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Background Paper

Valuation of Bio-resources for Operationalizing "Access and Benefit Sharing" Mechanism: Search for Methodology

For

First National Level Discussion Meeting
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Valuation of Bio-resources for Operationalizing "Access and Benefit Sharing" Mechanism: Search for Methodology

PART 1

ACCESS AND BENEFIT SHARING MECHANISM

Access and Benefit Sharing (ABS)

The concerns over the indiscriminate exploitation of biodiversity, due to the increasing demand for the biological resources and the problem of biopiracy, *inter alia*, have led to the adoption of the Convention on Biological Diversity (CBD), an international treaty to sustain the rich diversities of life on earth, at the Rio-Earth summit in 1992. The Convention, with a near universal membership of 193 countries as parties, had the following objectives: (a) conservation of biodiversity, (b) sustainable use of its components and (c) the fair and equitable sharing of benefits arising from the use of genetic resources. CBD expressly calls for the rights of recognition of indigenous and local communities, in conserving the biological diversity and in protecting the traditional knowledge associated with the genetic resources. Moreover, the international community has adopted the legally binding Nagoya Protocol (2010) to ensure fair and equitable sharing of benefits, arising from the utilisation of the biological resources. India is one of the leading countries advocating for its early enforcement.

ABS is emerging as an innovative approach, and an incentive mechanism in biodiversity conservation and its sustainable utilization. The ABS framework provides a formal guidance for the way in which biological or genetic resources are accessed, and the way benefits are shared between people or countries using the resources (users), and the people or countries that provide them (providers). The ABS philosophy proposes that providers of bio-resources are entitled to receive fair benefits from the users. In this context, ABS balances the rights of the users of bio-resources with the rights of the providers of such resources. Further, the ABS can manage biodiversity as a community asset, and support biodiversity-based businesses in an effective and sustainable manner.

It is vital that both users and providers understand and respect the legal, administrative and policy frameworks at the national and local levels, as well as those outlined in the CBD and the Nagoya Protocol on ABS. The ABS is based on prior informed consent (PIC) being granted by a provider to a user, and negotiations between both parties that result in mutually agreed terms (MAT). The negotiation between a provider and a user of resources should be based on the true/actual value of the resources. Hence, understanding the real value of bio-resources is a pre-requisite, for the equitable benefit sharing and signing of ABS agreements.

ABS Process in India

As a party to the CBD and as one of the mega-diverse countries, India enacted the Biological Diversity Act in 2002, and notified the Rules thereunder in 2004. The objectives of the Biological Diversity Act are similar to those of the CBD and "fair and equitable sharing of the benefits arising out of the use of biological resources and knowledge associated thereto" is the key. The National Biodiversity Authority (NBA), the State Biodiversity Boards (SBBs) and the Biodiversity Management Committees (BMCs) oversee the implementation of the Act and Rules at the national, state and local levels respectively. ABS agreements under the Biological Diversity Act are divided into four categories, and necessitate the signing of legally binding arguments through various Forms. Form 1 deals with the direct access to biological resources and / or associated traditional knowledge; Form 2 deals with the transfer of the research results relating to biological resources from India; Form 3 deals with the applications for intellectual property rights; and Form 4 deals with the transfer of biological resources and/or associated traditional knowledge to third parties by individuals/entities, who have accessed these resources and knowledge through form 1.

Under Section 3 of the Act, all foreigners, non-resident Indians, and any corporate body, association or organization, that is either not incorporated in India or incorporated in India with non-Indian participation in its share capital or management, have to obtain the approval of the NBA, before they access / use biological resources and associated knowledge occurring in India or obtained from the country, for commercial or research purposes or for the purposes of bio-survey or bio-utilization. More than 100 agreements have been signed so far by NBA and the benefit sharing process is progressing.

However, increasingly it is being recognized that for determining appropriate benefits, especially monetary benefits, there is a need to suitably value the biological resources. So that the real – true value of such resources can be ascertained for benefit sharing components fixed that does not look purely arbitrary. At present, the NBA is following the criterion of fixing 2-3 % of the sale value of the final products derived from the bio-resources, as royalty for benefit sharing. NBA is currently re-examination of the criterion for fixing the royalty or assessing the value of bio-resources for purposes of ABS.

ABS: UNEP GEF MoEF Project in NBA

The project on "Strengthening the Implementation of the Biological Diversity Act and Rules with focus on its Access and Benefit Sharing provisions" deals with assessing and quantifying the economic value of biological resources, using appropriate methodologies to determine benefit sharing, which will help in better implementation of the Biological Diversity Act, and inform national decision makers on prioritizing conservative action. In other words, the project is an attempt towards mainstreaming and strengthening the ABS process in India.

The identification of bio-resources or genetic resources, with potential for ABS from selected ecosystems, such as forests, wetlands and agriculture, and their valuation (estimation of the real value) is an important task in this project. The major activities coming under this head, include: (a) Developing standardized economic valuation methods for valuing bio-resources, (b) Organizing three national workshops and five state level workshops on understanding the valuation methodology, and using the same in decision making, (c) Developing a methodology for using the economic valuation in deciding ABS permits, and (d) Developing a data base covering the economic valuation information in finalizing the ABS agreements. The project is implemented in 5 states in India (Andhra Pradesh, West Bengal, Sikkim, Himachal Pradesh and Gujarat) with the collaboration of the State Biodiversity Boards and Biodiversity Management Committees.

