"New" Forest Services and Property Rights

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by

Olman Segura and Bjorn Johnson*

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1. Introduction

Forest sector and environmental services from forest were not really important in national economies nor in economic policies, until recently. The development of the forest sector activities were at first linked in particular to logging activities and the sawmill industry. At that time, trees seemed to be very abundant and log supply was not a problem. Sawmills supplied timber, especially for construction and a few other industries, which were linked to the forest only through their use of wood as an input. Foresters were primarily interested in the efficiency of the transformation of logs into timber and in some silviculture activities, which allow trees to grow faster. In short, there was a clear bias emanating from technologies, institutions and policies against forest related activities in the past.

Recently, however there has been important changes in the economy of the forest sector. Now, it is widely accepted that forests are ecosystems, which besides producing timber, seeds and a few other marketable products, also produce ecological services. These "new" products and services (see box No.1) can only be maintained and further developed, however, if the traditional, non-sustainable, exploitation of the forest comes to an end[1]. Such a change requires institutional changes as well as new policies. (Institutional learning and policy learning).

But what do we mean by "new" forest services? As mentioned some where else[2], the forest's environmental services consist of essential properties of the forest ecosystem, which provide benefits to society in general and the economic sub-system in particular. Most of them are not new in their own respect. The novelty lies in their introduction into the economic sub-system. New opportunities are emerging for the development of the forest sector and for wilderness protection, to be pursued in interaction with other societal goals. So far these services have not been considered as part of the national innovation system in any country, and they have not been considered as elements of the learning economy.

Now, as indicated in Table 1.1, some of these new services, which we all agree have ethical, biological and economic value, are entering the economic sphere of society either through the market or through public investment and consumption.

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[1] Natural disturbances (as oppose as human made exploitation), such as events triggered by fire, wind and herbivores, are an inherent part of the internal dynamics of ecosystems. See Folke et.al. 1998 for more about this topic.

[2] Review Segura and Johnson, 1998, and Segura, 2000.

Box No.1: PRODUCTS AND SERVICES FROM FOREST

Timber: lodging and production of timber for housing.

Wood products: wood for pulp and paper, wood for energy, firewood, charcoal, posts for fences, wood for crafts and Christmas trees.

Non-wood products from forest: medicinal herbs, tints, ornamental plants, resins, seeds, constructions materials, genes, chemical substances, liens, odours, meat and animal skins,

Conservation: the retention, creation, maintenance, reproduction and survival of animal and vegetable species.

Education: the woodland environment, the biodiversity and the landscape in general may serve as living laboratories and outdoor classrooms, or we may create the new term bio-education which includes from kindergarten to Ph.D. research professionals.

Free Leisure: it refers to pleasant, tranquil, desired and needed rest, vacationing or sporting activities around the woods, especially for the local population.

Eco-tourism: it refers to leisure paying for services in National Parks, private or public reservation areas or vacation resorts.

*Maintenance of the hydrologic cycle: T*his refers to water recharge and the maintenance of rivers. Water for human, industrial and agricultural consumption, springs, and water for scenery is dependent of forestry. Prevention from floods, water transportation, and hydroelectric plants are also dependent from this cycle.

Soil and water quality conservation: run-off and wind erosion as well as sedimentation - which is reduced with forest- may affect quality of soil and water.

Microclimate regulation: local and horizontal precipitation and local humidity.

Wind and noise control: forest serve as fences for wind (agriculture activities) and noise (housing and vacation homes).

Carbon sink: carbon sink and fixation protecting the globe from climate change.

Hunting: Forest keeps wildlife, which also serve as food for rural communities as well as sport for urban vacationers.

Maintenance of biological diversity in the forest ecosystems: ecosystem resilience, maintenance of the forestry capability of reducing impacts on protected areas (buffer zones), natural history, research bank (or library) for future development (of agriculture and pharmaceutical discoveries for instance).

Cultural and religious services: Rural and indigenous communities also have believes, sacred places and cultural values which should be respected. Existence value.

Source: Segura, O. 2000.

In the case of Costa Rica some forest services have already been transformed into commodities. Other countries are trying to implement projects dealing with the possibility to sell such services. However, as mentioned above, the legal and institutional framework is not yet adapted to these changes; property rights, for example, are not well defined. This change from an "old" (or "traditional") forest sector towards a "new" (or "non-traditional") forest sector leads to a need to discuss and construct new social arrangements and institutional set ups. In this sense, we should be very open to also bring "new" property right regimes in case they are needed, to try to couple with conservation, ethic and distributional issues related to these kind of services.

Table 1.1.
Potential Markets for Goods and Services from Forest.

Forest Goods and Services	Currently in the market	Presently not in the market.
1. Timber	X	
2. Non-timber	X	X
3. Maintenance of the water cycle		X
4. Regulation of the micro-climate		X
5. Flood control		X
6. Control of erosion		X
7. Control of sediments		X
8. Water transportation		X
9. Wind and noise control		X
10. Scenery		X
11.Recreation and ecotourism	X	X
12.Maintenance of resilience		X
13.Cultural and religious services		X
14.Preservation of the ecosystem and biodiversity	X	X
15.Climate change	X	X

Source: Segura, O., 1998

Then, the objective of this paper are, first, to clarify why economic utilization of forest services may require changes of the property rights regime into something which is much more complex than any of the traditional pure property regimes; and second, to give a background for the policy conclusions concerning institutional change within the framework of improving sustainable innovation systems

The first section clarify what we understand by "new" forest services and why it is important to discuss property rights of such services; in the second section a theoretical explanation of the different types of property rights and the logic for the need for mixed system of property rights regimes are presented. In chapter three, a summary of the Costa Rican institutional evolution is presented and in section fourth the importance of institutions for innovation and the institutional innovations. Chapter five presents a example of cooperative research and property rights agreement (Chagaspace) is described. Finally in the last section lessons learned from this research are presented hoping to contribute not only to keep institutional options open, but also to encourage institutional innovations for forest services conservation and potential use.

2. The need for mixed system of PR regimes

The existence, valuation and entrance of forest services to the markets brings again the issue of property rights regimes into discussion. In spite that forest services, such carbon sequestration in trees, water maintenance, biodiversity conservation and others, have been always existing, there was not discussion

about the property of such services. It seems that an easy task would be to define the so called "clear" property for them; however, as we will show here it is more important to create and accept mixed systems of property right regimes.

Property rights are related to flows of benefits coming from a particular resource; therefore, new resources coming into scene in the economic sphere bring new discussions about them. It is uncertain when people started to think in terms of property rights, but this history certainly developed when natural resources were still far more abundant than nowadays and also, when it was shared by far less people. Property rights exist over most things that are valued by humans; in the case a thing is perceived to have no value, there is no reason to establish a property right.

However, all kind of property right regimes have exemptions and mixtures concerning the rights of other individuals and the need to share values or services coming from the property in question. For instance, to own a land property in a city, a town or a village does not give the owner the right to build whatever kind of industrial construction neither any type of house. To own a land with a forest does not allow the owner to cut the trees, to exploit the wild-life, or to use the biodiversity, without permission or without a management plan. Actually, depending of the context and the kind of institutional arrangements already in place in a country, to own a forest does not even allow the owner to expel others from visiting, enjoying and spending the day or even camping over night in it. The case of Sweden forest ownership shows a high contrasts with the more limited access that non-owners have to forest in Costa Rica, for instance. In short, different property regimes do not necessarily fit with the clear-cut definitions from the literature, and in spite of difficulties, it seems necessary to allow and encourage new arrangements for property regimes for forest services which are entering the market.

Bromley defines property as "a right to have control over a benefit stream". When someone purchases a piece of land or any other asset, its price is a reflection of the discounted value of all of its future benefit streams – that is the property, the thing the person actually owns[3]. In this sense also scarcity can be placed. With increasing scarcity of a certain resource, the significance of establishing property rights rises. This is the reason that during history, with increasing population, urbanisation, and increasing scarcity of resources, property rights have become more important. The same applies to forest services, since forest is more scarce all around the world, the services it provides are becoming much more scarce also; therefore the valuation and the definition of the property of such services emerge as important feature. In order to define who will receive the payment or the benefits stream from providing forest services, we must define some kind of property. In the following section we will review the existing different taxonomies for property rights.

[3] Bromley, 1991. In every day usage land its often called 'property', but the real property is the benefit stream.

2.1. Taxonomies of property rights

Property rights regimes have two components: property rights, which are bundles of entitlements defining owners' rights and duties in the use of a particular resource, and property rules, which are the rules under which these rights and duties are exercised[4]. Property rights - rules including both permissions and responsibilities – determine how decisions are made, how wealth is secured, and how income is distributed. Property rights govern who has the right to use a resource in which ways, and who has the duty to respect others' rights. They establish who must pay whom in order to exploit or protect resources[5].

Four basic forms of property right regimes can be distinguished:

- Private property
- Common property
- State property
- Open access or non-property

The regimes differ by the nature of ownership, the rights and duties of owners, the rules of use, and the locus of control. Table 2.1 shows the characteristics of different regimes of property rights. Property rights will only be effective, when there is a force that protects the rights. If you owns an asset, it is yours and nobody have the right to take it away, and if somebody does, this person should be punished by a third party (government).

Table 2.1
Types of property rights regimes with owners, rights and duties

Regime type	Owner	Owner rights	Owner duties
Private property	Individual	socially acceptable uses; control of access	avoidance of socially unacceptable uses
Common property	Collective	exclusion of nonowners	maintenance; constrain rates of use
State property	Citizens	determine rules	maintain social objectives
Open access (nonproperty)	None	capture	None
Source: Hanna et al., 1995			

2.1.1. Private property

In the case of private property an individual economic agent (this can be a person as well as an entity like a firm) owns the property. In a capitalist society the focus is on private property. Neo-classical economics has always hammered on the power of individuals. According to her theory individuals are rational,

[4] Hanna et al., 1995.
[5] Brubaker, 1995.

well informed and seek for economically efficient options. Neo-classical economists share the view that a private property regime is the only way to establish economic efficiency. The call of neo-classical economics, whereupon capitalist society is based, is strong and shared by many people. Civil society of today is based on private property rights, everything has to be owned by someone, otherwise it cannot be allocated efficiently.

Probably it is true that private property gives the strongest incentive for economic efficiency and provides the best way to induce economic growth, progress and innovation. But economic growth and efficiency should not be the ends, they should be the means to create a better society. Capitalism has created wealth for a part of the world, but many problems are associated with the system and the underlying principle of private property rights.

2.1.2. Common property

In essence common property is like 'private' property for a group of people. The title 'common property' is used whenever there exist some customary procedures or conventions governing use of the resource in question.

In common property regimes two problems may arise:
A breakdown in compliance by co-owners may be difficult to prevent because this will entail loss of opportunity arising from changes elsewhere in the economy; and
If the modern state holds common property in low esteem – that is, if the state disregards the interests of those segments of the population largely dependent upon common property– then external threats to common property will not receive the same governmental response as would a threat to private property.[6]

In most settings the best land has been privatised already, while worse land has been left in the public domain - as state property, as common property or as open access.

