# An evolutionary institutional approach to the economics of bioprospecting

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**Bibliographical reference**

Dedeurwaerdere, T., Krishna, V., and Pascual, U., 2007,"An evolutionary institutional approach to the economics of bioprospecting", in A. Kontoleon and U. Pascual (eds), *Biodiversity Economics. Principles, Methods and Applications.* Cambridge (UK): Cambridge University Press, pp. 417–445.

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## 1 Introduction

There is a significant strategic interest by 'Northern' industries of accessing and using genetic resources (GR) and associated traditional knowledge (TK) from the South. Such repository of bioresources in the South co-evolves through the development of TK and the continuous GR refinement adaptations in natural and managed ecosystems. The North/South debates over ownership, intellectual property rights (IPR) and access to the GR-TK stock were crystallized in the negotiations of the United Nations' Convention on Biological Diversity (CBD) which came into force in 1993, and now establishes the legal framework for the reciprocal transfer of bioresources between countries (Bhat 1999). In fact, the CBD stands as the only major international negotiated instrument that makes explicit provisions for the special link between TK, biodiversity and local and indigenous communities by granting rights to the latter in order to protect TK (Bodeker 2000).[1] The CBD also regulates bioprospecting activities carried out by industrial (usually Northern) firms and it assigns a formal protocol for sharing the benefits from bioprospecting activities based on the 'access and benefit sharing' (ABS) agreement to GR-TK between the parties.[2] In addition, it also calls for a free prior informed consent to be obtained from the holders of GR-TK prior to the bioprospecting activities taking place (Berlin and Berlin 2003). In addition,

[1] The recently ratified UN Convention to Combat Desertification (UNCCD) also makes explicit such provisions. Interestingly such provisions are included directly in the UNCCD text, while the CBD itself becomes more detailed in the later, and still non-binding, Bonn guidelines. The FAO International Treaty on Plant Genetic Resources for Food and Agriculture, adopted in 2001, also makes explicit this link. However, it covers only the plant genetic resources for food and agriculture and the treaty only attributes to the local communities the right to participate in the decision-making processes at the national level. Moreover, the 'access and benefit sharing' provisions become legally binding only if transited into national legislation.

[2] Here we use the term 'bioprospecting' following the definition by ten Kate and Laird (1999, p. 19), i.e. the research, collection and utilisation of biological and genetic resources, for purposes of applying the knowledge derived from it for scientific and/or commercial purposes.

the CBD effectively asserts the property rights of the bioresources and GR in particular to the source country (c.f. CBD Article 15: Access to Genetic Resources).

However, in many instances the rights of GR-TK holders, including the source country governments and indigenous/local communities, are being erased and replaced by those who have exploited their biogenetic and TK through prospecting endeavours. Such cases of biopiracy are being reported more frequently (Sheldon and Balick 1995; Shiva *et al.* 1997; Drahos 2000; Dutfield 2002a; Verma 2002).[3] The CBD acknowledges that when effective ABS systems are removed, it creates disincentives for *in-situ* conservation of the GR-TK stock. Against this backdrop, the debate on the conflicting approaches to IPR with regard to domesticated and wild bioresources and associated TK is re-emerging in order to devise ways of defensive protection against the misappropriation by bioprospectors (Dutfield 2002b).

In order to evaluate the potential contribution of benefit sharing systems to local communities and other relevant parties, a number of studies have focused on estimating the value of bioprospecting using a wide array of approaches (Principe 1989; Pearce and Purushothaman 1992; Simpson *et al.* 1996; Rausser and Small 2000; Craft and Simpson 2001). Broadly speaking, these studies assess the value of bioprospecting using standard cost-benefit analysis, in which the opportunity cost of land conservation, among others, is weighted to assess the expected benefits related to the discovery of a new useful property of a bioresource (net of the associated R&D costs such as biological material screenings). In the light of the debate on how to address the IPR problem, this chapter addresses the question whether such 'static' analyses are appropriate to approximate the social welfare loss from depreciating the GR-TK stock through non-adequate or absent North-South bioprospecting contracts and ABS agreements. We draw insights from contemporary economic analyses of contracts and property rights based on (evolutionary) institutional economics. The aim of this chapter is to address the challenge to build concepts that are better adapted to the specific character of the bioresources and that take into account their evolving

[3] The word 'biopiracy' was first introduced by Pat Mooney of the Rural Advancement Foundation International (now known as ETC, Action Group on Erosion, Technology and Concentration). RAFI defined biopiracy as 'the use of intellectual property laws (patents, plant breeders' rights) to gain exclusive monopoly control over genetic resources that are based on the knowledge and innovation of farmers and indigenous peoples' (RAFI 1996, p. 1).



(versus static) nature and the collective character of the associated traditional knowledge.

An important challenge in static valuation analyses of the costs and benefits from bioprospecting activities to local economies is the diffuse character of the values, both monetary and/or non-monetary, created by biodiversity within (intrinsically) complex and adaptive socio-ecological systems. The added value of biological resources does not arise at the final stage of the innovation process only. Instead, added value is created at each step of the innovation process – from the ecosystem itself creating the diversity of GR, through the contributions of the local communities' TK, the research laboratories and to final industrial applications and marketing (Swanson 2000). This implies that the existing IPR mechanisms that are associated with the property of the final stage of the innovation chain only address the tip of the iceberg. It thus remains insufficient as a mechanism for rewarding and adding value in all the other stages (Goeschl and Swanson 2002; Laird 2002). Furthermore, the current IPR mechanism remains insufficient for addressing the wider social values associated with the flow of resources and information generated by biodiversity (Brush 1996). For instance, in the case of TK, IPRs may conflict with the collective nature of indigenous knowledge and the importance of cultural and religious values towards nature.

Under such conditions, it seems appropriate to adopt a 'dynamic' approach to assess the use value of biodiversity in terms of conserving GR stocks and associated TK when benefits through bioprospecting can be realised (Dedeurwaerdere 2004). Such an approach incorporates the notion of bounded rationality and a broader vision of economic rationality (Driesden 2003), alongside the dynamics of economic and cultural change outside the view of a static (equilibrium) situation (North 1990). Accordingly, the focus shifts away from a narrow concern about the optimal allocation of existing resources (based on a static cost-benefit analysis mentality), to one about issues of dynamic efficiency. This entails focusing on knowledge acquisition throughout the entire process of value creation and incentives for the preservation of future possibilities of innovation and use of GR-TK under conditions of uncertainty.

By arguing in favour of a dynamic approach, new questions arise which have to be addressed in the implementation of any governance mechanism that is adopted, be it of a market, communal or public nature. That is, any mechanism that aims at valuing the diversity of GR and associated TK through bioprospecting needs to address the question regarding the creation of institutions for coordinating the diversity of social values associated with biodiversity and the enabling of collective learning processes in situations of intrinsic uncertainty.[4] This implies that an analysis of the full chain of innovation is necessary to assess the potential benefits from bioprospecting. Such analysis should address in a comprehensive and systematic manner the interconnected roles of the ecosystem, the local communities, the research community as well as private companies. Within this framework, this chapter attempts to show key shortfalls of static valuation approaches in the context of designing efficient benefit sharing agreements (e.g. through monetary compensation in terms of the current IPR framework) to the holders of valuable GR-TK sought by bioprospectors.

