COMMUNITY MANAGEMENT: AN OPTIMAL RESOURCE REGIME FOR TROPICAL FORESTS?

INTRODUCTION

An important strand of thinking about efficient use of natural resources is the economic theory of commons. It is conventionally argued that common property rights are inconsistent with efficient utilization of natural resources in the absence of some form of government intervention, and that given the impediments to effective intervention private property rights are a better bet (Gordon 1954, Scott 1955, Hardin 1968, Anderson 1977, p.29, Hartwick & Olewiler 1986, pp.8-9). Rose (1994) challenges the validity of this proposition for some types of property, and concludes that communal management may be socially wealth-enhancing for properties with certain of the characteristics of public goods. Also calling the conventional theory into question is a rich and growing body of empirical evidence from around the world which points to the successful management of a wide variety of natural resources as common/communal property: fisheries in Japan (Kenneth 1989), U.S.A (Acheson 1989), Mexico (Miller 1989); forests in India (Kant, et.al., 1991, Poffenberger & Singh 1991, Campbell 1992) and Canada (Brightman 1987); water in the Philippines (Cruz 1989), U.S.A (Ostrom 1990) and India (Wade 1987); grazing lands in Botswana (Peters 1987) and swamplands in Borneo (Vondal 1987). Rose's important essays (1994) are pathbreaking in articulating some of the underlying reasons for resources such as roads and waterways to be managed publicly. Some authors have used game-theoretic frameworks to explain the observed frequency of collective action in natural resource management (Runge 1994, Sethi and Somanathan 1996). While such game-theoretic models, together with the empirical literature, offer important insights into the sustainability of common property regimes, a solid theory of the optimal institutional bases for resource management is necessary both for a fully satisfactory understanding of such regimes and as a basis for policy prescriptions. In this paper, we attempt a more formal theory of optimal resource regimes in which institutional factors are taken account of explicitly; we also offer some policy suggestions.

A valid theory of institutional alternatives must reflect the real world influences critical to effective resource management and take account of the manner of their interaction. In his paper on social cost, Coase (1960) argued that economists had ignored the basic production input, "the right to produce". The still popular economic theory of commons (Gordon, 1954) has similarly overlooked the fundamental role of institutional structures and associated transactions costs (the costs associated with the maintenance of a given system of resource use--see below) as elements of the set of opportunity choices facing resource owners/managers. Gordon's (1954) argument is that, given the inability to exclude others, a set of competing individuals will use a common resource until total revenue equals total cost. In light of the alleged inefficiency of the commons, economists have argued either for a private property regime (Demsetz 1967, North and Thomas 1977, Posner 1977, 10-13) or for government intervention, in the form of quotas or taxes to reduce extraction to the optimal level (Plourde 1971, Bell 1972, Brown 1974). Despite the increasing recognition of the role of transactions costs as a determinant of productive efficiency, this has not led to a comparably general widening of the range of property rights systems discussed in the economic literature; the discussion of property rights has typically remained restricted to the comparison of private and state regimes. However, recently, property rights and institutions have attracted the attention of a large number of resource economists,[1] who have attempted a comparison of different resource management arrangements while treating the system of property rights ("resource regime") as a fixed input. Randall (1987, 159) argued that any one of the possible specifications of non-attenuated rights would lead to Pareto efficiency, but the efficient solution would be different for each specification of rights. Thus, he talked of the locally optimal outcome within the framework of a specific set of rights.

Dahlman (1980, p.138) argued the need to identify the exact relationship between production technology on the one hand and transaction costs on the other. Cheung (1987) suggested that the challenge to economists is to specify and identify what these transaction costs are and how they will vary under differing circumstances. But at the same time, he excluded common property from the set of possibly efficient institutions, arguing that the rent captured under common property is usually less than under a private regime, and making the strong claim that "No economy can survive if the majority of its scarce resources are commonly owned." Surprisingly, like Gordon thirty some years before, Cheung treated the common property regime as equivalent to open access. Meza and Gould (1992) highlight the fact that when the costs of enforcement of property rights are taken into account private decisions to enforce those rights may be socially inefficient; a social optimum may require free access to some privately owned sites. These authors also assume that high transaction costs exclude the possibility of efficient collective action, and limit their discussion of the effects of fixed enforcement costs to the case of private management. The same logic applies to state property. Thus, Meza and Gould’s discussion is also limited to private or state property.

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1 Including Krutilla and Fisher, 1975, 19-38; Scott and Johnson 1985; Bromley and Szarleta 1986; Randall, 1987, 153-63; Fortmann and John 1988; Magrath 1989; and Pearse, 1990, 173-93, Bromley 1991, Luckert 1992.

Thus, though the importance of the relationship between production technology, resource regime, and associated transaction costs has been recognised since the articles of Coase (1937, 1960), resource regime has not been fully incorporated into the economic production models to identify the most efficient such regime from the full set of options ranging from open access to private regime. An adequate economic model of resource regimes--one that can identify a global maximum, must treat both physical inputs and property rights as variables, and should account for variation in transaction costs. Such a model is missing from the literature.

The numerous examples of successful management of natural resources under common property systems have not yet led to a due recognition of the organisational capacity of community groups. The cited empirical evidence suggests that the alternative of collective action does warrant serious consideration under certain circumstances. Many local communities possess a wealth of knowledge regarding their environment and how to manage natural resources to meet their needs. Over the centuries, they have developed social and technological strategies to respond to diverse ecological settings. While the viability of many indigenous systems has been eroded with time, some newly emerging community organisations are establishing or re-establishing such systems. Their success will depend upon such factors as policy support, the existence of appropriate agencies to facilitate organisational development, and training capacity. In this paper, our emphasis is on identifying the socio-economic conditions under which different resource regimes will be economically efficient, so these issues are left aside.