2.1.3. State property

In a state property regime, ownership and control over use rest in the hands of the state. Individuals and groups may be able to make use of the resources, but only at the forbearance of the state. The state may either directly manage and control the use of state-owned resources through government agencies, or lease the resource to groups or individuals who are thus given the rights to use for a specified period of time.

State property regimes remove most managerial discretion from the user, and generally convey no long-term expectations in terms of tenure security. State property can be found at the opposite 'pole' of private property.

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[6] Bromley, 1991.

2.1.4. Open access or non-property

'Picture a pasture open to all…the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to this herd…the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom of the commons brings ruin to all'.[7]

This famous quote represents the 'tragedy of the commons'. This work of Hardin has provoked a stream of publications about the 'tragedy' and together with this a lot of confusion about the concept. In economic literature is often referred to common property resources[8] as if the prevailing institutional form were somehow inherent in a natural resource. But there is no such thing as a common property resource – there are only natural resources controlled and managed as common property. We have to keep in mind that in one place trees and fish and range forage are controlled and managed as private property, in another setting as common property, in another as state property and in another they are not controlled or managed at all.[9]

In Hardin's example, no one owns the grazing land. It is an open access resource to which herdsmen can bring any number of cattle to graze. At some point the addition of more cattle to the pasture will reduce the amount of food available for other animals and reduce the benefits herdsmen receive. Since there are no limits placed on the right to graze, each herdsman takes only his own benefits and costs into account and ignores the effect his actions have on others, creating the tragedy. He brings more cattle to graze than is socially optimal, and the pasture becomes overgrazed.

In the case of open access no property rights are defined. Everybody can enter the resource. With the interest of more and more people in the resource, the pressure increases. Every person uses the resource to achieve his own optimal situation, without considering the impact on others. A resource that is owned by no one (no property rights are defined) will not be protected. The people that make use of the resource are not going to invest money in the resource for future benefits, since everybody can enter, make use of it or even destroy it.

Existence of open access regimes occurs with the absence or the breakdown of a management and authority system. There are two possibilities: 1) the resource has never before been incorporated in the social system or 2) institutional failure occurred which has undermined former management regimes.

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[7] Hardin, 1961.

[8] Notice that the phrase 'common property' is used here to indicate open-access, while above it indicates 'private' property for a group of people. This easily produces confusion about the subject that is discussed.

[9] Bromley, 1991.

The early and widespread response to the 'tragedy of the commons' was to propose that natural resources and their ecosystems be privatised, the argument being that only under private ownership people would have incentives to protect the flow of services from resources into the future. But this is not the only solution. To eliminate open-access, property rights need to be defined; these can be private property or communal property rights. In areas with traditional people, private property is often not feasible as these peoples have social traditions of joint ownership. Controlling the access of others makes it possible for the local group to appropriate any benefits of the conservation effort. This establishes economic incentives to conserve.[10]

For an open access resource there is no method of excluding newcomers into the industry, nor is there any way in which existing firms can be prevented from changing their level of harvesting effort.

2.2 Property rights and environmental resources

In the past when there were natural resources in abundance, people did not see the necessity of establishing property rights over these resources. The environmental resources were for free. The deterioration of environmental resources (both in quality and quantity) caused by heavily risen population and bad management of the resources, provoked increased scarcity of these resources. With increasing scarcity, the price of a good or service rises. However, often property rights for environmental resources are not established and no market exists for these goods and services. A mechanism to reflect the induced scarcity is absent. The price does not change, and the deterioration continues.

Property rights are (within our economic system) fundamental to the use of environmental resources. Most environmental problems can be seen as problems of incomplete, inconsistent, or unenforced property rights regimes. A property right regime includes property rights, the bundles of entitlements regarding resource use, as well as property rules, the rules under which those entitlements are exercised. In order to facilitate sustainable use of environmental resources, it will be necessary to develop a property rights regime, but not sufficient. Sometimes, even with well-specified property rights, environmental resource use is inconsistent with social goals. Environmental resources have stock and flow benefits, which extend indefinitely over time. The time behaviour over which humans make decisions about resources can be collapsed from the future to the present for a number of reasons. Uncertainties caused by political upheaval, health risks, or financial variability can create incentives to focus on present consumption.[11]

[10] Gadgil et al., 1993.
[11] Hanna et al., 1995.

In the search for an ideal property rights regime, there should be taken care of three issues. The property regime has to be economically (efficiency), socially (equity issues) and ecologically (maintenance of stocks) sound. These three factors interact with each other and the design of a regime will be ultimately a combination, a sort of consensus, depending on which goal is given priority. If natural stocks are to be maintained, the economy faces a restriction that has to be dealt with. The social issue comprises several things. It can be a restriction to the economy, for example the building of a road right through a village as favourite economic option; economically efficient, but socially unacceptable. However, social issues are often associated with distribution effects rather than restrictions. Once it is clear what the ecological and economical efficient use of a resource is, the question arises how the use should be divided among the people; who are going to benefit from the use. Perhaps this is the toughest decision, since views and perceptions about equity are very divergent.

In the case of private ownership over an environmental resource, the resource can be seen as a capital asset. The owner has the ability to manage the resource and the right to enforce exclusion. He can made investment by deciding not to harvest today, allowing the stock to grow. Economic theory assumes that the owner takes decisions in any period so as to maximise the present value of his profits over some long period of time.

Often it is reasoned that if only private property rights could be established the problem would be solved. Yet when resource degradation is observed on private lands – soil erosion, water pollution – the cause is assumed not to lie with the property structure at all, but is attributed, instead, to unduly high rates of time preference on the part of the owner, or some incentive problem that can be rectified with taxes. This asymmetry of logic – blaming the absence of private property in one instance, and slipping to alternative causal explanations when private property is present – obscures rather than clarifies the real issues involved.

The creation of private property rights in the tropics has had some very positive effects on economic productivity of certain lands. However, it seems fair to note that the process of privatisation has had some rather sweeping negative effects on natural resource management. That is, the spread of private land – and the attendant individualisation of village life – has undermined traditional collective management regimes over natural resources.

When governments suddenly change the traditional forms of management to a private property regime without managing the institutional change, the new system will almost sure end up into a failure.

Common property regimes may offer some promise for forest management. Such common property regimes would stimulate local groups (villages perhaps) to undertake forest management. According to sceptics of this approach it are often the local people that engage in practices that result in overgrazing and over excessive use. Unfortunately, people often are victims of policies and

forces beyond their control. It is true that these people are the direct cause of over excessive use, but the truth cause has to be searched deeper.

The economic system itself failed by not taking care of the social costs in the first place. The slowness of reacting to this discovery has caused the major deterioration of the environment that is faced today. The status quo has been, and still is, difficult to alter. This is true for firms as well as individuals. Imagine a firm that uses a production process whereby it pollutes the near river, the ground and the ambient air. In this case different kinds of social costs occur, which in the past the firm was able to produce without accounting for. Altering this situation, internalising the social costs into the economic system, is not received with gladness of the firms.

2.3. Market imperfections and environmental resources

In table 2.2 the seven necessary arrangements for economic efficiency as presented in section 2.1 are listed once again to discuss their relationship with the common features of environmental resources. It was already stated that it is very unlikely that any economy exits wherein all these conditions are met. In the case of environmental resources their special characteristics play an important role in preventing the necessary arrangements from existing or being likely to exist. Either many environmental resources are not transacted at all through market processes, or the market processes in which they are exchanged are incomplete in some way or another. Examples of environmental resources that are not in general traded at all through markets (although efforts are made to change this) include the Earth's atmosphere, a large proportion of its water resources and many wilderness areas. Many environmental resources are traded through markets, of course. Most mineral deposits are privately owned and are marketed commodities. However, whereas current markets do exist and are highly developed for such resources, it is unusual for futures markets to exist for most commodities. Where they do exist, future markets are at best incomplete.

Table 2.2
Arrangements for an economic efficient 'allocation of resources'

1. Markets exist for all goods and services exchanged
2. All markets are perfectly competitive
3. All transactors have perfectly information
4. Property rights are fully assigned
5. No externalities exist
6. All goods and services are private goods
7. Long-run average costs are non-decreasing

The presence of market failures in dealing with environmental resources implies failure of the efficiency conditions and suggests that it is very unlikely that

resource allocation will be efficient. Market failures can be distinguished in the following types:

- externalities,
- public goods,
- imperfect competition and,
- imperfect information.

2.3.1. Externalities

An externality occurs when the production or consumption of one person influences the well being (or benefits) of another person in an unintended way, and when no compensation is made by the producer of the external effect. Externalities can as well be positive as negative; however, the vast majority of the cases show negative externalities. The reason the effects are called externalities is because they are working extern of the market. When a firm pollutes a river that serves as a drinking water resource, negative effects (physical or financial) occur to the people that receive this water. The firm seeks for profit maximisation and will only take into account private costs. The social costs are not accounted for. The difference between private costs and social costs is the externality.

On the other hand, externalities can be positive. When someone creates a beautiful garden with the loveliest flowers, this is likely to be of benefit to other people too. They don't have to pay for this service, they just walk by and enjoy.

2.3.2. Public goods

A second market imperfection is the existence of public goods. In a classification of goods, public goods are described as non-rival and non-excludable. Non-rival means that the use of one person of the good is not conflicting with another person's use, while non-excludability indicates that no person is being excluded from the good, everybody is free to use the public good. For example a park in the centre of a city is a public good. I can walk in the park and my neighbour can walk in the park too, both enjoying and receiving benefits (non-rival). Furthermore, everybody can enter the park (non-excludable). The cost of creation and maintenance of a public good are fixed; the number of visitors or users are not of influence.

Many environmental resources have the characteristics of public goods. The probability of markets existing to provide or conserve public goods is extremely low, even where their existence would yield positive net benefits. As a result, public goods will tend, in a pure market economy, to be provided in quantities that are too low from the point of view of social efficiency.

Wilderness areas have the property that, as long as use rates are not excessive, they are not divisible. If one person consumes the services provided by a visit to a wilderness area – yielding recreation, wildlife experiences and solitude, for example – that does not prevent others consuming those services as well. There is no rivalry between the consumption of different individuals, provided

that the overall rate of usage is not close to some threshold at which congestion occurs and one person's visit does not detract from other's enjoyment. In this sense, the services provided by a wilderness area could be described as indivisible. The implication for the marginal cost of provision of such a resource service is that this cost is zero, because an additional user's consumption of the resource does not require that the resource stock be increased.

2.3.3. Imperfect competition

Imperfect competition is associated with the market forms of monopoly and oligopoly. Prices are fixed at a higher level and efficiency and innovation are lower than in a perfect competing market. Firms that operate in a monopolistic or oligopolistic market can ask a higher price for their products, because access to use a certain resource is restricted. The resource can be divergent, arranging from knowledge of a specific production technique to a right of exploiting a natural resource.