We use the case of a unique ABS biodiversity contract in India as an example of how the monetary valuation of TK/GR may be assessed directly from the perspective of the TK holders themselves. This analysis allows us to identify some of the key gaps in static analysis of similar ABS cases that tend to focus primarily on the final stages of the innovation chain. The case study presented in this chapter is based on a widely acclaimed model of ABS that involves the Kani tribe of the Western Ghats (WG) in India (Anuradha 1998; Moran 2000). The WG is a 160,000-km$^2$ eco-region shared by six southern Indian states: Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala. It is one of the 25 biodiversity hotspots that have been identified globally with an estimated 10,000–15,000 plant and animal species, of which about 40 per cent are endemic (WGF 2003).

Besides being a hotspot for biodiversity, the Kani tribe of the WG has become well known for its model of benefit sharing. The Kani model of benefit sharing (KMBS henceforth) is recognised as the first instance in which payments have been made to the TK holders for a successfully developed pharmaceutical product with therapeutic properties.[5] This product is based on *Trichopus zeylanicus*, a small perennial herb that is distributed in Southern India, with the subspecies *Travancoricus* being found only at an altitude of approximately 1000 m (Anuradha 1998). After the incidental *in-situ* 'discovery' by a group of scientists of the therapeutic properties of the herb, the local botanical garden formulated a herbal tonic, known as Jeevani or 'the ginseng of the Kani people', that bolsters the human immune system. The production technology was then transferred to a private Indian pharmaceutical company for

[4] For an overview of the literature on institutional economics and the analysis of bioprospecting, cf. the special issue of *Ecological Economics* on Access and Benefit Sharing (Siebenhüner *et al.* 2005).

[5] The KMBS received the 'Equator Initiative award' from the UNDP for developing a novel benefit sharing model during the World Summit on Sustainable Development at Johannesburg in 2002.



its commercialisation and the company agreed to compensate the Kani community through the intermediation of a locally established welfare trust.

The rest of the chapter is structured as follows: first, we address some key questions that point towards the reasons for the inadequacy of the incentive mechanisms under current ABS regimes that lead to socially sub-optimal levels of investment in biogenetic resources as a source of innovation. The discussion is then applied to qualify the degree of 'success' of a unique bioprospecting case based on the KMBS. After briefly describing this bioprospecting case, the KMBS is analysed from a wider institutional angle. This allows us to address a specific question regarding the actual CBD-based access and benefit sharing system drawing on the acclaimed KMBS case: how does the realised KMBS agreement compare to the value of the compensation implicitly requested by the local community for sharing their traditional knowledge? We finally draw some policy conclusions from the analysis.

## 2 From a static to a dynamic IPR framework in access and benefit sharing contracts

The existing mechanisms for the regulation of bioprospecting contracts involve two main parties, the industrial sector in the 'North' (mainly the biotechnology and pharmaceutical sectors) and the providers of the biogenetic resources in the 'South' (mainly local communities, botanical gardens and government administrations). Two basic features are inherent in the contracts. Firstly, the contracts aim at providing an incentive for innovation through the IPR on the finished product at the end of the production line. Secondly, they aim at protecting the providers' rights through the insertion of clauses in the contract with regard to the *free prior informed consent* to be obtained from the holders of GR-TK and the equitable sharing of the benefits from the development of commercial applications, i.e. the 'access and benefit sharing' clause. Since the CBD came into force, numerous ABS agreements have been signed and analysed (see, for example, Mulligan 1999; Svarstad and Dhillion 2000; Peña-Neira *et al.* 2002).

CBD and ABS agreements are dependent on a static notion of efficiency that has characterized the classical economic analysis of regulation (Dedeurwaerdere 2005). This notion is linked to the idea of optimal allocation of existing resources under ideal conditions of perfect rationality. Moreover, it has characterized environmental policy during the last two decades, resulting in an intensive application of cost-benefit analysis in the determination of the objectives of environmental regulation and the recourse to economic incentives as the means to achieve these objectives, increasingly through the creation of markets for environmental goods and services (Driesden 2003; Pearce 2006). By contrast, a dynamic conception of efficiency focuses on the acquisition of new knowledge allowing the maximisation of the range of future choices of the product development processes.

In the context of regulations for the conservation of GR-TK, the actual approach by the CBD is largely based on the static approach ultimately seeking to provide the 'right' incentives to effective GR-TK conservation through market creation. The problem is that the actual IPR mechanisms rely in valorising (i.e., adding value) to GR-TK at the final stage of the innovation process. By contrast, the dynamic approach seeks to address each step of the innovation process from the ecosystem as the repository of co-evolutionary GRs to the industrial applications, and through the added value of local communities' TK and scientific research laboratories. This implies that there is a need to create incentives for innovation along the entire chain of the innovation process. In the broader field of biodiversity governance, there is already an increasing recourse to tools aiming to implement such a dynamic approach. Such mechanisms can include the creation of trust funds dedicated to the conservation of biological diversity[6] or certification schemes monitoring the flow of resources along the process of value creation (Barber *et al.* 2003; Gulbrandsen 2004), such as the International Plant Exchange Network (IPEN) for the exchange of biological resources between botanic gardens[7] or the unique identifier system for transgenic plants developed by the OECD.[8]

[6] The most recent example of such a fund on a global scale is the Global Crop Diversity Trust established in 2004 as a public-private partnership of FAO and the 15 Future Harvest Centres of the Consultative Group on International Agricultural Research (CGIAR). An early case for Trust Funds in the field of biodiversity has been made by Thomas Eisner (Eisner and Beiring 1994); other prominent examples (though with mixed success) are the Genetic Recognition Fund established at the University of California Davis (Gupta 2004) or the Healing Forest Conservancy of Shaman Pharmaceuticals. For an overview of the different types of trust funds in the ABS field and their use, cf. Guerin-McManus *et al.* (2002). For a discussion on the design principles of a biodiversity trust fund, cf. Swanson (1997).

[7] All plant material supplied by an IPEN member needs to be accompanied by an IPEN number that remains connected with the material and its derivatives through all generations to come. With the aid of this number it is possible to track where and under which conditions the plant entered the network.

[8] See OECD documents: (ENV/JM/MONO (2001) 5; 2001 and ENV/JM/MONO (2002) 7; 2004). OECD describes the unique identifier as being a key attributed to a biotech product, which could unlock information from a range of databases, as well as an harmonised unique entry point enabling information management related to that product.