Our main argument is that the wide range of possible resource regimes between the purely private at one extreme and open access (i.e access to anyone) at the other should not be neglected. Transaction costs, associated with the implementation and monitoring of the resource regime, can be a significant component of the total cost of using a resource. They vary with the characteristics of the resources, the characteristics of the regime itself and the socio-economic conditions of the surrounding community, and they constitute one of the factors determining the <u>optimal resource regime.</u> Quantitatively important transaction costs raise the likelihood that regimes somewhere in the middle of the spectrum--such as a community regime or a joint regime (among community and state, community and private, or private and state), will be the most efficient; the presence of such regimes in a variety of real-world settings further confirms this possibility.

Though the possible economic optimality of community regimes has been recognised in the empirical literature, it has not yet been incorporated in production models which would help to elucidate the reasons for its relatively superior performance in selected contexts. In this paper, we incorporate institutional structure into a static analysis[2] of optimal resource management regimes which aims to correct this neglect. Our analysis extends the existing literature in several respects. The main contribution is the incorporation of resource regime as

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2 The focus being on static analysis, dynamic issues as on-going interactions among agents and group dynamics are not discussed in this paper. These issues are addressed in Kant and Berry (1998).

a variable in natural resource production models. The paper also identifies: i) a continuous array of regime possibilities varying from open access at one extreme to private regime at the other rather than just the two extreme options of state and private regimes; (ii) the socio-economic characteristics of the resource's "user group" (those receiving some direct benefits from the resource) as the main determinant of the relative efficiency of different regimes; and (iii) a specific mathematical form for the transaction function, in order to facilitate empirical studies in this area.

Forests and woodlands occupy approximately two-fifths of the earth's land surface, and this area accounts for 60 percent of the net biomass productivity of terrestrial ecosystems (Olson 1975). Hence, forests are one of our important natural resources; in the present context of environmental degradation and global warming, they have acquired increased importance. Issues surrounding their management have received serious attention from every sector of society, from local communities to provincial and national governments and the international organisations. The importance of forests to society, together with the complex and varied institutional features which often surround their management, lead us to focus on them in this paper.

Forests are a stationary renewable resource characterized by relative indivisibility in the sense that they cannot be divided into small patches of a few hectares without losing some of their silvicultural characteristics, related sources of productivity, and the capacity to regenerate[3]. These physical features, together with the frequent non-exclusion of local communities, are the main reasons behind private market failure in the forest sector. In this paper, the special physical characteristics of the forest resource are treated as a given. As a result, the model we develop cannot be extrapolated to other resources with different physical characteristics. Fisheries, underground water, and surface water, for example, are unlike forests in being non-stationary resources, while agriculture differs in being more highly divisible without significant loss of productivity. Though the concepts we use in incorporating institutional structure into our analysis are general in nature, and can be extended to other similar "local commons" resources such as pasture-land and inshore fisheries, such extension requires careful attention to the physical characteristics of these resources.

The first section of the paper discusses concepts pertaining to resources, institutions, and resource regimes, as well as the social context of forest management in the developing economies where tropical forests are found. Based on these concepts, section II develops a general economic model for resource use, in which Gordon's (1954) model appears as a special case. In section III a mathematical form is suggested to represent the general nature of the transaction function. The optimal conditions for separable and non-separable transaction and transformation functions are discussed in section IV. Finally, we conclude with the need for developing area and resource-specific transaction cost functions to aid in the design of efficient resource management systems for diverse conditions. Some recent institutional shifts in forest management in India, which provide a backdrop to some of the points made in the text, are given in appendix.

SECTION I: CONCEPTS AND DEFINITIONS

A resource is something useful and valuable in the condition in which it is found (Randall 1987, p.12). Its use is determined by two aspects of a particular society-- available technology and institutional structure. A technology is a combination of physical and human capital used to convert inputs into outputs (Bromley and Szarleta 1986). The institutional structure is made up of a set of rules, compliance procedures, and moral and ethical norms which constrain the behaviour of individuals in the interests of maximizing the wealth or utility of principals (North, 1981, 201). A given resource-technology combination might be useless in the absence of an appropriate institutional structure. A resource regime is a structure of rights and duties characterizing the relationship of individuals or decision units to one another with respect to the resource.[4] Institutional arrangements are continually established (and refined) in order to determine (and to modify) the scope and nature of the resource regime (Bromley, 1991, p.22).

In this context a "property" is not merely a physical object (e.g. land) but rather the right to a benefit stream, a right that is only as secure as the duty of others to respect the conditions that protect that stream (Bromley, 1991, p.22). The relationship among relevant individuals or decision units can be specified as a set of rights, duties and privileges. When one's interest is protected by a right to undertake certain actions, one is protected against the claim of others by their duty to respect one's right. If the others do not have that duty, then the individual may have only a privilege; in that case one has no protection against the claims of others, but as long as one "gets there first" one can do as one wishes with the property in question, since the other parties also have no rights. Based on these concepts, resource regimes have been categorized into four classes: (1) private (2) state (3) common/communal and (4) open-access[5]. The first three categories involve both rights and duties while the fourth is a situation of privilege but no rights or duties. Under private, state, and common property regimes, the resource management rights are vested in an individual (or corporate bodies), government, and an identifiable community of resource users, respectively. Open access is characterised by the absence of well-defined property rights, implying free access to every one. However, physical characteristics of the resource and political boundaries typically limit freedom of access to a selected group; based on these limits, resources used under some form of open access are grouped into "global commons" and "local commons". In the case of global commons such as atmosphere, sunlight, and ocean resources, access is open to every one all over the world. In the case of local commons, freedom of access is, in practice, limited to the people who live close to the resource--limited by the political and administrative boundaries of a village, region, or a country, and by the high cost of travel for people who live far from the resource. Examples are pastureland, inshore fishery, and forest resources. However, we refer to these resources as "commons" only when they are under an open access regime; if their use is

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3 Forests, particularly tropical forests, are associations of thousands of species of flora and fauna. This association offers a natural environment that encourages growth and regeneration of these species. Division into small parcels destroys this natural environment and hampers the growth and regeneration capacity of these species, thereby resulting in a reduction of the total returns from the forest and the threat of extinction of many species. This difference in production process (indivisibility) and others (discussed in footnote 24) explain why the optimal resource regimes for are not the same in agriculture as in forests.

