HimFlorIS – an information system for flora in Himachal Pradesh, India

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The *himFlorIS* is an information system for flora in Himachal Pradesh (HP). At present, it provides information on 1141 plant species distributed across 49 landscape elements (LSE) in the state. It is based on the floristic survey of HP during 2003–2009. It provides information regarding LSE, LSE types, physiographic factors, abundance of the species at a particular location, geographical locations of a plant on the map, taxonomic classification of the species along with its photographs and ethno-botanical uses.

Keywords: Biodiversity, database, flora, ecology, survey.

AT the global level, many databases have been developed such as *Species 2000* and the Integrated Taxonomic Information System (ITIS) collaborative *Catalogue of Life* (www.gbif.org)[1]. The vPlants was developed for the Flora of Chicago[2]. *Index Herbariorum*[3] provides information on the herbaria of the world and the specimens housed in them. The Electronic Plant Information Centre (EPIC) (http://www.kew.org/herbcat) provides information on floral resources housed in the Kew herbarium. The Medicinal and Aromatic Plants Programme (MAPPA) (http://www.mappa-asia.org/index.pH.P.?id=94&key=medplant_db) holds information on medicinal plants of Asia that can be searched online. The *Medphyt* (http://www-itec.uni-klu.ac.at/~harald/medphyt/) provides information on flora of Europe.

In India, *Floral Resources of Karnataka*[4,5] and *Sasya Sahyadri*[6], databases on flora of western ghats, have been developed by the University of Agricultural Sciences[7]. Electronic catalogue[8] is the web interface developed by National Chemical Laboratory, Pune for information on microbes, plants, animals, etc. The Traditional Knowledge Digital Library involves documentation of traditional knowledge available in public domain from the literatures related to Ayurveda, Unani and Siddha (http://www.tkdl.res.in). The Indian Bioresources Information Network is a national level programme launched by the Department of Biotechnology, Government of India to develop a digital database of the bioresources of the country (http://www.ibin.co.in).

For effective conservation and planning, information on diversity, variability, distribution and volume of resources in the target area[9] is a prerequisite. And more importantly, this information should be easily and properly available. It has often been pointed out that biodiversity information is not properly retrievable so as to fulfil the goal of conservation[10,11]. Keeping this backdrop, a database *himFlorIS* has been developed by the Institute of Himalayan Bioresource Technology, Palampur. The database, presently developed in the form of desktop application is being converted into web-based application for wider disseminations.

The *himFlorIS* is based on observations recorded from natural forest area for about six years in Himachal Pradesh (HP) in western Himalaya. HP lies between 30°22′44″N to 33°12′40″N lat. and 75°45′55″E to 79°04′20″E long. and occupies an area of 55,673 sq. km. It is bounded by Jammu and Kashmir in the north, Haryana in the south, Punjab in the west and Uttarakhand in the southeast. In the northeast, it shares an international boundary with China.

The floristic surveys were conducted based on uniform resolution grid of 0.1° created for entire HP. Various landscape elements (LSEs) were identified within each grid. The LSEs were named after dominant tree species on the basis of their density in respective LSE types. LSE type is defined as the smallest homogenous unit visible at the spatial scale of a landscape, e.g. a forest LSE dominated by *Pinus roxburghii* has been referred to as *Pinus roxburghii* LSE type. A total of 6103 quadrats were laid following 446 transects across the LSEs using quadrat method suggested by Mishra[12], and Mueller-Dombois and Ellenberg[13]. The size of the quadrats for tree, shrub and herb was taken as 10 × 10 sq. m, 5 × 5 sq. m and 1 × 1 sq. m respectively. The population of plants was measured in terms of frequency and density using standard formulae[13] within each quadrat. The geographical coordinates and altitude of each location were recorded using global positioning system handsets. Ecological attributes such as moisture, light condition, slope, aspect, etc. within each LSE were recorded using standard instruments for measurement of such attributes. The ethnobotanical information was gathered by interviewing local vaids, traditional practitioners, etc. and also from published literature. The botanical classification of plants has been adopted from 'Bentham and Hooker system' of classification of plants[14]. Photographs of the plants have been provided primarily from field photography and other sources such as literature, Internet, etc.

