VEGETATION MAPPING AND PHYTODIVERSITY ANALYSIS IN DALMA WILDLIFE SANCTUARY JHARKHAND, USING REMOTE SENSING AND GIS

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VEGETATION MAPPING AND PHYTODIVERSITY ANALYSIS IN DALMA WILDLIFE SANCTUARY JHARKHAND, USING REMOTE SENSING AND GIS

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Submitted
In partial fulfilment of the requirement of the Degree of Doctor of Philosophy in Forestry of Mizoram University, Aizawl


Dedicated to the Memory of
My Father and Mother with
respect

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CERTIFICATE

This is to certify that the thesis entitled **"Vegetation mapping and Phytodiversity analysis in Dlama Wildlife Sanctuary Jharkhand, using Remote Sensing and GIS"** submitted by Sri Narendra Prasad for the Degree of **Doctor of Philosophy** in **Forestry** of Mizoram University, Aizawal embodies the record of original investigation under my supervision. He has duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. Degree. The work has not been submitted for any degree of another University.

(U.K. Sahoo)
Supervisor

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April, 2020

Declaration

I Narendra Prasad, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in Forestry.

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C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER – I

INTRODUCTION

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INTRODUCTION

1.1 General

Few balancing factors of this Universe like Sun, Earth, Air, Water & Vegetation are playing together a greater role in existence of life on this planet. Forest is one of the constituents of the vegetation considered as important natural resources. It is balancing the relation between the life and environment. Deforestation from long past has drawn attention at global level. The actual loss of natural resources is regularly detecting after using the modern system of technologies recognized as remote sensing and Geographical Information System. It was invented and applied in this field which has accurately convinced the thinker about the nature. In most of the developing countries, forest was utilised in interest of nation development using as railway sleeper and weapon for defense, consequently one of the major constituant of our environment balancing factors, which affect the life on earth was diminishing very fast rate. Land surface made by different layers have not the same features of landscapes from one time to next, because of unplanned utilization of natural resources at a certain place. Ecosystem of a particular place is depends upon the land use practices and its careful management for future. In present situation of time it may be termed as crucial use of land cover of biodiversity which make it a serious issue for the study for economical and biological point of view.

Vegetation maintains the ecological balance on earth for well being of human life. Land use practices lead as a driver of land cover loss which may be resolved by proper conservation through community involved forest management to save bio-resources for future generation. Forest is providing direct benefit to human being by various produce and indirectly serves as balance the ecology. It also protects our life, relation among the society, and gives a healthy life to all. It has been observed that majority of the population of the world is badly affected due decrease in biodiversity.

In a study it was found that in past one or two century, the extinction rate of plant species has increased by more than hundred times so the population of fauna is decreasing on this planet. The clever lives at this earth are rightfully and cruelly misusing the natural resources of earth surface which are changing unbelievable.

Ecologically forest cover has a vital role in protection and conservation of fertile soil, climate as well as aquatic and micronutrient for the vegetation on the earth. It also provide habitat for flora and fauna species. Woodland having a mature or over mature tree is the most valuable for repository of the world's flora for genetic heritage.

To get better information of land cover and changes over the periods of last five to ten years, remotely sensed data is required to know the slowly changes in vegetation creating a vegetation map which shows the internal consistency of a fixed locations where true knowledge is sparce (Roy and Joshi, 2002) for which remote sensing is very useful tools.

1.2 Research Background

Due to pressure of over population of fulfill their foods, the agricultural and demographic pressure is increasing on the land is facing a scarce of resources continuously, but the govt. agencies are working with outdated information. Now a day's land cover/land use related information is becoming possible, using Remote Sensing based data, which are useful in planning for optimal use of land to fulfill the basic human needs and social welfare. Information gathered from modern tools like remote sensing is also useful in the monitoring of dynamics of land use pressure of raising population.

A study on a natural use of land has indicated that less vegetation of our earth are remaining in its natural habitat and the earth surface is significantly changed due to unsystematic activities of human for their unlimited wants.

Fast change in land use and land cover in present time is challenge for policy maker in deciding strategies on monitoring and managing of natural resources and climate changes. The modernization of tools for vegetation mapping and clear

concept on the vegetation distribution, the scope of research on land cover, land changes is increased because it is providing true information on expansion of healthy forest, Agricultural produces and grass land in all over the world.

A view of this planet from the space has clearly shown the crucial intention of human activities about natural resources for past few decades. In managing and studying the feature of the earth over past time the satellite data has became very useful to provide objective full information of natural resources.

In present time, these two advanced technology based tools like Remote Sensing and Geographical Information System (GIS) are the boon for the modern research on Agricultural and natural resources, which providing largely accurate data of the thrust area. Now a day it became possible of synoptic analysis of the earth system with the data obtained from remote sensing and GIS through satellite images at local, regional and world over the time. According to Wilkie and Finn (1996) it also provides a link between national and international level research organization working on conservation and management of biodiversity.

Ecosystem, which provides the life support system at earth to human beings is one of the part of Biodiversity and working in favor of human, providing sustainable livelihood (Rai, 2012). Loss of Tropical forest is directly affect the economic development and well as ecological economics, by altering the biological function such as environmental stimuli and gene knockdown. In present time it is a great challenge for world society because loss of biodiversity is directly affecting the climate change and it is essential to utilize the available forest produce in a sustainable way, otherwise it will be a cause of fast degradation of our environment (Singh *et al.*, 2002; Rai, 2009; Rai and Lalramnaghinglova, 2010; Rai and Lalramnghinglova, 2011a). Out of 70% of Flora and Fauna, only 10% of the geographical area covered with tropical forest but working as reservoir for carbon sequestration. According to a report (FAO, 2001; Singh *et al*. 2006) tree of woody nature and its canopy covering at least 10% area of about 0.5ha is treated as forest. It is an important part of the environment and economy of a nation which provide food, timber, fiber and mentain the rich environment by way to carbon sequestration

as well as guide the nutrient cycle (Rai, 2012). The multiple benefit of forest for human being is help to keep balance of ecology at global level.

In view of United Nation, Remote Sensing have the use in advance method of forest as well as natural Resource Management for sustainable land use and environment protection is based on emitted electronic wave and reflection or refraction of the wave from the sensed objects. It is very useful in planning and management of land covered with vegetation (Singh *et al*., 2002). It provides required information of an object in recording form by the using available device of camera with sensor without touching the objects by reflection or refraction of radiation from the surface of earth. In this method satellite have a greater role in creation of vegetation map of a particular target area, providing a digital mosaic of the land covers. It gives parameters like patches of area of ecosystems (Roy and Bahera, 2002) and many more information like shape and size of the patches, interspersion and fragmentation which provide characteristics of the land cover of an ecosystem. These satelite are presently used to calculate Leaf Area Index (LAI), which shows the relation with Normalized Difference Vegetation Index (NDVI) (Kale *et al*., 2005). In present time these information on Cover Type and land classification is suitable for effective management of natural resources (Schriver and Russell, 1996)in estimation of Biodiversity with its characteristics like composition, extent, structure and condition.

Vegetation map also provide an area statistics of the study area by interpretation of the satellite data (Rai, 2013) by adopting either visual or digital technique of data interpretation with the assistance of interpretation of image obtained from satellite (Lillesand and Kiefer, 2000). Features like shape, size, pattern, tone and texture of the image data are generally refers to general forms, configuration, context of image scale, special pattern arrangement, brightness/ colour of objects and tonal change of the surface structure and its relation with nearby environment (Kushwaha *et al*. 1994). In identification of vegetation category, generally refers to Geographic or topography of the particular site. Due to similar features of different species at a particular site an association is formed with relation

to each other (Lilesand and Kiefer, 2000). Moreover, the use of interpretation key of an image in the process of image interpretation (Lillesand and Kiefer, 2000).

India is rich in endemic flora and fauna. The endemism of Indian biodiversity is high. The central India and part of east Indian forest -like Dalma is very significant due to their rich mineral resource and luxurious growth of *Shorea robusta*, the pioneer species and associated species like Adina cordifolia, Terminalia tomentosa etc, constituting the main timber source to most part of the northern India. More or less hilly topography covered by thick forests provides unique ecosystems for biological resources, which play active role in the sustenance of diversity of species. The ground with intensive grazing fire and inadequate vegetative cover lead to high degree of run off which often into flood disrupting the main communication between Chaibasa and Jamshedpur. The forests as well on these accounts, are derived of the benefit of rain water which otherwise would have increased the moisture status and aided significantly in maintaining a much better forest crop and luxuriant ground flora. The tract is gullied particularly along the banks of the rivers and sheet erosion is common throughout. The gully formation has been amply aided by the abuse of vegetative cover of the hills and undulating plains. Studies on inventorying and monitoring were scarce for Chotanagpur region. The only documentation that too, quantitative were found in forest department records of various forest divisions. Satellite remote sensing provides a means to obtain a synoptic view of forest cover and their condition on real time basis. It also saves both time and effort to discriminate spatial features. Phyto-sociology of the forest cover, understanding of spectral and temporal responses of vegetation, coupled with the digital image processing techniques and finally incorporation of GIS have brought about a profound benefits of the application of satellite remote sensing data in forest inventory and mapping (Roy *et al.*, 1993). The increased human pressure and consequent effects on the landform and land use changes has a profound effect on the present vegetation and the biodiversity. The present study is a project work on preliminary basis. The objective of the present study is to present initial information of vegetation through the application of RS and GIS techniques together with a

phytosociological analysis of the forests for their diversity. The study is basically based on three major approaches i.e. Remote Sensing, GIS and Ecology.

The growing human population and their requirements for food and energy resulted in overexploitation of natural resources. This indiscriminate use of our resources will definitely lead to complete depletion of our natural resources in the nearest future. Forests and wild life are the two most important natural living resources. In addition to food and shelter, they provide wood for cooking, timber for construction, cellulose and pulp tor the production of paper *etc*. They also have other important crucial ecological roles to play such as, maintaining and sustaining the supply of oxygen, by absorbing carbon dioxide, combating air pollution, regulating water resources, controlling water and wind erosion, mitigating floods and droughts, conserving genetic diversity and wildlife and providing recreational facility to public *etc.* (Pal, 1982). Any damage or depletion of forests and wildlife may cause rrepairable imbalance to the natural ecosystem. The results of forest resources survey conducted by FAO (1975) and UNEP (1980) indicate that the forests then covered a total of 3.6 million hectares. This is equivalent to 27.7 % of the global land area. Forests of the tropical countries and territories cover about 94 billion ha representing 53 % of the global forest area. About one half of it was tropical moist forest. The worlds decreasing forest resources covers a total of about 3.4 billion ha. which is equivalent to 27 % of the global land area.

In India, National Forest Policy (1952) and recent policy (1988) has also recommended that one third of the geographical area to be reserved for forest cover (Govt. of India, 1980). However, In India according to State Forest Report, 2017 forest cover is 24.39 percent of the geographical area of the country, which has been regularly, monitored and published in the form of "States of Forest" every alternate year by Forest Survey of India. Due to forest dependent developmental activities monitoring of day to day status of forest cover is required as entire ecosystems on earth is dependent on forests, which are also direct cause of change of environmental condition in the country. Therefore, information is needed and the progressive change in land cover over periods of decades is of interest. Remotely sensed data

may provide a better source for derivations of land cover due to internal consistency, reproducibility and coverage in locations where ground based knowledge is sparse (Roy and Joshi, 2002). Thus, remote sensing is one of the potential tools to carry out vegetation mapping.

Jharkhand with a geographical area of 79,714km² constitutes 2.42% of the country's area. The total recorded forest area of the state is 23,605 km² which is 29.61 % of the geographical area of the state. India State of Forest Report, 2017 published by Forest Survey of India, forest cover in the state is 23,553 km² which is 29.54% of the state's geographical area. The total forest and tree cover put together, it constitutes about 33.21% of the geographical area of the state.

1.3 Tropical Forests

Today around 13% of earth's land is covered with tropical forest (about 2 billion hectares or 7.7 million squire miles), of which much consists of tropical rain forest(Butler,2014), it plays a greater role like compositional and functional support to maintain the habitat on the earth surface which contain more than 50% of flora and fauna species, Maximum 18 out of 25 biodiversity belonging on Tropical forest in all over the world based hotspots. It may be also described in terms of biological population " the tropical forests are spreaded on only 13% of the total earth's area, but it contain 60-70 percent of total mass of biological species" which have most critical status of ecology system in world, which are the root cause of the avoidance by the research team. Geographical and climatic condition of such type of forest faces a natural barrier for field work. These types of forest showed many characteristic due to edaphic, organic and climatic condition.

Availability of tree abundance and its distribution is essential information for the management plan to implement the technique of biological conservation at a selected site, so the quantitative data have a large significance. Habitat and resources of a Rainforest area is also supported by different types of flora available in tropical forest, so a perfect knowledge on appearance and disappearance of a tropical forest is needed for planning and implementation for its conservation.

Biotic factor of self maintained forest is losing the power, because of human interference in its structure and function, which have need to conserve for their natural role on balance the ecosystem(Rao and Mishra, 1994), providing the natural habitat according to their vegetation cover with its variation according with change in season.

Due to the commercial plantation, establishment of power projects, commercially collection of MFP, grazing & browsing along with extension of cultivation of forest land in India, the natural characteristics of a forest is diminishing fast. It is unquestionable that the Geographical and Climatic situations in our country are changing with ecological habitats, so it is essential of sustainable use of plants and animals of a tropical forest.

The wide range of diversity of trees in tropical forest is felling for development projects affect the biological habitat of the tropical forests are diminishing (Suraj, 1997). The environment balancing capacity of tropical forest is with respect to temperate species which covers about 14% area of the world's forest area (19 million km). The maximum area of tropical forest exist in developing nation, whereas the artificial plantation of tropical wood species is available in developed countries ie. approximately double of the natural tropical forest. Tropical forest play a greater role in economy of developing countries using in railway and defence (Howard and Lanly, 1975), so it is necessary to study the Phytodiversity of the tropical forest regularly to know the actual species richness of floral species available in this area.

1.4 Geospatial Assessment of Tropical Forest

The joint form of Geographical Information System Remote Sensing and Global Positioning System (GPS) is known as Geospetial Technology. It is very useful technology to know the structural component of the tropical forest. In present time the advance version of spectral, temporal, spatial and radiometric resolution with remote sensing based data for past few decades are available to know the actual status of the tropical forests. These advance technique has improved the ability of the scientists, working in field of ecology and environment to study the characteristics of

forest. Recently the ecologist has worked in many sanctuaries, Tiger reserve and National park and found a good result of reliable, accurate and recent data with the help of remote sensing and Geographical Information System (GIS) which shows the actual exploitation of natural resources, which help in planning on conservation and maintenance of environmental condition of a protected forest. Researchers are therefore interested in developing methods for quantifying the provision and value of ecosystem services so this information can be incorporated into planning and decision-making at different scales and in different sectors (Hein et al. 2006; Kemkes et al. 2010).

Using GIS based map for the study of medicinal plants in a natural forest, rarity and other important information can be found, using the image analyzing software.The use of geographic information systems (GIS) to aid in conserving MH plants by assessing their distribution has been indicated in many studies (e.g. ustalish *et al*., 1996; Schumaker, 1996; Sperduto and Congalton, 1996) The available data of a place can be loaded on a global positioning system (GPS) Coordinates to create a vegetation map of study area. It also helps in prediction on damage of forest by disease or by other damaging agarics. The numerical value of plant density may also be calculate using the image satellite and which can be cross verified by ground truth or by matching the data available in govt. offices. Approaches to map forest canopy density, produced categorical maps with two (Boyd et al., 2002) or more classes (Rikimaru, 1996; Rikimaru et al., 2002) rather than a continuous variable. Joshi et al. (2005a) argued that canopy density should be treated as a continuous rather than discrete variable.

1.5 Biodiversity Assessment

It has been universally felt after Rio's Earth summit, that the biodiversity is a central theme for not only subject related scientist but also for administrators, politicians and planners of environment saving organization and community of biology. All participating countries including India has a primary responsibilities to prepare a record on flora and fauna of the respective countries to study and to decide strategies on conservation and management of the natural heritage.

There are few issues and a common question into the mind of common people that why to study biodiversity? because they are unknown about present cause of climate change and the role of vegetation in daily life. It became compulsory to study the biodiversities of all countries, who participated in Rio's earth summit and also for many countries which was signatories of the convention on Biological diversity because it was declared as central theme of ecology and to rectify the incorrect data manually prepared by earlier investigators, showing variation in spatial and temporal diversity which are presently not tallied with the data provided after study by the well equipped scientist today.

In present situation of race for development, destruction of species and habitat are very fast so it became a task for us to conserve the biodiversity (Wilson,1988). Planning without knowing the proper composition, function and structure of a forest is not successful, so it is essential to collect data on floral composition of plants species and its pattern with status of diversity in a forest area. Remote sensing and GIS based data is very suitable for this purpose (Noss, 1990). If the data is cross verified through ground truth, it becomes more authentic for Govt. of India who has changed their policy on forest management, from timber production to conservation after implementation of 1980 National forest policy on forest management.

1.6 Land Use Land Cover (LULC)

Generally we describe a piece of land in two different ways, one in way of land use and another in way of land cover. Information related with physical material available on surface of land is compulsory for a planner, by which they decides the suitable activities for future. Pattern on land use, support us for future use of land and if, we feel any crucial factor which influence the use of land, because Natural resources are directly regulated by the land surface cover which helps in maintenance of hormonal relationship between natural resources and its use by the human.

Land cover refers to the physical characteristics of Earth's surface, captured in the distribution of vegetation, water, soil and other physical features. Landuse refers to the way in which land has been used by humans and their habitats

(such as agriculture, settlements, industry etc.). Although land use is generally inferred based on the cover, yet both the terms land use and land cover being closely related are interchangeable. For example, settlement is cover but if we include buildings whether it is being used for residence or industrial activity, it shows the land use component (Chaudhary et al, 2008).

Composition of vegetation along with its characteristics of available land cover indicates the environmental condition of its surrounding area. Information on land surface cover and its nature is useful for planner for future course of action. Due to the effect of environmental change all over the world has attracted their attention towards its proper management. Land cover mapping is not new and it is applied for earlier but it was not popular, now a day, our forest is managed with the application of modern technology, which is very affective for vegetation mapping of a larger area. It covers a large area mapping in a short period with the help of satellite. Data obtained using remote sensing of land surface cover, provide better opportunities in research of threat related with environmental segments like estimation of biodiversity, characteristics of habitat, production capacity of a forest and in hydrological field. It also helps to nature management planner for scientific management of agricultural field also (Kuchler, 1988).

Two systems like GPS (Global Positioning System) and GIS (Geographical Information System of the Geospetial technique is providing a very deep (internal) information of the target area, using this data, a group of scientist is characterizing the forest resources in terms of status and locate the study area. Remote sensing based forest management has increased dependency for future planning because every required information for characterization is available in remotely sensed form.

1.7 Vegetation Mapping

The life on the earth is chiefly governed by the natural resources available on the earth surface or its atmosphere, which provide food and oxygen to living organism. Flora (vegetation) available on the earth surface is also known as primary and main producer of the ecosystem so it is considered as most essential component

of life. The environment around the earth is also regulated by vegetation as and when its status change, it reflects in form of climate change. Assessing and monitoring the state of the earth surface is a key requirement for global change research (Committee on Global Change Research, National Research Council, 1999; Jang *et al*., 2006;Lambin *et al*., 2001). Classifying and mapping vegetation is an important technical task for managing natural resources as vegetation provides a base for all living beings and plays an essential role in affecting global climate change, such as influencing terrestrial CO_2(Xiao *et al*., 2004).

Scientist from different location of world has studies the relationship between vegetation and environment of surrounded area in individual temporal scales to know the floral dynamics. It has also been observed that during the last hundred years, the climate and vegetation is change accordingly in proportionate, which show the inter relation between these two important component and affect the climate change. Such type of studies draw an attention to all responsible to plan in more scientific way so that a real prediction can be forecasted on changed condition of vegetation and climate accordingly.

Earth is occupied by 70% ocean and 30% land. It is realty that ocean is the major part and regulating the global climate, but it is also a fact that vegetation on land area is also dominantly affecting the biochemical cycles. Land use map shows a relation between objects and its features. Vegetation map shows the distribution of different diversity of flora and its relation with local climate of location (Thakker *et al*., 1999). The application of vegetation map is not new and adopted for last few decades known atlases and archives maps (Mathews, 1983) which was created by local method by different expert, presently use in reference for review the land cover distribution (Defries and Townshend, 1994). There were many systems for classification of vegetation was available to use for scientist to study ecology.

Proper information on distribution and composition of forest eco- system is a key factor of proper management and planning to restore the lost component of ecosystems, may give the benefit to society in terms of rain and comfortable weather to living organisms.

1.8 Study of Vegetation using Remote Sensing & GIS

A device that helps to obtain details of information of an area without touch with the object is known as Remote Sensing. It is a combination of arts and science both because we use satellite for area photography is science and its Social analysis is an art (Lillesand and Keifer, 1994). In remote sensing, the images are repetitive or overlap during aerial coverage, across the larger area of forest or other target area for monitoring of natural resources. Information on natural resources is computised by Remote Sensing with the help of few software tools for image processing, GIS and GPS recognize the data more authentic.

In present time, using this tools and technique of remote sensing help in monitoring the global natural resources, apply in Mapping and surveying to differentiate in desire Forest type and crown density for proper monitoring. It also help in the management and planning for disaster, Forest mapping, Forest management with the target of ecological balance. Joint use of Remote sensing and geographical Information System is giving very positive result in planning for management of landscape by policy maker.

The data with less error, provided by the satellite, apply in mapping and classifying the vegetation cover in affordable cost is accepted by expert, also use in proper management of green cover of earth for future (Thcker *et al*., 1985, Botkin *et al*., 1984). The data on Mapping and Classification of natural resource prepared is effectively utilized in study of the structure and function of vegetation changes with time (Troll, 1971), So the remote sensing technique is universally accepted for planning and monitoring of natural resources.

Remotely Sensed data provided by satellite is also closely linked to previously store geographical data, provide strong opportunity to sort-out the environmental problems. It has been observed that information provided by remote sensing is becoming primary source of Geographical Information (Trotter, 1991). It has been also forecasted that the joint use of remote sensing and Geographical Information System (GIS) may be the most suitable tools with technique to eliminate the problem related with ecology and environment in next century, because remote

sensing is working in mode of natural resource manager to analyzing the landscapes for larger area. It is also very important to know that the means provided by remote sensing can be used in decision making by policy maker without any hesitations (Colwell, 1983) as it is widely accepted in all around the world very fast.

There are various uses of remote sensing technology in many fields for monitoring and planning in operational way. Two important bands like spectral and spatial, related with mapping along with resource information are now available in high resolution sensors of satellite.

Advancement in remote sensing technology to receive better quality of data for the target has been achieved to work in new discipline for new challenging issues of worldwide on change of climate and its effects, so as to monitoring of land cover became very easy.

Creation of multi temporal images at a short interval of time for a various spatial resolution helps in monitoring of forest area is also an advantage of remote sensing because it save time and money. Due to multi use of remote sensing, the satellite based technologies are also modified accordingly to extend its application in more and more new field as like to extensively use in vegetation studies in world.

1.9 Need to Study of Vegetation

In proper conservation and management of ecosystem of wildlife sanctuaries, it is essential to know the details of existing vegetation by classifying and mapping of the protected area. Change of status and distribution of vegetation with time is now possible to study, using the technology of remote sensing, which provides information in quantitative aspects of floral composition of the target area (Muller-Dombois and Ellenberg, 1974).

Because of costly and time taking with less accuracy, the traditional method of study of the vegetation of remote area is now a days not in use, whereas due to repetition of coverage of a area by satellite in very less interval of time, the data provided by remote sensing have less percentage of error (Sharma *et al.*, 1989). Remote sensing is also providing valuable informative data to derive and quantify

the spatial pattern and ecological information to study species richness and real cause for the loss of species richness are reason of global change (Dhinwa *et al*., 1992). These all information from remote sensing technology are playing key role in planning and management of natural resources. To know the role of forest in climate change is essential to study the cause of fast degradation in forest health.

Remote sensing and GIS provides very authentic information on rate of loss of forest resources during the past few decades. It is essential for better management plan for future strategies. The success of plan on conservation in future of natural resources is highly depends on accurate information obtained from modern technologies.

It is easy to develop the management plan of a Wildlife sanctuary and vegetation because it has a fixed area with identified and familiar to local people and frontline staff. Such types of area are a prime centre of conservation of biodiversity because quantitative & qualitative information is available on flora species. If details of biological information of Dalma Wildlife & Sanctuary is obtained using remote sensing, it will be better opportunities to formulate a very effective management plan. Due to more diversity in adaphic and climatic factor within the habitats area, the microclimatic functions show crucial and tangible diversity. In this context, the present study envisages an ecological study with the help of geospatial tools of Dalma Wildlife Sanctury, a protected area with unique phytogeography, rich and diverse flora and fauna have a great ecological and environmental significance.

The forests of the Sanctuary belong to 5 B/C_{1c} (Northern tropical dry peninsular Sal forest) and 5 B/C_2 (Northern tropical dry mixed deciduous forests) as per the Champion and Seth's classification.

The topography of the Sanctuary varies from slightly undulating to quite steep slopes with luxuriant vegetation, which makes it one of the best natural habitats in the country. The hill range popularly known as Dalma Hill Range, on which the Sanctuary is situated stretches up to the southwestern portion of West Bengal State. Among the fauna, the Asian Elephant, Sloth Bear, Mouse Deer, Pangolin, Barking Deer, Mongoose, Indian Giant Squirrel, Large Owls, Python are the main species.

Dalma wildlife sanctuary plays a pivotal role in maintaining the genetic variance of the Asian Elephants as it connects many elephant areas of the Central Indian Elephant population.

Even after the heavy devastation of the forested areas by different biological factors, the Sanctury, especially in Dalma Hill Range, remains species rich due to the inaccessible pristine forests at the top of hills and valleys of Sanctury area, which lodge a number of rare and threatened plants. Thus biodiversity documentation of a protected area like Dalma Wildlife Sanctury is of great significance. No detailed vegetation analysis has so far been carried out for this elephant reserve, excepting perhaps for some passing references in Forest Working Plans based on some randomized sampling of plots. The present study based on advanced geospatial techniques followed by detailed phytosociological analysis may provide valuable information as status of vegetation profile, stratification, species richness, species rarity etc. which may aid in proper management of Dalma Wildlife Sanctuary.

Objectives

The proposed study is designed to meet the following objectives:

1. To analyze vegetation cover and types in DWS using RS & GIS techniques
2. To quantify and map the phytodiversity in DWS
3. To prepare a comprehensive map of vegetation in DWS

CHAPTER – II

REVIEW OF LITERATURE

CHAPTER – II

REVIEW OF LITERATURE

2.1 Forests, Environment and Flora

Green plants are the basic food producing living organisms on which life of all other organism are dependent, particularly animal and human. In past, plant classification was mainly based on ground survey, however now a days with the development of Remote Sensing and Geographical Information System, plants occurrence. There are some difficulties in definition of vegetation classes based on their spectral responses alone, due to the common heterogeneity of the cover type and the factors affecting spectral responses.

Tropical forest containing more than half of all plant and animal species occupy less than seven percent of the terrestrial surface, (Groombridge and Jenkins, 2000). And most genetically diverse terrestrial communities on earth is present in tropical forest (Hubbel and Foster, 1983). Tropical forests have much significance due to their species richness (Kraft *et. al*. 2008), high standing biomass and carbon storage (Bonan, 2008) and global net primary productivity (Sabine *et. al*. 2004). Biodiversity surveys and ecological studies have mainly focused on areas with a high concentration of plants and animal diversity, intact biological reserves and protected areas with low level of human intervention (Fazey *et al.* 2005). The absence of baseline data and the lack of monitoring mechanisms have severely hampered the conservation of tropical forests. A number of attempts have been made to understand the compositional organization of tropical forest (Hubbel, 1979; Hubbel *et al*., 1999; Myers *et al.* 2000; Condit et al., 2002; Forest *et al*. 2007 and Kraft *et al*., 2008).

In ground ecological systems represent a continuum on an environmental gradient consisting of different land cover types in the form of landscapes, which is Landscapes, which is depicted by a mosaic of interacting ecosystems in relatively large to very large areas consisting of patches of land use and land covers (Forman and Godron, 1986). The prerequisite for management of landscape depends upon

extent and distribution of land cover types which represents easily measured indices to assess the effects of changing environmental conditions.

It is very important to know the facts of environmental components alongwith its origin and function, prior to study the biodiversity pattern assessment. Keeping in view on above two components, it is essential to consider a small size plots (Quadrate) for proper study of biodiversity of place. The role of Alpha and Bita diversity was studied by Davidar *et al*. (2005 and 2007), who reported that seasonality is the initial driver of β (beta)diversity. Similarly they reported that Alpha diversity is also highly related with seasonality. Ramesh *et al*. (2010) has reported of work Alpha diversity have a chief role in rain fall at a place. Joseph *et al*.(2008) studied the Mudumalai Wildlife Sanctuary and published in his report with facts that the plant richness play a great role in drainage density (Climate and topography effect each other) The recent version of Geospatial technology has given a new tool for study and analysis of tropical forest in tropical conditions (Johnston, 1998; Wardsworth and Treweek, 1999; Turner *et al*. 2003; Pettorelli *et al.* 2005; Townsend *et al*. 2008).

2.2. Mapping of Vegetation of an ecosystem

Vegetation is the primary producer of any ecosystem, which controls all types of living things on earth and is being considered as one of the most essential components on earth. Champion and Seth (1968) have given an elaborate classification of vegetation, which is universally adopted system of forest classification. Vegetation map obtained from remote sensing, provides all dimensional view which help to distinguish the different types of landscapes and their characteristics (Gordon, 1991). In a study using Vegetation map obtained from remote sensing data provided by satellite of Madhav National Park, Madhaya Pradesh, Shirish and Roy (1993) found a qualitative characteristics of vegetation which can be adjusted according to aims and objectives of the survey (Kuchler, 1988). A collaborative work on Land use land cover map have been started (Legris and Meeher-Homji, 1968 for south India by by French Institute, Pondicherry and State Forest Departments (Legris and Meher-Homji, 1968). Raturi and Bhatt (2004)

has also effectively used the Vegetation map to analyse, monitor and for conservation of natural forest of Rudraprag. The forest of East Champaran district of Bihar was also studied by Manju *et al*., (2005) using remote sensing data obtained from IRS-1D LISS 3 Satellite.

Prediction on land cover pattern may support to next generation for accessing the scenarios of land cover and the rate of change of pattern that reflect the present and near future trends (Brown *et al.* 2002). (Gariola, 2008) have also studied the Forest vegetation patterns according to altitudinal gradient of west Himalaya in India.

Analysis of Vegetation Cover Map of disturbed Gradient of forest in Warangal District, Andhra Pradesh was done by Reddy *et al*. (2008) using Remote Sensing and GIS techniques. Similar study of Vegetation pattern was also observed by Reddy *et al*. (2008). To study a Kerala based watershed area using remote sensing and GIS was done by Renjith *et al*. (2010).

2.3 Significance of Remote Sensing and GIS in Vegetation analysis

India on aerial photographs of natural forest to know the real physical features was just started in end of 18^{th} century and gradually further more activities like discovery of aerial cameras along with wide angle lens to create useful image in research. Wilber Wright in year 1909 has tried first time to take aerial photographs from his invented aeroplane. In India, Vikram Sarabhai, Homi Jahagir Bhabha and other had used Remote sensing data obtained from USSR aircraft in year 1970

In India, this technique was also used for the mapping of delta in year 1924. The regular survey started in Asian countries during the period of I950-60's. Since 1925, aerial photographs are in use in India for preparation of topographical maps. Since 1965, for Pre- Investment Survey of Forest Resources, aerial photographs were used for forest type mapping and inventories in India. Opening of the Indian Photointerpretation Institute (IPT) in Dehra Dun was a major break through in this field. With the opening of IPT, the photointerpretation technique was more

popularised and subsequently many organization.like Forest Survey of India(FSl), started photointcrpretation works.

Tiwari (1978) have used this technique for comparative study forest types by creating a land use map of forest stock. Colour infrared photography became universally popular, although its potential use in forestry was referred to earlier (Spurr, 1948). Application and studies of infra red colour photography were also undertaken by many researchers (Fritz, 1967 and Benson and Sierns, 1970). Vegetation mapping using 1:10,000 scale B&W panchromatic aerial photographs has been carried out in the western part of Kanha National Park (Roy *et al.* 1986). Changes taking place in the vegetation cover of Kanha National Park has been identified on the aerial photographs and mapped by Shetha *et al*. (1986).

Using self prepared manual on interpretation of forest cover Tomar,(1968) have analysed the tropical forest of Central and North India for land use identification in 1969 Tomar). Similarly Versteegh (1968) prepared forest cover type map of Bastar in Madhya Pradesh in I:25,000 scale using B&W aerial photographs, Gupta and Abichandini (1968) conducted air photo analysis of plant communities in relation to edaphic zones in the arid zone of western Rajasthan. A new scale suggested by Tomar (1971) from 1:25000 to 1:30,000 of aerial photographs for vegetation studies of Himalaya region with reference to Jammu& Kashmir Van and Joshi (1972) conducted a survey to collect information of the forests in Doon Valley using aerial photographs by which 15 land cover classes were identified in 1: 60,000 scale. Seth and Joshi (1972) recommended the scope of photo interpretation for the study of Indian Forests. A work was on volume class estimation using black and white photographs , Land use(forest type) classification and mapping for survey was done by Seth and Tomar (1973), Tomar and Maslekar (1974) and Tomar and Maslekar (1974) using 1: 60,000.

To dispose a proposal to care the vegetation of FAO (1975) for tropical forests and Maslekar (1977) have studied young teak plantations of Attappadi reserve forest in Kerala, using 1:10,000 scaled aerial photographs. Shedha (1978) have described the role of photographs captured from aeroplane in creation of forest cover

maps. In the same time Tiwari (1978) suggested method for comparative estimation of cost and time in preparation of forest and land use maps using I:15,000 scaled Black and White aerial photographs along with stock maps for Tehri Garwal, and found aerial and the result on photo map preparation was really a cost effective. A map prepared for Gudem Reserve Forest, Andra Predesh using aerial photographs by Shedha (1981) was also cost effective. Soil and land use types of Tarai forest of Utter Pradesh using aerial photographs was also correlated by Mathur *et al*. (1984).

Forest cover map of Godavari basin was prepared using aerial photographs of 1:25,000 scales by Madhavanunni *et al*.(1985). Similarly a drainage map of Eastern India from aerial photographs was also prepared by Rekha Ghosh (1989). Vegetation map of Attappadi forest division, Kerala was also obtained using 1:15,000 aerial photographs by Menon (1988), where more than 20 units were mapped. An aerial photographs of scale I:10,000 for mapping Kanha National Park, Madhya Pradesh were used by Porwal and Roy, 1991) .

Landsat data for forest inventory in China was also used as it was reported by Fang (1980). Ibrahim *et al*. (1986) discussed the use of aerial photographs in Malaysian forestry. Ibrahim and Hashim (1990) mapped and classified mangrove forests by using 1:40,000 aerial photographs in Malaya. Tiner (1990) used high altitude photographs for inventorying wet lands in the United States. Aerial photographs of two different dates were used to monitor changes in Sinharaja forest. Srilanka (Banyard and Fernando, 1992).

The application of RS and GIS for Land cover mapping of south West of Nigeria used by Daniel (2007). Many more studies on use of remote sensing data to analyse the diversity of vascular plant species (Stohlgren *et al*. 1997; Gould, 2000; Griffiths *et al*.2000; Nagendra, 2001; Murthy *et al*. 2003; Asner *et al*. 2008; Mc Roberts, 2009). Goparaju *et al*. (2005) used GIS and RS to analyze the effects of fragmentation on plant diversity. The scope of a geo spatial technique based biodiversity assessment was studied by Murthy *et al*. (2006) for Indian forest. The use of geo informatics as a tool to know of Rare, Endangered and Threatened (RET) plant species was tried by Varghese and Krishna Murthy (2006). The Phytodiversity

assessment of Parambikulam Wildlife Sanctuary using geospatial approach studied by Magesh *et al*. (2010).

2.4 Application of Satellite imagery data in vegetation mapping

Effects of fire on forest cover were successfully studied the vegetation changes, using remote sensing techniques with in Bandipur National Park and Mudumalai Wildlife Sanctuary, (Madhavanunni *et al*. 1986). Satellite data was used to study and monitor desert and delta of South Africa by Prince (1985).

NRSA in year 1983 prepared the land cover maps of forest loss in Kodagu district, Karnataka using 1:250,000 Landsat MSS data for the period 1972-75 and 1980-82. Lal *et al*. (1990) assessed the extent and location. Porwal and Roy (1992) used 1:50,000 Landsat TM Fee to mark the edge and mapping of Distinctness Uniformity and Stability (DUS) forests of Western Ghats, Kerala with overall accuracy as 88.33 percent.

Mapping of Chandka Wildlife Sanctuary, Orissa was done using 1:50,000 Landsat TM Fee and it was compared with aerial photomap by Roy *et al*. (1992). Nanda Kumar and Menon (1992) and Roy *et al*. (1993) applied remote sensing in mapping of tropical forests of Andaman situated Islands natural resources using Lands at TM FCe of 1:50,000 scale and also identified nine land cover classes.

In context of Indian forests, many scientists have used spatial technologies for the study of Habitat assessment ofKaziranga National Park in 1986 by Parihar, Panigrahi and Lahar. Using the same technology of remote sensing (Roy *et al*. 1991) reported a relationship between grassland and biomass of the same species in Kanha National Park, Madhya Pradesh.

A research was conducted by Varghese *et al*. (1996) in bamboo dominant forest using spatial technology of remote sensing, where a stock mapping was derived for detail information for future planning. Similarly a cover map for Chimony Wildlife Sanctuary of Pariyam, Trissur, by Suraj*et al*. (1996). Sureshbabu *et al*. (1997) has also studied the Kanan Devan hill based Eravikulam National Park of Keral using the same method of remote sensing to get information of Shola forest.

2.5 Procedure of Digital Image preparation

Using different remote sensing sensors for object extraction is a common issue in classification tasks (Bigdeli, et al. 2015; Bigdeli et al. 2014). Classifying and mapping vegetation is a cardinal issue for managing natural resources because it plays a significant role in influencing global climate change. Also, it contains a broad domain of applications such as designing strategies for the optimization of urban ecosystems, better-conserving plant communities and so on (Xie et al.; 2008, Feng et al., 2015).

Various studies have been done in vegetation mapping; some of them were predictive models based on statistical or machine learning methods (Franklin, 1995). Overall, we can group vegetation mapping methods based on using ground truth reference to supervised and unsupervised methods. Supervised classifiers are widely used since they are more robust than model-based approaches (Belgiu and Drăguț, 2016). Recently, Convolutional Neural Networks have been successful in classifying satellite images due to their ability to omit disturbances at different scales (Maggiori et al., 2016; Fu et al., 2017).

Using of spectral information along with radar data can provide more improvement in object classification (Bigdeli and Pahlavani, 2016 and 2017). Due to spectral variability existence in the Sentinel-2 bands, it has more capacity for defining biomass and vegetation indexes. Sentinel-1 images are only available at two polarizations, and this limits the definition of more informative indexes. So, it is necessary to test our vegetation mapping result using sent.

Changing conditions owing to increasing forest fragmentation make land cover and change detection analysis an extremely important consideration for sustainable forest management. This study applied supervised classification using maximum-likelihood algorithm in Quantum GIS to detect land use land cover changes in the Bosomtwe Range Forest Reserve, Ghana from 1991, 2002 and 2017 using Landsat 4 – TM, Landsat 7 – ETM and Sentinel-2 satellite imageries respectively. Mensah et al.(2019) based on the results of the study, it is concluded

that land use/cover of Bosomtwe Range Forest Reserve have undergone remarkable changes for over the period of 26 years.

