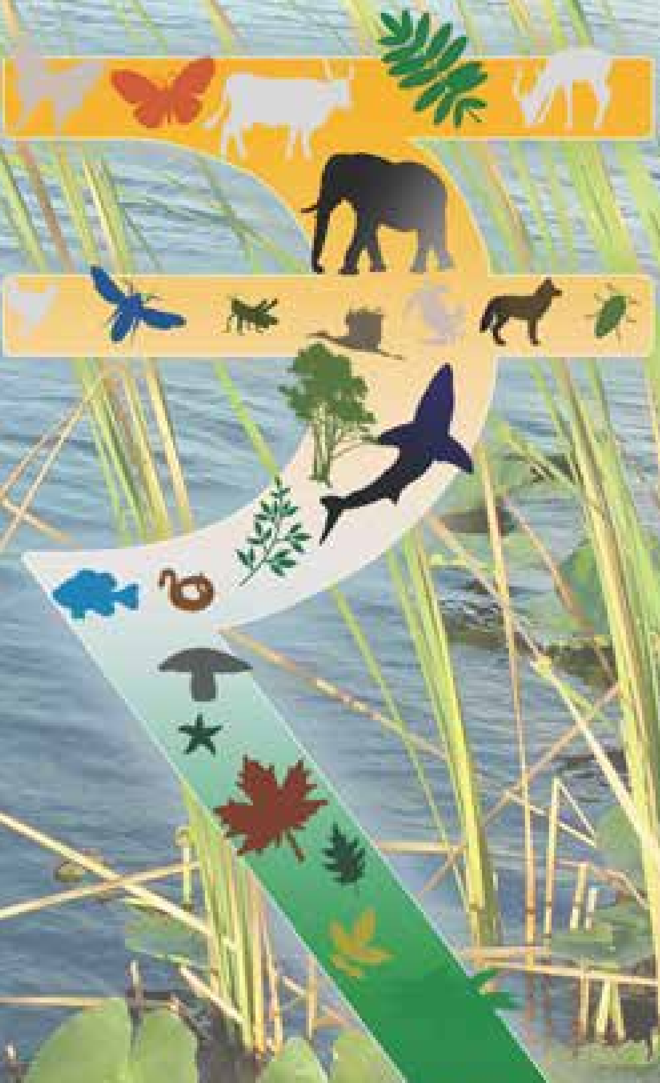
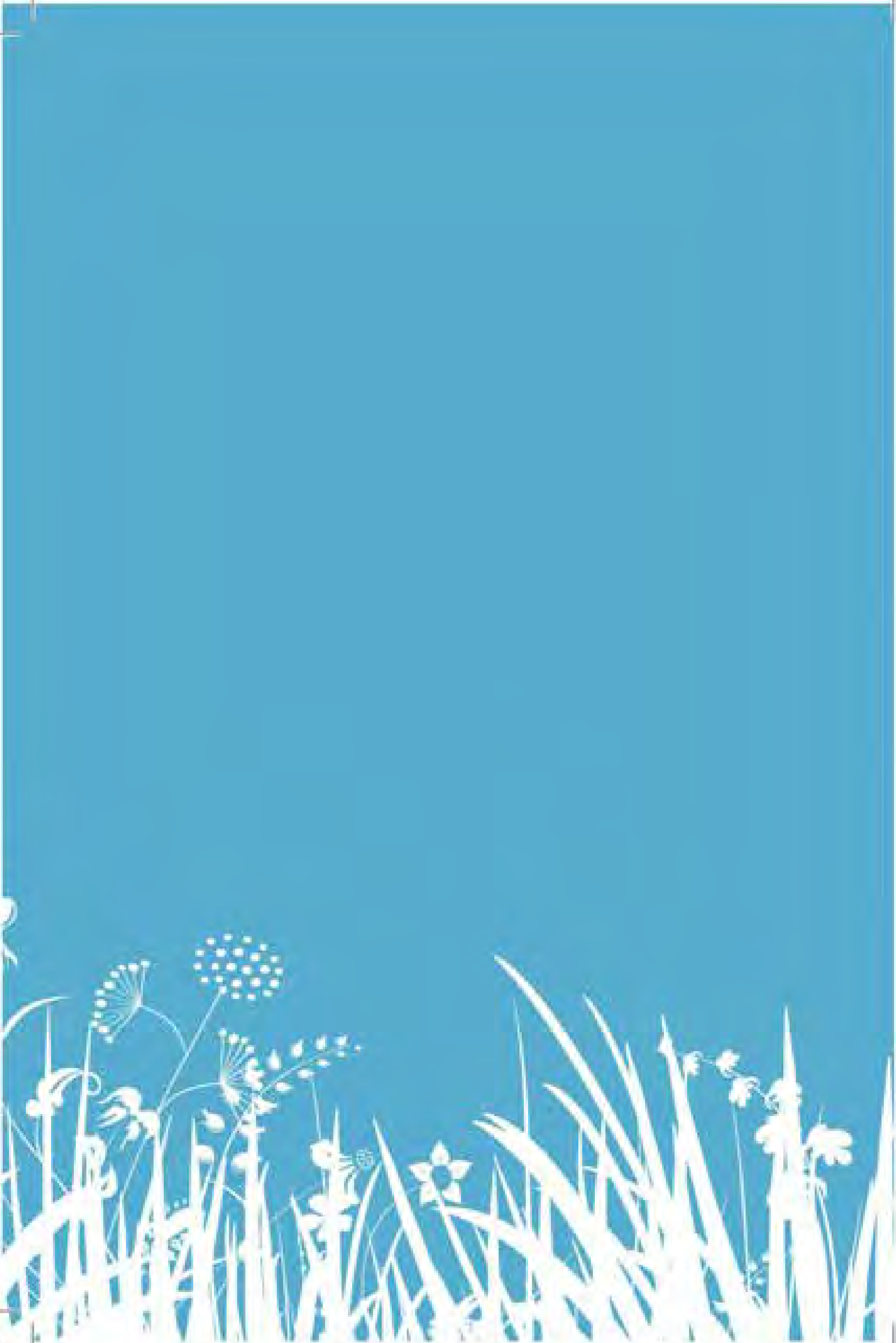
VALUATION OF BIODIVERSITY

Dissemination Paper - 3

Bio-resources Valuation through Selected Literature: A Review





Bio-resources Valuation through Selected Literature:

A Review

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FOREWORD

The report of The Economics of Ecosystems and Biodiversity (TEEB) that was launched during the tenth Conference of Parties to the Convention on Biological Diversity (CBD-COP 10) in 2010 raised a lot of awareness among policy makers on the need to look at economic valuation.

At the National Biodiversity Authority (NBA), we have been focusing on designing an appropriate benefit sharing mechanism related to implementation of the Biological Diversity Act for the past two years where the intention was to understand the economic potential of biodiversity goods for determining suitable benefit sharing plans. We realized, in pursuit of the above, that there are no standard methods to do the same nor there is appropriate understanding of economic valuation for ABS purposes.

The set of three reports compiled through the UNEP-GEF ABS Project is an attempt by NBA to raise the understanding on issues above for suitable determination of benefit sharing under the access and benefit sharing regime.

We are aware that some of the ideas and approaches presented here are not particularly mainstream thinking of environmental economics or economists but we are placing before the readers a perspective that needs attention now. Your comments, if any, are welcomed by the authors.

Happy reading!

Balakrishna Pisupati
Chairman,
National Biodiversity Authority

Chennai
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1. Introduction

Valuation of bio-resources is a fundamental step towards determining its real value, and operationalizing the Access and Benefit Sharing (ABS) provisions under the Convention of Biological Diversity (CBD) and the Biological Diversity Act of India. We realized that the development of economic valuation methodology, one of the components in the ABS project, and estimation of the real value of the bio-resources is an innovative aspect and a process, since the existing literature on environmental economics is scanty with ABS related experiences.

In connection with understanding the specificities of dealing with economic valuation in the context of Access and Benefit Sharing (ABS), substantial literature has been collected and reviewed. A majority of the studies have tried ecosystem valuation with emphasis on its non-marketed services. However, some of the studies attempted to value different bio-resources. The intentions of these studies were to:

(a) Understand and disseminate the bio-prospecting values of bio-resources or biodiversity.

(b) Assess the value of biodiversity spots such as cultivable (agriculture) land, forests and wetlands, where the bio-resources are growing and derived from, and

(c) Understand the significance of bio-prospecting values in biodiversity conservation as a source of revenue.

In brief, the authors of these studies argued, that through estimating and assigning a value to ecologically fragile lands like forests, considering their resources (such as medicinal plants) may help in conserving the land or resources and overcome the threats of different land use changes.

2. Studies on Bio-Resources

For convenience, the available studies on bio-resources are broadly classified in to six categories:

1. Microorganisms
2. Genetic Resources
3. Marine / Coral Resources
4. Crops
5. Medicinal Plants, and
6. Pharmaceutical Research

Review has been carried out, and the essence of the studies is explained in this paper. Further, the sophisticated statistical models and methodologies used by these studies for deriving the economic values of different bio-resources are presented in the Appendix.