2.3.4. Imperfect information

Neo-classical economics presupposes perfect information on the part of all transactors of goods and services, of both direct and external effects. En reality perfect information is seldom the case. Poor information can be a reflection of fundamental scientific uncertainty. In other cases, poor information simply reflects the fact that most people are poorly informed about many things in a complex world. Imperfect information and uncertainty become particularly important in circumstances where actions have irreversible consequences. It does appear to be the case that many of the consequences of decisions about environmental resource use are irreversible. For example, it is arguable that once developed, a natural wilderness area cannot be returned to its original state, at least not within time scales that are relevant to human behaviour.

In developing a property rights that does take care of both economically, socially and environmental consequences, market imperfections should be considered and provisions should be made to deal with these imperfections. In this thesis the market imperfection that is of particular importance is the existence of externalities. Conventional markets focus on the timber benefits of the tropical forests or the benefits of other land uses. Other services of the forest, like carbon sequestration, scenic beauty, water management, biodiversity benefits, etc. should be included in the market. With deforestation not only forest disappears, but also these other services. Costa Rica has developed and applied systems to include some of the 'unconventional' services of the forest into her economy. This must not be seen as the end, but rather as the beginning of a new form of economy, a new paradigm that hopefully can facilitate 'sustainable development'.

Government intervention in the operation of market economies offers the possibility of realising substantial efficiency gains, by eliminating or mitigating situations of market failure, though there are limitations on the ability of

government to rectify inefficiencies in the allocation of resources. Here some of the opportunities for the government are given.

Firstly, many resources are not traded through competitive market structures in which property rights are clearly established. Efficiency gains may be obtained if government can create and maintain appropriate institutional arrangements for market and property rights. This may well require that the legal and judicial structures of the country in question be developed in such a way that redress for damages arising from external effects can be quickly and cheaply obtained. Similarly, the public system should ideally allow generators of beneficial public goods and externalities to receive appropriate compensation for the benefits their activities generate but which are not reflected in market transactions.

An alternative direction that government policy might take is to use fiscal instruments (tax and subsidy systems, marketable permits) to create economically efficient patterns of incentives on private behaviour. The use of fiscal incentive schemes is likely to be particularly appropriate where markets do already exist, but fail, for one reason or another, to achieve efficient outcomes. However, for some goods – public goods – market economies may simply fail to provide them, even though supply at some positive level would be socially desirable.

Furthermore, governmental intervention may take the form of providing information, or funding research activity that can reduce uncertainty and increase the stock of knowledge. Given that much knowledge and research has the characteristics of a public good (as we will see in section 2.4), there is a strong case for its provision or financing by the public sector.

2.4 Creation of knowledge and property rights

The development, ownership and access of knowledge plays an important role in the model of economic development. Market failures related to knowledge are of importance and should be considered when discussing knowledge and a system of intellectual property rights (IPRs).

Knowledge is often described as a non-rival good, that is, a good that is infinitely expansible without being diminished in quality, so that it can be possessed and used jointly by as many as want to do so. Secondly, the process of knowledge generation is cumulative and interactive. Due to these properties, the process of knowledge generation produces "positive externalities".[12] The more that is invented the easier it becomes to invent still more, provided that the conditions of wider distribution, and timely, inexpensive access to new finding are fulfilled.

Openness is vital for the efficient use of costly research resources creating reliable knowledge. However, the conditions for the efficient distribution and

[12] Edquist, 1997

utilisation of knowledge cannot be expected to arise automatically from the interplay of market forces. Various obstacles impede knowledge distribution. The growing awareness that knowledge is a cumulative store of individual effort and that scientific knowledge could be put to practical commercial use led to the creation of intellectual property rights.

IPRs, as the term suggests, are meant to be rights to ideas and information, which are used in new inventions or processes. These rights enable the holder to exclude imitators from marketing such inventions or processes for a specified time; in exchange, the holder is required to disclose the formula or idea behind the product / process. The effect of IPRs is therefore monopoly over commercial exploitation of the idea / information, for a limited period. The stated purpose of IPRs is to stimulate innovation, by offering higher monetary returns than the market otherwise might provide. Exclusion can occur through the creation of intellectual property rights (a patent system or trade secrets). Yet, even patents require the inventors to disclose a great deal of information to the public that may be applied by others.

The patent systems of Western economies provide strong protection for innovators but impede the rapid disclosure of information. They place greater emphasis on novelty and on the monopoly rights that accompany the award of a patent, while reducing disclosure requirements.

In economic terms, patents create profits and they also create a form of market inefficiency. Because research (knowledge) is one of the most important inputs into the production of further knowledge, raising the price of knowledge may actually reduce follow-on research and slow the pace of innovation. Thus, it is essential to reward research and innovation while ensuring the widespread access to knowledge and protection against monopoly rents.

Indigenous knowledge

In the context of knowledge over natural resources indigenous knowledge is of importance. Knowledge can be seen as an outcome of model making about the functioning of the natural world. All societies, pre-scientific and scientific strive to make sense of how the natural world behaves and to apply this knowledge to guide practices of manipulating the environment.

Modern scientific knowledge, with its accompanying worldview of humans as being apart from and above the natural world has been extraordinarily successful in furthering human understanding and manipulation of simpler systems. However, neither this worldview nor scientific knowledge have been particular successful when confronted with complex ecological systems. These complex systems vary greatly on spatial and temporal scales rendering the generalisations that positivistic science has come up with of little value in furnishing practical prescriptions for sustainable resource use.[13]

[13] Gadgil et al., 1993

It is in this context that the knowledge of indigenous societies accumulated over historical time, is of significance. The view of humans as a part of the natural world and a belief system stressing respect for the rest of the natural world is of value for evolving sustainable relations with the natural-resource base.

That indigenous people are aware of a large variety of uses of local biodiversity including medicinal uses that have been incorporated in the modern pharmacopoeia is well known, as is their knowledge of habitat preference, life history, and behaviour relevant to efficient foraging for such resources.[14]

As seen above the knowledge of indigenous people is not estimated on its real value. One of the reasons is that it is a different kind of knowledge as western knowledge and that only private created knowledge can fall under some form of intellectual property right. For example although it is known that firms use indigenous knowledge, in reality, it will be difficult to prove how often scientists working for firms use guides or plant keys developed through ethnobotanical investigation. Indeed, firms may not be directly talking with local and indigenous peoples, but they might be using previously published ethnobotanical information to locate samples. Thus, we cannot say when local knowledge is employed and when it is not.

To use indigenous knowledge is not good or bad in itself, but to use it without recognition and compensation when the users are profiting from it is clearly not ethic. However, it is realistic to assume that information collected by an ethnobotanist fifty years ago may be used by modern day corporate bioprospectors without them knowing about it. Furthermore, in one way it is often difficult to trace the information back to its source community in order to create benefits, and in other way it is somehow easy to argue this difficulty in order to avoid the responsibility and the profit sharing of benefits and recognition. Thus, biopiracy can occur in today's information age in which it becomes increasing difficult to determine the source of local knowledge. As a result, local knowledge is potentially employed without any direct contact or compensation agreements with indigenous groups.

2.5 Other relevant institutions

As we have seen, different kinds of institutions ('rules of the game') are being distinguished, which are formal (international agreements, laws) and informal 'rules' like norms, culture, etc. We have seen the impact of different property right regimes; this section deals with the other institutions relevant to the forest sector. This will help to understand the working of this sector and the changes that occur (innovations) in the behaviour of the people regarding the forests and its services.

[14] Gadgil et al., 1993

2.5.1. International agreements

The developments in the international community that are relevant to the forest sector are issues related to biodiversity and intellectual property rights (IPRs). In the international community over the past decade an increasing amount of attention has been paid to the alarming rate of loss in global biodiversity. Conservation of biological diversity and the sustainable use of plant and animal species were highlighted in the first global, comprehensive agreement; the Convention on Biological Diversity (CBD) signed in 1992 in Rio de Janeiro. The other major international agreement that deals with the issue is the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) of the World Trade Organisation (WTO). Both will be discussed here as well as the linkages and frictions between the two agreements.

In the preamble the CBD states that the contracting Parties should:

"Reaffirm that States have sovereign rights over their own biological resources,

Reaffirm also that States are responsible for conserving their biological diversity and for using their biological resources in a sustainable matter".[15]

Which means that the CBD provides the answer to the long unanswered question 'who owns biodiversity?' And at the same moment it states that ownership means also a duty - the sustainable management of this biodiversity. Under the Convention, biodiversity and its economic benefits were re-defined from the 'common heritage of mankind' to 'national goods' that nations could protect and trade as commodities. Even though it stated that conservation was the 'common concern' of all humanity, the Convention thus gave a great deal of emphasis to the rights of developing countries to exploit, and reap benefits from, discoveries made in their own territory.

The objectives of the CBD were stated as "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources."[16]

The CBD leaves a great deal to the signing Parties. In Article 6 is stated that each contracting Party shall, in accordance with its particular conditions and capabilities:

"a) *Develop national strategies, plans or programmes for the conservation and sustainable us of biological diversity or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned; and*

[15] CBD, 1992.

[16] www.american.edu.

b) *Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies".*[17]

The Uruguay Round of Multilateral Trade Negotiations under the General Agreement on Tariffs and Trade (GATT) has substantially expanded the normal purview of trade agreements to include trade in investment, services and intellectual property. As a result, an Agreement on Trade-Related aspects of Intellectual Property Rights (TRIPS) has been in effect by the majority of the developing and developed nations alike under the World Trade Organisation (WTO).

The agreement recognises that widely varying standards in the protection and enforcement of intellectual property rights and the lack of a multilateral framework of principles, rules and disciplines dealing with international trade in counterfeit goods have been a growing source of tension in international economic relations. Rules and disciplines were needed to cope with these tensions. To that end, the agreement addresses the applicability of basic GATT principles and those of relevant international intellectual property agreements.

In Article 7 the objectives of the agreement are stated as follows:
The protection and enforcement of intellectual property rights should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations.[18]

Part I of the agreement sets out general provisions and basic principles, notably a national-treatment commitment under which the nationals of other parties must be given treatment no less favourable than that accorded to a party's own nationals with regard to the protection of intellectual property. It also contains a most-favoured-nation clause: with regard to the protection of intellectual property, any advantage, favour, privilege or immunity granted by a Member to the nationals of any other country shall be accorded immediately and unconditionally to the nationals of all other Members.[19]

Part II addresses each intellectual property right in succession.

Part III of the agreement sets out the obligations of member governments to provide procedures and remedies under their domestic law to ensure that intellectual property rights can be effectively enforced, by foreign right holders as well as by their own nationals.[20]

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[17] CBD, 1992
[18] TRIPS agreement, Article 7. Downloadable from WTO site
[19] TRIPS agreement, Article 4. Downloadable from WTO site
[20] www.wto.org. Legal texts: the WTO agreements, A Summary of the Final Act of the Uruguay Round.

The TRIPS Agreement recognises intellectual property rights (IPRs) to be private rights and incorporates specific obligations on the issue of patenting life forms to the extent that it obliges members to provide product patents for micro-organisms and for non-biological and microbiological processes. In addition, it stipulates that all members must accept the protection of plant varieties, either by patents or by an effective *sui generis* system or by any combination thereof.