This brings us to the debate on the necessity to move beyond the actual ABS provisions of the CBD. This debate also joins discussions about the new forms of governance that emerged in the 1990s as being linked to an overly simplified conception of the path of application of the norms of regulation, both in economic theory and in the theory of legal regulation. In particular, if the evolutionary economics approach of Nelson and Winter (1982) and Dosi (1988) is followed, the conception of efficiency at work in the emerging regime of ABS can be criticized (Driesden 2003). For instance, expanding on theoretical insights by evolutionary institutional economics (Dopfer 2005), a broader vision of the rationality governing the economic decisions of parties engaged in bioprospecting agreements (e.g. government agencies and businesses) can be obtained. A key factor is the analysis of how institutional objectives have to cope with behavioural routines and partial information.[9]

The actual ABS agreements based on a static idea of efficiency have a double limitation as regards providing effective incentives for biodiversity conservation in the context of the actual IPR mechanisms. The first limitation is situated at the level of the short time-scale considered in the ABS agreements, which is inappropriate for dealing with a long-term investment in biological resources. The static approach tends to lock in the innovation process by providing only institutional incentives related to the current market opportunities and not addressing the future options of development. The second limitation is that the static view of ABS is incapable of dealing with the integration of the 'distributed knowledge' generated along the entire innovation chain. Instead, it focuses on IPRs where benefits and ownership can more easily be established. These two limitations are addressed in more detail in the following paragraphs.

The first limitation in the actual IPR model that constrains CBD as regards bioprospecting activities arises due to the overwhelming attention to those products that are '*currently*' interesting to the industry, making the bilateral contract mechanisms considered in the ABS regime inadequate from a social perspective which is concerned with the long-term investment in biological resources. The main reason for this inadequacy from a broader socio-economic point of view is the lack of investment in biogenetic resources that will potentially be productive in the future. Hence, the actual IPR mechanism is inadequate regarding a resource that is itself evolutionary by definition (Swanson and Goeschl 1998). An

[9] Examples of behavioural routines and bounded rational behaviour are developed more extensively in Dedeurwaerdere (2005). For example, conservation policies for agricultural genetic resources should take into account cooperative habits and insurance mechanisms in rural communities, such as informal seed exchange amongst farmers (Brush 1998).

illustrative example is that of the agricultural sector in which a highly productive, competitive seed that is resistant to pathogens is introduced. This introduction induces an adaptation in the population of pathogens in a way that can make them more 'aggressive', therefore enhancing the relative fitness of successful mutants adapted to intensively cultivated crops (Swanson and Goeschl 1998) or by increasing resistance of the pathogens to pest control technologies (Goeschl and Swanson 2002). As a result, the resistance of these newly introduced productive seeds decreases with time and its latent competitive disadvantage needs to be taken care of permanently by adapting the seeds and/or the means of production in reaction to the adaptation of the population of pathogens in the environment. Similar mechanisms operate in the pharmacological field, where one observes, for example, a decrease in the effectiveness of antibiotics and anti-malarial products (*Ibid.*).

Moreover, coupled to the evolutionary nature of GR, the associated TK and know-how also co-evolves with the bioresources (Brush 1996), adding another layer of complexity to the process of generating and using biological diversity. Yet the IPR mechanism creates an artificial monopoly on a productive seed or an effective drug, in the present, but it does not stimulate the investment in potentially useful biological resources able to cope with new populations of pathogens in the future. In order to maintain the innovation process over the long term, an incentive for the maintenance of a population of biogenetic resources that is potentially productive in the future needs to be established, for example satisfying the constant need for new innovations which can thwart the dynamics of natural evolution of pathogens.

The second limitation arises due to the focus of the ABS agreement on the 'end of the pipeline' of the knowledge generation process, where benefits and ownership can clearly be established, and not addressing the other stages of the innovation process, where ownership in knowledge is distributed amongst different players and benefits are highly uncertain.

Solving the problem of the uncertainty about the potential value of these contributions to knowledge generation by only compensating the few fortunate cases of bioresources that make it to the marketplace is a poor strategy from an economic perspective. Figure 15.1 represents the problem of uncertainty by adapting the scheme proposed for analysing a four-step industry (Swanson 2000) to the case of knowledge generation for research/industry input through bioprospecting. The latter depends on an investment in the resource at the level of (1) ecosystems that produce GR diversity; (2) communities of local users (traditional farmers, healers, etc.) that co-evolve and manage the bioresource stock; (3) the scientific community doing research into new properties; and (4) product



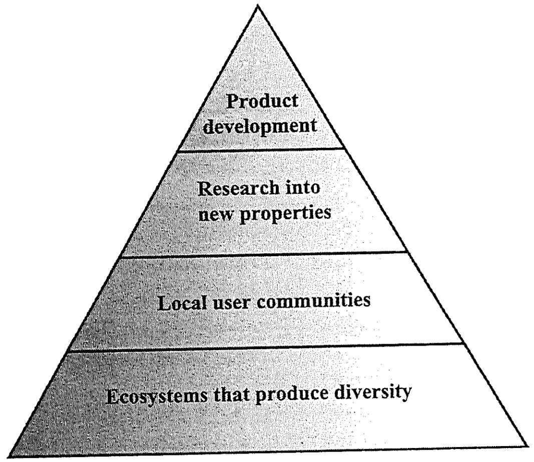


Figure 15.1. The bioprospecting chain

development. At each of these steps, the outcome of the investment is uncertain and, moreover, the investment at each stage is motivated by a broader set of social values than merely utilitarian values related to potential monetary benefits.

It is clear that the current ABS mechanism does not address the entire innovation chain. The contracts generally regulate those cases in which the development of an effective marketable product is likely (ten Kate and Laird 1999), or the case of a specific sector (e.g. cancer research) where such a development can be anticipated. But the problem is that in reality all of those involved in the initial stages of the innovation process are in a period of intense experimentation, knowledge gathering, exchange of materials and information, etc. with outcomes that are difficult to predict. Innovative biotechnological applications reach only so far because they are standing on the shoulders of giants, e.g. the scientific merits of researchers, the cultural heritage of so many years of traditional seed and other bioresource improvements and the social networks of exchange of knowledge and resources (Brush 1998). The point is that bioprospecting depends on initiatives at different stages of the innovation chain to guarantee a permanent flow of creation and regeneration of valuable biogenetic resources.

The double limitation addressed here leads effectively to sub-optimal levels in biodiversity conservation investment as a source of innovation. This idea fits with Goeschl and Swanson's (2002) view point about the three main kinds of insufficiencies that result from actual ABS regimes, all based on incentives relying on the existing IPR mechanisms. First, the IPR mechanism does not offer sufficient incentives to invest in products that have a short life span. It thus creates an underinvestment in GRs with high adaptability. Second, the IPR mechanism creates a trend of monopolisation and is therefore not compatible with the requirements of an innovation process based on diversity. Third, the IPR mechanism acts at the level of individual companies and does not create an incentive to invest in the other stages of value creation whose benefits are diffuse. In particular, it produces an underinvestment at the level of the ecosystem and its local or indigenous users.