3. Microorganisms

Economic value of microbial resources: *Masahiro Miyazaki*

Masahiro Miyazaki's (2006) study on the "Economic value of microbial resources" emphasized the undiscovered biological and genetic resources, in particular microbial resources, preserved in natural habitats, and their potential as valuable sources for future innovation of pharmaceutical and other industrial products. Since there is no established method for evaluating the economic value of microbial resources collected from natural habitats, the benefit-sharing agreement on microbial resources, in the context of implementing the Convention on Biological Diversity (CBD), is difficult to conclude. The economic value of microbial resources used as screening materials for developing new pharmaceuticals, was estimated based on the sum of an initial charge and expected royalties obtained from pharmaceutical companies. This would vary from US$ 2-60/strain, depending on their quality and value-added information attached to the strains.

This study estimated the economic value of ex-situ microbial resources collected from natural habitats. Since pharmaceuticals represent one of the biggest potential markets for microbial resources, the economic value when used as screening materials for developing new pharmaceuticals, has been emphasized. Many of the pharmaceutical companies, when they obtain microbial resources from resource providers, often offer royalties for such microorganisms after the product launch, in addition to an initial charge. Therefore, the sum of an initial charge and the expected royalties obtained from pharmaceutical companies, were considered in the model applied on the economic value of microbial resources.

The paper concludes that the estimation of the economic value of microbial resources collected from natural habitats for screening materials for developing new pharmaceuticals have resulted in a relatively low value (US$2-60/strain). For the source countries to gain a greater share of the benefits from microbial resources, they should, for example, build human and technological capabilities to isolate, preserve and characterize microorganisms and provide users with more value-added resources, in country. This could be realized through conducting scientific and technological education and training, scientific research, and technology transfer, as provided for in the relevant articles of the CBD. For this purpose, priority should be given to non-monetary benefit-sharing rather than monetary benefit-sharing, in negotiating an ABS agreement with resource users in the context of implementing the CBD.

A: Genetic Resources

1. Valuing Animal Genetic Resources: Lessons from Plant Genetic Resources: *Douglas Gollin and Robert Evenson*

Gollin and Robert Evenson's (2003) study on "Valuing Animal Genetic Resources: Lessons from Plant Genetic Resources" indicated that a number of theoretical and empirical studies has examined issues relating to the valuation, utilisation, and management of plant genetic resources (PGRs). This paper summarised the relevant lessons from the literature for animal genetic resources and came to the point, that conceptually and methodologically, there are strong similarities between plant and animal genetic resources. However, the literature on PGRs makes it clear, that most of the important policy questions require empirical information about the costs of collection and storage; the "uniqueness" of desirable traits; technologies for in-situ and *ex-situ* conservation, etc.

There are about 4000 rare breeds of livestock globally. The cost of maintaining these rare breeds could be quite low. The indirect use value - an option value - of preserving these breeds is probably high enough to justify the costs. More generally, consider a rough cost calculation for the conservation of all plant and higher animal species, that can be conserved using cryopreservation techniques. For plant species, using ex-situ gene bank technology, the cost of maintaining ex-situ preservation of all 250 000 higher plant species is probably a little higher than the cost of one million or so distinct crop landraces. Similarly, for all higher animal species, the cryopreservation cost may be quiet modest, to the extent that the technologies for preservation can be made feasible. If the cost per livestock species conserved is within an order of the magnitude of the cost of conserving each plant species, there cannot be much doubt that the economics justify the extensive conservation efforts. From a methodological stand point, many techniques developed for assessing the value of PGR seem to be appropriate for animal genetic resources, as well. The authors propose that, improving the empirical understanding of animal genetic resource conservation should be the focus of future research.

a. Valuing Animal Genetic Resources: a choice modelling application to indigenous cattle in Kenya: *Eric Ruto, Guy Garrod and Riccardo Scarpa*

Eric Ruto et al's (2008) study on "Valuing Animal Genetic Resources: a choice modelling application to indigenous cattle in Kenya" pointed out, that in an effort to improve productivity and profits, many farmers have replaced traditional livestock breeds with higher yielding alternatives. While such changes may bring about short-term economic gains, the loss of traditional livestock breeds could result in the loss of an important genetic resource, as a variety of important genetic traits adapted to local conditions, gradually becomes less common in the population. This is a particular problem in Africa, where livestock makes a substantial contribution to human livelihoods. Based on the example of cattle in Kenya's pastoral livestock markets, this study uses a choice experiment approach to investigate buyers' preferences for indigenous breeds, such as the maasai zebu.

The analysis employs a latent class approach to characterize heterogeneity in valuations both within and across respondents, buying cattle for breeding, slaughter, or resale. The results show that there are at least three classes of buyers with distinct preferences for cattle traits, and that most buyers favour exotic rather than indigenous breeds. The segment associated with those buying cattle for the purpose of slaughter or resale account for nearly 80% of the samples. Such preferences have implications for the conservation of indigenous cattle in Kenya and in other developing countries, and suggest that some form of intervention may be required to ensure the preservation of these important animal genetic resources.

5. The Economic Value of Coffee (Coffea Arabica) genetic resources: *Lars Hein and Franz Gatzweiler*

Lars Hein and Franz Gatzweiler's (2006) study on "the Economic Value of Coffee (Coffea Arabica) genetic resources" indicated, that whereas the economic value of genetic diversity is widely recognized, there are relatively few instances of the actual valuation of genetic resources. This paper presents an analysis of the economic value of *Coffea arabica* genetic resources, contained in the Ethiopian highland forests. The valuation is based on an assessment of the potential benefits and costs of the use of *C. arabica* genetic information, in breeding programs for enhanced coffee cultivators. The study considers the breeding of three types of enhanced cultivars (increased pest and disease resistance, low caffeine contents and increased yields). The costs and benefits are compared for a 30 years discounting period, and result in a net present value of coffee genetic resources of 1458 and 420 million US$, at discount rates of 5% and 10%, respectively. The value estimate is prone to considerable uncertainty, the major sources of uncertainty being the length of the breeding programs required to transfer valuable genetic information to new coffee cultivars, and the potential adoption rate of such enhanced cultivars. Nevertheless, the study demonstrates the high economic value of genetic resources, and underlines the need for urgent action to halt the currently ongoing, rapid deforestation of the Ethiopian highland forests.

The method is based on the assumption that the value of coffee genetic information, equals the benefits that can be obtained from applying this information in a breeding programme. Hence, capturing the full economic value of genetic *C. Arabica* resources requires global collaboration between coffee growers and producers. The study confirms the market failure in the case of the conservation of genetic resources. Whereas the global economic value of coffee forests is considerable, this value is not reflected in the incentive structure of the local population.

The study emphasizes the need for urgent action to halt the ongoing rapid deforestation of the Ethiopian high land forests. The high potential economic value of coffee genetic resources could provide an incentive for the Ethiopian government to support the more sustainable use of these forest resources. The study concluded that the valuation of the genetic information may increase the awareness of local and national stakeholders of the economic value of forests, and may be instrumental in setting up a payment mechanism for the sustainable use of genetic information.

4. Valuation of Plant Genetic Resources: *Ramanatha Rao*

Ramanatha Rao's (2012) study on the "Valuation of Plant Genetic Resources" pointed out that Plant Genetic Resources (PGR) refers to the biological diversity of crops and their wild relatives, encompassing both phenotypic and genotypic variation, including cultivars or verities recognised as agromorphologically distinct by farmers and /or as genetically distinct by crop improvement scientists. The value of plant genetic resources is as per the people who depend on it. However, as a the need for conservation mounts, it seems to be true that every conservation action needs to be supported with argument that shows tangible and measurable benefits from such actions to get the funding needed. In this paper, the value of genetic resources is briefly discussed, along with the cost of plant genetic resources conserved in gene banks and on farms.

The author has briefly reviewed the literature on; (a) the value of plant genetic resources from the formers' perspective, (b) the value of agro biodiversity in research and development, (c) the value of PGRs based on the use in crop improvement, (d) value of PGRs conserved in gene banks, (e) valuing biodiversity in public perception and (f) the limits of the economic valuation of the biodiversity of PGRs.

The study concludes that PGRs are the raw material used by plant breeders to create improved crop cultivars. Due to the socioeconomic and cultural complexities involved, it is exceedingly difficult to ascribe a purely economic value to any particular PGR. While the market value of a new variety of rice or wheat is fairly easy to calculate, it is almost impossible to estimate the value of any one characteristic derived from an individual accession, which would always be, at best an estimate based on several assumptions, and heavily dependent on one's perspective.

5. Marine / Coral Resources

1. Marine System Valuation: An Application to Coral Reef Systems in the Developing Tropics: *Jack Ruitenbeek and Cynthia Cartier*

Jack Ruitenbeek and Cynthia Cartier's (1999) study on "Marine System Valuation: An Application to Coral Reef Systems in the Developing Tropics" has reviewed the Genetic Resource Valuation Models in Pharmaceuticals, and arrived at the following points: (a) Most modelling efforts to value genetic resources for pharmaceutical use have taken a change in the production approach, and (b) The value of preserving a species for pharmaceutical use is based on the potential value of an unknown or untested species in the production of a new drug.

The models often attempt to address somewhat different policy problems; and, various ways to demonstrate how selected issues or exogenous factors can influence "values". The early models use the gross revenues of all plant-based drugs, to impute a value for individual plant species responsible for those drugs. More recent models estimate the net revenues from hypothetical new drugs; these make an assumption regarding the number of species or biotic samples required to find a new drug source, and thereby calculate an average value for those species. Another modeling approach is to calculate the marginal value of a species. In this case, the net revenues are used to calculate the change in the value of a collection of species, when one more species is added. Most of the studies take a change in the production approach or explicitly attempt to value rents. Some modelling efforts have used a royalty approach to value genetic resources.