In a study, Zaitunah et al.(2018) of Various activities around watershed areas of Besitang have changed the land cover and vegetation index (NDVI) that exist in the region. In order to detect changes in land cover and NDVI quickly and accurately, we used remote sensing technology and geographic information systems (GIS). The study aimed to assess changes in land cover and vegetation density (NDVI) between 2005 and 2015, as well as obtaining the density of vegetation (NDVI) on each of the land cover of 2005 and 2015. The research showed the extensive of forest area of 949.65 ha and a decline of mangrove forest area covering an area of 2,884.06 Ha. The highest vegetation density reduced 39,714.58 Ha, and rather dense increased 24,410.72 Ha between 2005 and 2015. The land cover that have the highest NDVI value range with very dense vegetation density class is the primary dry forest (0.804 to 0.876), followed by secondary dry forest (0.737 to 0.804) for 2015. In 2015 the land cover has NDVI value range the primary dry forest (0.513 to 0.57), then secondary dry forest (0.456 to 0.513) with dense vegetation density class.

There are several indices for highlighting vegetationbearingareas on a remote sensing scene. NDVI is a common and widely used index. It is an important vegetationindex, widely applied in research on global environmental and climatic change (Bhandari *et al*. 2012). NDVI is calculated as a ratiodifference between measured canopy reflectance in the red and near infrared bands respectively (Gandhi *et al*. 2015).

Visualization of satellite image and aerial photography have also been used for measurements of vegetation, canopy types,and vegetation density, this process takes a long time when applied to a large area. Image visualization has a limitation since the digitization process and the data editing process requires synchronization and consistency in interpretation (Roy *et al*. 2015). Differences in perceptions of interpretation can also affect the mapping accuracy, thus an interpretation method is

needed to calculate vegetation density quickly. The use of imagery is dependent on the purpose and level of detail of studies.

With the aid of remote sensing data covering coastal southern California and a historical wildfire dataset, the effects of short interval fires (<8 years) on chaparral recovery were evaluated by comparing areas that burned twice to adjacent areas burned only once. Twelve pairs of once- and twice-burned areas were compared using normalized burn ratio (NBR) distributions. Correlations between measures of recovery and explanatory factors (Meng et al. 2014) (fire history, climate and elevation) were analyzed by linear regression. Reduced vegetation cover was found in some lower elevation areas that were burned twice in short interval fires, where non-sprouting species are more common.

Ghosh *et al*. (2019) classified SPOT-6 and RapidEye data and used the outputs as training data to create continuous field layers of Landsat-8 imagery. The area outside the overlapping region was predicted by fractional cover analysis due to the larger extent of Landsat-8 imagery compared with VHR datasets. Results showed clear discrimination of understory lantana from upperstory vegetation with 87.38% (for SPOT-6), and 85.27% (for RapidEye) overall accuracy due to the presence of additional VHRSI derived DSM information. Independent validation for lantana fractional cover estimated root-mean-square errors (RMSE) of 11.8% (for RapidEye) and 7.22% (for SPOT-6), and R^2 values of 0.85 and 0.92 for RapidEye (5 m) and SPOT-6 (1.5 m), respectively. Results suggested an increase in predictive accuracy of lantana within forest areas along with increase in the spatial resolution for the same Landsat-8 imagery. The variance explained at 1.5 m spatial resolution to predict lantana was 64.37%, whereas it decreased by up to 37.96% in the case of 5 m spatial resolution data.

A comparative study on hardness of wood of existing tree with previous available record of Northern Maine, using vegetation cover mapping by Dodge and Bryant in 1976. The area of hard wood/soft wood and total forested area were compared with existing records. Bryant *et al*. (1980) used Landsat digital data for

forest mapping and compared it with aerial photographs. Computer classification of data from Landsat has resulted in measurements and maps of forest type's tor two New Hampshire Countries (Arthur and Emily, 1976). Studies on spectral separability of cover classes were done by many researchers. Analysis of several forest cover classes, based on separate spectra of individual plant species using Landsat data of North eastern states by (Ashbind Singh, 1987).

Worldwide scientists like Adeneyi (1985), derived land use cover map for desert area of African countries using remote sensing data from Landsat. Skidmore *et al*. (1987) also used Landsat provided digital data for mapping of Australian forests. Study of Pakhat sub- watershed in Tihri garhwal of U.K. using cost effective data from Remote sensing by Kachhwaha (1983) for mapping. Change of forest cover of a location over a time was studied by Singh and Khan (1989) using the remotely sensed data. To refine the supervised classification, Ashbindu Singh (1990) have also used satellite provided remotely sensed data. Menon, Sashidhar (1990) and Menon (1991) have used spatial technology to prepare land cover mapping to evaluate the forest of Eravikulam National Park located in silent valley, kerala to study the phytosociology of Rubber plants. Ranganadh (1992) also applied remote sensing data to study the biodiversity of Silent Valley .

John *et. al.* (1993) has reported the use of Spatial Technology to analyze the flora in reference of vegetation status, productivity and potential of physiological activity.

2.6 Phytosociological studies / Estimation of Biodiversity

Two main components of ecosystem are Synecology and Autecology. Composition of community structure of vegetation at an area is known as Synecology, where as the functions of its components is Autecology. Both are complementary to each other so it is essential to study all components by way of modern developed technology. Under autecology, we study about the classification of vegetation. The status of vegetation directly influences the Carbon, Nitrogen and Water on earth.

The biodiversity in an area is studies by various methods, which are broadly grouped into three main categories -

(a) Floristic method – Here the species are studies by listing various genera and species present in community. Such methods, however give little or no idea of the composition, structure, growth, forms etc., of the community.

(b) Physiognomic method – Various species of the community are studied in terms of their life forms, general status, spread etc. Out of a number physiognomic methods, Raunkiers life form method is the most popular method.

(c) Phyto-Sociological method – This method provides detailed information on the composition, structure, species diversity, growth, trends and succession and other characteristics of the community. On the basis of the nature of sampling units there are three sub-methods –(i) Quadrat method- In this case the sampling unit is having definite area, which is taken in the form of a squire, rectangle or a circle e.g. list quadrat, list count quadrat, chart quadrat and experimental permanent quadrat; (ii) Transect method – Here the sampling unit is in the form of line of suitable length e.g. line transact, belt transact; and (iii) Point method – In this case sampling unit is taken in the form of a point.

Classification of vegetation is not new, it was done by Champion in 1936, Champion and Seth in 1968 and Stebbing in year 1922 on the basis of physical structure of floral communities.

In India, the Classification of green biodiversity was started by Meher-Homji (1984). Under this task the India was divided into 14 phytogeographic zones, keeping in view of all bio-climatic parameters. 11 zones was kept in Peninsular, and three in Himalaya, Andaman and Nicobar islands. Vegetation belonging to all eleven zones had been categorised into twenty nine vegetation types.

In due course of time the term Succession was defined by different scientist in different form. (Odum, 1969) defined it as the process of development of

ecosystems is known as succession, whereas it was defined by Tansley (1920) that the development of plant community is succession. Clements (1916) has also defined it as an orderly change of community structure is succession.

Quadrate system of quantitative study of vegetation was initiated by (Pound and Clernents, 1898) for American vegetation. The size of Quadrat is differing for different vegetation types. The standard size of Quadrat was fixed by (Cain, 1938) on the basis of species/area curve. Jaccard (1912) has suggested that the size of Quadrat should be changed according to change in number of plant species which was later followed by Brawn-Blanquet (1932), Cain (1938), Misra and Puri (1954), Oosting (1956), Misra (1968), Singh *et al*. (1984), Basha (1987), Subhash *et al*. (1987), Pascal (1988) and Ray (1993).

The presence of a individual in a randomly selected area (Quadrate) is expressed as constancy (Du Rietz, 1930). It has been reported by Raunkiaer (1934) that the description on frequency and law of frequency is percentage frequency . Raunkiaer (1934) has given a concept of frequency analysis which is calculated on the basis of presence or absence of a individual in a Quadrate. Similarly Curtis (1959) has given a basic idea on index of dominance. It is calculated with the value of density, frequency, abundance, IVI and Basal area.

In study of Phytodiversity, an useful tool termed as Maturity Index has been reported by Pichi-Sermoli (1948). (Menon and Balasubrarnanyan, 1985)) has studied the Maturity index values of undisturbed and disturbed evergreen semi evergreen and moist deciduous forests of Attappadi. On the basis of Maturity Index Value, Ray *et al*. (1993) has reported that the forests of Andaman and Nicobar delta in India is semi mature.

Few workers (Fracker and Brischle, 1944, Whitford, 1948; Ashby, 1948 and Cole, 1949) have indicated that habitat distribution of individual is a valuable aspect for vegetation that gives great research opportunities to ecologists. Contagiousness among the individual was studied by Whitford (1948) using the ratio of abundance and frequency. If the abundance and frequency ratio is below 0.025, it means the distribution of individual is regular whereas, if the value 0.025 to 0.05, it means

random distribution of species, if this value is more than 0.05 contagious (Curtis and Cottom, 1956).

Curtis and Mclntosh (1951) have reformed in continuum concept by which an effect of environment over the plants community structure can be evaluated. It helps in study of quantitative and qualitative modifications ofbiodiversity; it was widely used for a longer period (Gleasan, 1920: Ellenberg, 1956; Pandeya, 1961; Sorenson, 1948).

A clear idea was on community co-efficient was given by put forward by Jaccard (1912) which is a tool for compare of two or more forest flora communities. It was later on reformulated by Gleason (1920), Sorenson (1948) and Ellenberg (1956).

In 1949, Shannon & Weaner has jointly published a formulae in a original research paper/book (The mathematical theory of communications) to calculate Diversity index. It is widely applied by researcher in quantify the plant community structure for environmental studies. In the same period of 1949 Simpson has also recommend other method to evaluate the plant biodiversity and dominance of individual species.

A study carried out on Phytosociological study indicated presence of 88 plant species belonging to different families (Prasad,2003). Out of these 3 species were noticed in the stage of tree, 18 species of Shrub form, 41 herb species and 26 species as climbers. The highest value of frequency density and abundance were found for Sal (*Shorea robusta*). In case of shrub layer Karond (*Carissa opeca*), Rendi (*Casearia graveolens*) and Kendu (*Diospyros melanoxylon*) gave highest frequency, density and abundance, whereas in herb layer Dub (*Cynodon dactylon*), Premjori (*Crotolaria striata*), and in climbers group, Kujrilar (*Celastrus paniculata*), Ramdatun (*Smilex macrophylla*), Bankundari (*Melothria heterophylla*) etc. showed highest frequency, density and abundance. Variation in appearance of a few species such as Rendi (*Caseria graveolens*) was found with highest parameters in the month of March 2001, but rapid disappearance in the month of April, May and June 2001 is noticed. Later on a few species like *Carissa opeca* and *Diospyros melanoxylon*,

dominated with higher values. Maximum variation were noticed in the case of climber, which is due to the change in local climatic conditions. A number of factors such as grazing browsing, fire, fodder & fuelwood collection etc were found to influence the vegetation & floristic composition of the area.

Plant diversity index of Coppice Sal (*Shorea robusta*) forest of 17 years old age have indicated presence of rich plant biodiversity having 88 plant species. Out of 88 species. The importance value Index (IVI) of Shorea robusta (tree) *Carissa opeca* (Shrub), *Cynodon dactylon* (herb) and *Melothoia heterophylla* (climber) was as 111.26, 24.45, 8.10 and 3.18, respectively. The species richness calculated by Shannon Diversity Index formula was found maximum (1.16) in the month of July 2001 and minimum (1.03) in the month of May 2001. (Prasad and Siddiqui, 2004).

The detail study of 88 species found in Rarha Forest Area were found distributed in 36 families and maximum number of species belonged to the family Papilionaceae followed by Convolvulaceae. Plant diversity status of coppice Sal forest of Rarha under protected condition indicated rich flora in the area due control of biotic interferences(Narendra and Siddiqui, 2005).

Pande *et al*. (1988) has reported that higher the density of individual indicates the higher value of species richness, they have published on the basis of study of plant biodiversity and dominance for a man made orchard having the plantation of four different species. According to (Knight 1975), Braun, 1950,Monk, 1967; Risser and Rice, 1971) the value of Diversity index is more of newly established tropical forests (5.06) and old (5.4), while for the temperate forests, the diversity index value was found in 1.16 to 3.4.

Siddiqui (2001) has presented detail account of plant Biodiversity of Jharkhand State and suggested many conservation strategies. A list of 14 plant species including R*auwolfia serpentina, Mesua ferea, Sterculia urens* etc. are given in endangered category, beside seven species are given in vulnerable and rare categories. Emphasis was also given in *in situ* and *ex situ* conservation methods.

Quli and Siddiqui (1997) explained the global concern for biodiversity conservation for the extent and magnitude of endandered and threats to the natural resources, which form the very base for human existence on this plant. The paper elaborates an attempt to facilitate the conservation of biodiversity in the interest of human race. The conservation planning has been dealt under two main steps (1) The status survey of the resources, and (2) conservative strategies, followed by restorative measures. To illustrate the most complex challenges of the biodiversity conservation, a self explanatory flow chart has been drawn and to facilitate the evaluation of resources status a standard format SITE DATA SHEET is prepared for implementation of conservation strategies. Some restorative measures have also been suggested.

Kumar *et. al.* (1994) found the effect of biotic disturbances on the population structure of 6 important tree species (*Shorea robusta, Terminlia tomentosa, Bauhinia variegata, Aegle marmelos, Diospyros melanoxylon and Emblica officinalis (Syn. Phyllanthus emblica)* of dry peninsular Sal (*Shorea robusta*) forest was studied at 2 sites (protected and unprotected) in the Palamau Tiger Reserve, Daltonganj, Bihar, from July 1991 to July 1992. Separate data were recorded for trees, saplings and seedlings. The reduction in (adult) tree density over all 6 species was 33% at the disturbed (unprotected) forest site and 9% at the protected forest site. The reduction in density of the 2 most dominant tree species, S*horea robusta*and Terminalia *tomentosa* was 10% and 27% respectively, at the disturbed forest site, while it was 4% and 10% respectively, at the protected forest site.

Pimental *et al.* (1992) mentioned that the importance of protecting the biological diversity existing in managed agricultural and forest ecosystems should be discussed with emphasis on the patterns of species biodiversity in these environments, the role of diversity in maintaining ecosystems, the viability of ecosystems, and the nature of the threat to biological diversity. Arthropods contribute a great amount of biomass and a great number of specific ecological strategies and policies that enhance the conservation of biological diversity in agricultural and forest ecosystem are suggested.

Hossain *et al.* (1998) made quadrat analysis in the understory vegetation of *Eucalyptus camaldulensis* (5 plantations, 5-16 yr old), *Acacia auriculiformis* (9 yr old), *Cassia siamea Syn* Senna siamea (5 yr old) and *Xylia dolabriformis* (5 yr old) plantations in the degraded Sal (*Shorea robusta*) forest areas of Tongail Forest Division, Bangladesh. Thirty eight species were identified, and were listed showing their presence/ absence in each plantation. *Eupatorium odoratum (Chromolaena odorata)* and *Glycosmis pentaphylla* were the most common species, followed by *Adina cordifolia* and *Shorea robusta* copopices. The understory of 6 and 8 yr old *Eucalyptus camaldulensis* plantions produced the maximum oven dry biomass.

Whittaker and Nicring (1965), Rissem and Rice, 1971) studied the dominance of tropical and temperate forest and found that the Concentration of dominance values of both type of forest is between 0.16 to 0.99. and 0.06 respectively (Knight, 1975). The rate of concentration of dominance is inversely related with rate of evolution and diversification of communities in plantation ecosystems. The same have been reported for temperate vegetation (Connel and arias, 1964; Simpson, 1964). Dominance Concentration varied from O. 15 to 0.22 for trees, 0.18 to 0.3 for saplings and 0.14 to 0.21 for shrubs (Joshi and Tiwari, 1990) 0.89 to 0.308 (Joshi and Behera, 1991) and O. 14 to 0.155 (Pathak *et al*. 1993) for mixed tropical forests of Orissa. KFRI (1980) conducted a phytosociological study in Attappadi reserved forests. Menon and Balasubramanyan (1985) for Trichur Forest Division and Pascal and Pelissier (l996) for tropical evergreen forests of south west India.

Phytosociology of several forests in Indian context has been studied by Singhal (1986). Vegetation analysis of woody species in Chakrata Forests of Himalayan range was studied by Singhal and Soni (1989). Diversity and Dominance of manmade forests was also studied by Srivastava (1986). Machhlad watershed of Pauri Garhwal, Utter Pradesh was studied by Laxmi *et al*. (1987) using same method. Phytosociology of better quality alluvial forests and tropical moist deciduous forests of Doon Valley was studied by Singhal and Shanna (1989) .

Menon and Shah (1981) studied the general nature of vegetation i.e. density, frequency, abundance and constancy. vegetation analysis of major forest divisions of Gir, Girnar, Bhavnager and Rajkot Jamnagar divisions of Saurashtra was done by Menon (1982).

Phytosociological aspects and Influence of forests on ecosystem for rainfall, soil erosion, watershed management, air pollution, wind, climate, energy and recreational aspects were studied by (Joshi and Behera, 1990; Sushi) Kumar *et al*. 1991; Room Singh *et al*. 1991; Lata and Bisht, 1991 and Dani *et al*. 1991)

To understand the characteristics of vegetation, it is essential to study the species diversity and its habitat to compare with similar other habitats. Such types of study indicates the level of adaptation in another environment. Structure (species composition with interrelation) and function of vegetation is termed as vegetation ecology. It shows the variation in plant community according to change in sence of geography (MullerDombois and Ellenberg, 1974).

Few disturbancefactors like forest fire, grazingand anthropogenic reasons are main cause of depletion of past uneven aged structure of natural forest of Kuldiha Wildlife Sanctuary, Odissa, India (Rout *et al.* 2018) reported in a study on identification, classification and its characterization of vegetation of natural forest of this reserve, which have the need of proper management and conservation to improve their value for other life forms.

In a study report (Malik *et al*.(2014) for three broad leaved forest have showed a negative relation of species richness and diversity indices with disturbance factors. It reveals that the reducing trend in species richness and diversity indices are directly related with anthropogenic disturbance of forest structure and its composition in Kedar Nath Wildlife Sanctuary of Garhwal, Himalaya, India.

It is pertinent that Species diversity at different altitude are different in the sense of different scales of vegetation structure and diversity pattern, Bhatt *et al*.(2015). And it is regulated by community structure and its composition in a plant community of Hangla Devi forest of Champawat(Kumaun Himalaya), India.

Henrik *et al*. (2006) has reported through a study of relation between Species richness of bryophytes and macro lichens at different altitude and local topography, which shows that vascular plants based species have unimodal relationship with altitude, whenever lichens have more richness at higher altitudes. Species richness of smaller size shrubs has less value at higher altitude. Result of this study also show that declining in species pool and its composition with increase in altitude.

The Conservation of socioeconomically adopted important plant species was very less because of its habitat destruction and anthropogenic activities (Hameed, M. *et al*. 2012) in the Himalayan foothills region, Pnjab. It was found also that the species diversity was high according to topographic altitude and slope with aspects. *Podonea viscose* a shrub was found dominant at lower altitude followed by *Carissa opeca* where as *Themada anthera* a grass species was found as dominant at higher altitude.

Study analysis of Similarity among four major ecosystem in a forest area was found between 0.014 – to 0.036,which indicates heterogeneity of the forest species composition, Met*et al*. (2016). Similarity is low because of regular activities of selective logging, agricultural work, Horticulture farming and so many anthropogenic activities.

In a comprehensive study of three communities with respect to stem density, basal area, diversity and species composition indicated as Combretaceae, Euphorbiaceae and Anacardiceae has greatest IVI(Naidu, *et al*. 2016) The biodiversity of tropical forest in eastern Ghats of Andhra Pradesh are under threat due to mining and anthropogenic activities.

The impact of altitude on species richness and diversity (Sharma,*et al*. 2009) reported that it is maximum at lower altitude , medium at middle and minimum at higher altitude. Density and richness pattern was found negative correlation with altitude and slope, which suggests that distribution and species richness pattern of different tree species are largely regulated by altitude and climatic conditions.

Human cultures and land uses influencing the Himalayan mountain biodiversity (Khanet *et al*. 2012). Plant biodiversity decreases along the altitude. Diversity value is highest in north facing slopes t middle altitudes. Snow cover period also influence the plant diversity at different altitudes and slope which are relatively dense tree cover with respect to southern slopes, which has indicated that species diversity decreasing along ecological elevation because of deforestation with global climate change.

The forest stands along the altitudinal gradients showed *Tsuga Dumas* isthe dominant plant species in both upper and lower altitude having the highest IVI values, Pandey *et al*. 2016. In this study it was reported that the contribution of forest composition in terms of species richness and Shannon Diversity is significant in lower Temperate zone. The upper subalpine zone has less diversity and may also be less endangered.

A large number of ecologist from different states in India have worked on phytosociological characteristics of natural forest of their area, such as in Kerala based was studied by Singh *et al*. (1984) in Silent Valley, Basha (1987) studied on the evergreen forests of Silent Valley and Attappadi, Menon and Balasubramanian (1985) studied the Trichur forest division, similarly Pascal and Pelissier (1996) worked for tropical evergreen forests of southern states in India. Kolli hills forest was studied by Jaya Kumar *et al*. (2002) using vegetation map and vegetation analysis. In south India, Nilgiri Biosphere Reserve and Western Ghats was studied by Jaya Kumar (2003). Adetails of phytosociological study of plant communities in New Amarambalam Reserved Forests. Poles and matured plant species ofKerala reserveforest was done by Nath *et al*. (2000). All important parameters of biodiversity like Density, frequency, abundance, IVI was deeply studied jointly by Phillips (1959) and Muller-Dombois and Ellenberg (1974). For the quantitative study of any natural as well as man made forest have studied applieng the equation developed by Shannon and Wiener (1949) all over the world. Similarly Simpson (1949) index method was also applied in study of Floristic diversity as well as Concentration of dominance. Uncommon indices provided by Margalef (1958) and Menhinick (1964) to quantify the species richness. Vegetation analysis of woody

species of Uttarakhand was also analysed by Singhal and Soni (1989). Tree species of evergreen forests of Raja kurtrallam was also studied for Biodiversity assessment with reference to plant population density by Parthasarathy and Karthikeyan (1997).

West Bengal based forest has been studied by Kushawaha*et al.*2012 to know the Species diversity and community to compare two individual area receiving different rain fall precipitation.

Vegetation status and species diversity of the forests in southern Western Ghats of Kerala have been studied by Magesh *et al*. (2011). Other than these, several more ecologists have reported the study on phytosociological aspects of forest vegetation for forest rich states of India by Menon, (1978, 1981, 1991, 1999 and 2006). Manilal and Sivarajan, 1982 have published few compiled report on floristic diversity of reserve forest area of Indian tropical forest. Bhaskaran *et al*. (2010) reported that Many Indian Scientists worked on Environment, like Mohanan and Henry, (1994); Sasidharan, (1997, 1998, 1999, 2004a, 2004b, 2006, 2007). Sivarajan and Mathew, (1997) have shared very useful information to resolve the Taxonomic challenges of forest biodiversity conservation in the 21st century.

CHAPTER – III

STUDY AREA

CHAPTER – III

STUDY AREA

3.1 Location

The study was conducted atDalma wildlife sanctuary which is situated on the Chhotanagpur plateau of Jharkhand near the steel city of Jamshedpur and extends into portions of the East Singhbhum and Saraikela-Kharshanwa districts of Jharkhand it lies between Latitudes 22^0 46’ 30” N and 22^0 57’N and Longitudes 86^0 3’ 15” E and 86^0 26’30”E. Its eastern limit extends up to the border of Purulia district of West Bengal on the eastern side. The entire Forest of Dalma Sanctuary fall in the catchment *area* of Subarnarekha River and Dimna Lake of Jamshedpur.

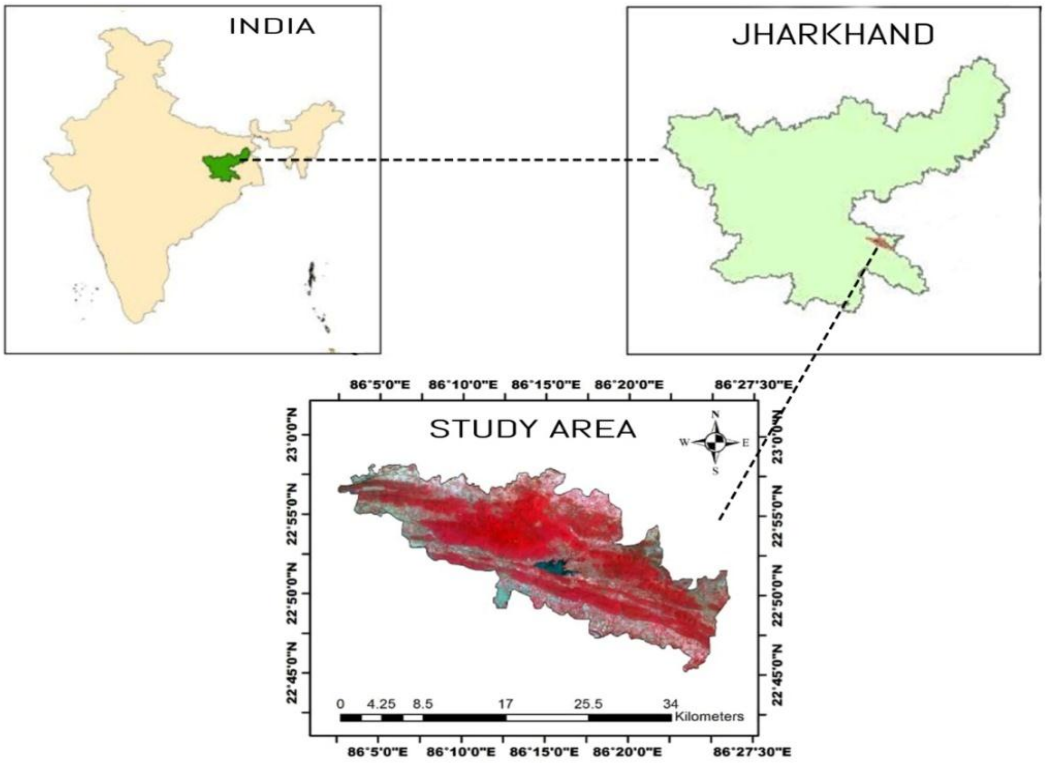

Figure 3.1: Study Area

Plate No 3.1. Boundry Map of Dalma Wildlife Sanctuary

Plate No. 3.2. Evergreen View of Dalma hills

The Sanctuary is 193.22 sq. kms (R.F. 45.56 sq. km, and P.F.—147.44 sq.km out of which 157.71 sq. kms were transferred by Dhalbhum Forest Division and the remaining 35.51 Sq.kms by Chaibasa North presently Saraikela Forest Division. Out of this, 193.22 sq. kms, the core area consists of 59.27 sq. kms.

The Sanctuary is close to many big cities such as Jamshedpur (25 km), Ranchi (120 km), Kolkata (270 km), Bokaro (140 km), Dhanbad (200 km), Patna (450 km) with National Highway No. 32 & 33 touching the western and southern boundaries of the sanctuary. The nearest railway station is Tatanagar, which is 33 km from Makulakocha forest naka the main entry point to the sanctuary. Previously the main entry point to the sanctuary was at Chakulia but it was shifted 3 kms inside on the forest road after the village chakulia due to S.M.P canal and embankment.

Village Chakulia entry point to the sanctuary is on the P.W.D Road called Old Purulia Road. It is 3 Km. away from Saharbera on N.H.-33, and 100 kms From Ranchi. Further Tatanagar railway junction has good railway connections to many big cities of India such as Delhi, Kolkata, Mumbai, Chennai, Patna. Ranchi, Bokaro, Dhanbad & Rourkela.

The nearest aerodrome is Sonari Aerodrome at Jamshedpur which is 28 kms. from the entry point to the sanctuary. The national daily air services to Delhi, Patna and Kolkata are available from Jamshedpur and Ranchi airport.

3 .2The Statement of Significance

3 .2.1 Values and Significance

An important for the long ranging elephant across its remnant habitats in Singhbhum East, Purulia and Bankura of West Bengal. The sanctuary is one of the significant elephant habitats in lower eastern India. It seems to be the only habitat of elephants in this region though once they were well distributed in different tracts of Singhbhum East, Saraikela-Kharshanwa and Singhbhum West in Jharkhand, Purulia and Midnapur in West Bengal and Sundargarh in Orissa. Forest department has completed wildlife census for Dalma wildlife Sanctuary on 21st and 22nd May, 2019 and reported that, there are a total of 66 elephants are presence there.

The Sanctuary is comprised of a series of hills. Its highest peak is at an altitude of 926 meters called Dalma top. Several perennial and seasonal streams, which are lifelines of wildlife and People, originate in these hills. The watershed function cannot be overstressed. Sanctuary is a significant watershed of the Subarnarekha River.

The habitats represent the characteristic floral and faunal wealth of this region. The sanctuary happens to be one of the largest forest areas in a large landscape dominated by highly fragmented and degraded forests.The discernible species loss in recent times underscores the need for urgent managerial and societal attention. Among the Large Cats, the Leopard has become rare. The last Tiger's Pugmarks were seen in 1986. It is not known when the Sambar disappeared. The Sloth Bear, Wolf, Fishing Cat & Mouse Deer are among the other endangered species, besides the Elephant.

Elephants and the wilderness of the sanctuary are among the major attractions. Annually approximately 28865(2015 -2016) visitors are recorded in the sanctuary. Shiva Temple at the Dalma Top attracts a lot of pilgrims, worshipers and visitors. The surrounding forests are integral to the religious significance of the site.

The Sanctuary and its vegetation is a carbon sink. It has a special significance in context of the industrial city of Jamshedpur and its role in maintaining quality of life. The sanctuary has potential for research, recreation, environmental & nature education.

There are some negative values from conservation standpoint. For the Santhal tribals over a large regionof Dalma forests have served thearea for their annual traditional hunt - the "Sendra" or 'Akhand Shikar'. Illegal as it is, yet, it has an important local value within the tribal culture.There are 29 revenue villages inside the sanctuary and 73 on its periphery. Most villagers are dependent on the forest-based resources, one way or the other.

3.3 Boundaries

The sanctuary is oval-shaped and elongated in east-west direction. National Highway 32 up to 10 km from Chandil-Golchakra and then Chandil-Borham - Patamda road forms the northern boundary of the sanctuary. The state boundary of Jharkhand and West Bengal and district boundary of Singhbhum East and Purulia forms 80% of its eastern boundary and the remaining portion by Ghatshila range of Dhalbhum Forest Division. The N.H. 33 forms its western and part of its southern boundary up to Chotabanki village and then Chotabanki to Sukhlara-Black top & - mudroom road forms the rest part of southern boundary.

As far as forests on its boundary is concerned, the northern and western sides are covered with the forests of Chandil range of Saraikela Forest Division, on southern side by forests of Mango range and on eastern side by forests of West Bengal and Ghatshila range of Dhalbhum Forest Division. The forest boundaries were used to be maintained earlier by boundary pillars making heaps of stones and plantation in its centre but it could not be maintained properly for last few years.

Further there are 29 revenue villages inside the sanctuary area and it seems very difficult to find the boundaries around each of these areas. In this case, it is an uphill task to detect cases of encroachment in these areas. To blame sanctuary staffs for ill maintenance of boundaries and encroachments will not solve the real problem. It takes long time before encroachment cases are finalized in the court. It should be requested to the concerned judiciary department to expedite the process interest of the sanctuary

3.4 Terrain

The Sanctuary comprising an area of 193.22 sq.km is part of a hill range running South East to North West and traditionally called the Dalma hill range. The whole range has several peaks having different local names, each having some story behind its name. The highest point of the range in Dalma hill is at the height of 926 meters above M.S.L. and local name is Sadhubera Pahar and now it is called as Dalma top. It falls within the core zone of the sanctuary, which is 55 sq. km in area.

The Buffer of the Sanctuary is 138.22 sq. km and is divided into east and west buffer zones with core lying in between. The minimum elevation of the Sanctuary is 154 meters above M.S.L. and the average elevation of the sanctuary is 544 meters above M.S.L. The Buffer zone, though it appears large due to the total area it covers, is in fact made up of islands of degraded forests on the parallel hill ranges, interspersed with agriculture and habitation which has encroached over the forest land in recent years. The woes of the buffer zone are augmented by the fact that it is at a lower elevation hence easily accessible and virtually without protection.

The Dalma hill range has steep and rugged southern slopes and undulating northern slopes and the two differ in a variety of features. The Subarnarekha River cuts through the Dalma range on the northwest and flows along the Southern boundary of the sanctuary for some distance before turning southward.

3.5 Geology, Rock and Soil

There are three important geological formations in the Singhbhum region of rich Dalma represents one known as "Dalma Lava flows" named after the hill range. The formation extends into the Ranchi district on the north—west and into West Bengal on the Southeast (Bihar District Gazettes Singhbhum). The Singhbhum region alone contributes a fourth of the total mineral produce of India and is marked prominently on the industrial map of India. However it also houses about a fourth of the tribal population of India, and is one of the least development areas in India in terms of amenities.

The entire district of old Singhbhum (along with East, Saraikela – Kharshawan and west) is extremely rich in minerals. There are vast deposits of Iron ore along the south-west border in Singhbhum West adjoining Orissa. The Roam, Mosabani hill range south of Dalma and Subarnarekha River, has copper and uranium deposits and is the home of a small population of elephants having no future due to the open strip mining activities and deforestation. The Porahat Plateau in the West of Singhbhum West districts is said to hold gold deposits but no commercial prospecting has yet been done. The river Subarnarekha gets its name due to traces of gold found in its bed. In the sanctuary itself, small scale prospecting for gold is done

in the streambeds on the northern slopes nose to the villages and several 1mm diameter grains of gold, harvested by tribals have been observed mostly during rainy seasons. Jackpots of larger size are not a rarity.

To east of Subarnarekha River, the area is occupied by gravels, pebbly grits, sands and rare metal generally semi-consolidated clays. These beds extend towards east beyond the boundary of Singhbhum East into Midnapur. In the lower reaches of the river Subarnarekha, recent alluvium from river wash assumes a considerable spread and thickness.

Other types of minerals which occur in different location in this region and lower portions of the sanctuary include asbestos, apatite, chromite, clay minerals, magnetite, manganese, lime acid kainite etc.

3.5.1 Soil

Soil of the sanctuary area is generally sandy-loam and clayey-loam. The depth of soil greatly varies. Soil depth is moderate in the plain areas and minimum in the hillocks. Often at places, pure laterite and moorum exist.

On the hills and their slopes, soil is generally missing or very shallow. Erosion has exposed rocks, but due to water & soil conservation measures by contour trenches done in past years, the soil depth has built-up. In valleys, however, clayey-loam and clay do occur which sustain better quality of forests. Soil is generally shallow and mixed with rock and pebbles. Nutrient status of soil is low.

The Sanctuary comprises of a series of disjointed forest hillocks and short hill-ranges. Its entire area is watershed of Subarnarekha River, which flows eastward along its southern boundary. The terrain is quite hilly and there are quite a few precipitous hill slopes. The upper rocky portion of the area forms a fine plateau at the top with gentle undulations in between. The highest point of Dalma hills is 926m i.e. 3038 ft. above M.S.L. Moderate to stipe slopes are found downwards with flat areas at some of the places and elsewhere, there are gentle slopes. Round trap boulders are found at different places. Large sized rock are also seen in abundance.

The highest point is known as Dalma top. There is a Shiva temple at [tie top and at the topmost point there is a Bajrangbali temple. Below these temples there is a plateau with an old well, which never dries up. Going below this hill there is a flat area where Dalma house owned by TISCO exists and at the same plateau there exists a Microwave Repeater station of South Eastern Railways.

On the Southern slopes from the Dalma top, there are steep to moderate slopes downwards and on the eastern side the slope is again steep to gentle forming a hillock of 680m height and again of 492 m height on the south eastern side of previous one. On the northern side of Dalma top, there is steep and precipitous slopes downwards forming alternate valleys and near Konkadhasa there is a hillock of 615 m height above m.s.l. and Konkadhasa is a plain and flat valley of height '483m above M.S.L where there is a revenue village hamlet of Bonta having a population of 150. Along the valley line there are series of water streamline forming the main water streams, which drain out to Dimna Lake, lying on the south - eastern corner of Dalma top and south of villages of Bonta and Bhadudih. On the northern side of Konkadhasa, there are series of hillocks of various heights 423 m, 446m, 459m, 610m and 399 m and in between there are various valley lines giving out perennial and seasonal streams.

On the western side of Dalma top, there are continuous hill ranges having peaks of height 801 m. i.e. Katasini pahar, 670m, 535m and in the south of later two, there are other hillocks of height of 474 m and 260 m and 200 m. Again in between the spurs of these hill-ranges, there are various valley - lines along which perennial or seasonal streams are flowing.

The hilly terrain described above forms the "core area" of the sanctuary and serves as a complete ecological unit and is capable to sustain all types of wild animals.

It contains miscellaneous forests with moist deciduous patches near nallas and perennial water sources in the northern aspects. Quality of forest-crops on the upper portion of hills is of better quality than that of lower hills and hill slopes.

On the northwestern side of the core-area, i.e. in the Western buffer there exists a continuous hill range of conspicuous heights of 491 m, 422 m, and 369 m and after that it divides into two hill ranges. Between these two hills ranges there is a valley-elongated westwards and in the valley there are two revenue villages i.e. Tankocha and Bachkamkocha. On its northern hill range there are two prominent peaks of height 378 m. and 347 m. and on its southern hill-range the prominent peaks are of height 436 m, 329 m. and other hillocks. Along the valley line of these hill ranges, there are various streams that drain out to Subarnarekha River in the south and to the railway lake in the valley and these hill ranges forms the western portion of the sanctuary. It supports marvelous pole-sized sal crops. The eastern buffer has distinct parallel hill ranges interspersed with revenue villages.

On the southern boundary of the Dimna lake, there are disjointed hillocks of height 275m, Sanpdaha pahar with two distinct peaks of heights of 381rn and 335m and after that there is a continuous hill ranges of different peaks-Mirjadih pahar with two prominent peaks of height 369m and 4O3m, Bhelaipahari pahar having peaks of height 394m, 440m and 424m, Katranja pahar having peaks of height 448m and 397m and Dalapani pahar with peak height of 308m. In these hill ranges Dalapani pahar and Bhelaipahari pahar have reserve forests having dense forests with main species of sal but the other hills have status of protected forests having dense jungle of main species of sal.

Just north of the these hill ranges there is one middle hill range starting from Sahargora and Patipani which is a disjointed hillock of conspicuous peaks of height of 275m and 200m and it is completely degraded. Kalabani is other disjointed hillock of conspicuous peaks of height 250m and 200m. It had previously dense forest with main species of sal but now it is also degraded having bushy forests. Only Nutandih pahar in this hill range is partly joined to the previous hill range and it has status of protected forests with main species of Sal. Along this hill-range the eastern part has locally well known hills namely Amadapahari, Burha-Burhi pahar of height 471 m and Jhunjhka Pahar having peaks of height 422m and 364 m. and other in-between these hill ranges at the eastern portions of conspicuous hill-peaks are of height 346 m and 250m and these hill ranges, touch the state boundary of west Bengal.

In between the previous two hills ranges there are conspicuous valleys having human settlements with status of revenue lands. The main villages are Mirjadih, Gerua, Rahergora, Bataluka, Rangamati, and Amdapahari. At the same time there are various streams flowing along the valley line between the spurs.

In this part of the sanctuary, the northern hill range is continuous from Patamda road near Pagda and forms different hills Lailam pahar of heights 425m, Sari forests of heights 421m and 451m, Gobarghusi forests of Chhagaltopa pahar of height 502m, Jerka hill of height 405m, Kukru pahar having peaks of 350m and 400m, Meghadah pahar of peaks 269m & 300m and after that these ranges touch the state boundary of West Bengal. The whole range consists of dense sal forests.

In between the northern and middle ranges, there are various revenue villages and hamlets namely Pagda, Bangora, Nutandih, Simajura, Mohanpur, Sari, Mahuldih, Parukoclia, Jerka, Kukru, Rajabasa, Mghadah. Meghadah is just on the state boundary of West Bengal.

Apart from these hill ranges there are disjointed smaller hills having almost plain areas lying on south eastern portion of Dalma hill and on the northern and north eastern side of Dimna Lake and hills are Bagoda, Lailam. Karpakol Dangardih, Bharagadari, Bhuiyashinantota, Kutimakuli, and Bhadudih. Dangardih pahar of height 426m is joined to the main part of the sanctuary and lies on the north side of Patamda road near Bhulyashinan tola.

