2. REVIEW OF LITERATURE

A review on the crucial database, helps in planning and designing the study approach in a more proper and perfect manner to achieve the study objectives. In this process, for the present study, research related to taxonomy, floral diversity, endemism, threatened plants, phenology and studies used recent tools like Geographical Information System (GIS) and Remote Sensing (RS) to explore the flora were collected at global, national and regional levels.

2.1. Global level

2.1.1. Taxonomy and floral diversity studies

Vazquez and Givnish (1998) found a sharp decrease in species richness, genera and families with altitude in Sierra de Manantlan Biosphere Reserve in Jalisco, Mexico. Werff and Consiglio (2004) and Ghani and Khalik (2005) also observed a similar trend in Peru and in Gebel Elba National Park in Egypt respectively. Enoki and Abe (2004) found that the topographic gradient influences the plant species diversity while Nagaike et al., 2003 found that landscape parameters influence the species diversity. Onaindia et al. (2004), Johnson et al. (2004) and Rodriguez et al. (2005) reported that forest thinning, forest fire and environmental variables influence species diversity respectively.

Killen et al. (1998) proposed that the timing of leaf drop and foliage regrowth is a flexible response and the amount of time that trees remain leafless is due to soil moisture that varies spatially and temporally according to local rainfall pattern. Further, Marques et al. (2004) also observed phenology of tree, shrub, lianas and epiphytes in Araucaria forest and concluded that, phenologies varied among the four life-forms. It was highly correlated with climatic variables, daylength and temperature.
Linera et al. (1997) and Straede et al. (2002) proposed protecting the isolated trees on fragments and developing “community forestry” as suitable measures respectively in the habitat improvement plan.

### 2.1.2. Species loss, endemic and threatened species studies

Turner et al. (1994) and Trinder-smith et al. (1996) suggested that the increasing rates of alien species, urbanization and fire regimes are the major responsible factors for the degradation of the endemic plants. Vischi et al. (2004) found that afforestation programs in the forest area using exotic species for improving vegetative cover would function as a threat.

### 2.1.3. GIS based studies

Keel et al. (1993) and Mota et al. (2004) surveyed various vegetation types and prioritized sites for conservation using GIS. Poorter and Weiringa (2001) developed effective conservation policy using GIS for the rare and endemic plants.

Further, Kohn and Walsh (1994) used Pathfinder maps and identified the persistence of more diverse habitats. The extent of area in islands was responsible for determining the species richness in Islands.

Godefroid and Koedam (2003) studied species composition in forest edges (city zone) and the interior of the neighboring forest in Brussels, Belgium using GIS and RS. He concluded that the urbanization affect the flora of neighbouring semi-natural areas (forest edges) by allowing the alien species to invade. Linkie et al. (2004) found that the road and farmland development were the major reasons for the forest degradation in Tapan valley.
2.2. National level

2.2.1. Taxonomy and floral diversity studies

Singh (2003) explained that the composition of the forest layer in terms of species richness, representation of taxonomic groups and uniqueness of species depends on over storey vegetation of the forest of Central Himalayas while Hussain et al. (2008) found altitudinal gradient as a factor in Kumaon Himalaya. Chauhan et al. (2008) explained that the evenness and richness between natural and planted forest of Terai-Bhabhar region are the results of microclimatic and edaphic characteristics of the forest. Gupta and Narayan (2006) also reported soil organic carbon and disturbance regimes of pre - urban areas of Bulandshahr, Western Uttar Pradesh.

Yadav and Yadav (2008) reported that drought is a major factor for leaf initiation and leaf fall in several woody species of Bala - fort tropical dry deciduous thorn forest located in north - eastern Rajasthan.

Kumar et al. (2000) stated that human related activities in Khatana forest region could be the reasons for having poor diversity of plants than the Waghai forest region of North Western Ghats, South Gujarat. Krishnankutty et al. (2006) also found similar results in the Alagar hills of Eastern Ghats. Chhangani (2001) reported overgrazing, tree cutting, dominance of exotic weeds, forest fire and flash flood to be the factors responsible for habitat and species loss in Kumbhalgarh wildlife sanctuary, Rajasthan.

Negi et al. (2008) found that the traditional management of the forest by the local community through people’s participation have good species richness and composition when compared with the management of the Reserve Forest which is under the directive of the state, Garhwal Himalaya.
2.2.2. Species loss, endemic and threatened species studies

Study on ecology, status and distribution of threatened plant species of Aravalli Hills with special reference to Kumbalgarh wildlife sanctuary was carried out by Vyas and Ramdeo (1964) and Pandey and Singh (2000). GEC, MSU and GUIDE (2002) carried out a detail study on the status, distribution and conservation strategies on rare and endangered plants and animals species in the entire Gujarat, India. The region specific enumerations of plants were carried out by field transects. Based on that the conservation and threat status of threatened species were revised. Species specific conservation plans and distribution maps were developed.