CBD on the other hand, in its Preamble categorically reaffirms that nation-states have sovereign rights over their own biological resources, recognises the desirability of sharing equitably the benefits arising from the use of these resources as well as traditional knowledge, innovations and practices relevant to the conservation of biological diversity and its sustainable use, and acknowledges that special provisions are required to meet the needs of developing countries.

The CBD upholds the role of indigenous communities in conservation and protection of genetic resources and states that there should be a fair and equitable sharing of benefits arising out of the utilisation of the knowledge systems of such communities.

More specifically, the objectives of the CBD as stated in Article 1 are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. Genetic resources are defined in the CBD as any material of plant, animal, microbial or other origin containing functional units of heredity, which has actual or potential value. In addition, Article 15 specifically obliges Parties to take necessary measures to share in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilisation of genetic resources with the Party providing such resources, on mutually agreed terms. The fair and equitable sharing of benefits arising out of the patenting and commercial exploitation of genetic resources is not dealt with at all in the TRIPS Agreement.

Therefore, TRIPS and CBD represent two significantly separate approaches to the utilisation of living resources. While TRIPS seeks to promote and foster technological innovation by ensuring the certainty of IP protection and of world markets for at least some biotechnological inventions, the CBD seeks to facilitate access to living resources, while focusing on conservation and sustainable use, as well as the equitable sharing of benefits of such use. In its attempts to create a stake for developing countries in conservation, the CBD emphasises the need to share with them benefits, which include the need to share in the development and transfer of technology.

2.5.2. National legislation

At national level there is considerable activity. Several countries (Costa Rica, Eritrea, India, Mexico, Peru among others) are coming up with legislation, or

other measures, which respond to the discussed treaties. The Biodiversity Law in Costa Rica, of 1996[21], established the legality of some of the points agreed in the international agreements. In Article 6 of this Law is stated that biodiversity is owned by the general public, following the CBD. The State will authorise the exploration, investigation, bioprospecting and the use of the elements of biodiversity.

2.5.3. Culture, public opinion, norms

The difference of the role of the environment in societies depends on the attitude towards this environment in people's minds. During history this attitude has changed. In the early days people were more dependent on environmental resources, they were living closer to nature. With the increasing urbanisation and industrialisation people sort of forgot their dependence on nature.

3. The Costa Rican forestry sector

3.1 Evolution of the forest sector services en Costa Rica.

From the 1950s up to 1979 the transformation of the forest cover in Costa Rica was mainly supported by development policies which encourage production of traditional products. According to Segura (2000) in 1950 Costa Rica had 72% of its land in natural forests, to only 49% in 1983, and 35% in 1994. In project PRISMA-FORD[22] is stated that 30,7% of Costa Rica is covered with forests, while a TSC / CIEDES study concluded that in 1996/1997 about 40.5 per cent of the land was covered with forests representing 2,063,487 ha.

The first direct legal provisions on forests appeared in 1969, with the enactment of the Forestry Law, No. 4465. However, during the 1960s and 1970s, government policies and economic interactions supported linking development to agriculture, cattle ranching, and other 'basic' activities, which contributed to deforestation. In the 1970s cattle ranchers and crop farmers who expanded their lands were the principal cause of deforestation.[23] It is estimated that during the 70s the average rate of deforestation was 50,000 ha per year. It was not until 1979 that were created the rules *(reglamento)* for the law and more enforcement was developed.

In the period 1975-1984 the average legal exploitation of forest was 24,000 hectares per year. Although the Law established limits on deforestation, results of different studies show that the rate of deforestation for the 70s was approximately 50,000 hectares per year.[24] This means that 26,000 hectares (52% of the total number) were cleared on a yearly basis without the authorisation of the General Forestry Directorate and therefore, in violation with the Law.

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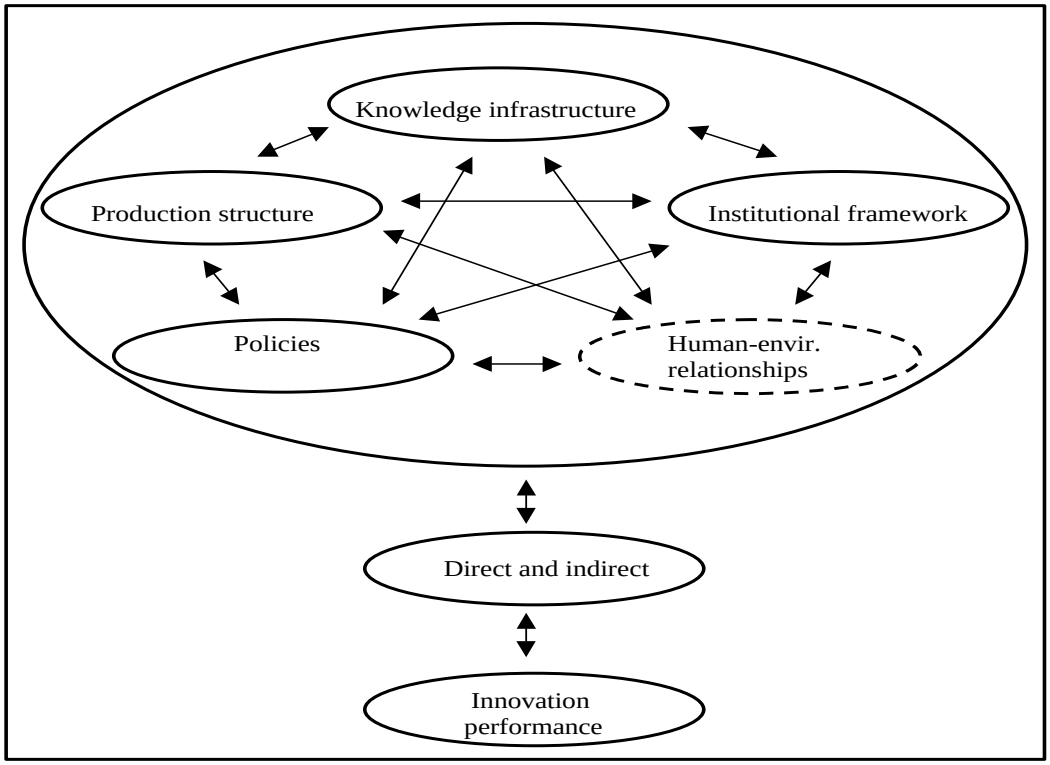
[21] Ley de biodiversidad, No.7788
[22] Soto et al., 2000.
[23] Camino, de et al. (2000).
[24] FONAFIFO, 2000

Lately during the 1990s, reform has progressed more quickly in the forest and natural resources sector than in any other area of Costa Rica government. A National System of Conservation Areas (SINAC) has been created, which is legally defined as a 'system of management and institutional co-ordination that is decentralised and participatory.' The creation of SINAC has provoked major changes in the organisational structure and culture of the forestry administration in Costa Rica.

New laws and new incentives for reforestation, forest conservation and forest management were developed along this time. These economic instruments evolved and influenced private property owners to protect or manage their forests rather than eliminating it, and also to reforest hundreds of thousands of hectares all around in the country.

The change or evolution of the forest valuation and forest services is not a matter of only one policy, one law or more education. The change correspond to an evolution were several factors are present. The forest sector as a system of innovation is influenced by the institutional framework, the production structure, policies, the knowledge infrastructure, and human-environmental relationships. As it is represented in figure 3.1 there are at least five factors affecting learning and innovation in the forest sector, as well as their relationships, are represented. The 'human-environment relationships' is differentiated since it is not at the same level as the others. Ecosystem services are more like a base supporting the whole set of interactions; it is presented in every interaction.

Figure 3.1 The main factors affecting learning and innovation in a sustainable system of innovation



Source: Segura, 2000

3.2 'New' forest services

Forests have always produced a package of many products and services; forests have always 'breath' carbon dioxide, they have always provided a home to an infinite number of different species. However, only a small part of the package has been marketed in the past. In conventional markets only timber is being traded. Costa Rica is trying to incorporate other goods and services in the market. In table 3.1 forest goods and services are shown together with the values they provide to humans.

Only timber is fully represented in the market. Several Non-timber forest products (NTFPs) are being commercialised in Costa Rica. Indigenous people and the peasants living in the forests have been extracting these NTFPs for many years. Some of the species used by Costa Ricans are medicinal products such as wild coffee, Chinese root or sarsaparilla and trees of Quassia Amara, for soft drinks. Furthermore, materials such as vines, palms and lianas, which have been traditionally been used by indigenous and rural communities, are now demanded in large quantities by the tourism industry for the construction of huts, bungalows and other purposes.[25]

Recreation and (eco) tourism as a service provided by the forest is partially integrated in the market. Visitors to national parks pay an entrance fee and tourists coming to Costa Rica pay taxes; part of money flows back to the protection of forested areas. According to the Costa Rican Institute for Tourism, the country received 435,000 international visitors in 1990 and earned US$275.2 million in tourist income. In 1997, the country had 787,000 visitors, who generated US$714.1 million in income. Between 1990 and 1997, 38 per cent of tourists visited the country's national parks, indicating the importance of forests for tourism. In 1994, the entrance fee for the national parks was raised from approximately US$1-15 per foreign visitor. As a result, the number of visitors declined significantly in 1994 and again in 1995. Despite the reduction in visits from 1993 to 1995, the income of national parks has increased. In 1990, there were 453,033 national and international visitors to the parks, while in 1997, there were 715,104.[26] At this time the entrance fee is US$6 per foreign visitor.

[25] Segura, 2000
[26] Camino de et al. (2000)

Table 3.1 Values and market potential for forest goods and services

Forest goods and Services	Direct use Value	Indirect use value	Option value	Existence Value	Bequest Value	In the Market	Partly included in the market or efforts to include	Not in the market
Timber	X					X		
Non-timber forest products	X	X					X	
Recreation and (eco) tourism	X		X				X	
Biodiversity	X	X	X	X	X		X	
Economic security	X							X
Community integrity		X	X					X
Landscape / scenic beauty	X		X	X			X	
Maintenance of the water cycle		X	X				X	
Climate change		X					X	
Water pollution		X						X
Air pollution		X						X
Control of erosion		X						X
Regulation of the microclimate		X						X
Flood control		X						X
Control of sediments		X						X
Water transportation		X						X
Wind and noise control		X						X
Maintenance of resilience		X	X					X
Preservation of the ecosystem and biodiversity		X	X		X		X	
Source: Modified from Perman et al. (1996) and Segura (2000).								

All the presented goods and services have the potential to be taken up in the market one day, but this will depend on future events. For this moment, in Costa Rica the eyes are on Payment for Environmental Services.

3.2.1. Payment for environmental services (PSA)

PSA can be seen as a social innovation that has not emerged spontaneously. Innovations, 'new things', are constructed upon former developments and are part of the dynamics of interaction and activities within a particular society. The emergence of PSA is a reaction on the overexploitation of natural resources, disappearance of biodiversity and high rates of deforestation in the past.

The Forestry law No.7575 introduced the concept of PSA. In general, it is based on the principle that the owners of forests and forest plantations will receive payments to compensate them for the benefits that these forests and plantations provide to the Costa Rican society in particular and mankind in general.

