

# DNA barcoding: access to biodiversity and benefit-sharing policy issues in the Indian context\*

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*Access to biodiversity for research and development in India is regulated by the National Biological Diversity Act (NBDA) of 2002 which gave effect to the Convention on Biological Diversity. Some of the provisions of the Act have been amended on the basis of reactions to the Act. In addition to the provisions that govern access and benefit-sharing for commercial research, specific provisions regarding access and benefit-sharing in the context of non-commercial research have to be evolved in the wake of DNA barcoding becoming a reality for advancing taxonomic knowledge of biodiversity in the country. In the context of barcoding technology, policy questions relate to regulation of access to biodiversity and ethical questions relate to consequences for the livelihoods and culture of the stewards of biodiversity and the environment. Stewards of biodiversity must be involved in evolving norms regarding the access and benefit-sharing in the context of extending access to biodiversity for commercial and non-commercial research, in the development of barcoding technology and its use so that they are empowered to monitor, maintain and develop biodiversity.*

**Keywords:** Access and benefit-sharing, culture of conservation, DNA barcoding.

ENACTMENT of National Biological Diversity Act (NBDA)<sup>1</sup> in 2002 accomplished two things: (i) it established national sovereignty over biological resources in the country; and (ii) it gave effect to the Convention on Biological Diversity (CBD) in 1993. However, advances in molecular biology created conditions for a new era in taxonomy, based on genotypic description in contrast to the Linnaean taxonomy based on phenotypic characteristics. DNA barcoding is a new tool for the science of taxonomy at genotypic level. In this context, several policy related questions regarding access to biodiversity for barcoding and ethical, social, cultural, economic and political including benefit-sharing issues assume importance in the Indian context.

DNA barcoding as a scientific idea, initiated by Paul Hebert in 2003, has been attracting international attention for its significance in advancing the taxonomy of life forms. The objective of DNA barcoding is to transform conventional taxonomy by digitizing the identity of a given species. DNA barcoding employs sequence diversity in short segments of standardized regions of the genome as a digital system for species recognition<sup>2</sup>.

Linnaean taxonomy, which began 250 years ago, is based on phenotypic separation of species by morphological dichotomies. Stoeckle *et al.*<sup>3</sup> point out that Linnaean classification is an abbreviated label for morphology of a species; the short sequence is an abbreviated label for the genome of the species.

DNA barcoding promises several useful applications apart from species recognition. Ensuring food quality and monitoring agricultural pests, disease vectors and invasive species are some of the areas in which barcoding technology may be deployed. The digital codification system that barcoding seeks to create could lead to innovations in electronics, bioinformatics and devices such as handheld barcoders.

Although a few million species have been discovered and identified, many millions more, including microorganisms, are yet to be discovered and documented. Whether a species is endemic to a geographical region or is widely distributed, barcoding of life is truly international in scope. However, geographical regions are divided into modern nation-states, and each nation-state decides whether or not to sign international treaties based on national interest. CBD has been signed by 168 countries ([www.cbd.int/convention/parties/list](http://www.cbd.int/convention/parties/list)). The Government of India, for example, signed it on 18 February 1994, but the Government of United States of America, though a signatory to the CBD, has not yet ratified it. The objectives of the International Consortium for the Barcode of

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Life (CBoL) are related to those of the CBD. Members of the iBOL consortium are 'committed' to the regulatory framework established under CBD<sup>2</sup>.

### Society and technology dynamics

Throughout history, human beings have interacted with nature through the medium of technology. This interaction has transformed nature while simultaneously transforming society and social relations. Since the latter half of the 20th century, science and technology on the one hand and economy, polity and culture on the other have been intimately interconnected so that it is now difficult to maintain the classical distinction between science as the 'act of knowing' and technology as the 'act of doing'. Science has undergone a cultural revolution, from academic science and its associated values like disinterestedness, to post-academic science and its associated values like profit and efficacy<sup>4</sup>. Technoscience, a concept first coined by the Belgian philosopher Gilbert Hottois, captures the character of science in the 21st century<sup>5,6</sup>. Modern biology has become a technoscience. For example, mapping the genome of a crop plant or an animal species is not merely aimed at describing the whole complement of the genes but also at understanding the functions of the genes for possible technological interventions. Similarly, DNA barcoding enhances our descriptive understanding of the diversity of species and may pave the way for new interventions. The pursuit of knowledge about and manipulation of life forms or parts thereof raises interrelated questions of policy and ethics. Policy questions relate to access to biodiversity for research and development, and ethical questions relate to consequences – intended and unintended – of barcoding for individuals, groups and communities.