2.2.3. GIS based studies

Indian Institute of Remote Sensing (IIRS 2002) undertook a pioneering effort to create geospatial data base on vegetation cover types, disturbance regimes and biological richness to build national data base on biodiversity at landscape level. Later, Ramesh et al. (1997), Dineistein (1998), Nagendra and Gadgil (1999), Sankaran (2001), Menon et al. (2001) and GEER and GUIDE (2001) attempted to explain the habitat change over the period of years using GIS and RS. Recently, Kumar et al. (2002) evaluated the natural resources and environment of the Kolli hill, Tamil Nadu using RS and GIS. They had also prepared an area specific mitigatory plan for sustainable utilization, conservation and development.

2.3. North Gujarat Region level

2.3.1. Taxonomy and floral diversity studies

2.3.1.1. Studies in overall North Gujarat Region

Saxton and Sedgwick (1918) listed 614 plant species belonging to 88 families and 346 genera from the Northern Gujarat and classified them under Warming’s classification scheme. Later, Saxton (1922) increased the list to 678 plant species, which includes 500 species of dicotyledons and
178 monocotyledons of which 175 were cultivated. Shah and Inamdar (1965) and Shah (1970) also made similar kind of studies in NGR. Later, Shah and Yogi (1974) added another 200 species of plants in the list.

Chavan and Sabnis (1959) documented different members of the family Cyperaceae in few sites of North Gujarat as part of their study in the North, Central and South Gujarat. Shah (1963) has added eight more species in the family Cyperaceae from this region.

Most recently, Rajendrakumar et al. (2007) and Rajendrakumar and Kalavathy (2010b) attempted to evaluate the woody plants and its management in Dry Deciduous Forest and Tropical Thorn Forest of NGR, based on the prevailing threats.

2.3.1.2. Sabarkantha district


Although, no specific attempt has been made to explore the aquatic vegetation, Churda (2004) tried to correlate the aquatic and hedge vegetation with soil and water components in three different seasons.

2.3.1.3. Banaskantha district

Society for Research and Initiatives for Sustainable Technologies and Institution (SRISTI 2000) did a study on the status and distribution of flora in Jessore Sloth Bear Wildlife Sanctuary (JSBWS) and Balaram - Ambaji Wildlife Sanctuary (BAWS) and reported 406 and 483 species of plants respectively. Further, they also reported 15 globally endangered & endemic plants and 89 highly medicinal species from both sanctuaries.

Patel (2001), Sidana (2001) and Patel (2002b) also carried out similar studies in Vijayanagar and Danta forest area of North Gujarat Region. Patel (2000) and Bhasker (2002 and 2004) did ethnobotanical and socioeconomical studies in Banaskantha and in Banaskantha and Sabarkantha districts respectively.

2.3.1.4. Mehsana district

Bharathi (1959) had enumerated the status and distribution of 215 angiospermic plant species from Visnagar Nagar. Shah (1964a, 1964b and 1964c) carried out the floristic inventory of Taranga hills.

Patel (1999) did a study on saline soils, salinity levels and its effect on different crops in parts of North Gujarat to reduce the soil blowing and to improve the productivity of the groundnuts. He also mentioned the adaptability and survivability of the tree species in saline soil.

Patel (2002a) performed eco-floristic and ethnomedical study in Taranga a protected hill and discussed phenological events. Another study was done by Chaudhary (2003) to establish the ethno-medicinal aspects of 499 angiospermic plants of Mehsana, Vadnagar, Visnagar, Kheralu Taluks.
2.3.2. Species loss, endemic and threatened species studies

These ecosystems are not only rich in terms of biodiversity but also in endemism. Earlier, Shah (1978), Nayar and Sastry (1988), GES, MSU and GUIDE (2002) reported the existence of eight threatened plant species such as *Citrullus colocynthis*, *Commiphora wightii*, *Ephedra foliate*, *Gloriosa superba*, *Heliotropium rariflorum*, *Indigofera caerulea* var. *monosperma* and *Tribulus rajasthanensis* species in NGR. In addition, SRISTI (2000) and Joshi and Joshua (2003) listed *Anogeissus sericea*, *Ceropegia odorata*, *Chlorophytum borivilianum*, *Heleotropium baccifera*, *Pavonia arabica*, *Sterculia urenas*, *Solanum indicanum*, *Tecomella undulate*, *Capparis cartiaginea*, *Phoenix sylvestris*, *Dendrocalamus strictus*, *Psoralea corylifoia* and *Plumbago zeylanica* and *Enste superbun* (Wild Banana) as species threatened regionally.

Based on secondary information and revised classification of threatened plants, there were 11 species (*Anogeissus sericea* var. *nummularia*, *Dipcadi erythraeum*, *Chlorophytum borivilianum*, *Citrullus colocynthis*, *Commiphora wightii*, *Ephedra foliate*, *Gloriosa superba*, *Heliotropium rariflorum*, *Indigofera caerulea* var. *monosperma*, *Ipomoea kotschyania* and *Tribulus rajasthanensis*) belonging to 10 families recorded as endangered category in Gujarat state (Joshua *et al.*, 2005). Of these, eight were dicots, two monocots and one gymnosperm. Rajendrakumar *et al.* (2008), Rajendrakumar and Kalavathy (2010a) recorded above the said eight dicot species and developed conservation strategies.