4 In this paper, resource regime is a broader concept than ownership. The terms "resource regime" and "property regime" are used interchangeably.

5 Godwin and Shepard 1979, Bromley 1986 and 1989, Jacobs and Munro 1987, p.442, Berkes et al., 1989, p.91, Bromley and Cernea 1989, p.3-5, Gibbs and Bromley 1989, Feeny et al., 1990.

controlled by well defined property rights, we consider this to be a community regime.

******* Our paper is based on forest resource that has the characteristic of local commons. (This sentence does not appear accurate).****************

Any resource regime will have de facto rules which set the rights, privileges and duties with respect to each type of benefit stream the resource can provide. Control of access involves limitations on the privileges of the various actors, those who have such privileges and those who do not. Overuse of the type which plays the central role in the simplest "tragedy of the commons" stories can come either from outsiders--those with no privileges which are recognized by the group in control of the resource, or from insiders, whose privileges are recognized. The objective of the group in control of the resource is to minimize extraction by outsiders; thus outsiders who try to make off with a forest product in an area "controlled" by a group of which they are not a part will be treated as thieves by the insider group. Overuse by insiders is a different matter; where it is a threat it is to be expected that the group will devise rules to limit use by each member. Control will tend to be preferentially through internalization of those rules by all members, and, where this fails, by sanctions of some sort.

The difference between a de jure condition and a de facto condition is also important in the description of resource regimes. A state or privately owned resource may in reality be under open access if the owner is unable or uninterested in excluding potential user groups. In other cases, a discrepancy between the de jure and the de facto situations can cause conflict around the resource. Inefficiency in the use of a resource is frequently associated with such a difference between the de facto regime and the de jure one. Hence, one objective of this paper is to suggest policy changes such that de facto resource regimes converge to de jure resource regimes.

A resource regime typically has several economically important dimensions (comprehensiveness, exclusiveness, benefits conferred, responsibilities, managerial system, technologies employed, etc), each of which varies across a spectrum (Pearse 1990, p.181). For simplicity we focus here only on the dimension of principal interest to us--access or exclusiveness,6 and we distinguish among resource regimes in terms of a bounded but continuous variable, rather than a discrete one, i.e. we think not only of the four discrete regimes just identified but of a multitude of possible options along a property continuum from open access to a purely private regime where access by anyone except the agent who controls and manages the resource is zero (Rohlmann,1992).7 Hence, in our terminology, a resource regime involving a state or privately owned resource not characterized by exclusion of other potential users (in particular the local community) group will not be described as a state or private regime, respectively. A state or privately owned resource may be under open access, or under a community or joint regime depending upon who is excluded.8 For example, in India, almost all the forests are owned by the state. Some are used by local communities without regulations or control by community members; we refer to this arrangement as a de facto open access resource regime and not a state regime. Similarly, some of these state forests are used by communities which have their own set of rules for management and use; such forests are legally under state regime but de facto under community regime. In some other areas, state governments have formally recognised the use and management rights of local communities, and the forests are managed jointly by communities and the state government; we refer to them as joint regime forests. They may be joint between: (i) communities and the state government, as in India; (ii) the state government and private companies, as with Forest Management Agreements in Canada; and (iii) private companies and communities, a combination which is not common in forest resources. The wide variety of joint forest management systems observed in different parts of the world argues for thinking in terms of a continuous spectrum.9

In the case of forest resources, the two broad categories of outputs are timber and non-timber products. In the case of tropical forests in developing economies, frequent examples of non-timber forest products are leaves, roots, flowers, and fruits. Under open access, there are no restrictions on the use of any output from forests, or exclusion is zero. Under a community regime, the user group is entitled to all the products, but the use is regulated in terms of harvesting time and quantities that can be harvested at a particular point of time. Hence, there is some exclusion. In the case of a joint regime (between state and community), the user group gets only a fixed share of timber products and of nationalized non-timber products, while getting the full harvest of non-nationalized non-timber products. In the case of a state regime, the local user group is totally excluded from timber and nationalized non-timber products, but not from the use of some non-nationalized non-timber forest products. Under a private regime, the user group is usually excluded from all products. Hence, as we move from open access to the private regime along a spectrum defined in terms of the degree of exclusion of the local user group, the sequence of regimes is from open access to community regime to joint regime (between state and community) to state regime, and finally to private regime.

The enforcement and monitoring of a resource regime typically involves costs, commonly referred to as transaction costs or information, contracting and policing

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6 Such variables as technology and managerial style will of course be at least in part a function of the more clearly institutional features of a resource regime (inclusiveness, etc), but they can in principle also be determined exogenously to these particular institutions, in which case they constitute other dimensions or variables helping to define the resource regime in a basic sense. The dimension of primary interest to us here is openness of access.

7 In the case of open access regime of forest resources, as discussed above, access is open to all members of the identified user group only. However, due to absence of well defined rights and duties of user group with respect to resource use and management in the case of open access regime, it is not the same as of the community regime.

8 Because degree of access is a complicated concept, involving not only exclusion of outsiders but also control of use by insiders, the use of a simple spectrum of degree of access is a considerable oversimplification of reality. It is adequate, nonetheless, to allow a basic discussion of some of the implications of degree of access and systems to control it. Note that, since access depends not only on who owns the resource but how desirous and able they are to exclude various potential users, there is no unambiguous relationship between de jure ownership and degree of exclusion or de facto resource regime.

