Reconciling Biodiversity Conservation and Economic Development through Property Rights: An Analysis of Extractive Reserves in the Brazilian Amazon

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Abstract

Extractive reserves have been touted as a novel approach to assigning property rights such that biodiversity conservation and economic development objectives can be reconciled. On this basis, the areas under this peculiar property rights regime are currently being expanded. Here, we analyse the merits of the development aspects of this claim by using a simple model of spatial competition between an extractive reserve and a plantation. We show that an extractive reserve is economically viable as a competitor in markets for existing extractive products only under very restrictive assumptions. Long-run viability is potentially feasible by either a continuous process of product discovery that allows monopolistic rents to be extracted over some period of time or by a shift in the role of extractive reserves from competitors of plantations in the output market to producers of inputs for plantations. We then study the current system of the property rights over the inputs and outputs of extractive reserves to assess how well they align with the various pathways to economic viability. The finding is that current property rights systems over inputs and outputs are efficient only with respect to competition in markets for existing extractive products. This has problematic implications for the development objectives pursued under this property rights structure.

1. Introduction

The Brazilian Amazon contains some of the world's most biologically diverse ecosystems. These ecosystems generate significant global benefits in the form of ecosystem services, species habitats etc. On the other hand, the land required to keep these ecosystems intact and the value of natural resources, especially timber, that the Amazon could produce are substantial. This means that a decision not to convert these areas imposes a high opportunity cost on the economy of a developing country as a whole, and on local populations with a high incidence of poverty and destitution in particular.

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The importance of balancing this trade-off has increasingly been recognised in Brazilian development policy. While the 1960s and 70s were characterised by the clearing of vast areas in the Amazon region for agriculture and pastureland under ambitious development programmes, Brazilian development policy started shifting towards considering ecosystem and biodiversity preservation objectives in the late 80s and 90s. One specific initiative in this context has been the creation of a novel form of property rights arrangements in parts of the Brazilian Amazon under the title of 'extractive reserves'. Although the reserves were originally thought as a proposal for agrarian reform adapted to the needs of populations living from the extraction of non-wood forest products (NWFP), in reality they were set up as conservation units. Reserves nowadays represent a strategic element in a new model for Amazon development combining economic competitiveness with environmental sustainability[1].

Extractive reserves are an innovative property rights-based answer to the fundamental conservation-development trade-off. Some observers credit the Brazilian model with considerable success (Peluso 1994, Allegretti 1990 and 1994, Menezes 1994) while others have questioned its capacity to fulfil its economic development objectives (Southgate 1998, Brown and Rosendo 2000, Assies 1997, Almeida 1994, Homma 1992). This paper makes an analytical contribution to this literature by exploring the relationship between various possible development pathways that the production system of an extractive reserve offers and the property rights structure governing the inputs and outputs of this production system. Our fundamental result is a negative one: The current property rights structure properly supports only one of three principal development pathways, namely the extraction of established NWFP. This is compounded by analytical and empirical evidence that this development pathway has very limited capacity to serve as a growth engine for the communities living in extractive reserves. On the other hand, the current property rights structure generates no or very limited rents for the inputs required to access the other two pathways, diversification into newly discovered NWFP and supply of biological inputs into the intensive production of NWFP. We conclude

[1] For a discussion on the creation of the extractive reserves, see Allegretti (1990).

therefore that under the current set of institutions, the development objectives inherent in the extractive reserves model are unlikely to be accomplished.

The paper proceeds as follows: In the next section we provide some background on the origins and current status of extractive reserves in Brazil. We then analytically characterise a general NWFP production system and highlight extractive reserves as a special case in section 3. In section 4 we use a model of spatial competition to derive the three development pathways that are compatible with the specific production conditions of an extractive reserve. In section 5, we assess the current property rights structure governing the inputs and outputs of the NWFP production system in an extractive reserve and, in section 6, contrast this structure with the input rents required to support the three development pathways. Section 7 concludes

2. Extractive reserves: Origins and current status

Extractive reserves are based on a peculiar property rights structure: The property rights in the land and the biological capital stock situated on the land lie with the federal government. Property rights in the flow of NWFP generated by the biological capital stock on the other hand are devolved to traditional communities already settled in the area. Their property rights are codified in long-term concessions to live in the designated land and exploit its natural resources in an "environmentally sustainable" manner. According to the law that creates the reserves (decree 98,897/90), the extractive reserves are considered as territorial spaces of particular ecological and social importance for the country. In order to concede the right of accessing the flow of NWFP generated on public land, the federal government should approve a use plan elaborated by the related communities.

The creation of extractive reserves aims to promote the joint objective of forest conservation and economic development in the designated areas by granting the use right of its multiple resources for already settled communities in a sustainable way.

Three aspects of the extractive reserve model are expected to contribute to this joint objective: (1) The income generated through the resource exploitation allows the populations to remain in the forests and prevent alternative uses that rely on land conversion. (2) The explicit public ownership of land resolves property rights uncertainty over the areas involved and thus encourages the conservative use of its resources. Finally (3), the limitation of economic activities to non-wood forest products (NWFP) contributes to ecosystem maintenance and hence to the conservation objective. In addition, according to Allegretti (1990), by creating a setting for research the "extractive reserves could represent dynamic laboratories for investigating both traditional and innovative forms of human interaction with the Amazonian environment".

In 1992, the Brazilian Institute of the Environment and Renewable Resources (IBAMA) created the National Centre for the Sustainable Development of Traditional Populations (CNPT) with a mandate to establish and assist in maintaining extractive reserves. In 1995, these reserves encompassed around 21,600 sq. km (an area half the size of Switzerland). The number of federal reserves has been continuously increasing and in 2000 they were 12 across the Amazon states. Table 1 presents some figures of the current extractive reserves.

Due to the economic importance of rubber extraction for local populations, the concept of extractive reserve has been structured in most cases around the autonomous extraction of native rubber. This is underlined by a census data that estimate that 68,000 families were involved in rubber tapping in 1980 (Allegretti 1990). A typical family living in the largest extractive reserves had a yearly income of US$ 2,000 (ECOTEC / PPG7). In average about 30% of the income is derived from different extractive activities. Agriculture, animal ranching, hunting, and fisheries complement their income. Table 2 shows this composition.