Many of the model results are exceedingly sensitive to key economic or biophysical assumptions. Many models that generate positive values in a base case scenario, return negative (or significantly smaller) values when tested under different (yet still plausible) sets of assumptions. For example, a great deal of attention is often paid to what are loosely called "hit rates", or the basic probability of success in developing a commercial drug from some randomly sampled species, natural product, or extract.

2. Montego Bay Pharmaceuticals Bioprospecting Valuation: *Cynthia Cartier and Jack Ruitenbeek*

Cynthia Cartier and Jack Ruitenbeek's (2000) study on "Montego Bay Pharmaceuticals Bioprospecting Valuation" used the utility, production, and rent valuation approaches, to estimate the value of marine products through bioprospecting. The review confirmed that for marine organisms, the biochemical information derived from these organisms is as the actual use of the organism itself. A key recommendation was that, any chosen methodology should be capable of addressing the information content of coral reef or marine organisms. Most utility oriented approaches are incapable of separating this information value. A second aspect of the review confirmed that institutional structures and revenue or rent sharing arrangements are key influencing variables in the valuation of marine products.

Successful data must be available to translate sampling information (e.g species types and counts) into final commercial products, which is usually done through a series of "hit rates". But such hit rates are known only at advanced stages of Research and Development. Using typical cost estimates for Jamaica, and typical hit rates and end use values, scenario analyses were conducted using a parametric model. The reference case places marine bioprospecting values at just under US$ 2,600 per sample or US$ 7,775 per species.

The model demonstrates the sensitivity of total and marginal values to ecosystem yield and institutional arrangements, for capturing genetic prospecting value. The relatively low "price", and the apparently small drop in benefits from significant coral reef degradation, underlines the importance of the ecosystem yields. The economic effect of the "lost samples" is discounted substantially, and would consequently have less of an impact on current management decisions.

6. Crops

1. Valuation of Perennial Crops Associated with Agricultural Land Sales: The Case of Sugarcane in Louisiana: *Michael E. Salassi, Lonnie P. Champagne, and G. Grant Giesler*

Michael et al's (2000) article on "Valuation of Perennial Crops Associated with Agricultural Land Sales: The Case of Sugarcane in Louisiana", focuses on the estimation of the market value of "short-lived" perennial crops, which have a productive life of a relatively short defined period of years. This exercise would help in taking effective policy decisions related to agricultural land sales. The valuation methods used for estimating the value of the perennial crop (sugarcane) would also be applicable to other perennial crops, such as fruits, nuts, spices, and ornamental crops.

Three general valuation procedures recommended for valuing specialized properties, which contain perennial or permanent agricultural plantings are: (1) the sales comparison approach; (2) the cost approach; and (3) the income capitalization approach. The sales comparison approach is a frequently used method. The cost approach estimates the value of improvements made to the land. In terms of sugarcane production, these improvements are the expenses incurred by the producer (who in most cases is not the landowner) to prepare the land and plant sugarcane. The valuation method is the most appropriate for immature plantings (before any returns have been realized), but can be used at any stage of crop development. The income capitalization approach estimates the net present value of the investment, in sugarcane production at any point in time, and includes the present value of future expected net returns, through to the end of the current crop cycle. This approach is more appropriate to use when the sugarcane crop has reached a mature or sustained stage of production, but can be used at any point in time. The basic calculation used in this analysis determines the current year production costs, the appropriate allocated and unallocated planting costs, as well as the net present value of any future net returns (through the the end of the crop cycle).

1. Estimating the Value of Agricultural Cropland and Pastureland in India: *Haripriya.G, Sanjeev.S, Rajiv. S and Pavan. S*

Haripriya et al's (2005) study on "Estimating the Value of Agricultural Cropland and Pastureland in India" provides a comprehensive picture about the status and challenges of Indian agriculture, as its significance in incorporating into the System of National Accounts. Agricultural land, constituting 57% of the geographical area of India, contributed around 20% to the total GDP in India for the year 2002/03. In the System of National Accounts (SNA), agricultural land is treated as a non-productive economic asset, which provides economic benefits to its users. The economic activities considered under "agriculture" in SNA include 1) growing field crops, fruits, nuts, seeds and vegetables, 2) management of tea, coffee, and rubber plantations, 3) agricultural and horticultural services on a fee or contract basis 4) ancillary activities of cultivators, such as making gur (raw cane sugar). The economic use of land is often connected with short or long term processes of deterioration. To understand the relationship between economic activities and the environment, one should consider both the use of the land and the potential of the land for different economic activities from an ecological point of view.

The main aim of this study was to develop an accounting frame work, that reflects the real contribution of agricultural land and pasture land to society. The more specific objectives include: (1)

to estimate the value of the stocks and flows of agricultural land and pasture land; (2) Incorporate the loss in value caused due to the depletion of agricultural and pastoral resources into the national accounts; and (3) estimate the impact of the sector on the degradation of the environment, and thereby estimate the sector's real contribution to the economy. This study focused on various states in India relies mainly on secondary data.

The net present value (NPV) approach has been used to estimate the value of the asset and the changes in the assets. The concept behind the NPV approach is land characterisation based on soil quality, soil texture, and soil fertility, associated water resources and other inputs such as seeds, rainfall, fertilizers etc. Some output is produced which can be marketed at some market value. When the values of man-made inputs are deducted from the output, one can get the economic rent or land rent, which is considered as the payment for the use of natural resources. The variations in these economic rents are due to the differences in the quality of the land and the inputs mentioned earlier. The economic rent is expected to change every year with changes in the levels of input /output use, their prices and the discount rate. The land rent is obtained by estimating the annual net returns from the use of the resources over time, less a reasonable allowance for profit.

3. Valuation of crop genetic resources in Kaski, Nepal: *Farmers' willingness to pay for rice landraces conservation: Diwakar Poudel and Fred H. Johnsen*

Diwakar Poudel and Fred H. Johnsen's (2008) article on the "Valuation of crop genetic resources in Kaski, Nepal: Farmers' willingness to pay for rice landraces conservation" explains, that the crop genetic resources constitute an important aspect of biodiversity conservation, both because of their direct value to the farmers and due to their indirect global value. This study uses the contingent valuation method to document the economic value of crop genetic resources based on the farmers' willingness to pay for conservation. A total of 107 households in Kaski, Nepal were surveyed. Their mean willingness to pay was USD 4.18 for in-situ and USD 2.20 for ex-situ conservation per annum. Landholding size, household size, education level, socio-economic status, sex of the respondent, number of crop landraces grown, and knowledge of biodiversity influenced the willingness to pay for in-situ conservation, whereas only the landholding size and household size influenced the willingness to pay for ex-situ conservation. The respondents were willing to contribute more for in-situ than ex-situ conservation, because of the additional effect of direct use and direct involvement of the farmers in in-situ conservation. This study supports the view that the economic valuation of crop genetic resources can assist the policy makers in setting right the conservation priorities.

The fact that the farmers show willingness to pay for the conservation of landraces does not imply the suggestion, that conservation should be funded through contributions from the potential beneficiaries. It is not feasible or socially equitable to expect the poor farmers to pay for conservation, which has global public good attributes. The values obtained in this study are quantified indications of the value placed by the farming community on the CGR, specifically rice landraces. As such, they are useful for the cost benefit analysis, and for debate and decision-making on conservation strategies. The study may contribute to drawing the attention of the policy makers to the formulation of appropriate policy mechanisms, raising public and political awareness of the importance of the issue, and helping to set conservation priorities.

7. Medicinal Plants

1. Screening Plants for New medicines: *Norman R. Farnsworth*

Norman R. Farnsworth's (1998) study on "Screening Plants for New medicines" examined the global importance of plant derived drugs. Approximately 119 pure chemical substances extracted from higher plants are used in medicine throughout the world. In many countries herbal drugs are significant. Apart from this, there is a great deal of interest in and support for the search for new drugs from higher plants, in countries such China, Japan, India and Germany. The National Cancer

Institute in the U.S has tested 35,000 species of higher plants for anticancer activity, and the same species has effective principle for other diseases such as arthritis, blood pressure, AIDS and / or heart trouble.

The NAPRALERT database is maintained by the University of Illinois at Chicago. There is a specialised computer data base of information on natural products derived from a systematic search of the world literature. The data that can be retrieved from the system include, folkloric medicinal claims for plants, the chemical constituents of plants, the pharmacological effects of naturally occurring substances, or the pharmacological effects of crude extracts prepared from plants. There are many approaches to drug discovery from plants, but the reasonable approach is simply to collect every readily available plant, prepare extracts, and test each extract for one or more types of pharmacological activity. This random collection and broad screening method ultimately should produce useful drugs, but it is contingent on the availability of adequate funding and appropriate predictable bioassay systems.

Thus, in the author's view, future programs of drug development from higher plants should include a careful evaluation of historical as well as current claims of the effectiveness of plants as drugs from alien cultures. Such information is rapidly disappearing, as our own culture and ideas permeate the less developed countries of the world, where there is a heavy dependence on plants as sources of drugs. Also, it is found that there is a lack of interest in new drug discovery programs from plants, due to reasons such as natural products not being patented with the same degree of assurance as synthetic compounds; most promising plants seems to be indigenous to developing countries, many of which do not have stable governments, and thus cannot provide an assurance that there will be a continuous supply of the raw material needed to produce useful drugs, and also finding the scientific documentation is difficult. Many of these unique gene sources may be lost forever through extinction, as plants have a great potential for producing new drugs of great benefit to mankind, and hence, have to preserved.