The front end of the *himFlorIS* has been prepared using Visual Basic 6.0 programing language for the query and display of the information. The application can run on PC with PIII or PIV processor and 256 MB RAM on Windows XP Professional/Windows 2000/Windows 2003 server. The information gathered from the field was entered in MS-Access database management system, which also served as back-end of the software. All the tables are linked through primary keys[15] with one-to-one

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Table 1. Interface for data search and their functions in *himFlorIS*

Modules of *himFlorIS* interface	Functions
LSE details	LSE, LSE types, physiographic factors (latitude, longitude, altitude, vegetation zone, slope, aspects)
Species distribution map	Geographical locations of plants on the map of Himachal Pradesh
Species details	Botanical classification and ethno-botanical uses

Figure 1. User interface of *himFlorIS*.

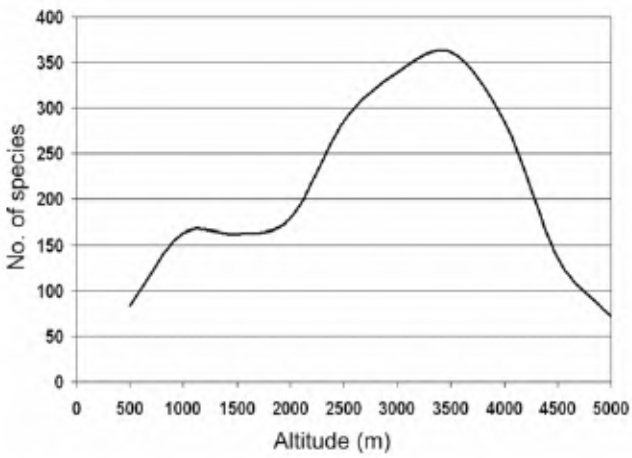

Figure 2. Altitudinal distribution of plant species.

and one-to-many relationships[16]. The *himFlorIS* consists of three user interfaces such as LSE details, species distribution map and species details (Figure 1). Data controls[17] have been used for linking of interfaces with back-end for easy and fast retrieval of the information. Each user interface contains a group of modules for data search and several other functions (Table 1).

Collating information based on ground surveys and ecological sampling makes *himFlorIS* a pioneer and unique application. It contains primary information on 1141 plant species (129 tree, 207 shrubs, 805 herbs) distributed in 49 LSEs across HP. The *himFlorIS* comprises 6.52% of the Indian flora and 32.6% of the flora of HP. Of the available records, maximum representation is from Lahual–Spiti (36.7%), Kinnaur (35.4%) and Chamba (19.1%) districts of HP followed by Kangra (13.9%), Mandi (10.8%), Kullu (9.9%), Sirmaur (6.9%), Solan (5.8%), Hamirpur (4.3%), Una (3.7%), Shimla (3.2%) and Bilaspur (2.9%) districts. Besides, it has information on 45.9% of critically endangered, endangered and vulnerable plant species reported from HP[18] (Table 2). Comparative statistics for the 20 most dominant families reported from HP[19] are shown in Table 3.

Table 2. Critically endangered, endangered and vulnerable species in *himFlorIS*

Plant	Status
Aconitum heterophyllum	Critically endangered
Dactylorhiza hatagirea	Critically endangered
Arnebia euchroma	Critically endangered
Betula utilis	Endangered
Picrorhiza kurrooa	Endangered
Angelica glauca	Endangered
Dioscorea deltoidea	Endangered
Ephedra gerardiana	Endangered
Jurinea dolomiaea	Endangered
Meconopsis aculeata	Endangered
Podophyllum hexandrum	Endangered
Rheum emodi	Endangered
Hyoscyamus niger	Endangered
Zanthoxylum armatum	Endangered
Bunium persicum	Vulnerable
Aconitum violaceum	Vulnerable
Bergenia stracheyi	Vulnerable
Ferula jaeschkeana	Vulnerable
Heracleum lanatum	Vulnerable
Hippophae rhamnoides	Vulnerable
Hyssopus officinalis	Vulnerable
Polygonatum multiflorum	Vulnerable
Polygonatum verticillatum	Vulnerable
Rheum spiciforme	Vulnerable
Rhodiola heterodonta	Vulnerable
Rhododendron anthopogon	Vulnerable
Rhododendron campanulatum	Vulnerable
Valeriana jatamansi	Vulnerable

Table 3. Family-wise comparison for dominant species reported from Himachal Pradesh