9 These include joint forest management in India (Malhotra and Poffenberger 1989), CAMPFIRE (Community Areas Management Program For Indigenous Resources) of Zimbabwe, and ADMADE (Administrative Management Design) for game management areas of Zambia (Forests, Trees and People 1991). The spectrum of inputs and benefit sharing arrangements in joint forest management in India (Kant & Nautiyal, 1994) also strengthens this case.

(ICP) costs. A particular structure of transaction costs is associated with each resource regime (Bromley 1991, p.142). Developing a new regime is likely to involve additional costs of inducing behaviour patterns which do not yet have the sanction of common practice. The optimal regime for a given resource depends not only on the physical production (transformation) efficiency with which the inputs it provides are converted to outputs, but also the level of transactions costs (transaction efficiency). Socio-Economic Factors (SEF) may be important determinants of optimal resource regime in a given resource cum "user group" environment[10]. We focus on two such factors: user group heterogeneity with respect to the resource ("), and the degree of user group direct dependence on the resource ($).

User Group Heterogeneity with respect to the resource ("). Members of the user group will often have a range of somewhat differing preferences regarding resource management, or assign different priorities to the various objectives of resource management, either because of differing personal interests in the resource or differing degrees of involvement in the social group. People think of themselves both as separate "individuals" and as "members of a social group". In traditional societies, where people see themselves first as members of the group and only secondarily as independent individuals, an inherent spirit of cooperation is generally present even in the face of large economic differences and social stratification. This spirit is muted in modern industrial societies, where people are first and foremost "individuals", more truly homo-economicus. The heterogeneity of individual interest with respect to how a resource is managed reflects both economic differences (e.g. income level) and social and cultural traditions or norms[11]; the extent to which "personal" interest fully determines an individual's behaviour with respect to the resource depends on the degree of "community spirit"; hence, the level of heterogeneity (", allowed to range between 0 and 1) will vary inversely with the degree of such "community spirit" as well as with economic differences[12, 13].

Rose (1994) argues that under some circumstances property might be more valuable as a commons than it would be in individual hands, because the administrative costs of customary management are low relative to those of an individual property system. In so arguing, she cites social or group customs as

10 The "user group" (those receiving some benefits from the resource) is defined somewhat loosely here in the sense that we do not take into account the fact that the resource regime selected will in fact determine to some extent which individuals and families are able to take advantage of the resource. In other words, the composition of the user group is endogenous. Since our analysis is not sufficiently detailed or refined to permit an interesting treatment of exactly who the beneficiaries will be, we disregard such endogeneity. One might, alternatively, think of the community which we define as the user group as the "potential user group".

11 It may be useful to consider a hierarchy of levels of heterogeneity. The basic level consists of cultural, economic, ethical and social differences. Due to these basic heterogeneities, the members of the user group may have diverse preferences for timber and non-timber products and hence prefer different product mixes (this could be termed second level heterogeneity). Diverse product preferences will result in different preferences with respect to the resource management regime (third level hierarchy). In summary, heterogeneity with respect to the resource regime can be treated as a function of the product preference differences, which can in turn be treated as a function of cultural, economic, ethical, and social heterogeneity. Researchers appear to have discussed only the first level of heterogeneity; for example, Ostrom (1990, p.89) argues that none of the successful CPR situations involves participants who vary greatly in regard to ownership of assets, skills, ethnicity, race, or other variables that could strongly divide a group of individuals. But, we think that for the success of CPRs, it is the third rather than the first level homogeneity that is the most critical (See Footnote 20).

12 This heterogeneity is the inverse of full agreement on and support for the same resource management regime. The greater it is the less will shared interest in a given regime help to make it work effectively, either in the positive sense of assuring positive contribution, as necessary, to effective management or in the negative sense of assuring that no members of the group will behave in ways which sabotage or lower the payoff from the resource. At the simplest, heterogeneity can be measured by the share of the total user group which has the same preference on resource management. For example, if a particular patch of the forest can be managed in any of four alternate ways (A, B, C, and D) and 80% of the user group feel that it should be managed in way A while the remaining 20% favour one of the other three, " could be defined as 1-0.8 =0.2. Under some circumstances it might make sense to define " in a more complicated way, takeing account also of strength of individual views, distribution among the non-first choice regimes, etc. For the heuristic purposes of this paper such complexity is not necessary. Heterogeneity is measured as a continuous variable.

Heterogeneity and dependence of the user group were measured in six villages (three in Madhya Pradesh, and three in Orissa state of India). Details of measurement methodology, and values of these variables are available in Kant, Nautiyal, and Berry, 1995. In the majority of the villages, the values of " and $ were in the range of 0.4 to 0.6.

13 Normally, homogeneity of preferences on resource management will depend upon first and second level homogeneity. But, sometimes, a strong mutuality of interest may override social, economic, or cultural heterogeneity. For example, when large catches by New Jersey fishermen depressed prices on the New York fresh fish market, they decided to form a local marketing co-operative. The co-operative decided on total catch levels for the fleet, and provided for the sharing of revenues regardless of the catch levels of individual boat (McCay 1980). Thus the marketing co-operative forced homogeneity with respect to resource (fish) management. Similarly, in South India (Wade 1988), Nepal, Indonesia, and Philippines (Ostrom 1993), mutual dependencies among head-end and tail-end farmers of an irrigation system forced homogeneity with respect to resource management among asymmetric (or first level heterogeneous) participants. On this point, see also Footnote 24.

one of the main factors in the success of commons. Our concept of homogeneity (heterogeneity) of the community is designed to include but go beyond the concept of group customs. Strong shared customs relating to resource management are likely to make a user group homogeneous in its preferences for resource management. Homogeneity of preferences can come from other sources as well, however, including societal features not easily encompassed in the idea of customs. Seabright (1993) points out that the degree of trust economic agents have in one another serves a crucial role in common property regimes. He offers a model of "habit forming" co-operation, in which the fact that players' beliefs about each other's trustworthiness are confirmed contributes to co-operative behaviour. Such a "habit forming" process is, however, unlikely to work in a community which starts with a high level of heterogeneity with respect to resource management preferences. Other factors such as small size of the user group, feelings of mutual obligations, and shared norms which have been suggested as encouraging conditions for successful CPRs (Bardhan 1993, Wade 1988, p.215), can also contribute to the homogeneity of the group.

