

Indian Integrated Plant Taxonomic Information System: A Conceptual Framework

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ABSTRACT

Taxonomic is one of the oldest and basic scientific work on living organisms. This basic research is the foundation for all modern fields of research. Taxonomic research has generated huge amount of knowledge in India which unfortunately is scattered and unorganised largely due to lack of coordination between different scientific government and non-government organisations. This paper highlights the value of taxonomic information, problems faced in accessing the information and proposes the need for the development of an Integrated Plant Taxonomic Information System (IPTIS) at national level to meet the growing needs of taxonomic information.

Keywords: Botanical Survey of India, databases, Indian Integrated Plant Taxonomic Information System (IIPTAXIS), information systems, libraries, plant taxonomy, systematics

1. INTRODUCTION

The Swiss botanist, A.P. De Candolle coined the term taxonomy in Geneva in 1813. Taxonomy is basically a sub-division of an agglomerate subject termed Systematics. Systematics has been variously defined by many authors. But the most preferred definition is given by Simpson, who defines systematics as "the scientific study of the kinds and diversity of organisms and of any and all relationships among them".¹ In other words systematics is the study of biological diversity and its origins, focusing on understanding evolutionary relationships among organisms, species, higher taxa, or other biological entities such as genes, and the evolution of the properties of taxa including intrinsic traits, ecological interactions, and geographic distributions. Systematics is also concerned with the development of methods including numerical methods, for various aspects of phylogenetic inference and biological nomenclature/classification. A.P. De Candolle defined taxonomy as the study of the laws and principles underlying a system of classification.² The term classification has a dual meaning in taxonomy, as it does colloquially. It refers to both, a process and a product. As a process, it is an act of grouping and ranking organisms based on criteria of relationship, and as a product, it is the resultant hierarchy of taxa. The importance of classification to biology and society results from both the

process and the product of classification.³ Classification consists of two associated activities, namely, identification and nomenclature. It involves referring an individual specimen to a previously classified and named group.⁴ The naming of groups of organisms and the rules governing the application of these names is called nomenclature.⁵ Swingle made a distinction between systematics and taxonomy with the latter regarded as dealing with phylogenetic classification, and the former being broader to include taxonomy and nomenclature.⁶ Many biologists still equate taxonomy with systematics.⁷ In fact, Crowson concludes that "the words classification, systematics, and taxonomy are now commonly treated as synonyms, an example of the confusion and the carelessness in the use of words which is prevalent in so much modern writing".⁸ Table 1 outlines the methodology of systematics. Following the nature of other scientific disciplines, plant taxonomy has also inter-disciplinary approach. Plant taxonomy applies a number of subjects tool to diversify into various domains of research like Cytotaxonomy, Chemotaxonomy, Molecular Taxonomy, Numerical Taxonomy, Taxonometrics, etc.

2. VALUE OF TAXONOMIC INFORMATION

In 1992, 150 government leaders signed the Convention on Biological Diversity, which recognised the crucial role of taxonomy in promoting sustainable

Table 1. Outline of methodology of systematics

<p>I. Accumulation of Comparative Data</p> <p>A. From the Organism</p> <p>(i) Structures</p> <p>(ii) Processes (interactions among structures)</p> <p>B. From the Organism-Environment Interactions</p> <p>(i) Distribution</p> <p>(ii) Ecology</p> <p>II. Use of comparative Data to Answer Specific Questions</p> <p>A. Classification (most predictive system of classification at all levels)</p> <p>(i) Method and result of grouping of individuals</p> <p>(ii) Level in the taxonomic hierarchy at which the groups should be ranked</p> <p>B. Process of Evolution</p> <p>(i) Nature and origin of individual variation</p> <p>(ii) Organisation of genetic variation within populations</p> <p>(iii) Differentiation of population</p> <p>(iv) Nature of reproductive isolation and modes of speciation</p> <p>(v) Hybridization</p> <p>C. Phylogeny</p> <p>(i) Mode</p> <p>(ii) Time</p> <p>(iii) Place</p>

Source: Stuessi, F. (2002). *Plant taxonomy: systematic evaluation of comparative data*, p.7

development.⁹ The impact of taxonomic information has both theoretical and practical implications. For ease of discussion, we can divide the usefulness of information generated by the taxonomists into two categories, namely scientific and societal.