Among them *Anogeissus sericea* var. *nummularia* is distributed in the whole of India, but specific records were also found in the semi-arid regions of Rajasthan & Gujarat (Shah, 1978). The reason behind the rareness of this species was due to hefty exploitation for commercial purpose (for making agricultural implements and furniture) and it has been categorised as ‘**Rare (R)**’ by WCMC (1994).
Similarly, *Citrullus colocynthis* is a native to dry areas of North Africa (Duke, 1978). This species is also common to semi-arid and arid condition in India and it has been reported from 15 districts of Gujarat state (Bharti, 1959; Oza, 1962; Shah, 1964; Shah, 1969; Rao, 1981; GEC, MSU and GUIDE, 2002). Over exploitation to extract oil from the fruits for medicinal purpose is a major threat to this plant. Hence the status of this plant is designated as ‘**Insufficiently Known (I.K)**’ (IUCN, 2000).

IUCN (2000) report also mentioned *Commiphora wightii* as ‘**Data deficient**’ at the global level. In Gujarat it is classified as ‘**Lower risk and conservation dependent (LRcd)**’ (GEC, MSU and GUIDE, 2002), because it shows wider distribution and is reported from North, Central Gujarat, Kachchh and Saurashtra regions (Shah, 1978; Pandey *et al.*, 1983; Sabnis and Rao, 1983; GEC, MSU and GUIDE, 2002).

*Dipcadi erythraeum* is widely distributed in Rajputana, Sind Jamadar ka Landa near Karachi, lower hills of Sindh Arabia and Egypt (Cooke, 1908; Blatter and Hallberg, 1984). In India it was recorded from Rajasthan (Blatter and Hallberg, 1984) and Gujarat states (Rao, 1981) and WCMC (1994) designated it as an ‘**Intermediate (I)**’.

*Gloriosa superba* is usually found in the tropical Africa and Asia. In India, it shows distribution in the sub-himalayan ranges, Western Ghats and Peninsular regions (GEC, MSU and GUIDE, 2002). In Gujarat, this plant was recorded from forests of North, Central and South Gujarat (Shah, 1978; Bharti, 1959; Shah, 1969; Pradeepkumar, 1993). The plant is categorized as ‘**Lower Risk and conservation dependent - LRcd**’. But the destruction of the plant under superstition and medicinal purpose may threaten its existence in future (GEC, MSU and GUIDE, 2002).

*Heliotropium rariflorum* is widely distributed in India, Afghanistan, Sudan and Pakistan. In India it is mostly reported in Gujarat, Rajasthan and Punjab states (Bhandari, 1978; Shah, 1978; Bhandari, 1990). A survey shows that, this plant was recorded from three districts of Gujarat and the
maximum numbers were found in Kachchh (GEC, MSU and GUIDE, 2002). Current status of this plant is Common, but habitat destruction is a main threat of this plant and therefore WCMC (1994) has designated it as an ‘Intermediate (I)’.

There was no much specific information about Indigofera caerulea var. monosperma. In the previous record in Gujarat, it was reported from Saurashtra (Shah, 1978), Kachchh (Sabnis and Rao, 1983) and Banaskantha districts (GEC, MSU and GUIDE, 2002). The distribution is also restricted to specific substratum. So habitat conversion is a major threat for this plant and hence it comes under ‘Rare (R)’ category (WCMC, 1994).

An ‘Endangered (E)’ plant Tribulus rajasthanensis extends up to south Gujarat and westwards to Pakistan (Bhandari and Sharma, 1992). It is restricted to drier regions of Rajasthan and Gujarat (Rao, 1981; Bhandari, 1990).

2.3.3. GIS based studies

Sharma (2001) classified the land use pattern and forest cover of the Banaskantha district by using satellite image of 1996 - 1997. The important forest patches were identified and recommendation proposed for improving the forest cover.

2.4. Conclusion

The North Gujarat Region (NGR) is well marked with the existence of open scrub, thorn forest, dry deciduous, moist deciduous along with agriculture and desert ecosystems. It supported over 1200 angiospermic plant species and 52 species of lower group taxa. It has greater heterogeneity in species composition and structure over short geographic and altitudinal variations while, it is also a residence for eight globally endemic and threatened plant species.
As literature survey suggested, the NGR is explored to a certain extent through floristic inventory and ethnobotanical studies over the past few decades. But in recent times, studies are much focused on ecological and floral diversity of Sabarkantha (Vijaynager forest, Dholani forest, patches of Wagaeshwari, Shamlaji, Rajendranagar, Adahathrol, Puskar, Abhapur, Mehru, Budharasan, Mau, Torda, Rampuri) and Meshana (Taranga hill forest). Yet, there is no study available for the entire NGR. So the present study will fill up the research gaps in NGR. It is also aimed to describe the forest types, species distribution, species diversity and abundance in different forest types, along with the critical factors for forest degradation, species loss and habitat fragmentation.