OPEN ACCESS AND BIODIVERSITY CONSERVATION: CHALLENGES AND POTENTIALS FOR THE DEVELOPING WORLD

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ABSTRACT

Access to and sharing of data is essential for biodiversity conservation. However, workers from developing nations that harbor rich biodiversity often do not have access to biodiversity information and often are not keen on making what data they have accessible to others. Open access initiatives offer a great opportunity to make the world's biodiversity information accessible to anyone, at any time and in any place. This article reviews the state of open access in the developing world and argues for the increase of data on biodiversity in the public domain. It makes specific suggestions about how the developing world can reap the benefits of this global S&T movement to better conserve and sustain biotic resources through the creation of a "virtual biodiversity research space".

Keywords: Biodiversity, Open Access, Developing World, Archives, Public Domain, Conservation, Biodiversity Informatics, Virtual Research Space**.**

1. BIODIVERSITY INFORMATION

Information technology has come up as an extremely powerful tool for disseminating information and has capacity to reach at a faster and wider range. The Internet has made a strong impact on scientific publications and communications, leading to opening of possibilities for scientists and researchers to contribute to the global knowledge. To reduce the digital gap between the scholars from developed and developing countries, barrier free open access mechanism is necessary for vital research (Smith, 2003), which can be accessed through journals, archives, repositories and databases that are operated on open access principles. It is now well established that information on biotic resources of a nation is crucial for efficient and sustainable resource management (PCAST, 1998). Data and information on biodiversity is a must in wide range of scientific studies such as ecological niche modeling and forecasting, phylogeny, DNA barcoding, education leading to conservation, environmental monitoring, natural resource management, socioeconomic aspect with respect to valuing ecosystem services (Costanza, d'Arge, de Groot, Farber, Grasso, Hannon, et al, 1997), use of natural wealth for human welfare and for decision makers to set up policies for sustainable conservation (Canhos, Souza, Giovanni, & Canhos, 2004).

Even though only 1.8 million of the estimated 10-12 million species are described by science so far (May 1999), data and information associated with these species is enormous (O'Neill, Bauldock, & Lawlor, 2003). For instance, the world's major natural history collections alone house over 3 billion specimens associated with these described species (Butler, Gee, & Macilwain, 1998). However, similar to uneven distribution of these specimens, data and information about biodiversity too is unevenly distributed and accessible (Chavan & Krishnan, 2004). The world's biodiversity is concentrated in tropical regions consisting of developing and under-developed nations. Especially, emerging developing nations such as India, China, Brazil, and under-developed regions like Africa are "biodiversity storehouses" with unique taxa and species diversity (Peterson, Vieglais, Siguenza, & Silva, 2003). Ironically information on this "biodiversity storehouse" is accessible through major

scholarly publications in the form of journals, which are from developed countries like USA and European nations. Notably the important publishers from developed countries such as Elsevier, Harvard University Press, and Blackwell advocate the loss of revenue and copyright issues due to providing the open access to all (Agosti, 2005). This is contrary to the fact that for scientific studies and sustainable management of this biotic diversity, information has to be made accessible to all when and where needed (Lane, 2000).

In the past several initiatives were taken by open access supporters and scientific publishers such as Oxford University Press, Public library of science (PLoS), International Scholar Communication Alliance (ISCA) and Open Archives Initiative (OAI) to encourage, support and explore the possibilities of open access publishing, but these calls themselves are not heard in the developed countries. For instance, a survey conducted by the Centre for Information Behaviour and the Evaluation of Research at City University London, reveals that 82% of scientists know little or nothing about open access (Butler, 2004). Hence researchers and scholars across the globe need to make concerted efforts in taking advantage of technology and share biodiversity information.