Table 1 - Extractive Reserves in the Amazon

Name / Federal Unit	Area (ha)	Population	Main Resources
Alto Jurua – AC	506,186	4,170	Rubber
Chico Mendes – AC	970,570	6,028	Nuts/Copaíba / Rubber
Alto Tarauacá – AC	151,199	-	-
Rio Cajari – AP	481,650	3,283	Nuts / Copaíba Oil / Rubber / Açaí Fruit
Rio Ouro Preto – RO	204,583	431	Nuts/ Copaíba Oil / Rubber
Lago do Cunia – RO	52,065	400	Fishery
Extremo Norte do Tocantins – TO	9,280	800	Babaçú Fruit / Fishery
Mata Grande – MA	10,450	500	Babaçú Fruit / Fishery
Quilombo do Frexal – MA	9,542	900	Babaçú Fruit / Fishery
Ciriaco – MA	7,050	1,150	Babaçú Fruit
Tapajos Arapiuns – PA	647,610	4,000	Rubber /Fishery / Oil and Resin
Medio Jurua – AM	253,226	700	Rubber / Fishery
Total	**3,303,411**	**12,164**	

Source: web site of Brazilian Ministry of Environment (www2.ibama.gov.br/resex/amazonia.htm)

(Notes: 1.Copaiba is a tree producing oil used for pharmaceutical purposes. Its wood is also used for furniture and construction; 2. Babaçú is a palm. Is nuts are used to produce cooking oil as well as for charcoal and animal feed; 3. Açaí is a palm tree of which both the fruit and the "palm heart")

Table 2. Composition of Family Income Sources in Extractive Reserves - 1993 (%)

Income Source	**Extractive Reserves**				
	Chico Mendes	Alto Jurua	Rio Ouro Preto	Rio Cajari	Average
Agriculture	47,12	36,08	26,43	43,06	43,06
Cattle /small animals	8,92	10,80	13,69	14,92	12,08
Hunting and fishery	5,78	32,52	8,92	9,66	14,22
Sub total	61,82	79,40	49,04	87,22	69,36
Extractive Products					
Rubber	29,56	20,60	50,96	0,76	25,57
Nuts	8,62	-	-	3,63	3,06
Palm heart - fruits	-	-	-	8,29	2,07
Sub-total	38,18	20,60	50,96	12,68	30,70
Total	100	100	100	100	100

Source: ECOTEC - PPG7 (extracted from www2.ibama.gov.br)

The extraction of latex from rubber trees (*Hevea brasiliensis*) is the main activity among the extractive ones. A typical family produces an average of 900 kg of rubber annually (Brown and Rosendo, 2000). The income derived from rubber sales is not constant throughout the year. In the wet season, rubber harvests decline considerably, since the rubber trees tend to be concentrated on floodplains. Although rubber is the economically most significant product, the Brazil nut (*Bortholletia excelsa*) and oils (such as Copaiba oil derived from a palm tree (*Copaifera spp.*)) constitute locally important sources of revenue.

For extractive reserves to offer an answer to the development-conservation trade-off, the economic activities allowed to be carried out within the reserves need to generate above-subsistence levels of revenue over prolonged time periods. In the following sections, we develop the main three development pathways that have a revenue potential given the peculiar production conditions in the reserves. We start by giving an abstract characterisation of the NWFP production systems and then look at a set of favourable market conditions that offer revenue potential.

3. A Model of NWFP Production

The production of NWFP involves the harvesting of products generated by trees or shrubs. This makes clear that the production process relies on an underlying stock of biological capital. This capital stock differs from the standard physical capital used in conventional production systems in that the composition and size of the capital stock are directly linked to the rate of capital depreciation. Take the rubber tree as an example. Prior to the development of rubber plantations in Brazil, incidence of leaf blight was limited due to genetic variability in natural tree populations from which rubber was extracted. Early rubber plantations using intensive methods were devastated by the impact of leaf blight epidemics that made Brazilian rubber permanently uncompetitive on world markets while South-East Asian plantations evaded the disease through mere serendipity at the time when rubber saplings were smuggle out of South America (Kloppenburg 1988). In all, there are about 90 species of fungi known to attack *Hevea* trees, two species of bacteria, and various nematode and insect pests (Duke 1983). These pathogens seriously impact on the costs of intensive pro development since they require continuous investment into the protection of the biological capital base, mostly significantly through breeding (FAO 1995). On the other hand, intensive production in plantations benefits in a static sense from lower harvesting costs and in a dynamic sense from productivity gains in complementary inputs (physical capital, human capital) driven by technological progress and knowledge (FAO 1995).

3.1. Cost and profits of the NWFP enterprise

The general dynamics of an industry dependent on a biological resource stock imply that production costs of a NWFP producing enterprise *i* will vary over time depending on the productivity of its capital stock: The productivity of the biological capital stock will be negatively affected by increases in the size of production that can be mitigated through simultaneous investments in biological resources. We refer to this process as the 'biological depreciation function' denoted by $\delta(q_i,I_i)$ with q_i denoting production of enterprise *i* and I_i the size of its investment in biological resources. This is offset by productivity increases arriving through the physical capital stock K_i of enterprise *i*. We refer to the process as the 'technological augmentation function' denoted by $A(K_i)$. Assuming constant marginal production costs, we can summarise the behaviour of the cost function c_i of enterprise *i* over time as

$$\dot{c}_i(t) = \delta(q_i, I_i) - A(K_i) \qquad (1)$$

with partial derivatives $\delta_q(\ )>0$, $\delta_{qq}(\ )>0$, $\delta_I(\ )<0$, $\delta_{II}(\ )<0$ and $A_K>0$, $A_{KK}<0$.

The instantaneous profit function for the NWFP enterprise *i* is

$$\pi_i(t) = [p_i(t) - c_i(t)]q_i(t) - \eta_i(t)I_i(t) - \theta(t)\dot{K}(t) \qquad (2)$$

where

p_i is the price of a NWFP

c_i is the unit cost of production

q_i is the production of firm i

I_i is the volume of investments in biological resources and

η_i is the price of biological resources.