From the point of view of the legislation, subsection k of Article 3 of the Law clearly defines environmental services, as follows: "those provided by forests and forest plantations in the protection and improvements of the environment". They are:

- Mitigation of emissions of greenhouse gases (reduction, absorption, fixation and storage of carbon).
- Protection of water for urban, rural or hydroelectric purposes.
- Protection of biodiversity to preserve it: sustainable, scientific and pharmaceutical use; genetic research and improvement and protection of ecosystems and ways of life.
- Natural scenic beauty for tourism and scientific purposes.

With regard to the beneficiaries of said services, they can be grouped into three categories: the owner of the forest, the inhabitants of the country and the world society in general. The system should permit the creation of a financial flow between beneficiaries, whether they are international, national or local, and the owners of the resources, in such a way that the latter be compensated by maintaining and developing them, thus making this system self-sufficient from a financial perspective.

The implementation of the PSA system is in the hands of the National Forestry Financing Fund (FONAFIFO). It was created by the Law No.7575 for the following objective:

To finance, for the benefit of small and medium-sized producers and by means of credit or other mechanisms for promotion of forest management, whether with intervention or not, the processes of forestation, reforestation, forest nurseries, agricultural-forest systems, recovery of cleared areas and technological changes in the exploitation and industrialisation of forest resources. It shall also attract financing for payment of the environmental services that are provided by forests and forest plantations (Article 46, Law No.7575).

Article 69 of the Forestry Law provides that one third of the amounts collected from the excise tax on fuels and hydrocarbons shall be annually allocated to programs directed to compensate owners of forests and forest plantations for the environmental services of mitigation of greenhouse gases and for the protection of and development of biodiversity, generated by the activities of protection, preservation and management of natural forests and forest plantations.

The current PSA system shows that fossil fuel tax revenues go through the Ministry of Finance due to the constitutional principles of "unique accounting" and "centralised tax collection" that require tax revenues to be included in the national budget. The total amount collected through the tax for PSAs has never been fully budgeted for its original purpose. The amount allocated to PSAs can vary greatly depending on the government's budget deficit (Camino de, et al.,

2000). The point is that PSA is paid to forest owners arguing that they are the forest services producers; therefore, somehow they are the benefitiaries of such production. Other countries are in the process of internalising the environmental externalities coming from forest in the national economies; then the discussion about property rights are going to be present in their policy design.

3.2.2. Protection of water for urban, rural or hydroelectric purposes

The private hydroelectric company Energía Global made the first Environmental Payment (PSA). The payment consisted of US$10 per hectare per year for reforestation, forest management, and protection of the Río Vólcan watershed. The second project was negotiated with the Compañía Nacional de Fuerza y Luz for US$ 40 per hectare per year for five years in the Rio Aranjuez watershed.

3.2.3 Protection and use of biodiversity

Protection of biodiversity to preserve it: sustainable, scientific and pharmaceutical use; genetic research and improvement and protection of ecosystems and ways of life.

The National Institute on Biodiversity (Instituto Nacional de Biodiversidad, INBio) was created in 1989 to implement the concept of bioprospecting. The Institute formally exists outside of the government as an autonomous, non-profit, private, public interest institution. The mission of INBio includes promoting a 'new awareness of the value of biodiversity, and thereby achieving its conservation and using to improve the quality of life.'[27] Costa Rica's National Council on Biodiversity estimates that approximately 83 per cent of the country's biodiversity have not yet been identified.[28] INBio is researching these species and chemicals produced by plants, insects, and microorganisms that may be of use to pharmaceutical, medicinal, and agricultural industries. The famous first bioprospecting contract was signed in 1991 with Merck and Co.

The future of the bioprospecting market depends upon industry's interest. The possibility of industries like the pharmaceutical one losing interest in bioprospection is a realistic threat to INBio.

3.2.4. Natural scenic beauty for tourism and scientific purposes

The tourism sector forms the biggest part of the Costa Rican GDP. Tourism is the number one activity in the GNP after microelectronic component (Intel), and most of the visitors are interested and visiting national parks, which denotes the significance of preserving the nature areas.

[27] Bryan, 2001
[28] Camino de et al., 2000

Until this moment no concrete projects exits for this environmental service. There are negotiations going on about an ecotourism project. In this project, the idea is to establish a convention between FONAFIFO and rafting companies, which are operating at the rivers Reventazón and Pacuare.

3.2.5 Mitigation of emissions of greenhouse gases (reduction, absorption, fixation and storage of carbon)

Through the Clean Development Mechanism[29], Costa Rica is trying to negotiate payment for global services by buying Carbon Tradable Offset certificates (CTOs), the only environmental services traded internationally. CTOs are financial instruments that can be used to transfer or sell greenhouse gas offsets in the international market. FONAFIFO, which is responsible for financing forest products at the national level, disburses payments to forest owners, who then relinquish their right to market their forests' carbon sequestration. FONAFIFO is in charge of trying to sell CTOs to countries and firms willing to compensate their emissions through carbon sequestration activities.

The carbon market could yield between US$6.5 and US$13 million annually if the market begins to operate fully.[30] Success depends on progress made in the Climate Change Convention and the implementation of developed countries' commitments.

The first contract of this kind was a bilateral treaty between Costa Rica and Norway signed in 1996. Norway purchased carbon bonds for 200,000 tons of carbon at US$10/ton, yielding US$2 million for reforestation measures. These revenues already have been disbursed to forest owners. Another transaction with the government of the Netherlands reduces the equivalent of 500 tons of methane gas. The Dutch government also financed reforestation of 78 ha, and will receive the corresponding CTOs for both investments. http://unfccc.int/program/aij/aijproj.html. More contracts have been signed between Costa Rica and the USA, the Netherlands and other countries.

[29] Under the Framework Convention on Climate Change developed countries have agreed to decrease their carbon emissions. One of the mechanisms adopted under this convention is the CDM. By means of the CDM developed countries finance carbon reduction measures in developing countries. In change for this effort developed countries receive carbon credits, which allows them to reduce less in their own countries.

[30] Camino de, et al., 2000

Values of the forest; explanation of table 3.1.

As showed before the value of forests was restricted to the conventional benefits associated with timber By bequest value is meant the utility derived from individuals from the knowledge that an environmental asset will be conserved for the benefit of future generations.

As far as the particular types of forest benefit are concerned, most of those listed in the table are self-explanatory. Economic security consists of the advantages an economy may derive through having supplies of a basic raw material readily available and under its own control. This was once regarded as a principal benefit of forests, particularly in times when the probability of war was very high. Its importance is now generally regarded as rather low. Community integrity benefits have their basis in the possibility that woodlands may support the maintenance of communities with cultures that are regarded as being of intrinsic worth, or that contribute to cultural diversity. In extreme cases, such as indigenous cultures in some areas of tropical forest, deforestation can eliminate an entire culture (Perman et al., 1996).

It is common for environmental resources to exist in the form of 'multi-dimensional packages'. For example a wilderness area (a tropical forest) constitutes an interrelated set of resources/services. Some of these will be marketed or be inputs to products which are marketed, and so the resource in question will command a price reflecting this. On the other hand, many of the items of this resource set will not be marketed.

The market price of the resource set will be poorly approximated by the market value of the land area in question. In the main text we see that recently efforts are being made to compensate provision or maintenance of other services (biodiversity, greenhouse impact and watershed maintenance). products. David Pearce has popularised the concept of total economic value. He has explored the valuation of forest benefits. Values are distinguished in different types, which are use value, option value, existence value and bequest value.

Use values denote the values derived from actual or potential future consumption of a good or service. A distinction can be made between direct and indirect use values of forests, presumably the former referring to utility contemporaneously derived from timber products or woodlands in themselves, and the latter referring to benefits that derive from consumption of other goods and services whose provision is supported by the existence of forests and woodlands.

Option value refers to the value that arises from retaining an option to a good or service for which future demand is uncertain. The option value is an additional value to any utility that may arise if and when the good is actually consumed. If we are certain as to our future preferences and the future availability of the resource, option value will be zero. But if we are uncertain about our future preferences or about future availability, we may be willing to pay a premium to keep the option of future use open.

Individual preferences may exist for maintaining resources in their present forms even when actual or future 'use' of the resource is not expected. These preferences are the basis for what could be called existence value. Existence value derives from human preferences for the existence of resources as such, unrelated to any use to which such resources may be put.

4. The importance of institutions for innovation and the importance of institutional innovation.

It is a common characteristic of all systems of innovation approaches that property rights and, more generally, institutions play a crucial role for innovation performance. In fact, there is an increasing focus on the role of different types of institutions in theories of learning and innovation.

On the empirical level it has always been clear to most observers that the institutions of property rights may affect incentives for economic activity and economic change in very different ways. For example, in Latin America concentrated and more or less unrestricted land ownership and the accompanying political power structure have been identified with static societies with small incentives for technical and organizational change. On the other hand, unsecured, badly defined or non-existing property rights to land is widely regarded as hindering its productive utilization including its use as collateral for innovative activity. Also intellectual property rights, as patent rights, have been widely seen both as stimulating invention and innovation and as retarding the diffusion and utilization of new knowledge.

On the theoretical level there are simple and straight-forward arguments for the importance of property institutions for learning and innovation. These activities have strongly interactive characteristics and since property rights regulate relations between people they also deeply affect patterns of economic interaction, competitive as well as co-operative. It follows that there are strong links between property and innovation.

Both the empirical observations and the theoretical arguments can be extended to include other institutions than property rights. A whole lot of both formal and informal institutions are influencing innovation processes. This broader institutional approach can also, increasingly, be found in development thinking. It has for example become a standard argument in the latest World Development Reports that a broad spectrum of institutions are important for development. The world Bank especially stresses the role of institutions for transaction costs and for market building and market support. But also when we shift the focus from market support to learning and innovation, it is quite reasonable to expect close connections to institutions. These are usually regarded as reducing uncertainty, managing conflicts and co-operation, providing incentives and channeling resources - all "functions" which deeply affect communication and interaction and, hence, learning and innovation.[31]

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[31] The institutional framework is here defined as the system of norms, rules, laws, rights, incentives, etc., which shape the regularities of behavior and the patterns of interaction in the economy. Institutions may be both formal and explicit like written laws and informal and implicit like most [social] norms. In the institutional framework seen as a whole the formal and informal institutions by and large complement each other and the balance between them may change over time and differ from country to country.

4.1 Which Institutions matter?

The main idea of the innovation system approach to innovation analysis is that the innovation performance of the economy as a whole, be it national, regional or local, depends not only on the innovation capabilities of its individuals, firms and organisations, but also on how these interact with each other and with the public sector. The institutional set-up of the economy fundamentally influence these interactions and thereby its innovation performance. The institutional framework as a whole forms a more or less coherent system which in its totality affects the innovation activities in the economy. But of course, some institutions matter more than others. It may be obvious that *institutions related to the knowledge infrastructure* which contain public, semi-public, and private institutions for production, maintenance, distribution, management, and protection of knowledge are important for the innovation performance (Smith 1997). Within this category we find for example the school system, the universities and research centers, the vocational training system, the system of technological service center, research councils, telecommunication network, libraries, and databases. The quality of, and the access, to these institutions and organisations clearly affect the learning capability of both individuals and firms.