2. BIODIVERSITY INFORMATION AND DEVELOPING WORLD

In developing countries biodiversity information is not presently managed in a manner that enables efficient and optimum use for conservation (Peterson, A.T. et al 2003) with few exceptions such as Brazil, and Mexico (De Carvalho, Bockmann, Amorim, De Vivo, De Toledo-Piza, Menezes, et al., 2005). Though cutting edge technologies are being developed for efficient spread of scientific information in developed countries, it has been a difficult situation to implement them in developing countries due to lack of funds, infrastructure and orthodox mind set. This is partly due to concern that private agencies from the developed world would use the biodiversity information to produce commercial products without giving any benefit to the developing and under developed world (Masood, 2004). Unfortunately both ecologically and economically valuable information in the developing countries is often locked in cupboards in print format such as survey reports, monographs, research reports and publications in low circulation local journals, making their access difficult (Chavan, et al 2004). Above all researchers are very skeptical for sharing information and do not appreciate use of information technology in their research as they feel that it will reduce their importance. Often researchers avoid sharing for the reason that the data are classified and cannot be shared or are restricted for use within the nation itself. Further scientists interested in information management and sharing activities are discouraged, as they are not considered as scientific activity. Accurate natural resource inventory will completely depend on efficient and timely access to authentic information on biodiversity resources, which the developing and under-developed countries lack. Hence the scientific communities at large from developing and under-developed countries need to recognize the use of information and communication technology in biodiversity conservation and ecology as the corner stone for their future economy, social and environmental well being (Fonseca & Benson 2003 and Chavan, & Krishnan, 2004). Further, it has become a matter of prime concern for the researchers and scientists with respect to the identification and acquisition of information on species, yet to be described and published, before they disappear.

In developing countries, subscription to multiple journals becomes prohibitive due to budget constraints of many academic institutions. In sub Saharan Africa most libraries have not subscribed to any journals for years, as they cannot afford to maintain good libraries. In recent times, information and communication technology has also escalated the content divide due to lack of infrastructure and access to internet in under developed and developing countries (Subbiah, 2003 .a.). To overcome this problem, developing countries have started their own indigenous local journals produced using the print technology, which is expensive to produce and distribute (Scaria, 2003). A few local journals are indexed by the Science Citation Index. Due to low international readership, however, these publications do not get proper recognition, which results in low visibility and low impact factor (Chan, Kirsop, & Subbiah, 2005). These factors hamper the growth of such journals into mature, reputed and internationally recognized publication. (Ramchandran, & Scaria, 2004).

To illustrate these points, we chose India as representative of the developing world and carried out searches in Google, to determine numbers of both online and print journals published from India related to biodiversity, ecology, forestry, agricultural biodiversity, flora, fauna and environment sciences. We could find 129 Indian journals (Table 1) of which only 6 journals are openly accessible through the Internet. This is in contrast to the total of 83 open access journals (Table2) related to biodiversity and allied subjects accessible on the Internet. Both accessibility to these journals and their visibility are caught in a unique vicious cycle. On the one hand, the majority of the premier Indian institutions are not able to ensure access to all of these 129 biodiversity related journals published in India. On the other hand, researchers are reluctant to publish their results in these journals owing to their low impact factors and limited circulation, leading to low visibility. The majority of these journals were commissioned solely to disseminate information more rapidly, but most of them are now extinct or on verge of becoming extinct due to lack of funds, lack of sustained manuscript submissions, and limited readership. Because of the high impact factors (as measured by the ISI Science Citation Index), researchers are more interested to publish their findings in nationally and internationally recognized journals, which are often inaccessible to other scientists from the developing world, making it difficult for funding agencies and policy makers to take stock of their research output (Chan et al. 2005).

Table 1. List of Journals from India on Environmental and Biodiversity

Agra University Journal of Research (Science)
Agricultural Research Journal of Kerala
Agrobios India, Jodhpur
Annals of Entomology
Annals of Forestry
Annals of Zoology, Agra
Asian Biotechnology and Development Review
Biological Bulletin of India
Biovigyanam
Bulletin Department of Marine Sciences
Bulletin Department of Zoology.
Bulletin Entomological society of India

