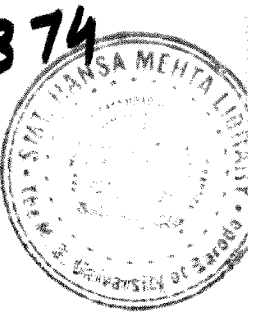

THESIS SUMMARY

DESIGNING A SOFTWARE FOR GENERATING A DATABASE, RETRIEVAL AND IDENTIFICATION SYSTEM, AND ITS EFFICACY EVALUATION FOR MAJOR TREE FORMS OF GUJARAT (BIOINFORMATICS FOR TREES)

By

Bindiya D. Oza
M. Sc.

Guided by

Prof. Yogesh T. Jasrai

Department of Botany
Faculty of Science,
The Maharaja Sayajirao University of Baroda,
Vadodara – 390 002

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The earth abounds in a range of living organisms, from depths of the sea to the tropical rain forests and from the polar icecaps to the hot springs. Over the years, the amount of work being done in each specialized branch of biological science has increased potentially. More over, with the advent of advanced methods, equipments and technologies enormous amount of knowledge with potential applications is being gathered; as a result a vast data is being generated and complied in various forms. As far as plants are concerned, the diversity is so vast and volumes of data is available for each species, therefore our traditional methods to record and analyze the data has become very tedious and difficult to handle and maintain. India is unique, not so much of its numerical species but for the range of biodiversity attributable to a variety of biogeographically and physico-environmental situation. A characteristic feature of Indian forests is the interspersion of human inhabitation with people dependant on the biological resources for their sustenance and livelihood. India has about 12% of the global plant wealth. Amongst these, there are nearly 3,000 tree species.

Gujarat has a variety of climatic and edaphic conditions. In spite of continuous onslaught on the biological resources, the overall range of biodiversity of Gujarat is still unmatched. Gujarat has many kinds of natural ecosystems due to varied environmental conditions. The Gujarat flora is representing nearly 13% of the flora of the country. Total number of species recorded in Gujarat is 4,228. These occur on land, freshwater and marine habitats. The species diversity in Gujarat as compared to the country shows that numerically algae are represented the most in the State. More than 1,900 species of algae have been reported from Gujarat of which 210 are marine macro algae. Out of 16,500 species of Fungi reported from the Indian region, only 164 species are documented from Gujarat (Anonymous, 1996). The groups like Bryophytes, Pteridophytes and Gymnosperms have the minimum number of recorded species. The angiosperm flora of the State is varied in extent and composition. According to tree census in the non-forest area done by the Gujarat state forest

department, the approximate number of trees the non forest area of the state is 2,510.33 lac (Anonymous, 2000).

The taxonomic literature has increased quantitatively to such an extent that some people called it an embarrassment. It is disturbing that one who wants to collect comparative data on any given group may find even elementary comparisons unavailable. The situation is so exasperating that Watson (1971) commented that it is easier and probably more reliable to start at ground level, making one's own observations, than to search the literature of data on salient aspects of general morphology. This, in fact, has persuaded several biologists to discuss alternative devices for more efficient storage and retrieval of information. The enormous number of organisms and the potential number of characteristics that could be recorded for each, calls for the use of modern Electronic Data Processing Equipment to store and retrieve information in meaning full configuration. Thus, the concept of use of Bioinformatics in taxonomy came in to existence. Bioinformatics, in simple terms can be considered as an application of computer technology to the management of biological information. It is the fusion of biology and computer science. The science of informatics is concerned with the representation, organization, manipulation, distribution, maintenance and use of information particularly in digital form, the fictional aspect of bioinformatics is the representation, storage and distribution of data. Bioinformatics is being used in following fields: Molecular medicine, Personalized medicine, Preventative medicine, Gene therapy, Drug development, Microbial genome applications, Waste cleanup, Climate change Studies, Alternative energy sources, Biotechnology, Antibiotic resistance, Forensic analysis of microbes, Bio-weapon creation, Evolutionary studies, Crop improvement, Insect resistance, Improve nutritional quality, Development of Drought resistance varieties, Vetinary Science etc.