2.1 Scientific Value

Scientific usefulness can be described as:

- ✘ One of the most pertinent contributions is the role that taxonomy plays as the “data processing system for biology”.¹⁰ Taxonomy allows construction of framework with the millions of pieces of data collected by the taxonomists from the natural world to arrange the total available biological information, the data about life. In simpler terms, taxonomy inventorises and catalogues the sum total of plant and animal biomass.
- ✘ Systematics also helps to understand the process of evolution, which is information used by other areas of biology. The microprocesses of evolution including individual variability, population variation, reproductive isolation, modes of speciation, etc., are revealed through systematic studies.
- ✘ Systematics studies also help reveal patterns of evolution or phylogenetic relationships, which stimulate ideas on the origin of life, the development of ecological zones through geological time scale.
- ✘ Ecology, Phyto-geography, Palaeobotany, etc., are virtually dependent on the data generated in systematic studies.

2.2 Societal Value

Societal usefulness can be described as:

- ✘ The most important societal value of taxonomic information is in its role in conservation of natural resources, loss of biodiversity, and upholding the issue of sustainable development. As Herdberg puts it: “In a world with rapidly increasing population pressures and accelerating exploitation it is imperative to utilise biological resources sagaciously on a sustained yield basis, and to this end we must have all adequate knowledge of its flora”.¹¹
- ✘ Systematics helps to identify the new economic plant resources like food, medicinal plants, and industrially useful plants to enrich our existing knowledge base. Thus, it has an immense potential to ensure global food security, sound health, and boost our agriculture-based economy.
- ✘ Biological control of exotic plants, searching solution for land reclamation, phyto-remediation, etc., can be done utilising the taxonomic information.
- ✘ Before any industrial projects, building any dams, canals, etc., systematists play an indispensable role by advising on possible ecological impact on organisms through Environmental Impact Assessment (EIA) studies.
- ✘ The knowledge and techniques gained by the systematists through study of relationships of wild species can often be used to improve our existing

cultivated food crops by similar methods of cytogenetics and artificial selection.

- ✘ Identification and documentation of ethnobotanical information.

3. STAKEHOLDERS OF TAXONOMIC INFORMATION

The consumers of taxonomic information are the taxonomists themselves, scientists, ecologists, environmentalists, agriculturists, industrial sectors, policy makers, engineers, government bodies and all others who require biodiversity-related information.

4. PRESENT SITUATION AND PROBLEMS

The present taxonomic information infrastructure in India is not at all satisfactory. The various sources of information are scattered and mainly limited to individual institutions. As there is no common platform for sharing these important taxonomic data at the national level, timely retrieval hampers research and development. The only visible initiative taken by the Ministry of Environment and Forests (MoEF) is the establishment of the Environmental Information System (ENVIS), which is a decentralised information network consisting of 76 network partners out of which 46 are subject-specific and 30 are on State-related issues. This information network basically caters to general environment-related information demands and do not include any comprehensive national floral or taxonomic inventory.

There are some ENVIS institutional taxonomic specific centres like Botanical Survey of India for Floral Diversity; Centre for Ecological Sciences; IIS for Western Ghats Biodiversity; GB Pant Institute of Himalayan Environment and Development for Himalayan Ecology; and Foundation for Revitalisation of Local Health Traditions for Conservation of Medicinal Plants.¹² But the content of these databases are either region-specific or area specific. For example, the Centre of Floral Diversity contains information on rare and endangered plants, medicinal plants, allergic pollen, experts and RET taxa., assessment of coastal plant diversity in Indian mangroves in India, wetlands, etc.¹³ Therefore, the consumers of taxonomic data are facing enormous problems, known as 'taxonomic impediment': The taxonomic impediment is because:

- ✘ More than any other science, the domain of systematic biology is utterly dependent on the historical literature of published descriptions of species; publication in print still determines the legitimacy of naming the credit for new discoveries. Therefore, proper access to retrospective published literature is very important but due to its scattered

nature, at present the researchers are facing difficulties in retrieving.

- ✘ Lack of any centralised database, there are chances of duplication of research.
- ✘ Time lag.
- ✘ Biopiracy.