Bulletin of Association of Zoologists
Bulletin of Indian Geological Association.
Bulletin of the Indian Society for Malaria & other Communicable diseases.
Bulletin of Zoological Survey of India
CSIR Zoological Memoirs on Indian Animal Types- No. 1
CSIRO Entomology Technical Paper
Current Science
Division of Entomology
Entomon
Environment & Ecology
ENVIS Publication Series
Geobios
Gujarat Agriculture University Research Journal
Haryana agriculture University Research Journal
Haryana Veterinary
Hexapoda
Himalayan Journal of Environment and Zoology
Himalayan Journal of Science
Indian Bee Journal
Indian Biologist
Indian Colloquial Micropalaentology Stratigr.
Indian Forest Memoirs
Indian Forester
Indian Forestry Records Delhi
Indian Hydrobiology
Indian Journal Animal Research
Indian Journal Experimental Biology
Indian Journal f Fisheries
Indian Journal of Acarology
Indian Journal of agricultural Research
Indian Journal of Agricultural Sciences
Indian Journal of Animal Health
Indian Journal of Animal Sciences
Indian Journal of Comparative Animal Physiology.
Indian Journal of Dryland Agricultural Research & Development
Indian Journal of Ecology
Indian Journal of Entomology
Indian Journal of Environmental Health
Indian Journal of Forestry
Indian Journal of Helminthology
Indian journal of Hill farming
Indian Journal of Marine Sciences
Indian Journal of Microbiology
Indian Journal of Natural Rubber Research.

Indian Journal of Nematology
Indian Journal of Parasitology
Indian Journal of Physical Natural Science
Indian Journal of Plant Protection
Indian Journal of Science and Industry
Indian Journal of Sericulture
Indian Journal of Systematic Entomology
Indian Journal of Zoology
Indian Journal of Zootomy
Indian Museum Bulletin.
Indian Museum Notes
Indian Phytopathology
Indian Veterinary Journal.
Indian Zoologist
Insect Environment
Jammu University Rev.
Journal Indian Bioscientist Association.
Journal of Andaman Science Association
Journal of Asiatic Society of Bengal, Calcutta.
Journal of Assam Science Society
Journal of Bengal Natural History Society
Journal of Biosciences
Journal of Bombay Natural History Society
Journal of Earth System Science
Journal of Entomological Research (New-Delhi).
Journal of Environmental Biology
Journal of Experimental Zoology India.
Journal of Indian Association for Environmental Management
Journal of Indian Bird Records and Conservation
Journal of Indian Ocean studies
Journal of Karnataka University (Science)
Journal of Marine Biological Association of India
Journal of Science: University of Kashmir
Journal of Tamilnadu Agriculture University, Coimbatore.
Journal of the Geological Society of India, Bangalore
Journal of the Zoological Society of India.
Journal of Vector Borne Disease (Formerly-Indian Journal of Malariology)
Journal: Indian Academy of Wood Sciences
Journal: Indian Botanical Science
Journal: Inland Fisheries Society of India
Journal: Palaeontology Society of India
Journal: Proceedings of Asiatic Society of Bengal
Journal: Research Assam Agriculture University
Journal: Research of Asiatic Society of Bengal

Journal: Research of Punjab Agriculture University
Journal: Timber Development Association of India.
Journal: University Bombay (Science)
Journal: Uttar Pradesh Journal of Zoology
Mahasagar
Marathwada University Journal of Sciences
Matsya
Memoirs Department of Agriculture. India. Entomology Series
Memoirs of Asiatic Society of Bengal
Memoirs of Entomological Society of India
Memoirs of the Indian Museum
Memoirs of the Zoological Survey of India
Mysore Journal of Agriculture Science
National Geographical Journal of India
Newsletter Zoological Survey of India.
Paryavaran Abstracts
Records of Indian Museum
Records of the Geological Survey of India
Records of the Zoological Survey of India
Records Zoology. Biol. Sol.
Research Bulletin of the Punjab University (Science)
Sanctuary Asia
Technical Monograph of Zoological Survey of India
The Indian Zoologist
The Journal of the Zoological Society of Kerala.
Thesis Abstract Harayana. Agriculture University
Uttar Pradesh Journal of Zoology
Visva Bharati Journal of Research.
Zoo's Print

Table 2. OA journals

Acta Botanica Brasílica	www.scielo.br/ scielo.php?pid=0102-3306&script=sci_serial
Acta Protozoologica	www.nencki.gov.pl/ap.htm
Acta Veterinaria Brunensis	http://www.vfu.cz/acta-vet/actavet.htm
Agbioforum	http://www.agbioforum.org/
Annales Botanici Fennici	http://sekj.pc.helsinki.fi/journals
Annales Zoologici Fennici	http://sekj.pc.helsinki.fi/journals
Annals of Agricultural and Environmental Medicine	http://www.aaem.pl/
Applied Entomology and Zoology	http://www.jstage.jst.go.jp/browse/aez
Arid Lands Newsletter	http://ag.arizona.edu/OALS/ALN/ALNHome.html
Asian Environmental Technology	http://www.aptn.org/envtech.htm
Biogeosciences	http://www.biogeosciences.org/
Biological Research	http://www.scielo.cl/scielo.php?pid=0716-9760&script=sci_serial