The consequences of barcoding for maintenance, development and exploitation of biodiversity on the one hand and for communities and stewards of conservation on the other have to be visualized at the time of accessing biodiversity for barcoding. A pertinent question related to the communities and stewards of conservation is: what are the consequences – intended and unintended – of barcoding of a species that has commercial value and on which a particular community depends for its livelihood? Similarly, the consequences of barcoding of a plant species that has medicinal value have to be anticipated. As the tendency is to barcode the species that have utility or aesthetic value on a priority basis, consequences of such prioritization and the actual barcoding of the prioritized species may be perceived by the community that has been involved in conserving the species and using them or the components of the species for sustaining their livelihood as a posing risk. **If the potential loss – monetary and/or non-monetary – for the livelihood of the community and its social and cultural life arising out of barcoding turns**

**out to be greater than the benefits, then the species should not be barcoded until alternative livelihoods are made available to the community.** Hence, assessment of risk, if any, must be undertaken by an independent third party in collaboration with the community. Also, the following questions have to be addressed in the right perspective: (i) what norms should govern sharing of benefits – monetary and non-monetary – arising out of barcoding with the community for conserving the species? (ii) in what ways the communities and stewards and their representatives could be involved in the wide-ranging activities relating to barcoding work?

Democratization of decision-making regarding technological choices, regulating technology and equitable access to technology – has assumed significance in the context of economic and social development. It is against this backdrop that the study on barcoding technology and its interface with social, ethical, economic and political domains needs to be explored.

The objectives of the exploratory study are to:

- understand issues relating to access to biodiversity for barcoding of species in the Indian context, as well as relevant ethical, social, economic, political and legal issues, relating to prior informed consent, risks and benefit sharing in order to incorporate these elements in the policy framework, and
- provide a perspective on the basis of viewpoints of actual or future users, beneficiaries and participants of the technology, including scientists, policymakers, and in particular, the owners or stewards of the natural resources being barcoded by examining the provisions of the NBDA 2002.

I drew upon the Indian legislation on biodiversity to examine the policy environment, which has implications for DNA barcoding in India. Using a theoretical sampling strategy<sup>7</sup> to select the research sites, for the purpose of the present exploratory study, I selected 10 scientists based in reputed molecular biology research institutions located in Hyderabad for depth interviews. The scientists, belonging to the disciplines of molecular biology, taxonomy and plant breeding, were selected on the basis of their involvement in barcoding and/or taxonomy/conservation and related work. One of them is involved in a project on barcoding bird species in India. I also interviewed representatives of two civil society organizations (CSOs). The interviews were conducted during September–October 2009. I relied on the material collected from the interviews with scientists and the CSOs because, to the best of my knowledge, there are no users of barcoding technology among members of the general public. Interviews with individuals engaged in research related to the phenomena were useful in understanding the issues and in developing an analytical framework to address the issues. Hence, on the basis of the findings of this small-

scale intensive study, we cannot draw generalizations, but the study raises issues that have to be explored further.

## Findings and discussion

India is one of the 'mega hotspots' of biodiversity in the developing countries of the South. As in many developing countries, communities in India have acquired knowledge regarding various species of crop plants, medicinal plants and animals over time. This knowledge is based on trial and error to determine the usefulness or otherwise of each species. The communities have evolved their own local taxonomies that are shared among the community members.

### *Potential applications of DNA barcoding technology in the Indian context*

The present study indicates that scientists recognize the need to describe and document the wide-ranging biodiversity that remains to be explored in India. They stated that DNA barcoding is a valuable technology for this purpose. In India, as in many other countries, there is a perception that taxonomy is a less attractive specialty<sup>8</sup>. Perhaps, one of the reasons is that scientists seem to attach more 'glamour' to a research career in molecular biology<sup>9</sup>. Research relating to DNA barcoding may change the situation and fill the shortfall in the number of taxonomists. This calls for focused training programmes that attract young scientists. There are only three projects related to barcoding of species in the country. The scientists interviewed expressed the view that DNA barcoding will create new interest in taxonomy among scientists. Further, scientists suggested that conventional taxonomy will not disappear, rather that DNA barcoding will be a complementary tool in the hands of scientists engaged in taxonomy.