There is a disjointed hillock named Bonta RF, which Is surrounded from all sides by revenue village of Bonta, and its different hamlets.

On the northern side, there is one hill range which is joined to the main Dalma hill of the sanctuary in its western side near Chimti and looks as if it is hanging from Dalma Pahar but completely disjointed on the southern and eastern the hill range is of moderate height with different peaks 300m, 370m etc. and is called in general Beldih jungle. It supports dense and mixed forests.

The revenue villages and hamlets encompassed by these hill ranges and northern hill range described above are Pahariadih, Chimti, Manjhidih, Khariadih, Kumari, Sardardih, Rapacha, Dhusra, Dungrikuli etc.

There are two disjointed hillocks on the northern side namely Baghpocha and Ballagoratola which are included in the sanctuary area for its mere protection; because there is no other forest areas near these hillocks.

3.5.2 Drainage

Singhbhum district (east, west and Saraikela Kharsawan) in which DWLS lies is drained by three major river systems Subarnarekha, Baitarani and Brahmini. The plains of Midnapur, Purulia and Bankura in West Bengal have Kansabati river system. Of the three rivers in Singhbhum, only Subarnarekha flows through the eastern part of the Saraikela - Kharshwa West and Singhbhum East, while Baitarni drains south and the Brahmini drains the west in the Singhbhum West District through its tributary the south koel and its feeders the north karo and the south karo, the later in turn is fed by the Deo river. These rivers are fed by numerous streams from the hills of the area. All the rivers contain little water throughout the year except during rains when they rise and fall suddenly after a heavy rainfall. None of the rivers dry up altogether in summer and most of them has a very low water level during the hot season. Kharkhai is the principal tributary of Subarnarekha. It originates in Kolhan, south of the Singhbhum West District, and meanders in different directions before joining the Subarnarekha at north/west end of Jamshedpur. All rivers are easily crossed by elephants.

The Kansabati River is dammed, forming a big reservoir, In purulia district where It originates. It continues in the district of Midnapur and passes close to and south of Midnapur town while continuing south east and finally flows into the Bay of Bengal.

Dalma WLS, itself, has a well network of 159 streams spreading throughout the sanctuary, out of which 82 are perennial or semi perennial and the rest 77 streams are seasonal. Apart from these streams there is a reservoir called Dimna Lake owned

by Tata Companies; and completely surrounded by different forested Hills of the sanctuary. Partly constructed and abandoned Subarnarekha Canal constructed under World Bank added multipurpose project originates from Chandil dam and runs touching the southern boundary of the sanctuary. It also cuts the boundary at many places and in the eastern buffer it enters the Sanctuary near Patipani and passes through various forests of the sanctuary and exits at its southern boundary at the junction of Palasbani and Chhotabanki forest and again runs parallel along the southern boundary. The Subarnarekha River, Subarnarekha canal and the Dimna lake are fed by different streams of the sanctuary and the sanctuary, on the whole, serves as a complete watershed for these major rivers.The drainage system in the sanctuary supports varieties of flora and fauna.

3.6Climate

3.6.1 Rainfall pattern and distribution

The sanctuary experiences the similar rainfall pattern as experienced by northeastern side of the Singhbhum area of Chhotanagpur plateau. But particularly during rainy season rainfall is comparatively more as compared to plain areas. There is no record of rainfall - data in the sanctuary area, but according to locally available information from sanctuary staff, there used to be rain gauge stations at Pindrabera and Konkadhasa. According to working plan of Dhalbhum forest division the average rainfall in this area is 57 inches (1400 mm) and (lie average number of rainy days observed in a year are 85. The core area of the sanctuary experiences a bit more rainfall than the other parts of the sanctuary.

The rainy season extends from the middle of June to the middle of October with peak in July and August. It never rains incessantly or in torrents. Occasional drizzle in winter season is also experienced. Even sometimes in summer season the Dalma hill receives localized precipitations particularly in the afternoons.

3.6.2 Temperature monthly data and a summary of pattern

The area has three distinct seasons-Summer, Rainy and Winter Seasons. An unpleasant hot and dry weather prevails from March to June and hot westerly winds

blow during the period. Hill barriers on the southeast block the sea freeze and (the atmosphere Is generally dry. The maximum day temperature reaches 48°C and more. In the peak summer, the maximum day temperature recorded is 47°C in core area and *50*°C in buffer area: The average day-night differs by 10° C. the temperature difference between the foothill and northern and southern slopes is considerably between 15°C to 20°C. Due to extreme variations of temperature are different parts of the sanctuary, considerable variation in flora and fauna is observed. In extreme summers one experiences complete microclimate in the core area. The rainy season extends from middle of June to middle of October and moderate temperature prevails in the area. Winter season sets in the month of November and continues up to February. Hoarfrost may be seen in the valleys, but no fog and mist occurs in the area. The temperature sometimes drops to 3°C or lower in winters in summer season some of the streams and small water holes get dried up and water becomes scarcely available. Due to scarcity of water, grasses dry up which affects the total animal food requirements of herbivores.

Distinct seasons are a follows -

Summer : Middle March to Middle June.

Rainy Season : 15th June to 15th September

Winter : I November to 1 5’ of March

3.6.3 Humidity

In summer very low values of humidity of the order of 15 percent or lower is experienced in the sanctuary. In rainy and winter season humidity is much more.

3.6.4 Wind speed

The prevailing wind direction in the area is from south to north. In summer hot westerly winds flow. In the period from February to June violent storms from the northwest accompanied by thunder, lightening, rain and hail occur occasionally.

3.7 Water Sources

Between the different hill ranges and hill slopes there are various water sources in the sanctuary. Along every valley line between spurs there are seasonal as well as perennial water streams, and few such streams meet together to form a bigger one which flows along the valley. Most of them are seasonal and becomes active in rainy season. Due to hilly slope their run-off is very fast.

In the core area, there are various perennial streams and there is no shortage of water even in extreme summer, whereas in buffer zone of the Sanctuary there is shortage of water in summer due to denudation of some hills.

There are 74 water sources in the sanctuary, out of which 7 are big water holes only in namesake but they are basically water reservoirs. They contain sufficient amount of water throughout the year and the depth of water is quite high since the elephant's bath in these water holes by totally dipping themselves under the water even in extreme summer.

Soil conservation work by contour trenches has been carried out on slopes above some of these water holes a few years back and the level of water in these water holes increased significantly.

Each water hole has been assigned a name such as Barhka bandh, Majhla Bandh, Nichla Bandh, Chhotka Bandh, Bijlighati, Mahajal and Kashjobhi. Near Manjhala bandh, A watch tower had been constructed in 1995 and four other watch towers had been constructed – 2 at Pinderabera 1- at Dalma Top & 1- at Kasjobhi w.h at each of the big water holes facility of hideouts has been provided. These hideouts are used to watch and monitor the behavior of elephants and other wild animals, which visit the waterholes. These water holes are being desilted and cleaned up at regular intervals to increase their capacity of holding water. Apart from these there are 67 small water holes constructed by making small earthen dams in the perennial water streams. To increase its capacity to hold water, earthen check dams are maintained and the water sources are channelized annually. Sometimes due to scarcity of fund, these important waterholes or those waterholes which get

completely filled up due to soil erosion in the upstream are only cleaned properly. These water holes are useful even for elephants for drinking water and are mostly visited by small animals.

Subarnarekha River is in the southern portion of the sanctuary but due to inadequate cover and improper habitat, elephants from the Sanctuary do not visit the river even in summer. There are two big lakes present near the sanctuary. One of them is Dimna Lake surrounded from all sides by sanctuary hillocks of eastern buffer. It is well-managed lake maintained by TISCO. This lake is a rarely visited by elephants due to lack of sufficient cover, busy Patamda road and dense habitation along its bank.

The other lake is Chandil Lake (or Railway lake) which is naturally covered on three sides by sanctuary limits and situated at its western end. These lakes are also frequently used by elephants and other wild animals of the sanctuary. They attract a lot of migratory birds, and require wider publicity to attract wildlife's ornithologists for study and research. It is one of the few lakes in Jharkhand which get such a large concentration of migratory birds in such small area.The Subarnarekha canal whose construction is still incomplete passes through the sanctuary and it holds sufficient water even in summer and elephants are attracted to this canal. The sanctuary has no wet lands and marshes.

Mr. Hernant S. datye, Scientist, BNHS during his study conducted habitat analysis of Dalma WLS by applying strip transect or belt transects method. Water availability as one of the most important component of habitat was determined by studying the distribution of the 66 water sources during the period, within the sanctuary and the frequency of visits of these water sources by mainly elephants.

The special distribution of waterholes in the sanctuary and maximum number of elephants accessing them has been found in his study as follows:

Parameters	East Buffer	Core	West Buffer	Total
No. of waterholes	18	49	7	74
No. of elephants accessing in summer	15	66	8	89

There were only 20 waterholes for 133.95-sq km. area of two buffer zones put together, where as the core area of 59.22 sq. km. had 47 waterholes. The number of elephants accessing them throughout the summer was also disproportionate as the elephants concentrated in the core in much more number than they did in the two buffers. There were 6 water holes in the core area viz. Nichla bandh, Majhala bandh, Badka Bandh, Chutka bandh, Kashjobhi and Mahajal which had sufficient water through ought the pinch period to take care of the bathing and drinking requirements of elephants. Most of other waterholes were actually rocky pools located at different places down the course of the several streams originating on the hilltops. These pools could be used by elephant only for water sprays and quenching thirst of a few individuals. Similarly, only one waterhole in the East Buffer viz. Amdapahadi and one In west buffer viz. Jharidih could he used by the elephants for bathing. The rest of the waterholes were used only for occasional sprays to cool the body. The majority of the water holes were located on the cooler western slopes had a gentler gradient than those on the southern slopes of the sanctuary and many on the southern slopes usually dried up in the scorching heat of summer where ever they were exposed due to lots of cover.

3.8 Vegetation

3.8.1 The biogeographically classification

Rodgers and Panwar, 1988 has divided India into 10 biogeographical zones. Dalma wildlife sanctuary falls in biotic province of Chhotanagpur (6B) of Deccan peninsula zone within the Indomalayan region.

The sanctuary has been included as one of the localities of great significance for the conservation of India's biodiversity as it falls in the dry deciduous forest type having *Shorea, Cleistanthus & Croten* series (Gadgil & Meher).

3.8.2 The forest types

According to Champions and Seth's revised classification, the forest of the sanctuary conforms to upper hills of core area consist of mainly dry mixed deciduous forests with small patches of moist mixed forests near water streams and in the northern aspects.

Code	Forest Types
5B	Northern Tropical Dry Deciduous forest
5B/C1	Dry peninsular Sal forest
5B/C2	Northern dry mixed deciduous forest

The upper portion of the hills and particularly on the northern aspects consists of comparatively better quality of mixed forests. The miscellaneous crop consists of mainly *Terminalia tomentosa, Oogenia oogenensis Anogeisus latifolia, Diospyios melanoxylon, Adina cordifolia, Albizzia lebbek. Pterocarpus, marsupium, Terminalia belerica, Bombax Ceiba, Mangifera indica, Sterculia urens, Emblica officinalis*.

On the lower slopes and on the hill-ranges of buffer zone in the western and eastern portion of the sanctuary, there are mixed forests with sal as predominant species. Sal Corp is generally of pole size. They are generally found in the felling series of Kadamjhor, Chandil and Bonta etc.

The general formation of trees is not very healthy except at the upper Slopes of core area and water streams. Some portion of the buffer zone and lower slopes of core zone has been worked earlier and they have not yet restocked fully. The average canopy density varies from 03 to 0.8 and average crop-diameter is 6" to 8". In the northern aspects of Dalma hills, good crop in the forests of Bandhdih, khokhro and Kaira is found apart from bamboo which exists in degraded condition on the southern aspects mainly in Asanbani, Ramgarh and Saharbera

Climbers are mostly found in moist areas and on the upper portion of hills. Main climbers are *Bauhinia vahlii, Combretum decandrum, Spat holobus roxburghii* etc. Main grasses are *Saccharuimspontaneum, Heteropogon contortus, Ischarum angustifolium* etc.

The flora composition of Dalma WLS has been described in details by Mr. Hemant S. Dyte, Scientist Bombay Natural History Society Bombay who had conducted field study in Dalma WLS and Its adjoining forest areas for about three and half year:; from January 1989 to April 1992 in his report on "Ecology of Elephants of Dalma WLS Bihar, Central Zone" published in 1995.

The Sal Forest is located mainly in patches on the cooler Northern slopes. Other than the usual sal associates such as species of *Terminalia, Diospyros, Buchnania, Anogeissus and Dillenia, Cleistanthes* and Croton are the two associates found in the sanctuary. This flora system has been identified as shorea-clesitanthes – croton series (Gadgil, Meher – Hanji, 1986). Sal is one of the most prominent trees and grows gregariously in patches in different places throughout the D.W.L.S. and it is seen mostly in a poll crop and coppiced due to cutting over the years.

The forest is more or less leafless during the dry season but the cool valleys, contain a flora which somewhat differs from the general type; and the tops of some of the highest hills possess species of moist climates. Although essentially tropophilous, there is a marked tendency towards a xerophilous structure, which is seen e.g. in the most characteristic tree of the area, the sal. On the hills the trees become low and enlarged with relatively massive stems and smaller leaves. The sat is neither long enough deciduous nor sufficiently xeropli1ous to grow on the drier aspects and hence it is supplemented by other trees e.g. *Cleistanthus collinus, Anogeissus latifolia, Lannea coromandelica, Nyctanthes arbortdstis* and other species of the mixed forest. On the direct and the most exposed rocks are found entirely xerophilous plants such as fleshy Euphorhia nivulia. Sal extends into West Bengal till the edge of literite plateau. Its absence in many areas in plains is certainly due to extermination, while its companion, the Mahua, *Bassia Iatifoiia* has survived according to tho rule that timber trees are more liable to extermination than fruit

treesHaines, 1910). Next to the agricultural land the first noticeable man made change is reduction of the forest to a coppice or scrub condition in which the species are exposed to selective browsing. The species which survive longest are those with good chemical and physical defenses. Some of the flank hills are entirely covered with cleistanthes and chloroxylon. Although thorn forest is a formation due to climatic factors, there is ample evidence in chhotanagpur of its formation as a result of selective cutting and grazing. People avoid thorny trees and bushes as animals avoid them. The quantity removed for fencing purposes is comparatively small.

Sal, though it gives a peculiarly distinctive character to the flora, does not appear at all in a list of dominant plant families. The area is well characterized by general association in large numbers of *Shorea robusta, Anogeissus latifolia, Bassia latifolia, Gardenia gummifera, Gardeni latifolia, Gardenia turgida, Butea monosperma, Butea superba, Scleichera oleosa* and the grass *Heteropogon con tortus*. On the other hand such common sub Himalayan associate of *Shorea robusta* as *Dillenia pentagyna and D. indica, Careya arborea and herbacea, Streospermum chelonoides and Slerculia villosa* are scare and Cuputfferae, Coniferae, Teak and Sissu the wild state are conspicuous by their absence. A second charaderistic group of feature is the abundance of individuals of Rubiaceae, notably the genera *Gardenia and Wendlandia, Acanthaceae* (*Bauhinia spp. Diospyros, Terrminalia spp Ziziphus). Spp. Cleistanthes collinus, Nyctanthes arbortristis, Aegle marmelos* and the Bamboo. *Dendrocalamus strictus, Dillenia penfagyna,* a close associate of sal in sub-Himalayan tract is replaced by Dillenia aurea. The Annonnceae are fairly well represented, so also are many smaller families like Combretaceae, Minisperiniaceae, Capparidacoae, Polygadaceae and Lythiaceae.

Grass is very sparse in most parts of the sanctuary and grass patches are seen only in the places where the canopy is open. Most of the ground flora and under storey is composed of regenerating saplings of different height and girth classes. Annuals grow in large numbers during the rains and change the picture of the forest for a few months. Giant climbers such as Bauhinla vahili, Spat holobus roxburghii, Butea superba, Erycibe paniculata, and Porana pariculatea are seen commonly in the sanctuary and the surrounding forest areas.

The physical characters of the southern and northern slopes are considerably different in topography, the gradient and the amount of solar radiation and this reflects on the variation in the species composition and the habitat quality on the two slopes. The northern portion of the hill has much gentler slopes than the southern slopes. The habitat quality includes water, food; cover (vegetation cover) is comparatively much better on the northern slopes compared to that on the southern slopes.

CHAPTER – IV

METHODOLOGY

CHAPTER – IV

METHODOLOGY

The chapter deals with methodology section of the study and various data sets being to use for the research purpose. This study is carried out systematically to estimate forest parameters for applications ofVegetation Mapping and Phytodiversity analysis, to identifying the issue which is caused by anthropogenic activities using integrate geospatial techniques. The methodology applied in the study can be categorized into three segments such as pre-field work fieldwork and post field work. It comprises of generating input layers or parameters that were considered driving forces for occurrence of forest.

4.1 Airborne Image (Aerial photographs)

A technique of taking photographs of earth surface from any flying platform is known as aerial photo graphs or airborne image. It helps in the study of natural resources through mapping of the study area. Photogrametry and Photo interpretation are two main steps to process the image of natural resources to show in pictorial form.

4.2 Landsat imageries

A high quality and multispectral, remotely sensed image in several layers of earth surface provided by satellite in high resolution form is named as land sat imageries. It may or may not be visible. These images are processed to look the vegetation in different types at earth surface. There are mainly two Land-sat satellites like Landsat 8 since 2013 and Landsat 7 since 1999 in use. These both satellites are providing regular global image at free of cost. NASA has available imagery since 1972, which was captured by Landsat 6 series. Landsat 8 is well equipped of sensor like multi-spectral scanner, Thematic mapperand enhanced Thematic mapperto achieve the goals of the project on land cover analysis.

4.3 Satellite Imageries and Collateral (Ancillary) Data Used

Satellite imageries and ancillary data of Dalma wildlife sanctuary was obtained from Landsat-8 for vegetation & land use mapping. Open Series Topographic maps (Fig. 4.1) topographic map no. F45I1 and 73J/5) of 1:50,000 scales was obtained from Survey of India (SOI) Ranchi office, from which Drainage, road networks, railway network, specific locations and places were generated through manual digitizing and geo-referencing according to WGS 1984 UTM ZONE 45N.

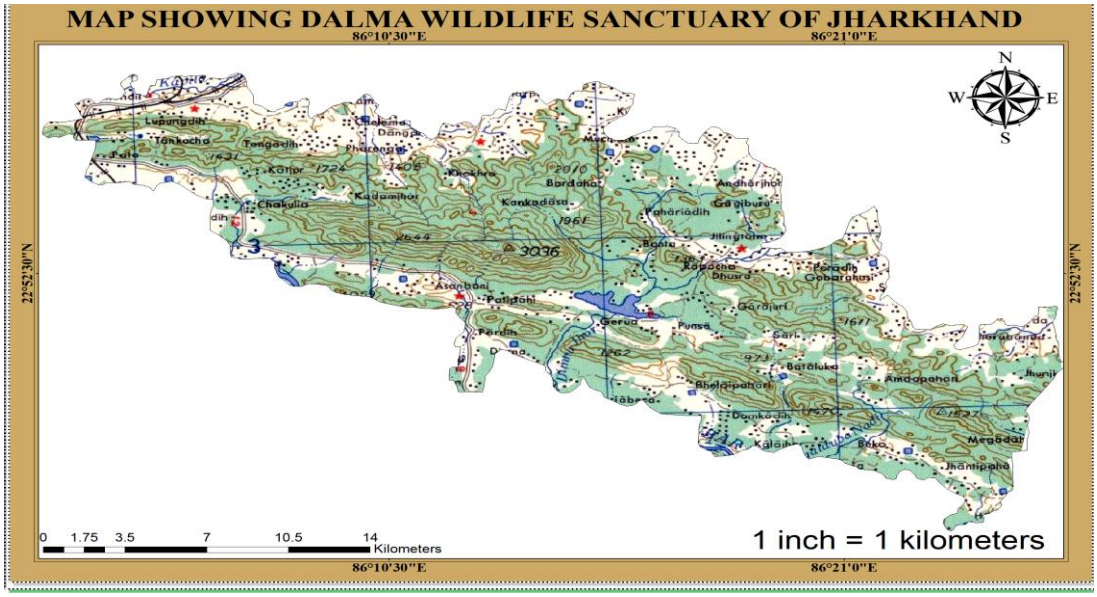

Figure 4.1 Topographic map of Dalma Wildlife Sanctuary (Source: SOI, Ranchi office)

Data obtained from google earth and Ground truth is considered as important tools for assessment of earth surface. The informative data gathered from ground truth was used in verification of satellite data. Landsat- 8, which are equipped with operational land imager (OLI) were used to aquire image of same level of resolution for the same seasion of the year 2016. The satellite image was downloaded from the earth explorer portal of the USGS domain. It was effectively used for comparison of changes and patterns occurred according to change of height, as mentioned in discussion. The images were downloaded from the Global Land Cover Facility of the University of Maryland (GLCF, 2013) and the United States Geological Survey (USGS) and spatially referenced in the Universal Transverse Mercator (UTM)

projection with datum World Geodetic System (WGS) 1984 UTM. These data sets were imported in ERDAS Imagine version (Leica Geosystems, Atlanta, U.S.A.), for processing the data(image) using software to create a false colour composite (FCC). Several tools of ERDAS imagine software was used to stacking composite (FCC) of images obtained from USGS to generate FCCs for the study areas as shown in Figure 4.3.

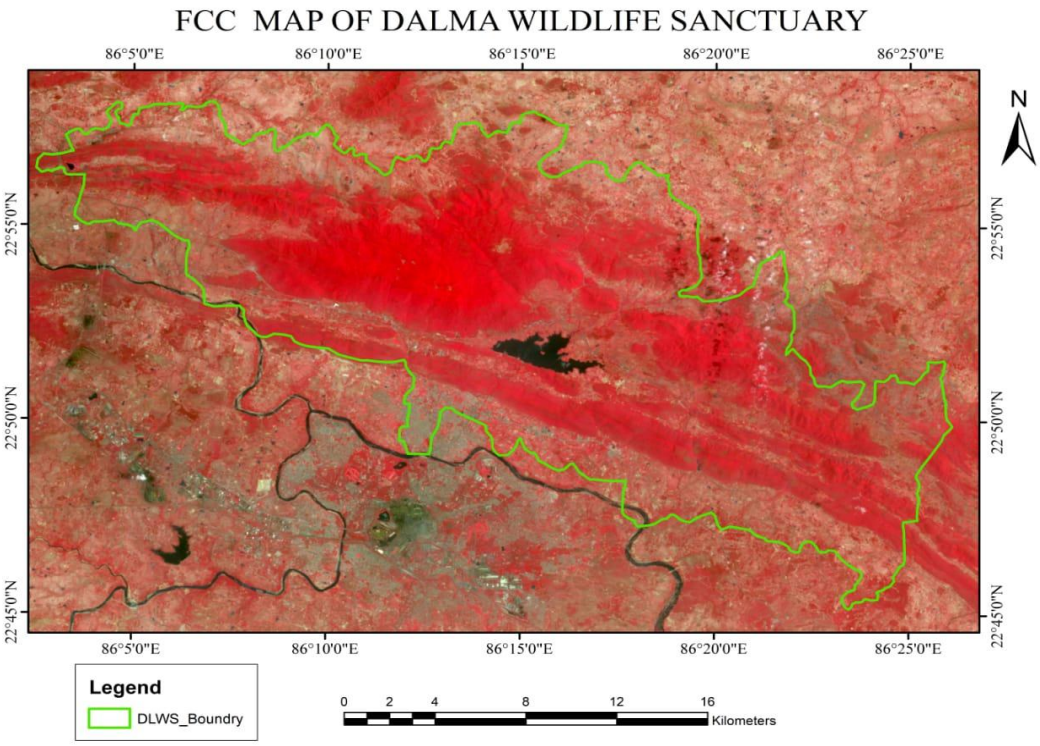

Figure 4.2 FCCMap of the year 2016 of Dalma Wildlife Sanctuary (Source:USGS)

4.4 Image Processing

The obtained satellite image was processed using other tools of ERDAS image software for the extraction of study area in Dalma Wildlife Sanctuary through geo-referencing of outline boundary taken from Open Series Topographic Map of east Singhbhum of Jharkhand. All the data and the software that are used in the study are enlisted in the Table 4.1

The original satellite image data was pre-processed, using radiometric correction to minimise the error in digital images. It has improved the interpretability of remotely sensed data. Rediometric correction is compulsory to remove atmospheric noise to avoid unwanted recording of sound energy emitted or reflected from surface of earth ground.

Table 4.1 List of Data Sources and Material

I. SATELLITE IMAGES					
I. Sensor	**Path**	**Row**	**Spatial Resolution**	**Date of Accusation**	**Source**
Landsat 8 OLI	140	044,045	30*30 meter	15 July 2016	USGS
II.TOPOGRAPHICAL MAPS			SOURCE		
Topographic Map Number			SOI		
III. SOFTWARE USED					
• Erdas Imagine 2014 used for Geo-referencing, Re-sampling, Image Processing and Image Classification • Arc Gis 10.3 (Arc Map) used for GIS analysis & mapping • Other Software used in this study include Google Chrome, Earth, Microsoft Excel, Word					

Image enhancement is solely to improve the appearance of the imagery in original brightness value to assist in visual appearance of the imagery to improve interpretation and analysis. Contrast enhancement has been performed to increase the tonal distinction between various features in a scene, and spatial filtering to enhance (or suppress) specific spatial patterns in an image. Arithmetic operations (i.e. subtraction, addition, multiplication, division) are performed to combine and transform the original bands into "new" images which better display or highlight certain features in the scene. The image pre-processing, enhancement and transformation operations are done using ERDAS IMAGINE. Few more enhancement in image are found in image processing software like Linear stretch, Histogram, Density slicing and Edge enhancement.

Table 4.2 Details of Bands used in this study

Spectral Bands	Wave Length	Resolution
Band 1- Coastal/Aerosol	0.433 to 0.453 μm	30 m
Band 2- Blue	0.450 to 0.515 μm	30 m
Band 3- Green	0.525 to 0.600 μm	30 m
Band 4- Red	0.630 to 0.680 μm	30 m
Band 5- Near Infra Red	0.845 to 0.885 μm	30 m
Band 6- Short Wave Infra Red	1.560 to 1.660 μm	30 m
Band 7- Short Wave Infra Red	2.100 to 2.300 μm	30 m
Band 8- Panchromatic	0.500 to 0.680 μm	15 m
Band 9- Cirrus	1.360 to 1.390 μm	30 m

The forest types that covered the study area, according to Champion and Seth (1968) are Northern Tropical dry Deciduous Forest (5B), Dry Peninsular Sal Forest (5B/C1) and Northern dry mixed Deciduous Forest (5B/C2).(Management plan of DWLS).

4.5 Coordinate Transformation & Geo referencing

Transfer of Geometrical data into Geographical data is called Geo-referencing using Co-ordinate system. All the data are transformed into the common projection system that is WGS_1984_UTM_Zone_45N by geo referencing them, which the process of assigning real –world coordinates to each pixel of the raster. The topographical maps are geo referenced with the help of GCPs which are the proper latitude and longitude values.

4.6 Preparation of NDVI (Normalised difference Vegetation Index)

This vegetation index is a ratio based VI. It is calculated by the difference of the infrared and red bands as ratio to their sum, as per Slady and Samant(2016)

- NDVI = {(IR - R)/ (IR + R)}
- IR = pixel values from the infrared band
- R = pixel values from the red band

The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum and is adopted to analyse remote sensing measurements and assess whether the target being observed contains live green vegetation or not (Rose *et al.*, 1993).

This index outputs values between -1.0 and 1.0, mostly representing greenness, where any negative values are mainly generated from clouds, water, and snow, and values near zero are mainly generated from rock and bare soil.

4.7 Conversion to TOA Radiance

Landsat 8 used in this study consists of quantized and calibrated scaled Digital Numbers (DN). It is 16-bit unsigned integer format with range value from 0 to 28= 65536. It needs to convert into radiance value to calculate the vegetation indices. This process has been done by using equation (1).

$$L\lambda = ML * Qcal + AL$$

Where, Lλ= TOA spectral radiance (Watts/ (m2 * srad * μm))

ML= Band-specific multiplicative rescaling factor from the metadata.

AL= Band-specific additive rescaling factor from the metadata.

Qcal= Quantized and calibrated standard product pixel values (DN).

4.8 Image Classification

Based on the idea that different feature types on the earth's surface have a different spectral reflectance and remittance properties, their recognition is carried out through the classification process. The process of categorizing all pixels in an image or raw remotely sensed satellite data to obtain a given set of labels or land cover themes (Lillesand, Keifer 1994).

4.8.1 Image Classification Techniques

There are various classification approaches that have been developed and widely used to produce land cover maps (Aplin, Atkinson 2004). They range in logic, from supervised to unsupervised classification. There are two broad types of classification procedure and each finds application in the processing of remote sensing images: one is referred to as supervised classification and the other one is unsupervised classification. These were used as alternative approaches.

Classification technique

Methods	Examples	Characteristics
Supervised	Maximum Likelihood, Minimum Distance and Parallelepiped classification etc.	Analyst Identifies training sites to represent in classes and each pixel is classified based on statistical analysis
Unsupervised	ISODATA and K-means etc.	Prior ground information not known. Pixels with similar spectral characteristics are grouped according to specific statistical criteria

4.8.2Nomenclatures of Land cover Classes

Classification is defined as an abstract of representation of situation using diagnostic criteria and arrangement of objects into groups according to their relationship with each other is carried out. It requires the class boundaries with clear precise, possible quantitative and based on objective criteria. The classification and nomenclature of land cover classes is shown inTable 4.3.

Table 4.3Land cover class nomenclature (Source: Wikipedia)

Land cover classes	Description
Artificial (Built-up) surfaces	Consists of Urban fabric, Industrial, commercial and transport units, Mine, dump and construction sites, and artificial non-agricultural vegetated areas
Agricultural areas	Arable land, Permanent crops, Pastures and Heterogeneous agricultural areas
Forests and semi-natural areas	Forests, Shrub and/or herbaceous vegetation association
Open/barren areas	Open spaces with little or no vegetation, beaches, dunes sands, bare rocks, sparsely vegetated areas
Water bodies	Inland wetlands and Coastal wetlands
Wetlands	Water courses, water bodies, sea and ocean areas, coastal lagoons

4.9 Accuracy Assessment

It is an important programme of compassion of data of classification with the data another source which is considered as accurate data from ground truth from field. Ground truth data is collected directly from field or obtained from existing classified data layer of Geographical Information System (GIS) to asses the accuracy, few random points are selected using Global Positioning System (GPS) during the ground truth and the gathered data is compared with confusion matrix. Although the basic approaches to accuracy assessment seems relatively direct and easy, a variety of errors encountered when evaluating an image classification and capturing remotely sensed data. Evaluation of the accuracy of a classified image can be done using an error matrix sometimes called confusion matrix (Senseman et al, 1995; Foody, 2002).

4.9.1 Error Matrix

It is an important steps of remote sensing data analysis in which array numbers are arranged in rows and columns which express the number of sample units feeded targeted category relative to the actual category as ground truth data. The columns normally represent the reference data, while the rows indicate the classification obtained from categorised image. An excellent summary of the two thematic errors is provided named as omission and commission. Error of omission related with pixels in the reference map that were identified as something other than their "accepted" value, whereas error of commission, on the other hand, refers to pixels that were incorrectly classified as a class in a row (Senseman et al, 1995).

Measurement of classification accuracy is derived from an error matrix. Howeverit is commonly expressed in percentage of error. Generally the user's accuracy is supposed that a given pixel can be found in the ground is same in the classified image and the producer's accuracy mention to the percentage of a given class that is correctly identified on the map (Yesserie, 2009).

PARADIGM OF STUDY

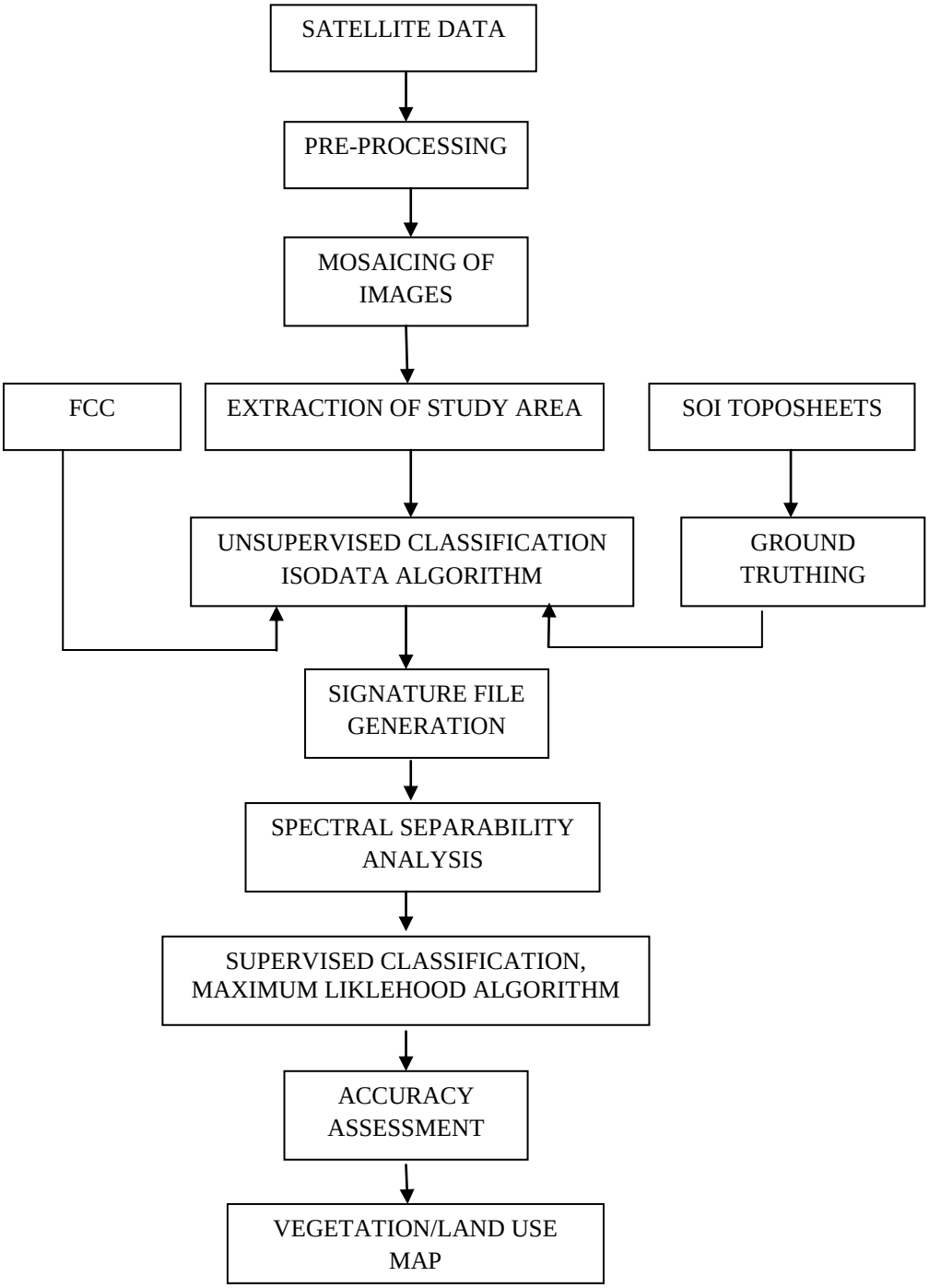

Figure 4.3Showing Methodology & Procedure

4. 10 Ground truthing

Ground truthing refers to information collected from the study areas (location) during fieldwork. The collected /gathered data was analysed to compare with sensed data. Ground truth data are primarly accepted as the truest data because it is collected in physical presence of men involved for ground truth at the same time of remotely sensed data, so that the data tallied as much as possible at ground level. Reconnaissance survey was made in the study area to recognize and relate vegetation types to their tonal variation on the satellite images. Intensive ground truth was done to develop interpretation process for stratifying the vegetation into different vegetation types. Sample plots of size 0.1 ha were laid randomly at different location was observed to ensure that these are real representative of previously created vegetation types. Ground truth has always applied for a good classification.

4.10.1 Forest cover density

Data from Landsat-8 OLI of the year 2016 was used to prepare False Colour Composite to monitor and mapping of Dalma Wildlife Sanctuary. The same data obtained from same source was rectified radimetrically as well as geometrically. Ground truth data of study area was gathered, using toposheets scaled of 1:50,000 of local forest maps, Global Positioning System (GPS) and by envolving of local people. The accuracy of the forest features were tested using GPS in the ground. Universally adopted rules on classification of forest canopy is that, if Very Dense Forest (VDF) with canopy density more than 70%, Moderately Dense Forest (MDF) with canopy density between 40-70% and Open Forest (OF) with canopy density between 10-40% and very low density areas have been classified under Degraded Forest (DF) / Scrub with canopy density less than 10%. (SFR, 2011).

Plate 4.1 Searching of sample plots location using GPS

Plate 4.2 Lay out of Sample plots in study area

Plate 4.3Measurement of DBH of trees in DWLS

Plate 4.4 Measurement of Girth of tree in DWLS Jharkhand

Plate 4.5 Discussion on identification of plant species

Plate 4.6 Natural vegetation of Dalma Wildlife Sanctuary

Plate 4.7Forest rest house at Dalma Wildlife Sanctuary

4.10.2 Phytosociology

It is defined as a relationship between plant communities and its vegetation characteristics, classification. It is expressed in terms of qualitative characters. Spectral signature of plant communities in structural variation are the basis of qualitative character and description for community structure (Thomos*et al*. 1993) using remote sensing data. It helps to formulate sample plots for the study of the community structure quantitatively. To study the quantitative structure of community, first the vegetation of the study area is mapped according to qualitative characters. The vegetation is sampled according to a plot method in various strata. Such sampling helps in obtaining maximum information about community with minimum efforts in the least time (Roy *et al*. 1993). Phytosociological analysis provides the real meaning to any biodiversity analysis by quantifying the structural parameters of communities. The methodology used for vegetation studies of DWLS are as follows:

In order tostudy the phytosociology of vegetation in Dalma Wildlife Sanctuary, the study area was devided into three zones acoording to their altitudinal

heights like upper zone (454m – 603m), middle zone (250m – 452m) and lower zone (199m – 250m). A thorough reconnaissance survey was carried out initially to assess the structural characteristics of the permanent vegetation so as to design the sampling procedure and intensity. Based on the species area curve method, minimum quadrant size of 10m X 10m has been considered as a matter of convenience for phytosociological data collection from all the forest types. In each quadrate all the species names of trees (height, girth), herbs, shrubs and climbers were recorded. Stratified random sampling was applied to analyze vegetation composition of all the forest species. The quadrate of each zone was fixed on vegetation map and it was located on ground with the help of Global Positioning System (GPS). The census quadrate method (Oosting, 1956) was adopted and in each of the plot, trees of 30 cm and above Girth at Breast Height (GBH) of 1.37m above the ground level were enumerated (Roy, 1993). At the centre of the plot 5m x 5m plot is taken for measurement of shrubs. In corners of the plot, 1m x 1m sub quadrate was done to account herbs. For shrubs, total number of tillers for each species was enumerated. In each of these quadrates, tree, shrubs and herbs and climbers data were collected for assessment of species richness, diversity and predominant species. A total of 54 plots of 100 sqm meters were laid out in the study area at Dalma hills of Dalma Wild Life Sanctuary during the year 2016 to enumerate the trees, shrubs and herbs and climber. The spatial location (latitude and longitude) and altitude of each quadrate was recorded using GPS and Ravi Multi Meter (height of tree and shrubs) with a sensitivity of 20m. The distribution of sample plots in DWLS is depicted in Fig. 4.5. Details of Latitudes and Longitues are given in (Table 4.4-4.6). The identification of flora was done by front line staff of the Forest Department and also by local people in local language living in fringe area of Sanctuary. The local name was scientifically confirmed, using “Forest Flora of Chhota Nagpur (H.H.Haines, 1910 Reprint 1974 & 1994) and The Botany of Bihar and Orissa (H.H.Haines, 1974) and also by taking assistance from experts.