BMC Biology	http://www.biomedcentral.com/bmcbiol/
BMC Ecology	http://www.biomedcentral.com/bmcecol/
BMC Evolutionary Biology	http://www.biomedcentral.com/bmcevolbiol/
BMC Genetics	http://www.biomedcentral.com/bmcgenet/
BMC Plant Biology	http://www.biomedcentral.com/bmcplantbiol/
Brazilian Journal of Biology (Former title:Revista Brasileira de Biologia)	http://www.scielo.br/scielo.php/script_sci_serial/pid_1519-6984/lng_en/nrm_iso
Brazilian Journal of Plant Physiology	http://www.scielo.br/scielo.php/script_sci_serial/pid_1677-0420/lng_en/nrm_iso
Brazilian Journal of Veterinary Research and Animal Science	http://www.scielo.br/scielo.php/script_sci_serial/pid_1413-9596/lng_en/nrm_iso
Bulletin of the Geobotanical Institute ETH	http://www.geobot.umnw.ethz.ch/publications/periodicals/bulletin.html
Caribbean Journal of Science	http://www.caribjsci.org/
Chronica Horticulturae	http://www.ishs.org/pub/chronica.htm
Contributions to Zoology	http://biology.bangor.ac.uk/research/journal/Contributions%20to%20Zoology
Current Science	http://www.ias.ac.in/currsci/
Dendrobiology	http://www.idpan.poznan.pl/dendrobiology/
Ecology and Society	http://www.ecologyandsociety.org/
Economic Botany	http://www.econbot.org/home.html
Electronic Journal of Polish Agricultural Universities	http://www.ejpau.media.pl/
Endangered Species Research	http://www.int-res.com/journals/esr/
Entomotropica	http://www.entomotropica.org/
Environmental Health	http://www.ehjournal.net/
Environmental Health Perspectives	http://ehp.niehs.nih.gov/
Environmental Protection	http://www.eponline.com/
Experimental Animals	http://wwwsoc.nii.ac.jp/jalas/english/en_journal.html
Fishery Bulletin	http://fishbull.noaa.gov/
Florida Entomologist	http://www.fcla.edu/FlaEnt/
Fungal Genetics Newsletter	http://www.fgsc.net/newslet.html
Geodiversitas	http://www.mnhn.fr/publication/geodiv/ageodiv.html
International Journal of Environmental Research and Public Health	http://www.mdpi.org/ijerph/
Japan Agricultural Research Quarterly	http://ss.jircas.affrc.go.jp/engpage/jarq/firstpage1.html
Japanese Journal of Applied Entomology and Zoology	http://odokon.ac.affrc.go.jp/en/
Japanese Journal of Biometeorology	http://www.jstage.jst.go.jp/browse/seikisho
Journal of integrative plant biology (Formerly Acta Botanica Sinica)	http://www.blackwellpublishing.com/journal.asp?ref=1672-9072
Journal of Biological Sciences	http://www.biolsci.org/
Journal of Biology	http://jbiol.com/
Journal of Biosciences	http://www.ias.ac.in/jbiosci/index.html
Journal of Circadian Rhythms	http://www.jcircadianrhythms.com/home/
Journal of Culture Collections	http://www.bioline.org.br/cc
Journal of Insect Science	http://www.insectscience.org/
Journal of Pesticide Science	http://wwwsoc.nii.ac.jp/pssj2/index-e.html
Journal of Rural and Remote	http://www.jcu.edu.au/jrtph/