Based on these assumptions we describe the dynamic optimisation problem of a NWFP enterprise as

$$Max \int_0^\infty e^{-\rho t} \pi_i dt \quad (3)$$

$$\text{subject to (1) and } c_i(0) = c_i(K_i(0))$$

with ρ denoting the discount rate and $c_{K(0)}<0$, $c_{KK(0)}<0$.

The problem for the enterprise is therefore to maximise the net present value of profits from NWFP production subject to the dynamics of the cost function driven by capital stocks. We also assume for the initial conditions that the size of the initial capital investment determines the unit costs at the starting period. High initial capital implies a lower initial cost position.

3.2. Extractive reserves and NWFP production

A normal enterprise will be able to optimally choose price p_i and output q_i as well as the path of its production technology (I_i, K_i) to solve the decision problem contained in (3). By contrast, extractive reserves combine a severe restriction with regard to the choice of production technology with an abundance of biological capital. This has implications for the format of expressions (1) and (2) when describing an extractive reserve.

With respect to NWFP production, extractive reserves are peculiar because not the community, but the government is the owner of the biological capital stock. It grants the community free use of that stock subject to that stock not being depreciated. Implicit in this use condition is also a restriction of the production technology that limits the marginal productivity of physical capital (Browder 1992). These restrictions together with the intrinsic difficulties in operating within the forest, low capital intensity, little access to capital and the persistence of traditional methods suggest that the depreciation of the biological capital stock in NWFP production in reserves is negligible. Conversely, the rate of cost reduction *A(K)* driven an existing physical capital stock *K* will be extremely low in the reserves because labour intensive production involves little physical capital. With this configuration, the cost dynamics in expression (1) are not relevant to the intertemporal management of an extractive reserve. What will matter for the profitability of NWFP production, however, is that the level of unit costs will be at a level commensurate with the constrained production conditions in the reserve.

While constrained in the choice of technology, the abundance of biological capital means that extractive reserves have direct and inexpensive access to a critical input in the NWFP production process. This stock allows a diversification of NWFP production into the various activities documented in table 2, thus reducing the reliance on each individual product. It also opens up the interesting perspective of extractive reserve potentially benefiting from the demand for biological inputs I_j from other NWFP producing enterprises *j* subject to cost dynamics (1). This demand could be met in accordance with the use restrictions as long as the reserve can supply these inputs at a price lower than the cost of bioprospecting to the enterprises. The equivalent of the NWFP instantaneous profit function (1) for extractive reserve needs to reflect the revenue potential that diversification and sale of biological inputs represent. Assuming a diversification over *n* NWFP and demand for biological inputs from the reserves, I_j^R, profit for the reserve at time *t* will be

$$\pi_R(t) = \sum_{m=1}^{n} [p_R^m(t) - c_R^m(t)] q_R^m(t) + \eta_R(t) I_j^R(t) \qquad (4)$$

with η_R denoting the price of biological inputs.

Expression (4) states that profits for the reserve a time *t* will consist of profits over the *n* existing NWFP plus any income derived from supplying biological inputs demanded by other NWFP.

The peculiar production conditions in the extractive reserves present both a set of constraints for each NWFP production process by virtue of not being able to choose the first-best technology and a set of opportunities through the free access to an abundant biological capital stock that allows both diversification of output and sale of biological inputs. In terms of biodiversity conservation, these production conditions have clear benefits as they secure land use rights for activities that do not rely on land conversion. Economically, these conditions represent a significant improvement in terms of social equity compared to the traditional "aviamento" system of rubber 'barons' and quasi-indentured labour. However, it is less clear whether this constrained production system offers viable pathways to development through sustainable income flows for their populations. This question is explored in the following section.

4. Markets

4.1. Markets for existing NWFP

NWFP enterprises generate revenue through sale of their products on markets where they interact with other producers of NWFP. We focus on two peculiar features of this market for NWFP: The first is the spatial structure of enterprise location in the NWFP sector. Due to the considerable distance involved in the domestic market and resultant transportation costs, space is an important determinant of the profitability of operations. At the same time, production depends on peculiar local characteristics that are not present everywhere, thus limiting the choice of production sites. To tackle these spatial peculiarities, we use of a variant of the Hotelling model (1929) in order to analyse market interactions. The second peculiar feature is the heterogeneity of enterprises competing on the market. What is expected of extractive reserves is that they are able to generate revenue on output markets where they will be competing with other producers that are operating using different technological choices and resource bases. We limit our analysis to a model in which an extractive reserve competes with an enterprise modelled along the lines of section 3.1.

The combination of spatial considerations and producer heterogeneity is not only analytically interesting, it is also empirically relevant: Extractive reserves and potential plantations are usually localised in different parts of the country (in rubber production most of the plantations are localised in the South East of the country). Wunder (1999) shows that NWFP production outside extractive reserves is very concentrated and 18 municipalities account for 25% of the total extraction values.[2] These product belts are mostly characterised by proximity to market areas and by previous intervention or degradation in current sites of extraction. These environments are now dominated by the commercial species, sometimes up to the point of forming "quasi-plantations", as a consequence of natural re-growth combined with management practices to deliberately eliminate competitive vegetation (Wunder 1999).

We build on Tirole's (1988) presentation of the Hotelling model: A "linear country" represented by a real line segment between (0,1) provides the spatial structure for the model. Consumers are distributed uniformly along the country with density 1. There are two firms operating in the market, each located at one extreme of the country, producing the same physical good. Firm r (representing an extractive reserve) is located at $x = 0$ and firm p (representing a plantation) is located at $x = 1$. Consumers have transportation costs τ per unit of length. Consumers have unit demand. Each individual either consumes one unit of the good or doesn't consume at all. Finally, consumers derive a surplus $\bar{s}$ when consuming the good.

[2] These municipalities form the so-called "assai belt" (Para state) and "babassu belt" (mainly Maranhao state).

For a consumer located at co-ordinate x the generalised price is $p_r + \tau x$ to buy at firm r or $p_p + \tau(1-x)$ to buy at firm p. Given prices p_r and p_p transportation costs τ and surplus $\bar{s}$, the utility of a consumer located in x is $\bar{s} - p_r - \tau x$ if buying at firm r and $\bar{s} - p_p - \tau(1-x)$ if buying at firm p or zero if not consuming the good.