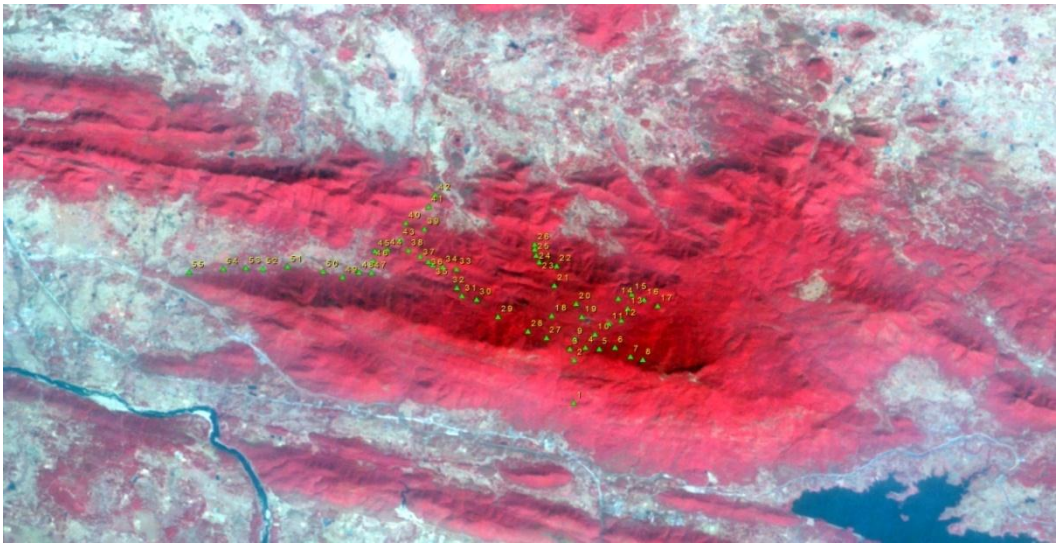

Fig. 4.4 Locations of sample plots shown in study area map of Dalma Wild Life Sanctuary

4.11. Details of Latitudes and Longitues of 54 sample plots in all three zones

4.11.1 Upper Zone

Table 4.4(Altitudenal Height: 454m – 603m)

Code	Longitude	Latitude
1	86D 11' 48.920" E	22D 53' 5.725" N
2	86D 11' 49.379" E	22D 53' 36.300" N
3	86D 11' 46.390" E	22D 53' 44.285" N
4	86D 11' 57.006" E	22D 53' 45.380" N
5	86D 12' 6.415" E	22D 53' 44.285" N
6	86D 12' 17.126" E	22D 53' 45.380" N
7	86D 12' 27.636" E	22D 53' 38.778" N
8	86D 12' 36.005" E	22D 53' 36.575" N
9	86D 11' 49.577" E	22D 53' 51.439" N
10	86D 12' 3.426" E	22D 53' 54.748" N
11	86D 12' 13.041" E	22D 54' 2.228" N
12	86D 12' 21.342" E	22D 54' 4.706" N
13	86D 12' 25.843" E	22D 54' 13.195" N
14	86D 12' 19.268" E	22D 54' 20.354" N
15	86D 12' 28.533" E	22D 54' 23.382" N
16	86D 12' 36.902" E	22D 54' 19.528" N
17	86D 12' 46.168" E	22D 54' 15.122" N
18	86D 11' 34.135" E	22D 54' 7.964" N

4.11.2. Middle Zone
Table 4.5 (Altitudenel Height: 250m – 452m)

19	86D 11' 54.537" E	22D 54' 7.185" N
20	86D 11' 50.660" E	22D 54' 16.674" N
21	86D 11' 35.928" E	22D 54' 29.714" N
22	86D 11' 37.386" E	22D 54' 43.583" N
23	86D 11' 25.579" E	22D 54' 46.302" N
24	86D 11' 23.412" E	22D 54' 51.154" N
25	86D 11' 22.441" E	22D 54' 55.490" N
26	86D 11' 22.516" E	22D 54' 58.966" N
27	86D 11' 30.548" E	22D 53' 52.270" N
28	86D 11' 17.995" E	22D 53' 56.951" N
29	86D 10' 57.574" E	22D 54' 7.336" N
30	86D 10' 43.026" E	22D 54' 19.597" N
31	86D 10' 33.012" E	22D 54' 22.281" N
32	86D 10' 29.610" E	22D 54' 27.951" N
33	86D 10' 29.336" E	22D 54' 41.469" N
34	86D 10' 19.951" E	22D 54' 42.970" N
35	86D 10' 13.240" E	22D 54' 44.260" N
36	86D 10' 10.056" E	22D 54' 46.670" N

4.11.3. Lower Zone
Table 4.6 (Altitudinal Height: 199m – 250m)

37	86D 10' 4.549" E	22D 54' 50.434" N
38	86D 9' 56.504" E	22D 54' 54.779" N
39	86D 10' 7.457" E	22D 55' 9.909" N
40	86D 9' 54.738" E	22D 55' 14.339" N
41	86D 10' 10.215" E	22D 55' 26.028" N
42	86D 10' 14.929" E	22D 55' 34.478" N
43	86D 9' 50.868" E	22D 55' 2.308" N
44	86D 9' 42.264" E	22D 54' 55.080" N
45	86D 9' 33.832" E	22D 54' 54.349" N
46	86D 9' 32.584" E	22D 54' 47.250" N
47	86D 9' 31.423" E	22D 54' 38.689" N
48	86D 9' 23.034" E	22D 54' 38.990" N
49	86D 9' 11.789" E	22D 54' 35.565" N
50	86D 8' 58.641" E	22D 54' 39.592" N
51	86D 8' 34.257" E	22D 54' 43.262" N
52	86D 8' 17.555" E	22D 54' 41.647" N
53	86D 8' 6.025" E	22D 54' 42.077" N
54	86D 7' 50.565" E	22D 54' 41.553" N

4.11.4Data Analysis

The data gathered from various quadrates of each zone were analyzed type wise. The phyto-sociological parameters like frequency, density, abundance, basal area and Importance Value Index (IVI) were worked out for each plot according to the formulae of Curtis & McIntosh (1951) and Mishra (1968) and as given below in 4.10(5- 15). Importance Value Index (IVI) of various species was worked out as the sum of Relative density, Relative frequency and Relative dominance of each of them. The quadrate data were then processed for quantitative and qualitative analysis to evaluate structural composition of the community.

4.11.5 Materials and tools used for vegetation study

The following materials and tools were used to mark the quadrates and to record the vegetation data (Fig. 5.6 and table:4.7 below)

Table 4.7 Tools used during Ground Truth

Sl.No	Tools /Instruments	Use
1.	30 metres measurement tape	Lay out of Quadrates
2.	Calliper	Measurement of DBH & GBH
3.	Red colour nylon rope	Framing around the Quadrates
4.	Ranging rod/ Stick of 1.37 m	To mark the breast height
5.	GPS Instrument	To find the location of sample plots/ Quadrates across the study area

Plates 4.8100m measuring tape, Calliper, Abney level and Lens

Plate 4.9 GPS Instrument

4.12 Density, Relative Density, Frequency, relative frequency,Abundance, Basal Area and Relative Basal Area

4.12.1 Density

Density is an expression of numerical strength of a species in a community and can be calculated as follows

$$\text{Density (D)} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrates studied}}$$

4.12.2 Relative density

It is the study of numerical strength of a species in relation to total number of individuals of all species and can be calculated as:

$$\text{Relative density (\%)} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

4.12.3 Frequency

Indicates the number of sampling units in which a given species occurs and then expresses the distribution or dispersion of various species in a community.

$$\text{Frequency (F)} = \frac{\text{Total number of quadrates in which species occurs}}{\text{Total number of quadrates studied}} \times 100$$

4.12.4 Relative frequency

Relative frequency is calculated as:

$$\text{Relative frequency (\%)} = \frac{\text{Total number of quadrates in which the species occurs}}{\text{Sum of Frequency of all species}} \times 100$$

4.12.5 Abundance

It is an appreciation of the number of individuals of different species in a community per quadrate in which they occur and calculated as follows:

$$\text{Abundance} = \frac{\text{Total number of individuals of a species occurring}}{\text{Total number of quadrates in which species occurred}} \times 100$$

$$\text{Relative Dominance (\%)} = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$$

4.12.6 Basal area

Basal area is regarded as an index of dominance of a species. Higher the basal area, greater the dominance. The average basal area and the relative basal are calculated out of the average diameter of the stem at the breast height using the following formula.

$$\text{Basal area (BA)} = (\text{GBH})^2/4$$

4.12.7 Relative basal area

$$\text{Relative basal area (RBA)} = \frac{\text{Basal area of the species}}{\text{Total basal area of all species}} \times 100$$

4.12.8 Importance value index (IVI) / Dominance

A total picture of the ecological status of a species with respect to community structure can be obtained only by synthesizing the percentage values of Relative density, Relative frequency and Relative basal area. When these all three are added together give the IVI whichexpress the association of plant communities.

Important value index (IVI) = Relative density +Relative Frequency +Relative basal area

IVI of individual family is finding out by adding the IVI of all species of concern family. The mean value of density, abundance, frequency, importance value index of different species and the percentage value of IVI of each species with respect to the total IVI value of the locality as a whole are calculated separately for each locality to establish the stand relationships.

4.12.9 Species distribution

Distribution of Species is an important component to study the ecology of a place, which has alarmed a special attention to the ecologists. It is calculated by Abundance/frequency ratio to know the present status of distribution of species. There is a correlation between species distribution, richness and altitudinal variation which provide a basis of biodiversity conservation which is is governed by various ecological factors. According to study report by (Bajpai *et al.* 2012), Bliss (1963), Douglas & Bliss (1977) and Billings (1973) "the vegetation of any place is the interaction on result of many factors like topographic gradients, the elevation, soil, species composition and biotic interferences. It has been also said that the patterns of species richness are result of local factors, such as plant species productivity, competition among tree species, geographical configuration of the area, plant species dynamics, regional, variation of environment condition and human interference (Woodward 1988, Palmer 1991, Eriksson 1996, Zobel 1997, Criddle *et al*. 2003).

4.12.10 Diversity index and Evenness

Community diversity is the most direct measure of ecosystem fitness. The study of diversity is the study of variation in the number of different ecological circumstances. Diversity can be used as a measure of environmental constraints at play. It has therefore been suggested that the 'Index of Diversity' can be an indication of the relative importance of the factors that are affecting the population balance as a whole. Diversity is composed of two distinct components, *viz.* the total number of species and how the abundance data are distributed among the species. First component refers to the richness and the second component is evenness or equitability.

4.12. 11 Alpha diversity (£) – It is measured as the number of species occurring within an area of a given size (Huston1994). It helps to measure potentially interactive assemblage of species.

4.12.12 Beta diversity (β) diversity - it is expressed as degree of species change in a given habitat. It indicate the rate of proportion, normally it is termed as Similarity Index or species turnover rate.

$$\beta = Sc / S$$

Where Sc = Total number of species encountered in all community

S = Average number of species for community.

Shanon and Wiener diversity index(H^1) is calculated by the formulae using

$$H^1 = \sum_{i=1}^{s} p_i \ln p_i$$

Where, S = the number of species, pi = the proportion of individuals or abundance of the $_i$th

Species expressed as a proportion of total cover, ln = log base n

4.12.13 Species richness (SR)

Species richness is a measure of the number of species found in a sample. Since the larger the sample, the more species we would expect to find, the number of species is divided by the square root of the number of individuals in the sample. This particular measure of species richness is known as SR. (Menhinick's index 1964)

$$SR = \frac{S}{\sqrt{N}}$$

Where,

S = Number of species in a community

N = Number of individuals of all species in a community

4.12.14 Similarity between study zones

There are few indices are available that compare the similarity and dissimilarity between sites. The main objectives is to express the ecological similarity of different sites .

4.12.14 (a) Jaccard's index of similarity(Si) :

The Jaccard's index (Krebs 1989; Krebs 2014) was used to calculate the species similarities between the forest ecosystem types. Jaccard's index is an approach based on abundance-based similarity index by comparing two cosystems depend on three incidence counts which takes into consideration the number of species shared by two ecosystems and the number of unique species found in each ecosystem (Chao et al.,2006; Loice, 2010).

$$Si = a /a+ b + c$$

Where;

Si = Jaccard's index of similarity

a = number of the same species appear in both ecosystem

b = number of unique species found in ecosystem 1

c = number of unique species found in ecosystem 2

4.12.15 Rarity of tree Species

Rarity of tree species are also calculated according to theKadavul and Parthosarthy (1999) finding Species having less than 2 individuals were considered as very rare, whereas species having having 2-10 individuals were considered as rare. On the other hand Species having 10-20 individuals were considered as common, whereas species having more than 20 species were considered as dominant.

CHAPTER – V

RESULTS

CHAPTER – V

RESULTS

5.1 Land cover mapping

The image data that was used for this study are Landsat-8 (Figure 5.1) Satellite imageries and ancillary data were collected in order to forest & land use mapping of Dalma wildlife sanctuary.

5.1.1 Land Use Land Cover Map of 2016.

Using supervised classification method Landsat 8 OLI classifies in the year 2016. While making land use land cover change of Dalma Wildlife Sanctuary it was distributed into seven classes such as agriculture, evergreen forest, deciduous forest, degraded forest, grassland, settlement, water body .

The area is dominantly covered by Deciduous Forest (36%) and Grass land (27%) followed by Evergreen forest (17%) and Agriculture land (13%). The land cover classes, area statistics and percentage of area are given in Table 5.1 and Fig. 5.1.

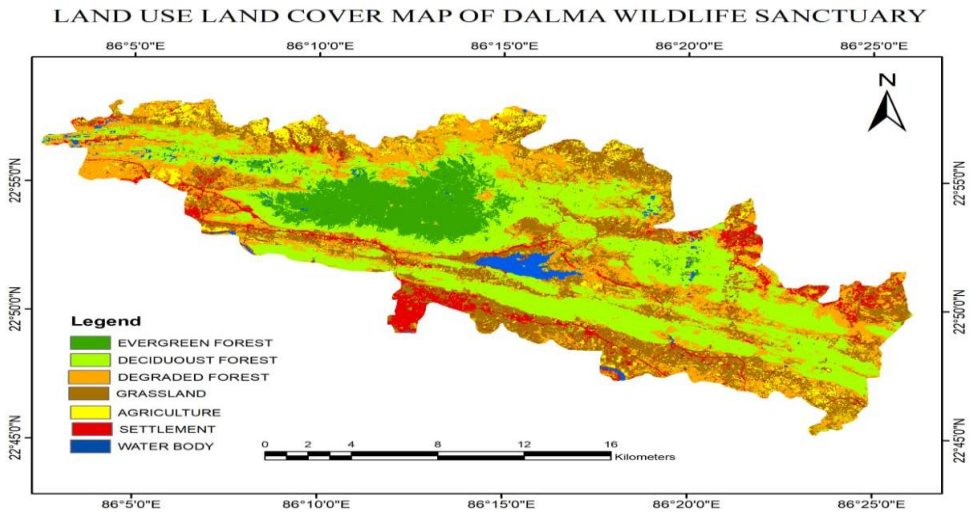

Figure 5.1: Map Showing LULC of Dalma Wildlife Sanctuary for the year 2016

Table 5.1: Area of land cover classes in sq.km derived from Landsat -8 data of 2016

Vegetation/Land Cover Types	Land Covers Area (Sq.km)
Agriculture Land	25.80
Evergreen Forest	33.78
Deciduous Forest	71.45
Open/Degraded Forest	3.96
Grass Land	53.59
Settlement	7.93
Water Bodies	1.98
TOTAL	**198.45**

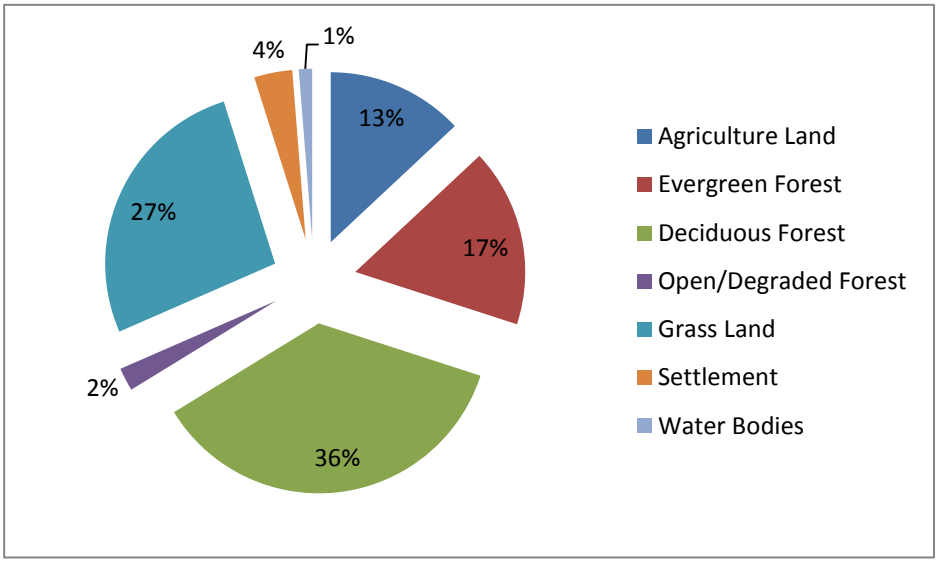

Figure 5.2: Area of land cover classes in percentage derived from Landsat- 8

Photoplates of Land cover types

Plate 5.1 Agriculture Land

Plate 5.2Water Bodies

Plate 5.3DegradedForest

Plate 5.4Deciduous Forest

Plate 5.5Settlement

Plate 5.6Grassland

Plate 5.7Evergreen Forest

5.2 NDVI of 2016

The NDVI map of Dalma Wildlife Sanctuary of 2016, illustrating vegetation of different health conditions and various other features like barren land settlement, river, water bodies etc. The image indicates high to low values. The values vary between 0.1 to 0.4(Figure 5.3). The NDVI was found to be related to many properties of the plants. It was, and in many cases still is used to identify the health status of plants, to depict phonological changes, to estimate green biomass and crop yield and in other applications. However, the NDVI has particular weaknesses. Atmospheric condition and thin clouds can influence the calculation of the NDVI when satellite data are used. When vegetation cover is low, whatever is under the vegetation canopy contributes to the recorded reflectance signal.

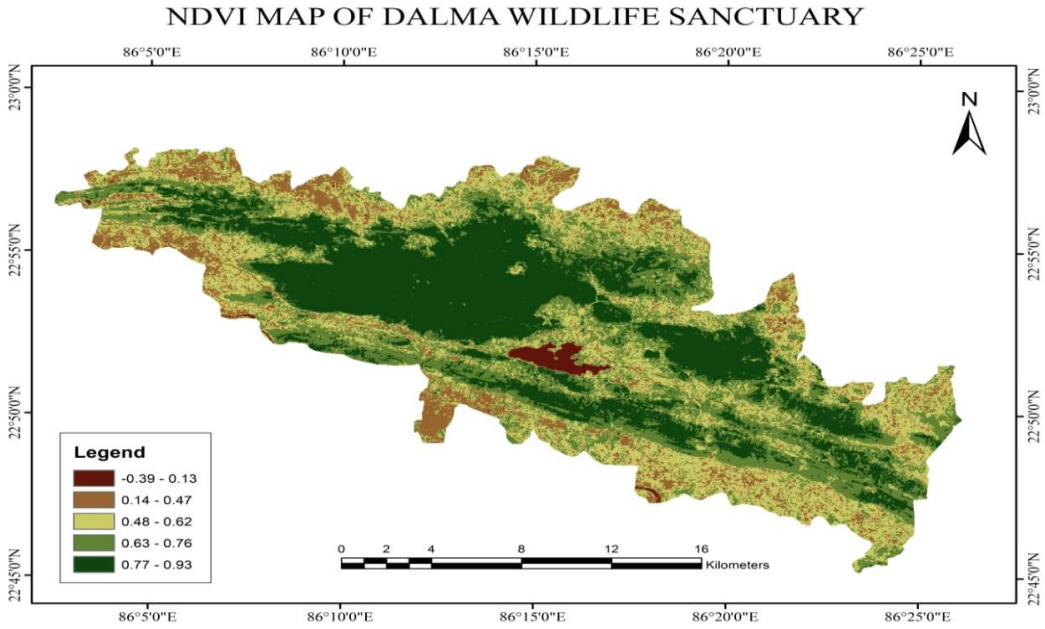

Figure 5.3 Map Showing NDVI of study area for the year 2016

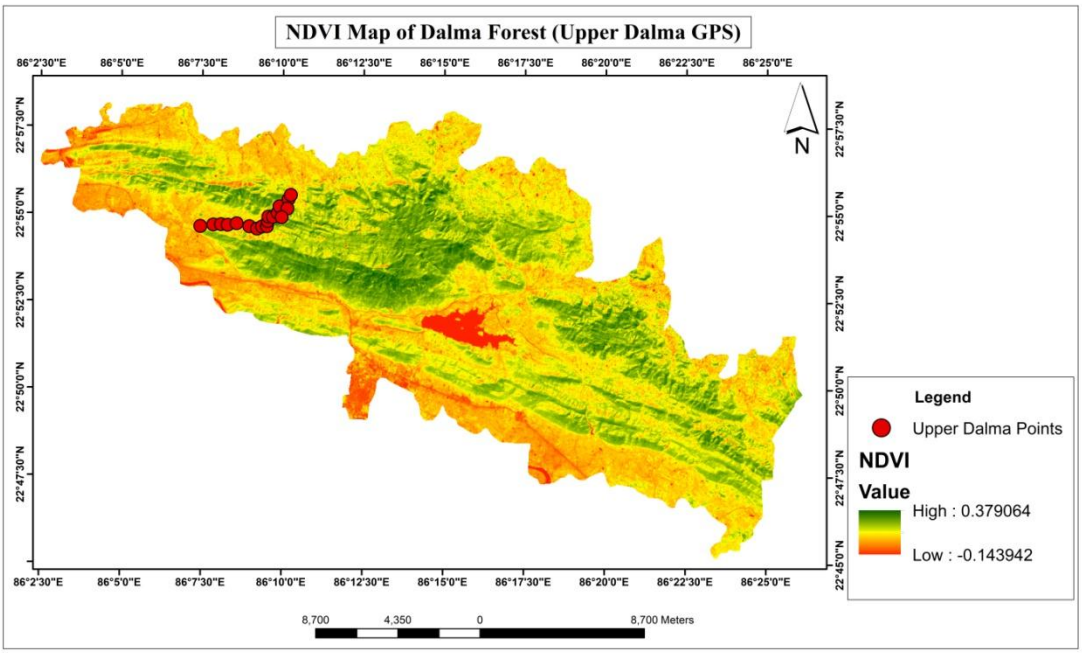

Figure 5.3 (a) Map Showing NDVI for Upper zone of study area for the year 2016

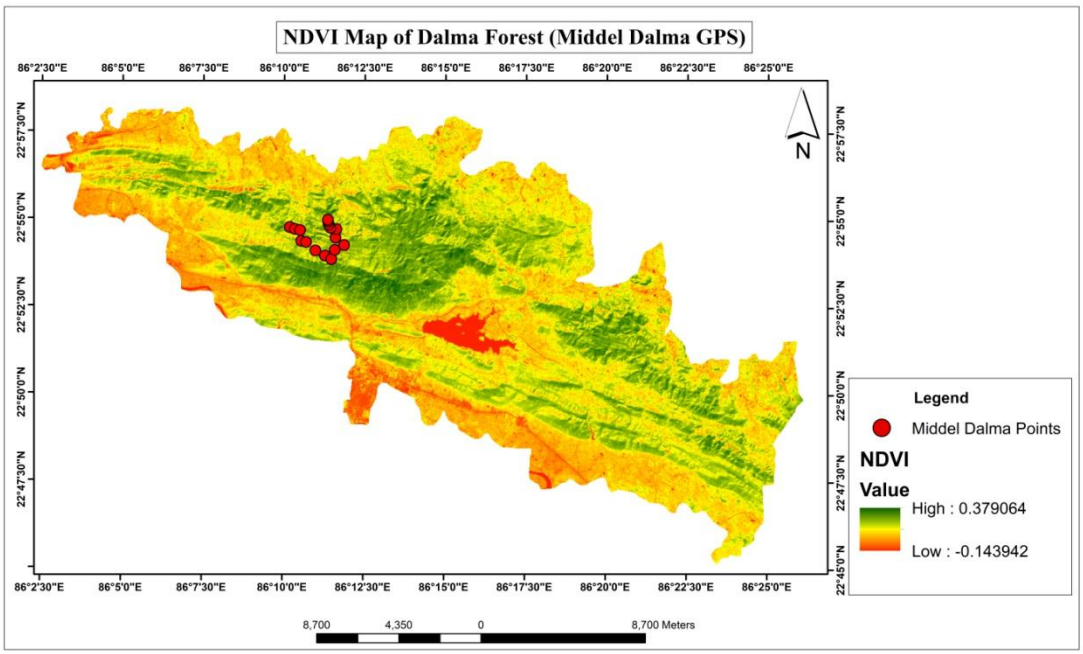

Figure 5.3(b) Map Showing NDVI for middle zoneof study area for the year 2016

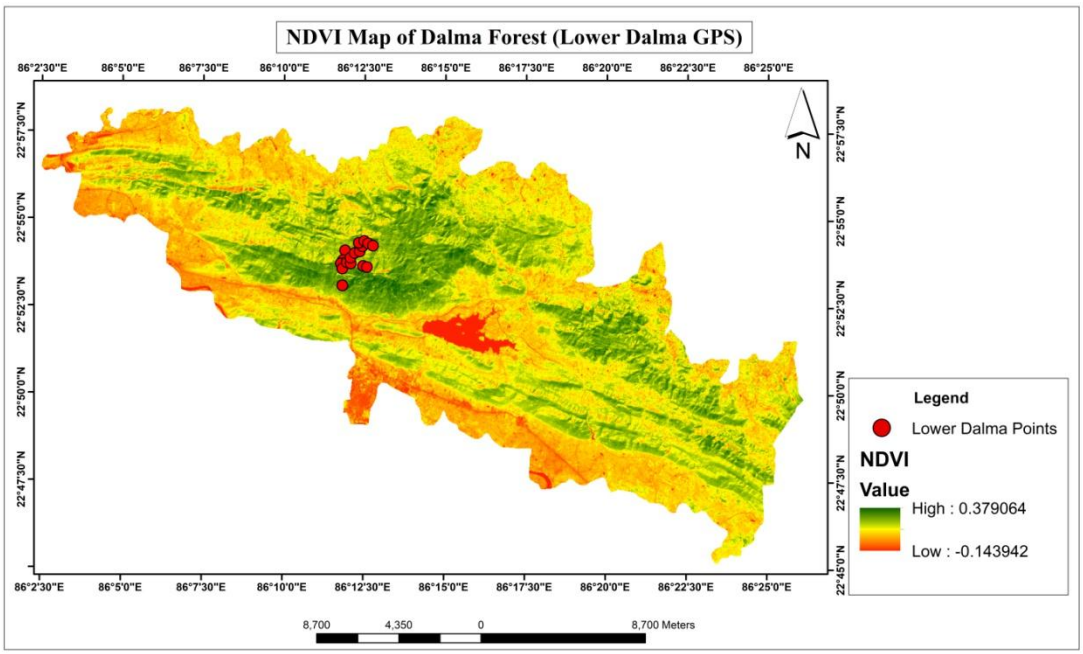

Figure 5.3(c) Map Showing NDVI for lower zoneof study area for the year 2016

5.3 Spectral Reflectance Curve of Cover Type :

The spectral reflectance for all the identified land use systems of Dalma Wildlife Sanctuary is shown in Figure 5.4

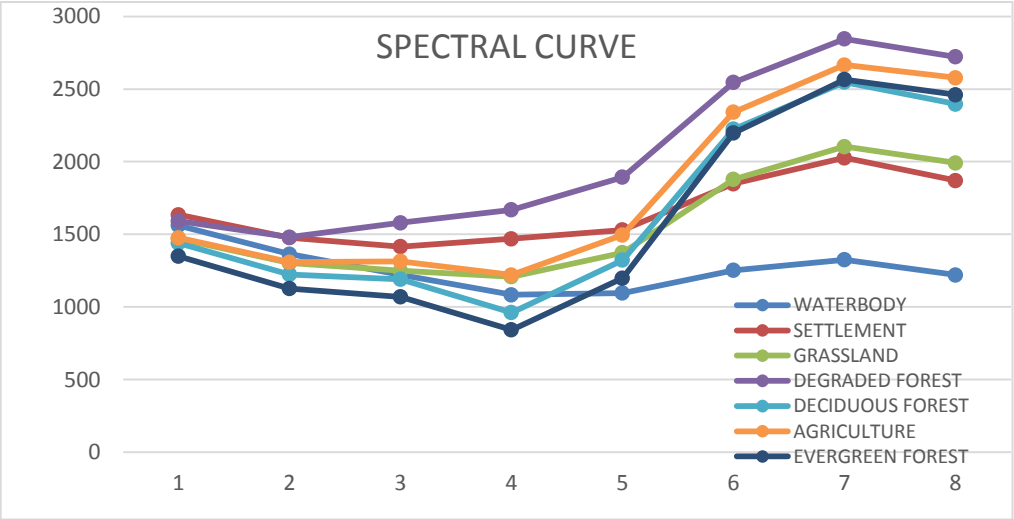

Figure 5.4:Spectral reflectance from different vegetation & Landuse types in Dalma Wildlife Sanctuary

5.4 Aspect and Slopes of Dalma Wildlife Sanctuary

The aspect identifies the down slope direction of the maximum rate of change in value from each cell to its neighbours. The values of each cell in the output raster indicate the compass direction that the surface faces at that location. Flat areas having no down slope direction are given a value of -1. Aspect can be thought of as the slope direction. The value of each cell in an aspect grid indicates the direction in which the cell's slope faces. Flat slopes have no direction and are given a value of -1 as shown in Fig.5.5. And 5.6

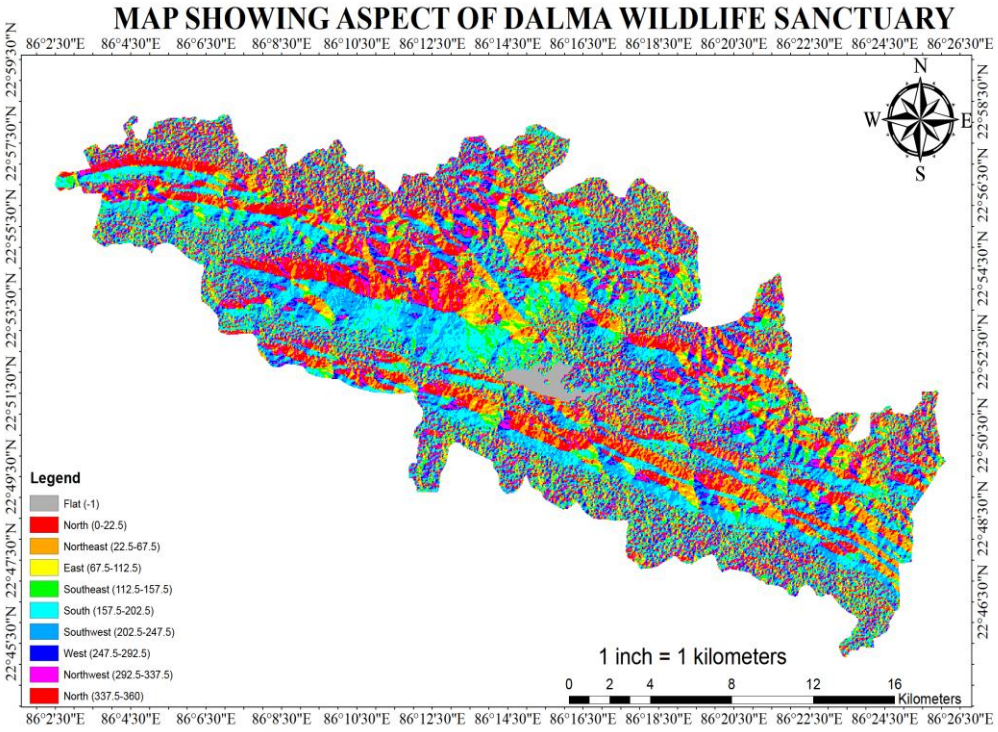

Figure 5.5 : Aspect map of Dalma Wildlife Sanctuary for the yearc 2016

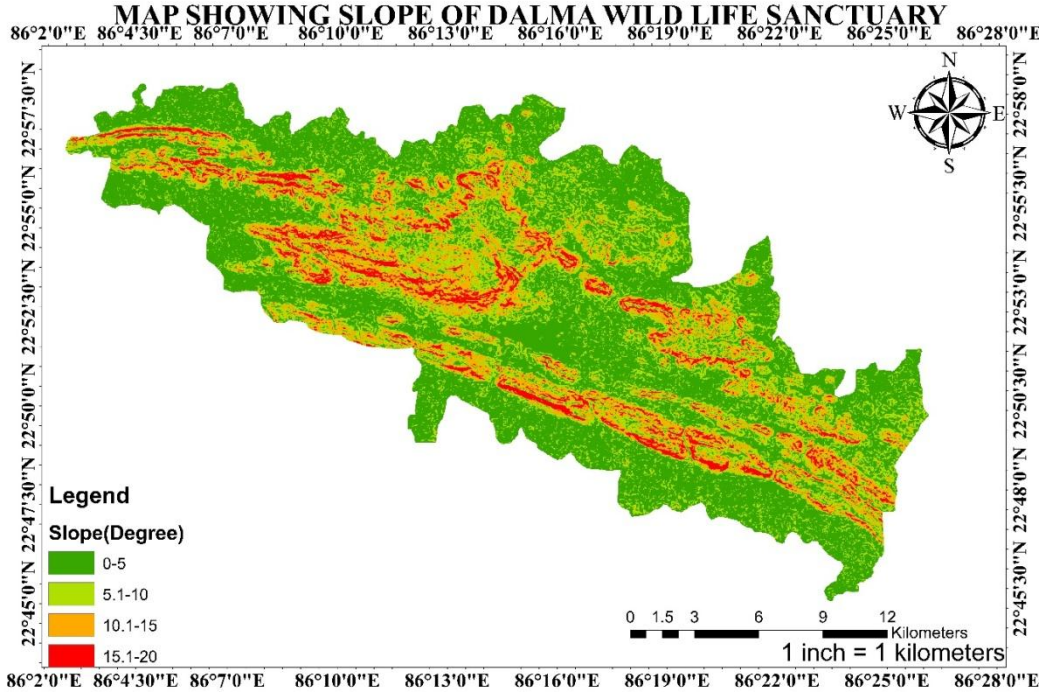

Figure 5.6 : Map Showing Slope of Dalma Wildlife Sanctuary for the year 2016

5.5 Drainage network map

Satellite images used for this study include Landsat image for the year 2016 with a spatial resolution .Drainage networks and other baseline information of the study area were prepared from the Survey of India top sheets on 1:50,000 scale and were further updated using satellite data. Landsat data of study area co-registered to Survey of India topo sheet was used for displacement in the crust of the earth and have an important role to play in development of drainage network of the region. The area has experienced structural disturbances leading to development of well-marked set of joints and fractures. ASTER 30 m DEM was also used for the study. Using the DEM slope map of the watershed was prepared.In GIS the channel segments were ordered numerically as order number 1 from a stream's headwaters to a point downstream. The stream segment that results from the joining of two first order streams was assigned order 2 and so on. Watershed parameters, such as: Basin area (A), Basin perimeter (P), Basin length (Lb), Stream length (L), and Stream order (N) were calculated. These parameters are used to determine other influencing factors, such as bifurcation ratio, stream frequency, and drainage density.

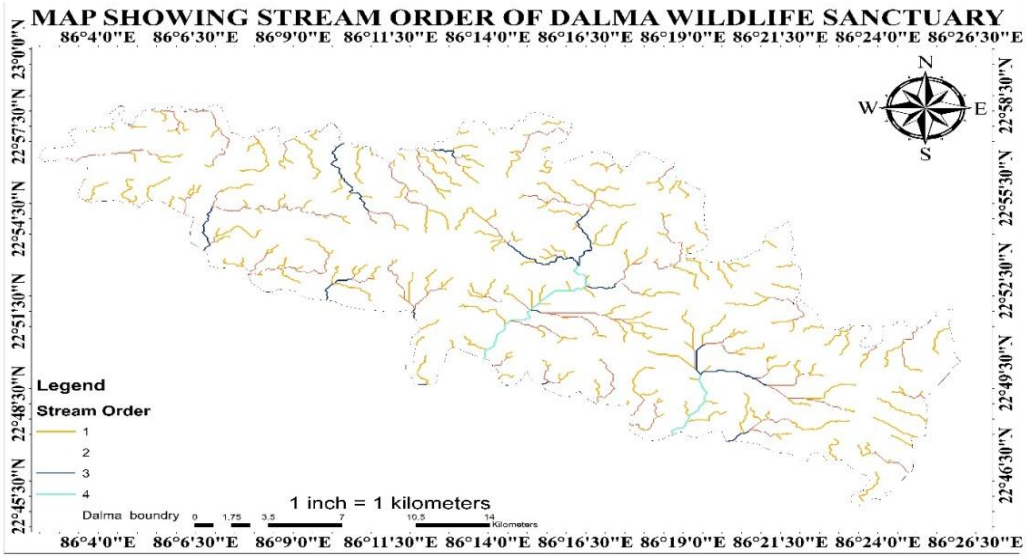

Figure5.7Drainage network of the Study Area

Table 5.2 Stream orders, stream number, stream length in the study area.

Sl No	Stream Order	Stream Number	Total Stream Length (Km)	Mean Stream Length	Bifurcation Ratio	Stream Length Ratio
1.	1st order	409	2.315	0.00566	1.9023	-
2.	2nd order	215	1.159	0.00539	4.8863	0.50064
3.	3rd order	44	0.290	0.00659	1.0476	0.250215
4.	4th order	42	0.128	0.00304	-	0.44137

5.5.1 Drainage area

The drainage area is the entire area drained by a stream or system of streams such that all streams flow originating in the area is discharged through a single outlet. In other words, the drainage area is defined as a collecting area from which water would go to a river. The boundary of the area is determined by the ridge separating water flowing in opposite directions. The total area of the study area is 195.6 km2. Basin area has been identified as the most important of all the morphometrics parameters controlling catchment runoff pattern. This is because, the larger the basin, the greater the volume of rainfall it intercepts, and the higher the peak discharge that result. The maximum flood discharge per unit area is inversely related to the size of the basin.

5.5.2 Drainage density

By definition drainage density of a basin is the total length of the streams of all orders per drainage area. Dd is expressed as the ratio of the total sum of all channel segments within a basin to the basin area i.e., the length of streams per unit of drainage density. It is a dimension inverse of length. Drainage densities can range from less than 5 km/km2 when slopes are gentle, rainfall low and bedrock permeable (e.g. sandstones), to much larger values of more than 500 km/km2 in mountainous areas where rocks are impermeable, slopes are steep and rainfall totals are high . The drainage density (Dd) of the study area is 0.88 km/km2. Thus, in this study, the drainage density falls less than 5km/km2 which indicates that the area has a gentle slope, low rainfall and permeable bedrock.

5.5.3 Stream frequency

The stream frequency (Fs) or channel frequency or drainage frequency of a basin may be defined as the total number of stream segments within the basin per unit area. The stream frequency value of the study area is 0.60 indicating very low stream frequency (Fs) which can be attributed to the low relief and high infiltration capacity. The low stream frequency of the basin is indicating low relief and permeable sub surface material. The existence of less number of streams in a basin indicates matured topography, while the presence of large number of streams indicates that the stream is youthful and still undergoing erosion. It is an index of the various stages of landscape evolution. Number of streams in each order varied because of the physiographic conditions of particular area.

5.5.4 Basin Perimeter

Basin perimeter is the outer boundary of the watershed that enclosed its area. It is measured along the divides between watersheds and may be used as an indicator of watershed size and shape.

5.6 Accuracy Assessment of the Classification

It is a right step to know the accuracy in classification of land use / land cover done on the basis of remotely sensed data provided by Landsat-8. In this process of accuracy assessment, the classified image is compared with the ground truth (reference data) gathered from field. It helps to improve the classification.