Since innovation is a process over time in which decisions have to be made in anticipation of future returns it is also obvious that *financial institutions* matter for innovation. It is not only a question of the access to and cost of finance, but also of how much innovating firms depend on external as compared to internal finance. Furthermore, the institutional characteristics of the financial system, for example the division of labour between different institutions, the degree of concentration and decentralisation and its relations to the non-financial sector and to the government affect the performance of the innovation system. Different financial systems (for instance capital-market based systems and credit-based systems) influence innovation processes in different ways, for example in their ability to influence and support selective and lasting borrower-lender relationships in the system (Christensen 1992).

The increasing tendency to treat information and knowledge as commodities have put more and more focus on *intellectual property rights* and their relation to innovation performance. The commodification of knowledge is accompanied with increasing costs for entering, maintaining, and developing the knowledge infrastructure. Seen from the perspective of developing countries the knowledge commodification process is mainly adding to the barriers to catch-up. Formal institutions as the Trade Related aspects of Intellectual Property Rights (TRIPs) agreement under the World Trade Organisation may further ad to this.[32] The developed countries dominate the scene and most developing

[32] By integrating a number of international IPR conventions the TRIPs agreement aims to introduce more order and predictability in the system and to settle disputes more smoothly (Rasiah 2002, p. 12). The agreement covers: Copyrights and related rights, Trademarks (products and services), Geographical indication, Industrial Designs, Patents, Layout-designs of integrated circuits, and Undisclosed information (including trade secrets). For an overview and

countries have only a weak capacity to participate in the TRIPs agreement (Rasiah 2002).

But beside obvious examples like the ones mentioned above there are also many less obvious but still important institutional influences on the innovation performance. For example, social norms may support a more or less effective *learning culture*.

A learning culture is a culture where learning is valued positively, where time and other resources for learning are available, where broad and diversified participation is encouraged and where internal processes for managing the created value exist. It is difficult to identify the sub-set of institutions which matters most, but since all learning is interactive and requires communication, interaction and co-operation it depends on *trust*, which in its own turn develops through interaction and co-operation. Trust is a multifaceted and complex concept which refers to things like expectations between the parties of an interaction about consistent behaviour, full revelation of relevant information and in general good intentions. If there is trust between the parties they will interact and co-operate better and at lower cost in long-term, complex processes of interactive learning. There is for example always a risk that individuals or individual firms may try to appropriate for themselves the fruits of long periods of co-operation between several firms. Trust reduces this risk. Without trust co-operation in R&D may be practically impossible.

It can be expected, then, that learning and innovation capabilities are low in conflict riddled, low-trust societies. Trust is not scarce in traditional sense, but since it, like knowledge, tends to grow when used and erode when not used it is possible to get trapped in a condition of low trust. This seems to be the case in many developing countries. Here we often find a very uneven distribution of income, wealth, and power. There is generally only little co-operation between the government sector and private interests and the relations that do exist are often contaminated by corruption. This is not a good environment for learning and innovation and may also be the deeper reason why so many problems in the public-private interface remain unsolved even when there is no lack of resources in a traditional sense.

Within economics it is normally assumed that *instrumental rationality* is a general rule for human behaviour or at least that it dominates completely in the private economic sphere. Economic transactions in the form of single, isolated, arms-length exchange acts in a capitalist environment tend to support patterns of behaviour corresponding to instrumental rationality. However, when learning is important, including learning new skills through interaction with other agents, it is no longer the only kind of relevant behaviour. If instrumental rationality were completely dominating the behaviour of and the relations between teachers and pupils, masters and apprentices and engineers in R&D efforts between different firms, very little learning would take place. Innovation

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discussion of these different areas and their potential consequences in different types of developing countries see Rasiah (2002).

systems, where *communicative rationality* is playing a major role in activities related to learning and innovation, will probably perform better in the long run.

It is *the actual mix of different rationalities* that affects the performance of the innovation systems. It is perhaps possible to distinguish between predominantly static and dynamic types of rationality. Are the choice of activities and occupations in society, which result in a specific specialization pattern, viewed as determined by tradition or as maximizing choices from a given set of possibilities, i.e. in a static way, or is it seen as changing all the time, as evolving, i.e. does learning play a role for how people decide which activities to pursue and how to conduct them? The actual mix of rationalities in the economy may, thus, be more or less conducive to innovation and development. It may stimulate change or it may support status quo.

The distinction between short-termism and long-termism in investment decisions is a crucial sub-aspect related to the dominating mix of rationalities in the economy. It is quite obvious that the *time perspective of investment* is important not only for the allocation of finance but also for other aspects of technical innovation. Certain technology areas will only be possible to develop into commercial success by agents with a long-term perspective, while other areas might be easier to exploit with a short-term view. Likewise, ecological factors may be seriously taken into account in development only if a long time horizon is accepted. There are many examples of how short-termism creates ecological problems. Allowing and stimulating a long time perspective is an essential aspect of a learning society.

4.2 Institutional Learning

In a development perspective the observation of a connection between institutions on the one hand and learning and innovation on the other often leads to considerations of the need for changes in the institutional set-up. In fact building and improving innovation systems as a part of development policy is to a very large extent a question of improved institutions. We may refer to this as a process of institutional learning and institutional innovation. Because of the complexity and inherent stability of institutional systems this process will also tend to be complicated, slow and uncertain with respect to the results.

It has been pointed out by Rodrigo and Sutz (199?) that most innovation system research has been done in the North in countries with relatively effective institutional support for innovation processes. Furthermore, innovation systems have mostly been studied as already existing entities. When their histories are tracked it becomes clear that they have evolved rather than been consciously designed. Only in few cases (patent rights, the technical university, etc.) have institutions been deliberately constructed and implemented with the direct aim of supporting technical change. Countries with strong innovation systems have got them more by accident than by choice. Only on the level of the individual firm or organisation can we find something which resemblance deliberately designed innovation systems.

Still, countries in the South, which realize the need to improve their innovation capabilities as a response to development problems, may need to actively promote institutional change. Arocena and Sutz refer to this as a need to change from an ex post to an ex ante perspective. On a theoretical level this implies a need for important adaptations and changes of the theories about innovation systems. For example, the character and role of local (as compared to regional and national) systems of innovation need to be understood much better and the political and power aspects of development should be treated more adequately. (Reference).

The main problem, however, may very well be that that the present empirical as well as theoretical knowledge about the institutional set-ups of most developing countries is very week. In fact, there is no consensus of how to define and delineate institutions or how to identify the ones which are most important in connection to innovation. The existing empirical mapping of institutions is very incomplete and almost no serious attempts to describe and compare institutions between countries in the South have been made.

This may not be surprising since it would require a quite considerable amount of research. Especially the informal institutions are difficult and costly to describe. They are very complex and in many instances they have to be described with qualitative rather than quantitative data and, as hinted at above, several very different institutions combine to determine learning and innovation. The present knowledge about the structure of the innovation systems in Central America, their weaknesses and strengths, is far from adequate. Especially one needs to know more about which institutional changes that would be conducive for improving the learning and innovation capabilities.

The viewpoint taken here is that improving these capabilities is not only a question of more resources for education and research (more and better schools and universities) but also of better institutions supporting interactive learning and innovation in many parts of society including the individual families, communities, firms and organisations. Learning and innovation capabilities are not autonomous, isolated capabilities. It is a fundamental aspect of the capability based approach to development that different capabilities – political freedoms, social capabilities, economic facilities and not the least learning and innovation capabilities – are highly complementary and feed upon each other (Sen, 1999). Furthermore, these capabilities depend broadly on the institutional set-up of society; of its political, social, and economic arrangements. If one wants create institutions which support learning and innovation capabilities one has to take both the interdependence with other capabilities and the systemic character of the institutional set-up into account.

4.3 Property and Markets are not enough.

On this background any policy recommendation invoking the efficiency of "clearly specified and implemented" property rights (often implicitly understood as the rights of *private* property) seems grossly inadequate. Clear, and enforced private property may be effective in relation to some goals in some

situations but it can not be used as a recommendation of general validity. Especially, it can not be used as a recipe for improving innovation systems performance. As we have seen learning and innovation capabilities have a much broader and more diversified institutional foundation than private property.

This may seem as an obvious and superfluous statement. There is, however a tradition in economic thought, which considers property rights to be a very potent tool for many types of policy. In environmental policy for example the idea is that if environmental resources are left untraded they will be allocated non-efficiently, some times even destroyed. Lacking well-defined and implemented property rights prevent exchange and in such situations property reforms rather than environmental regulation may provide a better allocation of environmental resources. Even distinguished scholars sometimes formulate oversimplified policy advice in this line of reasoning: "Still even the limited information that is available suggests that, to alleviate poverty while protecting the environment, developing countries should: (I) Introduce well-defined property rights. (ii) Establish markets – particularly capital and insurance markets – whenever they will support better management of environmental resources. (iii) Measure growth with better indexes than conventional GDP measures, including GNP" (Mähler, 1998, p. 265)

Strengthening of market-supporting institutions is also often suggested as a remedy to the imbalance between the North and the South in knowledge creation and distribution (World Bank, 2002). High transaction costs related to inadequate information, market uncertainty and incomplete definition and enforcement of property rights is seen as the main problem. It follows that institutional changes which reduce transaction costs and increase market opportunities should be placed high on the political agenda for development. In such a perspective commodification of knowledge, for instance in the form of patents and other types of intellectual property rights, is regarded as a key instrument to stimulate innovation and create new market opportunities in both the North and the South.

This type of reasoning resemblances a search for a best-practice in development policy. Multi-purpose, simple policy principles of general validity are envisioned. But since it is impossible to define an optimal institutional set-up, it is also futile to search for a best-practice in development strategies. In fact, the more the relations between institutions and knowledge creation are emphasised the more clear it becomes that there are different roads to enhanced learning and innovation capability. Each country has to create its own institutional framework for development.

Furthermore, it is not a question of "getting the institutions right" - once and for all. It is more a question of embarking upon a road of continued, reflected, negotiated and balanced institutional change. Such a process may be called institutional learning. It includes ongoing processes of minor as well as major institutional adaptations and innovations. Some of these have to be deliberately planned and implemented by the government, sometimes in communication

and cooperation with private firms, organisations, local communities, etc. Institutional learning, thus, includes policy learning.

4.4 Policy Learning

Economists often look upon policy making as a branch of rational choice; policy makers attempt to use their instruments in order to reach some given targets or maximize some welfare function. However, seen over time policy making may also be a process of learning. Policy making may improve over time and it can make a fundamental difference if the process of policy learning is handled badly or well and if it is slow or fast.

It is not so much a question of policy makers becoming more competent, even if that also matters, but rather that a whole set of necessary policy elements evolve over time. Experiences and practices, bureaucratic competence, statistical data, policy preparing organizations in the government administration, organizations and institutions for economic counseling and advice, economic theory and visions and ideas of what is politically and economically possible and valuable may co-evolve, supporting each other in a self-reinforcing way. Considerable development of values, institutions and organisations may occur over time.