If price difference between the firms does not exceed transportation costs along the whole country and if prices are not too high with respect to the consumer surplus, then exists a consumer with location $\tilde{x}$ who is indifferent between buying from firm r or p. In this case we have $p_r - \tau\tilde{x} = p_p - \tau(1-\tilde{x})$. We can then derive demand curves for firm r and p solving the above identity for x and $(1-x)$ respectively. Then we have

$$D_r = x = \frac{p_p - p_r + \tau}{2\tau} \qquad (5)$$

$$D_p = (1-x) = \frac{p_r - p_p + \tau}{2\tau} \qquad (6)$$

The benchmark case in the Hotelling model arises if firms have the same unit cost. Then it is possible to show that the Nash equilibrium in prices obtained from firms' profit maximisation occurs with firms sharing the market equally. With this basic set up, due to transportation costs, we have horizontal differentiation even with physically identical goods. Transportation costs also reduce competition and creates "neighbouring clientele" (Tirole, 1988, p. 280). Consequently market power is formed and firms can increase prices above the competition levels, resulting in above-normal profits.

The benchmark case will arise in NWFP in a setting with two identical players. The market for NWFP differs from this benchmark case on account of the different cost structures for the prototypical extractive reserve and the plantation that are both competing on the market. Thus, in order to approximate this basic model to the reality of NWFP in Brazil we introduce different unit costs c_r and c_p for reserve and plantation respectively. The symmetry in the model is partially broken if firm's unit costs are assumed to be different. Profit functions become $\pi_i = (p_i - c_i)Di$, $i = r, p$. From first order conditions we now find that equilibrium prices become

$$p_r = (\frac{2c_r + c_p}{3}) + \tau \qquad (7)$$

$$p_p = (\frac{c_r + 2c_p}{3}) + \tau \qquad (8)$$

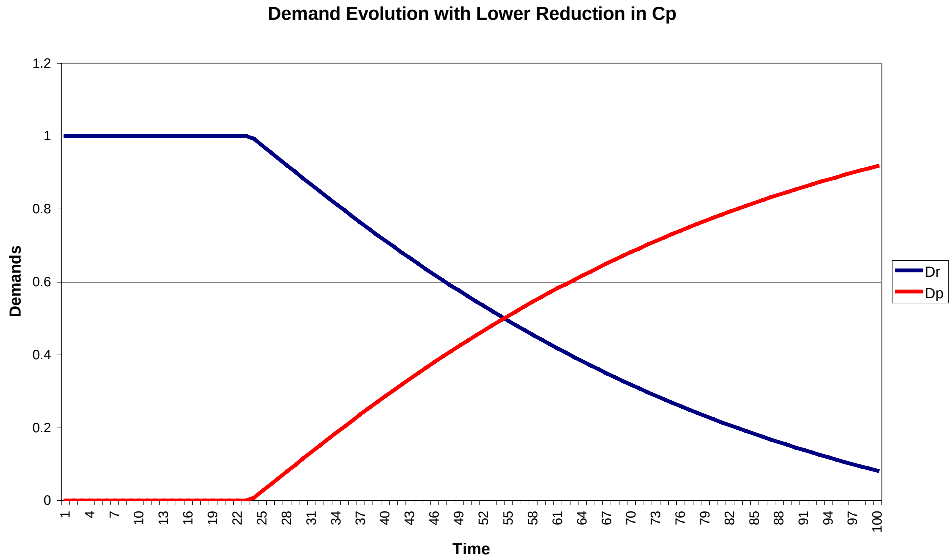
Substituting (7) and (8) in demand curves (5) and (6) we find that

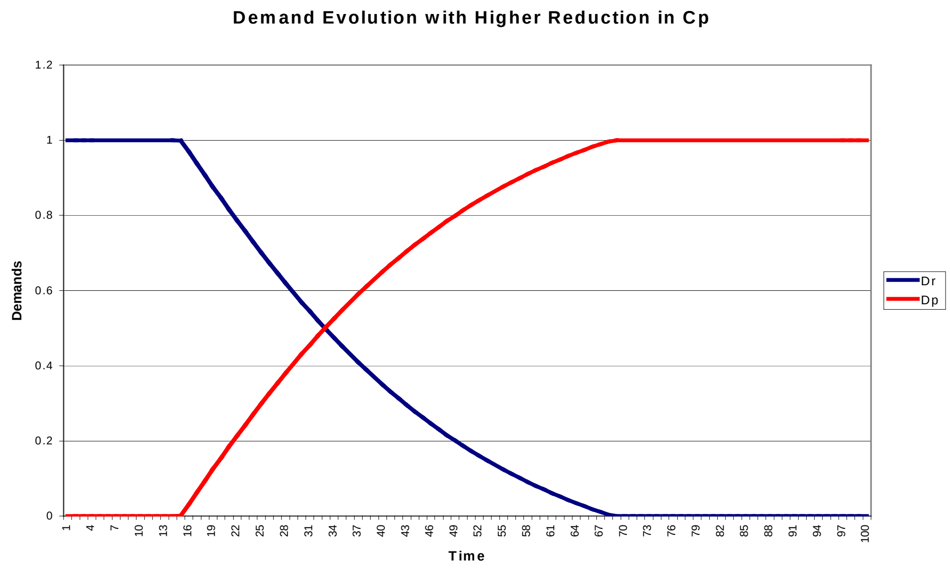
$$D_r = \frac{(\frac{c_p - c_r}{3}) + \tau}{2\tau} \qquad (9)$$

$$D_p = \frac{(\frac{c_r - c_p}{3}) + \tau}{2\tau} \qquad (10)$$

With different unit costs, demands with equilibrium prices are no longer equal. The firm with higher unit cost looses market share as a result of the cost difference. If, eventually $c_i - c_j = 3\tau$, firm i would have no demand and firm j would take over the whole market.