The degree of direct dependence ($) of the user group on the resource. Every one depends on forests in some way. Forests provide many values suc~~h as items of consumption, recreation~~, environmental benefits, and spiritual benefits. In developing economies of South and South-east Asia or Africa, some tribal groups depend heavily on forests located close to their habitation for many consumption items such as food, fuel, medicines, and even monetary income (from sale of minor forest products) that are necessary to their subsistence. In developed economies, the "user groups" mostly depend on forests for derived items, such as pulp and furniture, which may be obtained from forest areas either near or far; similarly, their deriving recreational benefits does not depend only on nearby forests. The relationship between the user group and the forest is both less intense and less specific, in the sense of its linking a particular user group to a particular forest. Though some aboriginal groups do have this sort of "one to one" direct dependency relationship with a particular forest, this is less frequent than in developing economies. Here, we are interested in the degree of one to one direct dependence of the user group on a forest.

The degree of direct dependence by the user group is defined by the importance of direct benefits from forests in the group's total consumption bundle. Its range is here defined as running from 0 to 1. The fraction of the user group's GDP contributed by the forest may be taken as a first approximation of this level of dependence.[14] Also to be borne in mind is the extent to which the users can, if necessary, substitute away from their direct forest benefits to other sources. This depends both on the utility function itself and on the practical availability of substitutes for forest-derived benefits. If the utility function includes only forest-based benefits, there is no possibility of such substitution and hence the degree of direct dependence will be equal to one. The case of some subsistence tribal communities approaches this extreme; though in principle there are substitutes for most of the forest-based benefits, the user group is unable to take advantage of them because of its limited monetary income and perhaps its physical isolation. In the case of some benefits there are no substitutes, e.g. spiritual values. The importance of such spiritual values is hard to quantify, but both its central role in a number of conflicts between indigenous groups (tribal people of India) and the dominant society and evidence from participatory rural appraisal methods leaves little doubt that they can matter a lot.

The model specified below must be understood in the social context of forest management in developing economies. It is relevant to situations where community involvement in resource management is an interesting option, because there is a community (or communities) with a history of reaping some benefits from the forest or living in sufficient proximity to make that a natural aspiration. Any resource regime which excluded this potential user group would likely involve significant costs of exclusion. Often the user group community has experience in collective management which raises the potential efficiency of community control. Our focus is on the attributes of the potential user group which are likely to determine the performance of a community management resource regime.

SECTION II: GENERAL STATIC MODEL

Any economic activity, including those related to the use of natural resources, may usefully be thought of as involving a "transformation function" and a "transaction function". The former describes the process whereby physical inputs are transformed into physical outputs; the costs directly associated with this process can be termed technological or transformation costs (Wallis and North 1986). However, a given set of physical inputs may yield more or less output and that output may yield more or less revenue to the de facto right holder depending on the transaction function. In the case of certain natural resources, the transaction function assumes special importance due to the fact that efficiency in transformation is especially sensitive to the surrounding social institutions. For example, if a forest owner (say the state) is unable to exclude a local population (user group) it (the owner) may be unable to complete the transformation process. If we define output as the amount of product that generates economic return for the right holder, and the resource regime is treated together with labour, capital, and technology as a variable, then the production relationship can be expressed as:

$$Q = F(L, K, T, R), \qquad (1)$$

where Q is the output, L and K are physical labour and capital inputs1, while T and R refer to technology and to the resource regime respectively. The distinctive features of the resource regime are discussed in sections III and IV[15].

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14 What Wade (1988, p.215) refers to as the level of users' demand for the success of a common property regime is similar to our concept of degree of dependence. Our concept of dependence is somewhat broader than Ostrom's (1992) concept of scarcity, since in cases where the user group is independent or only indirectly dependent on the forest, the scarcity of the resource will not have any impact on the group's perception of and preferences on the forest regime.

15 One must also consider the impact of the resource regime on the value of output received by the society as a whole, not just that going to the de facto right holder. Qs could then be interpreted as the output received by the society, which would be equal to or greater than output received by the right holder. The optimal resource regime for the society would not necessarily, hence not in general, be the same as the optimal regime from the perspective of the right holder. The presence of benefits accruing to others than the right holder constitutes a form of externality which, as always, implies that the profit maximizing

Equation (1) differs from the standard production equation used in economics in that both resource regime and technology are treated as input variables. Since under the conditions discussed here the resource regime selected may constrain and hence determine the range of possible technologies and their productivity, it is useful to include technology (i.e. the set of technological options available) explicitly as a variable. Here, however, our focus is on the optimal resource regime. Accordingly, relationships between regime and technology are not addressed directly and only the resource regime is treated as a variable, along with capital and labour. Equation 1 thus reduces to:

$$Q = F(L, K, R). \qquad (1a)$$

The transformation and transaction functions may be separable or non-separable. In the former case, the transformation process is independent of the resource regime, hence total physical output is the same regardless of resource regime arrangements. The process of creating value for the society is completed in two separate stages. The transformation process can then be expressed as:

$$Q1 = F1(L, K), \qquad (2a)$$

where Q1 is physical output produced by transformation process, and F1 is the transformation function. The transaction function makes available all or part of Q1 to the right holder.16 It can be expressed as:

$$Q = Q1.G(R), \qquad (2b)$$

where Q is quantity of product received by the property holder, and G is the transaction function. In this simple case, the share of physical output received by the property holder is dependent only on the resource regime. In the non-separability case, the transaction and transformation processes interact such that the form of each function depends on the characteristics of the other. In the case of a natural resource like forests, this assumption, as expressed by Equation (1a), seems the more appropriate one.