The interest of addressing this triple insufficiency from the point of view of a dynamic approach is to show the necessity to change the static efficiency notion underlying the actual IPR framework which in turn governs bioprospecting and constrains actual ABS systems for GR/TK conservation. We argue that there is a need to progress towards a conception that better accounts for the collective character of the innovation process and the relationship between the natural evolution of GRs and efficient markets for such resources. The question that arises then is: what are the consequences of using a dynamic framework for the economic analysis of bioprospecting contracts?[10]

As shown by North (2005), dynamic efficiency ultimately depends on the cognitive belief structure of the broader community involved, such as the beliefs underlying science and democracy, which have played an important historical role in organising processes of permanent inquiry and social learning. However, these beliefs are the evolutionary product of centuries of path-dependent institutional change. The complexity of this historical process is beyond the scope of any empirical relevant model of dynamic efficiency, so that no general dynamic theory that is useful is likely to be developed (North 2005, p. 71–78, p. 125–126). Nevertheless, North also indicates some more modest and pragmatic goals that should be the object of an economic analysis of dynamic efficiency (*Ibid*: p. 163–164). These involve four complementary goals: (1) analysing why dynamic efficiency locks in suboptimal development paths; (2) understanding the cultural heritage of a society and the margins at which the belief system may be amenable to changes; (3) developing the institutional and organisational framework for capturing the productivity potential inherent in integrating the dispersed knowledge essential to efficient production in a world of specialisation; and (4) analysing the conditions for more effective monitoring of the political system. While

[10] Several general methodological consequences have been drawn from these insights on dynamic efficiency, most importantly in Aoki (2001, p. 387); Eggertsson (2005, p. 184) and North (2005, p. 155–165). Here we follow in particular the cognitive framework put forward by North (2005).



the second and fourth goals are beyond the scope of this chapter, the first and the third have been the focus of our analysis thus far, and it is to these two objectives that we turn in the next two sections.

In the next section, we address the reasons why bioprospecting contracts are not able to realise the full potential for biodiversity conservation as a condition for economic development. In order to do so a unique bioprospecting case from the Western Ghats of India is introduced. After this bioprospecting case is described, an institutional 'fitness' analysis is carried out in order to point out how even such seemingly successful cases may prove unsustainable and therefore fail their long-run conservation and development goals. We argue that in order to achieve a more sustainable contract design an alternative institutional design needs to be adopted. This is the one in which the holders of TK (i.e. the Kani community) also need to be full 'owners' of their TK. This would effectively allow them to directly enter into the ABS contract to obtain what they would perceive to be a fair amount of compensation for sharing their TK with any given bioprospecting company or alternatively decide upon another (and from their point of view, legitimate) use of their TK.

Then section 4 carries out an assessment of the way in which this alternative institutional context is perceived as being a source of economic progress by the different contractual agents (i.e. the TK holders, the private commercial company and the State). The two alternative situations that are addressed are (1) the full transfer of IPRs to the private company, as is the case in current contract described in section 3, versus (2) a situation in which the TK holders retain full ownership of their TK. We argue that the latter case would provide a more sustainable contractual design because it takes into account the perception of a key agent in the innovation chain, i.e. the local community, which is not taken into account in the actual contract design.

## 3 The Kani model of benefit sharing (KMBS): An institutional fitness analysis

This section introduces and then analyses the widely acclaimed Kani model of benefit sharing (KMBS) in the Western Ghats of India from an institutional economics perspective. The focus is on addressing the appropriateness of the 'evolutionary rules in use' in such ABS cases (even in those qualified as 'successful') drawing on the idea of 'institutional fitness' (Folke *et al.* 2002; Brown 2003). Such fitness is largely determined by flexible and open institutions that allow for multi-scale governance systems which in this case could facilitate the adaptive capacity of ABS systems within the CBD framework.

Before the institutional 'misfits' of the KMBS that limit the scope of a more complete ABS system are addressed, let us first describe in a nutshell this ABS case that prides itself on being a unique case in which actual payments have been made to the TK holders for a successfully developed commercial therapeutic product (Anuradha 1998).

The Kani community comprises around 18,000 people spread across 30 settlements and villages mostly in the forests of the Agasthiyar Hills of the Western Ghats in Kerala (some few households are also located in the border state of Tamil Nadu). This area is designated as a reserved forest, rich in biodiversity and strictly regulated by the Forest Department of the State Government. Following a visit to the reserve by a group of scientists, an *in-situ* 'incidental discovery' of the therapeutic properties of a small perennial herb, *Trichopus zeylanicus*, known as *Sathan Kalanja* or *Arogyappacha*, locally and traditionally consumed to reduce fatigue (Pushpangadan *et al*, 1988) took place.[11] On the basis of the discovery, the Tropical Botanical Garden and Research Institute (TBGRI) from Kerala standardised a herbal tonic to bolster the immune system and provide energy known as Jeevani ('provider of life') and formulated with *T. zeylanicus* in combination with three other medicinal plants. Then in 1996 the production technology was transferred to an Indian pharmaceutical company, Arya Vaidya Pharmacy Coimbatore Ltd (AVP). The TBGRI licensed *Jeevani* to AVP, and it agreed to share the licence fee of Rs 1 million (about US$23,000) and a royalty of 2 per cent on the profits with the Kani community on a one-to-one basis.

This was then followed by the creation of a local Trust Fund for the Kanis known as the 'Kerala Kani Community Welfare Trust', first registered with members from the Kani tribe. In 1997 the amount due to the Kanis was transferred to the Trust with the understanding that it was to be used for welfare-enhancing activities of the Kanis (Sahai 2000). More specifically, under the establishment of the Kani Welfare Trust, the KMBS was based on the transfer by AVP of Rs 519,000 to the account of the Trust (Rs 500,000 as the 50 per cent of the licence fee and the rest the first instalment of royalties from the sale of the drug, which up to 2003 generated Rs 100,000).[12] The mode of expenditure of the Trust was decided by majority voting.

[11] The phytochemical and pharmacological studies of *T. zeylanicus* have revealed the presence of certain rare glycolipids and non-steroidal polysaccharides with profound adaptogenic, immuno-enhancing, antifatigue properties.

[12] The inadequate supply of the leaves of the herb was the main reason for the relatively low amount of royalty accrued during this period. Subsequently, the pharmaceutical firm AVP began to use a limited quantity of raw drug collected from another Western Ghat region of the nearby state of Tamil Nadu.



Once Jeevani started to be marketed, the fast proliferation of domestic and international markets for the herbal tonic necessitated regular supply of fresh leaves of *T. zeylanicus*. Since the wild collection was both inadequate to meet the market requirements and could create ecological overexploitation due to being habitat-specific (the therapeutically active compounds are produced only when the herb is cultivated in and around its natural habitat), AVP proposed a plan for the cultivation of *T. zeylanicus* to the Kerala Forest Department, part of the State Government, and the Tribal Welfare Department. According to this plan, the AVP would enter into a buy-back arrangement with the local community to buy the leaves harvested from the cultivated plants. The firm was prepared to buy five tonnes of leaves per month and the TBGRI trained fifty Kani households for a pilot-level cultivation season in 1996 by availing a subsidy of Rs 1,000 for each cultivating household. However, due to the lucrative nature of the leaf sale of *T. zeylanicus*, the local community began to collect the whole plant from its natural forest habitat. This induced the Forest Department to proscribe its cultivation, fearing the ultimate extinction of the wild varieties through overexploitation.[13] It was not until several years of negotiation concluded in 2003 that the Forest Department re-issued consent to cultivate the herb and the Kanis were in a position to bargain for a better price for their 'cash crop'. However, the contract with AVP lasted only another six months, and the pharmaceutical firm was unwilling to negotiate a new price contract. The monetary benefit flow from the KMBS is illustrated in Figure 15.2.