Bio-resources from Selected Ecosystems and their Economic Significance

Bio-resources / biological resources means: plant, animals and micro-organisms or parts thereof, their genetic material and by-products (excluding value added products) with actual or potential use or value, but not human genetic material (The Biological Diversity Act, 2002). The valuation of biodiversity goods (bio-resources) derived from different ecosystems with the help of an appropriate methodology, is a fundamental step towards operationalizing the "Access and Benefit Sharing (ABS)" principle.

Forests:

Apart from the various non-marketed ecosystem services a large number of resources (goods) come from the forests as timber and non-timber forest products and are exchanged at a low price at the forest gates. These goods include timber, fuel wood, drinking and irrigational water, fodder, non-timber forest products, food (honey, mushrooms, fruit, and other edible plants, game), genetic resources and cultural resources. Most of these resources are used as an unavoidable input factor for manufacturing various value added products, having a huge market potential.

Wetlands:

Inland and coastal wetlands are the most productive ecosystems and their functions include nutrient cycling and hydrological cycling. The system also has attributes of a diversity of species. Coastal ecosystems can provide goods such as, fish and shellfish, fish meal (animal feed), seaweeds (for food and industrial use), salt, genetic resources and cultural resources. The goods provided by the freshwater ecosystem are drinking and irrigational water, fish, hydroelectricity, genetic resources and cultural resources. Wetland species (animals and plants) have huge economic value and ABS potential.

Agriculture:

Agricultural biodiversity includes, harvested crop varieties, livestock breeds, fish species and non-domesticated ('wild') resources in fields, forests, rangelands, and in aquatic ecosystems; non-harvested species within production ecosystems that support food provision, including soil micro-biota, pollinators and so on; and non-harvested species in the wider environment that support food production ecosystems (agricultural, pastoral, forest and aquatic ecosystems). The primary goods provided by the agriculture and grassland ecosystems include, food crops, fibre crops, crop genetic resources, other crops (energy, fodder, etc), cultural resources, livestock (food, hides, fiber) and water. Agricultural products or outputs have a huge market and business potential, and play a significant role in manufacturing different food items and achieving food security.

PART II

VALUATION OF BIO-RESOURCES AND DRAFT METHODOLOGIES

Paradox in Valuation

Biodiversity or ecosystems have significant economic values, which are implicit, in general, rather than explicit. Most of these values are often not captured by the market; hence, their economic potential is unidentified, which is considered as one of the factors for the rapid depletion or degradation of biodiversity, and the extinction of species. However, understanding the benefits of biodiversity (goods and services) is critical for initiating effective policies towards the conservation and sustainable use of ecosystems.

The Total Economic Value (TEV) of ecosystems consists of use values and non-use values. Use value (direct or indirect uses) is associated with trade and commerce, or cultural and spiritual aspects. Non-use value is derived from the inherent nature of ecosystems and aims to maintain the flora and fauna and ecological balances. Methodology development, particularly for valuing the non-marketed services of the ecosystem has progressed substantially in the last two decades. Methodologies, such as market prices, replacement costs, avoidance of damage cost, production function, hedonic price, travel cost, contingent valuation, participatory environmental valuation and benefits transfer are well established, and widely used in valuing ecosystem services in different parts of the world.

However, we need to re-examine the valuation process adopted on goods derived from the ecosystem. At present, Environmental Economists are assigning the values of ecosystem goods, based on their current exchange rate or price (multiplying the quantity of goods with the price) at their collection point, such as the forest gate or the nearby local market. On the other hand, the non-marketed benefits (values) of ecosystems are estimated based on the standard valuation tools, prescribed above. Here the paradox, is that in the case of ecosystem/biodiversity goods, case the existing market prices are revealed as value, but in the case of services the actual valuation takes place with the help of an appropriate methodology.

Why the Real Value Estimation of Bio-resources is Significant?

Generally, large quantities of divergent “ecosystem goods” are collected or extracted from the ecosystems, which human beings can directly or indirectly use either as food, medicines or biomass. These goods are also involved in research and development (which lead to the innovation of new consumer products) and trade, and act as the basic raw-material or input factor in manufacturing many products. However, most of our ecosystems (forests, rivers, estuaries, oceans, etc) are common properties. Hence, the goods from these sources experience market failure or distortion, and the current market price at their collection point does not represent their real or true value or price but only an exchange rate that is too arbitrarily assessed or fixed. In other words, due to the market imperfections, ecosystem goods are 'under-priced'. This might be the reason for the less percentage (negligible share) of goods' value in the TEV of ecosystems, in most of the empirical studies.