5.6.1Producer's Accuracy (Omission accuracy):

It is calculated through deviding of correctely classified number of pixels of every category on the diagonal by the total reference pixel number of known category i.e., column total. The find out value represents the wellness of reference pixels of classified earth surface cover.

5.6.2 Overall Accuracy

Overall accuracy is most common error or basic accuracy estimation. It is calculated in percentage by dividing the total number of correctly classified pixels (i.e., the sum value of the elements along the main diagonal) by the total quantity of correctly classified pixels (ground truth).

5.6.3 Overall accuracy (%) = (Correctly classified pixels/Total number of pixels)

It shows overall output of the tabular error matrix. The overall accuracies were found 84.39% in study of Dalma wildlife sanctuary for the period 2016. Anderson *et al.* (1976) has reported that 85% overall accuracy value should be a reliable land cover classification; However, according to Foody (2002) this baseline makes no sense to be a universal standard for accuracy under practical applications because a universal standard is not a study report of any specific area. Foody (2002) has also commented on Anderson*et al*. (1976) report that it does not explain about the evaluation of map for universal applications. Lu *et al*. (2004) has also mentioned in his study that the accuracies of change detection results highly depend on a number of factors, like: resources's accessibility and quality of collected ground truth (reference data), the difficult site vegetation of the study area, A Change detection and classification is evaluated by the change detection method using algorithms.

5.6.4 User's Accuracy

It is also known as commission error, which reflects the real features of the ground as shown on the classified map. It is computed by dividing of the number of correctly classified pixels in each class (Pixels) by the total number of pixels that were classified in that category of the classified image (row total).

User's accuracy (%) = (Correctly classified pixels /Classified total pixels. It represents the probability that a pixel classified into a given category actually represents that category on the ground. The maximum accuracy in classification of land cover of Dalma Wildlife Sanctuary is 99.17% in year 2016 that was of settlement and it was correctly classified, where as 68.05 % accuracy was found for agriculture i.e. minimum as shown in table – 4.5 of Error Matrix of LU/LC.

According to Václavík and Rogan (2009),due to the mixture of multiple crops in different phonological stages along with ploughed fields. The spatial resolutions of Landsat data have shown an influence on the image classification. According to Zhou *et al*. (2009) for detailed land use and land cover mapping at very fine scales, high spatial resolution imagery from satellite sensors.

Table 5.3 Error Matrix of LU/LC classification of 2016

Classified Data	**Agriculture**	**Evergreen Forest**	**Deciduous forest**	**Degraded Forest**	**Grass land**	**Settlement**	**Row Total**	**User Accuracy**
Agriculture	2058	610	500	00	02	01	3171	68.05%
Evergreen Forest	00	2582	53	00	20	00	2655	97.25%
Deciduous forest	84	01	1129	154	270	22	1660	70.55%
Degraded forest	00	00	00	4588	190	73	4851	94.57%
Grass land	116	00	16	00	598	40	770	77.66%
Settlement	00	05	01	00	00	720	726	99.17%
Column Total	2258	3198	1699	4742	1080	856	13833	
Producer Accuracy	91.14%	80.73%	66.45%	96.75%	55.37%	84.11%		
Over All Accuracy is -84.39%								

Po = 2058+2582+1129+4588+598+720 =10546
Pc=(3171*2258/13833)+(2655*3198/13833)+(1660*1699/13833)+(4851*4742/13833)+(770*1080/13833)+(726*856/13833)

5.7 Vegetation Analysis of Dalma Wildlife Sanctuary

5.7.1 Vegetation and Land Use

Different forest types identified through the interpretation of satellite images (Figure-2) were Evergreen, Deciduous, Open degraded and Grass Land. Non forest category occupied rest of the area was dominated by Agriculture, Settlement and water bodies. Forest types classified using remote sensing data were compared with forest types described by Champion and Seth in the study area.

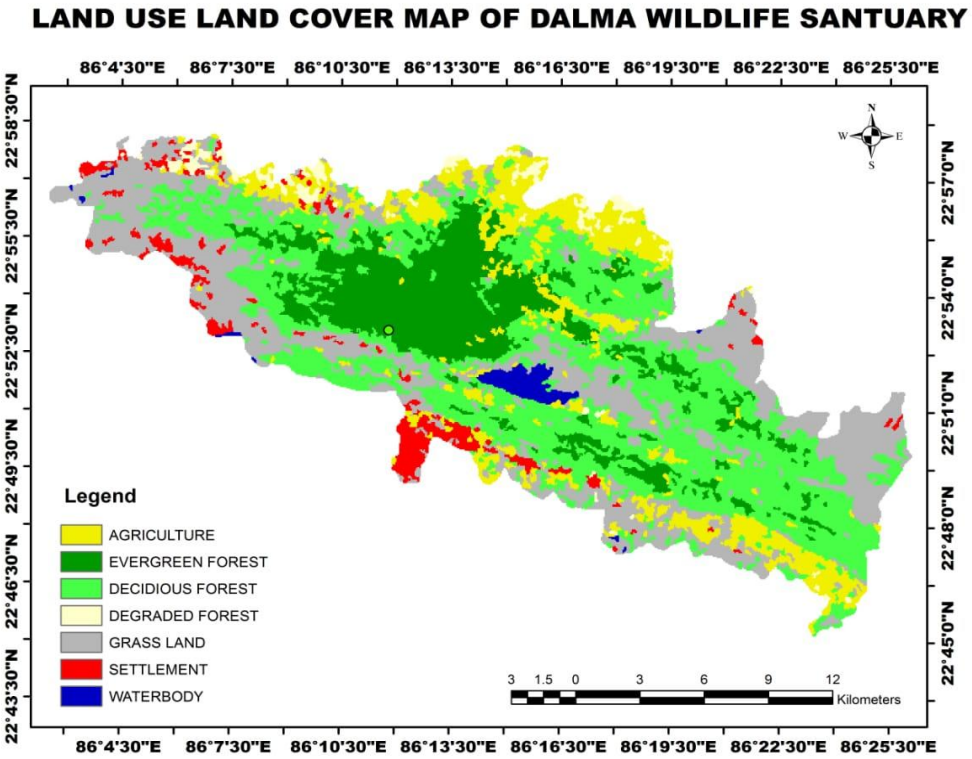

Figure 5.8 Vegetation & Land Use Map of Dalma Wildlife Sanctuary, Jharkhand

According to Forest Types as described by Champion and Seth, three types like Northern Tropical dry deciduous forest (5B), Dry Peninsular Sal Forest (5B/C1) and Northern Dry Mixed Deciduous Forest (5B/C2). They have also mentioned characteristics associates among the floral species of *Shorea-Anogeisus-Woodfordia*, *Shorea- Gardenia-Diospyros* association were described.

According to vegetation map (Figure 3) of Dalma Wildlife Sanctuary, the Upper Zones of core area consist of mainly Evergreen forest, dry mixed deciduous forests with small patches of moist mixed forests near water streams and in the northern aspects. The upper portion of the hills and particularly on the northern aspects consists of comparatively better quality of mixed forests of evergreen and deciduous. Details of species observed at Upper, Middle and Lower Zones are shown in Table 1. In upper zone many important timber species are observed which consists of mainly *Shorea robusta* (Dominant), *Terminalia tomentosa* (Dominant),

Anogeissus latifolia, Diospyos melanoxylon,Adina cordifolia, Pterocarpus marsupium, Terminalia belerica, Bombax ceiba, Emblica officinalis.

Table 5.4 Forest Flora Species in Dalma Wildlife Sanctuary, Jharkhand.

Sl. No	**Botanical Name**	**Family**	Sl. No	**Botanical Name**	**Family**
	Tree			**Shrub**	
1	*Terminalia tomentosa*	Combretaceae	1	*Clerodendron infortunatum*	Verbinaceae
2	*Shorea robusta*	Dipterocarpaceae	2	*Desmodium cephalotes*	Papalionaceae
3	*Lagerstroemia parviflora*	Lythraceae	3	*Melastoma malabathricum*	Melastomaceae
4	*Aegle elephantum*	Rutceae	4	*Agave vera*	Amaryllidaceae
5	*Bauhinia retusu*	Caesalpiniaceae	5	*Vernonia anthelmintica*	Compositae
6	*Calicarpa arborea*	Verbinaceae	6	*Vitex Negundu*	Verbinaceae
7	*Diospyros embryopteris*	Ebenaceae	7	*Hibiscus cannabinus*	Malvaceae
8	*Adina cordifolia*	Rubiaceae	8	*Alangium lamarki*	Cornaceae
9	*Aegle marmelos*	Rutaceae	9	*Antedesma ghaesmbilia*	Euphorbiaceae
10	*Morinda citrifolia*	Rubiaceae	10	*Melia azedarch*	Miliaceae
11	*Cassia fistula*	Caesalpiniaceae	11	*Diospyrus melanoxylon*	Ebenaceae
12	*Albizia stipulate*	Compositeae	12	*Phylanthus emblica*	Euphorbiaceae
13	*Kydia calycina*	Marvaceae	13	*Flacourtia romantechi*	Bixaceae
14	*Cassia siamia*	Caesalpinnaceae	14	*Gordenia gumnifera*	Rubiaceae
15	*Schrebera swieteniodes*	Oleaceae	15	*Flacartia cramalatum*	Bixaceae
16	*Alstonia scholaris*	Apocynaceae	16	*Helicteris isora*	Sterculiceae
17	*Bauhinia racemosa*	Caesalpiniaceae	17	*Holarrhena antidysenterica*	Apocynaceae
18	*Albizzia stipulae*	Mimosaeae	18	*Randia dumetorum*	Rubiaceae
19	*Anogeisus latifolia*	Combretaceae	19	*Xylosma longifolium*	Bixaceae
20	*Bridelia aretusa*	Euphorbibiceae	20	*Zyzyphus cenoplia*	Rhanaceae
21	*Buchnania latifolia*	Anacardiaceae		**Herb**	
22	*Casearia graviolens*	Bixaceae	1	*Antidesma ghaesmbilia*	Euphorbiaceae

23	*Caseria tomentosa*	Samydaceae	2	*Curcuma amada*	Zingiberaceae
24	*Cedrella toona(Toona ciliate)*	Meliaceae	3	*Echinochloa Crusgali*	Graminae
25	*Cochlospermum gossipium*	Bixaceae	4	*Heteropogon contortus*	Gramineae
26	*Cleistanthus collinus*	Euphorbiaceae	5	*Chrysopogan aciculate*	Gramineae
27	*Cleistanthus patulas*	Euphorbiaceae	6	*Panicum maximum*	Gramineae
28	*Dillenia pentagyna*	Dilieniaceae	7	*Chrysopogan Gryllus*	Gramineae
29	*Eugenia jambolana*	Myrtaceae	8	*Imperata Cylindrical*	Gramineae
30	*Feronia elephant*	Rutaceae	9	*Cynodon dactylon*	Gramineae
31	*Ficus hispida*	Moraceae	10	*Ischaemum amjustifolium*	Gramineae
32	*Grewia tiliaefolia*	Tiliaceae	11	*Pennisetum setaria*	Gramineae
33	*Odina wodier*	Anacardiaceae	12	*Ipomea batatas*	Convolvulaceae
34	*Oroxylom indicum*	Bignoniaceae	13	*Clerodendron siphonanthus*	Verbenaceae
35	*Pterocarpus marsupium*	Papilionaceae	14	*Ruellia berlaria*	Acanthaceae
36	*Semicarpus anacardium*	Anacardiaceae	15	*Basella latefolia*	Amarantaceae
37	*Soymida febrifuga*	Meliaceae	16	*Apluda varia*	Gramineae
38	*Pterospermum pteragonum*	Sterculiaceae	17	*Cryptolepis buchanani*	Asclepidaceae
39	*Terminalia belerica*	Combretaceae	18	*Justicia betonica*	Acanthaceae
40	*Terminalia chebula*	Combretaceae	19	*Vernonia cinerea*	Compositeae
41	*Zizyphus jujube*	Rhamnaceae	20	*Indigophera pulchella*	Papilonaceae
			21	*Wrightia tomentosa*	Apocynaceae
	Climber				
1	*Melothria heterophylla*	Cucurbitaceae	8	*Rivea hypocrateriformis*	Covolvulaceae
2	*Vigna catjang*	Papilionaceae	9	*Abrus precatorius*	Papilionaceae
3	*Chonemorpha macrophylla*	Apocynaceae	10	*Celastrus paniculata*	Acanthaceae
4	*Barleria spp.*	Acanthaceae	11	*Bauhinia vahlii*	Caesalpiniaceae
5	*Barleria cristata*	Acanthaceae	12	*Vitis repanda*	Ampelidaceae
6	*Cryptolepis buchanani*	Asclepiadaceae	13	*Smilex macrophylla*	Liliaceae
7	*Dioscorea belophylla*	Dioscoreaceae	14	*Asparagus racemosus*	Liliaceae

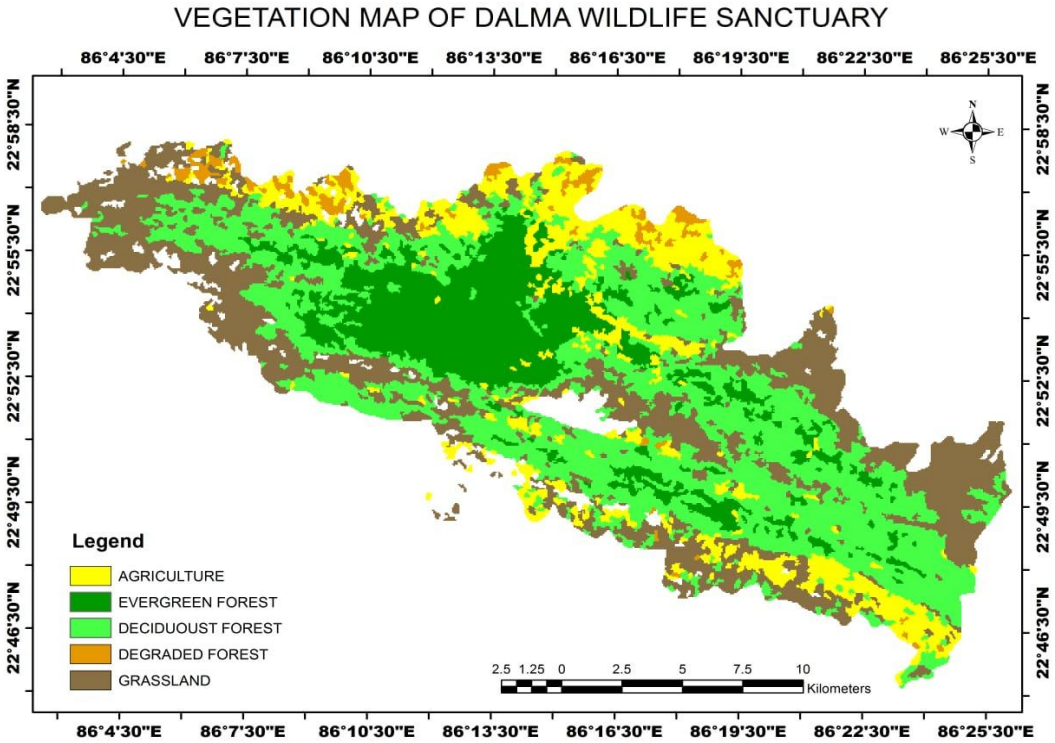

Figure 5.9Forest Vegetation Map of the Study Area of Dalma wildlife Sanctuary, Jharkhand

In the Middle Zones (parts of core area) and Lower Zones covering buffer area in the western and eastern portion of the sanctuary, there are mixed forests with *Shorea robusta* as predominant species.

It was found that the trees are not very healthy except at the upper Zone of core area and water streams. Some portion of the buffer area of lower zone has open degraded forest.

The existing species as categorised in Tree, Shrub, Herb and Climber are shown Table 5.4. It indicated that number of tree species were more as compared to Shrub (20), Herbs (22) and Climbers (14). Comparative numerical strength of plant groups are shown in Figure 5.10.

Table 5.5Distribution of plant species as per type (Tree, Shrub, Herb,Climber)

S.N.	Plant Types	No. of Families	Total Plants
1.	Tree	25	41
2.	Shrub	15	20
3.	Herb	13	22
4.	Climber	11	14
	Total	**64**	**98**

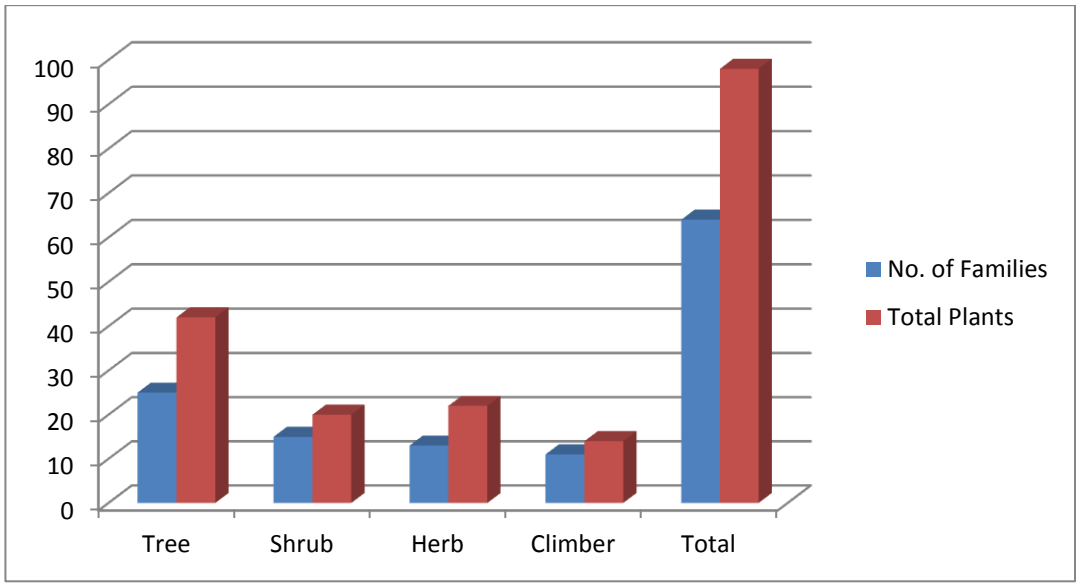

Figure 5.10Numerical strength of plant group of Dalma Wildlife Sanctuary.

The occurrence of different plant species have been also categorised according to plant families as shown in Table 5.6 with respect to upper zone, middle zone and lower zone. It is noticed that Gramineae (10) family is most represented followed by Euphorbiaceae (6).In upper zone many trees maximum representation was from Combretaceae, whereas in case of Shrubs maximum representatives was from Bixaceae family. However in case of Herbs and Climbers Gramineae and Acanthaceae showed maximum plant species. In middle zone Caesalpiniaceae family is represented by five tree species,whilefor Shrub, Bixaceae family is having two tree species. However Gramineae family is represented by highest number of plant

species belonging to herbaceous group. In case of lower zone maximum species is found belonging to Caesalpiniaceae for tree, Rubiaceae and Euphorbiaceae for shrubs and gramineae for herbaceous species. Therefore data indicated that, Upper zone is rich with respect to plants families (40 families). However, at middle and lower zone, decreased in plant distribution to different families is noticed. Most represented families are Graminae & Euphorbiacea. Dominating families in case of tree species are copmbretaceae, Caesalpinaceae and Euphorbiaceae.

Table 5.6Zone wise family distribution of Tree and Shrubs.

Family	**Total**	**Upper Zone**				**Middle Zone**				**Lower Zone**			
		T	Sh	Hrb	Cl	T	Sh	Hrb	Cl	Tr	Sh	Hrb	Cl
Combretaceae	4	4	-	-	-	-	-	-	-	-	-	-	-
Dipterocarpaceae	1	1	-	-	-	1	-	-	-	1	-	-	-
Lythraceae	1	1	-	-	-	1	-	-	-	1	-	-	-
Rutceae	3	3	-	-	-	2	-	-	-	2	-	-	-
Caesalpiniaceae	5	4	-	-	-	4	-	-	-	3	-	-	1
Verbinaceae	4	1	-	1	-	1	-	1	-	1	-	1	-
Ebenaceae	2	1	1	-	-	-	1	-	-	-	1	-	-
Rubiaceae	4	2	2	-	-	2	1	-	-	1	2	-	-
Compositeae	2	-	1	1	-	-	1	1	-	-	-	1	-
Malvaceae	2	1	1	-	-	1	1	-	-	-	-	-	-
Oleaceae	1	1	-	-	-	-	-	-	-	-	-	-	-
Apocynaceae	2	1	1	-	-	1	1	-	-	1	1	-	-
Mimosaceae	2	2	-	-	-	1	-	-	-	2	-	-	-
Euphorbibiceae	6	3	2	1	-	2	1	-	-	1	2	1	-
Anacardiaceae	3	3	-	-	-	3	-	-	-	3	-	-	-
Bixaceae	5	2	3	-	-	1	2	-	-	2	-	-	-
Samydaceae	1	1	-	-	-	1	-	-	-	1	-	-	-
Dilieniaceae	1	1	-	-	-	1	-	-	-	-	-	-	-
Myrtaceae	1	1	-	-	-	1	-	-	-	1	-	-	-
Moraceae	1	1	-	-	-	-	-	-	-	1	-	-	-
Tiliaceae	1	1	-	-	-	1	-	-	-	1	-	-	-
Bignoniaceae	1	1	-	-	-	-	-	-	-	-	-	-	-
Papilionaceae	5	1	1	1	-	1	1	1	1	1	1	1	1
Meliaceae	3	2	1	-	-	1	1	-	-	1	1	-	-

Sterculiaceae	2	1	1	-	-	-	1	-	-	1	-	-	-
Rhamnaceae	2	1	1	-	-	1	-	-	-	1	-	-	-
Melastomaceae	1	-	1	-	-	-	1	-	-	-	1	-	-
Amaryllidaceae	1	-	1	-	-	-	1	-	-	-	-	-	-
Cornaceae	1	-	1	-	-	-	1	-	-	-	-	-	-
Zingiberaceae	1	-	-	1	-	-	-	1	-	-	-	1	-
Gramineae	10	-	-	10	-	-	-	7	-	-	-	6	-
Liliaceae	3	-	-	1	1	-	-	1	2	-	-	-	1
Convolvulaceae	2	-	-	1	-	-	-	1	-	-	-	-	1
Acanthaceae	5	-	-	1	2	-	-	1	3	-	-	1	2
Amaranthaceae	1	-	-	1	-	-	-	1	-	-	-	-	-
Asclepiadaceae	2	-	-	1	-	-	-	-	1	-	-	-	1
Apocynaceae	2	-	-	1	1	-	-	1	1	-	-	1	1
Cucurbitaceae	1	-	-	-	1	-	-	-	1	-	-	-	1
Dioscoreaceae	1	-	-	-	1	-	-	-	1	-	-	-	-
Ampelidaceae	1	-	-	-	1	-	-	-	-	-	-	-	-
TOTAL		40				32				32			

5.8 Species Composition and IVI Index

The IVI calculated for all the existing species in Upper zone of Dalma Wildlife Sanctuary shown in (table 5.7)indicated that its value for 41 trees varied from 1.57 for *Calicarpa arborea* a member of family Verbinaceae to highest value of *Shorea robusta* (19.25) a member of Dipterocarpaceae which is a dominating species in the area.

With respect to 19 shrub species *Clerodendron infortunatum* belonging to Verbinaceae familydominated the area have maximum IVI value(30.40), while *Agave vera-cruz* showed lowest value(9.63).

For 21 herbaceous maximum value of IVI was observed for *Ipomea batatas* (19.53) belonging to Convolvulaceae family. On the other hand in case of 8 Climber species, the highest IVI value was calculated for *Vitis repanda* (42.47) a member of Ampelidaceae family.

Table 5.7 Species composition and IVI Index of plant species in Upper Zone of Dalma Wildlife Sanctuary

TREE			
Sl. No.	**Name of the Species**	**Families**	**IVI**
1	*Terminalia tomentosa*	Combretaceae	9.44
2	*Shorea robusta*	Dipterocarpaceae	19.25
3	*Lagerstroemia parviflora*	Lythraceae	5.79
4	*Aegle elephantum*	Rutceae	3.02
5	*Bauhinia retusu*	Caesalpiniaceae	5.54
6	*Calicarpa arborea*	Verbinaceae	1.57
7	*Diospyros embryopteris*	Ebenaceae	3.36
8	*Adina cordifolia*	Rubiaceae	8.80
9	*Aegle marmelos*	Rutaceae	4.22
10	*Morinda citrifolia*	Rubiaceae	4.84
11	*Cassia fistula*	Caesalpiniaceae	7.26
12	*Albizzia stipulate*	Compositeae	7.47
13	*Kydia calycina*	Marvaceae	6.37
14	*Cassia siamia*	Caesalpinnaceae	9.93
15	*Schrebera swieteniodes*	Oleaceae	0.15
16	*Alstonia scholaris*	Apocynaceae	12.34
17	*Bauhinia racemosa*	Caesalpiniaceae	11.37
18	*Albizzia stipulae*	Mimosaeae	13.73
19	*Anogeisus latifolia*	Combretaceae	7.42
20	*Bridelia aretusa*	Euphorbibiceae	6.19
21	*Buchnania latifolia*	Anacardiaceae	5.93
22	*Casearia graviolens*	Bixaceae	6.57
23	*Caseria tomentosa*	Samydaceae	8.67
24	*Cedrella toona*	Meliaceae	5.46
25	*Cochlospermum gossipium*	Bixaceae	7.73
26	*Cleistanthus collinus*	Euphorbiaceae	7.06
27	*Cleistanthus patulas*	Euphorbiaceae	5.85
28	*Dillenia pentagyna*	Dilieniaceae	6.81
29	*Eugenia jambolana*	Myrtaceae	3.95
30	*Feronia elephant*	Rutaceae	9.14
31	*Ficus hispida*	Moraceae	3.59

32	*Grewia tiliaefolia*	Tiliaceae	9.05
33	*Odina wodier*	Anacardiaceae	8.72
34	*Oroxylom indicum*	Bignoniaceae	2.70
35	*Pterocarpus marsupium*	Papilionaceae	10.39
36	*Semicarpus anacardium*	Anacardiaceae	3.13
37	*Soymida febrifuga*	Meliaceae	5.55
38	*Pterospermum pteragonum*	Sterculiaceae	5.26
39	*Terminalia belerica*	Combretaceae	11.14
40	*Terminalia chebula*	Combretaceae	8.28
41	*Zizyphus jujube*	Rhamnaceae	11.96
	Total		**295.02**
SHRUB			
Sl.No	**Name of the Species**	**Families**	**IVI**
1	*Clerodendron infortunatum*	Verbinaceae	30.40
2	*Desmodium cephalotes*	Papalionaceae	21.76
3	*Melastoma malabathricum*	Melastomaceae	23.76
4	*Agave vera-cruz*	Amaryllidaceae	9.63
5	*Vernonia anthelmintica*	Compositae	13.57
6	*Vitex negundu*	Verbinaceae	13.06
7	*Hibiscus cannabinus*	Malvaceae	24.34
8	*Alangium lamarki*	Cornaceae	15.16
9	*Antedesma ghaesmbilia*	Euphorbiaceae	12.21
10	*Diospyrus melanoxylon*	Ebenaceae	12.72
11	*Phylanthus emblica*	Euphorbiaceae	13.17
12	*Flacourtia romantechi*	Bixaceae	14.27
13	*Gordenia gumnifera*	Rubiaceae	10.72
14	*Flacartia cramalatum*	Bixaceae	8.35
15	*Helicteris isora*	Sterculiceae	11.25
16	*Holarrhena antidysenterica*	Apocynaceae	19.32
17	*Randia dumetorum*	Rubiaceae	10.01
18	*Xylosma longifolium*	Bixaceae	10.72
19	*Zyzyphus cenoplia*	Rhanaceae	20.79
	Total		**295.21**
HERB			
Sl.No.	**Name of the Species**	**Families**	**IVI**
1	*Antidesma ghaesmbilia*	Euphorbiaceae	12.49

2	*Curcuma amada Roxb.*	Zingiberaceae	16.00
3	*Echinochloa crusgali*	Graminae	12.98
4	*Heteropogon contortus*	Gramineae	18.95
5	*Chrysopogan aciculate*	Gramineae	12.97
6	*Panicum maximum*	Gramineae	12.29
7	*Chrysopogan gryllus*	Gramineae	17.47
8	*Imperata cylindrical*	Gramineae	10.63
9	*Cynodon dactylon*	Gramineae	14.88
10	*Ischaemum anjustifolium*	Gramineae	14.78
11	*Pennisetum setaria*	Gramineae	17.03
12	*Ipomea batatas*	Convolvulaceae	19.53
13	*Clerodendron siphonanthus Br.*	Verbenaceae	13.39
14	*Ruellia berlaria*	Acanthaceae	9.65
15	*Basella latefolia*	Amarantaceae	8.95
16	*Apluda varia Hack.*	Gramineae	13.10
17	*Cryptolepis buchanani Roem.*	Asclepidaceae	12.62
18	*Justicia betonica L.*	Acanthaceae	__
19	*Vernonia cinerea Lees.*	Compositeae	17.62
20	*Indigofera pulchella Rox.*	Papilonaceae	9.52
21	*Wrightia tomentosa Roem.*	Apocynaceae	15.52
	TOTAL		**280.37**
CLIMBER			
Sl.No	**Name of the Species**	**Families**	**IVI**
1	*Melothria heterophylla Cogn.*	Cucurbitaceae	20.52
2	*Chonemorpha macrophylla G. Don.*	Apocynaceae	17.63
3	*Barleria cristata L.*	Acanthaceae	21.28
4	*Dioscorea belophylla Voight.*	Dioscoreaceae	23.05
5	*Celastrus paniculata Wolld.*	Acanthaceae	23.04
6	*Bauhinia vahlii W. & A.*	Caesalpiniaceae	20.45
7	*Vitis repanda W. & A.*	Ampelidaceae	42.47
8	*Smilex macrophylla Roxb.*	Liliaceae	37.29
	TOTAL		**205.73**

In Dalma Wildlife Sanctuary, there are seven uncommon tree species observed in Upper zone, the IVI value of all these were also calculated and shown in

Table 5.8. Maximum IVI value (7.73) was recorded for *Cochlospermum gossipium* a member of Bixaceae family.

Table 5.8IVI Index of Uncommon tree species only found in Upper zone/Core Area

Sl. No.	Name of the Species	Families	IVI
1	*Aegle elephantum*	Rutceae	3.02
2	*Diospyros embryopteris*	Ebenaceae	3.36
3	*Schrebera swieteniodes*	Oleaceae	0.15
4	*Bridelia aretusa*	Euphorbibiceae	6.19
5	*Cochlospermum gosyipium*	Bixaceae	7.73
6	*Oroxylom indicum*	Bignoniaceae	2.70
7	*Soymida febrifuga*	Meliaceae	5.55
	Total		**28.70**

The IVI value of middle zone of Dalma Wildlife Sanctuary has been also calculated for tree, Shrub, Herv and Climber found and shown in (table 5.9). Out of 29 Tree species highest value of IVI was observed for *Adina cardifolia*(18.21) belonging to family Rubiceae, while lowest value was found for *Calicarpa arborea*(1.95) of family Verbinaceae.

The IVI value of Shrub, Herbs and Climber indicated maximum value for *Clerodendron infortunatum*(37.32), *Cynodon dactylon* (25.74) and *Celestrus paniculata*(39.11)respectively.

Table 5.9 Species composition and IVI Index of plant species in Middle Zone of Dalma Wildlife Sanctuary

TREE

Sl. No.	Name of the Species	Families	IVI
1	*Terminalia tomentosa* W. & A.	Combretaceae	10.213
2	*Shorea robusta*	Dipterocarpaceae	12.820
3	*Bauhinia retusu*	Caesalpiniaceae	6.250
4	*Calicarpa arborea*	Verbinaceae	1.956
5	*Adina cordifolia*	Rubiaceae	18.210

6	*Aegle marmelos*	Rutaceae	8.990
7	*Morinda citrifolia*	Rubiaceae	5.403
8	*Cassia fistula*	Caesalpiniaceae	6.910
9	*Kydia calycina*	Marvaceae	8.950
10	*Cassia siamia*	Caesalpinnaceae	10.540
11	*Alstonia scholaris*	Apocynaceae	15.430
12	*Bauhinia racemosa*	Caesalpiniaceae	12.250
13	*Albizzia stipulae*	Mimosaeae	10.160
14	*Anogeisus latifolia*	Combretaceae	6.030
15	*Buchnania latifolia*	Anacardiaceae	12.140
16	*Casearia graviolens*	Bixaceae	9.220
17	*Caseria tomentosa*	Samydaceae	14.880
18	*Cedrella toona*	Meliaceae	6.690
19	*Cleistanthus collinus*	Euphorbiaceae	10.660
20	*Cleistanthus patulas*	Euphorbiaceae	8.400
21	*Dillenia pentagyna*	Dilieniaceae	9.097
22	*Eugenia jambolana*	Myrtaceae	10.270
23	*Feronia elephant*	Rutaceae	8.440
24	*Grewia tiliaefolia*	Tiliaceae	15.510
25	*Odina wodier*	Anacardiaceae	8.680
26	*Pterocarpus marsupium*	Papilionaceae	8.580
27	*Semicarpus anacardium*	Anacardiaceae	7.360
28	*Terminalia belerica*	Combretaceae	15.520
29	*Zizyphus jujube*	Rhamnaceae	14.210
	TOTAL		**293.769**
SHRUB			
Sl.No.	**Name of the Species**	**Families**	**IVI**
1	*Clerodendron infortunatum*	Verbinaceae	37.320
2	*Desmodium cephalotes*	Papalionaceae	24.370
3	*Melastoma malabathricum*	Melastomaceae	27.390
4	*Agave vera-cruz*	Amaryllidaceae	16.390
5	*Vernonia anthelmintica*	Compositae	9.210
6	*Hibiscus cannabinus*	Malvaceae	29.660
7	*Alangium lamarki*	Cornaceae	17.510
8	*Antedesma ghaesmbilia*	Euphorbiaceae	23.320
9	*Melia azedarach*	Miliaceae	18.140
10	*Diospyrus melanoxylon*	Ebenaceae	10.920
11	*Flacourtia romantechi*	Bixaceae	21.360
12	*Helicteris isora*	Sterculiceae	16.120
13	*Holarrhena antidysenterica*	Apocynaceae	22.280

14	*Randia dumetorum*	Rubiaceae	14.420
15	*Xylosma longifolium*	Bixaceae	17.980
	TOTAL		**306.390**
HERB			
Sl.No.	**Name of the Species**	**Families**	**IVI**
1	*Curcuma amada* Roxb.	Zingiberaceae	20.28
2	*Echinochloa crusgali*	Graminae	16.93
3	*Heteropogon contortus*	Gramineae	19.49
4	*Chrysopogan aciculate*	Gramineae	17.66
5	*Imperata cylindrical*	Gramineae	29.23
6	*Cynodon dactylon*	Gramineae	25.74
7	*Ischaemum anjustifolium*	Gramineae	9.07
8	*Pennisetum setaria*	Gramineae	15.98
9	*Ipomea batatas*	Convolvulaceae	14.2
10	*Clerodendron siphonanthus* Br.	Verbenaceae	13.72
11	*Ruellia berlaria*	Acanthaceae	10.011
12	*Basella latefolia*	Amarantaceae	7.61
13	*Apluda varia* Hack.	Gramineae	21.99
14	*Vernonia cinerea* Lees.	Compositeae	14.91
15	*Indigofera pulchella Rox.*	Papilonaceae	10.81
16	*Wrightia tomentosa* Roem.	Apocynaceae	17.56
	TOTAL		**265.191**
CLIMBER			
Sl.No.	**Name of the Species**	**Families**	**IVI**
1	*Melothria heterophylla* Cogn.	Cucurbitaceae	19.06
2	*Vigna catjang* Endl.	Papilionaceae	7.12
3	*Chonemorpha macrophylla* G. Don.	Apocynaceae	8.17
4	*Barleria spp.* L.	Acanthaceae	17.62
5	*Barleria cristata* L.	Acanthaceae	14.67
6	*Cryptolepis buchanani* Roem.	Asclepiadaceae	11.76
7	*Dioscorea belophylla* Voight.	Dioscoreaceae	5.28
8	*Celastrus paniculata* Wolld.	Acanthaceae	39.11
9	*Bauhinia vahlii* W. & A.	Caesalpiniaceae	7.49
10	*Smilex macrophylla* Roxb.	Liliaceae	29.6
11	*Asparagus racemosus* Willd.	Liliaceae	32.04
	TOTAL		**191.92**

The IVI value of different species of lower zone of Dalma Wildlife Sanctuary is shown (Table 5.10)with respect to tree (25), Shrub(19), Herb(15) and Climber (9). Maximum IVI value was observed for *Shorea robusta* (27.79) in case of tree species, while *Clerodendron infortunatum* shared maximum IVI(42.88) among the 19 shrub species. On the other hand in case of herbaceous species *Panicum maximus*gave highest value of IVI(25.03) and under climber group *Asparagus racemosus Willd* observed highest (51.96).

Table 5.10Species Composition and IVI Index of plant species in Lower zone of Dalma Wildlife Sanctuary

TREE

Sl. No.	Name of the Species	Families	IVI
1	*Terminalia tomentosa W. & A.*	Combretaceae	15.20
2	*Shorea robusta*	Dipterocarpaceae	27.79
3	*Lagerstroemia parviflora*	Lythraceae	13.51
4	*Calicarpa arborea*	Verbinaceae	3.66
5	*Adina cordifolia*	Rubiaceae	16.89
6	*Aegle marmelos*	Rutaceae	5.98
7	*Cassia fistula*	Caesalpiniaceae	6.67
8	*Albizzia stipulate*	Compositeae	13.94
9	*Cassia siamia*	Caesalpinnaceae	10.66
10	*Alstonia scholaris*	Apocynaceae	10.74
11	*Bauhinia racemosa*	Caesalpiniaceae	20.21
12	*Buchnania latifolia*	Anacardiaceae	11.71
13	*Caseria tomentosa*	Samydaceae	17.33
14	*Cedrella toona*	Meliaceae	13.59
15	*Cleistanthus collinus*	Euphorbiaceae	9.45
16	*Eugenia jambolana*	Myrtaceae	10.66
17	*Ficus hispida*	Moraceae	5.88
18	*Grewia tiliaefolia*	Tiliaceae	18.19
19	*Odina wodier*	Anacardiaceae	11.68
20	*Pterocarpus marsupium*	Papilionaceae	16.93
21	*Semicarpus anacardium*	Anacardiaceae	9.81
22	*Pterospermum pteragonum*	Sterculiaceae	6.53
23	*Terminalia belerica*	Combretaceae	18.81
24	*Terminalia chebula*	Combretaceae	9.27
25	*Zizyphus jujube*	Rhamnaceae	17.39
	TOTAL		**322.48**

SHRUB			
Sl. No.	**Name of the Species**	**Families**	**IVI**
1	*Clerodendron infortunatum*	Verbinaceae	42.88
2	*Desmodium cephalotes*	Papalionaceae	23.15
3	*Melastoma malabathricum*	Melastomaceae	29.92
6	*Vitex negundu*	Verbinaceae	6.55
9	*Antedesma ghaesmbilia*	Euphorbiaceae	21.02
10	*Melia azedarach*	Miliaceae	22.18
11	*Diospyrus melanoxylon*	Ebenaceae	22.16
12	*Phylanthus emblica*	Euphorbiaceae	20.83
13	*Flacourtia romantechi*	Bixaceae	22.59
14	*Gordenia gumnifera*	Rubiaceae	11.97
17	*Holarrhena antidysenterica*	Apocynaceae	18.88
18	*Randia dumetorum*	Rubiaceae	10.30
19	*Xylosma longifolium*	Bixaceae	15.14
	TOTAL		**267.57**

HERB			
Sl. No.	**Name of the Species**	**Families**	**IVI**
1	*Antidesma ghaesmbilia*	Euphorbiaceae	4.13
2	*Curcuma amada* Roxb.	Zingiberaceae	16.43
3	*Echinochloa crusgali*	Graminae	14.93
4	*Heteropogon contortus*	Gramineae	17.35
5	*Chrysopogan aciculate*	Gramineae	19.45
6	*Panicum maximum*	Gramineae	25.03
7	*Imperata cylindrical*	Gramineae	19.70
8	*Cynodon dactylon*	Gramineae	20.58
9	*Clerodendron siphonanthus* Br.	Verbenaceae	17.32
10	*Ruellia berlaria*	Acanthaceae	13.59
11	*Apluda varia* Hack.	Gramineae	13.81
12	*Justicia betonica* L.	Acanthaceae	8.36
13	*Vernonia cinerea* Lees.	Compositeae	16.22
14	*Indigofera pulchella Rox.*	Papilonaceae	14.42
15	*Wrightia tomentosa* Roem.	Apocynaceae	13.87
	TOTAL		**235.19**

CLIMBER			
Sl. No.	**Name of the Species**	**Families**	**IVI**
1	*Melothria heterophylla* Cogn.	Cucurbitaceae	38.70
2	*Vigna catjang* Endl.	Papilionaceae	22.41

3	*Chonemorpha macrophylla* G. Don.	Apocynaceae	15.64
4	*Barleria cristata* L.	Acanthaceae	16.44
5	*Cryptolepis buchanani* Roem.	Asclepiadaceae	20.97
6	*Rivea hypocrateriformis* Chois.	Covolvulaceae	4.87
7	*Celastrus paniculata* Wolld.	Acanthaceae	51.14
8	*Bauhinia vahlii* W. & A.	Caesalpiniaceae	16.95
9	*Asparagus racemosus* Willd.	Liliaceae	51.96
	TOTAL		**239.08**

5.9 Basal Area(m^2ha^{-1})

The Basal area of tree species spreading over the upper zone, middle zone and lower zone of Dalma Wildlife Sanctuary is shown(Table 5.11, 5.12 and 5.13).Maximum basal area contributed by *Terminalia belerica*(1.323m^2ha^{-1}) followed by *Albizzia stipulate*(1.145). The basal area contributed by *Cedrela toona* was found minimum(0.040 m^2ha^{-1}).