Despite the acclamation of the KMBS, we argue that it has not yet achieved its full potential due to various institutional impediments. These are based on the conflict of interests and coordination problems between the local botanical garden (TBGRI), the Forest Department, the pharmaceutical firm and the Kani local community. For example, whereas the TBGRI as a part of the State Government licensed AVP to manufacture the drug, the Forest Department did not facilitate the manufacturing process (Anuradha 1998). Hence, improper coordination amidst various governmental bodies led to partial execution of the scheme. Moreover, the major source of income from the ABS would have come from the supply of *T. zeylanicus* leaves for drug manufacturing. However, the Kanis could harvest only two crops in 1996, and their effective bargaining made AVP offer a threefold increase in the price of the raw drug (from Rs 25/kg of fresh leaves to 75/kg). But due to fear of overexploitation of the herb

[13] TBGRI tried with only limited success to develop a propagation technique through tissue culture seedlings.

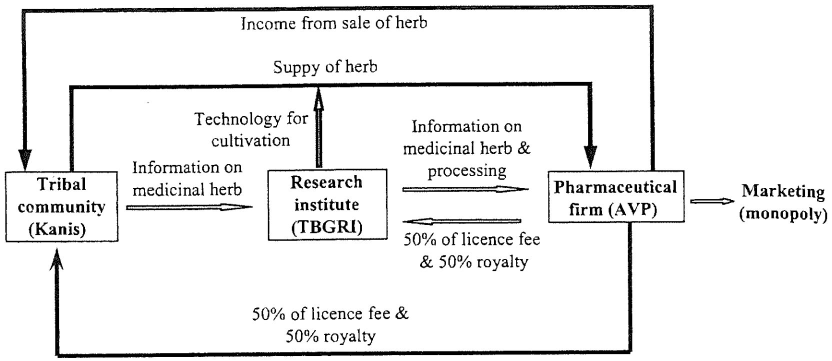


Figure 15.2. The monetary benefit flow from the KMBS
Source: Adapted from TBGRI Scientists, the TRUST trusties and Anuradha (1998), Moran (2000), Pushpangadan (2000) and Gupta (2002)

from its natural forest habitat, the State Forest Department banned its cultivation.[14]

The 50 households which first cultivated the herb witnessed a significant increase in income given the low opportunity cost of family labour. As a result, more households began to cultivate the plant in the next growing season. Despite the small size of the area for cultivation by each household (average of 0.1 ha), its cultivation allowed households to generate an average net revenue of Rs 1,123 and Rs 849 respectively during the two harvests in 1996 (the Rs 1000 subsidy given by the ITDP being primarily responsible for the higher figure for the first crop). Hence, had the scheme been implemented according to the proposal by AVP (in which a monthly demand of 5 tonnes of fresh leaves was anticipated), the community could have earned a minimum of Rs 4.5 million annually at a fresh leaf price of Rs 75/kg. Even without taking into account the associated increase in royalty (due to the increased raw drug supply and resulting higher level of production and sale), the income forgone by the Kanis is significantly greater than what they had achieved.

But this begs the question of whether the cultivation in the forest reserve would have been ecologically sustainable. Moran (2000) has expressed concern over the present system of sourcing *T. zeylanicus*, since there is no information on sustainability studies connected to methods of managing and harvesting the herb. There are countless examples of why mere

[14] It bears a resemblance to the harvest of the entire adult population of *Maytenus buchananni* (a source of anticancer compound Maytansine) by the US National Cancer Institute in Kenya for testing its drug development programme (Oldfield 1984; Reid *et al.* 1993).



market creation for bioresources need not always facilitate conservation (Barrett and Lybbert 2000). In fact, in this case unregulated bioprospecting and drug development could speed up the destruction of the resource. This experience points out that the question of the control and sanction mechanisms for dealing with overexploitation of the wild variety and illegal trade should also be addressed.

The ABS agreement with the Kani was established on a voluntary basis and not on a broader legal framework for regulation of bioprospecting, specifying the rights and duties of the TBGRI and private companies. In this situation, even with a clear incentive for the Kani members involved in the contract to adopt sustainable management practices, there could be no guarantee that other groups would not free-ride on the contract through exploitation of the wild variety or, alternatively, that the pharmaceutical company would not look for other providers of the same plant under less restrictive conditions (as, in fact, it subsequently did).

Moreover, the appropriate protection of the rights of the indigenous community over its TK also depends on the existence of such guarantees. In the case of the Kanis, the disclosure of their traditional knowledge to the Indian scientists was entirely based on trust and good faith. It was based on the belief that they would honour their promise of benefit sharing in case of the development of a new product. Hence, it is not possible to replicate the contract automatically to other situations, where these relationships of trust may not be robust. Under these conditions, the incentive to disclosure TK by other communities remains limited to situations where personal relations and informal guarantees that their property rights will be protected and that the contract will lead to appropriate benefit sharing exist.[15]

Lastly, looking at the Kani example we can explore whether the focus on the issues of IPR and the associated ABS system has not shifted the attention away from the question of the involvement of other actors in the negotiation of the contract. In the Kani case, the contract is clearly the outcome of an agreement negotiated between scientists from the TBGRI and the AVP pharmaceutical company, which in turn was initially based on a confidential agreement between the scientists and the Kanis. The property right holders of the physical asset, the forest administration and the members of the tribal community, seem to have been involved only marginally in the drafting of the terms of the contract, and consequently the legitimacy of the agreement is not recognised with the same intensity by all the actors. In particular, as Ramani (2001) shows, different

[15] In other cases, such as the Costa Rican InBio-Merck agreement, an ABS agreement is already signed at this stage.

perceptions subsist between the younger and the older tribal Kani members, the latter caring more about the loss of cultural identity.[16] This lack of legitimacy may be due to the fact that the focus of the TBGRI had been on the bilateral contract between the pharmaceutical company and those Kani guides who transmitted the local knowledge to the Indian scientists, thus by *de-facto* acknowledging them as the original providers of the TK-GR. This clearly begs the question of the possible disregard of the role of the majority of the community members and that of the Forest Department.

## 4 Valuing the bioresource from the TK holders' perspective

The classic model of bioprospecting in the case of a GR-TK system, such as in the KMBS case, involves three main actors: (1) the ecosystem as the natural repository of the GR base, (2) the indigenous community acting as stewards of the ecosystem and thus the GR-TK base, and (3) the commercial firm interested in the search for new chemicals from nature. Here we pay special attention to the second node of the chain: the local community as the custodian of TK. We seek to provide an approximate estimate of how the Kani community values its role in the innovation chain leading to the successful commercialisation of Jeevani. That is, the interest is in shedding light on the Kanis' willingness to pay (WTP) for protecting their TK with regard to the external appropriation of bioresources and on the various household socio-demographic and economic characteristics that affect their implicit valuation. The results can be interpreted more directly as the level of compensation that representative members of the Kani community demand for their involvement in the *T. zeylanicus* bioprospecting activities by the botanical garden and the pharmaceutical firm. We carry out this analysis by employing a contingent valuation study.