5. INFORMATION SYSTEM: THE CONCEPT

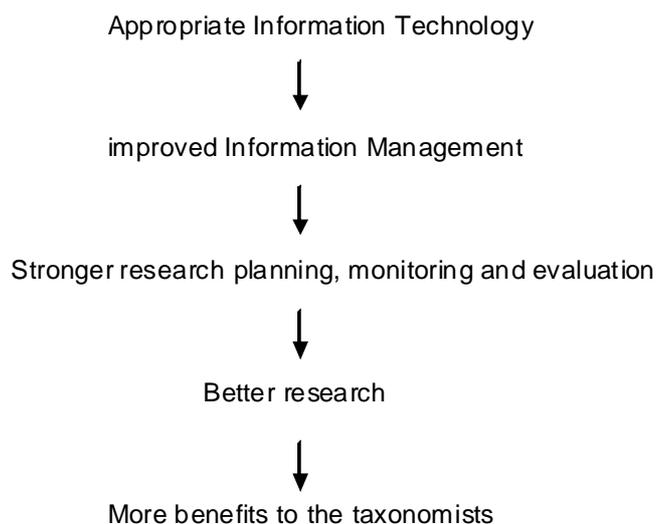
Information Systems are type of communication systems, which select, organise, store, and disseminate public knowledge to the users as per objectives laid down by the Information Programmes. An information system is composed of all the components that collect, manipulate, and disseminate data or information. It usually includes hardware, software, people, and communication systems. Activities pertaining to an information system include inputting of data, processing of data into information, storage of data, and information and production of services and products.

Before setting up any information system, there should be a declared information programme, which specifies the objectives to be achieved, infrastructure required, and sources of funds for setting up the information system.

6. INDIAN INTEGRATED PLANT TAXONOMIC INFORMATION SYSTEM: PROPOSED STRUCTURE

An information system on plant taxonomy integrated with taxonomic details, identification tools, traditional knowledge and economic perspectives can probably be a big step towards effective dissemination of huge amount of taxonomic data being generated at the expense of public exchequer. It will not only bridge the gap between the info-rich and info-poor sectors of the society but also enrich the nation in its scientifically intellectual capital.

In the Fourth National Report in the Convention on Biological Diversity, Government of India has also identified one of the areas that need urgent attention of all concerned stakeholders in the Indian context is "Integrated database development at all organisational and management levels to effectively utilise the data sets as one of the important tools for decision support systems and establishment of a national information system".¹⁴ The system will act as a common platform for collection, processing, storage and dissemination of taxonomic information, and digital repository of national phytodiversity will not only reduce "taxonomic impediment" in research but also encourage conservation and sustainable development. Utilisation of information system has also been demonstrated by Annon¹⁵ as:



7. OBJECTIVES OF INDIAN INTEGRATED PLANT TAXONOMIC INFORMATION SYSTEM

The main objectives of IIPTAXIS are:

- (a) Designing and organising user-oriented and automated information system.
- (b) Retrieving relevant data and information system in a user-friendly way.
- (c) Providing data and information support to research and action-aimed for sustainable national development.
- (d) Dissemination of information globally through network.
- (e) Sharing the resources at an optimum level.

8. MODEL OF THE INFORMATION SYSTEM

The apex body would be Botanical Survey of India (BSI) along with its 11 regional centres under MoEF. It will coordinate with the other network partners like Botany Departments of various Universities; National Botanical Research Institute, Lucknow; GB Pant Institute of Himalayan Environment and Development; and Agricultural Universities. BSI Headquarters will host the main server. All the regional centres will house server class machines for every regional database. All servers will be pooled together to access databases of respective regions through a centrally monitor server grid technology using VPN (Virtual Private Networking). The public access to the database may be provided through a central server or distributed network with metadata on a web portal. The regional centres will have a crucial role in collecting, processing, managing, monitoring, and coordinating taxonomic data generated by the respective centres in the states under its jurisdiction. In other words, BSI will act as a national clearing house with respect to

taxonomic data. Figures 1 and 2 depict the model of the proposed Plant Taxonomic Information System and different modules of the Information System, respectively. The network will comprise: Libraries network; Herbarium/Museum network; and Botanical Gardens network.

The information system will comprise several centralised databases. A database may be defined as a collection of inter-related data stored together without redundancy to find multiple applications. It is in fact, an array of data organised in a logical manner with minimum functional and maximum tolerable redundancy, indexed in a way most optimal for the kind of application the user is interested in. The database environment can be classified into operational environment and decision-support environment. The primary aim of operational environment is towards online performance and data integrity, whereas the decision-support environment is aimed at user flexibility. Relevant data can be populated to form the following types of databases:

8.1 Database of Indian Plants

India ranks 10th among the major plant rich countries of the world. Three out of the 34 biodiversity hotspots, viz., Himalaya, Western Ghats and Sri Lanka and Indo-Burma are in the region. In India, there are about 17,527 vascular plant species including 67 gymnosperms and 1200 pteridophytes. The cyptogams includes 2500 bryophytes, 2223 lichens, 14500 fungi, 7175 algae and 850 viruses and bacteria. India, known for its rich heritage of biological diversity, has so far documented over 45,500 species of plants in its 10 bio-geographic regions. Besides, it is recognised as one of the eight vavilovian centres of origin and diversity of crop plants, having more than 300 wild ancestors and close relatives of cultivated plants, which are still evolving under natural conditions.¹⁴ Keeping this rich diversity in view, the following databases may be populated:

- ✘ Database of live collections conserved in BSI and other gardens.
- ✘ Database of phytodiversity of protected areas.
- ✘ Database of phytodiversity of fragile ecosystems.
- ✘ Database of ethnobotanical information (plant based folklores).
- ✘ Database of medicinal plants.
- ✘ Database of gymnosperms.
- ✘ Database of pteridophytes.
- ✘ Database of bryophytes.
- ✘ Database of lichens.
- ✘ Database of fungi.

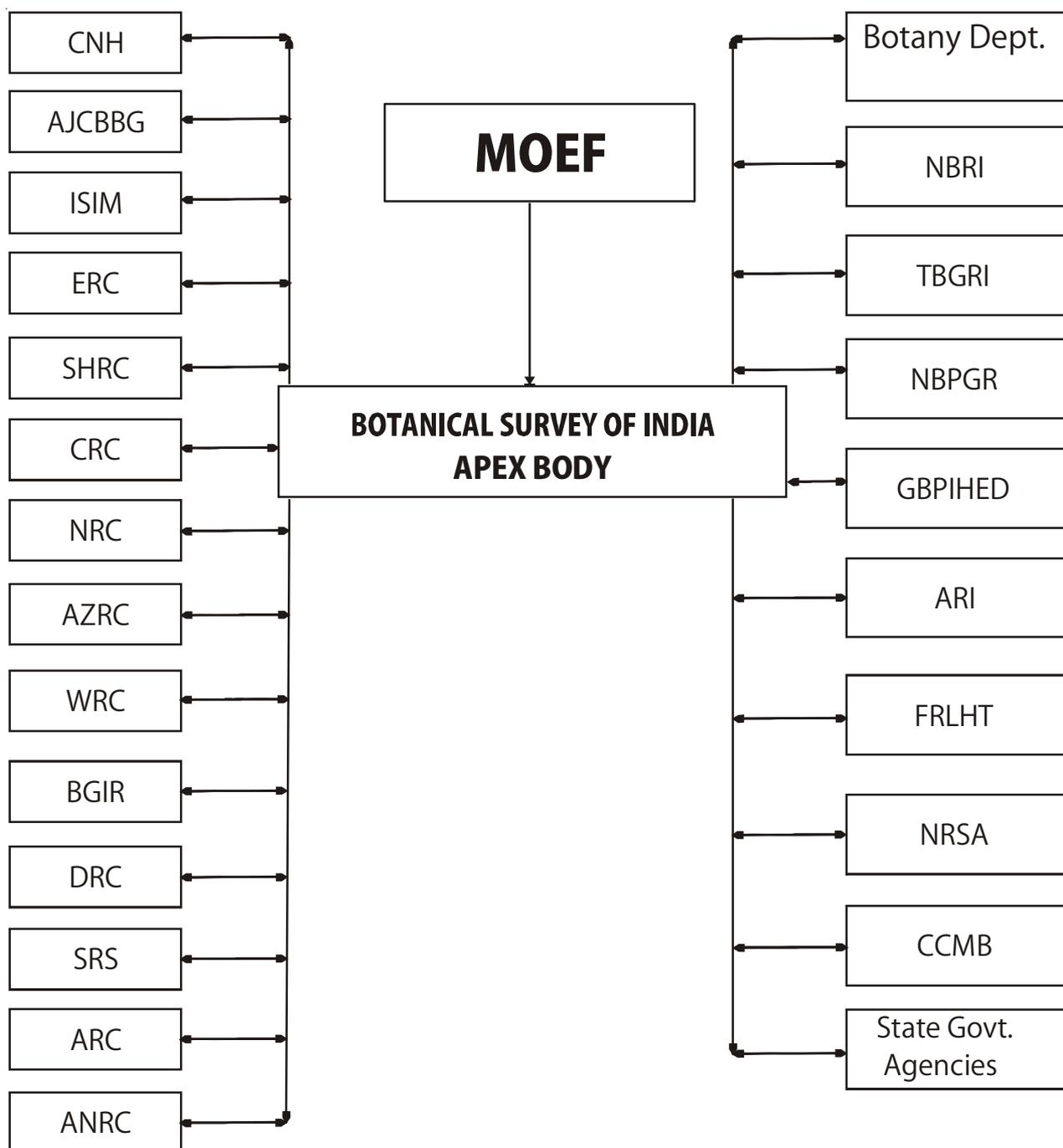


Figure 1. Information system model for plant taxonomy in India.