In case of middle zone out of 30 tree species, maximum basal area contribution was observed for *Terminalia belerica*(1.44 m^2ha^{-1}) followed by *Adina cordifolia*(1.00 m^2ha^{-1}) similar to upper zone contribution to basal area by *Cedrela toona* remained minimum(0.063 m^2ha^{-1}) in middle zone(Table 5.12).

In case of lower zone of Dalma Wildlife Sanctuary, out of 25 tree species basal area contribution of *Terminalia belerica* was found maximum(1.44 m^2ha^{-1}), followed by *Bauhinia racemosa(* 0.93 m^2ha^{-1}).

Twenty common tree species observed in upper, middle and lower zone are given in (Table 5.14)indicated highest value for *Terminalia belerica* as 1.32, 1.44 and 1.44 m^2ha^{-1} for upper, middle and lower zone respectively.

A comperative view of total Basal Area of all the species existing in all the three zone of Dalma Wildlife Sanctuary and also for common species occurring on all the three sites is shown (figure 5.11) .It indicated wide difference in total basal area of upper zone with respect to other zone (middle and upper). Whereas, for common tree species there is not much difference in total basal at the three studied zone.

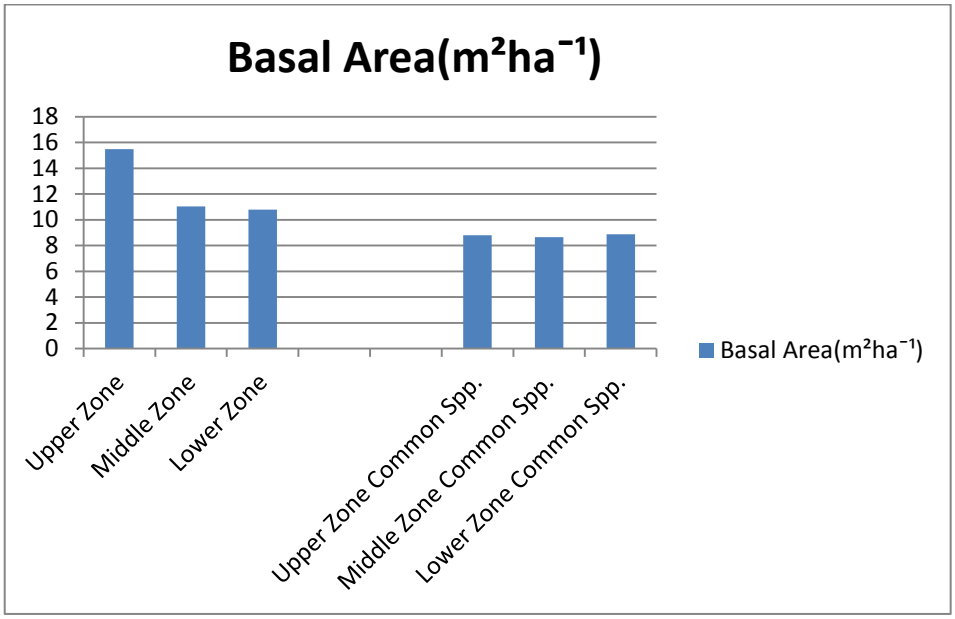

Figure 5.11 Basal Area of Dalma Wildlife Sanctuary for total species Upper, Middle and Lower Zones and for common tree species presence in all the three identified zones.

Table. 5.11 Canopy Height andBasal Area of tree species in upper zone found at Dalma Wildlife Sanctuary

Canopy Height(m) & Basal Area(m^2ha^{-1}) of different trees species in Upper Zone

Sl. No.	Name of the tree species	Canopy height(m)	Basal Area(m^2ha^{-1})
1	*Terminalia tomentosa* W. & A.	21.00	0.25
2	*Shorea robusta*	23.00	0.64
3	*Lagerstroemia parviflora*	21.00	0.25
4	*Aegle elephantum*	10.00	0.16
5	*Bauhinia retusu*	9.00	0.09
6	*Calicarpa arborea*	7.00	0.09
7	*Diospyros embryopteris*	6.00	0.12
8	*Adina cordifolia*	15.00	1.00
9	*Aegle marmelos*	5.00	0.25
10	*Morinda citrifolia*	5.00	0.09
11	*Cassia fistula*	7.00	0.56
12	*Albizzia stipulate*	9.00	0.39
13	*Kydia calycina*	10.00	0.30
14	*Cassia siamia*	8.00	0.64

15	*Schrebera swieteniodes*	7.00	0.39
16	*Alstonia scholaris*	10.00	0.86
17	*Bauhinia racemosa*	6.00	0.09
18	*Albizzia stipulae*	11.00	1.15
19	*Anogeisus latifolia*	7.00	0.16
20	*Bridelia aretusa*	5.00	0.04
21	*Buchnania latifolia*	3.00	0.12
22	*Casearia graviolens*	5.00	0.20
23	*Caseria tomentosa*	4.00	0.06
24	*Cedrella toona*	5.00	0.04
25	*Cochlospermum gossipium*	8.00	0.20
26	*Cleistanthus collinus*	6.00	0.16
27	*Cleistanthus patulas*	6.00	0.12
28	*Dillenia pentagyna*	10.00	0.36
29	*Eugenia jambolana*	4.00	0.25
30	*Feronia elephant*	4.00	0.56
31	*Ficus hispida*	6.00	0.09
32	*Grewia tiliaefolia*	12.00	0.56
33	*Odina wodier*	15.00	0.42
34	*Oroxylom indicum*	7.00	0.16
35	*Pterocarpus marsupium*	20.00	0.81
36	*Semicarpus anacardium*	5.00	0.09
37	*Soymida febrifuga*	15.00	0.39
38	*Pterospermum pteragonum*	13.00	0.64
39	*Terminalia belerica*	18.00	1.32
40	*Terminalia chebula*	10.00	0.81
41	*Zizyphus jujube*	11.00	0.56
	Total		**15.48**

Table. 5.12Canopy Height(m) & Basal Area (m^2ha-1) of different trees species in Middle Zone

Sl. No.	**Name of the tree species**	**Canopy Height(m)**	**Basal Area(m^2ha^{-1})**
1	*Terminalia tomentosa* W. & A.	21.50	0.25
2	*Shorea robusta*	24.00	0.64
3	*Bauhinia retusu*	12.00	0.16
4	*Calicarpa arborea*	9.00	0.09
5	*Adina cordifolia*	15.00	1.00
6	*Aegle marmelos*	7.00	0.25

7	*Morinda citrifolia*	6.00	0.09
8	*Cassia fistula*	8.00	0.56
9	*Kydia calycina*	9.00	0.39
10	*Cassia siamia*	10.00	0.64
11	*Alstonia scholaris*	11.00	0.81
12	*Bauhinia racemosa*	6.50	0.09
13	*Albizzia stipulae*	13.00	0.16
14	*Anogeisus latifolia*	8.00	0.09
15	*Buchnania latifolia*	5.00	0.20
16	*Casearia graviolens*	7.00	0.16
17	*Caseria tomentosa*	6.00	0.09
18	*Cedrella toona*	5.50	0.06
19	*Cleistanthus collinus*	8.00	0.16
20	*Cleistanthus patulas*	6.15	0.12
21	*Dillenia pentagyna*	11.00	0.39
22	*Eugenia jambolana*	7.00	0.25
23	*Feronia elephant*	5.00	0.16
24	*Grewia tiliaefolia*	12.00	0.56
25	*Odina wodier*	11.00	0.42
26	*Pterocarpus marsupium*	17.00	0.81
27	*Semicarpus anacardium*	7.00	0.16
28	*Terminalia belerica*	20.00	1.44
29	*Zizyphus jujube*	8.00	0.16
	Total		11.02

Table 5.13Canopy Height(m) & Basal Area(m^2ha^{-1}) of different trees species in Lower Zone

Sl. No.	**Name of the tree species**	**Canopy height(m)**	**Basal Area(m^2ha^{-1})**
1	*Terminalia tomentosa* W. & A.	24.00	0.16
2	*Shorea robusta*	25.00	0.36
3	*Lagerstroemia parviflora*	20.00	0.25
4	*Calicarpa arborea*	11.00	0.12
5	*Adina cordifolia*	17.00	0.90
6	*Aegle marmelos*	8.00	0.25
7	*Cassia fistula*	11.00	0.36
8	*Albizzia stipulate*	8.00	0.36
9	*Cassia siamia*	9.00	0.49
10	*Alstonia scholaris*	13.00	0.25

11	*Bauhinia racemosa*	17.00	0.93
12	*Buchnania latifolia*	8.00	0.20
13	*Caseria tomentosa*	8.00	0.09
14	*Cedrella toona*	8.00	0.63
15	*Cleistanthus collinus*	8.60	0.16
16	*Eugenia jambolana*	13.00	0.49
17	*Ficus hispida*	9.00	0.16
18	*Grewia tiliaefolia*	14.50	0.49
19	*Odina wodier*	15.00	0.42
20	*Pterocarpus marsupium*	20.00	0.81
21	*Semicarpus anacardium*	9.00	0.16
22	*Pterospermum pteragonum*	16.00	0.49
23	*Terminalia belerica*	19.00	1.44
24	*Terminalia chebula*	12.00	0.64
25	*Zizyphus jujube*	13.00	0.16
	Total		**10.78**

Table. 5.14Basal Area(m^2ha^{-1}) of different trees species Commonly presence in all three zones

Sl. No.	**Name of the Species**	**Basal Area(m^2ha^{-1})**		
		Upper altitude	**Middle altitude**	**Lower altitude**
1	*Terminalia tomentosa* W. & A.	0.25	0.25	0.16
2	*Shorea robusta*	0.64	0.60	0.36
3	*Calicarpa arborea*	0.09	0.09	0.12
4	*Adina cordifolia*	1.00	1.00	0.90
5	*Aegle marmelos*	0.25	0.25	0.25
6	*Cassia fistula*	0.56	0.53	0.36
7	*Cassia siamia*	0.64	0.64	0.49
8	*Alstonia scholaris*	0.86	0.80	0.25
9	*Bauhinia racemosa*	0.09	0.09	0.93
10	*Buchnania latifolia*	0.12	0.20	0.20
11	*Caseria tomentosa*	0.06	0.09	0.09
12	*Cedrella toona*	0.04	0.06	0.63
13	*Cleistanthus collinus*	0.16	0.16	0.16
14	*Eugenia jambolana*	0.25	0.25	0.49
15	*Grewia tiliaefolia*	0.56	0.56	0.49
16	*Odina wodier*	0.42	0.42	0.42
17	*Pterocarpus marsupium*	0.81	0.81	0.81

18	*Semicarpus anacardium*	0.09	0.10	0.16
19	*Terminalia belerica*	1.32	1.44	1.44
20	*Zizyphus jujube*	0.56	0.16	0.16
	Total	**8.80**	**8.66**	**8.88**

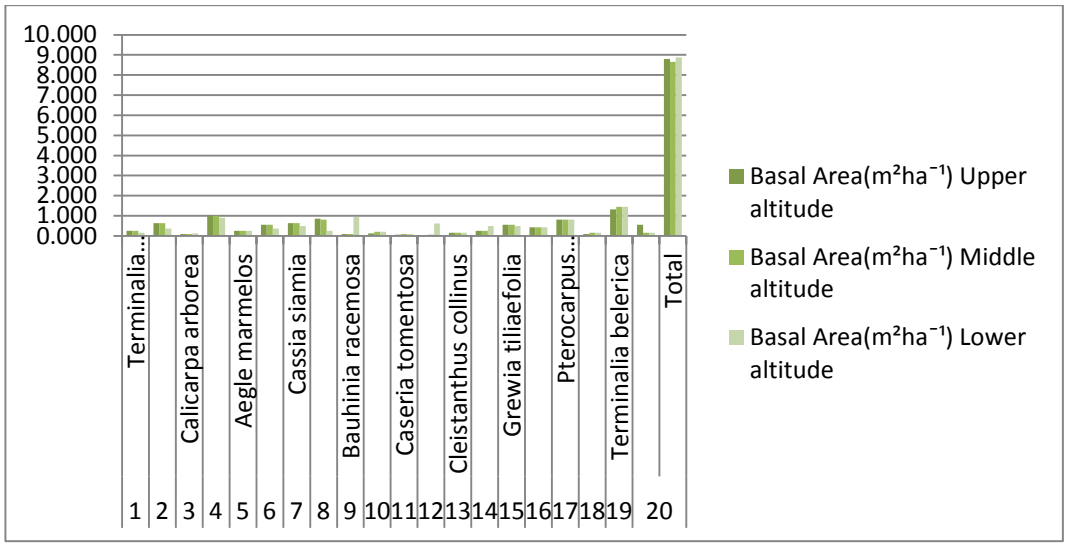

Fig. 5.12Graphical presentation of Basal area of common tree species found in all three study zones

5.10 Canopy Height Class

The tree species observed in upper, middle and lower zone of Dalma Wildlife Sanctuary has been also classified in different canopy height classes as 1 to 10m, 11 to 20 m and 21 to 30m, respectively for lower canopy height, middle canopy height and top canopy height. The data representing canopy height for upper zone, middle and lower zone are shown in table 5.15(a), 5.15(b) and 5.15(c).

Perusal of the data of table 5.15(a) indicated presence of 23 tree species in lower, 15 species in middle and 3 species in upper zone which occupied top canopy.

In case of middle zone (table 5.15(b) the canopy is represented by 18, middle by 9 and top canopy is by two species namely *Terminalia tomentosa* and *Shorea robusta.*

At lower zone lower canopy height is represented by 13 tree species, middle zone by 11 and top canopy height by 1 species.

It further observed that Terminalia tomentosa is a common species that occupies top canopy height at all the three zones (Upper, middle and lower).

Table 5.15(a)Tree Canopy height class in Upper zone

Canopy Height Class(m)	**Number of tree species**	**Name of the tree species**
1m – 10m (Lower canopy height)	23	*Calicarpa arborea, Diospyros embryopteris, Aegle marmelos, Morinda citrifolia, Cassia fistula, Albizzia stipulate, Cassia siamia, Schrebera swieteniodes, Bauhinia racemosa, Anogeisus latifolia, Bridelia aretusa, Buchnania latifolia, Casearia graviolens, Caseria tomentosa, Cedrella toona, Cochlospermum gossipium, Cleistanthus collinus, Cleistanthus patulas, Eugenia jambolana, Ficus hispida, Oroxylom indicum, Semicarpus anacardium, Zizyphus jujube*
11m -20m(Middle canopy height)	15	*Aegle elephantum, Bauhinia retusu, Adina cordifolia, Kydia calycina, Alstonia scholaris, Albizzia stipulae, Dillenia pentagyna, Feronia elephant, Grewia tiliaefolia, Odina wodier, Pterocarpus marsupium, Soymida febrifuga, Pterospermum pteragonum, Terminalia belerica, Terminalia chebula*
21m – 30m (Top canopy height)	3	*Terminalia tomentosa* W. & A., *Shorea robusta, Lagerstroemia parviflora*
TOTAL	**41**	

In middle and upper zone, *Shorea robusta* has also occupied as top canopy height, while one more species i.e. Lager *Stroema parviflora* has been also occupying top canopy height at upper zone .

The canopy height has also been represented with bar diagram (Fig. 5.13),which indicatedpresence of maximum number of tree species at upper canopy height.

Table 5.15(b)Tree Canopy height class in Middle Zone

Canopy Height Class(m)	Number of tree species	Name of the species
1m – 10m (Lower canopy height)	18	*Calicarpa arborea, , Aegle marmelos, Morinda citrifolia, Cassia fistula, Kydia calycina, Alstonia scholaris, Bauhinia racemosa, Anogeisus latifolia, Buchnania latifolia, Casearia graviolens, Caseria tomentosa, Cedrella toona, Cleistanthus collinus, Cleistanthus patulas, Eugenia jambolana, Feronia elephant, Semicarpus anacardium, Zizyphus jujube*
11m -20m (Middle canopy height)	9	*Bauhinia retusu, Adina cordifolia, Cassia siamia, Albizzia stipulae, Dillenia pentagyna, Grewia tiliaefolia, Odina wodier, Pterocarpus marsupium, Terminalia belerica*
21m – 30m (Top canopy height)	2	*Terminalia tomentosa, Shorea robusta*

Table 5.15(c)Tree Canopy height class in Lower zone

Canopy Height Class(m)	Number of tree species	Name of the species
1m – 10m (Lower canopy height)	13	*Calicarpa arborea, Aegle marmelos, Albizzia stipulate, Albizzia stipulate, Alstonia scholaris, Bauhinia racemosa, Buchnania latifolia, Caseria tomentosa, Cedrella toona, Cleistanthus collinus, Ficus hispida, Semicarpus anacardium, Zizyphus jujube*
11m -20m(Middle canopy height)	11	*Terminalia tomentosa, Shorea robusta, Adina cordifolia, Cassia fistula, Eugenia jambolana, Grewia tiliaefolia, Odina wodier, Pterospermum pteragonum, Terminalia belerica, Terminalia chebula*
21m – 30m(Top canopy height)	1	*Terminalia tomentosa*

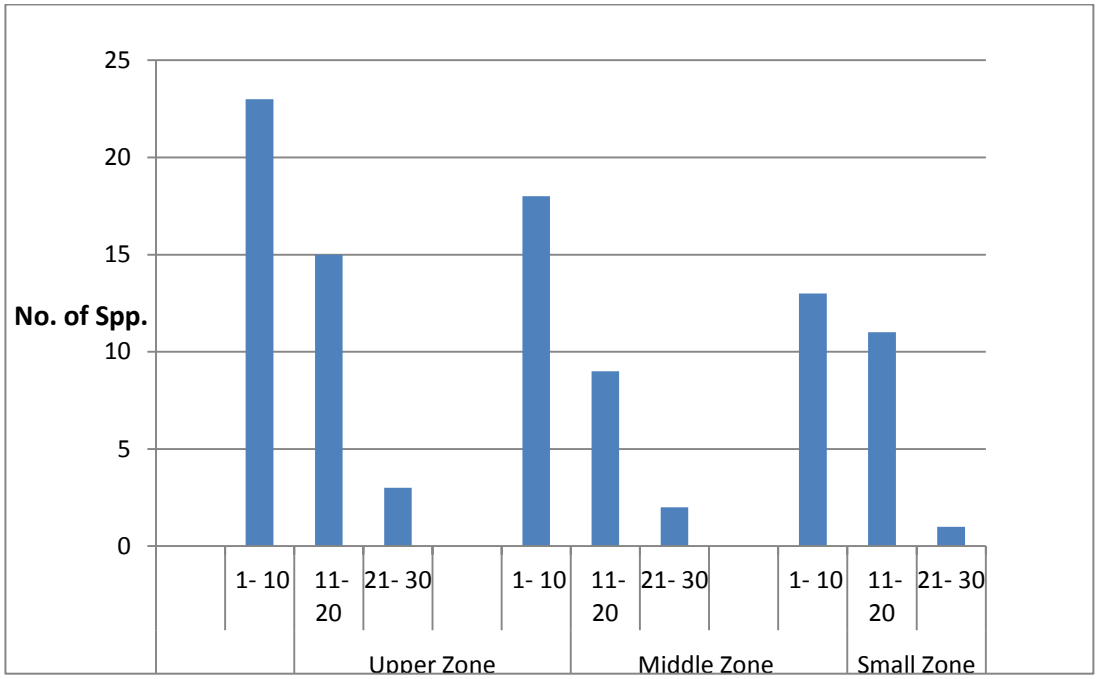

Figure 5.13 Numerical strength of plant species of vertical stratified classes based on canopy height found in upper, middle and lower zones of Dalama Wildlife Sanctuary

5.11 Distribution of tree species as per Girth class

Contribution of tree stands according to Girth class distribution in Dalma Wildlife Sanctuary for analysis of individual GBH(Girth at breast height) class, all tree species found in all three zones were taken into consideration. The recorded girths of all individual trees were classed at a range of 20cm into ten classes.

A comparison was made for the relative distribution of the total number of individuals in respect of Girth class. The highest number of tree species was occurred in girth class of 61-80cm in all three zones, which are quantified as 8 in upper zones, 9 in middle zone and 6 in lower zone followed by Girth class of 41-60cm with 9 species in upper zone, 5 in middle zone and 3 in lower zone as shown (table 5.16), where as the tree species having highest Girth (> 200cm) are*Terminalia belerica(2.30)*and*Albizzia stipulae(2.10)*in upper zone and Terminalia belerica(2.30) with same value of GBH was found in both middle and lower zone respectively. It has been also shown in fig. 5.14.

Table 5.16 Girth class (cm) of tree species for Upper, Middle and Lower zones

Tree Diameter Class (cm)	No. of tree species		
	Upper Zone	Middle Zone	Lower Zone
20 – 40	0	0	0
41 – 60	9	5	3
61– 80	8	9	6
81 – 100	7	4	5
101 – 120	5	2	0
121 – 140	1	1	5
141– 160	6	4	2
161 – 180	2	2	1
181 – 200	1	1	2
201 - above	2	1	1
Total	**41**	**29**	**25**

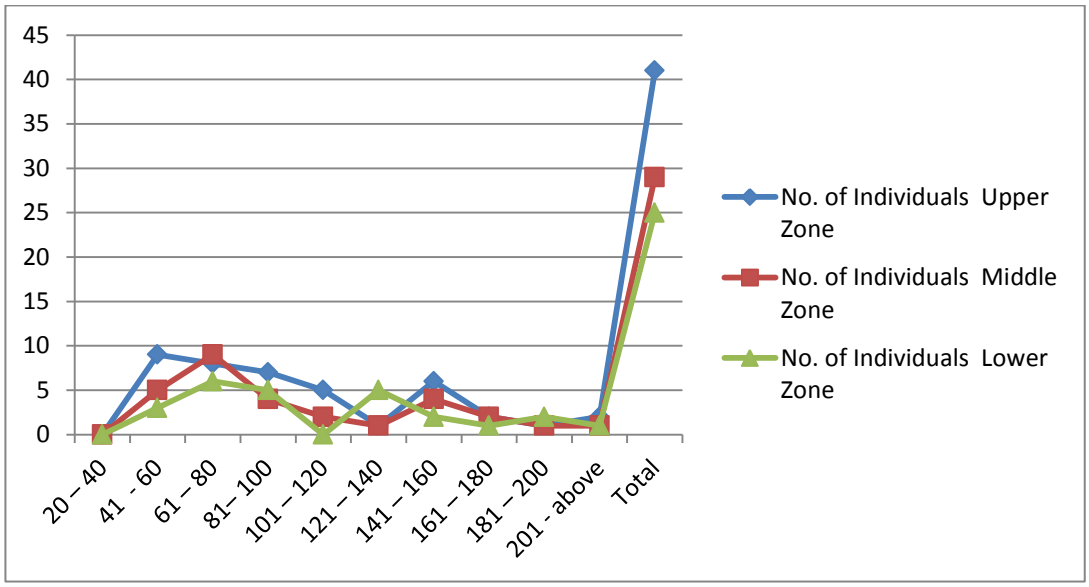

Fig. 5.14Girth class of total tree species found in all three zones

5.12 Rarity of tree Species

Rarity of tree species are also calculated according to Kadavul and Parthosarthy (1999). Species having less than 2 individuals were considered as very rare whereas species having having 2-10 individuals were considered as rare. Species

having 10-20 individuals were considered as common whereas species having more than 20 species were considered as dominant, these are listed in Table 5.17, which were found in upper, middle and lower zone of Dalma Wildlife Sanctuary. In upper zone dominant group is represented by a maximum of 24 species consisting of important timber species like *Shorea robusta, Terminalia tomentosa, Anogeisus latefolia* etc. In middle zone Dominant group is represented by 18 tree species and similar to upper zone *Terminalia tomentosa, Shorea robusta* etc. and it has been noticed as important timber spp. However in case of lower zone, maximum number of tree species are found is Common group comprising *Cedrella toona, Pterocarpus marsupium* etc. The comperative overview of spp. Rarity with respect to different group are shown with bar diagram also (Fig.5.15).

Table 5.17 : Rarity of Tree species observed at Dalma Wildlife Sanctuary.

Species category based on number of individuals		**STUDY ZONE**				
		UPPER ZONE		**MIDDLE ZONE**		**LOWER ZONE**
	Total	**Species**	**Total**	**Species**	**Total**	
Very Rare	0	—	0	—	0	—
Rare	8	*Aegle elephantum,Calicarpa arborea Adina cordifolia,Aegle marmelos Oroxylom indicum,Pterospermum pteragonum,Terminalia belerica Terminalia chebula*	4	*Calicarpa arborea, Cassia siamia, Dillenia pentagyna, Terminalia belerica*	7	*Calicarpa arborea,Aegle marmelos,Cassia fistula Ficus hispida,Pterospermum pteragonum,Terminalia belerica,Terminalia chebula*
Common	9	*Diospyros embryopteris,Cassia fistula,Cassia siamia,Eugenia jambolana,Feronia elephant Ficus hispida, Pterocarpus marsupium,Semicarpus nacardium, Soymida febrifuga,*	7	*Aegle marmelos,Morinda citrifolia,Kydia calycina, Anogeisus latifolia,Cassia siamia,Odina wodier, Semicarpus anacardium*	10	*Adina cordifolia,Albizzia stipulate,Cassia siamia, Alstonia scholaris,Cedrella toona,Cleistanthus collinus, Eugenia jambolana,Odin*

						a wodier,Pterocarpus arsupium, Semicarpus anacardium
Dominant	24	*Terminalia tomentosa, Shorea robusta,Lagerstroemia parviflora,Bauhinia retusu,Morinda citrifolia,Albizzia stipulate,Kydia calycina,Schreber a swieteniodes Alstonia scholaris,Bauhinia racemosa,Albizzia stipulae, Anogeisus latifolia, Bridelia aretusa, Buchnania latifolia, Casearia graviolens, Caseria tomentosa, Cedrella toona, Cochlospermum gossipium, Cleistanthus collinus, Cleistanthus patulas, Dillenia pentagyna, Grewia tiliaefolia, Odina wodier, Oroxylom indicum, Zizyphus jujube*	18	*Terminalia tomentosa, Shorea robusta, Bauhinia retusu, Adina cordifolia, Cassia fistula, Alstonia scholaris, Bauhinia racemosa, Albizzia stipulae, Buchnania latifolia, Casearia graviolens, Caseria tomentosa, Cleistanthus collinus, Cleistanthus patulas, Eugenia ,jambolana, Feronia elephant, Grewia tiliaefolia, Pterocarpus marsupium, Zizyphus jujube*	8	*Terminalia tomentosa, Shorea robusta, Lagerstroemia parviflora, Bauhinia racemosa, Buchnania latifolia, Caseria tomentosa, Grewia tiliaefolia, Zizyphus jujube*
TOTAL	**41**		**29**		**25**	

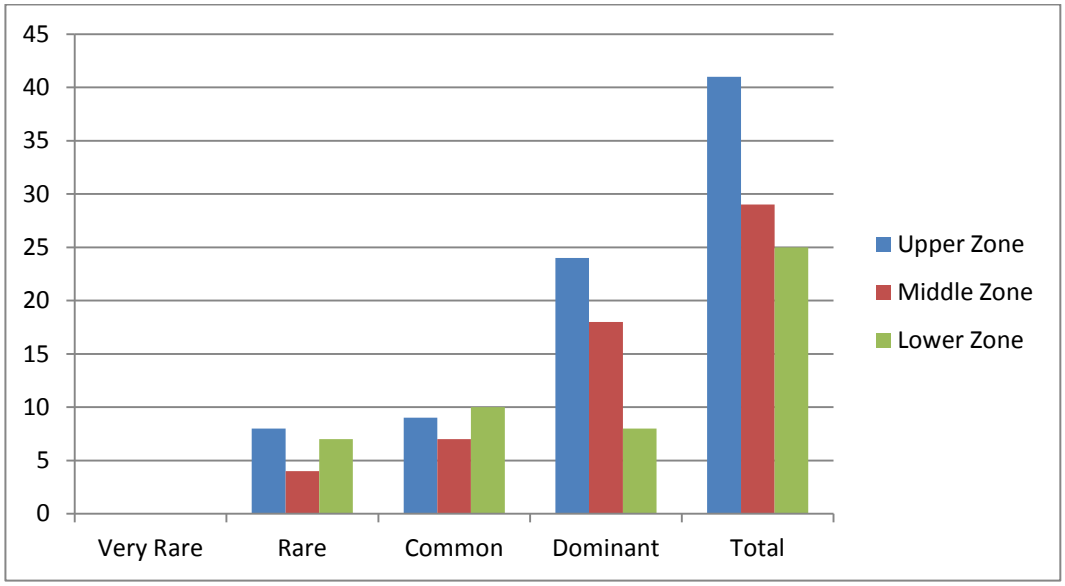

Figure 5.15.Rarity of Tree species in Dalma Wildlife Sanctuary.

5.13 Similarity value (Si) between Upper, Middle and Lower Zone of DWLS

Similarities value between Upper and Middle Zone

a = 29

b = 12 Si = a / a+b+c = 29/41 = 0.707

c = 0

Similarities value between Upper and Lower Zone

a = 25

b = 16 Si = a / a+b+c = 25/41 = 0.609

c = 0

Similarities value between Middle and Lower Zone

a =20

b = 9 Si = a / a+b+c = 20/33 = 0.606

c = 4

Table 5.18Similarity Value of tree species in all three study zones

Comparisons between Study zones	Number of species in study zones			Similarity value
	Upper zone	Middle zone	Lower zone	
UZ and MZ	41	29	0	0.707
UZ and LZ	41	0	25	0.609
MZ and LZ	29	0	25	0.606

UZ: Upper zone, MZ: Middle zone and LZ: Lower zone , Si: Similarity value.

The Similarity value(Si) also indicates that the highest value (Table 5.18)shown by the combination of upper zone and middle zone forest(0.707) followed by upper zone and lower zone(0.609). The combination of upper zoneand middle zone, upper and lower zone, middle and lower zone forest exhibits slightly lower degree of similarity with the value of 0.707, 0.609 and 0.606 respectively. In conclusion, the degree of similarity for the entire three zone forest is low. Potts et.al (2002) also indicated that the range of floristic similarity value within the ecosystem of northwest Borneo in Lambir Hills Sarawak varies from 0 to 0.5. A similar conclusion was drowned by Lopes et.al. (2012) in their study on Forest in Southeast Brazil.

The floristic similarity analysis between the three zones of Dalma Wildlife Sanctuary of Jharkhand show the similarity value range from 0.606 – 0.707 which is floristically low in similarity indicating heterogeneity in the species composition. This is attributed to Anthropogenic activities like over-exploitation of plant resources for economic uses, heavy grazing pressure of local livestock, utilization of land for construction and agricultural purposes, and population density are continuously changing the species composition and vegetation structure in the Dalma Wildlife Sanctuary.

5.14 Species Richness

The species richness for all the three zones of Dalma Wildlife Sanctuary is shown in Table 5.18. The total richness of tree species in the study area was recorded as 2471, and upper zone was found maximum number as 1163 trees followed by

middle & lower zone. Richness value of upper, middle and lower zones were calculated as 1.20, 1.05 and 1.91 respectively. The total richness value for entire study area is found 1.91.

Table 5.19. Species richness for Dalma Wildlife Sanctuary

Particulars	Upper zone	Middle Zone	Lower zone
Total number of tree species	1163	756	552
Richness value	1.20	1.05	1.06
Total number of tree species in all zones	2471(squire root = `49.70)		
Over all richness of study area	1.91		

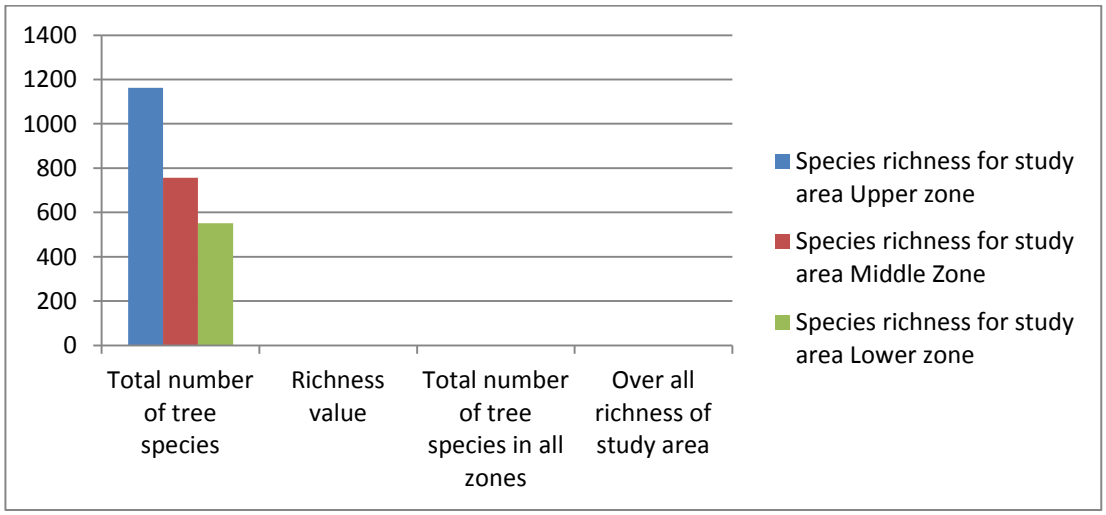

Fig. 5.16Species richness for study area

5.15 Species richness and diversity pattern

In the present study, the species richness and Shannon Weinner diversity index varied from 25 to 41 and 3.07 to 3.997 respectively along study zones of Dalma Wildlife Sanctuary(Table 5.20) Lowest number of species (SR=25) was found from lower zone due to maximum disturvance of anthrapogenic cause while least disturbed zone possessed highest number of species (SR=41). Middle zone occupied an intermediate position with respect to species richness (SR=29). The highest value of Shannon Wiener index (3.997) was found for middle zones followed by upper zone(3.33) and lower zone(3.073). In the lower zone maximum and minimum

species diversity was recorded for *Shorea robusta*(H= 0.518) and *Odina wodier(H=0.015)* respectively. In the middle zone maximum and minimum species diversity was recorded for Shorea robusta H = 0.798) and *Cleistanthus collinus(D =0.010)* respectively while the maximum and minimum value for upper zone was recorded for *Shorea robusta(D =0.257)* and *Pterospermum pteragonum* (D = 0.006) respectively.

Table 5.20Species richness and diversity pattern along study zones

Study zone	Species Richness(SR)	Shannon Diversity Index(H)
Upper Zone(454m – 603 m)	41	3.333
Middle Zone(250m – 452m)	29	3.997
Lower Zone(199m – 250m)	25	3.073

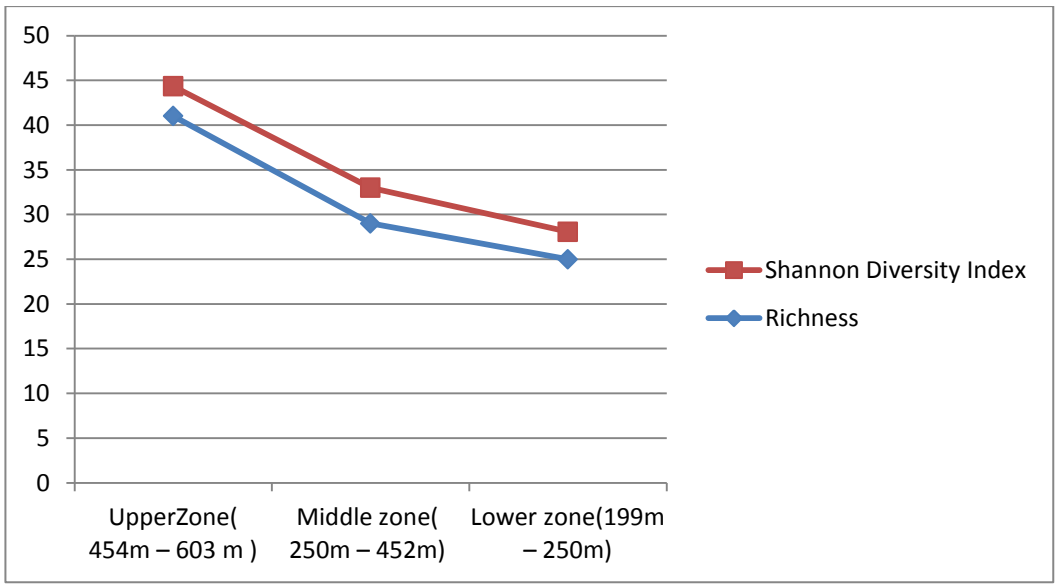

Fig. 5.17 Species richness and diversity pattern of tree species in upper, middle and lower zones

5.16 Beta Diversity (β)

The Beta diversity of different plant type (Tree, Shrub, herb, and Climber) is shown in table 5.20. Perusal of the data indicated in upper zone value of β – diversity is found maximum for Shrubby species(2.70), while in middle zone similar

situation observed i.e. for shrub beta diversity is found maximum. On the other hand, for lower maximum beta diversity was calculated for tree species(3.80). The comperative of β- diversity value of tree, shrub, herb and climber species found at Dalma Wildlife Sanctuary for upper, middle and lower zone is also shown with graph (Figure 5.18). In upper zone the value of beta diversity was observed low for tree, shrub, herb and climber.