The monetary benefits realised from the current Kani ABS scheme reach the community in the form of cash payments to the Trust. Since the rights to the service under consideration (the use of TK) are held by the local community, compensation for participating in the biodiscovery process by disclosing its traditional ethnobotanical knowledge would be the appropriate format for value elicitation (Shyamasundar and Kramer 1996). One difficulty of using the WTA format is that the local community receives indirect payments through the provision of public goods to the community by the Trust, making direct elicitation of WTA less precise

[16] Concerns have been raised by the elder tribe members that the expected welfare benefits could be outweighed by the loss of traditional medicinal practices (Ramani 2001).



in reflecting households' preferences. Hence, the question posed to the Kani community members is based on the maximum WTP to protect their traditional knowledge from outside illegal appropriation.[17]

The survey for the statistical analysis was carried out in 2004 in the Western Ghats. The statistical sample is made up of 68 households randomly selected from ten settlements of the Kanis and stratified into cultivators (50 per cent) and non-cultivators of *T. zeylanicus* (50 per cent). Using the local language (Malayalam), household heads were invited to report on households' socio-economic characteristics, the management of *T. zeylanicus* cultivation, and various aspects concerning the knowledge and attitudes towards the implementation of the bioprospecting contract and protection of their traditional knowledge.

The average annual per capita income of the surveyed household was found to be Rs 7,727 (about US$176 at 2005 prices) with 68 per cent of income arising from homestead farming in about one hectare of land that includes crops such as coconut, tapioca, banana, betel nut, black pepper and rubber. Approximately 20 per cent of income accrues from wage labour and 12 per cent from selling various permitted non-timber forest products (NTFP) such as wild gooseberries, asparagus, honey and nutmeg.

The contingent valuation study is based on a dichotomous choice model and the results are shown in Table 15.1 together with a description of variables. The hypothetical scenario presented and the question posed to the households is the following: 'Suppose a pharmaceutical firm markets a herbal medicine using the traditional knowledge of the Kanis without asking for your prior consent. In this regard, the Trust or any other NGO (dealing with Kani welfare) has decided to bring this particular firm to court. If the Trust/NGO wins the case, the right to the use of this particular traditional knowledge will rest within the community only, or alternatively the community may get a fair amount of compensation for sharing the knowledge. The Trust/NGO decides to collect money from Kani tribes to meet the court expenses. In this regard, would you be willing to donate Rs X to the fund?'[18] This dichotomous choice question was followed up by two more questions which asked respondents whether they would be willing to pay a higher or lower amount, setting upper or

[17] The estimated Kanis' WTP value for protecting their TK through the CV study is possibly a lower bound of the true compensation required, as suggested by most studies comparing WTP and WTA values (e.g. Adamowicz *et al.* 1993; Shogren *et al.* 1994; Morrison 1997).

[18] The bids of the first WTP question ranged from Rs 50 to Rs 400 with a constant interval of Rs 50. The amount was specified as a one-time payment.

Table 15.1 *Variable definitions and estimated double bounded dichotomous choice model*

| Variables | Description and measurement (mean ± std. deviation) | Coefficient (Std. error) Model I | Model II |
|---|---|---|---|
| Constant | | $-706.46$ (535.16) | $-414.67^{*}$ (230.53) |
| Per capita income# | Per capita annual income of household in 000 rupees (7.73 ± 6.61) | $98.38^{**}$ (42.16) | $71.47^{**}$ (33.66) |
| Age# | Chronological age of the respondent in years (33.31 ± 12.00) | 45.54 (108.32) | – |
| Education# | Formal education attained by the respondent in years of schooling (4.00 ± 4.14) | $-95.79^{**}$ (49.19) | $-95.83^{**}$ (47.21) |
| Household size# | Number of members in the household of respondent (4.03 ± 1.47) | 23.62 (99.00) | – |
| Farm size# | Size of farm managed by the household of respondent in acres (2.97 ± 1.94) | $-20.84$ (52.01) | – |
| Wage labour | 1 if respondent participates in the non-farm labour market, 0 otherwise (63 %) | $-159.62^{**}$ (64.68) | $-146.71^{***}$ (57.35) |
| Remote# | Distance between respondent's household to public transport facility in kilometres (9.27 ± 3.89) | 107.99 (89.49) | 83.81 (76.33) |
| City# | Frequency of visiting nearby city by respondent in number per month (8.34 ± 4.91) | $126.79^{**}$ (64.67) | $112.50^{*}$ (58.62) |
| Adults | Proportion (0–1) of adult members in the family size (0.77 ± 0.32) | $-50.38$ (114.61) | – |
| Community development | 1 if the respondent actively engaged in community development activities, 0 otherwise (32 %) | $-5.42$ (67.50) | – |
| Read | 1 if respondent read newspapers regularly, 0 otherwise (46 %) | 182.53 (116.12) | $173.48^{*}$ (100.52) |
| Radio | 1 if respondent listened to radio programmes regularly, 0 otherwise (78 %) | 94.46 (67.74) | 70.85 (61.09) |
| Television | 1 if respondent watched television programmes regularly, 0 otherwise (54 %) | $166.52^{***}$ (63.14) | $174.59^{***}$ (59.15) |
| Cultivator | 1 if respondent was engaged in *Trichopus* cultivation, 0 otherwise (50 %) | $106.26^{*}$ (59.03) | $97.50^{*}$ (55.07) |
| NTFP | 1 if respondent engaged in non-timber forest product collection, 0 otherwise (81 %) | 70.84 (80.53) | – |
| Herb Consumption | 1 if respondent consumed *Trichopus* fruits regularly, 0 otherwise (87 %) | 113.71 (87.76) | $153.99^{**}$ (78.68) |
| Log likelihood function | | $-65.04$ | $-65.88$ |
| $\chi^2$ | | 36.86 | 35.17 |

Notes: Sample size, N = 68. Coefficients can be directly interpreted as marginal effects
$^{*}$,$^{**}$, and $^{***}$: statistically significant at 0.1, 0.05 and 0.001 levels, respectively
#Variables are taken in their natural logarithmic form



lower bounds. A double-bounded dichotomous choice (DBDC) format is thus used (Hanemann *et al.* 1991). These questions intend to capture the Kanis' view of the prior-informed consent aspect within the ABS system. It should be noted, however, that even prior-informed consent was granted, the question does not help to resolve how this is obtained or who decides that it is obtained in a legitimate way (Berlin and Berlin 2003). Here, the DBDC model just tries to capture the effect of various socio-economic factors on Kanis' willingness to donate to the proposed fund as a proxy to their efforts to protect their TK from misappropriation.