It is reasonable to assume that when a plantation starts to produce it has a higher cost than reserves due to knowledge gaps or maturity of trees. However, due to higher capital intensity, better production conditions or facilities regarding technological progress, the plantations are more likely to obtain cost reduction over time and therefore gain market share. To reproduce the dynamics of reserve's demand contraction it is possible to elaborate a simple simulation assuming that time evolution is composed by a series of "one shot" Nash equilibrium, adopting an exogenous cost reduction path for the plantation, and holding unit cost in the reserve constant. If we set the initial cost in the plantation exceeding the cost in the reserve by three times the transportation cost, then the reserve experience a temporary monopolistic situation. For our simulation exercises we set $c_{p_t} = \frac{c_{p_{t-1}}}{(t - t_0)^{\alpha}}$, $c_r = 0.05$, $c_{p0} = c_r + 5\tau$, and $\tau = 0.02$. Diagrams 4 illustrate the market share evolution considering low ($\alpha = 0.005$) and high ($\alpha = 0.01$) cost reduction in the plantation.





The development of the market share for the extractive reserve highlights that under most realistic assumptions, the constrained production conditions in the reserve lead to a declining revenue stream. This is on account of the unconstrained producer being able to reduce costs through investment. This investment is justified because it allows the producer to capture a higher market share from the reserve in the spatially differentiated market. If eventually the cost difference reaches a threshold the low cost firm takes over the whole market. This implies that there is only a limited time period over which production of a NWFP will generate significant revenues for the reserve. This limitation is exacerbated by the fact that the more revenue potential that product has, the greater are the incentives for the unconstrained producer to reduce costs quickly, and consequently the shorter the time period of profitable operation for the reserve.[3]

This rather pessimistic view regarding the revenue prospects in established markets for NWFP is supported by various empirical observations. Homma (1992), analysing the historical development of extractive activities in the Amazon, characterises the dynamics of NWFP as an economic cycle composed by 4 phases: expansion, stabilisation, and decline of the extraction, followed by cultivated plantations. The expansion phase is characterised by the existence of large reserves of resource and by the monopolistic position of the extraction region in the product market. The stabilisation occurs when the market tends to equilibrium close to the maximum capacity of extraction. The decline starts with the reduction of the resource base and with the increase in the extraction costs. Finally, the domestication phase begins during the stabilisation phase as long as technological and substitution constraints are not high enough and the demand remains reasonably stable. This theory of a revenue cycle is also supported by more recent empirical evidence for current NWFP produced in extractive reserves, most strikingly in the case of rubber over the last ten years. Although rubber is still the main product of extractive reserves, its production has been constantly declining since their creation. The rubber production in Brazil started the 1990s with almost 25,000 tons a year and finished the decade with less than 6,000 tons, facing a decline of more than 75%. In addition, rubber plantations are increasing in other regions of Brazil, particularly in the state of Sao Paulo. Charts 1 and 2 present the time evolution of rubber extraction and cultivation over the last decade. These charts give empirical support to the characterisation of the NWFP cycle by Homma (1992). Similar developments have been observed for nuts and other NWFP.

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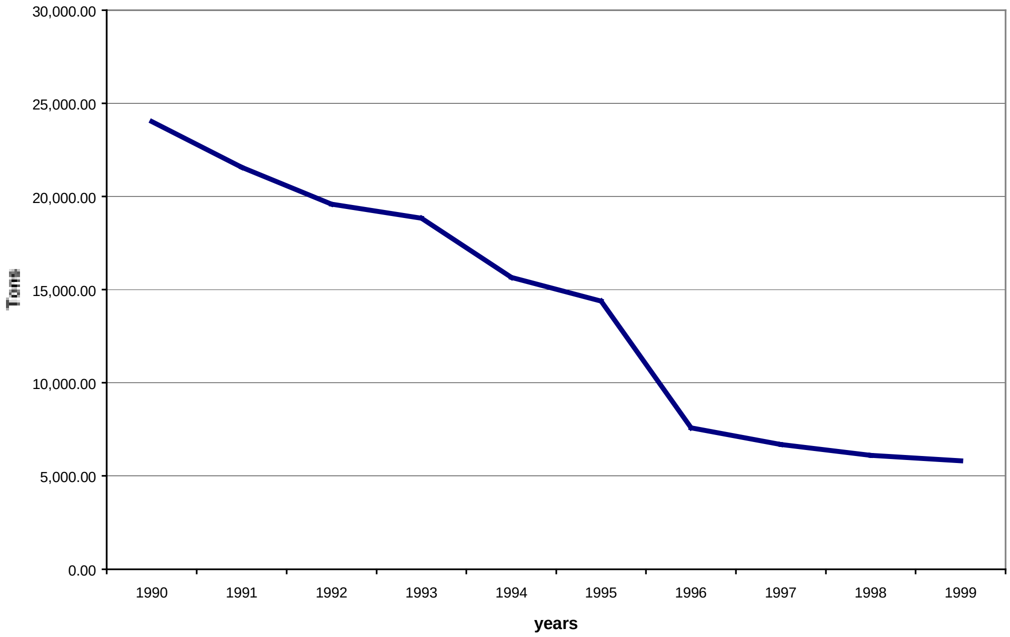
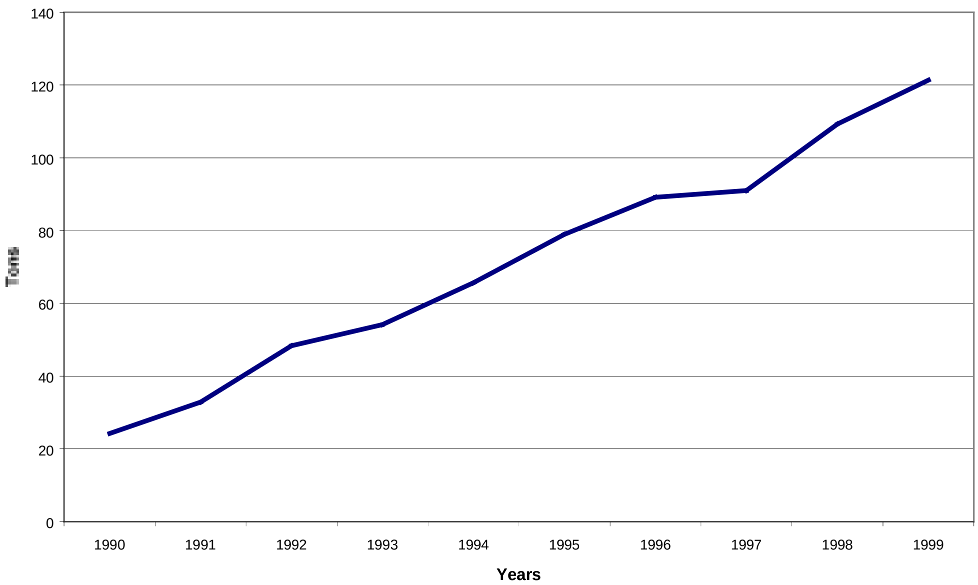
[3] Apart from the threat of domestication in plantations, revenues from NWFP produced in reserves are limited by the availability of substitutes. The substitution of natural products by synthetic ones can be triggered either by a shortage of supply or by technological advance.