It can be argued that Keynesian fiscal policy was first born in Sweden in the 1930' several years before the publication of "The General Theory" in 1936 It took a considerable number of years, however, before a capability of conducting a reasonable effective counter-cyclical stabilization policy was developed. First employment policies such as governmentally financed construction investments, increased public consumption and unemployment benefits leading to budget deficits were forced onto the political agenda and implemented against strong political opposition and against the advice of most economists which were argumenting for balanced budgets based on what in those days seemed to be sound theoretical grounds. Later and over a long period of time theories and data, institutions and organisation, values and visions were developed into a developed framework for macroeconomic stabilisation policy.

Now it seems that the focus has changed and that policies for knowledge creation and innovation have become a new center for policy learning. Environmental policy is an other one. In these new areas, however, policy learning has not yet advanced very far. There is still a serious lack of developed values, visions, theories and institutions.

This is quite obvious when it comes to policies for utilisation of services of nature as an element of a sustainable development strategy. Institutional learning and policy learning is needed for several reasons:

First, the values and visions in this area are not yet very clear. Especially a workable consensus between different intersts and groups on which to build a policy have not been created. There is not even a clear consensus on what sustainable development is about.

Second, the potential conflicts are large. Services of nature bring forward conflicts between ecological, distributional and economic goals and between different population groups. For example: How important are ecological factors (biodiversity, clean air and waternatural resouce conservvation, etc) compared to income and wealth in economic sense in the short and in the long run and how should the power to decide about utilisation of services of nature be distributed and how should the different rents emanating from them be distributed? The high level of corruption and a general lack of trust in many developing countries add to the severity of the problem.

Third, the scientific understanding (for regarding natural and social science) of the interactions between ecological and social systems is poor because of the enormous complexity of these interactions. The systems are very complex in their own respect and scientific discussion of how they interact has only just begun. This means that any strategy construction and policy making in this area have to be contucted under very high uncertainty.

Finally, it is still not clear how such policy questions should be prepared and implemented. Which kind of new organizations are needed? Which data should be supplied? Which types of local experience and knowledge could be mobilised and utilised? Which communication channels and routines have to be created, etc. In short, the organisational and institutional framework for policy about services of nature is still not developed.

5. The Chagaspace Project

5.1. Introduction: The Chagas disease

The Chagas disease (American Trypoanosomiasis) is an infection caused by the parasite *Trypanosoma ruzi* (*T.ruzi*). The inch-long insect responsible for transmitting Chagas is called the 'Kissing bug' in Central America, South Americans use the name Vinchuca, and to scientists it is *Triatoma dimidiata*. The 'Kissing Bug' is a common, secretive rain forest bug that lives in the trees, biting birds and jungle animals. The innocuous-looking insect sucks blood, much like a mosquito does. Its habit of defecating and urinating immediately after eating provides the Chagas parasite, which lives in the bug's feces, ready access to the prospective host's blood stream.

There are two stages of the human disease: the acute stage which appears shortly after the infection and the chronic stage which appears after a silent period that may last several years.

The acute stage of the disease is generally seen in children, and is characterised by fever, swelling of lymph glands, enlargement of the liver and spleen, or local inflammation at the site of infection. But, commonly, there are no acute clinical manifestations, and those infected may remain without symptoms. In about one-third of acute cases, a chronic form develops some 10-20 years later, causing irreversible damage to the heart, oesophagus and colon, with dilatation and disorders of nerve conduction of these organs.

Patients with severe chronic disease become progressively more ill and ultimately die, usually from heart failure. There is, at present, no effective treatment for such cases.

In human Chagas disease, after the penetration, a short period of 7 to 9 days elapses until the beginning of the classical symptomatic acute phase (incubation period), in which the parasite undergoes an intensive process of tissue multiplication and invades the bloodstream and several organs. The variants of Chagas, which can remain dormant or semidormant and undetected in the host for 20 years, can attack the human body in three principal ways. In Costa Rica and most of Central America the parasite usually lodges in the heart muscle. When it becomes active, it begins attacking the muscle. The tissue eventually becomes so thin it simply bursts from normal vascular pressure. It is believed that in geographical regions where the bug lives, many of what are diagnosed as hearth attacks, especially in younger people and among the poor, are the result of Chagas. More virulent strains in South America attack the colon and esophagus. These latter manifestations have a better chance of diagnosis and can often be corrected by surgery to remove the affected parts.

The risk of infection with Chagas disease is directly related to poverty. The original landscape of human Chagas disease in all Latin America is composed of rural areas with huts covered by grass or palm leaves and constructed with mud, stones or wood cracked walls, sheltering a very poor human population living side by side with rats, mosquitoes, cockroaches and triatomines. Rural production is very primitive in such areas, because of the absence of political priority, the lack of industries, the almost non-existent transportation and the extreme difficulties of crop storage. Illiteracy, poverty and weak social organisation mark the population. These features make that Chagas is classified as a poor man disease.

The malady can be traced back to antiquity. Tell-tale-signs of it have been found in diseased hearts of 27 Inca mummies in Peru and the north of Chile. The mummies have an estimated age of 4,000 years.[33] Charles Darwin made a description of the insect, the 'Kissing bug', while he was making his famous research voyage around the world. Since Darwin died from a megacolon ailment, it is thought that he might have become infected with the Chagas disease while visiting South America.
However, the disease was not diagnosed until 1909, when Dr. Carlos Ribeiro Justiniano das Chagas, while working as a sanitary doctor in Brazil, discovered the relationship between the parasite, the 'Kissing bug' and the disease. [34]

Spreading of the disease

Two cycles of transmission of Chagas disease can be distinguished, the sylvatic cycle and the 'domestic' cycle. The ancient sylvatic cycle of Chagas disease

[33] www.oni.escuelas.edu.ar
[34] Chagaspace project folder

involves the interaction between wild vectors and hosts in different natural ecotopes of American Continent. In a general way, there is an ecological balance between the parasite and its vectors or hosts, since the parasitism seems not to harm triatomines or wild reservoirs. The domestic cycle results from human-vector contact, involving the colonisation of artificial ecotypes by the invertebrate vector (triatomines) and a series of social and ecological modifications in the environment. In this latter cycle, parasitism can cause important damage in the vertebrate hosts, with high degrees of morbidity and mortality frequently detected among infected people. The interaction between domestic and sylvatic cycles occurs as a product of different factors, the majority of them dependent on human behaviour. Two good examples that demonstrate the influence of ecological and social factors in human Chagas disease are:

1) Its absence among Indian populations in the forest of central Brazil, where wild vectors and mammalians hosts co-exit, but where the natural environment is preserved by native culture.

2) The absence of human autochthonous cases (only 3 have been detected) in the USA, where the prevalent triatomines have a very small capacity to colonise dwellings and where the social process did not produce huts or similar artificial ecotopes favourable to vector colonisation.[35]

Although the distribution of wild vectors and reservoirs is much greater than that of the human disease, the 'domiciliation' of the triatomines exposes at least 90 million persons at risk of the infection, from south of the US to Argentina. Nevertheless, the better living standard of the population and the conditions of the local species of triatomines make the human infection by the vector extremely rare in the United States.

As humans continue to cut down the forest, it is losing its natural home. The 'Kissing Bug' adapts well to substitute accommodations, finding suitable hiding places in the cracks and crevices of typical peasant dwellings around the rain forests.

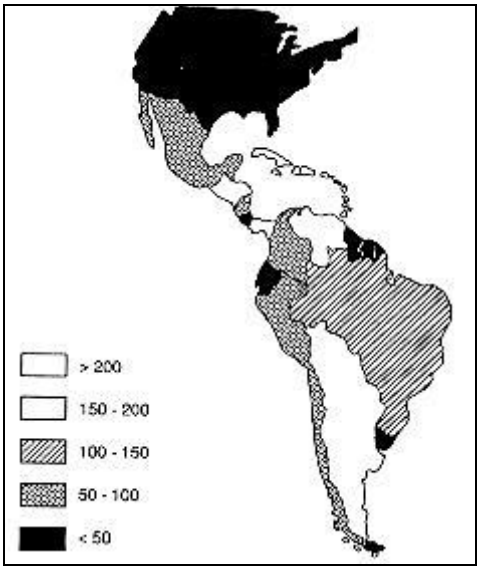
As studies have continued, some alarming numbers concerning the range of Chagas disease have come to light. In endemic countries, it has infected an estimated 20 million people and kills 20,000 people every year.[36] The disease manifests itself from southern Texas all the way down through Central and South America (see figure 4.1 with data related to each million of inhabitants per region). Data details cases in all but the heart of the Amazon. According to Boletín Chileno de Parasitologiá (1989) percentages of infected people living in areas where the Chagas parasite is found range from 3% in Uruguay and 11% in Costa Rica, to 33% in Colombia and 50% in Bolivia [37]. This percentages are

[35] www.dbbm.fiocruz.br
[36] Interview with B.Kohlman at EARTH, Costa Rica, Feb. 2002
[37] www.cocori.com/library/eco/chagas.htm

related to the areas at risk in each country, no to the whole country; however, the numbers are significant.

Classically considered as a typical rural disease of Latin America, a new trend is modifying the spectrum of human American Trypanosomiasis in the entire Continent: that of urbanisation. Profound economic and social changes in the last four decades are stimulating rural-urban migration in most of endemic areas, with more than 60% of the population presently settled in urban centers. It is estimated that, because of migration, about 300,000 infected individuals are living today in the city of São Paulo and more than 200,000 in Rio de Janeiro and in Buenos Aires. In addition, chagasic patients are migrating northward to the USA and even eastward to Europe: nowadays, around 100,000 infected people are living in the USA, most of them immigrated from Mexico and Central America.[38]

Figure 4.1 Estimated incidence of Chagas disease in the American continent (approximate relation for every million inhabitants per geographic area)



Source: www.dbbm.fiocruz.br/tropical/chagas/incidenc.html

Chagas disease in blood transfusion is also an increasing problem in Latin America. Between 1960 and 1989, the prevalence of infected blood in blood banks in selected cities of South America ranged from 1.7% in São Paulo, Brazil to 53.0% in Santa Cruz, Bolivia.[39] Only Brazil, Argentina, Chile, Uruguay and

[38] www.dbbm.fiocruz.br
[39] www.who.int/ctd/chagas/burdens.htm

Honduras check for Chagas disease. The USA is starting with it, because of immigration of people from endemic countries. Costa Rica has started recently with checking on Chagas. The reason of not doing it in the past, was the lack of information. The government had no information on Chagas and therefore it simply assumed that the disease did not exist in Costa Rica.[40]

5.2. The Chagaspace project

Chagaspace is a joint project between NASA and several universities and institutions, with EARTH College in Costa Rica as the co-ordinating entity. The project (which started in 1994) brings together a team of researchers from seven different countries of the Americas to jointly solve a critical regional health problem.