Answers to the two sequential WTP questions of DBDC format are sorted into four intervals: $(-\infty, P^L)$, when the first and second answers are both 'NO'; $(P^L, P^*)$, when a discount offer is accepted at the second bid; $(P^*, P^H)$, when the premium is rejected; and $(P^H, +\infty)$, when both answers are 'YES', where $P^*$, $P^L$ and $P^H$ denote initial price bid, lower price bid (bid with a discount) and higher price bid (bid with premium), respectively. The probabilities for the above choice indices can be specified as:

$$\begin{aligned} Prob(yes/yes) &= Prob(WTP \geq P^H) \\ Prob\,(yes/no) &= Prob(WTP \geq P^H) - Prob(WTP \geq P^*) \\ Prob(no/yes) &= Prob(WTP \leq P^*) - Prob(WTP \leq P^L) \\ Prob(no/no) &= Prob(WTP \leq P^L) \end{aligned} \tag{1}$$

Correspondingly, the log-likelihood function for this WTP model is,

$$\begin{aligned} \ln L = \sum_{i=1}^{n} I^{YY} \ln\left[1 - \Phi\left(\frac{P^H - \beta' x}{\sigma}\right)\right] + I^{YN} \\ \ln\left[\Phi\left(\frac{P^H - \beta' x}{\sigma}\right) - \Phi\left(\frac{P^* - \beta' x}{\sigma}\right)\right] + I^{NY} \\ \ln\left[\Phi\left(\frac{P^* - \beta' x}{\sigma}\right) - \Phi\left(\frac{P^L - \beta' x}{\sigma}\right)\right] + I^{YY} \\ \ln\left[\Phi\left(\frac{P^L - \beta' x}{\sigma}\right)\right] \end{aligned} \tag{2}$$

where the $I$ symbols denote binary indicator variables for the four response groups. The coding of our likelihood model allows one to estimate $\beta$ directly and the coefficients can be interpreted as the marginal effects of the $x$ variables on WTP in rupee terms. The socio-economic variables assumed *a priori* to have a bearing on respondents' WTP are included in the DBDC model and are presented as Model I in Table 15.1. Some of the estimated $\beta$ parameters associated with the explanatory variables are found to be insignificant, and hence to save degrees of freedom those variables having $z$ values less than unity were omitted and the model was re-estimated (Model II).[19]

We incorporated household level variables including household income, education, age structure of the household, as well as variables related to their livelihood activities (e.g. whether households cultivate and are direct consumers of the herb, whether they engage in the collection of non-timber forest products) and how connected they are to the 'outside world' geographically and through the media.

As expected, the data suggest that the Kanis' (per capita) income controls their ability to pay. In other words, poorer households are less able to afford the proposed voluntary contribution to the community's fund to protect their TK. On average, a 1 per cent increase in per capita income increases the (latent) WTP to the hypothetical fund by Rs 71 (i.e. 0.9 per cent of per capita income). Hence, the income per capita is close to being unit elastic with respect to the (latent) WTP to protect TK by the Kanis. Interestingly, the *a priori* expectation that older tribe members would be more likely to donate for TK conservation as they may be assumed to be more attached to traditional community values is not reflected by the data (albeit its positive sign) given its low statistical significance. Further, although the level of formal education among Kani members is associated with a lower willingness to donate to the fund, other forms of information channels, such as access to newspapers and television and through direct visits to nearby cities, increase their WTP considerably. Regarding the livelihood activities carried out by the households, it is suggested that households which cultivate the herb are willing to donate a higher amount to the fund than non-cultivators, which could possibly be the result of direct experience by the former with respect to deriving a tangible use value from trading with the herb. This result may also be associated with the positive effect on WTP of having the direct experience of consuming the *Trichopus* fruit. Lastly, the results from the DBDC-CV model suggest that the households which participate in the non-farm labour market and derive daily wages in that sector are less willing to donate for the community's TK protection cause. This may also be associated with their lower attachment to the agro-ecosystem and the values that they derive from it.

[19] A log-likelihood test conducted to verify whether the coefficients of the omitted variables were jointly zero, failed to reject the null hypothesis, implying that dropping of variables is statistically justified. The test statistics are defined as $-2(L_0 - L_{max})$, where $L_0$ and $L_{max}$ are the values of the log-likelihood functions for the restricted and unrestricted models respectively. The unrestricted and restricted models are statistically significant at the 0.01 level with $\chi^2$ values of 36.86 and 35.17 respectively, i.e. $\chi^2_{16} = 1.68$. Thus, the null hypothesis that omitted variables are jointly not different from zero cannot be rejected at any meaningful significance level.



Table 15.2 *Mean WTP of Kani households (in Indian rupees[#])*

| Household group | Mean WTP (std. error) |
|---|---|
| Cultivators | 409.71* (113.82) |
| Non-cultivators | 246.39 (103.85) |
| Average WTP (weighted by the share of cultivating and non-cultivating sample) | 251.29 (174.98) |

* Significantly different from mean WTP of non-cultivators at 0.01 level
\# 1 US$ = Rs 44 (exchange rate of 2005)

Using the estimated coefficients in Model II, the mean WTP is Rs 410 (Rs 246) for a representative household that cultivates (does not cultivate) the herb (c.f. Table 15.2). The difference, also depicted in Figure 15.3, is significant at the 1 per cent level. The weighted mean WTP is Rs 251 (around US$ 5.7) per household which is about 3.3 per cent of their annual per capita income. Notwithstanding the possibly lower bound with regard to the implicit true WTA value, this amounts to 1 million rupees by the whole Kani community. If this is compared to what the pharmaceutical AVP offered which was shared on a one-to-one basis between the Kani community (through the Trust) and the TBGRI, it is clear that the community obtained just half of the minimum benefit that is perceived as appropriate compensation for engaging in the bioprospecting contract.

Hence the valuation study sheds some light on the degree of the inadequacy of compensation levels in ABS cases, as we displayed that even in those cases hailed on being successful such as the KMBS there is a significant disparity between actual payments and what is perceived as appropriate and necessary compensation by the local TK holders.

It is important to note, however, that these types of valuation studies need to be complemented by a broader analysis to fully address the stake of preserving future possibilities of use and innovation and the contributions of the other actors involved in the entire innovation chain. For instance, the danger of the extinction of the herb from the forest ecosystem is not addressed in the bilateral (Kani-AVP) relationship, and it is the conservation policy of the Forestry Department that takes into account this preservation value within the conservation of the habitat.