The very important and one of the main branches of plant biology – Taxonomy can also assisted by bioinformatics, it can be useful as the medium to compile

the data of each species, or the data of specific area. Lots of work is being done in this direction. Online floras provide description about plants and simply by inserting the characters user can get the genus to which the plant belongs. The concept of e – herbarium has been already introduced (Jasrai *et al*, 2000) and has generated over whelming response. In addition to commonly adopted taxonomic practices, adapting information technology and preparing computer herbarium sheets of plant taxa, can further strengthen the science of taxonomy. In recent practices computers have been increasingly used in data collection, processing and integration. Computers can also be used in plant identification even if the user is not well trained botanist. Appropriate programs may be developed, which can construct a taxonomic key based on the taxonomic information about the taxa, in the same way and based on the same logic which is used by man to construct keys manually. Such keys permanently stored in a computer can be handled as above for the step wise process of identification. Simultaneous character-set identification methods can be used in which whole set of characters of the unknown plant may be fed into the computer simultaneously and a computer programme used to compare the description matches. Assemblage of the analyzed biological information into central, shareable resources is a database. It deals with the pool of information in a concerted way so as to establish, maintain and disseminate the data, providing easy – to – use software so as to access the information it contains, and designing state of the art analysis tools to visualize and interpret the structural and functional clues latent in the data.

Plenty of work is going on in this field. However, we don't have single media to access this enormous information at one desk. Now a days many institutions and experts are preparing database in their respective fields in digital form. NBRI Bioinformatics Centre is maintaining a World Database of 19,000 taxa. A CD-ROM named as 'Sasya Sahyadri' has been prepared for the trees of Western Ghats by Dr. K. N. Ganeshaiah and Dr. R. Uma Shannkar, University of Agriculture, Bangalore in 2004. Flora Europaea is available as CD-ROM

for. Digital flora of Texas is available on the internet. The scope of plant taxonomy has greatly expanded on account of our better understanding of the plant wealth with the help of Geographic Information System (GIS) and Remote Sensing. We can get the information online by just few clicks through online journals, books and paper uploaded on World Wide Web. But, the information about plants on international websites is more related to the respective area and environment. And also the information is so wide and sometimes complicated that even on the internet; it becomes tedious to gather the useful information about single plant species. Biological data is complex and interrelated. Hence the vast amount of biological information needs to be stored, organized and indexed so that the information can be retrieved and used. Therefore there should be some media to connect all the information on one site itself. The main purpose of the study is to prepare such a programme so that one can get the information about the single species at one site only which will be easy to use and is less time consuming. As a starting effort the present study has been done to generate a database for major tree forms of Gujarat state, and to produce a retrieval system as per the requirement. The study is restricted to tree forms available in Gujarat state including various aspects of bioinformatics.

Gujarat is the Westernmost State of India located between 20° 1' and 24° 7' North latitudes and 68° 4' and 74° 4' East latitudes, with an area of 1,96,024 km^2 and a coastline of 1,600 km, the longest coastline in India. Its boundaries are defined by Arabian Sea on the west, the State of Rajasthan the north-east, Madhya Pradesh on the east and Maharashtra on the south-east and south. On the north-western fringe it shares the international border with Pakistan.

To plan any type of database first we need to decide the proper method of data collection. There are two types of data i.e. primary and secondary. The primary data are those which are collected fresh and for the first time, and thus happen to be the original in character. The secondary data, on the other hand, are those

which have already been collected by someone else and which have already been passed through the statistical process. Based on the literature, studies and various data available for trees of Gujarat, a tree list was prepared. The Flora of Gujarat State was published by Shah (1978). This was first of its kind in the country. In this flora about 1,808 angiospermic taxa belonging to 155 families and 827 genera were enlisted. Total 252 tree species were recorded in Gujarat flora belonging to 156 genera and 57 families. The studies at Gujarat Ecology Commission, Vadodara renewed the interest of all concerned in the floristic exploration. Anonymous (1996) compiled all the work carried out beyond 1978 (Shah, 1978) and prepared the base line report. This report was published as - The Biological Diversity of Gujarat (1996) and the number of explored plant species reached to 2198. Kshirsagar *et al* explored South Gujarat region and seven more angiospermic plant species were recorded. Therefore the number has reached to 2,205 (Singh and Pàrabia, 2003). Based on these records, the present study involved 383 tree species belonging to 225 genera and 74 families. The families with major number of tree species are Sterculiaceae, Fabaceae, Caesalpiniaceae, Mimosaceae and Bignoniaceae. The details included in database for each selected tree species are local name, english name, description of species, identification characters, phenology, distribution, origin/native, ecology, category of threat, special characteristics, economic importance, horticultural value, medicinal value, suitable environmental conditions, agricultural value, uses etc. Trees were selected from the list on the basis of their importance in economic, medicinal, timber, NTFP (Non Timber Forest Produce) values and detailed database has been prepared for them. Exhaustive field work has been done in various parts of Gujarat to collect the plant specimen for herbarium preparation and photographs were taken with help of Sony digital camera. Some of the plant parts were also scanned by HP laserjet scanner for better close up to cover morphological characters of the plant. Regarding the need for database preparation, a small survey with some basic questions about responses of individuals from various fields on plants and trees has been conducted. The survey involved semi-structured questionnaire