The total cost of production in the exploitation of the resource will depend on quantity received by the property holder (Q), and the prices of labour, capital, and the resource regime (Pl, Pk, Pr) (The concept of resource regime price is discussed in sections III and IV.). Total cost can be represented as:

$$T.C = C(Q, Pl, Pk, Pr). \qquad (3a)$$

Under separability between the transformation and transaction functions, total cost is also separable into its transformation and transaction components. It can be expressed as:

$$T.C = C1(Q1, Pl, Pk) + C2(Q, Pr), \qquad (3b)$$

where C1 is the transformation cost function, and C2 is the transaction cost function. In the case of non-separability, total cost is expressed as in Equation (3a).

Since from the resource holders' point of view both the transformation and the transaction functions are 'productive', there is no need for a special 'transaction costs theory'; conventional price theory suffices (Wallis and North 1986).

Assuming that the quantity Q available to a right holder is sold in a competitive market, at an externally determined price P per unit, the level of profits (Z) is given by:

$$Z = P.Q(L, K, R) - C. \qquad (4)$$

Necessary first order conditions for profit maximization are:

$$(MZ/ML)=0 \text{ or } P.(MQ/ML)=(MC/ML), \qquad (5a)$$
$$(MZ/MK)=0 \text{ or } P.(MQ/MK)=(MC/MK), \qquad (5b)$$
$$\text{and,}(MZ/MR)=0 \text{ or } P.(MQ/MR)=(MC/MR), \qquad (5c)$$

i.e., the marginal value of the product with respect to each input should equal the marginal cost of that input. The "marginal cost" of resource regime is the cost of marginal change in the resource regime. These three conditions give a point/points in three- dimensional labour, capital, resource regime space, which can be tested for sufficiency.

In his (1954) theory Gordon abstracted from the resource regime.17 When transaction costs are independent of the regime, it is plausible to argue that greater rents may be obtained by bringing the resource under unified control. But if there are transactions costs which vary across regimes, this result is not assured. No theoretical generalizations are possible as to which regime is optimal.

For simplicity, let us assume that the average transformation cost is linear in output (as assumed by Gordon) and is independent of the resource regime, i.e. there is separability between the transformation and transactions functions. Figure 1 represents a situation in which average per unit costs rise with output due to increasing scarcity of the resource. The curve CpCp' is the average cost curve which would obtain in the case of a single constant returns to scale producer

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combination of inputs and outputs chosen by the property holder will not generally be the socially optimal one.

However, it is arguable that the two will normally be close to each other. A regime under which non-right holders receive a substantial share of total output provides less incentive for effective management of the resource by the holder and is therefore less likely to generate a high total output, especially if the production process requires significant management inputs. Also, to the extent that output received by others than the right holder has been obtained in an illegal manner (by theft) and assuming the society possesses a strong sense of right and wrong, the output extracted by theft would not be assigned much if any social value.

16 The part of Q1 not accruing to the right holder may go to other members of the society (as an externality) or be dissipated in some way such that it does not accrue to anyone.

17 The model was also spare in that there was only one physical input, labour.

in this industry.18 Under competition, which would occur given open access, this curve becomes a supply curve and equilibrium would occur at point A where this supply curve intersects the demand curve, here assumed to be horizontal at DD'. All producers would have average and marginal cost equal to OD and the total social rents would be zero. In the absence of transactions costs the socially optimal level of output is that at which marginal production cost, given by curve CpMp' (marginal to CpCp'), equals the price, i.e. point B. A single producer facing the same costs as the open industry would select that "efficient" point and would produce quantity Qb. Rents accruing to the producer would be the area DBFE. A set of producers induced to produce there by taxes or quotas would do the same as the single producer, as long as those instruments were set at the right level, though social gains would be less if there were significant administrative costs to such intervention.

The relative benefits from different regimes are naturally altered when regime-sensitive transactions costs are taken into account. If the private or state regime mentioned by Gordon faced the average transaction cost functions depicted as CtCt',19 then the average total cost curve for this single producer (including production and transactions costs) would be CC' (the vertical summation of curves CpCp' and CtCt'). The marginal total cost curve CM' intersects DD' at Qg, a lower output level than Qb. With sufficiently high transactions costs, any given regime (e.g. private or state) might fail to yield any rents.

Insert Figure 1.

We now develop a more complete model to determine the optimal resource regime under different socio-economic situations and the correspondingly different transactions costs. For the model to have real content, it is essential to know the general character of the transaction function, i.e. the way resource regime arrangements actually function. Though the precise shape of the function will vary with each combination of particular resource and user group, identifying general features constitutes a useful first step.

SECTION III: THE NATURE OF THE TRANSACTION FUNCTION

Heterogeneity of the user group with respect to the forest resource, and the group's dependence on that resource are two important socio-economic factors (SEFs) helping to determine, respectively, the costs of coordination and of exclusion. A user group nearly independent of the forest resource (implying that $ is close to 0) will have little or no interest in forest management, so exclusion of that group poses no problem to a private or a state regime2; such regimes have by definition no coordination costs. Hence, independence or very low dependence of the user group on the forest will contribute towards the optimality of a state or a private regime. A higher level of dependence by the user group will lead to costs/difficulties of exclusion; at a certain level of dependence, exclusion may become prohibitively expensive or impossible, leading to the failure of either private20 or state regimes and leaving the community regime as the only viable one21 Under community regimes, the users themselves design the management rules and implementation procedures. Their closeness to the resource and the strength of their local information system facilitate implementation.

While high costs of exclusion work in their favour, a main obstacle to an effective community regime is user group heterogeneity. Heterogeneity involves diversity in the interests of group members; as it increases, the chances of reaching a consensus and hence of smooth and effective resource management diminish21 and

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18 If there were decreasing returns to scale and the industry were under unified control, it would take the form of a number of small producing units under that unified control.