EARTH University opened in 1989, with the mission of providing a university-level education "in the agricultural sciences and natural resources, contributing to sustainable development of the humid tropics."[41] Realising that their jungle laboratory might disappear before they could fully understand it, they felt that an ambitious curriculum of applied research would greatly benefit the university and its students.
Costa Rica's astronaut, Doctor Franklin Chang, an inspiration to Costa Ricans for many years, offered to help EARTH. Through his contacts at various institutions, a joint project team was formed to study medicinal uses of tropical plants. Two universities in Chile that were part of the team had been working for years to develop a cure for the deadly Chagas disease. This was a project that fit in with the tenets of EARTH, so scientists started their quest. During the research it became clear that many organisations were needed in the search for a cure, all with their own specialisation. Below the different organisations participating in the project are presented with a short overview of their task.

5.3. The knowledge appropriation

The parasite and its destructive ways are known. Finding a safe way to block its action is the problem. Finding a cure for Chagas disease requires that the causative parasite is eliminated by blocking its life-supporting enzymes.

Two possible methods of developing a medicine exist, which are both used in the Chagaspace project. The first one is to design a drug on a computer. The CMC in the USA is working with computer models in order to generate an inhibitor that perfectly matches with the structure of the enzyme that has to be blocked.

The second possibility to develop a medicine is to check natural compounds. In the Chagaspace project the emphasis lays on this second method of researching. The search is for a natural compound that has the ability to block key enzymes in the parasite. The rain forest with its great biodiversity provides

[40] Interview with B. Kohlman
[41] www.cocori.com/library/eco/chagas.htm

an almost infinite number of natural compounds; the challenge is to encounter the right ones. For this, several hundred natural compounds are being extracted and purified by teams in Costa Rica and Chile. Each compound's interaction with the enzymes of the parasite are assayed and evaluated. Combinations of these substances are being crystallised both on earth and in space for further study.[42]

In this study the information sources being used are of interest. In Costa Rica, two project members, INBio and EARTH, are collecting probable useful natural compounds. EARTH is searching on its own property, the university's campus. INBio collects in the national parks; the organisation has an agreement with the Costa Rican government that allows them to search in these public areas. Furthermore, the scientists have made use of popular knowledge (knowledge about substances that have been useful against similar diseases). In Chile and Costa Rica, where the search for helpful biological resources (plants, trees, etc.) takes place, researchers make use of popular medicinal (*not necessarily indigenous*) knowledge.

[42] Chagaspace project folder

Organisations in the Chagaspace project

Costa Rica
EARTH (Escuela de Agricultura de la Región Tropical Húmeda)
INBio (Instituto Nacional de Biodiversidad)
UNA (Universidad Nacional)
EARTH as the co-ordinating entity has the task to manage and administrate the project. One of the most important tasks of EARTH is to search for financial resources in order to keep the research going. Although every participant in the project is searching for financial resources locally, EARTH tries to find support for the group as a whole.[43] Furthermore, scientists at the university are collecting plants from the forests surrounding the campus and doing bioprospection.

The participation of INBio consists of the search for compounds of plants, insects, (hongos endofitos and moluscos) that can eliminate life-fulfilling enzymes of the parasite.

Universidad Nacional, experiments with mais at the veterinary school, in the Faculty of Health Sciences.

USA
NASA

NASA provides the space flights for bringing the compounds to space to crystallise them. It also has given permission to make use of the spacestation MIR that is being built right now (one of the first modules will be a crystallography).

CMC (Center for Macromolecular Crystallography, University of Alabama)
As the biggest crystallography center in the world, CMC analysis the compounds before and after they go to space. The Center is also working with computer models that can help to identify the structure of the enzyme that has to be blocked, which is another way to search a cure.

Chile
USACH (Universidad de Santiago de Chile)
UCN (Universidad Católica del Norte)

USACH works in the field of biomedical aspects. This university deals with biochemical analysis, medical chemistry and human health aspects. For example, USACH will test if the cure is not harmful or aggressive to humans.

UCN does part of the crystallisation and also searches for compounds in the country's natural areas, and do bioprospecting.

Argentina
INP (Instituto Nacional de Parasitología)

For this moment INP extracts and expresses genes for the project. Furthermore, INP is the only Latin-American institute that is allowed to do human tests on Chagas. Once the research has been more advanced, human testing will be done by this institute.

Mexico
UNAM (Universidad Nacional Autónoma de Mexico)
This university in Mexico is expressing and extracting genes.

Uruguay
UR Universidad de la República. UR crystallises compounds that may hold the cure.

[43] interview B.Kohlman

As said before, for the development of the medicine, the exact structure of the target enzyme that has to be blocked must be determined. To uncover this structure, scientists use X-ray crystallography. A crystal of the protein is bombarded with X-rays to produce a pattern that, much like a fingerprint, reveals the identity of the protein's structure. To get an accurate pattern, the crystal must be as free of imperfections as possible.[44] Due to the force of gravity crystals grown terrestrially generally develop irregularities. This is were the help of NASA came up. Doctor Chang, the Costa Rican astronaut, asked for the help of NASA to carry the crystals to space. Until now, Chagas crystals have been flown on four shuttle missions. In February 1996, the first joint US-Latin America space experiment flew aboard mission STS-76 on the space shuttle Columbia. Scientists needed to know if the material from the parasite would grow crystals in space. The results were positive and a second batch of samples flew aboard STS-77 in May of 1996. Results of this flight indicated that although the crystals grew well, more time in space was needed to have sufficiently large samples for the process of X-mapping. In 1998, two space shuttle missions included another series of enzyme crystal growing experiments related with the Chagas research.[45]

The advantage of crystallisation done in space is that the crystals form slowly and are not deformed by the force of gravity and develop more uniformly with fewer defects. The higher quality crystals often yield higher resolution data than their earth-grown counterparts. This last point is of paramount importance for developing drugs against diseases, since they can be designed as a result of the higher quality crystals, in a more efficient manner. Protein crystals grown on space shuttle missions provide scientists with up to 40% more information than crystals grown on earth.

The scientists, again with the help of Doctor Chang, have sought permission to grow the crystals aboard the International space Station that is being built. This will facilitate the possibility of a longer crystal growing process in space. A problem that is being faced at the moment by the scientists is that gravity has its effect on crystals brought back from space. In the future they expect to be able to do analysis on these crystals in space, in the IST station.

Since the start of the project more and more organisations have been participating and at this time ten organisations are working jointly on the development of the cure. In order to have clear what the object of the project is and to facilitate a good working process, the organisations have made up a written agreement of the Chagaspace project. Herein is stated that everything, all developed knowledge / information belongs to the group and all information will be shared among the group members. Furthermore, the project members agreed that commercialisation is not the aim of this project. Kohlman describes the aim of the project as follows:

[44] weblife.ksc.nasa.gov
[45] www.cocori.com

"this is not business, we're not going to make money like pharmaceutical concerns. Our aim is to find something that works to help the people."[46]

Since commercialisation is not the aim, the participating organisations cannot count on high benefits when a cure is being found and sold. However, for the research huge amounts of resources are needed. EARTH is in charge of searching money for the project group as a whole. The American Congress provided financial resources for the research. EARTH tried to get interest of pharmaceutical concerns, but failed. The Americans in the project said they had good contacts with pharmaceutical concerns and tried another time. However, they also failed in receiving money from the concerns. Since the disease of Chagas is a poor man disease, infected people will not be able to pay much for the medicine. For this, pharmaceutical concerns have no interest, since they feel there is no 'big money' to earn. This is the reason the search for a cure is dominated by universities. The participation of NASA is of major importance regarding to financial resources. Kohlman states that without the help of NASA every trip of the crystals to space would cost the project about a million dollars.[47]

Furthermore, the different participants try to find resources locally for their part of the project. NGOs, mining companies in Chile and the Chilean airforce have donated financial resources in the past. The Costa Rican government donated some money through the CR congress approval of the budget, which has been split up by the three Costa Rican organisations in the project.

5.4. Future findings and property rights

Obviously, the aim of the project is to find a cure for the Chagas disease as soon as possible. However, in this paper the interest is more in the possible future events that will occur when the cure is actually encountered. What will happen when the cure is being found, who is going to bear the cost of development of a medicine, who will benefit from the product development, and what potentially conflicts could arise, are important question in this sense.

On the question what will happen when a medicine is being found, Kohlman of EARTH responds with saying that they have not been much thinking about this. For the moment the most important thing is to find something that works. However, the group has some ideas in case a cure is found. The idea is to give the cure to a local health organisation, so they can set up a national health program or to give it to an international health organisations. Another idea of the members of the project relates to the 'domestication' of the needed compounds for the medicine. To make the medicine, for example a certain plant, will be needed in large amounts. The idea is to give the knowledge and the right to produce to local

[46] Interview B. Kohlman
[47] Interview B. Kohlman

farmers, so they can produce this plant and earn benefits from it. In this sense the project will be of help to local people in two ways; by solving a severe health problem and facilitating an additional source of income.

The cure will, of course, be patented (for ten years). This must be seen more as a defensive action (otherwise other people, for example, pharmaceutical concerns, can take the outcome of the project), rather than an offensive idea of 'this is ours', since the cure will be probable given away.

Looking at the organisation form of the project it is possible to consider it as a regime of communal property rights. All together the organisations have the right to in the project developed knowledge and should follow up rules that have been agreed in the written agreement or during the research process. For example they should not share information with actors outside the project and in the case the cure is encountered the decision of what to do has to be made by the group, not by an individual party. The maintenance of these rules is purely based on trust between the different organisations; no compliance mechanisms exist. In the future, as we see the situation, this might become a source of conflict since it is not sure which party is going to find the cure. The CMC in the United States is researching with the method of computer modelling , the rest of the group, is researching trying to find a cure by making use of natural compounds, this may also make a difference at the end.

In the future, all these issues could become a real conflicting issue, since already plans exist to extend the project to similar research involving malaria and dengue fever, which affect not only Latin American countries, but parts of Asia and Africa as well. A cure to these diseases, especially to malaria, will certainly attract the interest of more organizations. Commercialization will probably lead to huge benefits, since the potential and the actual amount of affected people (of which a part is more wealthy and thus in the ability to pay a 'reasonable' price for a medicine) is much higher than in the case of Chagas. However, again this is only a speculation of the researchers and not the ideas of the ChagaSpace group. To deal with potentially future events as such, the rules between the different participants have to be clear and strong, so that the agreement is not going to be violated and provide unequal benefits between the different organisations; but again trust, confidence and cooperation among the parties seem to be the key elements to develop new institutional arrangements and solidarity.

6. Lessons learned

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1. Really existing property rights systems in this world of ours are complex and mixed. They do not look very much like any of the basic forms outlined in chapter 2. (We can refer to the impurity principle discussed by Hodgson in many of his books for example in "How economics forgot history" (2001))

2. Property rights should not be seen in isolation from other institutions in the institutional system of which they are a part. How they function depends on how they interact with other, formal and informal institutions and there are often several possible institutional solutions to the same problem.

3. Specification and implementation of property rights is connected to, and part of, a larger task of institutional learning and design.

4. The need for ongoing policy learning with built-in feedback mechanisms should be acknowledged. Mobilisation and utilisation of local experience, knowledge and competence should be part of the policy learning.

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