2. Valuing the Biodiversity of Medicinal Plants: *Peter Principe*

Peter Principe's (1991) Chapter "Valuing the Biodiversity of Medicinal Plants" emphasized on various prospects of and challenges to biodiversity, and the significance of economic approaches in biodiversity management. According to the author, the most daunting aspects of the biodiversity issue are our almost complete ignorance of the magnitude of both the problem and the potential benefits that may be lost or retained. The world's genetic resources are steadily and rapidly diminishing. During the 300 years between 1600 and 1900, about 75 species of plants and animals became extinct, because of human activity. However, the preservation of biodiversity has received considerable attention over the last two decades, from both the scientific community and public policy debates.

This paper deals with the medicinal benefits of high plants; it must be recognised that there are many other possible benefits, including agricultural products, industrial products (e.g. a plant oil that can substitute for whale oil, thereby lowering prices and saving whales), insight into new processes and mechanisms, a better understanding of nature, and direct environmental/ ecosystem benefits (e.g. their role in the carbon cycle, removal of pollution and prevention of erosion). Clearly, most of these benefits represent knowledge: either insight into known or altogether new products or processes. And every plant species offers different insights and understanding.

In addition to the ecological information, and aesthetic benefits derived from the preservation of plant species, there are economic reasons as well. Biodiversity is of great importance to the world's economy. Plants are used for food, clothing, fuel, and as building material, drugs and so on. For example, the world's main agricultural crops are based on fewer than 20 crop species. The availability of diverse germ-plasms to adopt current crop varieties to changing climatic and disease conditions, is of great importance. The most obvious difference is that the value of crop biodiversity can be demonstrated within one or two crop cycles. In contrast, the value of a medicinal plant species takes considerably longer to establish, and the conceptual link between the plant and the final drug is far more tenuous than that between crops.

The market value of a resource varies from its Economic Value. The market value is the value the market place attributes to a given commodity or its derivative products, as represented in the market price, and the quantity of the commodity that is sold. The economic value, in contrast, represents all the societal benefits of a particular type of product, including the market value. The economic value can be viewed as an expression of the total benefits of a product. The relationship between the economic value of a medicinal plant species, and the market price of the drugs derived from it, is not a direct one. However, it can be argued that the market prices are minimum valuations, assuming that: (1) the demand for the drug is inelastic; and (2) it is appropriate to value the essential inputs at their own cost, plus the economic rent obtained from them plus the associated consumers' surplus.

In developing the estimates of the market value of the medicinal plants, it has been argued that the use of the market price data inflates the market value thus derived, because of the large difference between the raw material cost and the final product cost. This is expected, because of the large development and manufacturing costs, as well as the incorporation of research costs for failed efforts. However, while it is clear that only some part of the market price of the plant derived drugs is attributable to the plant raw materials, the existence of the consumers' surplus indicates that there is a willingness to pay that is greater than the market price. This is due, in part, to the inelasticity of the demand for products such as pharmaceuticals. Consequently, while there are flaws in using the final market price, it is probably a better indicator of the market value than the market price of the raw material.

With respect to the medicinal plant species, there are two aspects of economic value that must be considered. First, the economic value of the drugs derived from these plants includes not only the market value, but also the societal benefits from increased good health (e.g no wages loss, health care costs averted, the value individuals placed on the better health, etc.). Second, the non-pharmaceutical uses and benefits that the plants provide (i.e. the informational and environmental benefits). One way to assessing this is through the net benefits of preservation (NBP). This value is the sum of the expected consumers' surplus, the option value, the existence value, and the expected value of the product revenues, minus the expected costs of product development and the costs of implementing the preservation program. The major problem is that, the first three values are very difficult to quantify. Furthermore, several specific benefits of biodiversity are not included within any of these terms; so, so even if NBP were calculated, it would be a considerable underestimation of this portion of the economic value of these plants.

5. Assessing the Economic Value of Traditional Medicines from Tropical Rain Forests: *Michael Balick and Robert Mendelsohn*

Michael Balick and Robert Mendelsohn's (1992) study on the "Assessing the Economic Value of Traditional Medicines from Tropical Rain Forests" made an attempt to quantify the value of the forests for their therapeutic products, using the data from Belize. The study pointed out, that increasing attention has been given to the value of the tropical rain forests as a source of non-timber market products. Although these product estimates do exist, many have yet to be quantified. One important class of products that has not yet been valued is tropical pharmaceuticals. Tropical forests are a rich source of unknown chemicals that may eventually prove useful to medicine. In addition, traditional medicines are currently the basis of much of the primary health care delivered in tropical nations. For example, traditional practitioners provide up to 75% of the primary health care needs of rural people in Belize, and the local forests are the sources of the plants.

In order to quantify the value of managing forests as a source of traditional medicines, an inventory of the plants in specific plots is a pre-requisite. According to the authors, the results of this study will stimulate follow- up studies to quantify the stock and growth of plant medicines in primary and secondary forests. Systems for the sustainable collection of plant medicines and other non-timber products from tropical forests, need to be documented and developed for use on a much broader scale. Combining the present value of medicine with that of other sustainable non-timber forest products, provides a compelling and quantifiable argument for the conservation and careful management of tropical and subtropical forests.

4. The Economic Value of Biodiversity: *David Pearce and Dominic Moran*

David Pearce and Dominic Moran's book (1997) on the "Economic Value of Biodiversity" is an enquiry on why biodiversity disappears, and how its economic value might be captured. The economic value of medicinal plants and plant based drugs constitutes in a segment in this book. Plant species are used for medicines in two ways: (a) major commercial use, whether by prescription or over-the-counter sales, and (b) as traditional medicines which may or may not attract a market price. In the rich world, perhaps 25 per cent of all medical drugs are based on plants and plant derivatives. In the poor world, the proportion is closer to 75 per cent.

For ascribing an economic value to medicinal plants two bases have to be considered. The first relates to the existing use values which, in turn, are for commercial drugs and for traditional medicine. The second relates to the option value of the plants, ie, the extent to which conservation is required to protect future use values. Option values, in turn, are critically dependent upon the future of research in the medicinal drug sector, with respect to the base materials that are likely to be used.

The authors suggested the following ways in which one can approach valuation:

By looking at the actual market value of the plants when traded;

By looking at the market value of the drugs of which they are the source material;

By looking at the value of the drugs in terms of their life-saving properties, and using a value of a 'statistical life'.

A model has been developed for determining the medicinal plant value of a unit of land as biodiversity support. The approach is fraught with difficulties, given the considerable data deficiencies, but it is worth pursuing.

5. Valuation of medicinal plants for pharmaceutical uses: *Pushpam Kumar*

Pushpam Kumar's (2004) paper on the "Valuation of medicinal plants for pharmaceutical uses" attempted to review the acclaimed valuation work done during 1985-2000, with an emphasis on the valuation of plant diversity for pharmaceutical uses. From this, the methodologies used by the different studies have been scrutinized carefully, and their possible applications examined, in the valuation of bio-resources for Access and Benefit Sharing (ABS) purposes. These studies were meant to address different concerns; it is difficult to arrive a general consensus on the methodologies they developed or adopted.

However, the value of a medicinal plant varies from $ 0.2 to $ 340 million per annum. In the broader sense, the emphasis of these studies was on the conservation of biodiversity based on the benefits of medicinal plants or bio-prospecting.

The economic valuation of biodiversity and its different components, in terms of their use and option values, induces efficiency in the decision making process. As far as the contribution of biodiversity to society is concerned, medicinal plants and herbs are one of the crucial components, that have huge commercial potential. Medicinal plants provide significant inputs for drugs. However, with a progressive loss of biodiversity, especially in the tropics, society is not only losing the present benefits from its current use, but is being deprived of the option of future availability, known as option value. Hence, loss through the extinction of a species could lead to considerable social costs. In this context, the economic valuation of the components of biodiversity, such as medicinal plants, helps us to understand how the conservation of biodiversity affects social welfare.

The valuation studies done so far, have been classified into three categories: gross estimation, net estimation and estimation of lead for the drug industry. In the first one (estimation of gross economic value), the total contributions of medicinal plants have been estimated on the basis of the drug sales; the economic estimates done by Farnsworth and Soejarto, Principe and Mendelsohn, and Ballick come under this category. The second group (the estimation of net economic value) of studies, tries to adjust the cost of drug discovery and marketing and arrive at some sort of a net value. Studies by Aylward, Artuso, and Pearce and Purushothaman fall in this group. The third category (Estimation of lead for drug discovery), of estimations was based on probabilistic models of a search for a useful clue to a new drug by the R&D wing of the pharmaceutical firms. Recent works of Simpson et al and Rausser and Small come under this category.

The author proposed that a local or area based study taking into account its features of species and genera, and their ecological function, should be the preferred approach. For example in India, instead of a thumb rule study for the entire country, the valuation of the species in a particular landscape or habitat like Western Ghats or North East Himalayas gives better insights. This will help in providing a meaningful direction to the policy makers for efficient land use planning. Valuation studies will need more refined ecological data such as detailed taxonomic information on plants and animals, and R&D information such as real costs and transfer pricing data, that can enhance the quality of the estimate, and make the policy recommendations more convincing and meaningful.