(Kothari, 2003). As per survey people use the World Wide Web as an easy source of information for any subject or field. The reason is the easy availability and fast access to the data. How ever, academicians, students and researchers still refuse to rely totally on internet information doubting about the authenticity of the information. In present work the maximum information about trees of Gujarat has been included.

The database was prepared with help of scientific data from literature study and data collected during field study like photographs/images of trees and their parts and herbariums etc. The identification key-system was also prepared for important trees of Gujarat. A data on plant morphological characters was also prepared with images as a basic need for various plant characteristics. The computer software used to prepare present work includes Macromedia Dreamweaver 8.0 and PHP language. Dreamweaver 8 is the industry-leading web development tool, enabling users to efficiently design, develop and maintain standards-based websites and applications. With the help of software developers the programming of prepared database has been done for trees of Gujarat and introduced on internet by a website named **www.gujtrees.com**. The programme CD is also prepared including the database of trees, images, glossary of botanical terminology and easy to use key to indentify tree species. The software used to prepare the CD-ROM includes HTML (Hyper Text Markup Language), FrontPage, Javascript, Adobe Photoshop. The hardware requirement is windows 98/XP/2000, minimum 128 MB RAM and 20 GB hard disk. Second survey was conducted to find out the efficacy of the prepared database. People were selected from different fields i.e. academic, business, home maker and service or job. As per survey the percentage of usage of internet as the data source has been increased over the years. How ever, most of the users are from academic and industrial background and during the survey the respondents have told that the data source on the internet is getting improved. The developed software is acceptable to the each of the respondents.

The public park in the state like Sayaji Baug in Vadodara and Indroda Park in Gandhinagar are very rich in tree diversity. Indroda Park has more than 180 tree species. Universities, colleges and other institutions have large number of trees. Some trees on private / public land locations seem to date back to several decades and in part define the long term association with the society. These trees have significant specification due to their characteristics/size/age etc. Such trees can be defined as VITs (Very Important Trees) as they have special / exceptional value to the community due to their enormous size / special characteristics or long term association of the species. The city must retain VITs (except when removal is mandatory for public health / safety or welfare) as they are the assets of our cities. The main tree species in the state are *Tectona grandis, Madhuca indica, Terminalia arjuna, Terminalia bellirica, Lagerstroemia indica, Adina cordifolia, Dalbergia latifolia, Firmiana colorata, Bombax ceiba, Butea monosperma, Morinda tinctoria, Anogeissus latifolia, Boswellia serreta, Diospyros melanoxylon and Dendrocalamus strictus*. Other species which are dominant in the driest area are *Acacia nilotica, Prosopis juliflora, Prosopis cineraria, Balanites aegyptiaca etc*, Mangrove like *Rhizophora mucronata* and *Brugeria gymnorrhiza* found in the deltaic regions of the state. The species composition of Gujarat state has altered over the years. The major species like *Terminalia elliptica, Lannea coromandelica, Schleichera oleosa* has been replaced by small species like *Lagerstroemia parviflora, Acacia nilotica ssp indica, Acacia catechu, Acacia leucophloea.* This could lead the major change in the tree composition of Gujarat in future years. The reason may due to the change in rain fall pattern, soil moisture conservation, rise of demand in timber, grazing and other disturbances. At present it seems like the thorny species has taken over most of the part the state. In the non forest areas trees like *Polyalthia longifolia, Mangifera indica, Acacia nilotica ssp indica, Bauhinia variegata, Butea monosperma, Prosopis juliflora, Areca catechu, Pongamia pinnata, Cocos nucifera, Eucalyptus globulus, Ficus* spp, *Peltophorum, Cassia spp., Delonix regia* and various Palm species are dominant (Tyagi et al, 2007).