Environmental Health (Journal of Rural and Tropical Public Health)	
Journal of Spatial Hydrology	http://www.spatialhydrology.com/journal/
Journal of Veterinary Medical Science	http://www.jstage.jst.go.jp/browse/jvms
Journal of Veterinary Science	http://www.vetsci.org/
Journal of Water and Environment Technology	http://www.jstage.jst.go.jp/browse/jwet
Journal of Wildlife Diseases	http://www.jwildlifedis.org/
Korean Journal of Parasitology	http://www.parasitol.or.kr/kjp/
LEISA Magazine	http://www.leisa.info/index.php?url=index.tpl
Mammal Study	http://www.mammalogy.jp/journals/
Marine Fisheries Review	http://spo.nwr.noaa.gov/mcontent.htm
Marine Ornithology	http://www.marineornithology.org/
National Geographic	http://www.nationalgeographic.com/
New England Journal of Large Animal Health	http://camelid.webis.net/Magazines/lah.html
Pakistan Journal of Biological Sciences	http://www.pjbs.org/pjbsnew/journal/vol3/toc1.htm
Plant Health Progress	http://www.plantmanagementnetwork.org/php/default.asp
Plant Pathology Journal	http://www.ansinet.org/c4p.php?j_id=ppj
Plant Production Science	http://wwwsoc.nii.ac.jp/cssj/pps/
PLoS Biology	http://biology.plosjournals.org/perlserv/?request=index-html&issn=1545-7885
Popular Science	http://www.popsci.com
Science & Technology Review	http://www.llnl.gov/str/
Science Insight	http://www.britishcouncil.org/home/science/science-publications/science-publications-online-news.htm
Scientist	http://www.sciencemag.org/
South African Journal of Animal Science	http://www.sasas.co.za/
Turkish Journal of Agriculture and Forestry Sciences	http://journals.tubitak.gov.tr/agriculture/index.php
Turkish Journal of Biology	http://journals.tubitak.gov.tr/biology/
Turkish Journal of Botany	http://mistug.tetm.tubitak.gov.tr/~bdyim/sayilar.php3?dergi=bot
Turkish Journal of Veterinary and Animal Sciences	http://journals.tubitak.gov.tr/veterinary/
Turkish Journal of Zoology	http://journals.tubitak.gov.tr/zoology/
Zoosystema	http://www.mnhn.fr/publication/zoosyst/zoosyst.html
Zootecnia Tropical	http://www.bioline.org.br/zt
Zoo's Print	http://www.zoosprint.org/
Sanctuary Asia	http://www.sanctuaryasia.com/

3. WHY OPEN ACCESS IN BIODIVERSITY

The scope of biodiversity conservation comprises both ecological and economical aspects. Genetic and ecosystem diversity can be considered as services that provide benefits in a variety of ways, such as medicinal values, securing nutrition, raw materials and indicator functions. Biodiversity as a resource is different from general resources having peculiar economic values. From the analytical point of view biodiversity resources can be considered a public good with insufficiently specified property rights. In developing countries the causes of biodiversity loss is inter-linked with rural poverty, population

growth, pressures on natural resources, food insecurity, agriculture etc, leading to economic imbalance (Scherr, 2003). According to Conservation International (2005), there are 34 biodiversity hotspots holding more population than expected as compared to the global average. Out of 34 biodiversity hotspots, 21 hotspots have population growth higher than the global average growth of 42 people per square kilometer. As per Conservation International's previous study, 16 hotspots out of 25 had 20% of population malnourished, accounting for a quarter of all malnourished people from the developing countries (Scherr, 2003). It is estimated that approximately 350 million poor people rely on forests for supplement income. Poor farmers often harvest and sell wild plants and animals to buy food. The situation in developing countries has become more critical as biodiversity is threatened due to food insecurities giving rise to over exploitation of plants and animals (UN Press Release, 2004).

The authors believe that scientists and researchers from the developing world would be able to address these conservation problems more appropriately if they knew the gravity and problems associated with them. However, it is true that biodiversity research and concerns tend to be greatly restricted wherever information on biodiversity is sparse or non-existence. Many research projects generate biodiversity data sets that are relevant for the wider scientific community, government natural resource managers, policy makers, and the public. It is important to allow for further shared use of these data to benefit the widest possible range of users. However, countries most rich in biodiversity, commonly considered as common heritage of humankind are relatively poor in having scientific information. Further, there is often resistance from developing countries for open sharing of the data. This lack of interest and restrictions from R & D managers impairs the conservation efforts and economical aspects of developing biodiversity rich countries.