Chart 1 Rubber Extraction in Brazil (1990-99)



Source: IBGE

Chart 2 Rubber Production in Permanent Plantations (1990-1999)



Source: IBGE

Both the industrial analysis and the empirical evidence strongly suggest that over a longer time horizon, extractive reserves are able to compete with plantations in the NFWP markets only under very restrictive conditions. These arise when plantations are not able to significantly reduce their costs or if transportation costs impede the plantations to compete in local markets around the reserves.

4.2. Markets for new NWFP

While the probability that extractive reserves can generate a long-run revenue stream in existing NWFP markets is limited, the empirical evidence points to temporary monopolies for extractive reserves in early stages of the market. Particularly in rubber[4], but also more recently in various nuts and oils, it has been observed that the initial phases of the NWFP market generate significant profits. There are various reasons to believe that such transitory periods of abnormal profits will generally exist: (1) Competitors face fixed costs of market entry; (2) initial production costs for competitors may be higher while cost reduction will not occur instantaneously, and (3) the demand for products may be partly endogenous and hence initially clustered around the reserve where it enjoys a location advantage over competitors even when its unit costs are higher.

This potential of a temporary monopoly in a specific NWFP market raises the possibility of a development pathway for extractive reserves that builds on the abundant biological capital available therein. If reserves are in a position to generate a sequence of novel NWFP, they are rewarded for this activity with a sequence of temporary monopolies in the markets for these new products. Whether this strategy is economically feasible depends on the returns to product search activities carried out in the reserve. Two factors need to be considered: One is the cost of product search carried out in the expectation of discovering a new NWFP with market potential; the other is the pool of potential products over which this search can be conducted. These factors will determine the returns to the search activity.

[4] It is sufficient here to mention the rubber boom in the late 19th and early 20th century.

4.3. Markets for inputs

Additional to pursuing a strategy of product discovery, the inexpensive access to a biological capital allows for a third strategy available for extractive reserves. This is to supply the biological inputs that its plantation competitors will be demanding in order to control the cost function dynamics (1).

A key variable is the price of biological capital. The plantation has a reservation price $\overline{\eta}$, which corresponds to the cost associated with setting up an enterprise to collect natural resources in the Amazon region. However the plantation can alternatively pay η_R, which is the price charged by the reserve to supply biological resources. If the inequality $\eta_R < \overline{\eta}$ holds, there are incentives for the plantation to buy biological inputs from the reserve. It is not unreasonable to assume that this inequality will be fulfilled given the labour-intensive production methods in the reserves. The methods allow those involved in the extractive activities to observe the traits of various tree varieties with respect to yield, disease resistance, quality of output etc. It is plausible, therefore, that extractive reserves will be able to identify characteristics valuable to plantations at a lower cost than a search process not relying on this prior information.

From the reserve's point of view, the most attractive feature of the supply of biological inputs to competitors is that it establishes a negative link between the development of the reserve's share of the market for NWFP and the revenue generated by the sale of inputs into NWFP production. Solving the production problem (3) faced by the plantation, it can be shown that the change in the plantation's demand for inputs from the reserve I_P^R is

$$\dot{I}_P^R = \frac{\delta_I(\bullet)}{\delta_{II}(\bullet)}\left[\rho + \frac{\delta_I(\bullet)}{\eta_R} q_P\right] \qquad (11)$$

Since $\delta_I<0$ and $\delta_{II}>0$, the change in the demand for inputs is a positive function of the production of the plantation, q_p. To the extent that reserves can supply these biological inputs, some mitigating compensation for the revenue loss on the NWFP market as q_p

expands is available. The dependence of the demand for inputs on the price charged by the reserve η_R generates an interesting interdependence that is an area of further research.

4.4. Development pathways

Based on the analysis of production possibilities available under the particular production conditions of the extractive reserves and the empirical studies reviewed, we have identified three main pathways potentially capable of supporting the economic viability of extractive reserves. The first is the continued production of existing NWFP. Although this is the most established mode of operation for extractive reserves, both the stylised spatial model and the empirical evidence cast doubt over the capacity of revenues from these markets to generate a sustained flow of income that can support growth in the reserves. The second pathway is the discovery of new NWFP that allow the creation of a sequence of temporary monopolies in NWFP markets. This pathway requires investment in product search and involves considerable uncertainty over the volume of returns generated. The third pathway we have identified is the supply of biological inputs to competitors on the NWFP markets based on the comparative advantages that the constrained mode of NWFP production in reserves creates in terms of knowledge about productivity-relevant traits in the biological capital stock. Here disease and productivity problems associated with intensive cultivation allow the reserves to serve as sites for *in-situ* conservation of genetic resources and supply the plantations of related products, transiting from output to input markets.

The long-term viability of extractive reserves hinges on whether at least one of the pathways identified can generate sufficient earnings to meet the scheme's development objectives. The structure of property rights over the outputs generated along these pathways and over the inputs necessary to generate them will be a critical determinant of whether these pathways have potential. The reason is that for development pathways to be pursued, the inputs required to access and support these paths need to earn economic rents. The quality of the property rights structure and the potential of the pathways available are therefore inexorably linked. Before we study this linkage, the following section surveys the property rights structure in place in extractive reserves.