19 Average transaction cost is assumed invariant to output for simplicity. The analysis would proceed in the same way with any other function. The character of this function could vary widely. In some instances the bulk of these costs might be fixed, in which case the average transaction cost would approximate a rectangular hyperbole.

20 A high level of resource dependence is not a sufficient condition for the optimality of a community regime. It raises the costs of exclusion, but the pressure for inclusion of the user group does not necessarily augur for communal management. The user group may be included either by division of the resource among individuals (de facto a private regime) or through a community regime, with the relative merits of these two options depending on other physical and economic characters of the resource. Thus, of two user groups equally highly dependent on a resource--the forest in one case and agricultural land in the other, a community regime may be optimal for forests but a private one in agriculture. In addition to divisibility, other features such as frequency of production, value of output, the possibility of increasing yields by intensive irrigation, manuring, and crop rotation favour the private regime in agriculture. In the case of forests, private ownership of small patches would interfere with controlled continuous yields and present problems in meeting the minimal needs of each household. A community regime allows annual harvesting to meet the needs of each member. Under some circumstances both private and communal regimes exist simultaneously (private regime for agriculture and community regime for forest resources), as in Swiss villages of alpine peasants (Netting 1976) and rural villages in Japan (McKean 1982). Netting’s (1976) arguments for this co-existence are somewhat similar to ours.

21An example would be a user group composed of the households of different castes where the caste system defines the dominant social distinction in the group. The problems associated with this sort of user group heterogeneity may sometimes be skirted if the user group agrees to divide the total forest resource into parts (not into small patches of a few hectares for each family but into large areas with each group managing one part of the resource independently under a caste-specific community regime, and with boundaries defined by the painting the boundary trees. In the state of Orissa (India), heterogeneity of the user group was seen to lead to either destruction of forests (failure of community regime) as in the case of Joranda village, or to the division of forest amongst different but internally homogeneous groups as in the case of village Mahapada (Kant et al. 1991).

at some point the private regime will dominate the community one[22]. In the case of a heterogeneous user group the collection and analysis of information and consensus building on resource management will also be more costly because of the diversity involved. In the case of homogeneous groups the information in question and the views will be almost identical so these costs will be low. The contract (i.e. the rule system designed by the community for management of the resource) has to be incentive-compatible and enforceable. Its design mainly involves incorporation of the economic incentives and enforcement procedures appropriate to the particular user group, and requires discussion with most or all members of the user group to identify incentives and procedures acceptable to the whole group. The cost of this exercise will naturally increase with the heterogeneity of the group. For example, if " = 0.2, so that only 20% of the people have an opinion different from that of the majority, neither convincing this small number nor evolving compatible incentives is likely to pose a major problem. If "=0.6, only 40% of the people agree on how to manage the resource, with the rest differing both from this plurality group and probably also among themselves. Both reaching some consensus on how to manage the resource <u>and</u> developing a system which is incentive compatible and enforceable will have higher cost. The probability that some members will not follow the system once it is adopted will also increase. A stronger enforcement system will be required, leading to higher enforcement costs and possibly lower physical output levels. Hence, the costs of information, contracting, and policing will all increase with the heterogeneity of the group. Meanwhile, the policing (exclusion) cost will increase with the dependence of the user group[23].

The nature of the coordination and exclusion costs thus imply that as the heterogeneity of the user group increases and/or its dependence level decreases the optimal resource regime will shift away from community and towards private regimes, an inference supported by field observations.[24] All of the observed successful cases of community management of forest resources have two specific features: the user group is heavily dependent on the resource and is quite homogeneous with respect to views on resource management (Kant, et. al. 1991). State-imposed state resource regimes have failed in situations where the user groups are highly dependent on the resource, and this has been one of the major causes of deforestation in developing economies (Bundestag 1990, p.262; Poffenberger, 1990, p.xxi).

Insert figure 2

In terms of Figure 2, the low dependence-high heterogeneity combination (lower-left part of the diagram) favours the private regime. The high dependence-low heterogeneity combination (upper right part of the diagram) favours the communal regime. When both SEFs are low the combination of coordination and exclusion costs will not be too high for either type of regime, so both may be feasible, while when both SEFs are high then costs will be high for both and it again depends on the details of the case which will be more effective. As one considers the various contexts for forest management it is evident that the levels of heterogeneity and of dependence are not independent of each other; there is a general tendency for low heterogeneity to go with high dependence and vice versa, so that most real world situations may tend to lie fairly close to the diagonal from north-east to south-west in the figure. Moving along that diagonal (towards the south-west) implies that coordination costs rise while exclusion costs fall, with both these tendencies working against the effectiveness of the communal regime and in favour of the private regime. Movements along the other diagonal (north-west to south-east) involve rising exclusion costs (favouring the communal regime) and rising coordination costs in the communal regime where such costs apply (favouring the private regime). Along this diagonal it is not clear from general considerations how the balance of advantage will shift as between the two types of regime. As noted above, it seems likely that state regimes, when they are optimal, will be so for intermediate levels of the SEFs.

To further probe this question, we consider how the two types of transactions costs may be expected to vary across alternative regimes for given specific levels of the SEFs--dependence and heterogeneity of the user group. In terms of Figure 3, it is evident that if regime options are defined along a spectrum from open access to purely private management, costs of exclusion, when present, will increase as the regime shifts in this direction and costs of coordination will fall. The sum of these two cost categories--total transactions costs-- may rise or fall monotonically or may bear a quadratic relationship with regime, depending on the position and shape of the two component cost curves. In addition to these two socio-economic factors, transaction costs will also depend upon the opportunity cost of time of community people, which itself may depend upon these or other socio-economic factors as well as on the prevailing wage rates in the area. For simple exposition in what follows, we focus not on these two components of transaction costs but on the transactions function which links the quantity of output received by the rights holder to the total output attainable (the difference between the two reflecting the level of these two types of cost).