Thus minimization of knowledge gaps would help to prevent duplication of research efforts and help scientists to focus on issues that are completely unknown or need urgent attention, for which financial support and easily free access to scientific information is needed. Hence, major developing countries like Brazil, China and India should take initiatives to promote open access to biodiversity information, which would motivate other developing countries to share their biodiversity knowledge (Subbiah, 2003 .b.).

4. OPEN ACCESS: THE STATE- OF- THE- ART

In recent times, efforts are being made by the scientific community to promote open access to scientific information, depicting a change in mind set. This is evident from the developments that are taking place at the global levels. For example, beginning with May 2, 2005, National Institutes of Health (NIH) has asked investigator(s) and scientists to submit voluntarily to the NIH manuscript submission system (NIHMS) their final submission upon acceptance for publication and deposit research results in the archives of National Library of Medicine of projects funded by NIH (Final NIH Public access policy implementation.). Analysis of the coverage and citation of open access journals by Thomson Scientific using the 2003 Journal Citation Report (JCR) reveals that (a) open access journals are not necessarily new publications. Many established journals are making their older content available online. (b) 55% of the journals and over 65% of the articles indexed in Web of Science in 2003 are produced by publishers who permit self-archiving, which could be brought into open access if archived by author (Mc Veigh, 2004). As per the ISI citation database in February 2004, there were a total of 192 open

access titles, which increased to 239 in June 2004. During this period the number of open access titles from life sciences increased from 50 to 73 titles. Open access journals have a higher Immediacy Index than the Journal Impact Factor showing that the open access journals are more rapidly accessed and cited as compared to traditionally accessed journals.

To promote open access to biodiversity information, conservation communities are coming forward to encourage organizations and institutions to put their biodiversity related data in public domain with the intention of improving conservation initiatives. Among the leading players in promoting and pioneering the initiatives is the Global Biodiversity Information Facility (GBIF), which intends to make all scientific biodiversity information freely available (GBIF, 2006). On January 16, 2006, the GBIF Governing Board representing 47 countries, 31 international organizations and the Secretariat on the Convention of Biological Diversity made a strong recommendation advocating open access to biodiversity data (GBIF, 2006). It requested funding agencies to (a) support proposals for biodiversity research that include a plan for the maintenance and sharing of digital biodiversity data generated in proposed projects, and (b) make publicly available species and specimen level data and associated metadata generated through such funded projects cooperating with GBIF, within a specified period after completion of the research. In fact, during its last five years of existence, GBIF has been able to pull together 86,419,602 biological collection records from nearly 642 biological collections, provided by 159 data providers (as of 7 February, 2006).

To disseminate and provide data to GBIF at the European level, the European network for biodiversity information (ENBI) was started on January 2003 as a three-year thematic network project. The network consists of 66 members from 24 European countries. In addition to ENBI, the Biological Collection Access Service for Europe (BioCASE) is providing information on biological collections from 35 institutions in 30 European countries, including Israel, using web based technology. The institutions providing the information about their biological collections have full control of the information on the biological collections that they are holding.

Internet based forums like Inter American Biodiversity Information Network (IABIN) work on interoperability of biodiversity datasets, data content, technical and scientific cooperation that would help in coordination between Western hemisphere countries. IABIN is involved in the development of a network for sharing information on invasive species and developing information resources for IABIN participants. For broader applications, to integrate and search across the diverse biodiversity databases a scientific name dictionary, which would give nomenclatural details and taxonomic authority, is required. For example, the Integrated Taxonomic Information System (ITIS) is a dedicated database for North American floral and faunal taxonomic nomenclatural data, where the taxonomic experts scrutinize the data before incorporating it in the database. ITIS at present has data on 392,000 species, of which more than 67% have been verified (as of 7 February, 2006). Along with taxonomic details this database provides information on biogeographical distribution also.

To document the species at the global level, Species2000 was established in September 1994 in a coalition of the International Union of Biological Sciences, the Committee on Data for Science and Technology (CODATA) and the International Union of Microbiological Societies. The main objective of Species2000 is to list all known flora, fauna, fungi and microbes on this earth for studying the global

biodiversity. It is a union of 40 taxonomic database organizations, where ITIS is the major contributor. Species2000 as on today has been able to collate 527,000 species across the globe in its database (as of 7 February, 2006).

