distinct classes of forest seen.

Forest mapping using Entropy and Alpha

This result is in agreement with previous research, which has suggested the use of, longer wavelength for forest applications. Using dual polarization data, Saatchi et al. 1997 showed that L-band HH and HV data were capable of separating three major forest cover classes in a Brazilian site. It has been seen from the result that decreasing Entropy is related to higher degradation level. Intact forest class has a high value of Entropy, indicating the dominance of a volume scattering mechanism. This characteristic has been observed in woody vegetation and details of the reports can be found elsewhere. On the other hand, highly degraded forests are shown to have very low Entropy. This indicates that a single deterministic scattering process dominates. This can be confirmed using classified satellite image showing that the area was dominated by dead stands without leaves or branches; therefore, a random scattering mechanism due to canopy structure was less visible. The forest floor in these regions was moist due to rainfall at this season, hence even-bounce scattering of ground-trunk interaction was responsible for this phenomenon.

The Alpha angle was found useful for explaining the scattering types. Although unclear, the Alpha angle could be valuable for distinguishing healthy and degraded forest covers. Intact forests, which have thick vegetation layers with well-developed structures, clearly fit into the dipole region (around 50°), whereas the degraded forest remained at 40°.

As opposed to using remotely sensed data from a single satellite sensor the synergy sensed data has shown to provide improve delineation of forest areas. Synergy proved to allow for the exploitation inclusion of forest and non forest collected by different sensors wherein attractive approach to combine optical and microwave data. The performance of, Modified IHS (MIHS), Ehler and Brovey techniques in different data combinations was analyzed statistically, visually and graphically. In the present work the classification of Dediapada was increased by applying a different fusion technique. Brovey was found to best technique in the present area in all the dataset (i.e. ETM $^{+}$ {MSS & PAN}., Envisat-asar & LISS-III and Radarsat-2 with LISS-III) .The best was seen using the full Polarimetric data of Radarsat-2. MIHS technique has become a standard procedure in image analysis and is useful in color enhancement of highly correlated data. Finally, Brovey transformation was developed to visually increase the contrast on the data as well as for better representation of RGB images with a high degree of contrast. For the present area visually the color was enhanced in both these techniques where different classes were separated. Only in Ehler's technique degraded forest was separated from the dense forest and identification of these areas is distinct.