The scientists mentioned that barcoding will be extremely useful to: (a) identify a large number of small species; (b) assign specimens to species for the purpose of *ex-situ* conservation; (c) avoid duplication of entries of varieties and landraces of crop species in *ex-situ* conservation; (d) to monitor and maintain biodiversity, and (e) detect foreign plant and animal material in food and pharmaceutical products. DNA barcoding will help in separating the original species from look-alike species. For example, *Pterocarpus santalinus*, popularly called red sanders or red sandalwood, is highly valued for its timber. It is a rare species that grows only in the hill ranges of southern Andhra Pradesh. If it is barcoded, the information can be used to separate the rare red sandalwood from the look-alikes.

In the Indian context, barcodes can be used to establish novelty under the provisions of the Protection of Plant Varieties and Farmers' Rights Act (PPVFRA) of 2001. If

the proposed novel product or process already exists as part of the prior art, the proposal becomes null and void.

### *Institutional arrangements for accessing biodiversity*

The Government of India is a signatory to CBD and the Parliament of India has ratified the trade related aspects of Intellectual Property Rights (IPR). The parliament passed the PPVFRA in 2001, designed to protect plant varieties. In the following year, the parliament passed the NBDA to give effect to CBD in the Indian context. The Act was the outcome of a process of consultations involving scientists, policymakers and CSOs, and treats all biological resources in the country as national resources. The two Acts, which extend to the whole of India, are intended to protect India's bioresources. The PPVFR Authority and National Biological Diversity Act (NBDA) have been empowered to take all necessary steps to achieve the objective of the two Acts. The objectives of NBA include: conservation of biological diversity, sustainable utilization of its components, and equitable sharing of the benefits arising from utilization of genetic resources. However, it should be mentioned here that prior to 29 December 1993, the date on which CBD came into effect, all the germplasm that has been collected/augmented/conserved in the international gene banks is called Food and Agriculture Organisation (FAO) designated germplasm which can be accessed legally and used.

Whereas NBA functions at the national level, the State Biodiversity Boards (SBBs) operate at the state level and Biodiversity Management Committees (BMCs) at the level of local bodies (Panchayat at the level of the village, municipalities at the level of small towns) to promote conservation and documentation of biodiversity and sustainable use of its components.

Some of the provisions of NBDA, initially formulated, were later amended. We should enumerate some of the salient original provisions so that we can understand what amendments were made to the original provisions. Some of the original provisions are as follows:

- NBDA regulates access to biological diversity for research and development. The Act allows access to biological resources for research by individuals and corporation, association or organization of foreign origin only after they obtain prior approval from NBA.
- Further, no person shall transfer the results (except publication of research papers or dissemination of knowledge in any seminar or workshop) of any research relating to any biological resources occurring in India (or obtained from India) for monetary consideration or otherwise to any person who is not a citizen of India or any corporate body, without obtaining prior approval of NBA.

- According to the Act, no person shall apply for any IPR in or outside India for any invention based on any research or information on a biological resource obtained from India without obtaining the prior approval of NBA.
- NBA may, while granting approval for filing the application for an IPR, impose a benefit-sharing fee, a royalty, or both. It may also impose conditions including sharing of financial benefits arising from the commercial utilization of such rights. This provision does not apply to those cases in which the application for the right comes under the purview of any law relating to PPVFR. Regarding the proceeds of the benefit sharing, the amount of money determined by NBA would have to be deposited in the National Biodiversity Fund.

### Reaction to the Biodiversity Act

Although the Act has been welcomed as a step in the right direction, scientists seem to differ in terms of what it will do to promote the basic science of taxonomy. Prathapan *et al.*<sup>8</sup> argue that the Act, by declaring the bioresources as national resources, will curtail the freedom of scientists and discourage research in taxonomy, as species identification requires international collaborative research for comparing the specimens before assigning them to the species. They argue: ‘...with the introduction of the Biological Diversity Act, we have completely lost the moral authority to use these (exotic germplasm obtained earlier from other countries) without the formal permission and benefit-sharing with the respective countries of origin’.