In the case of ecosystem goods, particularly those obtained from common property like forests and oceans, the demand, supply and price mechanisms do not function effectively as they do in the case of other commodities. Providers/sellers and buyers have limited knowledge and information about both the "price" and "value" of a product. Normally, information is disclosed by both the parties (sellers and buyers). In the exchange, the users of ecosystem goods / bio-resources (the companies or their representatives) have better knowledge about their significance and value than the providers. However, the providers (local communities) are being exploited (obtaining only a meagre price), by the traders and companies, who make substantial profits from the business.

In this context, the valuation of biodiversity/ecosystem goods is a fundamental step towards determining the real value of bio-resources, and operationalizing the "Access and Benefit Sharing (ABS)", one of the objectives of the Convention on Biological Diversity (CBD) as well as the Biological Diversity Act of India.

Development Process of the Valuation Methodology of Bio-resources

Evidences from Literature**:** A thorough review of the literature on 'ecosystem and biodiversity valuation' revealed that, some of the environmental economists attempted to value bio-resources such as medicinal plants and genetic and microbial resources. The intention of these valuation studies was to assign a value to cultivatable lands, and forests where the plants or resources are growing or derived from. The major findings of the studies and the models used are given in in Appendices 1 and 2 respectively. The authors of these studies argued, that through estimating and assigning a value to these 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. The following are the emerging inferences from the literature and the significance in the ABS Process.

- Biological resources have huge economic potential through bio-prospecting, and are capable of enhancing human welfare in multiple ways.
- The loss of a species is a major concern. Various developmental activities and land use changes are the main causes of biodiversity destruction.
- The lack of understanding of the ‘Economic Value’ of a species is a major lacuna.
- For preserving a species, its habitation (biodiversity hot spots) should be conserved. In this regard, the value of the species and ecosystems (forest areas and agriculture lands) has to be estimated and projected.
- Studies have not emphasized the valuation of non-marketed ecosystem services.
- The literature considered the bio-resources (such as medicinal plants, microbes, genetic resources), bio-prospecting, and the products’ (drugs, cosmetics, food items etc.) manufacturing capacity in valuation, which is significant for ABS.
- Some of the studies distinguished the market value from the economic value.
- All the studies used sophisticated statistical models for deriving the economic values of different bio-resources.
- The need for a comprehensive data base on bio-prospecting and taxonomy is highlighted.
- A majority of the studies attempted to value medicinal plants in the forests, based on the plant’s drug manufacturing potential. This type of valuation could create a better understanding of the economic significance of bio-resources (medicinal plants) among the policy makers and the public, and in designing appropriate strategies for the conservation and sustainable utilization of the resources.
- Different studies followed different methodologies that emphasized the field level circumstances and data availability, and arrived at different values.
- Broadly the values assigned by these studies to bio-resources, like medicinal plants, are low.
- Some of the studies strongly indicated the diminishing values of the marginal species, and the issues of redundancy in bio-prospecting. This is clearly revealed from the probability of new drug manufacturing from the marginal species.
- Certain studies advocated that the income derived from bio-prospecting is an ideal

source of revenue for the conservation of biodiversity.

- None of the studies approached or discussed the ABS type of valuation. These are primarily the ‘gap filling’ type with academic and research interests, rather than the “valuation for commercial purpose” like the ABS. Hence, according to the studies, whatever the final figure (value) arrived at is not a big 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 field level realities.

Lessons from Industrial Visits and Discussions

Since the industries’ role is significant in the ABS process, we paid preliminary visits to Chennai based bio-resources / bio-prospecting industries, and carried out interviews with the managements. Various bio-resources used for Research and Development (R&D) and manufacturing, the economics of R&D, the production process and its cost, stake in biodiversity management etc. were the major topics discussed. These attempts were immensely useful in understanding the need for industries’ cooperation in the operationalization of the ABS, and their willingness in sharing the required information and data for estimating the real value of bio-resources, when they are obtained from the community. For reasons of confidentiality, the details are proposed here as company A, B, C and D. The companies include:

1. **Company A**: Company A is a leading R&D Company involved in the inspection, verification, testing and certification of pharmaceutical samples. It has capabilities in analytical, bio analytical and clinical trial testing along with process management, which helps pharmaceutical companies to achieve maximum safety and cost effective production. Further, Company A is a nationally and internationally recognized agency for quality checking, and certification of pharmaceutical products and drugs. The company’s rough cost distribution allocates 50% to R&D, 30% towards administration charges and 20% as profit.

2. **Company B**: Company B is a government of India undertaking, which has partnered with the Ministry of Health and Family Welfare, to set up a premium facility for production of vaccines for the National Immunization Programme and other new

generation vaccines. The main objective of Company is to ensure safe and effective vaccines at affordable prices. They purchase microbial strains from the National Centre for Cell Sciences (NCCS), which collects and isolates the strains from nature in a limited quantity. Using the very small quantity of the initial collection of the strain, the required amount is cultured and maintained by the company for further use. Company B also seeks to develop a strong R&D base for the development of futuristic vaccines, apart from manufacturing and supplying vaccines required for the Universal Immunization Programme (UIP) in India. The major steps involved in the vaccine manufacture include: identification and sourcing of seed materials, process standardisation and development, testing and procedures – human and clinical, production and manufacturing, and marketing. The cost distribution pattern of the company includes 30% for R&D, 50% for the production including the capital and variable costs, and the balance 20% as profit.