6. The Value of Biodiversity in India's Forests: *Haripriya.G, Sanjeev Sanyal, Rajiv Sinha and Pavan Sukhdev*

Haripriya et al's (2006) study on the "Value of Biodiversity in India's Forests" attempted to value the biodiversity functions of India's natural ecosystem and suggest methods to adjust national and state income accounts. The main objectives of this study are to (1) identify an appropriate indicator to assess the state of biodiversity in different states in India, based on the available data from secondary sources, (2) estimate the value of biodiversity in the Indian Forests' Ecosystem, and (3) estimate the value of the depletion of biodiversity due to forest losses in different Indian states. The paper has discussed the biodiversity profile in India, the various biodiversity indicators, and the ways to estimate the value of biodiversity, and the results of estimation, and policy implications. One of the most important services that biodiversity provides to the economy, is in the form of genetic material. Modern pharmaceutical research has relied heavily upon plant based genetic material, to develop lifesaving commercial drugs that are marked nationally and internationally.

About 119 pure chemical substances taken from 90 species of higher plants are used internationally in medicines. For plant based drugs in the market, three approaches have been used to obtain the value of the genetic material contained within them. The first approach looks at the values arising from traded plant material, on the assumption that the market value represents the true WTP. The second approach uses the market value of plant based drugs. The third approach estimates the value of plant based drugs in terms of their life saving properties. According to the authors, many empirical studies of genetic materials, revealed a low value due to market imperfections.

7. Economic values of conservation and use of floral and medicinal plant genetic resources in Vietnam towards sustainable use: *Nguyen The Chinh*

Nguyen The Chinh's paper on the "Economic values of conservation and use of floral and medicinal plant genetic resources in Vietnam towards sustainable use" (-----) provides a comprehensive picture of conservation, and the use of floral and/or medicinal plant genetic resources. According to the author, conservation means the conservation of floral and medicinal plant diversity, within or outside their natural habitats, while 'use' means to remove the components from their natural habitats to meet human needs. To address this conflict in an optimal way, an approach to conservation and sustainable use of medicinal plant genetic resource should be adopted. This requires a wide range of relevant activities such as: (a) an inventory of populations and species, (b) assessment of their natural growth in given ecological regions, (c) removal of economically and ecologically ineffective and unplanned use or harvesting practices, and (d) the promotion of well-planned harvesting practices, and rational use of their components, taking into account the carrying capacity to specific ecological regions.

In considering the economic value of a biodiversity resource, we need to encompass its relevant issues of social importance. The value of biodiversity to society relies on its ecological significance that benefits the society, and it is not confined to a single nation. Biodiversity is a trans-boundary issue; hence, different countries commonly share it. Even within a society, the value of ecological resources is viewed, in different ways by different segments of the population. Thus, social and technological preferences, and even incomes should be included in an economic valuation. A market based evaluation of biological resources may lead to an omission of other benefits that are un-priced in the market, and this may result in the loss of opportunities for both the poor and other individuals of future generations, to have access to the resources.

Studies on the economic values of medicinal plants (Kerry Turner, David Pearce and Ian Bateman), show that the economic values can be derived from supplying the local and global markets with plant genetic material in per hectare monetary terms ranging from USD 250-750 to USD 12-250 respectively, making up a total of USD 260- 1000. It is also a fact, that in addition to their economic values that benefit local economies, floral and medicinal plant genetic resources are also of great global significance. This explains why there is a need in a global treaty dealing with efforts in conservation and the sustainable use of medicinal plant genetic resources.

Practical experiences show that other land uses for economic development purposes, but not conservation, are often subsidized. Therefore, the conservation of genetic resources of flora in general and medicinal plants in particular, has to face unfair competition, and this explains why the diversity of floral genetic resources is disappearing at an alarming rate in Vietnam and the rest of the world. Most of their indirect use values, such as soil protection, watershed protection and purification of air environment, often have no market. The "public good" nature of genetic resource diversity and the economic distortions in the market place, and as a result, the total economic value of a genetic resource will be imprecise, resulting in errors in policy making for the conservation and sustainable use of floral and medicinal plant genetic resources.

In operating a market mechanism by the economy in transition, it is impossible to prevent or restrict local people from access to these resources, unless an effective management mechanism is in place. This is because an individual's maximizing of profit is outweighing. In respect with positive aspect, it is obvious that high economic value species of medicinal plant could yield an abundant supply of plant genetic material for domestic pharmaceutical industry and exports if they are proliferated but not being extinct, through proper conservation and management with adequate financial and technical inputs.

8. Pharmaceutical Research

1. Valuing Biodiversity for Use in Pharmaceutical Research: *David Simpson R, Roger A. Sedjo, and John W Reid*

The study done by David Simpson et al on "Valuing Biodiversity for use in pharmaceutical Research," (1996) emphasized "Biodiversity prospecting" as a mechanism both for discovering new pharmaceutical products, and saving endangered ecosystems. However, it is unclear what values may arise from such activities. The study also focused on the value of the marginal hectare of habitat, and found that the incentives for habitat conservation generated by private pharmaceutical research, are very modest.

There has been considerable recent interest in "biodiversity prospecting," i.e, the search for chemicals produced by wild organisms. In nature, these compounds are employed to escape from predators, capture prey, enhance reproductive success, and fight infection. These chemical compounds might be of considerable commercial value, if adapted to industrial, agricultural, and, particularly, pharmaceutical applica-tions. Biodiversity prospecting has also been touted as a tool for conservation. It has been argued that incentives for the preservation of areas in which biological diversity is the greatest, particularly tropical rain forests, might be increased if landholders could be compensated, for the values generated by endangered organisms used in new product research.

In order to determine the strength of such conservation incentives, we would need to know the value of the "marginal species" in biodiversity prospecting. A number of studies have adopted a straightforward approach to valuing biodiversity for pharmaceutical research. These studies have multiplied an estimate of the probability of discovering a commercially valuable substance by the value of a discovery. The results of these exercises range from as little as $44 per untested species in-situ, to as much as $23.7 million. A more careful analysis of these studies is useful in that, they incorporate detailed treatments of the benefits of a new product discovery. According to the authors, the method underlying all these studies was flawed.

Existing work takes little account of scarcity. Redundant resources are not scarce and hence, do not have great value. By multiplying the probability with which an organism sampled at random contains some chemical compound of commercial value whether unique to that organism or not, by the expected value of a successful commercial product, earlier researchers have failed to recognize the possibility of redundancy among natural compounds. This paper's approach is more closely related to that, and valued the marginal species on the basis of its incremental contribution to the probability of making a commercial discovery.

The authors derive a simple demand function for biodiversity in pharmaceutical research, determine the willingness to pay for the "marginal species," and consider the sensitivity of the value of the marginal species to the probability of discovery, and assumptions concerning the overall profitability. The study concludes that the private value of the marginal species for use in pharmaceutical research and, by extension, the incentive to conserve the marginal hectare of a threatened habitat, is negligible.

2. Valuing Research Leads: Bioprospecting and the Conservation of Genetic Resources: *Gordon C. Rausser and Arthur A. Small*

Gordon C. Rausser and Arthur A. Small's (2000) study on "Valuing Research Leads: Bioprospecting and the Conservation of Genetic Resources" revealed, that bio-prospecting has been touted as a source of finance for biodiversity conservation. Recent work has suggested that the bioprospecting value of the "marginal unit" of genetic resources is likely to be vanishingly small, creating essentially no conservation incentive. When genetic materials are abundant, information rents are virtually unaffected by increases in the profitability of product discovery, and decline as technology improvements lower the search costs. The numerical simulation results suggest that, under plausible conditions, the bioprospecting value of certain genetic resources could be large enough to support market-based conservation of biodiversity.

Biodiversity prospecting, the search for valuable compounds from wild organisms, has been touted as a potential source of finance for biodiversity conservation. An open question is whether, or under what conditions, revenues from bioprospecting could be large enough to offset the opportunity costs, that host institutions may have to incur, in order to preserve genetic resources.

The magnitude of information rents depends on the degree to which ecological and taxonomic knowledge turns leads into 'differentiated products', creating a monopolistically competitive market in research opportunities. Rents for high-quality leads can be significant even when the aggregate supply of genetic materials is large. When biological resources are abundant, an increase in the potential profitability of product discovery has virtually no effect on the value of any lead, whereas technological improvements that lower search costs induce (weakly) a decline in the value of every lead. The numerical results suggest that bio-prospecting information rents could, in some cases, be large enough to finance meaningful biodiversity conservation. These conclusions stand in opposition to those advanced in an earlier analysis.

Viewed as inputs to the innovation process, genetic materials have the potential to become genuine resources in the context of a sufficiently rich set of complementary knowledge assets. The effective functioning of a market in genetic resources depends on these knowledge assets just as much as, if not more than, it relies on a sound system of intellectual property rights and a robust capital market. The study suggests that attempts to estimate the value of genetic resources should focus attention on how researchers form and update their beliefs. It also suggests that the institutions regulating bio-prospecting, including systems of intellectual property rights, should reward the provision of helpful prior information, as well as the conservation of the base biological material. When R & D firms compete both in the market for leads and in the race to patent commercial discoveries, they will be willing to pay a premium for exclusive access to research options.