5. Property Rights

5.1 Property rights structure within the reserve

Extractive reserves have an innovative and idiosyncratic internal property rights regime. It has a triple structure and can be seen as a co-management system involving the government, the community, and the individuals:

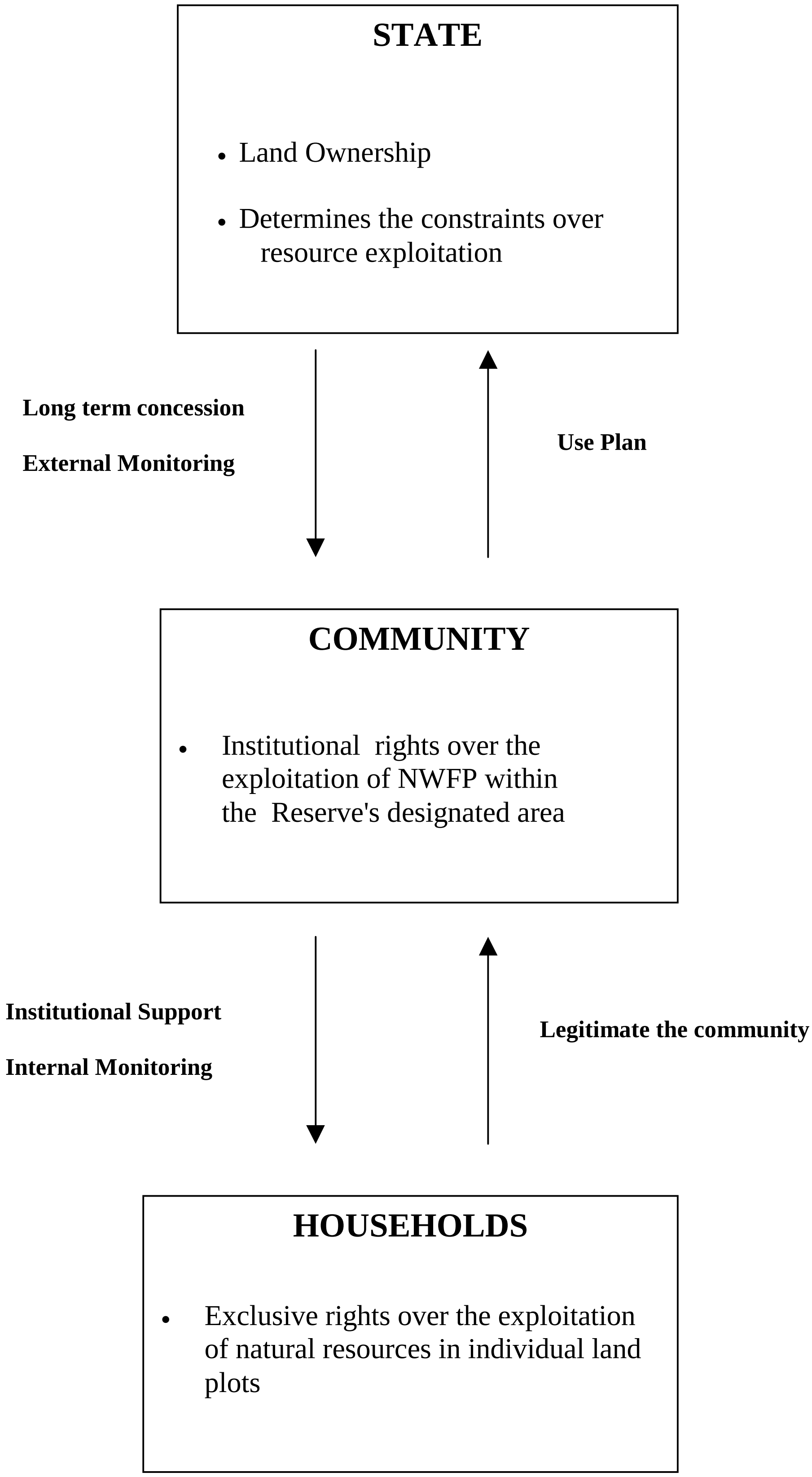
(a) The state owns the land and regulates the exploitation of the resources, giving the concessions to the communities and approving the use plan, and monitoring its compliance.

(b) The communities write the use plan, receive the long-term use concession of the natural resources, and are responsible for the full application and respect of the use plan. Communities also negotiate with the government the construction and management of health and education facilities in the reserves.

(c) The exploitation of the resources is made within individual land plots (“colocacoes”). Each household organizes his/her extraction activities and cultivation of subsistence crops. Co-operation between households is more or less frequent depending on the particular case, but the results are privately appropriated.

The external property right structure includes only the NWFP. The households can sell and fully appropriate the value of their production of extractive products. They cannot sell neither the land nor the use of exploiting the land.

Property Right Structure in a Typical Extractive Reserve



In order to assess the possibilities of a community to cope with the challenges of managing local natural resources based on collective action, Ostrom (1990) has elaborated seven "design principles" that characterize robust institutions, present in several cases of common property resources she studied. By "design principle" she means "an essential element or condition that helps to account for the success of these institutions in sustaining common property resources and gaining the compliance of generation after generation of appropriators of the rules in use" (Ostrom, 1990, p.90). Table 3 presents the Ostrom's principles.

Table 3 Design Principles Illustrated by Long-enduring CPR Institutions

1. Clearly defined boundaries. Individuals or households who have rights to withdraw resource units from CPR must be clearly defined, as must the boundaries of the CPR itself.
2. Congruence between appropriation and provision rules and local conditions. Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labour, material, and/or money.
3. Collective choice arrangements. Most individuals affected by the operational rules can participate in modifying the operational rules.
4. Monitoring. Monitors, who actively audit CPR conditions and appropriator behaviour, are accountable to appropriators or are the appropriators.
5. Graduated sanctions. Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offence) by other appropriators, by officials accountable to these appropriators, or both.
6. Conflict-resolution mechanisms. Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.
7. Minimal recognition of rights to organize. The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.

Source: Ostrom (1990, p.90)

In principle, extractive reserves have most of the necessary institutional characteristics, proposed by Ostrom in her design principles, to enhance the chances of a successful management of natural resource with an active role for the rural community:

(a) Boundaries and population with use rights are clearly defined;

(b) Although approved by the government, everyone involved in the community designs operational rules;

(c) Monitors are the appropriators themselves;

(d) There is an association, which is a local forum for conflict resolution. For more serious or complex problems there is also the National Council of Rubber Tappers, which congregates the associations of all reserves. The government also provides a institution structure which represents the communities called the National Centre for the Sustainable Development of Traditional Populations (CNPT) based on the Ministry of the Environment;

(e) Governmental authorities do not challenge autonomous institutional building. On the contrary there are a number of initiatives, sponsored by the government and NGOs focused on governance and institution building within the extractive reserves.