Family	No. of Species in *himFlorIS*	No. of species in HP flora[18]	Percentage of species of HP flora available in *himFlorIS*
Asteraceae	135	328	41.16
Poaceae	97	327	29.66
Fabaceae	71	278	25.54
Rosaceae	53	157	33.76
Scrophulariaceae	25	138	18.12
Lamiaceae	45	136	33.09
Cyperaceae	22	125	17.60
Ranunculaceae	32	116	27.59
Apiaceae	27	92	29.35
Brassicaceae	31	83	37.35
Caryophyllaceae	21	65	32.31
Polygonaceae	35	65	53.85
Gentianaceae	16	16	100.00
Orchidaceae	11	59	18.64
Boraginaceae	21	52	40.38
Euphorbiaceae	7	49	14.29
Liliaceae	15	47	31.91
Onagraceae	9	44	20.45
Primulaceae	5	42	11.90
Saxifragaceae	9	36	25.00

The occurrence of plants in a region can be linked to many ecological factors and the altitudinal gradient is well known as one of the decisive factors[20]. The analysis of the present data when done at an altitudinal interval of 500 m (ref. 21) revealed occurrence of maximum number of species and families at 2000–3500 m altitudinal range. Overall, landscapes at 3000–3500 m have highest number of unique species. The distribution pattern showed a hump shaped curve having lesser number of species at lower altitude, higher number of species at mid-altitudinal range and again lesser number of species at higher altitude ranges (Figure 2). The Asteraceae family showed its dominance at all the altitudinal ranges except up to 500 m, where plants of Fabaceae family were dominant.

The actual field derived information on population and ecological attributes of the plants species will be of great interest to researchers, managers and concerned people working on plant biodiversity. The geographical distribution of these plants on the map with an accuracy of ± 5 m is another unique feature of this application that has been developed in Visual Basic environment. Geographic information system software is generally needed to plot geographical coordinates but *himFlorIS* is an independent standalone application. Further, *himFlorIS* provides information on diverse plant resources as well as species specific distribution and density of plants in HP.

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What drives the increased phytoplankton biomass in the Arabian Sea?

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The seasonal variability of phytoplankton biomass in the Arabian Sea, though a well researched topic, its inter-annual variability is less explored and understood. Analysis of the satellite-derived chlorophyll pigment concentration in the Arabian Sea during 1997–2007 showed a weak increasing trend. Contrary to the earlier hypothesis, our analysis showed that this increased phytoplankton biomass was not driven by the strengthening winds during summer monsoon. In fact, the basin-averaged chlorophyll concentrations during summer monsoon tend to decline, whereas those in September–October and during the winter monsoon showed an increasing trend. Based on the analysis of wind and aerosol optical thickness data, we attribute the increased phytoplankton biomass during September–October to dust-induced iron fertilization when there is sufficient buildup of nitrate in the upper ocean. During winter, the enhanced evaporative cooling under the strengthening winds led to the increased convective mixing. Subsequent supply of subsurface nutrients to the euphotic zone coupled with the increased dust delivery support the observed increase in phytoplankton biomass during winter.

Keywords: Aerosol optical thickness, chlorophyll pigment concentration, iron fertilization, monsoon wind, nutrients, upwelling.

THE Arabian Sea is one of the most biologically productive regions of the world oceans[1]. Being in the tropical region and subjected to seasonally reversing monsoonal wind system, the biological productivity of the basin shows strong seasonality with blooms occurring in summer monsoon (June–August) and winter monsoon (December–February). The summer bloom is driven by upwelling along the coasts of Somalia, Arabia and the southern parts of the west coast of India[2–4]. In addition to coastal upwelling, processes such as wind-mixing, lateral advection, Ekman pumping, mesoscale eddies and filaments (see Lee *et al.*[5] and the references therein) also play an important role in supplying nutrients to the euphotic zone during summer. The winter bloom occurs due to winter-cooling and convective mixing[6–9]. During spring-inter monsoon (March–May) these waters are largely oligotrophic with very low chlorophyll pigment concentrations, whereas the fall-intermonsoon (September–November) representing the tapering phase of the summer monsoon sees rapidly declining chlorophyll pigment concentrations. The seasonality of the phytoplankton blooms and the associated high biological productivity of the Arabian Sea are well researched and understood phenomena (see for e.g. Banse[6], Smith[10] and the references therein, Prasanna Kumar *et al.*[11], Wiggert *et al.*[12]). However, the inter-annual variability of the phytoplankton biomass in the Arabian Sea remains less explored and understood. In a recent study, Goes *et al.*[13] argued that the increase in the phytoplankton biomass in the western Arabian Sea during 1997–2003 was driven by the strengthening of surface winds and enhanced upwelling due to the strengthening of the land–ocean thermal gradient associated with declining winter and spring snow cover over Eurasia. Subsequently, Prakash and Ramesh[14] showed

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