3. The Value of Biodiversity in Pharmaceutical Research with Differentiated Products: *Amy B. Craft and R. David Simpson*

Amy B. Craft and R. David Simpson's (2001) study on "The Value of Biodiversity in Pharmaceutical Research with Differentiated Products" emphasized that biologists and conservation advocates have expressed grave concern over perceived threats to biological diversity. On the other hand "Biodiversity prospecting" – the search among naturally occurring organisms for new products of agricultural, industrial, and, particularly, pharmaceutical value - has been advanced as both a mechanism and a motive for conserving biological diversity. Economists have attempted to estimate the value of biodiversity for use in new pharmaceutical project research. In this paper, a new approach has been applied to estimating values, and employs two models of competition among differentiated products. Each model confirms the previous findings, that the value to private researchers of the "marginal species" is likely to be small. The models can have very different implications with respect to social values, however. These findings underscore the need for a better understanding of the true meaning of diversity.

Natural organisms are great repositories of genetic information. This paper assumes that different products derived from different species can be imperfect substitutes for one another, and used two models between differentiated products to derive results. The first is Salop's (1979) model, in which the products are located at different places around a circle, representing the space of all consumers' preferences. The second model is Dixit and Stiglitz's (1977) model of monopolistic competition between sellers of products, with demands derived from the constant elasticity of substitution (CES) utility functions.

In the Salop model, the space of possible products – the circumference of the circular product space – is fixed. Hence, as more and more products are discovered, there are fewer and fewer consumers who are best served by any particular one. Every consumer would purchase a product that almost perfectly meets his/her needs, and pay a price that just covers the production costs. While consumers are always better served by the introduction of new products, the incremental improvement they experience is always declining. In contrast, there is no comparable sense in which the space of all possible products is fixed in the Dixit-Stiglitz model. Each additional product is assumed to be equally substitutable for each existing product, regardless of how many products are discovered.

4. The Value of Plants Used in Traditional Medicine for Drug Discovery: *Daniel S. Fabricant and Norman R. Farnsworth*

Daniel S. Fabricant and Norman R. Farnsworth's (2001) paper on "The Value of Plants Used in Traditional Medicine for Drug Discovery" describes and discusses several approaches to selecting higher plants as candidates for drug development, with the greatest possibility of success. The authors emphasize the role of information derived from various systems of traditional medicine (ethnomedicine), and its utility for drug discovery purposes, they identified 122 compounds of a defined structure, obtained from only 94 species of plants, that are used globally as drugs, and demonstrated that 80% of these have had an ethnomedical use, identical or related to the current use of the active elements of the plant. The advantages and disadvantages of using plants as starting points for drug development, specifically those used in traditional medicines have been described.

Since efforts in plant derived drug discovery began, the ethnomedical approach has been very successful. However, the random collection of plants, which provides the highest biodiversity, is forging ahead as the method of choice. The latter approach requires significantly more financial resources than the former. The body of existing ethnomedical knowledge has led to great developments in health care. With the rapid industrialization of the planet and the loss of ethnic cultures and customs, some of this information will no doubt disappear. An abundance of ethnomedical information on plant uses can be found in scientific literature, but has not yet been compiled into a usable form. The collection of ethnomedical information remains primarily an academic endeavour, of little interest to most industrial groups. The use of ethnomedical information has contributed to health care worldwide, even though efforts to use it have been sporadic are continue plant-derived drug discovery, because they anticipate that current industrial technology, i.e., mass screening, will provide novel drugs at a greater rate.

5. Search, Bioprospecting and Biodiversity Conservation: *Christopher Costello and Michael Ward*

Christopher Costello and Michael Ward's (2006) study on "Search, Bioprospecting and Biodiversity Conservation" raised a fundamental question: "to what extent can private sector bioprospecting be relied upon for the protection of biological diversity"? According to the authors, the existing literature contains drastically different estimates of bioprospecting incentives, from trivial to large. The authors resolve this controversy by isolating the fundamental source of discrepancy, and then providing empirically defensible estimates based on analysis. The results demonstrate that the bioprospecting incentive is unlikely to generate much private sector conservation. Thus, other mechanisms are required to preserve the public good of biodiversity. Bioprospecting the search for valuable products such as pharmaceuticals in biological organisms, is one incentive mechanism that has received much recent attention. The controversy rose from this point, and it is important for two reasons. First, the practical implications of biodiversity conservation are enormous. Second, the cause of the discrepancy in the final estimates is of great consequence itself.

This paper makes three contributions: the first is, contrary to the conclusion of Rausser and Small (RS), that information has only a trivial effect on conservation values in this important application. Second, the authors carefully examined the two models to illuminate the true source of the discrepancy in the estimates of private sector conservation incentives. They find that the main sources are simply different parameter choices. Third, the gap closed by assembling a defensible range of model parameters from a review of scientific literature, biodiversity databases, government reports, and laboratory interviews. Based on these parameters, the authors resolved the outstanding question of the private sector conservation incentives from bioprospecting.

According to the authors, the current bioprospecting incentives are probably insufficient to induce significant investments in biodiversity. However, future incentives could grow as more species suffer extinction. Thus, it might happen that bioprospecting could serve as a backstop preservation incentive, after a catastrophic mass extinction. While such as event may seem unlikely in the near term, this thought raises some interesting questions about the dynamics of land conservation, species loss, and the associated private sector conservation incentives. To the extent that biodiversity is a public good, other incentive mechanisms will be required for its protection.

6. Valuation of Bioprospecting Samples: Approaches, Calculations, and Implications for Policy-Makers: *William H. Lesser and Anatole Krattiger*

William H. Lesser and Anatole Krattiger's (2007) chapter on "Valuation of Bioprospecting Samples: Approaches, Calculations, and Implications for Policy-Makers" demonstrated, the revenue consequences of varying the collection fees and royalties with regard to germplasm prospecting contracts. The study emphasised that: (a) the principal factors are the uncertainty of finding marketable products and the value of these products, (b) Negotiation factors find a good balance between collection (initial) fees as opposed to royalty (delayed) payments, (c) Emphasizing the collection fees reduces the total payments, except when the national interest rates are very high, and (D) Reducing the risk of failure through in-country screening, including the use of indigenous knowledge, is a potentially valuable activity.

Issues for contract negotiators are outlined and the implications for biodiversity conservation are discussed. Conceptually, the highest valuation approach, royalties, will encourage conservation the most, but as the future is typically heavily discounted, collection payments may get more attention and be most effective. Policy considerations for national governments, NGOs, and development agencies are reviewed, and it is concluded that grants/loans and training/equipment for in-country screening, should be given high priority as a potentially viable activity in the long term.

The authors indicated that the valuation of samples, and by extension a country's biodiversity, is a negotiation and will depend on many factors, including alternative investment options by a company, alternative technologies that could be used for lead compounds' interest rates, and a range of risk factors, such as the political situation in a given country, surrounding the national debate on bioprospecting. The latter point is a key factor: valuation is always a calculation that has important political consequences. Another complicating factor is the need for confidentiality, with which a country and company will hold its overall business estimates. Neither a company nor a country will be likely to share their valuation basis purely for negotiation purposes, because neither would want to tip off other entities about the opportunity. It is therefore concluded that, from a practical perspective, a proper valuation is one that (1) provides the country with compensation and other benefits, such that it does not feel taken advantage of and can withstand criticism from its constituents, and (2) provides the licensee (typically a company) with a reasonable cost of obtaining the crucial raw or semi-finished goods it requires, as an input to its business.

7. An Economic Model for Bioprospecting Contracts: *L Onefried and H Ding*

L Onefried and H Ding's (2012) research on "An Economic Model for Bioprospecting Contracts" explored the use of a micro-economic model to analyse the provisions and parties of bioprospecting contracts. This study focuses on the pharmaceutical industry as the representative biodiversity buyer, presenting an original theoretical framework that explains the main contract characteristics or stylised facts. Against this background, it considers the main contractors involved in these private contracts, i.e., biodiversity sellers and biodiversity buyers, analysing both the magnitude and distribution of the respective payoffs. Particular attention is devoted to the different, mixed impacts of bioprospecting contracts and patenting on social welfare. The positive welfare impacts delivered by bioprospecting contracts, are associated with the potential discovery of a new drug product, i.e. productivity gains, non-monetary benefit-sharing or transfers, and royalty revenues. The negative welfare impact results from the legal creation of a monopoly, and the related well-known effect on the consumer surplus. Finally, the potential redistribution effects are limited, and a potential enforcement of this objective may jeopardise the desirability of the contracts, since this action would lead to a significant increase in the transaction costs.

8. Bioprospecting: *Creating a Value for Biodiversity: Alan L Harvey1 and Nigel Gericke*

Alan L. Harvey1 and Nigel Gericke's (2011) chapter on "Bio-prospecting: Creating a Value for Biodiversity" indicated that bio-prospecting is the exploration of biological material for commercially valuable genetic and biochemical properties. According to the authors, the search for activities could form the basis of new pharmaceuticals. Historically, most of the active ingredients in medicines have been natural products, and natural products continue to form a productive source of new drugs. Given that most drug discovery activity takes place in companies in the developed world, and that most biodiversity is found in countries of the southern hemisphere, there needs to be a means whereby access to biodiversity is possible under terms and conditions that are mutually acceptable. After hundreds of years of unregulated collection of samples for many different purposes, the United Nations produced a framework for preserving the world's biodiversity, while encouraging its sustainable use. This Convention on Biological Diversity has been widely accepted. The chapter described various attempts to calculate an economic value for biodiversity.

3. Conclusions

Broadly the above studies have not approached or discussed much on valuation related to ABS. These are primarily the 'gap filling' type analysis with academic and research interests, rather than "valuation for commercial purpose" like the ABS. Hence, according to the studies, whatever the final figure (value) arrived at it is not of great concern, since it is not directly used for any policy decisions. However, some of the methods or approaches used by certain studies are very promising, and can be considered for the valuation we are seeking for ABS, with the required modifications based on the product specific case and field level realities.