3. **Company C**: Company C is to discover and provide innovative, sustainable ingredients for health, nutrition and wellness, with limited dependence on nature. Company C uses biosynthetic and evolutionary technologies to create and optimise small molecular compounds and their production routes. Company C is actively involved in consumer healthcare and nutrition, as well as in pharms. This company uses yeast as its resource to make new ingredients by using new technology. Yeast can be used in pharmaceutical products and vaccines. The discovery and implementation of new ingredient production routes, as well as the discovery of novel functional ingredients are Company C's major role. The major steps involved in the company include: Yeast synthesis in the laboratory, developing new technology (R&D), and new novel ingredients, such as saffron crocus from saffron, stevia glycosin from the stevia plant, pomcins from pomegranate, and vanilla from vanilin.

4. **Company D**: Company D is a bio- fertiliser, and a bio-pesticide manufacturing and supplying company. This company is registered under the Central Insecticide Board and Indian Institute of Horticulture and Research. The basic culture required for manufacturing (tricoderma viride, tricoderma harzianum, pseudomonas flurescens azospirillum, gluconacetobactor, phosphobacterium, rhizobium, vesicular arbuscualr and mycorrhiriza) was procured from the Tamil Nadu Agriculture University. The estimated cost distribution of the company includes 30% for administrative charges,

50% for processing, (culture, multiplication, packing and stripes) and transport charges, and 20% as profit.

The major lessons learned from the interaction with the industrial experts are:

- The use of bio-resources by companies varies substantially, depending upon the purpose for which the company is seeking bio-resources, such as R&D and raw-material for production.
- Some of the companies collect bio-resources, such as strains from the authorized culture centres, and propagate them as per their requirements.
- According to these companies they are not 'destroying the bio-diversity', since their initial collection from the parent institutions is negligible.
- In bio-prospecting, the role of R&D is crucial, where the human brain and technology are the key factors.
- According to the R&D companies, even if they fail in their research, this could be a lesson for avoiding further failures.
- In R&D, a company may target some objective or product but may achieve some other things. In these circumstances, the correct judgement of success and failure is a challenge.
- In certain companies, the success rate of R&D is only 10%. But in bio-prospecting, the general success rate is indicated as 50%.
- In a broader sense, the bio-prospecting industries' R&D cost should cover only 20 to 30% of the total production cost. Hence, any achievement at a lower cost might be a big gain or benefit to the company.
- The detailed cost information of companies can be obtained through a questionnaire survey. However, the willingness to share information from the company's side is important.
- Companies do not think or anticipate resource crises or scarcity in future; hence their priority for biodiversity conservation is insignificant.

Possible / Draft Methodologies for valuation of Bio-resources

The economic valuation or estimation of the bio-resources at their collection point is an innovative aspect and a pre-requisite in operationalizing the ABS mechanism. Since the existing literature on environmental economics has not debated much on this issue, we do not have any standard reference for framing the methodology. However, based on the rough insights from selected literature and experts' (environmental economists, ABS specialists, statisticians, industrial consultants, NGOs, community representatives etc.) opinion, the following methodologies or approaches for valuing bio-resources have been drafted for discussion.

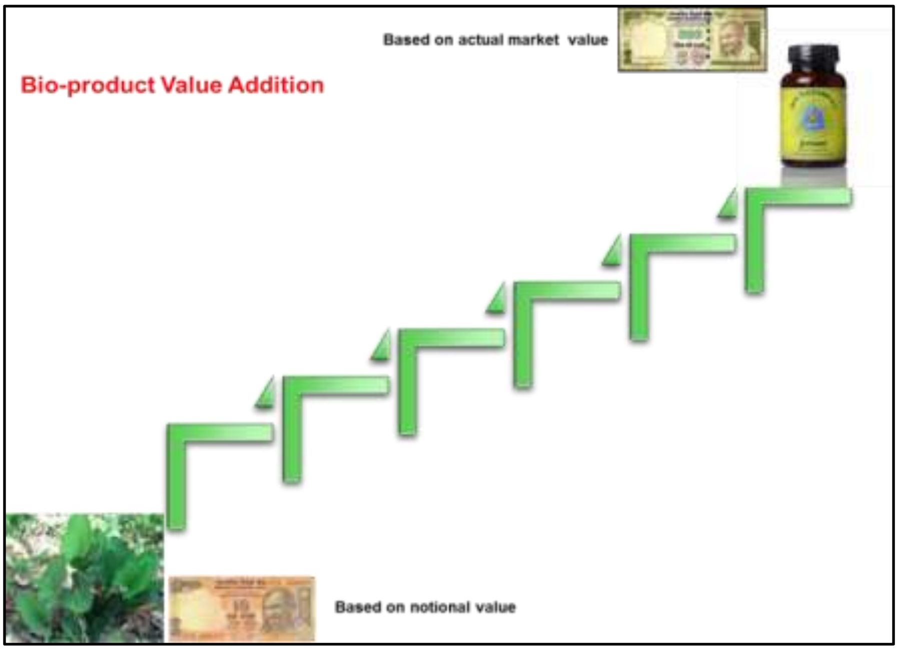
Value Chain Analysis:

Many value added products are derived from bio-resources. Generally, value addition for bio-resources (raw) and bio-resources based products occurs either through transaction costs or / and processing / manufacturing costs. Generally, the markets for bio-resources at their collection point are highly uncertain. A number of unexpected factors play a role at this stage, which makes for market imperfections. Transaction costs are the costs of particular bio-resources' movement from their collection point to the company gate, and occur through transportation charges and brokers or dealers' profits. For example: in the case of honey, the collection price at the forest gate may be Rs. 50.00 per kg, and its final consumer price at a distant city may be Rs. 200.00, transacted through different agencies such as federations, wholesalers, and retailers at different locations. Hence, the price spread is Rs. 150.00 (Rs. 200 - 50). The ABS concern is whether the price spread is reasonable or not, and if not, what are the abnormalities in, and how will it bounce back to the communities or providers of the honey?

Further, certain bio-resources are basic raw-materials for manufacturing final consumer products. For example: *Jeevani* an immuno-modulatory product (ayurvedic medicine) is manufactured from the plant known as *Arogyapacha*. Here the *Arogyapacha* (required for manufacturing one bottle of medicine) may be provided by an indigenous community for Rs. 108.00 and a bottle of *Jeevani* (450 grams) may cost Rs. 900.00. In this production process, *Arogyapacha* is an unavoidable input factor, but not an exclusive one. Many other products (inputs) and knowledge/skill (research and development) also contribute to *Jeevani* production. Hence, the processing / manufacturing costs at different stages are significant. Through an amortised (remunerated) pricing technique, one can estimate the real price of

Arogyapacha. The same approach is applicable in the case of bio-prospecting based R&D. But the probability of success and failure and their prediction, is a key factor.

Value Addition of Bio-resources through Transaction and Production Costs: Example



For a value chain analysis, the following steps (general as well as specific) are proposed with reliable information sources (see Tables 1 and 2). However, substantial support from various stakeholders, who are part of this exercise, is required for the successful estimation of the value of bio-resources.

Table: 1

Bio-resources real price estimation: basic/general steps

Steps	Tasks	Sources of Information
First	Identification of the **key bio-resources** (having economic and ABS potential) extracted from a geographical area / ecosystem	BMC, PBR, local community, indigenous group, forest department
Second	Understand its **potential /** purpose / usage	BMC, traders, research organizations, government departments, industries
Third	Identify its leverage / **movements**: local → regional → state → national → international	BMC, traders, industrial association, companies, exporters, customs department
Fourth	Prioritize the **promising uses** based on value addition (ranking)	Industries, traders, research organizations.

Table: 2

Bio-resources real price estimation: specific steps

Steps	Tasks	Sources of Information
First	Select any manufacturing or bio-resources processing company	Appropriate industry
Second	Estimate the transaction cost of bio-resources: from forest gate to company gate. **(Price at company gate – price at forest gate)**	Forest dwellers, traders, industries
Third	Identify the major production steps	Company management and production manager
Fourth	Identify the different factors of production involved in each stage and its cost / remuneration **(Factor cost method)**	Company management, production manager and labourers
Fifth	Identify the abnormal benefit claimers and rates **(differences between company rate with general market rate)**	Company management, production manager, labourers, industrial/govt. departments.
Sixth	Fix the optimum benefit and share the surplus to local communities who preserve the bio-resources **(Royalty;** institutional mechanism for distribution)	Company management, production manager, labourers, industrial/govt. departments and BMC

In brief, the value chain analysis is applicable where bio-resources are used an input factor in production, or considered as a commercial product. Here, the input output process and the value additions at different stages of production with cost accounting is the key to value chain assessment.

<u>The "Maximum Willingness to Pay" Approach:</u>

In bio-resources based economic activities and exchange, the provider or community may not know the actual value, since he is not involved in or aware of the potential use and the production process. But the buyers (industries and the R&D companies) are fully aware about the value of the resources. Hence, the maximum willingness to pay for bio-resources by the user at their collection point will reveal their 'real value'. For arriving at this strategy, the following pre-conditions and assumptions are necessary.

1. The final users of the bio-resources (industries or R&D sectors) need to directly procure the resources from the community. In other words, the exchange should not be through traders (who are not aware of the potential use of the resources).
2. The community's empowerment in bio-resources should be sensitized. Only then can the communities' active involvement in the exchange process (like auction) materialise, and fair prices obtained.

3. In empowering communities, the role of different local institutions like panchayats and Biodiversity Management Committees (BMCs) is significant.

In this process, the community (as a custodian of resources) can demand a higher price for each bio-resource it exchanges at its collection point. Automatically, the industries will come forward for negotiation, since these bio-resources may be an unavoidable input factor in their production. In this regard, the negotiated value will act as the “real value” for the resources. Through this method one can confine the value of the resources at their source, rather than targeting the final products percentage share, which is becoming more controversial.