Abbreviations: MoEF: Ministry of Environment & Forests; CNH: Central National Herbarium; AJCBBG: Acharya Jagadish Chandra Bose Botanic Garden; ISIM: Industrial Section of Indian Museum; ERC: Eastern Regional Centre, Shillong; SHRC: Sikkim Himalayan Regional Centre, Gangtok; CRC: Central Regional Centre, Allahabad; NRC: Northern Regional Centre, DehraDun; AZRC: Arid Zone Regional Centre; WRC: Western Regional Centre, Pune; BGIR: Botanic Garden of Indian Republic, Noida; DRC: Deccan Regional Centre, Hyderabad; SRC: Southern Regional Centre, Coimbatore; ARC: Arunchal Regional Centre, Itanagar; ANRC: Andaman & Nicobar Regional Centre, PortBlair; NBRI: National Botanical Research Institute, Lucknow; TBGRI: Tropical Botanic Garden & Research Institute, Palode, Kerala; NBPGR : National Bureau of Plant Genetic Resources, New Delhi; GBPIHED: GB Pant Institute of Himalayan Environment & Development, Almora; ARI: Agharkar Research Institute; FRLHT: Foundation for Revitalisation of Local Health Traditions; NRSA: National Remote Sensing Agency, Hyderabad; CCMB: Centre for Cellular and Molecular Biology, Hyderabad.

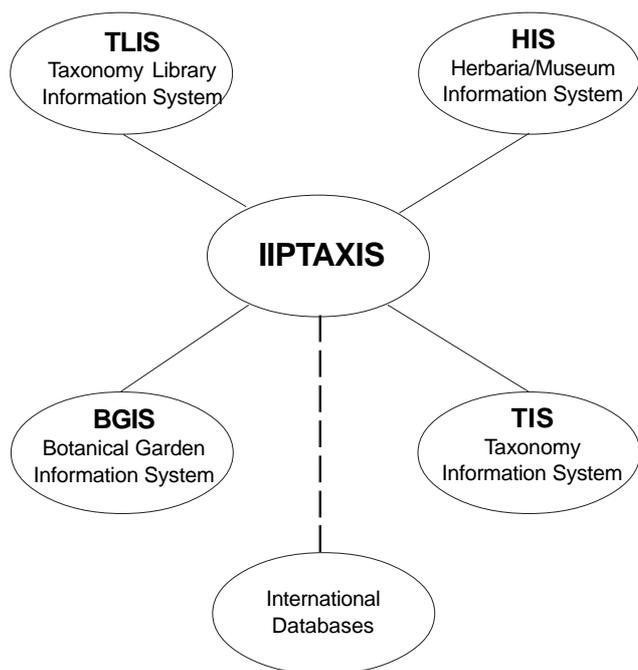


Figure 2. Modules of Indian integrated plant taxonomic information system.

- ✂ Database of algae.
- ✂ Database of Indian trees.
- ✂ Databases of economically important plants like fibre-yielding, oil-yielding, etc.
- ✂ Database of indicator plants.
- ✂ Database of phytoremediation plants.
- ✂ Database of invasive plants.

8.2 Virtual Herbarium

The herbarium plays a key role in floristics and for many is regarded as synonymous with traditional taxonomy (herbarium taxonomy). The essence of a herbarium is that like other museum collections, it provides the physical vouchers of living organisms, knowledge of which is essential for our understanding, conservation, and use of plant diversity. Herbarium collections provide baseline data about the extent and distribution of plant diversity.¹⁶⁻¹⁸ They also provide a near-permanent record of taxonomic concepts and the ways in which they have changed for a particular taxon.¹⁹ The herbarium of the future will be dramatically different and the concept of "virtual herbarium" has already come into being. It comprises primarily an interactive web front-end linked to a shared scientific names database with remote Internet links to distributed specimen and other taxon or specimen-associated datasets in the herbaria.