In this regard the essence of each study needs to be understood more carefully, and interpreted from the "Access and Benefit Sharing" perspective. With respect to this, the following issues or steps are significant:

a) The philosophical and ideological argument raised by each study and its linkages with ABS.

b) The methods or models used by different studies, and their relevance for ABS kind of valuation and

c) The kind of modification that can be proposed on these equations, based on the available data and ground level realities, for developing an effective valuation method for valuing bio-resources for "commercial purposes" and operationalizing ABS.

The above issues are being addressed by the National Biodiversity Authority (NBA) with the help of (a) guidelines from the expert members, including environmental economists, industrial bio-technologists, and ABS specialists, and (b) field level quantitative and qualitative information, obtained from the project state, through the State Biodiversity Boards and Biodiversity Management Committees for undertaking ABS cantered valuation methods. The accompanying volume (Book 1 - Biodiversity Economics from Access and Benefit Sharing Perspective, Book 2 – Valuation of Bio-resources for Operationalizing Access and Benefit Sharing Mechanism: Search for Methodology) to this compilation elaborates how such methods are being developed and pilot tested on-the-ground.

Appendix

Selected studies and Methodologies used for Bio-resources Valuation

Sl.	Author and Year	Study	Methodology (Equation or Model)
		Microorganism	
1	Masahiro Miyazaki (2006)	Economic value of Microbial Resources	$Ve = c + \sum_{i=n}^{m} \frac{p \cdot r \cdot Si}{(1+d)^i}$ Ve : Economic value of microbial resources (*ex situ* conservation) (per strain) c : initial charge (per strain) p : expected probability of success in developing a new pharmaceutical product Si : expected pharmaceutical sales in the ith year (per drug) r : royalty (rate of pharmaceutical sales) d : discount rate n : the year when pharmaceutical sales will start (i = n) m : the year when pharmaceutical sales will end
		Genetic Resources	
1	Douglas Gollin and Robert Evenson (2003)	Valuing Animal Genetic Resources: Lessons from Plant Genetic Resources	Theoretical Paper
2	Lars Hein and Franz Gatzweiler (2006)	The Economic Value of Coffee (Coffea Arabica) Genetic Resources	Theoretical Paper
3	Eric Ruto, Guy Garrod, and Riccardo Scarpa (2008)	Valuing Animal Genetic Resources: A Choice Modelling Application to Indigenous Cattle in Kenya	The Latent Class Model(LCM) of cattle choice Individual *n* faces a choice of selecting the preferred alternative amongst a set of J alternative of cattle in each of the T(*n*) choice occasions. Individual n belongs to segment $s \in J$ can be written as: $U(int\|s) = \beta_s' Xint + \varepsilon\ int\|s$ (1) The join logit probability of a set of choices T(*n*) made by an individual *n*, conditional on belonging to a given segment *s* is $P_{T(n)}\|s = \prod_{t(n)}^{T(n)} \frac{\exp(\beta_s' Xint)}{\sum_{j=1}^{J} \exp(\beta_s' Xint)}$ (2)

			X_{itk} = vector of observable attributes associated with alternative i n = observed making a choice on occasion t β_i = conformable vector of taste parameter Multinational Logit Model(MNL) (3) $P(s) = \frac{\exp(\lambda_s Z_n)}{\sum_{s=1}^{S} \exp(\lambda_s Z_n)}$ λs (s = 1, 2, ..., S) are segment specific parameters p(s) = sums to one across the S(to be determined) latent segments with $0 \le p(s) \le 1$. (Further development of this equation is given in the text)
4	Ramanatha Rao (2012)	Valuation of Plant Genetic Resources	Theoretical Paper
Marine / Coral			
1	Jack Ruiten beek and Cynthia Cartier (1999)	Issues in Applied Coral Reef Biodiversity valuation: Results for Montage bay, Jamaica	a) Pharmaceutical Prospecting is calculated by from the gross return $NR^{PP} = GR^{PP} - C^{PP}$ NR^{PP} = Net Return to pharmaceutical prospecting GR^{PP} = Gross return to pharmaceutical prospecting C^{PP} = Cost of pharmaceutical prospecting b) Net private return pharmaceutical prospecting (NPR^{PP}) $NPR^{PP} = GR^{PP} - [PC^{R\&D} + PC^{BS}]$ GR^{PP} = Gross return to pharmaceutical prospecting; $PC^{R\&D}$ = Private cost of R & D PC^{BS} = Private cost of biotic samples. Net social return to pharmaceutical prospecting (NSR^{PP}) is $NSR^{PP} = GR^{PP} - (SC^{SP} + (SC^{SP} + SC^{ET}) + SC^{R\&D}]$ f) Aylward (1993) developed a royalty based model $RY^{BS} = P * r * NS/n$ RY^{BS} = expected gross royalty on biotic samples P = Adjusting for the species success rate n = the number of samples provided per species (n) r = expected rate of royalty NS = net sales (distribution cost is removed from gross sale)
2	Cartie,c. and Ruiten beek (2000)	Montego Bay Pharmaceutical Bioprospecting Valuation	Global and Jamaican planning prices has the change in values as a result of a change in reef area, such that $P_G = \frac{\partial V}{\partial A}$ P_G = Global planning prices $P_J = \frac{\partial VJ}{\partial A}$ P_J = Jamaica planning prices

			a) Modelling the biodiversity seller's(BS) objective function formally expressed by equation (1) $Y_{BS} = F(s(\underline{\theta}), L(B;\underline{\theta}), T(B;\underline{\theta}))$ The expected profits of the BS as $\pi_{BS} = P_B(B;\underline{\theta}) \cdot F(s(\underline{\theta}), L(B;\underline{\theta}), T(B;\underline{\theta})) - C(s, L, T, B) + \mu$ $E[Roy(pat)]$ b) The production function for biodiversity buyer (BB) can be described by the following equation $Y_{BB} = G[Y_{BS}(B;\underline{\sigma}), K(B;\underline{\sigma}), TI(part\ (B);\underline{\sigma})]$ The objective function of the BB can be modelled as follows $\pi_{BB} = P_G \cdot G\ G[Y_{BS}(B;\underline{\sigma}), K(B;\underline{\sigma}), TI(part\ (B);\underline{\sigma})] - C(Y_{BS}$ ... μ ... $[Roy(pat)]$ ... $\underline{\sigma})]$ [illegible]
Crops			
1	Michael Salassi et al., (2000)	Valuation of Perennial Crops Associated with Agricultural Land Sales: The case of sugarcane in Louisiana	$VCt = (1+ROR)^{*}[\sum_{j=1}^{t} PLTCj(1+i)^{t-j} + \sum_{j=1}^{t} PRDC_j(1+i)^{t-j}]$ where, VCt = estimated value of sugarcane per acre in month t using the cost approach ROR = estimated rate of return on money invested in growing sugarcane PLTCj = unrecovered planting costs as of month j PRDCj = unrecovered production costs incurred through month j i = monthly interest rate Equation 1 tabulates initial $VIt = [\sum_{j=1}^{t} PLTC_j(1+i)^{t-j} + \sum_{j=1}^{t} PRDC_j(1+i)^{t-j} + \sum_{k=t} FNR_k/(1+r)^{k}$ Where, VIt = estimated value of sugarcane per acre in month t using the income approach PLTCj = planting costs as of month j PRDCj = unrecovered production costs incurred through monthj FNRk = estimated net returns from future harvests in the crop cycle i = monthly interest rate r = monthly discount rate
2	Haripriya. G etal (2005)	Estimating the Value of Agricultural Crop Land and Pasture Land in India	$NPV = \sum_{n=1}^{T} \frac{LR_n}{(1+i)^n}$ NPV= is the net present value of the asset in year "n" T = length of the planning horizon/ or economic life of

			the resource i = is the discount rate LR$_n$ = the land rent in year 'n'
3	Diwakar Poudel and Fred Johnson (2009)	Valuation of Crop Genetic Resources in Kaski, Nepal: Farmers willingness to pay for rice landraces conservation	TEV = DUV + EFV + OV + E V + BV (1) TEV = Total Economic Value DUV = Direct Use Value EFV = Ecological function value OV = Option Value EV = Existence Value BV = Bequest Value $WTP = \sum (A_i Y_i P_i) \sum_{i=1}^{N} (a_i y_i p_i)$ (2) WTP = Total willingness to pay for in-situ conservation of land races A_i = total area of conservation = $a_1 + a_2 + a_3 ... a_n$, Y_i = yield of preferred variety P_i = price of the preferred variety a_i = area for conservation of land races y_i = expected yield of land race i p_i = price of land race i N = total number of land races that the respondent to willingness to pay for (maximum six) $WTP = [\sum_{i=1}^{N} (X_i)/N]$ (3) WTP = average willingness to pay per landrace per year (exsitu conservation) X i = amount paid per month to conserve land race i (i=1- N), N = total number of land races that the respondent showed willingness to pay for (maximum six) $WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_n X_n + \varepsilon_i$ (4) WTP = Formers willingness to contribute to land races conservation β_0 = constant $\beta_1 ... \beta_n$ = Coefficients $x_1 - x_n$ = variables influencing WTP i_i εi = random error N (0,1)
		Medicinal Plants	
1	Peter P. Principe.(1991)	Valuing the Biodiversity of Medicinal Plants	NB_p = E(CS) + OV + EV + E(R) – E (Cpd) – Cp Where, NB_p = net benefit of preservation E (CS) = expected value of consumer surplus OV = option value EV = existence value