Application of the Appropriate Economic Instruments: (tax, cess, charges, royalty etc.)

The bio-resources which come under the purview of the ABS are predominantly the public owned resources or state property. Here, communities obtain the privilege of the users’ right. Since it is a state property, any resource-based management issues (such as scarcity, extension and unsustainability) should come under the purview of the Government. Bio-resources have multiple uses and diverse product manufacturing capacity and value generation (it is not a uniform resource like water). With this consideration the government authority concerned, can fix a ‘tax’ or apply any other appropriate instrument for the extraction of the particular resources.

The following criteria need to be considered, before selecting the appropriate economic instruments and fixing the tax rate. Further, this information needs to be carefully analysed.

(a) An inventory of bio-resources in a particular collection point
(b) Bio-resources’ current stocks, volume of extraction, sustainability rate, extinction level
(c) Anticipated changes in the resources in future (positive and negative).

In brief, these instruments can also act as an economic disincentive in the extraction of bio-resources, and in saving the biodiversity. However, as the money derived through tax goes as public revenue, the possibility of its direct application for the conservation of biodiversity, may be an issue.

Minimum Support Price for Bio-resources

The authority concerned (Biodiversity Management Committees) can fix a support price (with the consultation of experts) for the bio-resources prevailing in their jurisdiction. The availability of the resources, demand, purpose of collection, usage in industries, value generation capacity etc., may be considered as the criteria for fixing the support prices.

Collectors' Willingness to Accept and Minimum Livelihood

Generally, the local communities put in their hard work and unique knowledge in collecting the bio-resources from the wild. But in most cases, they are compelled to exchange the resources at negligible prices. Market imperfection, lack of ownership rights of the resources, and the least bargaining ability contribute to the lowering of the prices. Hence, the communities' willingness to accept should be considered. Further, a minimum or standard amount for rural livelihood or wage can be considered in the bio-resources collectors' case, and that amount fixed as the value of the bio-resources that he/she collected per day.

In Brief:

Developing an appropriate methodology for valuing bio-resources, which are used for commercial purposes, is extremely important for signing the ABS agreements, and charging the 'real value' for bio-resources from the users. In this regard, the possibilities in considering the above draft methods and / or identifying new methods should the main agenda of the "First National Level Discussion Meeting" on 13th July, 2013 at the National Biodiversity Authority, Chennai.

Appendix 1

Selected Studies in Bio-resources Valuation and Major Findings

S.No	Author and Year	Study	Major Inferences
			Microorganism
1	Masahiro Miyazaki (2006)	Economic value of Microbial Resources	* Microbial resources were used as screening materials for developing new pharmaceuticals * For valuation sum of an initial charge and expected royalties obtained from pharmaceutical companies were considered. * Values vary from US$2-60/strain, depending on their quality and value added capacity. * Microbes from natural habitants have low value. * For source countries to gain a greater share of the benefits from microbial resources, they should, build human and technological capabilities to isolate, preserve and characterize microorganisms and provide users with more value-added resources.
			Genetic Resources
1	Douglas Gollin and Robert Evenson (2003)	Valuing Animal Genetic Resources: Lessons from Plant Genetic Resources	* There are strong similarities between plant and animal genetic resources * From methodological standpoint many of the technique developed for assessing the value of PGRs seems to be appropriate for animal genetic resources as well * Hedonic pricing, simulation techniques and production function estimates all seem to be pertained in the case of animal genetic resources. * The challenges in these areas of research are primarily empirical rather than theoretical.
2	Eric Rutoa, Guy Garroda, and Riccardo Scarpab (2008)	Valuing Animal Genetic Resources: A Choice Modeling Application To Indigenous Cattle in Kenya	* 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. * For investigate buyers' preferences for indigenous breeds, choice experiment approach has used. * The study suggested that some form of intervention may be required to ensure the preservation of animal genetic resource.
			Marine / Coral
1	Jack Ruiten beek and Cynthia Cartier (1999)	Issues in Applied Coral Reef Biodiversity valuation: Results for Montage bay, Jamaica	* Most valuation techniques fail to adequately come to grips with issues of system complexity; these include issues such as non- linear ecological-economic linkages, interdependencies and redundancy in the species discovery process, cost interdependencies in the R&D process of bringing new products to market, and ecosystem yield in terms of species-area relationships for coral reef systems.