Another view within the scientific community is that DNA barcoding has to be carried out in accordance with the provisions of the Act as it provides a framework of rules regarding access to biodiversity, use of its components and benefit sharing. Scientists mentioned that a democratic decision has to be taken regarding which species in the country have to be barcoded, given the fact that there are endemic and endangered species some of which are commercially valuable. The scientists are of the view that the barcoded information has to be kept in the public domain except in the case of some endemic species which have commercial applications. In this connection, they strongly argue that in any international collaboration, Indian scientists should not part with samples (genetic material) of species to be barcoded to collaborating scientists in foreign countries. The samples should be kept in a national repository or a biobank and the sequence information (genetic information) may be shared with scientists in other countries. The scientists, especially those engaged in the basic science of taxonomy may not take adequate notice of the provisions of NBDA as they do not see the immediate relevance of the provisions of the Act to the basic science of taxonomy. Hence, such perceptions

are expressed based on inadequate acquaintance with the existing provisions of the Act and the consequent amendments.

CSOs seem to hold that the Act should not give exemption to the Indian scientists of corporate bodies to access biodiversity just by giving prior information to SBBs, as mentioned here. They should seek prior permission to access biodiversity as in the case of individuals who are not citizens of India and corporate bodies not registered in India or registered in India without Indian participation<sup>10</sup>. CSOs want the same rules applied to Indian citizens and corporate bodies, believing that their motivation in accessing biodiversity may be no different from that of outsiders. Gene Campaign, another professional CSO, believes that the Act falls short of fulfilling the national needs, suggesting that the Act hampers research and is not clear on the question of IPRs ([www.genecampaign.org/Publication/Article/Biodiversity/biodiversityAct-falls.pdf](http://www.genecampaign.org/Publication/Article/Biodiversity/biodiversityAct-falls.pdf)).

It appears that there are differences in the perceptions among the members of the scientific community regarding how the provisions of the Act will influence scientific research. However, this needs to be explored further. CSOs seem to hold the view that access to biodiversity especially for corporate bodies – both Indian and foreign ones – should be based on the same rules.

### Amendments to the original provisions of the Act

On the basis of the reactions to the Act, the Ministry of Environment and Forests, Government of India made some amendments. One of the amendments, notified through the official gazette dated 8 November 2006, was regarding the guidelines for international collaboration research projects involving transfer or exchange of biological resources or information relating to biological resources between Indian research institutions and their counterparts in other countries. This amendment is intended to facilitate transfer of biological resources for research purposes, which was not possible according to the original provisions of the Act. The amendment allows for the transfer of biological resources on the basis of one time approval. However, the project investigators have to provide annual reports to NBA about the outcome of the research until the completion of the project.

NBA has been inviting suggestions for amendments from the stakeholders—scientists in R&D institutions, CSOs and others. We have to wait and see as to how many of the amendments would be approved and incorporated in the provisions of the Act. At this point, it should be mentioned that the stakeholders have to see what amendments are needed to access biodiversity for barcoding and issues regarding benefit sharing associated with barcoding.

### Culture of conservation in India

In India, households and communities have been conserving germplasm of crop plants, horticulture, medicinal plants and some species of animals *in situ* over the years as part of utilitarian and aesthetic values. Traditionally, in the absence of written rules, conservation of biodiversity and utilization of its components were regulated by appealing to unwritten norms and sanctions often couched in religious terms. For example, *Ocimum tenuiflorum*, popularly called Tulsi, has some medicinal properties. It is protected by planting it on the premises of households to have ready access to the plant for medicinal purposes. In fact, Hindus accord a sacred status to the plant and worship it so that it is not neglected. Hindus attach religious meaning to some species and hence conserve them as part of their religious practices. For example, *Aegle marmelos*, popularly called Bilva tree (also found in Nepal, Sri Lanka, Pakistan, Myanmar, Bangladesh, Vietnam, Cambodia and Laos), is conserved by planting it in the premises of Hindu temples. Some species are protected by the communities in the form of sacred groves, which may contain endangered species. Communities do not use plant species or parts of the species from the sacred groves<sup>11–13</sup>. In the absence of legal norms, religion acted as an institution that exercised social control. Another example: Jeypore tract – comprising southern part of Orissa – is populated by tribal communities. The Jeypore tract is known to be the centre of primary origin of *Seihr*, the southeast Indian hill ecotype of rice<sup>14,15</sup>. The tribal communities have been conserving the germplasm of *Seihr in situ*. In India, a few species of goats and sheep reared and bred by some communities, have been shown to have genes that confer resistance against some diseases. In other words, the communities that conserved the species assumed the role of custodians or stewards.