The value of trees in urban environment is now generally recognized not only aesthetically but also functionally as that help to make cities and towns agreeable places to live and work in. The value of tree varies as per its characteristics and importance like medicinal, economical, aesthetic, religious, horticultural, industrial etc. Trees act as catalyst in nature's antipollution squad. Tree alleviate dust, cleanse the air and absorbs moisture and they play the role of cooling agents and as a buffer against noise. Trees with dense foliage like *Alstonia scholaris, Ficus benghalensis, Putranjiva roxburghii, Polyalthia longifolia, Mimusops elengi, Azadirachta indica*; shrubs like *Bougainvillea, Lantana, Cassia alata, Murraya exotica, Thevetia nerifolia, Nerium odorum* can be planted in industrial areas and cities. The tree with the characteristic shape of its canopy, its habit of growing tall and slender or small and spreading, its spring bloom or fall color, the shape and size of its leaves, and its evergreen or deciduous nature is a beautiful element in the otherwise concrete structures in the landscape. No single item distinguishes a city more than its green areas, and probably our first reaction to a society is to its abundance or lack of trees. According to the type of house, its location and available space one can choose the appropriate ornamental tree to enhance the aesthetic value of the house. Trees like *Annona squamosa, Citrus limon, Manilkara zapota, Mangifera indica, Syzygium cumini, Terminalia catappa* can be grown in the backyard of houses which provides shade as well as edible fruits. Near residential areas ornamental and flowering plants can be used as hedges which increase the beauty of area as well as serve the purpose of boundary.

In developing countries, the use of synthetic drugs is at its peak but majority of the people still rely upon traditional system of medicine for health care. Countries like India and China had their own well developed traditional system of medicines. *Ayurveda* is the oldest system of healing in the world. Tree species like Neem (*Azadirachta indica*), Baheda (*Terminalia bellirica*), Amla (*Emblica officinalis*) etc are known world wide for their medicinal uses. As per the age-old practice people collect firewood from the forest. They generally

collect the dry fallen material of trees like *Tectona grandis, Holarrhena antidysenterica, Acacia nilotica ssp nilotica, Terminalia elliptica, Butea monosperma, Prosopis juliflora* etc. The *Tectona grandis* is the best for fuel because it burns for long time, however, *Holarrhena antidysenterica* and *Acacia nilotica ssp nilotica* are also good for fire. Many trees are used in different industrial areas like wood pulp in paper industry, lac production on *Schleichera oleosa*; Gum and rubber, tanning, timber and furniture making. Trees support several industries like tanning, charcoal making, furniture making, match-box and stick, plywood making, silk industry, wood carving etc.

Along with art and craft, literature too mirrors a culture, and there are innumerable Indian literary references to trees. In many ancient cultures, trees held sacred. Long passages in the Mahabharata and Ramayana describes the kalpvriksha. Krishna recalls the Kadamba (*Neolamarckia cadamba*), under whose boughs he played his flute and in to whose branches he escaped after stealing the gopi's clothes. He is also associated with the night-fragrant harsingar or Parijat (*Nyctanthes arbor-tristis*), which is said to have stolen from the garden of Indra, the king of Gods. The Buddhist Jataka tales tell of similar tree inhabited by deities who feed and clothe weary travelers. Kalidasa in Shakuntala refers to kindly forest spirits who cared for the simple hermit girl. Given the religious and cultural ethos, common beliefs surrounding trees are legion. The Ashoka (*Saraca asoca*) dispels sorrow, the Neem (*Azadirachta indica*) bestows happiness. Women unable to conceive must pray to the Peepal (*Ficus religiosa*) to be blessed with offspring. Weddings are arranged between trees – in South India the Peepal (*Ficus religiosa*) and Neem (*Azadirachta indica*) are grown closer and ceremonial marriage is solemnized between these two.

It is an acknowledgement that man and tree are closely connected in their life and fate, an aspect of the wider interdependence of man and nature. Yet, in somewhere in this complex coexistence, humans have turned exploiters. The 20th century had seen a grave annihilation of these very trees and forests, a plunder so terrible that vast tracts of precious forests had been disappeared over the years. It might be the time to rekindle some of the religious, emotional and reverential bonds that we had very recently witnessed in the past. A time has come for man and trees to become friends once more.

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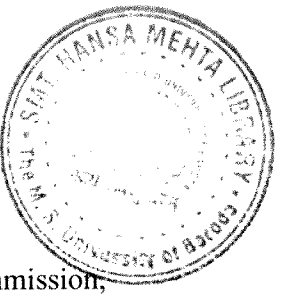
Place: Vadodara

(Bindiya D. Oza)
Research Student

(Prof. Yogesh. T. Jasrai)
Research Guide

Head,
Department of Botany

Dean,
Faculty of Science



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