8.3 Bibliographical Database

Bibliographical database will integrate all the publications related to taxonomy, systematics, ethno-

botany, and other related areas produced by the Indian scientists and researchers. Classical and rare retrospective taxonomic literature may be digitised and made available through this platform. Family-specific bibliographies with minimum bibliographic elements may be compiled to channelise the huge information flow. The most controversial issue of making primary research output into open access (OA) can be debated at all levels to come into a consensus. In fact, the Working Group on Libraries of the National Knowledge Commission set up by the Government of India recommends that: to enable equitable and universal access to knowledge resources, it is important to create more digital resources which can be shared. The concept of an "information commons" i.e., "resources shared by a community of producers and consumers in an OA environment" needs to be promoted. It strongly recommends that peer-reviewed published research papers resulting from publicly funded research in India must be available through open access channels, subject to copyright restrictions.²⁰ In this regard, BSI Libraries could act as a National Repository of bibliographic records related to plant taxonomic literature with uploading and downloading facilities.

The bibliographic databases may be of the following types:

- ✂ Databases of rare and classical full-text taxonomic literature without copyright.
- ✂ Databases of books (with location).
- ✂ Database of journal articles with restricted access from arrangement with publishers.
- ✂ Database of grey literatures like conference proceedings, reports, etc.

8.4 Image Database

Image databases will consist of illustrations, drawings, and photographs of plants for aiding identification process.

9. LIBRARY DATABASE

Library databases will integrate all the bibliographic details along with location of the holdings not only in BSI libraries, but also in other partner institutions. The union catalogue thus formed will be a comprehensive record of the nation.

9.1 Redefining the Roles of BSI Libraries

Under the proposed information system, BSI libraries will have to take proactive role in integrating the following elements of the information system in unison:

- (i) National Botanical Journals Consortium partnering all the 11 regional centres to reduce duplication and

optimum utilisation of funds. In this regards, CSIR model can be followed. In this connection, Madan S. Rana has proposed a consortium for all the MoEF libraries.²¹

- (ii) Union catalogue of all the books, monographs, journals and other documents of all centre libraries. In this regard, initiative has already been taken to set up a network of BSI libraries by the National Informatics Centre, New Delhi, by using e-Granthalaya, open source software developed by NIC.
- (iii) Setting up of an institutional repository gathering all the research output by the scientists and its availability in OA by using Open Source software like Greenstone, Dspace, etc.
- (iv) Digitisation of pre-linnaean publications. heritage publications and drawings should be digitised and could be part of Biodiversity Heritage Library Project (draft report of the Task Force constituted under Prof. Madhav Gadgil to make recommendations to the Government of India for strengthening of Botanical and Zoological Surveys of India).
- (v) Collection of local grey literature on floristics diversity.
- (vi) Digital archive of tour reports undertaken by the scientists for survey and exploration.
- (vii) Compilation and documentation of bibliographies on specific families and genera.
- (viii) Union catalogue of theses and dissertations.
- (ix) Digital archive of projects undertaken, reports, and the outcome.
- (x) CD-ROM library of photographs of plants for identification.
- (xi) Development of a special classification scheme and controlled vocabulary for effective information management in plant systematics and taxonomy.
- (xii) Coordination with state-level institutions and agencies involved in the research for procuring literature.

10. DATABASE OF ENDEMIC AND RET SPECIES OF INDIA

The unique features of the plant diversity, among others, include 60 monotypic families and over 6000 endemic species. Recent estimates indicate the presence of over 256 globally threatened plant species in India.¹⁴ Therefore, access to authenticate information in this regards will help to justify conservation efforts.

11. SECONDARY SERVICES

The secondary services generally direct the users to the primary sources should include the following databases:

- ✘ Databases of taxonomists active in this field of research.
- ✘ Directory of institutions along with their addresses, active research areas, and information about projects undertaken and completed.

12. BOTANICAL GARDENS NETWORK

It will be a database of all the experimental botanical gardens, orchidariums under BSI, and other institutions. Besides the Database services, other information services like translation service, referral services, document delivery services, current awareness services, selective dissemination of information service, press clipping, bibliography services and various communication service between the peer groups like Blogs, Forums, etc., can also be integrated. The information retrieval can be affected by developing a cross-platform common search engine extracting all related information from all the databases for a particular query. This National Database should be linked with major international databases like International Plant Name Index (IPNI), Index Fungorum, Algaebase, etc.

13. CONCLUSION

Indian Integrated Plant Taxonomic Information System will certainly be able to fill the information voidness in the field of plant taxonomy and related areas. The collection, processing, storage, and dissemination of taxonomic data can be done systematically to the right person at the right time. IIPTAXIS will not only serve the information need of the nation but also can go a long way to mitigate environmental degradation, promote conservation along with sustainable development.

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