Overall therefore, the structure of property rights within reserves creates incentives that are compatible with a conservative use of the biological capital base and provides incentives for the extraction of a defined set of NWFP in the extractive reserves. This structure ensures that contributions from members of the community to the specific extractive activities in the reserves will be rewarded in congruence with the local production conditions.

How well does this structure works with respect to contributions of members that are not related to the pre-defined set of NWFP? There is little evidence that the appropriation and provision rules reward two critical inputs required to access the development pathways of diversification and biological input supply. The critical input into accessing the pathway of diversification is search activity directed towards the discovery of new NWFP with revenue potential. However, as individuals in the reserves cannot exclude others within the reserve from benefiting potential discoveries, there are few incentives for putting efforts in research and development activities. In addition, the human capital base formed by the traditional populations not necessarily aggregates de necessary expertise to carry out systematic research and product development. The critical input into biological input supply is knowledge about production-relevant characteristics of the local biological capital stock. However, there is currently no mechanism to reward the information an individual has with respect to the biological characteristics, productive properties and resistance to diseases, the different varieties might have. Neither one of these inputs is therefore considered under the use plan or included in the quasi-contractual relationships between households and the wider community such as the ones that govern the benefit sharing over revenues from the marketing of NWFP.

5.2. Property rights structure in the wider economy

A related, but separate issue is the property rights structure over the commercial outputs generated by the extractive reserve in the wider economy. One factor that supports the functioning of the property rights regimes within the reserve with respect to existing NWFP is the fact that the property rights over the output of the production system can be easily defined and are well established both within and outside the reserve. The reason is that the existing NWFP produced such as rubber and nuts have the classical characteristics of private goods: They are both excludable and rivalrous in consumption and protected by adequate legal titles.

This rights structure over NWFP in the wider economy facilitates the definition of boundaries and helps ensure congruence between input provision and share of benefits from the output within the reserve. However, with respect to the discovery of new marketable NWFP and the supply of biological inputs, the property rights structure in the wider economy is less supportive. In the case of discovery, since the search procedure does not involve the *creation* of a novel product, extractive reserves are not protected from imitating companies. However, the property rights in the new NWFP itself are again compatible with rewarding inputs. This contrasts with the case of biological inputs. The property rights in biological inputs, most importantly genetic resources, are currently in the public domain. This means that no property rights in the local biological capital are assigned to the community living in the reserve. The obvious consequence is that the supply of biological inputs in a narrow sense cannot generate economic rents for the reserve under the current set of property rights.

6. Development pathways and property rights structure

As section 5 has demonstrated, the current set of property rights in extractive reserves is based around the continued extraction of established NWFP. This reflects the origins of the extractive reserve model favoured by the rubber tappers' movement. Within this narrow remit, the property rights structure represents a very effective response to the competing objectives of conservation and income generation.

Considering a wider choice of development pathways, the adequacy of the current property rights structure is less apparent: Rewarding contributions to an expansion of products that the community markets is conducive to a pathway directed towards diversification. Likewise, rewarding the supply of biological inputs and knowledge about the characteristics of these inputs contributes to a development process built around biological input supply. The current property structure both within and outside the reserves presents considerable deficiencies to provide incentives for these two possibilities of turning the extractive reserves economically viable. Table 4 summarises the contribution of the property right structures over inputs (i.e. rewards within the reserve) and outputs (rewards for the reserve) with respect to the three development pathways discussed in the paper.

Table 4. Contribution of Property Rights to Development Pathways

	Development Pathways:		
Property Rights :	*Existing NWFP*	*Diversification*	*Biological Input Supply*
over inputs	effective	deficient	deficient
over outputs	effective	effective/deficient	deficient

Table 4 demonstrates that only the currently pursued development pathway, which relies on the extraction of existing NWFP, is fully supported by the property rights both over inputs and outputs. A strategy involving diversification is discouraged by a lack of rewards for the input supporting that strategy, specifically the activity of product search, but has partial support in that the new NWFP themselves are covered by the current property rights over outputs. Lastly, the pathway involving the supply of biological inputs is supported neither by rights over input nor over outputs.

This finding is problematic when set into the context of section 4: The current property rights structure encourages the reliance on only one of the three possible pathways. This limits the width of the revenue base at any given point in time on which economic development of the extractive reserve could be based. Over time, this limitation is even more problematic since the analytical and empirical evidence suggest that revenues from existing NWFP production will either be insignificant or, if significant, only temporary. The current property rights regime also contains features that in themselves undermine the development objective of the extractive reserves. One example is that because no functioning property rights exist for biological inputs at the same time as the government conserves biological capital on public land (notably extractive reserves), plantations benefit from an inexpensive supply of these essential inputs into NWFP production. This reduces plantations' expenses for inputs, enabling them to compete even more effectively with extractive reserves on the NWFP markets that are supposed to generate the revenues to develop reserves economically. In such cases, the conservation and development objectives are clearly in conflict and require adjustment.

7. Conclusion

The instrument of extractive reserves has been advertised as a novel approach to reconciling biodiversity conservation and economic development. It is on the basis of this claim that their number and size is currently undergoing expansion in the Brazilian Amazon as well as in other parts of the developing world such as the Indonesian Kalimantan (Peluso, 1994).

In this paper, we characterise the peculiar production conditions for NWFP that exist in extractive reserves and assess the development pathways that these conditions offer to the communities living there. These pathways are the marketing of existing NWFP, the diversification into new NWFP and supply of biological inputs to other NWFP producing companies. The pathways are then set against the current property rights structure within the reserves and in the wider economy. The extractive reserves in the Brazilian Amazon have an innovative structure of property rights combining elements of public, communal and private ownership and use rights. This idiosyncratic combination seems to produce the appropriate incentives for efficient conservation and economic exploitation of existing NWFP. However, the analytical and empirical evidence suggests that the revenue potential in existing NWFP is very limited. On the other hand, the existing property rights structure does not facilitate accessing the remaining two development pathways. This suggests that without significant changes the development objectives of the extractive reserves are unlikely to be realised.

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