			E(R) = expected value of product revenues E (Cpd) = expected cost of product development Cp = costs of implementing preservation programme.
2	Michael Balick and Robert Mendelsohn (1992)	Assessing the Economic value of Traditional Medicines from Tropical Rain Forest	$V = R/(1 - e^{-rt})$ V = The present values of harvesting medicine R = net revenue from a single harvest r = is the real interest rate (5%) (analysis based on current market data) e = elevation t = time (the present value of an infinite stream of harvest every t years.
3	David Pearce and Dominic Moran (1997)	Economic value of Medicinal plants in 'The Economic Value of Biodiversity'	$V_{mp}(L) = p.\ r.\ a.\ Vi\ (D)$ *P* = Probability a = coefficient of rent capture =1 *D* = Drug *Vi (D)* = Value of drug (*i* =1) indicates one of two ways of estimating the value. The market price of drug on the world market. (i =2) value of statistical life r = royalty V_{mp} = Value of land for medicinal plants $V_{mp}\ (L) = [N_R.\ P.r.\ a\ \ Vi/n]/H$ *per Annam* *Where,* V_{mp} = Value of land for medicinal plant N_R = number of plant species at risk *n* = number of drugs based on plant species *H* = number of hectares of land likely to support medicinal plants and N_R = Number of species reduction *P* = the probability of success *r* = royalty(0.05) *a* = resulting range V_i/n = Value per plant in number *H* = Land area in hectares
4	Daniel S. Fabricant And Norman R. Farnsworth (2001)	The Value of Plants Used in Traditional Medicine for Drug Discovery	Theoretical Paper
5	Pushpam Kumar (2004)	Valuation of Medicinal Plants for Pharmaceutical Uses	Review Paper

6	Haripriya Gundimeda et al (2006)	The value of Biodiversity in India's forests	Net present bioprospecting value of nth lead (Used Rausser C. Goolen and Small model, 2000) a) $\sum_{t=0}^{\infty} \lambda (1+r)^{t} V_1 - \frac{\lambda V_n}{r}$ t = time λ = expected number projects carried out per year r = constant interest rate v_n = incremental value of nth lead $_{max}WTP = (\lambda/r)[(R-c)/(n+1)]e^{\lambda/n-c}$ λ = expected number of potential products to be identified n = number of species that could be sampled c = cost of determining whether a species will yield a successful product r = discount rate e = natural logarithm k = expected R&D cost for new product successfully produced R = Revenues from new product net of costs of new product sales but gross of R&D costs.
7	Nguyen Chinh (-----)	Economics values of Conservation & Use of Floral and Medicinal Plant Genetic Resources in Vietnam toward Sustainable Use	TEV = F (DUV, IUV, QOV, BV, EV) (1) TV = G (PV, TEV) (2) TV = Total Environmental Value TEV = Total Economic Value DUV = Direct Use Value IUV = Indirect Use Value QOV = Quite Option Value BV = Bequest Value PV = Primary Value EV = Existence Value F = Flora G = Genetic resource
Pharmaceutical research			
1	David Simson, Roger A. Sedjo; John W Reid (1996)	Valuing biodiversity for use in Pharmaceutical research	The expected value of the marginal species is $\sum_{t=0}^{\infty} \lambda(1+r)^{t}(pR-c)(1-p)^{n} = \frac{\lambda}{r}(pR-c)(1-p)^{n}$ p = probability r = returns are discounted at a constant rate t = time c = costs of R&D R = net revenue of R $(pR-c)$ = payoff in the event $(1-p)^n$ = search is unsuccessful in the set of n other species λ = remains constant over time
2	Gordon C. Rausser and Arthur A. Small (2000)	Valuing Research Leads: Bioprospecting and the Conservation of Genetic Resources	Simson. D, Sedjo.R model was changed through basic research to find the net present bioprospecting value of nth lead is then given by $\sum^{\infty} \lambda (1+r)^{t} V_1 - \lambda V_n$

			t= o r t = time λ= expected number of projects carried out per year r = constant interest rate V_n , incremental value of nth lead
3	Amy B. Craft and R. David Simson (2001)	The value of Biodiversity in Pharmaceutical Research with Differentiated products	The value of Marginal species is estimated through two models. a) The value of marginal species in the Salop Model b) The value of the marginal species in the Dixit- Stiglitz Model
4	Norman R. Farnsworth (2001)	Screening Plants for new Medicines	Theoretical Paper
5	Christopher Costello and Michael Ward (2006)	Search, Bioprospecting and Biodiversity Conservation	Rausser and small (2000) derive an iterative formula to calculate the marginal value of a research lead via backwards induction. That formula can equivalently be expressed as $v_k = Ra_{N+1} \frac{p_k}{1-p_k} - c\,[a_k - \frac{p_k}{1-p_k} \sum_{j=k+1} a_j]$ Revenue component - cost component v_k = marginal value of research lead, k c = cost incurred p_k = lead k yields a success worth R with probability i = expected return from searching lead
6	William H. Lesser and Anatole Kratiger (2007)	Valuation of Bioprospecting Samples: Approaches, Calculations and Implications for Policy Makers	5% royalty of $500 million = $25 million. Expected computing return for the base agreement is explained in the attached article.
7	Alan Harvey and Nigel Gericke (2011)	Bioprospecting: Creating a Value for Biodiversity	Theoretical Paper / Review Paper
8	L. Onofri and H. Ding (2012)	An Economic model for Bio prospecting Contracts	a) Modelling the biodiversity seller's(BS) objective function formally expressed by equation (1) $Y_{BS} = F(s(\underline{\theta}), L(B;\underline{\theta}), T(B;\underline{\theta})$ The expected profits of the BS as $\pi_{BS} = P_B(B;\underline{\theta})$. $F(s(\underline{\theta}), L(B;\underline{\theta}), T(B;\underline{\theta}) - C(s, L, T, B) + \mu\,.\,E[Roy(pat)]$ b) The production function for biodiversity buyer (BB) can be described by the following equation (2) $Y_{BB} = G[Y_{BS}(B;\underline{\sigma}), K(B;\underline{\sigma}), TI(part\,(B);\underline{\sigma})]$ The objective function of the BB can be modelled as follows $\pi_{BB} = P_D.\,G\,G[Y_{BS}(B;\underline{\sigma}), K(B;\underline{\sigma}), TI(part\,(B);\underline{\sigma})] - C(Y_{BS, K, TI(Part)} + (1-\mu)\,E\,[Roy(pat)]_{(B);\underline{\sigma}})]$

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About the Project:

The Objective of the UNEP-GEF MoEF project on ABS is to increase the institutional, individual and systemic capacities of stakeholders to effectively implement the Biological Diversity Act, 2002 and the Rules 2004 to achieve biodiversity conservation through implementing Access and Benefit Sharing Agreements in India.

This project is implemented in the 5 states of India namely Andhra Pradesh, Gujarat, West Bengal, Himachal Pradesh and Sikkim. The executing organisation includes NBA in collaboration with 5 SBBs, Botanical Survey of India (BSI), Zoological Survey of India (ZSI), United Nations Development Programme (UNDP), United Nations Environment Programme - Division of Environmental Law and Conventions (UNEP/DELC), United Nations University – Institute of Advanced studies (UNU-IAS) and Global Environment Facility..

The main components of the project are:

- ✓ Identification of biodiversity with potential for ABS and their valuation in selected ecosystems such as forest, agriculture and wetlands.
- ✓ Development of tools, methodologies, guidelines, frameworks for implementing ABS provisions of the Biological Diversity Act.
- ✓ Piloting agreements on ABS
- ✓ Implementation of policy and regulatory frameworks relating to ABS provisions at national level and thereby contribute to international ABS policy issues.
- ✓ Capacity building for strengthening implementation of the ABS provisions of the BD Act.
- ✓ Increase public awareness and education programmes.

About NBA

The National Biodiversity Authority (NBA) was established in 2003 to implement India's Biological Diversity Act (2002). The NBA is a Statutory, Autonomous body and it performs facilitative, regulatory and advisory functions for Government of India on issues of conservation, sustainable use of biological resources and fair and equitable sharing of benefits arising out of the use of biological resources.

The Biological Diversity Act (2002) mandates implementation through a decentralized approach with the NBA focusing on advising the Central Government on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of the utilization of biological resources; and advising the State Governments in the selection of areas of biodiversity importance to be notified under Sub-Section (1) of Section 37 as heritage sites and measures for the management of such heritage sites besides supporting conservations and sustainable management of biodiversity.

The State Biodiversity Boards (SBBs) focus on advising the State Governments, subject to any guidelines issued by the Central Government, on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources. The State Biodiversity Boards (SBBs) also regulate, by granting of approvals or otherwise requests for commercial utilization or bio-survey and bio-utilization of any biological resource by Indians.

The local level Biodiversity Management Committees (BMCs) are responsible for promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity.

The NBA with its headquarters in Chennai, Tamil Nadu, delivers its mandate through a structure that comprises of the Authority, Secretariat, SBBs, BMCs and Expert Committees.

Since its establishment, NBA has supported creation of SBBs in 28 States and facilitated establishment of around 33,000 BMCs at local level.

National Biodiversity Authority

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