Table 5.21Whittaker(β diversity)

Species	Upper zone	Middle zone	Lower zone
Tree	2.32	3.28	3.80
Shrub	2.70	3.60	2.84
Herb	2.48	3.25	3.47
Climber	2.54	3.00	3.67

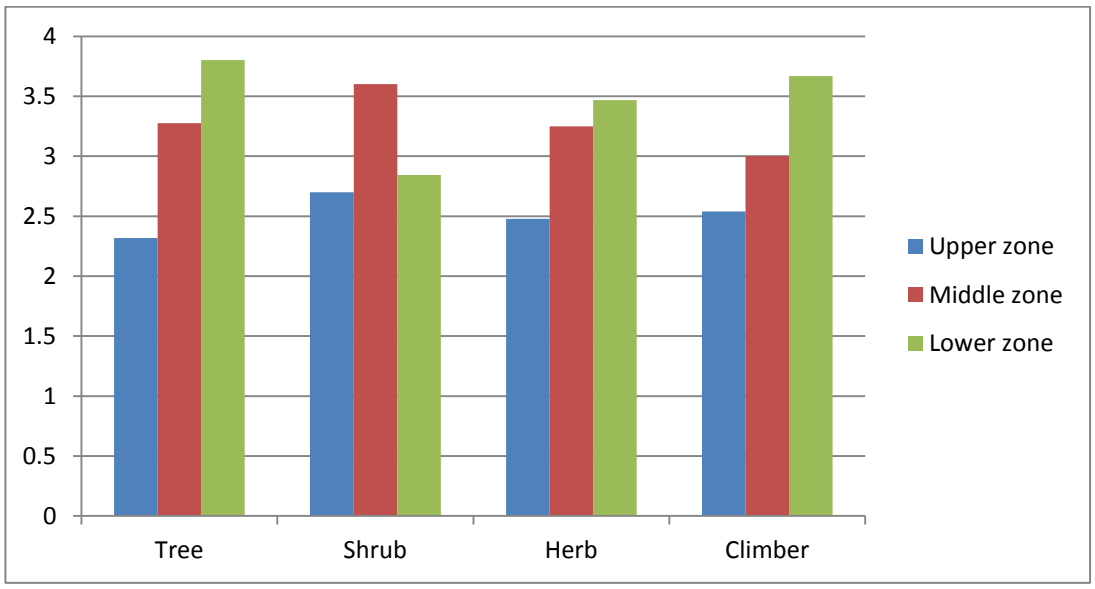

Fig. 5.18Whittaker (β diversity) of existing vegetation in all three zones

5.18 Plant Composition Summary

The summery of plant composition of study area of Dalma Wildlife Sanctuary is shown in table- 5.22. It included No. of trees, shrubs, herbs and climbers

for upper, middle and lower zones. The plant distribution is found to belong 47 families in upper zone, 40 families in middle zoneand 25 families in lower zone.

The total number of genera identified at upper, middle and lower zone were 71, 59 and 63 respectively, while total number of species found distributed in upper, middle and lower zones were 95, 72 and 74 respectively.

The density of tree species as calculated for upper, middle and lower zones were found as 62.51, 33.60 and 30.64 respectively. This indicates higher density of tree species at upper zone.

The species richness Index was also calculated for Dalma Wildlife Sanctuary at three three related sites ie upper zone, middle zone and lower zones. Its value was for upper(8.77) and less for lower zone(8.34).

The comparative summery of plant composition for upper, middle and lower zones is also depicted in figure 5.19 with bar diagram for Dalma Wildlife Sanctuary.

Table 5.22Summary of plant composition in study area of Dalma WildlifeSanctuary

Sl. No	Particulars	Upper altitude	Middle Altitude	Lower Altitude
1	Trees	41	30	25
2	Shrubs	20	15	19
3	Herbs	21	16	21
4	Climber	13	11	9
5	Family	47	40	25
6	Genera	71	59	63
7	Species	95	72	74
8	Tree density	62.51	33.6	30.64

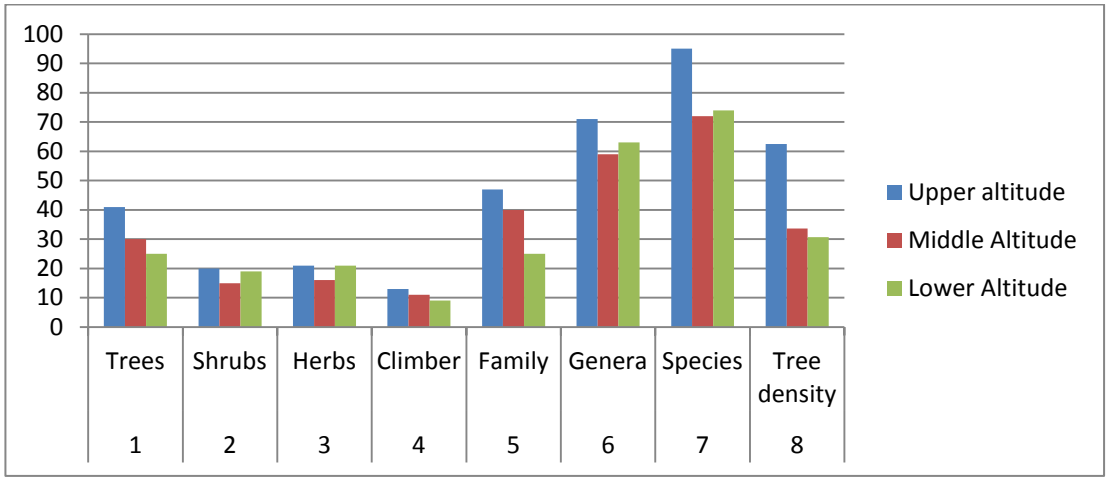

Fig. 5.19 Summary of plant composition in study area of Dalma Wildlife Sanctuary

5.19 Medicinal Plants

The medicinal uses of plants species have been recorded during ground truth survey and field studies.These people have traditional knowledge about use of this medicinal plant. It has been observed in the present study that out of 98 plant, 23 species have been identified as medicinal plants. The local people use the indigenous flora for various medicinal purposes in their daily life as local people have faith and belief in these medicines. A list of 23 species are mentioned in table 5.23.Medicinal plant such as *Aegle marmelos, Andragraphis paniculata, Asparagus recemosus, Vitis repanda, Beautia monosperma, Lagerstroemia parviflora, Pterocarpus marsupium, Terminalia chebula* and *Terminalia belerica* etc are harvested in bulk for preparation of medicines by local people.

Table 5.23. List of floral species locally used as medicinal

Sl. No.	Name of the species	Parts Uses	Tree/Shrub/Herb/ Climber	Existence in zone		
				Upper Zone	Middle Zone	Lower Zone
1.	*Calicarpa arborea*	Bark in small pox	Shrub	√	√	√
2.	*Hemidesmus indicus*	Roots in fever	Shrub	×	√	
3.	*Asparigus racemosus*	Provide energy	Climber	×	√	√

4.	*Vitis repanda*	Fracture of bone	Climber	√	×	×
5.	*Andrographis paniculata*	Diarrhaea	Herb	√	×	×
6.	*Beautia monosperma*	Diarrhea	Tree	×	×	√
7.	*Shorea robusta*	Leaves and Fruit	Tree	√	√	√
8.	*Lagerstroemia parviflora*	Leaves and fruits for lower blood pressure	Tree	√	×	√
9.	*Aegle marmelos*	Leaves and roots for hypoglycaemic action in human and rats	Tree	√	√	√
10.	*Casia fistula*	Root, bark and leaves in fever	Tree	√	√	√
11.	*Kydia calycina*	Leaves	Tree	√	√	×
12.	*Alstonia scholaris*	Bark juice in headache, fever	Tree	√	√	√
13	*Ficus hispida*	Whole plant	tree	√	×	√
14.	*Grewia tiliafolia*	Stem bark	Tree	√	√	√
15.	*Pterocarpus marsupium*	Bark for lower blood sugar/ diabetic	Tree	√	√	√
16.	*Terminalia belerica*	Saponin from fruits(spermicital)	Tree	√	√	√
17.	*Terminalia chebula*	Fruit for gargle in inflammation of mucus membrane of mouth	tree	√	×	√
18.	*Helicteris isora*	Root, stem, bark & flower	Shrub	√	√	×
19.	*Curcuma amada*	Roots powder in cosmetics	Herb	√	√	√
20.	*Echinochloa crusgali*	Flower for intestinal worm	Herb	√	√	√
21.	*Cynodon dactylon*	Whole plant	Herb	√	√	√
22.	*Dioscorea belophylla*	Bulb/tuber	Climber	√	√	×
23.	*Celastrus paniculata*	Oil in tuberculosis	Climber	√	√	√

5.20Food for Herbivores Wildlife species

Dalma WLS is rich in food species of trees and herbs. The food of elephants and other wild animals has been identified during field study and survey with the help of the experience of field staff. It is special mention against list of flora of Dalma WLS (Table 5.24) bark and branches are the main components eaten by elephants.

Table 5.24Preferred food species for herbivores wild animals found in Dalma Wildlife Sanctuary as below.

Sl. No	Name of the species	Tree/Herb	Upper zone	Middle zone	Lower zone
1.	*Bauhinia racemosa*	Tree	√	×	√
2.	*Bauhinia retusu*	Tree	√	√	×
3.	*Kydia calycina,*	Tree	√	√	×
4.	*Pterocarpus marsupium*	Tree	√	√	√
5.	*Heteropogon contortus*	Herb	√	√	√
6.	*Chrysopogan aciculate*	Herb	√	√	√
7.	*Panicum maximum*	Herb	√	×	×
8.	*Chrysopogan gryllus*	Herb	√	√	×
9.	*Imperata cylindrical*	Herb	√	√	√
10.	*Cynodon dactylon*	Herb	√	√	√

There are 10 preferred species in the diet of wild herbivores animals, in which four are the principal food species of elephants. They are species of *Kydia, Bauhinia racemosa, Bauhinia retusa, Pterocarpus marsupium* etc. are belong to tree species. Herb species are very sparsely distributed in sanctuaries. The percentage of grass in the diet of elephants is very low where as its use by Barking deer and other herbivores are much more. All six species of herbs were identified in Dalma WLS. They *are Heteropogon contortus, Chrysopogon aciculatus, Panicum maximum Chrysopogon gryllus, Imperata cylindrica, Cynodon dactylon*.

5.21 Factors affecting vegetation of Dalma Wildlife Sanctuary

The factors influencing vegetation of Dalma Wildlife Sanctuary has been observed and described in following para :

5.21.1 Fire-wood Collection and illegal cutting of trees : About 1,30,00 inhabitants of villages living inside the sanctuary and outside (fringe area) of all three zones and depend on forests of sanctuary for fuel wood and small wood for self use and also for sale in the local weekly market which have destructive effect on vegetation of down hills and hillocks.

5.21.2 Encroachment of Forest Land : There are 29 villages situated inside the Dalma Wildlife Sanctuaryand 73 villages situated just outside the sanctuary boundary are directly or indirectly affecting the vegetation of the sanctuary by encroaching for agriculture, houses and for other purposes. Out of 29 villages, these four, Barudih, Dhusra, Rapcha,Andharjho are situated nearby of Upper Zone, nine villages, Kukru, Jamdih, Khokaro, Baghra, Koyani, Bamni, Gagibura, Beldih, Jamdih are nearby of Middle zone and rest sixteen Bonta, Kutimakul, Bhadudih, Saldoha, Haludbani, Patipani, Mirzadih, Geruwa, Punsa, Nutandih, Bataluku, Sari, Laylam, Pagda, Kumari, Chimti are situated around the lower zone or at the foothills of the study area of the sanctuary (fig. 5.20.)

Table 5.25 Summary of the factors affecting the vegetation of the study area

Factors	Lower zone	Middle zone	Upper zone
Altitudinal height	199m – 250m	251m – 452m	453m – 603m
Number of villages	16	9	4
Encroached forest area(in ha)	4817.15 ha	3012.49 ha	675.97 ha
Firewood extraction	Sewere	Moderate	Nil
Livestock grazing	Throught the year	Throught the year	Specially in summer because water is available in few pond/ Bandh
Forest road(A network of road covering 158km which are made of Earthen and morrum)	56km	12km	90 km a network of road passing through core area
Source:- draft management plan for 2016-2025.			

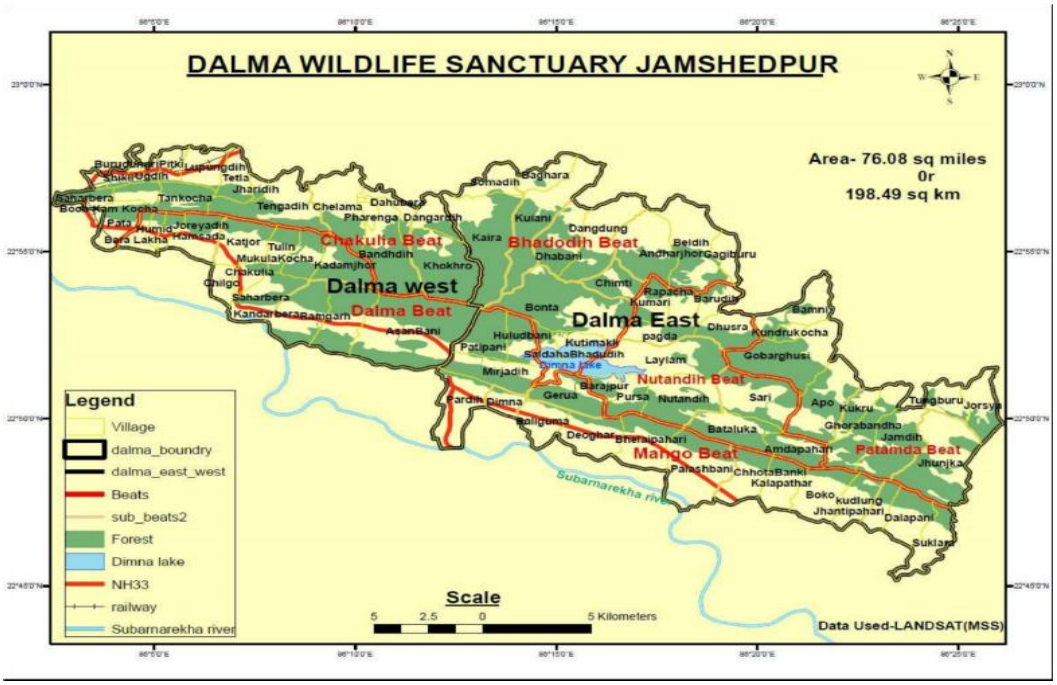

Fig. 5.20 Village location Map of Dalma Wildlife Sanctuary

Plate 5.8 Forest Village

Plate 5.9Forest land encroachment for agri. purpose

Plate 5.10 Agriculture Farming field inside DWLS

Plate 5.11 Forest Browsingby domestic animals

Plate 5.12 Extraction of Sapling of tree from Dalma forest for fuelwood

Plate 5.13 Transeporting of fuelwood to local market at Tata- Ranchi road

Plate 5.14 Spreading of Forest fire in lower zone of study area

Plate 5.15 Forest firein larger area of DWLS

5.22 Phytosociological Characteristics of tree species

Based on rarity of tree species (Table 5.6) 15 dominant tree species were selected from each zone-upper, middle and lower to know the different phytosociological characteristics like Frequency, Density and Abundance, A/F ratio and IVI (dominance) were calculated as details below –

5.22(a) Dominance(IVI) of trees of upper zone

The distribution analysis of dominant tree species in upper zone is shown in Table 5.26(a) Perusal of data indicated that out of 15 the 15 dominant tree species *Shorea robusta* have high dominance value (19.25) followed by *Albizzia stipulae* (13.73) and *Alstonia scholaris* (12.34) which are the co-dominant species. Highest frequency was observed for *Caseria tomentosa* (100) and *Shorea robusta* (94.4). Some species like *Terminalia tomentosa, Odina wodier, Alstronia scholaris, Bauhenia racemosa & Feromia elephantus* have more than 80% frequency. Similar to frequency, density & abundance of *Shorea robusta* was found more. Lower IVI

was noticed for *Terminalia chebula*. The frequency of *Terminalia belerica* was found less as compared to other species. In upper zone all the species are available with the high value of Relative Dominance of *Shorea robusta (11.06)* followed by *Zizyphus jujube* (5.00) and *Caseria tomentosa* (3.98).

The Relative Frequency of *Caseria tomentosa* (4.240) in Upper zone was found more followed by *Cassia siamia.* However, Relative Basal Area of *Terminalia belerica* was more (9.60) followed by *Adina cardifolia* (7.26) &*Alstonia scholaris*(6.28). The importance Value Index (IVI) has been also calculated to find out over all importance of of individual species with respect Community Structure. The IVI value of *Shorea robusta* was found maximum (19.25) followed by *Albizzia stipulae* (13.73) and *Alstonia scholaris* (12.34).

The A/F (Abundance vs. frequency) ratio indicated regular distribution of selected species. Dominance curve of tree species of upper zone is shown with Figure 5.21(a)**,** which indicates dominance of *Shorea robusta* in comparison to other species.

Table 5.26(a) Distribution analysis of tree species in upper Zone of Dalma Wild Life Santuary.

Sl. No.	**Tree Species**	**Freq.**	**Dens.**	**Abun.**	**A/F**	**RF**	**RD**	**RB**	**IVI**
1	*Shorea robusta*	94.40	8.00	847	8.97	3.55	11.06	4.64	19.25
2	*Albizzia stipulae*	66.00	1.90	291	4.41	2.80	2.62	8.31	13.73
3	*Alstonia scholaris*	83.30	1.83	220	2.64	3.53	2.53	6.28	12.34
4	*Zizyphus jujube*	66.60	3.66	550	8.26	2.82	5.06	4.08	11.96
5	*Bauhinia racemosa*	83.30	5.20	633	7.60	3.53	7.19	0.65	11.37
6	*Terminalia belerica*	27.77	0.27	100	3.60	1.17	0.37	9.60	11.14
7	*Pterocarpus marsupium*	72.20	1.05	146	2.02	3.06	1.45	5.88	10.39
8	*Cassia siamia*	94.40	0.94	130	1.38	4.00	1.29	4.64	9.93
9	*Terminalia tomentosa*	88.80	2.60	300	3.38	3.76	3.87	1.81	9.44
10	*Feronia elephant*	83.30	1.11	133	1.60	3.53	1.53	4.08	9.14
11	*Grewia tiliaefolia*	77.70	1.22	164	2.11	3.29	1.68	4.08	9.05
12	*Adina cordifolia*	27.70	0.27	100	3.61	1.17	0.37	7.26	8.80

13	*Odina wodier*	88.80	1.38	156	1.76	3.76	1.90	3.06	8.72
14	*Caseria tomentosa*	100.00	2.88	288	2.88	4.24	3.98	0.45	8.67
15	*Terminalia chebula*	38.80	0.53	142	3.66	1.64	0.37	9.60	8.28

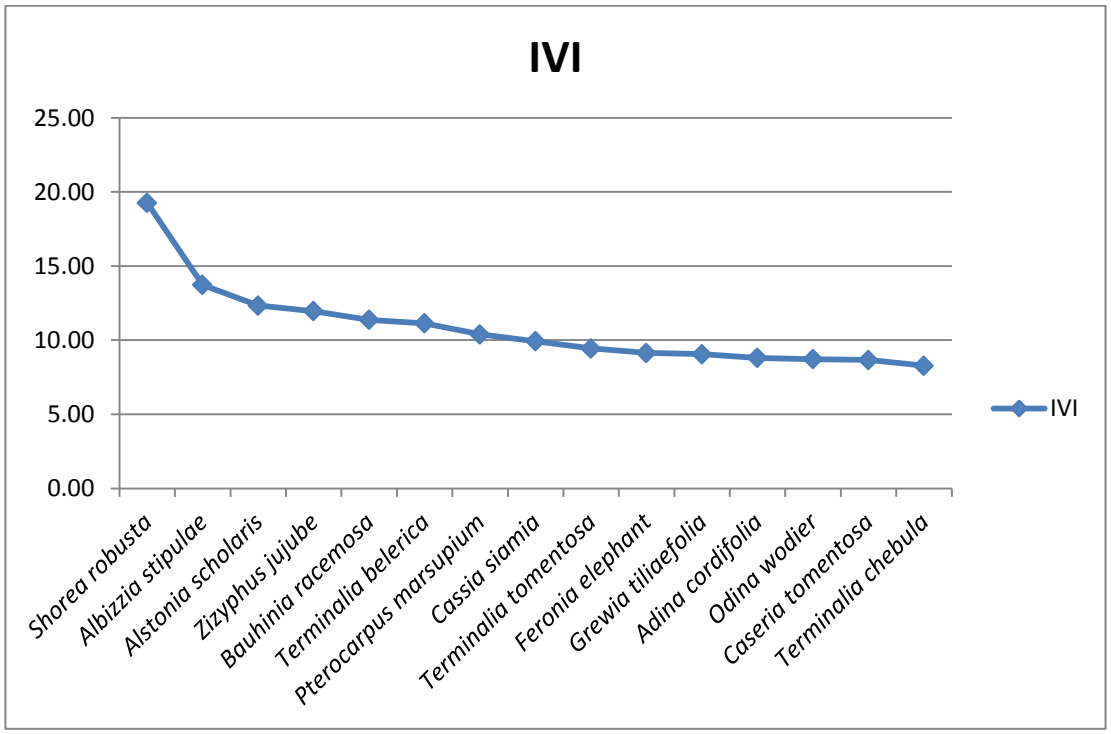

Figure 5.21(a) Dominance – Diversity Curve of tree species observed at upper zone of Dalma Wildlife Sanctuary.

5.22.(b) Dominance (IVI) of Tree Species of Middle Zone

The phytosociological characteristics of tree species observed at Middle Zone of Dalma Wildlife Sanctuary as shown in Table 26(b) Out of 15 tree species, dominance of nine species viz. *Adina cordifolia, Terminalia belerica, Grewia tiliaefolia, alstonia scholaris, caseria tomentosa, Zyziphus jujube, shorea robusta,Bauhinia racemosa and Buchnania lanjan*. The lowest IVI index was found for *Casearia graviolens*. Frequency of *Zizyphus jujube, Cleistanthus collinus, Grewia latefolia and Buchnania latifolia* was observed on higher side, while lowest frequency was noticed for *Terminalia belerica* (16.66).

In middle zone 29 species were observed maximum, Relative Density was observed in case of *Caseria tomentosa* (9.24), followed by *Bauhinia racemosa* izyphus (7.85) and *Zizyphus jujube* (6.93). The Relative Frequency of and *Cleistanthus collinus and Z izyphus jujuba* was highest (5.71) among 29 existing species at middle zone, followed by *Bauhinia latifolia*, *Grewia tiliaefolia* (5.39) and *Albizzia stipulatae* (5.07). The Relative Basal Area of *Terminalia balerica* was maximum (14.13) followed by *Alstomia scholaris* (9.81) and *Alstonia scholaris* (7.95). Perusal of the comparative value of IVI at middle zone indicated highest value (18.21) for *Adina cordifolia* followed by *Alstonia scholaris* and *Terminalia belerica* (15.52).

The A/F ratio indicated regular distribution of selected species in middle zone. Comparative Dominance of different species is shown in Figure 5.21(b)**,** which indicated dominance of *Adina cordifolia.*

Table 5.26(b)Distribution analysis of tree species in Middle Zone of Dalma Wild Life Santuary.

S. No.	Tree Species	Freq.	Dens.	Abun	A/F	RF	RD	RB	IVI
1	*Adina cordifolia*	66.60	1.16	175	2.63	3.80	4.60	9.81	18.21
2	*Terminalia belerica*	16.66	0.16	100	6.00	0.95	0.44	14.13	15.52
3	*Grewia tiliaefolia*	94.44	1.66	176	1.86	5.39	4.60	5.52	15.51
4	*Alstonia scholaris*	66.66	1.33	200	3.00	3.80	3.69	7.94	15.43
5	*Caseria tomentosa*	83.33	3.33	400	4.80	4.76	9.24	0.88	14.88
6	*Zizyphus jujube*	100.00	2.50	250	2.50	5.71	6.93	1.57	14.21
7	*Shorea robusta*	77.70	0.77	800	10.30	4.43	2.11	6.28	12.82
8	*Bauhinia racemosa*	61.11	2.83	463	7.58	3.49	7.85	0.91	12.25
9	*Buchnania latifolia*	94.44	172.00	182	1.93	5.39	4.77	1.98	12.14
10	*Cleistanthus collinus*	100.00	1.22	122	1.22	5.71	3.38	1.57	10.66
11	*Cassia siamia*	50.00	0.50	150	3.00	2.88	1.38	6.28	10.54
12	*Eugenia jambolana*	77.77	1.22	157	2.02	4.44	3.38	2.45	10.27

13	*Terminalia tomentosa*	50.00	1.77	355	7.10	2.85	4.91	2.45	10.21
14	*Albizzia stipulae*	88.88	1.27	143	1.61	5.07	3.52	1.57	10.16
15	*Casearia graviolens*	61.11	1.50	245	4.01	3.49	4.16	1.57	9.22

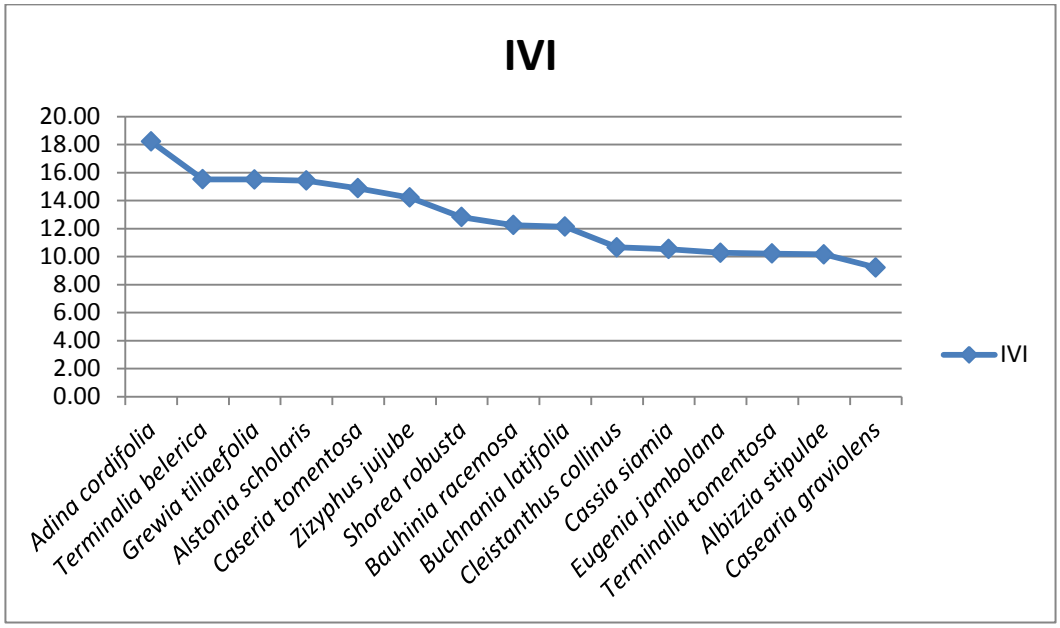

Figure 5.21(b) Dominance – Diversity Curve of tree species of Middle Zone of Dalma Wildlife Sanctuary

5.22 (c) Dominance IVI of Tree species of Lower Zone

Highest dominance value of *Shorea robusta* (27.79) was observed among 15 selected species.*Bauhinia racemosa, Terminalia belerica & Grewia tiliafolia* have shown significant dominance. Lowest dominance of *Alstonia scholaris* (10.74) was observed at lower zone.

Frequency of four species viz. *Shorea robusta, Grewia tiliafolia, Zizyphus jujube* and *Caseria tomentosa* was found highest (100). Density and abundance Value of *Shorea robusta* was also found maximum in comparison to other species. Similar to upper zone, the Relative Density of *Shorea robusta* was found maximum (17.39) at lower zone followed by *Zizyphus jujube* (9.23). Howler the Relative

frequency at lower zone was recorded maximum for *Albizzia stipulate* (6.66) followed by *Shorea robusta*. The Relative Basal Area of *Terminalia belerica* was maximum (16.1) followed by *Bauhinia racimosa* (10.4) and *Adina cordifolia* (10.09). Similar to the Relative Density the IVI of *Shorea robusta* was found maximum (27.79) followed by *Bauhinia racemosa* (20.21).

Similar to upper and middle zones regular distribution of tree species is noticed at lower zone. The Dominance curve of all the 15 species noticed at lower zone of Dalma Wildlife Sanctuary is given in Fig. 5.21(c)**,** indicating dominance of *Shorea robusta*.

Table 5.26(c) Distribution analysis of tree species in Lower Zone of Dalma Wild Life Santuary.

S. No.	Tree Species	Freq.	Dens	Abun	A/F	RF	RD	RB	IVI
1	*Shorea robusta*	100.00	5.33	533	5.33	6.38	17.39	4.02	27.79
2	*Bauhinia racemosa*	88.88	1.27	143	1.61	5.67	4.14	10.40	20.21
3	*Terminalia belerica*	22.22	0.40	150	6.75	1.41	1.30	16.10	18.81
4	*Grewia tiliaefolia*	100.00	1.94	194	1.94	6.38	6.33	5.48	18.19
5	*Zizyphus jujube*	100.00	2.83	283	2.83	6.38	9.23	1.78	17.39
6	*Caseria tomentosa*	100.00	3.05	305	3.05	6.38	9.95	1.00	17.33
7	*Pterocarpus marsupium*	72.22	1.00	138	1.91	4.61	3.26	9.06	16.93
8	*Adina cordifolia*	55.55	1.00	180	3.24	3.54	3.26	10.09	16.89
9	*Terminalia tomentosa*	94.44	2.27	241	2.55	6.02	7.40	1.78	15.20
10	*Albizzia stipulate*	66.66	1.00	150	2.25	6.66	3.26	4.02	13.94
11	*Cedrella toona*	61.11	0.83	136	2.23	3.90	2.70	6.99	13.59
12	*Lagerstroemia parviflora*	88.88	1.55	175	1.97	5.67	5.05	2.79	13.51
13	*Buchnania latifolia*	88.88	1.16	131	1.47	5.67	3.78	2.26	11.71
14	*Odina wodier*	61.11	0.94	154	2.52	3.90	3.06	4.72	11.68
15	*Alstonia scholaris*	72.22	1.05	146	2.02	4.61	3.34	2.79	10.74

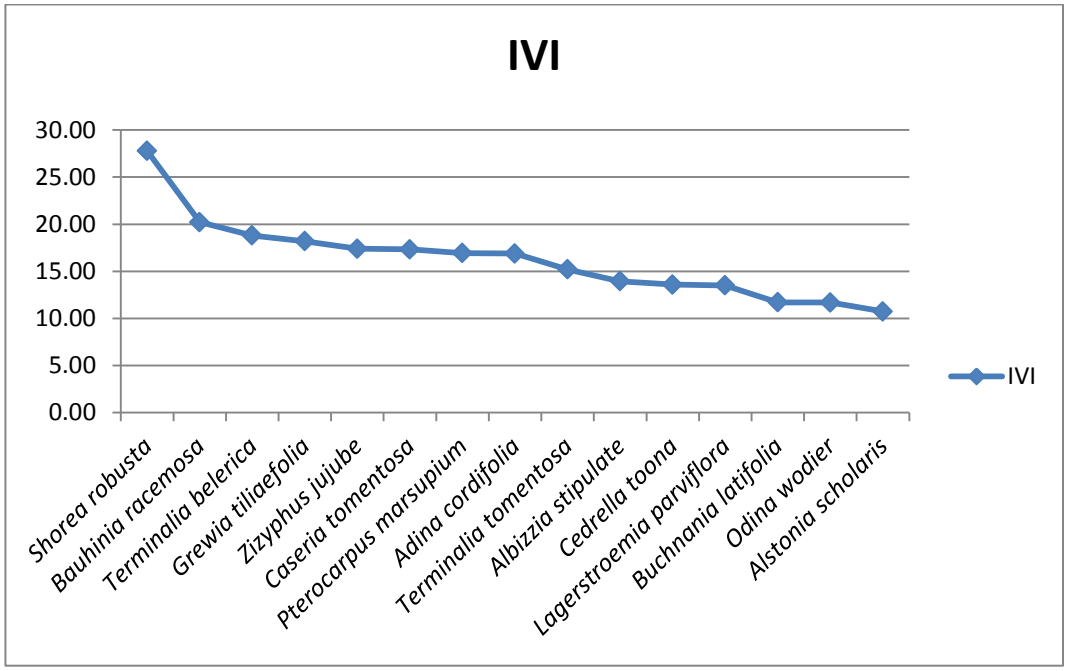

Figure 5.21(c) : Dominance –Diversity Curve of tree species of Lower Zone of Dalma Wildlife Sanctuary.

CHAPTER – VI

DISCUSSION

CHAPTER – VI

DISCUSSION

6.1 Land cover mapping

A vegetation types/land use was mapped from image data that was used for this study are Landsat-8 (Figure 5.1) Satellite imageries and ancillary data were collected in order to forest & land use mapping of Dalma wildlife sanctuary. Using supervised classification method Landsat 8 OLI classifies in the year 2016. While making land use land cover change of Dalma Wildlife Sanctuary it was distributed into seven classes such as agriculture, evergreen forest, deciduous forest, degraded forest, grassland, settlement, water body.The area is dominantly covered by Deciduous Forest (36%) and Grass land (27%) followed by Evergreen forest (17%) and Agriculture land (13%). The land cover classes, area statistics and percentage of area are given in Table 5.1 and Fig. 5.2The satellite-based vegetation types are compared with Champion and Seth classification scheme (1968). These are:Northern Tropical Dry Deciduous forest(5B), Dry peninsular Sal forest (5B/C1), Northern Dry Mixed Deciduous forest(5B/C2) The accuracy of the vegetation type/land use map was assessed. The overall accuracy was found to be 84.39 percent. The description of different vegetation types is described below along with species composition

6.2 Vegetational Biodiversity

The total vegetational biodiversity of Dalma Wildlife Sanctuary studied is indicated by presence of 96 plant species belonging to 41 tree species, 20 shrub, 21 herb species and 14 as Climbeing species. The 96 species was found distributed among 32 plant families in which maximum number of plants were observed from Gramineae 10 (Poaceae) family followed by members of Euphorbiaceae family. Beside this, in families Caesalpiniaceae, Bixaceae and Papilionaceae(Fabiaceae) have same number of plants(5) species. The number of families in upper zone

having tree species were found in 25 families, whereas in middle zone and lower zone , it is in 19 and families respectively.

The climber families were more in lower zone (3) followed by middle zone (2), whereas, in upper zone only one climber families represented by Liliaceae. Similar to present findings Rout *et al*. 2018, have reported presence of 108 plant species belonging to 38 familiesatthe findings of the present study are comparable with that of different ecosystems under tropical climates as studied by Bhadra et al. 2010, Behra *et al*. 2012, Jay kumar & Nair 2012, Mishra *et al*. 2013, Rabha 2014, Bajpai *et al*. 2015, Borah *et al*. 2016, Barua *et al*. 2018. Krishnamurthy *et al*. (2010) recorded 46 species from tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka. Sahu *et al*. (2012) recorded a presence of a total of 57 species in dry deciduous forest of Eastern Ghats. Studies of Thakur (2015) in tropical dry deciduous forest in Sagar district reported presence of a total 36 trees, 8 shrubs and 34 herbs. Pradhan & Rahaman (2015) recorded a total of 65 species belong to 36 families from three tropical dry deciduous forests of Birbhum District, West Bengal.

Altitudinal zonation of vegetation is one of the most important feature of stratification patterns of vegetation (Oshawa, 1977, and 1984**)** and much information is obtained on its local patterns. Theoretically, the division of vegetation zones should be based on the climax vegetation which refers to the forest structure. Research to describe the vertical and horizontal distribution of the vegetation of the Himalayas is still ongoing considering the spatial differences in forest canopy (Adhikari and Fischer, 2011; Adhikari *et al*. 2016) and diversity of the plant species between particular sections of this mountain range (Polunin and Stainton, 2000). Altitude is one of the most important determinants of tree distribution due to its direct impact on the microclimate of the habitat (Adhikari *et al*. 2012a). In the present study importance values of species differed along the altitude. This reflects the relative importance of each species in a spectrum of climax communities established in the park (Pandey, 2015). The variability of the distribution of plant species in the sampling plots at each vegetation zones could be attributed to the effect of co-factors like topography,

6.3 Species composition

The species composition of entire Dalma Wildlife Sanctuary has been also studied with respect to the distribution among the three zones viz. Upper, middle and lower zones.Besides IVI value of all the existing species have been also calculated separately for tree, shrub, herb and climbers in these zones. In upper zone maximum number of genera(4) belonged to Combretaceae and Caesalpiniaceae, whereas in middle zone similar to upper zone maximum genera were found from Caesalpiniaceae and in lower zone again Caesalpiniaceae is reported by three (3) species. Bixaceae family showed maximum plant in under shrub groups, upper zone(3) and middle zone(2) respectively. While in lower zone Rubiaceae and Euphorbiaceae have found from 2 genera in each. Under the herbaceous category in all these zones, members of Gramineae dominated indicating 10, 7, and 6 for upper, middle and lower zone respectively.

In upper zone for trees, maximum IVI was found for *Shorea robusta* (19.25) whereas in case of middle zone, the *Terminalia tomentosa* showed maximum IVI(15.52) and on the other hand in the lower zone again *Terminalia belerica* represented 18.81 IVI value.

The IVI value of shruby species for upper and middle zone was found for *Clerodendron infortunatum* as 30.40 and 37.32 and 42.88, respectively in upper, middle and lower zone.

The seven common tree species observed in upper zone(core area) has shown maximum IVI value for *Cochlospermum gossipium*(7.73). The IVI distribution(d-d) curve showed that the highly distributed stand had higher dominance or low evenness while the moderately and least distributed stand had lower dominance or higher evenness among tree. Similar results were obtained by Lalfakawma *et al* (2009) while studying community composition and tree population structure in undisturbed and disturbed tropical semi-evergreen forest stands of north-east India. Similar patterns of diversity across altitudinal gradients have been observed in other studies in the Himalayan regions (Kharkwal *et al*. 2005; Tanner *et al*. 1998; Vazquez and Givnish, 1998), Diversity of life-forms usually decreases with increasing altitude

and one or two lifeforms remain at extreme altitudes (Pavón *et al.* 2000). Altitude itself represents a complex combination of related climatic variables closely correlated with numerous other environmental properties (soil texture, nutrients, substrate stability, etc.; Ramsay and Oxley, 1997). Within one altitude the cofactors like topography, aspect, inclination of slope and soil type further effect the forest composition (Holland and Steyn, 1975).

6.4 Basal Area

The basal area of tree species for Upper, Middle and Lower zone of Dalma Wildlife Sanctuary (Table 5.11, 5.12 and 5.13) indicated that in upper zone, total basal area is represented by 15.48m^2ha^{-1} , whereas in Middle zone it is 11.02 m^2ha^{-1} and on the other hand Lower zone the minimum 10.78 m^2ha^{-1} basal area of the tree species is observed. In upper zone with respect to the basal area of individual tree species, maximum basal area is obtained for *Terminalia belerica*(1,32 m^2ha^{-1}) followed *by Albizziz stipulate*(1.15 m^2ha^{-1}. However contribution in basal area by *Cedrella toona* is found minimum (0.04 m^2ha^{-1}).

In case of middle zone, like upper zone contribution in the basal area for *Terminalia belerica* was found maximum(1.44 m^2ha^{-1}) followed by 1.00 m^2ha^{-1} basal area of *Adina cordifolia* one of the important timber species.

In case of lower zone, again contribution to the basal area observed maximum for *Terminalia belerica*(1.44 m^2ha^{-1}) .

A comprehensive basal area of twenty common tree species as indicated in (table 5.14) that *Terminalia belerica* has contributed maximum basal area in all three zones(upper, middle and lower zone). This is further substantiated in (fig. 5.12) showing comperatively high contributing tree species to total basal area. (*Terminalia belerica, Adina cordifolia, Pterocarpus marsupium).* Sagar and Singh 2006) observed basal area of tree in northern EG forests (mean 25.82 m^2 ha^{-1}, range 12.98 – 33.63)is much higher than the range (1.31 – 13.78 m^2 ha^{-1}). The reported basal area fro other studies include 7– 28 m^2 ha^{-1} from certain dry forest communities in India(Jha and Singh 1990). 10.79 – 20.44 m^2 ha^{-1} for tropical dry evengreen forests

of Southern India (Parthasarathy and Sethi 1997) and 3.9 – 16.7 m^2 ha^{-1} for Moimbo woodlands, Tanzania (Backeus *et al.* 2006). The values are less comparable with those reported from New Caledonia (47 – 49.5 m^2 ha^{-1}, Jaffre and Veillon 1990) and fan – palm dominated forests of coast peninsular Malaysia (25.3 – 48.6 m^2 ha^{-1}, Nizam *et al.* 2013). The difference in the basal area of tree layerssss among the study plots may be due to difference in altitude, species composition, age of trees and extent of disturbances and successional strategies of the stands. Girth class frequency showed that the population structure of trees exhihibited in the study plots are in harmony with other forest stands(Bhadra *et al.* 2010; Sahu *et al.* 2010). Tree distribution across different girth classes revealed how well the growing forest is utilizing functional and structural resources. The diameter distribution of tree has been often used to represent the population structure of forests (Rao *et al*. 1990).