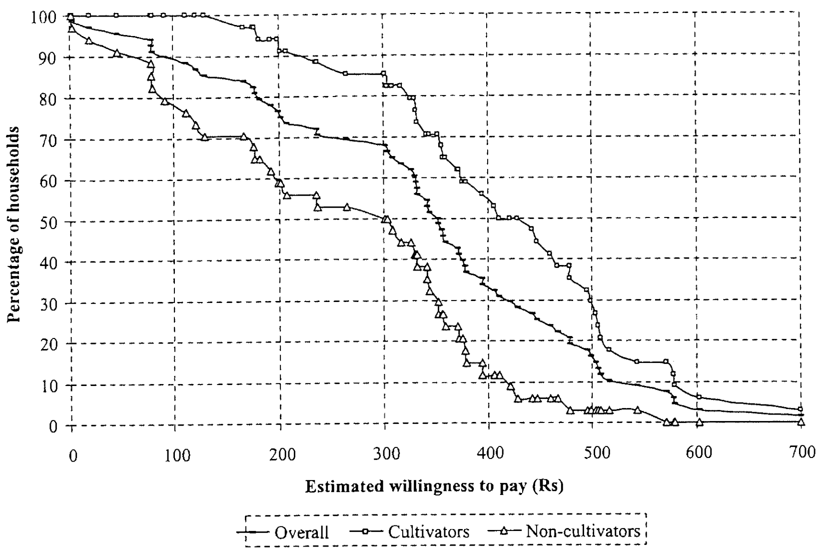


Figure 15.3. Estimated cumulative distribution of farmer households and their respective WTP, controlling for cultivating and non-cultivating households of *Trichopus*

Additionally, the value of the GR and associated TK for scientific research into taxonomy and plant-related medicine also needs to be accounted for, even though public actors are investing in it through government or international cooperation.[20] What is apparent is that in the actual institutional setting there is no real integration of these different players throughout the innovation process, and the ABS scheme has not been able to live up to its full economic potential. The estimated gap between the Kanis' perception of the value of sharing their TK and the actual compensation offered to them by the bioprospecting company is just one of the manifold manifestations of the suboptimality of these kinds of ABS contracts.

A full dynamic valuation approach should focus on a more balanced assessment of the different biodiversity related values, under conditions of strong uncertainty and evolving social preferences, hence addressing

[20] TBGRI benefits from several international projects for cooperation of research and value addition. In particular, a collaborative research project entitled 'Ethnopharmacology of Indian Medicinal Plants' is carried out between the TBGRI and the Department of Medical Chemistry at the Royal Danish School of Pharmacy, Copenhagen, Denmark, sponsored by the Danish International Development Agency. It is in the framework of this collaborative research that the components of *arogyapaacha* (the local name of *T. zeylanicus* ssp. *Travancoricus*) were isolated, some of them having been sent to Copenhagen for characterisation (Gupta 2004).



not only the market value of the final product of the innovation chain, but also other social values including the cultural values of the Kani community, the public good value of the preservation of a diverse genetic stock or the value for scientific research. This would imply combining the CV approach with qualitative information on the motives and attitudes underlying the local people's statements on the value of bioresources (O'Connor 2000; Spash 2000).

Furthermore, the WTP for keeping full property rights over TK analysed here is an aggregate measure of value, covering all the Kani tribe members who individually may have very different attitudes towards the Trust fund and the endeavour. Indeed, for some members, the estimated welfare measure covers the compensation for licensing the property rights on the TK, while for others it may also consist of the anticipated monetary return from engaging in cultivation and selling of *T. zeylanicus*. For others, it may represent the importance of preserving the traditional culture values attached to a broader notion of indigenous traditional healthcare.[21]

In summary, the CV carried out here shows a clear shortcoming of the static approach to ABS as it considers only the potential market value of the product at the end of the pipeline of its development process. In doing so, our analysis brings into the foreground another biodiversity-related value derived from the community which is the bearer of the TK.

## 5 Conclusion

This chapter has focused on the economic incentives for *in-situ* knowledge-sharing in the context of bioprospecting. We have adopted a dynamic approach to the economic institutions of contracts and property rights. In this dynamic framework, the focus is not on the *ex ante* determination of the optimal allocation of resources under conditions of perfect rationality, but on issues of dynamic efficiency, such as knowledge acquisition and incentives for the preservation of future possibilities of use under conditions of uncertainty. By applying this (institutional) evolutionary approach to the process of bioprospecting, the chapter has attempted to address the importance of analysing the full chain of bioprospection in the innovation processes.

[21] The importance of the preservation of culture value in *in-situ* conservation is also confirmed by an interesting case study of Dyer *et al.* (2000) on local seed markets in Mexico. The introduction of new crop varieties caused a diversification of farmers' activities. Nevertheless, because of local traditions and culture, they continue to grow the classical varieties, despite the fact that from a financial point of view one can show that they have no reason to do so.

In this way, the current analysis moves away from the position that considers the difficulties posed by the actual IPR system on genetic resources as being merely a technical and legal issue. At present, in the field of genetic resources, one sees a tendency to create new laws for each sector of activity. This results in the emergence of many specific legal regimes for the protection of genetic resources and related traditional knowledge. These include, for example, patents for processes relying on genetic manipulation, plant breeders' rights for plant varieties resulting from genetic selection, farmers' rights for traditional farmers' varieties and national sovereignty governing the rights to access and use the natural resources from ecosystems that maintain and create biodiversity. Nonetheless, the multiplication of different sector-based laws still falls in a static conception of efficiency and does not really meet the need for an integrated approach to the process of value creation through the whole innovation chain.

This problem calls for a more differentiated approach towards institutional mechanisms for promoting conservation and sustainable use of bioresources. For instance, in the case of bioprospecting they include the financing of plant-genetic resource conservation by research institutions such as the International Plant Genetic Resources Institute and community management of risk in agrarian societies based on a system of reciprocity allowing for the preservation of a high level of agro-biodiversity (Brush 1998). National programmes for the development of biotechnological capabilities can also play a key role in the sustainable use of bioresources and contribute to a differentiated institutional approach (Artuso 2002).

In the case of the Kani model of benefit sharing, the trust fund is an example of an institution for coordinating the different social demands coming from the community. However, as we have seen, it largely remains insufficient, because limited social learning is generated for bridging the conservation interests of the Forest Department and the interests of (a part) of the community involved in the benefit sharing agreement. Further, within the community different perceptions subsist between the younger and the older tribal Kani members regarding the appropriate protection of their traditional knowledge, the latter caring more about the loss of cultural identity.

Other means for enhanced institutional coordination that are currently being considered in international fora are the creation of an international system of certification of origin for monitoring the flow of genetic resources (Barber *et al.* 2003), the establishment of 'collection institutions' for traditional knowledge registries (Drahos 2000) or the creation of partnerships between research institutions and community-based



breeding programmes (Brush 2002). In the field of IPR, Reichman (2000) proposes that policy formation evolves from a paradigm that functions by hybridisation of existing tools, based essentially on patent and copyright, to a paradigm based on a system of liability regimes, allowing the *ex post* compensation of the prior link in the innovation chain. These proposals include mechanisms that aim at diffusing incentives through the entire production chain and maximising the future choices of development. These consider the necessity of new legal tools and governance mechanisms, but also the importance of the associated institutional means for social learning and information sharing.

This chapter has argued that there is a need for major reforms or the use of alternative mechanisms to the existing bilateral market approaches to bioprospecting contracts and the voluntary mechanisms of benefit sharing. The reformed bilateral market approach should at least be based on a more 'dynamic' approach to the assessment of the use value of biodiversity (in terms of conserving GR stocks and associated TK) in the case when benefits through bioprospection can be realised. Further, in a second-best world, it is important to design alternative institutional means, including informal norms and formal legal regulations, that allow the effective coordination of the different actors involved in the innovation chain. This should allow for appropriate sanctioning of opportunistic behaviour and collective learning.

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