2	Cartier.C, and Ruiten beek. (2000)	Montego Bay Pharmaceutical Bioprospecting Valuation	* Utility, production and rent valuation approaches can be used to estimate the value of the marine products through bio-prospecting. * Successful data is required to translate sampling information (species type and count) into final consumer product.
		Crops	
1	Michael Salassi et al., (2000)	Valuation of Perennial Crops Associated with Agricultural Land Sales: The case of sugarcane in Louisiana	* Value of the perennial crop (sugarcane) has estimated. Same methods would also be applicable to other perennial crops such as fruit, nut, spice, and ornamental crops * Three valuation procedures were followed: the sales comparison approach; the cost approach; and the income capitalization approach.
2	Diwakar Poudel and Fred Johnson (2009)	Valuation of crop genetic resources in Kaski, Nepal: Farmers willingness to pay for rice landraces conservation	* Used the contingent valuation method to document the economic value of crop genetic resources based on the farmers' willingness to pay for conservation. * The 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 respondent, number of crop landraces grown, and knowledge on biodiversity influenced the willingness to pay for in-situ conservation * Only landholding size and household size influenced the willingness to pay for ex-situ conservation.
		Medicinal Plants	
1	Peter P. Principe.(1991)	Valuing the Biodiversity of Medicinal Plants	* Distinguished between the market value of a commodity and its economic value. * The market value is the value the market place attributes to a given commodity or its derivative product. * Economic value is the total benefits of a product. * With respect to medicinal plant species, two aspects of economic value are significant. 1. 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 wages not lost. Health care costs averted the value individuals placed on the better health, (etc.). 2. The non-pharmaceutical uses and benefits that the plants provide (i.e. the informational and environmental benefits).
2	Michael Balick and Robert Mendelsohn (1992)	Assessing the economic value of traditional medicines from tropical rain forest	*Tropical forests are a rich source of unknown chemicals that may eventually prove useful to medicine and traditional medicines, currently the basis for much of the primary health cares in tropical nations. *In order to quantify the value of managing forests as a source of traditional medicines, an inventory of plant material in specific plots is a pre-request *Systems for the sustainable collection of plant *medicines* and other non-timber products from the tropical forest need to be documented and developed for use on a much broader scale.

3	David Pearce and Dominic Moran (1997)	Economic value of Medicinal plants in 'The Economic Value of Biodiversity'	* The study proposed the following valuation approaches: 1. By looking at the actual market value of the plants when traded; 2. By looking at the market value of the drugs of which they are the source material; 3. By looking at the value of the drugs in terms of their life-saving properties, and using a value of a `statistical life'.
4	Pushpam Kumar (2004)	Valuation of Medicinal Plants for Pharmaceutical Uses	*Attempted to review the acclaimed valuation works done during 1985-2000 with emphasized on the valuation of plant diversity for pharmaceutical uses. * Since these studies were address different concerns, it is difficult to arrive at general consciences on the methodologies they developed or adapted. * The value of a medicinal plant varies from $ 0.2 to $ 340 million per annum. * The study proposed that rather than a general study, local or area based studies taking into account its features of species and genera and its ecological function should be the preferred approach
5	Haripriya Gundimeda et al (2006)	The value of Biodiversity in India's forests	* For obtain the value of genetic material from the plant-based drugs, three approaches have been proposed: (a) values arising from traded plant material on the assumption that the market value represents the true WTP, (b) uses the market value of plant-based drugs and (c) estimates the value of plant-based drugs in terms of their lifesaving properties. * Empirical studies for genetic material, revealed a low value due to market imperfections.
6	Nguyen Chinh (-----)	Economics values of Conservation & Use of floral and Medicinal Plant Genetic Resources in Vietnam toward Sustainable Use	* Land uses for economic development purposes, but not conservation, are often subsidized. Therefore conservation of genetic resources of flora in general and medicinal plant in particular, has to face unfair competition. * The "public good" nature of genetic resource diversity and the economic distortions in the market place, and as a result, total economic value of genetic resource will be imprecise. This results in errors in policy making of conservation and sustainable use of floral and medicinal plant genetic resources.
		Pharmaceutical Research	
1	David Simson, Roger A. Sedjo; John W.Reid (1996)	Valuing biodiversity for use in Pharmaceutical research	* Biodiversity prospecting is a mechanism for both discovering new pharmaceutical products and saving endangered ecosystems. * The value of the marginal hectare of habitat and the incentives for habitat conservation generated by private pharmaceutical research are very modest. * Pharmaceutical researchers' willingness to pay for biodiversity as an input into commercial products is the concern. * The value of the marginal species must be very small. * There are several reasons why genetic resources may

			be relatively redundant. First, the same species may be found over a wide range. If all representatives of a species produce a particular compound, individuals in excess of the number needed to maintain a viable population are redundant. Second, there are numerous instances in which identical drugs, or drugs with similar clinical properties, have been isolated from different species.
2	Gordon C. Rausser and Arthur A. Small (2000)	Valuing Research Leads: Bio prospecting and the conservation of Genetic Resources	* Bio-prospecting has been touted as a source of finance for biodiversity conservation. * Bio-prospecting value of the 'marginal unit' of genetic resources is likely to be 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 search costs. * 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. * 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	Amy B. Craft and R. David Simson (2001)	The value of Biodiversity in Pharmaceutical Research with Differentiated products	* Biodiversity prospecting (the search among naturally occurring organisms for new products of agricultural, industrial, and, particularly, pharmaceutical value) has been advanced as a mechanism and a motive for conserving biological diversity. * For estimating values <u>two models</u> have been employed. The <u>Salop's model</u>, in which products are located at different places around a circle representing the space of all consumers' preferences. The <u>Dixit and Stiglitz's model</u> of monpolistic competition between sellers of products with demands derived from constant elasticity of substitution (CES) utility functions. * Model confirms that the value to private researchers of the "marginal species" is likely to be small.
4	William H. Lesser and Anatole Kratiger (2007)	Valuation of Bioprospecting Samples: Approaches, Calculations and Implications for Policy Makers	* The revenue consequences of varying collection fees and royalties with regard to germplasm prospecting contracts are demonstrated. * Uncertainty of finding marketable products and the value of these products were the emphasis. * Negotiation factors are finding a good balance between collection (initial) fees as opposed to royalty (delayed) payments
5	Onofri L and H. Ding (2012)	An Economic model for Bio prospecting Contracts	* Explored the use of a micro-economic model to analyse the provisions and parties of bioprospecting contracts. * Focuses on the pharmaceutical industry as the representative biodiversity buyer * The main contractors involved in these private deals are