### Access and benefit sharing

The examples mentioned here, suggest that any attempt to barcode such species must require prior informed consent of the custodians or stewards. Here, one may think of two kinds of purposes for which the consent is required: (a) consent for barcoding of species for non-commercial research purposes, and (b) barcoding for commercial research purposes. The normative basis of terms of consent obviously differs in the two situations. At present, NBDA seems to emphasize access and benefit sharing issues in the context of commercial research. The issues relating to access to biodiversity for non-commercial research are: what are the norms that should govern the access which (a) promotes non-commercial research; (b) protects the national sovereignty over genetic resources, and (c) ensures non-monetary benefits, if any. Schindel *et al.* (note 1) point out the tangible indicators of distinguishing

non-commercial research from commercial research. The indicators of non-commercial research are: (a) generation of new knowledge; (b) collection of reference specimens that generate benefits through public domain without proprietary benefits; (c) capacity building and development of human resources in using the technology in the case of developing countries that extend access to biodiversity for international research, better understanding of their genetic resources, improved basis of conserving and developing their biodiversity.

In the Indian context, NBA, scientific community and policymakers should examine whether or not these indicators are sufficient for extending access to biodiversity for international research. Regarding the third indicator of capacity building and development of human resources, one can say that in India there are qualified and competent scientists and well-endowed molecular biology research institutions to train scientists from less endowed developing countries (note 2). Further, institutions such as the National Bureau of Plant Genetic Resources (NBPGR) with its branches in different regions of the country, have been involved in collection of reference material, their characterization and *ex-situ* conservation of their collections. At present, CBD is engaged in the process of evolving an international regime on access and benefits sharing, that is likely to culminate in 2010. As India's NBDA gave effect to CBD, it is imperative that the Government of India as a member of Conference of Parties (CoP) communicate to the CBD process, the regulatory norms that govern access and benefit sharing in the case of non-commercial research that are appropriate from the point of view of India's national interests. It is necessary at this juncture because the barcoding technology for advancing taxonomic knowledge of species and monitoring, and conservation of biodiversity has become a reality after the enactment of NBDA in 2002.

Other issues that need to be addressed in the Indian context are related to evolving appropriate regulations to ensure that the biodiversity accessed for non-commercial research is: (i) not used for commercial research at a later date if it is discovered that the genetic material has commercial potential and (ii) not shared with a third party. There is a need to incorporate appropriate enforceable norms in different forms of agreements regarding material transfer. Regarding the prior informed consent in the Indian context, the provisions of NBDA envisage regulatory roles for state agencies at different levels: local self-governments like the village Panchayat, in addition to SBBs and NBDA as specified in Section 3 of NBA. However, the provisions do not specify the role of communities in the regulatory process. There is a need to evolve appropriate provisions regarding the role of the state agencies and communities in negotiations regarding access and benefit-sharing issues in the context of extending access to biodiversity for non-commercial research. In other words, the stewards and or their representatives



must be involved in the consent-seeking process and in negotiations regarding the sharing of benefits, both monetary and non-monetary, arising out of the use of components of biodiversity for research. As mentioned earlier, communities become vulnerable if they provide information for the purpose of barcoding about a species on which they depend for their livelihood. The information may be used by others, and the community could ultimately be deprived of its livelihood.