6.5 Canopy height (Stratification)

The stratification of different tree species existing in the three study zones have been categorised on the basis of three canopy height class (1-10m), (11 -20m) and (21-30m) (Table 5.11, 5.12, 5.13). In case of upper zone, only three species occupieng highest (21 – 30m) canopy height are *Terminalia tomentosa* (21m), *Shores robusta(23m) and Lagerstroemia parviflora* (21m*)*. Whereas in middle zone only two species of tree namely *Terminalia tomentosa* (21.50 m)and *Shorea robusta* (24m) dominated the upper canopy height (21–30m), while in case of lower zone only *Terminalia tomentosa*(24m) represented as top canopy height, 24 m (21–30).

In lower canopy height group of upper, middle and lower zone, the numbers of trees were 23, 18, and 13, respectively. The middle canopy height for upper zone was representd by 15 tree species, in middle zone by 9 species in lower zone by 11 species. In contrast to this, some of the tallest and largest trees in the Himalaya were reported between 2500 and 3000 m by Singh and Singh (1987). They had also revealed that with further rise in elevation, in response to a sudden decline in the rainfall, and in severely cold and windy conditions, tree height of Himalayan forests were found to be reduced drastically. In this study, canopy height was also found to be slightly decreased with the elevation in Dalma Wildlife Sanctuary. In the

mountains, gradual changes in vegetation structure and composition are expected as a consequence of changing environmental conditions along the increasing elevation. Also, anthropogenic activities cause changes in structural attributes (Gairola *et al*. 2009).

6.6 Girth class distribution of tree species

A comparison was made for the relative distribution of the total number of individuals in respect of Girth class. The highest number of tree species occurred in girth class of 61-80cm in all three zones, which are quantified as 8 in upper zones, 9 in middle zone and 6 in lower zone followed by Girth class of 41-60cm with 9 species in upper zone, 5 in middle zone and 3 in lower zone as shown in table 5.16,The tree species having highest Girth(> 200cm) are *Terminalia belerica (2.30)*and*Albizzia stipulae (2.10)*in upper zone and *Terminalia belerica* (2.30) with same value of GBH was found in both middle and lower zone respectively as shown in(fig. 5.14).A similar study reported that Girth class frequency showed the population structure of trees exhibited in the study plots are in harmony with other forest stands (Bhadra *et al*. 2010; Sahu, 2010). Tree distribution across different girth classes revealed utilization of locality factor. The diameter distribution of trees has been often used to represent the population structure of forests (Rao *et al.* 1990).)

6.6 Factors affecting vegetation of Dalma Wildlife Sanctuary

About 1,30,00 inhabitants of villages liviing inside the sanctuary and outside (fringe area) of all three zones and depend on forests of sanctuary for fuel wood and small wood for self use and also for sale in the local weekly market which have destructive effect on vegetation of down hills and hillocks. There are 29 villages situated inside and 73 villages shown in figure (5.20) situated just outside the sanctuary boundary are directly or indirectly affecting the vegetation of the sanctuary by encroaching for agriculture, houses and for other purposes. Out of 29 villages situated inside the sanctuary, 4 villages are situated nearby of Upper Zone, 9 are nearby of Middle zone and 16 are around the lower zone or at the foothills of study area.

The degradation of habitat can be judged by the over growth of less utilizable scrub species and relatively non palatable grasses, and over grazing of nutritious and more palatable species (Siddiqui *et al*. 2010). As a result, whole composition of vegetation structure can be disturbed, and a lot of species can fall into vulnerable to threaned class. The present study will certainly help to devise effective management plan, and ultimately extremely helpful in the conservation of indigenous species of the region.

The disturbance level for each study sites can be evaluated from tree composition. Understanding the effects of human disturbance on tree structure, composition and on the relationships among the component groups of tree species is essential in defining alternative sustainable forestry systems (Halpern and Spies, 1995; Lugo, 1995; Vetaas, 1997). From developed database, high density vegetation was at untrampled plot at Puncak. In general, human activities affect on tree cover abundance. One of the most obvious physical impacts is trampling because these areas are frequently used. Besides that, another factor that made amount of tree is low at both disturbance campsite compared to undisturbed area because of placed a tent from climber and open a new trail made a damage to the side trail trees. Effect of trampling begins with an impact on vegetation when users walk on the places. Then it occurs to three initials effects: abrasion of vegetation, abrasion of surface soil or organic layer and compaction of soils (Hendee *et al*. 1990). Naturally, an ecosystem is free from biophysical disturbance caused by human activities Lesslie *et al*. (1988). In this study camping and climbing activities were contributes to the impacts on trees and ecosystem. A huge impact occurred in both types of the plot.

Hameed *et al*. (2012) reported that the anthropogenic activities like over-exploitation of plant resources for economic uses, heavy grazing pressure of local livestock, utilization of land for construction and agricultural purposes, and population density are continuously changing the species composition and vegetation structure in the Murree region. This impact is relatively stronger at hotter and lower areas, where a complete dominance of scrub species like *Carissa carandas* and *Dodonaea viscosa* is rapidly replacing tall vegetation, which includes *Pinus*

roxburghii,Acacia modesta and *Olea ferruginaea.* A number of tree species found in the Himalaya exhibit varying patterns of distribution. Distributional ranges of several species were segregated along the widened altitudinal ranges by (Kharakwal *et al.* 2005). They reported species-area relation, which predicts that species richness increases with increasing area. Pangtey *et al.* (1991) argued that the effect of monsoon is not substantially weakened at higher altitudes and also the amount of rainfall is not much different from that of the lower altitudinal range of Central Himalaya. This has also been used to explain the patterns of decrease in species richness with altitude (Rahbek, 1997). The human impact at lower altitudes was evident in the form of open spaces left after selective tree felling. These spaces may exacerbate the establishment of shade–intolerant species and enhance the regeneration of mixed pine-broadleaved forest (Wangda & Ohsawa, 2006). Lopping of plant species for their fuel wood and fodder values, this activity reduces vigour and seed production (Saxena & Singh, 1984) in this species. Large scale extraction of selected species also causes structural change in plant communities (Spurr & Barnes 1980). Heavy browsing by animals at seedling and sapling stages is also responsible for poor representation in recruitment classes of *Q. leucotrichophora, Q. floribunda and Q. semecarpifolia* (Dhar *et al*. 1997).

6.8 Species richness and diversity pattern

In the present study, the species richness and Shannon Weinner diversity index varied from 25 to 41 and 3.07 to 3.997, respectively in study zones of Dalma Wildlife Sanctuary (Table 5.19) Lowest number of species (SR=25) was found from lower zone due to maximum disturbance of anthropogenic cause while least disturbed zone possessed highest number of species (SR=41). Middle zone occupied an intermediate position with respect to species richness (SR=29). The highest value of Shannon Wiener index (3.997) was found for middle zones followed by upper zone(3.33) and lower zone(3.073). In the lower zone maximum and minimum species diversity was recorded for *Shorea robusta* (H= 0.518) and *Odina wodier(H=0.015)* respectively. In the middle zone maximum and minimum species diversity was recorded for *Shorea robusta* (H = 0.798) and *Cleistanthus collinus (D =0.010)* respectively while the maximum and minimum value for upper zone was

recorded for *Shorea robust(D =0.257)* and *Pterospermum pteragonum* (D = 0.006) respectively.

The patterns of species richness with local topography from ridges to depressions have not attracted much attention in the literature, although it is implicit in many phytosociological studies (e.g. Vestergren 1902; Ochsner 1954; Gjærevoll 1956; Bültmann & Daniels 2001). The variable patterns for the functional groups considered a general decrease in species richness of all organism groups with altitude has long been well-established (e.g. von Haller (1742) for vascular plants). This diversity decrease is a pattern conceptually and ecologically related to the often cited biotic depauperation from the Equator towards the poles (Körner 2000; Lomolino 2001), although many differences between these two patterns exist (Körner 1995; Rahbek 1995). They observed that species richness approaches zero in the most extreme environments in the Arctic as well as on alpine summits, but the shape of, and the factors behind, the relationship are still much debated.

In a study Singh *et al*. (1994) reported that *P. roxburghii*-mixed broad-leaved forests had the highest species richness, while high elevation forests had the lowest. Burns (1995) and Austin *et al*. (1996) have found that the total species richness was greatest at lower elevation and warmer sites. The overall pattern of species richness showed a sharp decline as the altitude increased beyond 3000m asl. A similar pattern of tree species richness (deciduous) in timberline area was reported by Rawal et al. (1991). The low elevation appeared likely to be drier although precipitation varied inconsistently with elevation (Singh *et al.* 1994). At the highest elevation (2800-2700m asl) the maximum species diversity (0.52). They observed that overall maximum species diversity (Shannon-Wiener index) (2.37) was recorded at comparatively lower elevation (2600-2400m asl). The overall pattern of species richness, Margalef's index, Menheink's index, Shannon-Wiener index (species diversity) and Simpson's diversity index showed a sharp decline at the highest altitude (2800- 2700m asl). A similar pattern of tree species richness in timberline area was reported by Rawal *et al*. (1991). Tree species richness increases with increasing moisture in the Indian Central Himalaya (Rikhari *et al.*1989).

6.9 Food for Herbivorous Wildlife specie

Dalma WLS is rich in food species of trees and herbs. The food of elephants and other wild animals has been identified during field study and survey with the help of the experience of field staff. It is special to mention bark and branches are the main components eaten by elephants Dalma Wildlife Sanctuary (Table 5.24).

There are 10 preferred species in the diet of wild herbivores animals, in which four are the principal food species of elephants. The other species *Kydia, Helicteres, Acacia, Bauhinia retusa, Pterocarpus marsupium, Mallotus* etc.The sparce distribution of herbaceous is noticed in Dalma Wildlife Sanctuary. percentage of grass in the diet of elephants is very low where as its use by Barking deer and other herbivores are much more. All the six species of herbs were identified in Dalma Wildlife Sanctuary are *Heteropogon contortus, Chrysopogon aciculatus, Panicum maximum Chrysopogon gryllus, Imperata cylindrica, Cynodon dactylon.* In an earlier study Guy (1976) recorded 133 species of elephant fodder plants at Sungwa reserve at Zimbabwe. A study on Asian elephants foraging behaviour in southern India pointed out that elephants consumes at least 112 plant species. Study on feeding behaviour of wild Asian elephants in Raja Ji National Park suggested that elephant consumes 74 % of tree species, 14% grass species, 8% shrub species and 4% climber species out of 262 floral plants species Joshi and Singh(2008). During dry season 18 species of flowering plants were found to be eaten by elephants in Manas National Park(Lakhar *et al*. 2007). Another study in the conservation of Asian elephant in Bengladesh indicated that 143 plant species were present in Chunti Wildlife Sanctuary, out of which 17 species were eaten by elephants.

6.10 Medicinal Plants

The medicinal uses of plants species have been recorded during ground truth survey and field studies.The local inhabitant have traditional knowledge about use of this medicinal plant. It has been observed in the present study that out of 98 plants, 23 species have been identified as medicinal plants. The local people use the indigenous flora for various medicinal purposes in their daily life as local people have faith and belief in these medicines. A list of 23 species are mentioned (table

5.23) Plants parts or fruits having medicinal use, such as *Aegle marmelos, Andragraphis paniculata, Asparagus recemosus, Vitis repanda, Beautia monosperma, Lagerstroemia parviflora, Pterocarpus marsupium, Terminalia chebula and Terminalia belerica* etc are harvested in bulk for preparation of medicines by local people. Similarly in India (Kassam *et al.* 2011, Khan *et al.* 2011, Mehra *et al*. 2014, Bajpai *et al*. 2016) and also other parts of the world (Jones 2000, Maurer *et al.* 2006, Chowdhury & Koike 2010) have also found. The medicinal plant resources are depleting rapidly due to destructive harvesting, lack of awareness and unrestricted grazing by domestic animals from nearby villages. Unsustainable collection of above medicinal plants has placed them in threatened and vulnerable categories in Conservation Assessment and Management Plan (CAMP) of Odisha (Pattanaik *et al.* 2009). Sustainable utilization and conservation of biodiversity are essential for the continuation of ecosystem functioning (Srivastava & Vellend 2005). The indigenous people in the study area gave less attention to the long term ecosystem goods and services since they were focused on their marginal and short time benefits. They illicitly utilized plants for a number of uses including timber, fuel, medicines, food, grazing and fodder. Extensive use of natural vegetation in the sanctuary in the past has decreased the provisioning services (Stewart & Pullin 2008, Giam *et al.* 2010). This diminution is fairly remarkable in the categories of food, fodder, timber fuel and medicines. The consequence of the imbalance in supply of these services and the increasing human demands has been deterioration in the condition of the natural habitats and increasing rarity of plant biodiversity (Giam *et al.* 2010).

SUMMARY

SUMMARY

Dalma wildlife sanctuary the study site is situated in the Chotanagpur Plateau of Jharkhand State near the famous Steel City of Jamshedpur some portion and extends into East Singhbhum and Saraikela-Kharshanwa districts of Jharkhand. The territorial and administrative responsibilities of the declared area of 193.22 Sq Km. of the sanctuary was finally transferred to wildlife division, Ranchi on dated 14.12.90 to then Government of Bihar to enhance the efficiency of management.

The forests of the Sanctuary belong to 5 B/C_1 (Northern Tropical Dry Peninsular Sal Forest) and 5 B/C_2 (Northern Tropical dry mixed Deciduous forests) as per the Champion and Seth's classification.

The topography of the Sanctuary varies from slightly undulating to quite steep slopes with luxuriant growth of vegetation, which makes it one of the best natural habitats in the country. The hill range popularly known as Dalma Hill Range, on which the Sanctuary is situated stretches up to south western part of West Bengal State.

The upper and middle part of the study area falling under upper and middle zone is comprising of 35 sq.km of the sanctuary is situated in eastern part of the hilly terrain are well protected.It is natural home of a large variety of wild animals with high density. More than two-third of elephant's population resides in this zone(core area). The biotic interference in the zone is very less.

The forests of Dalma wildlife Sanctuary had been categorized in zones according to altitude to make it easy to achieve the objectives of my study. The present study entitled "Vegetation Mapping and Phytodiversity Analysis in Dlama Wildlife Sanctuary, Jharkhand using Remote Sensing and GIS" reflects the status of forest biodiversity on species level. In order to achieve the objectives, Dalma Wildlife Sanctuaryis demarcated topographic gradients and variable climatic condition. The study area has a spectra of forest types like Evergreen forest, Deciduous and Open/Degraded forest within the total area of 198.45 sq km of the

Sanctuary, where as the vegetation types in the sanctuary area is Agriculture land Evergreen forest, Deciduous forest, open/Degraded forest and grassland. Land cover map of study area was also derived using remote sensing data of Landsat Satellite, and it was classified as Agriculture land, Evergreen forest, Deciduous forest, open or degraded forest, Grass land, Settlement and Water bodies. The area statistics and percentage distribution of vegetation and land use showed that the study area is predominantly covered with Deciduas forest (71.45 sq km) followed by grassland (53.59 sq km) and Evergreen forest (33.75 sq km). It was confirmed during ground truth that the location of evergreen forest are distributed in upper zone of the study area, where as Deciduous and Degraded forest are available on middle and lower zone respectively.

To make a comprehensive study, the Dalma Wildlife Sanctuary was devided into three zones according to altitudes i.e. Upper, Middle and Lower zone.

The forests ofUpper Zone (454m -603m) are better than the rest of the zones due to its favorable aspect, moist & soil conditions. The movement of elephants remains mostly confined in this area. The dense forests and perennial water sources provide favorable condition for wild animals. The Sal forests and mostly miscellaneous crop are found in this zone.

The forests ofMiddle Zone (250m – 452m) are confined to the middle and lower slopes of the hills. They are comparatively poor in quality than forests of upper zone and need protection against illicit felling, grazing and fire. The main crop consists of miscellaneous species like *Terminalia tomentosa,Shorea robusta, Lagerstroemia parviflora, Aegle elephantum , Calicarpa arborea,Adina cordifolia* etc.

Lower Zone (199m – 250m) of study area contain very poor crop and are in most depleted condition. These Forests have been infested with heavy interference and consequently deteriorated badly. They consist of miscellaneous species.

The forests of upper zone are mostly dense and have many perennial water sources creating favorable conditions for wild animals. Large part of this zone is declared as "Core Area".The forests of middle and lower zone were observed as scrubby and rooted waste with high and pollarded stumps.

Due to over exploitation of natural forest for timber and sapling in lower zone (foot hills) is converted into open or degraded forest. During the ground truith work, it was also observed that a larger area of foothills are open or degraded forest, where Forest department has taken initiatives to fill the open area by fast growing fuel and fodder species like *Acacia auriculiformis*to fulfill the requirement of local people living in fringe area and depending on forest.

The use of remote sensing and GIS for the detection of land cover change according to the change in altitude of Dalma hills with appreciable accuracy of ground truth data. It is useful in deciding the meaningful strategies on conservation of available natural resources. The derived map along with its analytical information on vegetation structure distributed over all three zones according to change in height will also help in research carried out in future. The digital map based on remote sensing and GIS of Dalma Wild Life Sanctuary may be very useful in future planning for proper management of the sanctuary.

The major findings of the study are as follows

1. Overall, seven land cover classes have been derived and identified from the remote sensing data in all over the study area (DWLS) in year 2016. About 27% of the total study area is covered with grassland, which comprises 53.59 sq. km as shown in area statistics of land use map derived from satellite based remote sensing data.

2. Water bodies are distributed at different location of the sanctuary area, which was identified as water sources of sanctuary. It was confirmed during ground truth as barka bandh, Chhotaka bandh and few seasional as well as perential streams. Total area of the water bodies calculated by remote sensing spatial method is 1.98 sq km

which covers about 1% of the total area of sanctuary. It has been noticed that in few water bodies (perennial streams) water remain in summer season also, which acts as a shelter for elephants in extreme dry period of May-June.

3. Under the category of land cover types, the settlement is one of the major parts inside the sanctuary area. The area statistics of this land use mapping is distributed in 7.93 sq km of the total area of sanctuary, i.e. 17%. There are 29 villages situated on gentle slopes of the sanctuary hills. Most of the villages are connected by footpaths except few villages connected by forest roads.

4. In present study about 98 species of plants under 64 families were recorded distributed all over the forest types of the Elephant reserve area. Out of 98 species 41 were Tree species, 20 Shrub species, 22 Herbs and 14 Climber were found. With respect to zonal distribution of species, 40 species were recorded from upper zone, 32 species in middle zone and 32 in lower zone. The representation of plant belonging to Gramineae (10) is the family which contains 33 species followed by Euphorbiaceage (19 species). Out of all 98 species of flora, 36 tree species belong to various families among all three zones were recorded.

5. Fourteen climber species were recorded belonging to 11 different families. *Celastrus paniculata, Bauhinia vohlii, vitis repanda, smilex macrophylla, Asparagus racenosus, Dioscorea belophylla, Barlaria cristata* and Barleria spp. were found as common climber species, which are also found in other forest of Jharkhand, whereas *Melothria heterophylla, vigne catjung, Rivea hypocaterformis, Abrus Precatorius* and *Chonemorpha macrophylla* are not common climber and it was observed only in Dalma Wildlife Sanctuary. The list of 98 plant species prepared with its taxonomical identify with the help of expert and Hains flora of Bihar, Orissa and Bengal to basic understanding of biodiversity and ecosystem, which plays important role in future study and planning for conservation.

6. Shorea robusta in upper zone have high dominant value (19.25) followed by *Albezia stipulae* (13.73) and *Alstonia Scholaris* (12.34) are co-dominant, where as in

middle and lower zone Adina cardifolia (18.21), *Terminalia belerica* (15.52) and *Shorea robusta* (27.79) have the highest value respectively.

7. Highest frequency of C*assia tomontosa* (100), *Shorea robusta* (94.4) in upper zone, *Zizyphus jujuba* (100) *Cleinthus collinus* (100) in middle zone and *Shorea robusta* and *Grewia tiliafolia* in lower zone have the highest value frequency.

8. The relative frequency of *Caseria tomentosa* (4.24) followed by Casia Siamia and the relative basal area of *Terminalia belerica* (9.60) followed by *Adina Cardiafola* (7.26) was found with highest value in upper zone whereas in middle and lower zone Relative frequency of *Cleistanthus Collinus* (5.71), relative basal area of *Terminalia belerica* (14.13) and Relative frequency *Albizzia stipulate* (6.66), Basal area of *Terminalia balerica* (16.1) was found highest respectively.

9. The IVI calculated for all the existing species in Upper zone of Dalma Wildlife Sanctuary indicated that its value for 41 trees varied from 1.57 for *Calicarpa arborea* a member of family Verbinaceae to highest value of *Shorea robusta* (19.25) a member of Dipterocarpaceae which is a dominating species in the area. With respect to 19 shrub species *Clerodendron infortunatum* belonging to Verbinaceae familydominated the area have maximum IVI value(30.40), while *Agave vera-cruz* showed lowest value(9.63). For 21 herbaceous maximum value of IVI was observed for *Ipomea batatas* (19.53) belonging to Convolvulaceae family. On the other hand in case of 8 Climber species, the highest IVI value was calculated for *Vitis repanda* (42.47) a member of Ampelidaceae family.

10. The species richness and Shannon Weinner diversity index varied from 25 to 41 and 3.07 to 3.997 respectively along study zones of Dalma Wildlife Sanctuary. The lowest number of species (SR=25) was found from lower zone due to maximum disturbance of anthropogenic cause while least disturbed zone possessed highest number of species (SR=41). Middle zone occupied an intermediate position with respect to species richness (SR=29). The highest value of Shannon Wiener index (3.997) was found for middle zones followed by upper zone(3.33) and lower

zone(3.073). In the lower zone maximum and minimum species diversity was recorded for *Shorea robusta*(H= 0.518) and *Odina wodier(H=0.015)* respectively. In the middle zone maximum and minimum species diversity was recorded for Shorea robusta H = 0.798) and *Cleistanthus collinus(D =0.010)* respectively while the maximum and minimum value for upper zone was recorded for *Shorea robusta(D =0.257)* and *Pterospermum pteragonum* (D = 0.006) respectively.

11. Rarity of tree species was also studied. It was found that in upper zone *Shorea robusta, Terminalia tomentesaAnogeisus latefolia* and twenty one more species are dominant in upper zone. In middle zone dominant group of 18 tree species are similar to upper zone *Terminalia tomentosa, Shorea robusta* etc. were noticed as timber species. In case of lower zone maximum number of tree species like *Cedrella toona, Pterocarpus marsupium* etc., have been observed as dominant species.

12. 8 tree species like *Aegle elephanatum, Calcicarpa arboreae* etc. in upper zone, and 4 species like *Calicarpa arborea, Cassia siamia* etc., in middle zone and 7 trees species like *Cassia fistula, Terminalia belerica* in lower zone on the basis of number existence of individuals all over the studied zone have been kept under rare species.

13. The rare tree species of Dalma Wildlife Sanctuary has need to conserve. Several large trees, climbers and under storey of flora have a great to maintain the ecosystem of elephant habitat. Few unique flora like *Shorea robusta, Bosbeilia serrata, Sterculia urens, Beautia monosperma* etc attracting the wildlife in Dalma Wildlife Sanctuary is moving towards endanger or extinction species are threats for wildlife in coming future.

14. Maximum basal area contributed by *Terminalia belerica*(1.323m^2ha^{-1}) followed by *Albizzia stipulate*(1.145 ha^{-1}). The basal area contributed by *Cedrela toona* was found minimum(0.040 m^2 ha^{-1}).In case of middle zone out of 30 tree species, maximum basal area contribution was observed for *Terminaliabelerica*(1.44 m^2ha^{-1}) followed by *Adina cordifolia*(1.00 m^2ha ha^{-1}) similar to upper zone

contribution to basal area by *Cedrela toona* remained minimum(0.063 m^2 ha^{-1}) in middle zone. In case of lower zone of Dalma Wildlife Sanctuary, out of 25 tree species basal area contribution of *Terminalia belerica* was found maximum(1.44 m^2 ha^{-1}), followed by *Bauhinia racemosa(* 0.93 m^2 ha^{-1}).Twenty common tree species observed in upper, middle and lower zone with highest value for *Terminalia belerica* as 1.32, 1.44 and 1.44 m^2 ha^{-1} for upper, middle and lower zone respectively.

15. 23 tree species in lower, 15 species in middle and 3 species in upper zone which occupied top canopy. In case of middle zone the canopy is represented by 18, middle by 9 and top canopy is by two species namely *Terminalia tomentosa* and *Shorea robusta.* At lower zone lower canopy height is represented by 13 tree species, middle zone by 11 and top canopy height by 1 species. It further observed that Terminalia tomentosa is a common species that occupies top canopy height at all the three zones9 Upper, middle and lower).

16. The value of β – diversity is found maximum for Shrubby species (2.70), while in middle zone similar situation observed i.e. for shrub beta diversity is found maximum. On the other hand, for lower maximum beta diversity was calculated for tree species(3.80). In upper zone the value of beta diversity was observed low for tree, shrub, herb and climber.

17. The highest number of tree species was occurred in girth class of 61-80cm in all three zones, which are quantified as 8 in upper zones, 9 in middle zone and 6 in lower zone followed by Girth class of 41-60cm with 9 species in upper zone, 5 in middle zone and 3 in lower zone,whereas the tree species having highest Girth(> 200cm) are *Terminalia belerica(2.30)*and*Albizzia stipulae(2.10)*in upper zone and Terminalia belerica(2.30) with same value of GBH was found in both middle and lower zone respectively.

18. The medicinal uses of plants species have been recorded during ground truth survey and it was observed that out of 98 plants, 23 species have been identified as medicinal plants. The local people use the indigenous flora for various medicinal

purposes in their daily life as local eople have faith and belief in these medicines.Medicinal plant such as *Aegle marmelos, Andragraphis paniculata, Asparagus recemosus, Vitis repanda, Beautia monosperma, Lagerstroemia parviflora, Pterocarpus marsupium, Terminalia chebula and Terminalia belerica* etc are harvested in bulk for preparation of medicines by local people.

19. Dalma WLS is rich in food species of trees and herbs. Bark and branches are the main components eaten by elephants. There are 10 preferred species in the diet of wild herbivores animals, in which four are the principal food species of elephants. They are species of *Kydia, Helicteres, Acacia, Bauhinia retusa, Pterocarpus marsupium, Mallotus* etc. are belong to tree species. Herb species are very sparsely distributed in sanctuaries. The percentage of grass in the diet of elephants is very low where as its use by Barking deer and other herbivores are much more. All six species of herbs were identified in Dalma WLS . They are *Heteropogon contortus, Chrysopogon aciculatus, Panicum maximum Chrysopogon gryllus, Imperata cylindrica, Cynodon dactylon.*

20. Peoples liviing in or outside (fringe area) of all three zones of Dalma Wildlife Sanctuary are directly or indirectaly depend on forests of sanctuary for fuel wood and small wood for self use and also for sale in the local weekly market which have destructive effect on vegetation of down hills and hillocks. There are 29 villages situated inside and 73 villages are settled just outside the sanctuary boundary are directly or indirectly affecting the vegetation of the sanctuary by encroaching for agriculture, houses and for other purposes. Out of 29 villages situated inside the sanctuary, 4 villages are situated nearby of Upper Zone, 9 are nearby of Middle zone and 16 are around the lower zone or at the foothills of study area.

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IMPLICATION OF THE RESULT

The finding of present study has indicated presence of 98 plant species in Dalma Wildlife Sanctuary, Jharkhand. Out of this, ten preferred plant species belonging to tree, shrub, herb were identified as diet of wild herbivores animals, in which four are most prefared food of elaphant i.e. *Kydia, Helicteres, Acacia, Bauhinia retusa, Pterocarpus marsupium, Mallotus etc. are belong to tree species.*

Many plant species having potential medicinal effect on both human and animals were of great importance for treatment of various kinds of diseases such as – fever. Fracture, energy substitutes etc. Thus conservation is needed for sustainable exploitation in future. Besides, similar study is also required to be carried out in other forest areas of Jharkhand to know the trength of plant species existing there, which may be helpful for future planning and preparation of better management plan of Dalma Wildlife Sanctuary and also for sustainable utilization of forest produce.

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List of paper published related to present work

1. Narendra Prasad & U.K. Sahoo (2019) Land Use Mapping of Dalma Wildlife Sanctuary Using Remote Sensing & Geographical Information System. Journal of Emerging Technologies and Innovative Research (JETIR) 2019 Volume 6, Issue 6(ISSN-2349-5162).
2. Narendra Prasad, M.H. Siddique & U.K. Sahoo 2019 Floristic Biodiversity & Dalma Wildlife Sanctuary, Jharkhand proceeding of International Conference on Livelihood promoting Biodiversity Conservation and Social Security in Indian Sundarbans, First edition, 69(93-110).(ISBN:978-93-88879-26-2).

Conference participated :

1. International Conference on "Livelihood Promotion, Biodiversity Conservation and Social Seceurity in Indian Sunderbans (December 7-98, 2018) organized by Visva Bharti Sriniketan at Techno India University, Jharkhand, South 24 Pergana, West Bengal, India.

2. 3rd World Clear Enviornment Summit (19-20-21 August 2019 at St. Xavier College, Ranchi organized by Deptt. of Boteny, St. Xavier College Rancni in association with International Benvalent Research Foundation Kolkata and Conservation of Indian Universities, New Delhi.

3. National Seminar on Geo-Spetial Applicationfor Natural Resource Management (March 17-18, 2020) National Institute of Rural Development & Panchayati Raj North Eastern Regional Centre Jawaharnagar, Khanapara, Guwahati-781022.

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DATE OF ADMISSION	:	01.08.2014

APPROVAL OF RESEARCH PROPOSAL

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HEAD

VEGETATION MAPPING AND PHYTODIVERSITY ANALYSIS IN DALMA WILDLIFE SANCTUARY JHARKHAND, USING REMOTE SENSING AND GIS

THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

ABSTRACT

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The present study entitled “Vegetation Mapping and PhytodiversityAnalysisinDalma Wildlife Sanctuary Jharkhand, Using Remote Sensing and GIS” is underertaken to study forest biodiversity of DalmaWildlief Sanctuary Jharkhand were studied using Remote Sensing and Geographical Information System. The proposed study is designed to meet the following objectives:

1. To analyze vegetation cover and types in DWS using RS & GIS techniques
2. To quantify and map the phytodiversity in DWS
3. To prepare a comprehensive map of vegetation in DWS

The main aim of the study was find out land use land cover mapping (LULC) and Phyto-diversity analysis. The Image data used in this study are landsat-8 sateliteimegeries, and ancillary data were also collectedwith respect to forest land use mapping of the Sanctary using supervised classification techniques in Arc GIS software. The change of vegetation according to change in altitudinal height using land sat -8 OLI as classified in year 2016 were also used. Satelite imageries and survey of India (SOI) toposheets were used to generate data and its analysis. Several parameters such as frequency, density, basal area, IVI etcwere considered and calculated to compare with vegetation existed in altitude based three study zonesexisting between 199m – 603m height creating 54 quadrates, each of size 10m × 10m. The total richness of tree species in the study area was recorded as 2471 individuals of 25 families were reported among the three zones.

The Dalma Wildlife Sanctuary has been observed to have a spectrum of forest types covering Agriculture land (13%), Evergreen forest (17%), Deciduous forest (36%), Open/Degraded forest (2%), Grassland (27%), Settlement (4%) and Water bodies (1%) in an areas of 198.45 sqkm. Vegetation and land cover type mapping using landsat -8 OLI satelite data of the year 2016 showed that the area is predominantly covered with Deciduous forest followed by Grassland and Evergreen forest. In this way alltogether, seven land cover classes have been identified.

A total of 98 plant species recorded from all the three demarcated zones of the Sanctuary. Out of this 41 are tree species and 20, 22 and14 were found belonging to shrub, herb and climber categories respectively.Gramineae (10) family is most represented followed by Euphorbiaceae(6). It was noticed that the treedensity varied from 30.64 to62.51.

According to vegetation map of Dalma Wildlife Sanctuary, the Upper Zones of core area consist of mainly Evergreen forest, dry mixed deciduous forests with small patches of moist mixed forests near water streams and in the northern aspects. The upper portion of the hills and particularly on the northern aspects consists of comparatively better quality of mixed forests of evergreen and deciduous. Details of species observed at Upper, Middle and Lower Zones are shown in Table 1. In upper zone many important timber species are observed which consists of mainly *Shorearobusta* (Dominant), *Terminaliatomentosa* (Dominant), *Anogeissuslatifolia*, *Diospyosmelanoxylon*,*Adina cordifolia*, *Pterocarpusmarsupium*, *Terminaliabelerica*, *Bombaxceiba*, *Emblicaofficinalis*.

In the Middle Zones (parts of core area) and Lower Zones covering buffer area in the western and eastern portion of the sanctuary, there are mixed forests with *Shorearobusta*as predominant species. It was found that the trees are not very healthy except at the upper Zone of core area and water streams. Some portion of the buffer area of lower zone has open degraded forest.

The occurrence of different plant species have been also categorised according to plant families as shown in Table 5.6 with respect to upper zone, middle zone and lower zone. It is noticed that Gramineae (10) family is most represented followed by Euphorbiaceae (6).In upper zone many trees maximum representation was from Combretaceae, whereas in case of Shrubs maximum representatives was from Bixaceae family. However in case of Herbs and Climbers Gramineae and Acanthaceae showed maximum plant species. In middle zone Caesalpiniaceae family is represented by five tree species,whilefor Shrub, Bixaceae family is having two tree species. However Poaceae family is represented by highest number of plant species belonging to herbaceous group. In case of lower zone maximum species is found

belonging to Caesalpiniaceae for tree, Rubiaceae and Euphorbiaceae for shrubs and gramineae for herbaceous species. Therefore data indicated that, Upper zone is rich with respect to plants families (40 families). However, at middle and lower zone, decreased in plant distribution to different families is noticed. Most represented families are Graminae&Euphorbiacea. Dominating families in case of tree species are copmbretaceae, Caesalpinaceae and Euphorbiaceae.

The IVI calculated for all the existing species in Upper zone of Dalma Wildlife Sanctuary shown in (table 5.7)indicated that its value for 41 trees varied from 1.57 for *Calicarpaarborea*a member of family Verbinaceae to highest value of *Shorearobusta*(19.25) a member of Dipterocarpaceae which is a dominating species in the area.With respect to 19 shrub species *Clerodendroninfortunatum*belonging to Verbinaceaefamilydominated the area have maximum IVI value(30.40), while *Agave vera-cruz* showed lowest value(9.63). For 21 herbaceous maximum value of IVI was observed for *Ipomeabatatas* (19.53) belonging to Convolvulaceae family. On the other hand in case of 8 Climber species, the highest IVI value was calculated for *Vitisrepanda*(42.47) a member of Ampelidaceae family.

Out of 29 Tree species highest value of IVI was observed for *Adina cardifolia*(18.21) belonging to family Rubiceae, while lowest value was found for *Calicarpaarborea*(1.95) of family Verbinaceae.The IVI value of Shrub, Herbs and Climber indicated maximum value for *Clerodendroninfortunatum*(37.32), *Cynodondactylon*(25.74) and *Celestruspaniculata*(39.11)respectively.

The IVI value of different species of lower zone of Dalma Wildlife Sanctuary is shown (Table 5.10)with respect to tree (25), Shrub(19), Herb(15) and Climber (9). Maximum IVI value was observed for *Shorearobusta*(27.79) in case of tree species, while *Clerodendroninfortunatum* shared maximum IVI(42.88) among the 19 shrub species. On the other hand in case of herbaceous species *Panicummaximus*gave highest value of IVI(25.03) and under climber group *Asparagus racemosusWilld* observed highest (51.96).

A comperative view of total basal area of all the species existing in all the three zones of Dalma Wildlife Sanctuary and also for common species indicated

wide differences in total basal area of upper zone with respect to other zone (middle and lower), whereas, for common tree species not much differences in total basalarea at the three study zone is observed.

Maximum basal area contributed by *Terminaliabelerica*(1.323m^2ha^{-1}) followed by *Albizzia stipulate*(1.145). The basal area contributed by *Cedrellatoona was* found minimum(0.040 m^2ha^{-1}).In case of middle zone out of 30 tree species, maximum basal area contribution was observed for *Terminaliabelerica*(1.44 m^2ha^{-1}) followed by *Adina cordifoli*a(1.00 m^2ha^{-1}) similar to upper zone contribution to basal area by *Cedrelatoona* remained minimum(0.063 m^2ha^{-1}) in middle zone. In case of lower zone of Dalma Wildlife Sanctuary, out of 25 tree species basal area contribution of *Terminaliabelerica* was found maximum(1.44 m^2ha^{-1}), followed by *Bauhinia racemosa(* 0.93 m^2ha^{-1}).

The tree species observed in upper, middle and lower zone of Dalma Wildlife Sanctuary has been also classified in different canopy height classes as 1 to 10m, 11 to 20 m and 21 to 30m, respectively for lower canopy height, middle canopy height and top canopy height. 23 tree species in lower, 15 species in middle and 3 species in upper zone which occupied top canopy.In case of middle zone the canopy is represented by 18, middle by 9 and top canopy is by two species namely *Terminaliatomentosa* and *Shorearobusta.*At lower zone lower canopy height is represented by 13 tree species, middle zone by 11 and top canopy height by 1 species.

Contribution of tree stands according to Girth class distribution in Dalma Wildlife Sanctuary for analysis of individual GBH(Girth at breast height) class, all tree species found in all three zones were taken into consideration. The recorded girths of all individual trees were classed at a range of 20cm into ten classes.

The highest number of tree species was occurred in girth class of 61-80cm in all three zones, which are quantified as 8 in upper zones, 9 in middle zone and 6 in lower zone followed by Girth class of 41-60cm with 9 species in upper zone, 5 in middle zone and 3 in lower zone, where as the tree species having highest Girth (> 200cm) are*Terminaliabelerica(2.30)*and*Albizziastipulae(2.10)*in upper zone and

Terminaliabelerica(2.30) with same value of GBH was found in both middle and lower zone respectively.

In upper zone dominant group is represented by a maximum of 24 species consisting of important timber species like*Shorearobusta, Terminaliatomentosa, Anogeisuslatefolia* etc. In middle zone Dominant group is represented by 18 tree species and similar to upper zone *Terminaliatomentosa, Shorearobusta* etc. and it has been noticed as important timber spp. However in case of lower zone, maximum number of tree species are found is Common group comprising *Cedrellatoona, Pterocarpusmarsupium* etc.

The Similarity value (Si) also indicates that the highest valueshown by the combination of upper zone and middle zone forest(0.707) followed by upper zone and lower zone(0.609). The combination of upper zoneand middle zone, upper and lower zone, middle and lower zone forest exhibits slightly lower degree of similarity with the value of 0.707, 0.609 and 0.606 respectively. In conclusion, the degree of similarity for the entire three zone forest is low.The floristic similarity analysis similarity value between the three zones of Dalma Wildlife Sanctuary of Jharkhand show the range from 0.606 – 0.707 which is floristically low in similarity indicating heterogeneity in the species composition.

In the present study, the species richness and Shannon Weinner diversity index varied from 25 to 41 and 3.07 to 3.997 respectively along study zones of Dalma Wildlife Sanctuary. Lowest number of species (SR=25) was found from lower zone due to maximum disturvance of anthrapogenic cause while least disturbed zone possessed highest number of species (SR=41). Middle zone occupied an intermediate position with respect to species richness (SR=29). The highest value of Shannon Wiener index (3.997) was found for middle zones followed by upper zone(3.33) and lower zone(3.073). In the lower zone maximum and minimum species diversity was recorded for *Shorearobusta*(H= 0.518) and *Odinawodier(H=0.015)* respectively. In the middle zone maximum and minimum species diversity was recorded for Shorearobusta H = 0.798) and *Cleistanthuscollinus(D =0.010)* respectively while the

maximum and minimum value for upper zone was recorded for *Shorearobusta(D =0.257)* and *Pterospermumpteragonum* (D = 0.006) respectively.

At present the biodiversity ofthese forests are under threat due to the anthropogenic and illegal interference of outside people for cutting of furniture tree species. The presentstudy will help us to understand the patterns of tree species composition and diversity in the Dalma Wildlife Sanctuary, of India.