			biodiversity sellers and biodiversity buyers * 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.
6	Alan Harvey and Nigel Gericke (2011)	Bioprospecting: Creating a Value for Biodiversity	Bioprospecting is the exploration of biological material for commercially valuable genetic and biochemical properties * This paper emphasised on the search for activities that 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.

Appendix 2

Selected Studies and Methodologies used for Bio-resources Valuation

S.No	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	…………
2	Eric Rutoa, Guy Garroda, and Riccardo Scarpab (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 ϵ *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 $$P_{T(n)}\|s = \prod_{t(n)}^{T(n)} \frac{exp(\beta_s' Xint)}{\sum_{j=1}^{J} exp(\beta_s' Xint)} \quad (2)$$ X_{int}= vector of observable attributes associated with alternative i *n* = observed making a choice on occasion t β_s = 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 ≤ p(s) ≤ 1. (Further development of this equation is given in the text)

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. b)Net social return to pharmaceutical prospecting (NSR^{pp}) is $NSR^{pp} = GR^{PP} – (SC^{BP} + (SC^{BP} + SC^{TI}) + SC^{R\&D}]$ 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	Cartier.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 $P_G = \frac{\partial EV}{\partial A}$ P_G = Global planning prices $P_j = \frac{\partial EVj}{\partial A}$ 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 $\pi_{BS} = P_B(B;\underline{\theta}). F(s(\underline{\theta}),L(B;\underline{\theta}),T(B;\underline{\theta})$ _ C (s,L,T,B) + μ . 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 $\pi_{BB} = P_D. G\ G[Y_{BS}(B;\underline{\sigma}),K(B;\underline{\sigma}),TI(part (B);\underline{\sigma})] – C(Y_{BS, B,T1(Pat) + (1-\mu) E} [Roy(pat)]_{(B);} \underline{\sigma})]$

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 $VIt = [\sum_{j=1}^{t} PLTC_j(1+i)^{t-j} + \sum^{n} PRDC_j(1+i)^{t-j} + \sum_{k=t} FNR_k/(1+r)^{n-t}]$ 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 month j FNRk = estimated net returns from future harvests in the crop cycle i = monthly interest rate r = monthly discount rate
2	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 = $a_1 + a_2 + a_3 \ldots an$, 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)

			$$WTP = [\sum_{i=1}^{N} (X_i)/N] \quad (3)$$ 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) $WTP = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + \epsilon_i \quad (4)$ WTP = Formers willingness to contribute to land races conservation β_0 = constant $\beta_1 - \beta_n$ = Coefficients $x_1 - x_n$ = variables influencing WTP ϵ_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	Pushpam Kumar (2004)	Valuation of Medicinal Plants for Pharmaceutical Uses	Review Paper
5	Haripriya Gundimeda et al (2006)	The value of Biodiversity in India's forests	Net present bioprospecting value of nth lead (Used Rausser C. Gorden and Small model, 2000) a) $\sum_{t=0}^{\infty} \lambda (1 + r)^{-t} V_n = \frac{\lambda V_n}{r}$ t = time λ = expected number projects carried out per year r = constant interest rate V_n = incremental value of nth lead $_{Max}WTP = (\lambda/r)[(R-c)/(n + 1)e^{-R/R-K}$ 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.
6	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: Bio prospecting and the conservation of Genetic Resources	Simson. D, Sodjo.R model was changed through basic research to find the net present bioprospecting value of nth lead is then given by $\sum_{t=0}^{\infty} \lambda(1+r)^{-t} V_n = \frac{\lambda V_n}{r}$ t = time λ= expected number projects carried out per year r = constant interest rate V_n = incremental value of nth lead
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	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.
5	Onofri L 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) $Y_{BB} = G[Y_{BS}(B;\sigma),K(B;\sigma),TI(\text{part } (B); \sigma)]$ The objective function of the BB can be modelled as follows $\pi_{BB} = P_D. G\ G[Y_{BS}(B;\sigma),K(B;\sigma),TI(\text{part } (B); \sigma)] - C(Y_{BS, B,T1(Pat)} + (1- \mu)\ E\ [Roy(pat)]_{(B);}\ \sigma)]$
6	Alan Harvey and Nigel Gericke (2011)	Bioprospecting: Creating a Value for Biodiversity	……………

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