As a part of the process of democratization of barcoding technology, efforts should be made to build capacities of local communities by involving members of the communities in barcoding of the species, which they have been conserving. Such involvement could expedite the barcoding of millions of species. However, the consequences of barcoding – especially of species which provide livelihood for communities – need to be addressed in consultation with community representatives before barcoding takes place. They must be informed about the benefits, both monetary and non-monetary, of barcoding of species, and their rights as stewards of the species. The barcodes of the species must be shared with the communities, and the members of the community should be trained in using the barcoded information for monitoring and development of biodiversity.

## Conclusion

The context of knowledge production has been changing. Advances in molecular biology and the consequent prospect of the transformation of basic taxonomic research based on genotypic characteristics, increasing emphasis on commercial research and the policy regime that declared national sovereignty over biological resources through NBDA contribute to the change in the context of knowledge production and influence the practice of taxonomic research. Hence, a section of the scientists perceives that regulation curtails freedom to pursue basic taxonomic research. In this context, scientists have to negotiate with the regulatory system to see that the regulatory framework facilitates research. The DNA barcoding is a relatively new technology, and to date only a few scientists have initiated work on barcoding of some species. Similarly, civil society and its organizations have little awareness of this new technology. At present, no exclusive legal or administrative framework exists for regulating barcoding technology. Further, provisions of NBDA are concerned with access and benefit-sharing norms regarding commercial research. However, there is a need to evolve norms regarding the access and benefit-sharing relating to non-commercial research. As scientific organizations in the country start participating in barcoding activity in a big way, the barcoding technology may throw up new ethical, social, economic and political issues concerning both commercial and non-commercial

research which have to be addressed by the regulatory framework. Long-term research covering different regions of the country is needed to document the issues relating to the dynamic interface between DNA barcoding technology on the one hand and ethical, social, economic and political domains on the other. The outcome of such research may either suggest suitable amendments to the national biodiversity legislation, or lead to a new legislation to facilitate and regulate DNA barcoding in India. Attempts to make necessary amendments to the legislation, or to evolve a new legislation, should be initiated by the Government in partnership with the stakeholders: communities that have been the custodians of biodiversity and their organizations, local governments, the scientific community engaged in barcoding work, social scientists, members of the legal profession and society at large.

## Notes

1. The Bonn workshop report (2008) on 'Access and benefit-sharing in non-commercial biodiversity research' was submitted to the CBD Secretariat. The Executive Secretary of the CBD circulated the report for the information of participants in the Group of Technical and Legal Experts on Concepts, Terms, Working Definitions and Sectoral Approaches in the context of the International Regime on Access and Benefit-Sharing (UNEP/CBD/ABS/GTLE/1/INF/2, 29 November 2009).
2. The Government of India established the Department of Biotechnology in 1986 and invested a significant amount of resources over the years to support research and the state-of-the-art training in molecular biology and biotechnology in the conventional universities, agricultural universities and mission-oriented research laboratories (see <http://www.dbtindia.nic.in/>). The Rockefeller Foundation, as part of its International Program on Rice Biotechnology, supported research and capacity building in molecular biology and biotechnology during 1989–2000 (see [www.rockfound.org](http://www.rockfound.org)).
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## MEETINGS/SYMPOSIA/SEMINARS

### Lake 2010: Wetlands, Biodiversity and Climate Change

Date: 22–24 December 2010

Place: Bangalore

Themes include: Biodiversity – terrestrial, aquatic; Climate change and biodiversity: Integrated ecological carrying capacity: conservation, restoration and management of ecosystems; Coastal ecosystems: biodiversity, livelihood aspects, conservation; Lakes, rivers, estuaries: water quality, biotic resources, sustainable management; Environment – monitoring and management; Urbanisation impacts on ecosystems; Impact of climate change on wetlands; Climate change and natural disasters; Energy, ecology and environment, environmental education; Open source GIS, Application of geoinformatics in conservation and management; Solid waste management – Approaches (at home, city, State)

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### XX Annual Conference of Indian Association for Angiosperm Taxonomy (IAAT) and International symposium on 'Taxonomy, Plant Diversity and Conservation'

Date: 26–28 November 2010

Place: Coimbatore

Topics include: Systematics of angiosperms, Plant diversity and conservation, Endemism and phytogeography, Plant response to climate change, Ethnobotany and medicinal plants and Modern trends in plant taxonomy.

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