Many regional and local initiatives are being taken to collate and organize specimen data to make it openly available on the Internet. To network all these initiatives a protocol was needed. This was launched in 1998 as a prototype network called Species Analyst, based on Z39.50 information transfer protocol. The network consists of different collections like Fishnet (29 Ichthyological collections), Mammal Networked Information system (17 North American mammal collections) and HerpNet (37 North American herpetological collections) serving approximately 65 million specimen records from 120 institutions.

Collaborative projects like the Australian Virtual Herbarium (AVH) are providing information on botanical specimens from different Australian herbaria using the GIS application. AVM is able to provide access to six million botanical specimens from 9 contributing Australian herbaria through common query interface. Scientists or researchers residing in one part of the country can virtually view the specimens from different herbaria without visiting those herbaria, thus minimizing the time for accessing information and valuable funds.

As a result, a noticeable change in attitude amongst developing world researchers is growing with respect to open access to biodiversity information, thus complementing global initiatives in this area, though at a slower speed. Organizations with broader outlook are now engaging themselves in development of open access databases and information systems, such as IndFauna and IndOBIS. IndFauna, an electronic catalogue of known Indian fauna developed by the National Chemical Laboratory (NCL) in Pune, is able to disseminate baseline information on more than 91000 scientific names, 51000+ synonyms, 14000+ common names and over 168000 occurrence records (Chavan, et. al., 2004). Accessible at http://www.ncbi.org.in/, the development of IndFauna has also been able to demonstrate the web as an efficient collaborative platform for taxonomists both within India and overseas to exchange/share their data, views and opinions on topic such as taxonomy and discrepancies in taxonomy. Similarly, together with the National Institute of Oceanography (NIO) in Goa, NCL is engaged in developing an open access, web based information system called IndOBIS (Indian Ocean Node of OBIS) to document known life forms recorded in the Indian Ocean (Chavan, Achuthankutty, Berghe, & Wafar, 2005). IndOBIS in turn will contribute the data collated on life in the Indian Ocean to the Ocean Biogeographic Information System (OBIS), which is the data and information component of the Census of Marine Life (CoML) and the largest marine biodiversity data provider to the GBIF. However, such efforts in the developing world are small and countable and a boost of activities of a similar nature from the scientific community, governments, and funding agencies is required.

5. IMPLEMENTING OA AND BIODIVERSITY IN DEVELOPING WORLD

The preceding discussion emphasized the urgent need for bringing data and information on biodiversity from the developing and under developed world, which is currently trapped in institutional and individual cupboards, into the public domain by adopting open access principle,. Based on our

experience of data management activities in a developing nation such as India, we believe that the following strategies, if adopted, can help us in realizing the dream of free and open access to the world's biodiversity data including that from the developing and under developed part of our globe.

(a) We need to have distributed national, regional and institutional OA archives for biodiversity which not only facilitate OA archiving, but also can support those small and medium scale publishers and societies (who publish with limited circulation and a very low and insignificant impact factor) to convert their journals to the OA model of publishing. Further there is a need to bring about an attitudinal change on the part of publishers, societies, authors, institutions and funding agencies in favor of OA publishing.

(b) Funding agencies should make it mandatory that any data resulting from public funded research and survey should be published only in OA journals and that the data be made available through public domain or openly accessible databases, using software and programs which are non-commercial, open source, and GNU compliant.

(c) There needs to be more multi-lingual OA archives and OA journals. This shall certainly ensure better dissemination of research and survey outcomes, at the same time encouraging those people participation in generating and contributing data on biodiversity and its conservation.

(d) Every Ph.D. and Masters thesis, technical report, gray and white papers, review reports, survey publications should be deposited in one of the OA archives.

(e) There is a need to conceptualize and implement a global infrastructure for an open access regime in biodiversity. GBIF should prioritize its long pending work plan for the Digital Biodiversity Literature Bank. It should, for all practical purposes, adopt the OA archive and publishing model for the same.

(f) National and International funding agencies should provide encouragement to establish more biodiversity specific OA initiatives, especially within the developing world.

(g) There needs to be study of Impact Factor for OA than Immediacy Factor. OA journals should subject themselves to such studies. Also, study is required for Impact or Immediacy analysis for biodiversity data as well as for the legacy literature, which is increasingly being digitized and made available through OA model.

(h) It is imperative that concerted efforts are made to digitize legacy literature. In contrast to technical disciplines, literature in biodiversity is cited for longer time periods. In fact, in the case of systematics and observational data, older literature is cited more frequently while referring to the current scenario or during comparative analysis.

(i) Organizations and groups from developing nations working on biodiversity related aspects need to establish "institutional data archives or repositories" which would improve the visibility of the organization by facilitating wider dissemination of its research outcome or performance.

(j) These repositories can work as an assemblage of different subject information related to biodiversity conservation, such as ethnobotany, geology, hydrology, molecular taxonomy, biotechnology, agriculture, botany, zoology, systematics, statistics, GIS and remote sensing

and socioeconomic aspects and biodiversity informatics. The richness of these repositories would reflect the intellectual output of the organization or institution.

(k) We strongly believe that the Open Access treatment to existing as well as future biodiversity- and ecosystem-related information will develop data and information aided "virtual research space" for future studies in biodiversity (Figure. 1). Such a research space can draw data from a variety of sources such as publications, archives, and data repositories, as well as employ a variety of open source software to analyze such data.

(l) For a dream of such a "virtual research space" to become reality, an increasing number of data repositories as well open source software tools need to be made available. Similarly, biotechnology journals, biodiversity and ecosystem related journals need to demand from author(s) that they contribute data and supporting information to public domain databases and repositories.

(m) We strongly believe that such "virtual research space" not only would improve data exchange / sharing amongst research groups but also would create a collaborative platform for multi-disciplinary teams to work together.

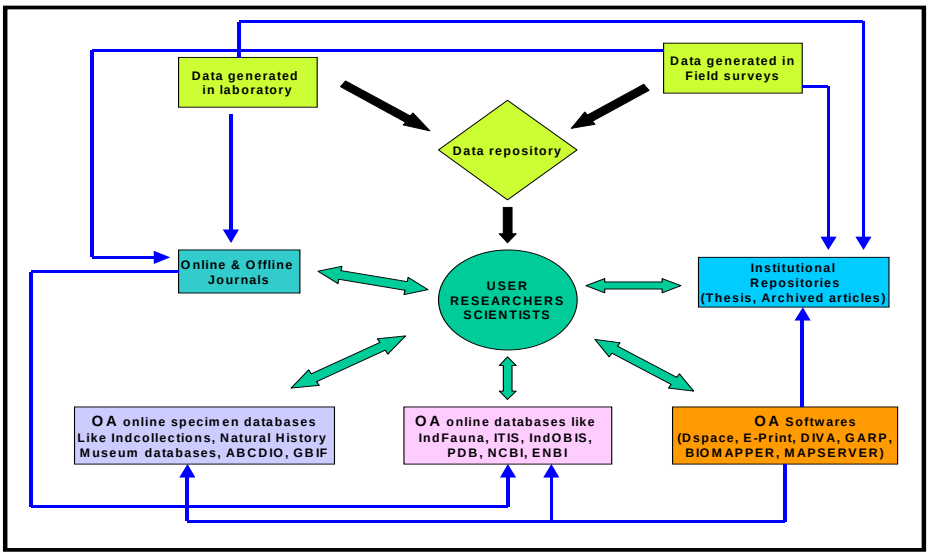

Figure 1. Open Access to biodiversity data and information can lead to development of data and information based virtual research space for future studies in biodiversity.

6. IMPLEMENTATION REQUIRES ENCOURAGEMENT

Doing research in developing countries is not easy. Similarly, spreading the open access movement among the biodiversity research community in such countries is going to be an equally daunting

task. This requires infrastructure as well as human resources for biodiversity information, which would require dedicated funds and sufficient budgetary planning (Arzberger, et al. 2004). This also calls for an integrated approach of awareness about benefits of open access, capacity building, support towards infrastructure development, and implementation of policies that would encourage the launch of data and information in the open domain. With a boost from funding agencies and governments, as well participation of the research community and demands for open data by international agencies such as GBIF etc., the developing world can certainly bring the dream of "virtual biodiversity research space" into reality.

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