The appropriately specified transaction function should capture the economic intuitions discussed above and the real life situations they are based on. For

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22 For purposes of this discussion it is convenient to think of all relevant socio-economic factors as belonging to one or the other of two groups, those (like dependence) which favour the communal regime and those (like heterogeneity) which favour the private regime. For simplicity of discussion and of mathematical presentation we assume only those two SEFs. In a more complete discussion or analysis it would sometimes be important to distinguish among types of dependence and heterogeneity, as well as to recognize that some SEFs might not fit clearly in either of the two categories distinguished i.e., they might under some circumstances favour the communal regime and under others the private one. The degree of dependence of the subsistence rural poor may be very critical in some communities, while spiritual dependence may be central for other communities. In contexts involving a variety of types of dependence it would be necessary to consider how best to aggregate them. Similarly with respect to heterogeneity it may be useful to distinguish cultural, economic, ethnic and social aspects as they bear on a particular situation.

23 For simplicity of exposition we mainly link group heterogeneity with issues of 'information and contracting' (coordination) and group dependence with policing (exclusion) cost, even though each of these SEFs has some effect on both coordination and exclusion costs. Broadly speaking it seems clear that heterogeneity is the main determinant of information and contracting cost and dependence is the main determinant of policing (exclusion) cost.

24 A lower level of user group dependency raises the viability of all types of regime by lowering exclusion costs, but since these costs are a bigger problem for private and state regimes than for community managed ones, it raises the relative effectiveness of the former. At the same time, dependency and heterogeneity have to be looked together.

simplicity we once more assume the separability case in which the transaction function expresses the ratio of output received by the right holder to output produced or producible given the physical inputs used or available. The most plausible simple assumption is that the value of the transaction function is always positive, and--given the way in which the two costs are linked to regime-- can either have a single maximum value or be monotonically increasing or decreasing as the resource regime ranges over its domain from open access at one extreme to private property at the other.

The range of possible shapes of this function reflect those of the total transaction costs curve discussed above. For illustrative purposes, let us express the transaction G(R) by the mathematical form:

G(R) = *.R" (1-R)$ (6)

where R is the continuous resource regime variable, scaled for simplicity between 0 to 1 (but excluding the end points, for reasons explained later). An open access regime is represented by a number near zero. Common/community management, joint management (between community and state), and state management regimes are arbitrarily assigned the numbers 0.25, 0.5, and 0.75, respectively, while a private regime would have a value near 1[25]. The parameters " and $ are the two SEFs defined above.

The maximum value of the transaction function (the ratio of output available to the legal right holder to that produced by the transformation process) is one. In many real life situations that maximum will be approached, as in the case of state-managed forests located far from human habitations and thus under no pressure from a local population. Sometimes even when state-managed research forests are close to habitations, the local populace respects the will of the government and leaves almost all the produce for it. Where homogeneous communities like small tribal villages also have legal right to the forests, the holder (in this case the user group) once again gets almost all the produce. In the illustrative transaction function used here this element of reality is captured by the introduction of a scaling factor *, which normalizes the maximum value of the transaction function[26].

The shapes of a few transaction functions for different values of " and $ are shown in Figure 4. Salient features are described in Table 1.

Insert Figure 4

Table 1
Salient Features of The Transaction Functions Associated With Different Values of " and $

Value of " and $	Shape	Possible Resource Regime for Optimal Outcome
" and $ >0	Quadratic	Any regime depending upon the location of maximum of function
" > 0 and $= 0	Increasing	Private
$ > 0 and " = 0	Decreasing	Open access

To illustrate how the optimal resource regime is affected by the heterogeneity of the user group (") and its

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25 As mentioned above, only one aspect of the resource regime, exclusiveness, is being considered. Hence, different values of R represent different levels of exclusiveness. Open access, represented by a number near zero, means no exclusiveness, in the limited sense used here that members of defined user group suffer no exclusion. Exclusiveness increases as we move from open access toward private regime. "Private regime" implies total exclusiveness of local user group and hence is represented by a number close to 1.

As discussed before when the state is in charge of forest property exclusion will be less complete than when it is privately managed and exclusion costs correspondingly less. At the same time we assume that coordination costs (e.g. in the form of some level of bureaucracy) will be greater than in the private case though less than in various forms of community management. Exclusion will be less in the case of a community regime than a state regime, and in the case of a joint regime (between state and community) it will be higher than in the former and lower than in the latter.

26 On substituting the value of the optimal resource regime from equation (8) into the transaction function, we get the maximum value of that function:

maximum G(R) =*.{"/("+$)}" {$/("+$)}$ (7a)

If we assume that the maximum value of the transaction function is m, less than or equal to 1, then:

* = m.{("+$)"+$}/"".$$ (7b)

Though the maximum value of the transaction function will vary from place to place there are, as noted above, many real life situations in which it approaches 1. Accordingly, for illustrative purposes (for calculating the value of transaction function for graphs and discussion) we have elected to set m=1. Hence, the value of scaling factor * is given by {("+$)"+$}/"".$$.

degree of dependence on the resource ($), Figures 5(a) and 5(b) show how the shape of the transaction function varies when one of the parameters (" or $) is held constant and the other is varied. When values of " and $ are the same, the transaction function has a maximum in the middle of the range of resource regimes i.e., a joint resource regime between state and community (Figure 4). As the degree of dependence of the user group on the resource increases while the heterogeneity of the user group remains the same, the maximum value of the transaction function occurs at lower values of R (farther to the left in the Figure 5a) since with this change in dependence a private resource regime becomes less effective relative to a common property regime. Similarly, as the heterogeneity of the user group decreases, while degree of dependence of user group remains the same (Figure 5b), the maximum of the transaction function shifts away from the private regime and towards the common property regime.

Insert Figure 5a & 5b

In general, for zero dependence of the user group on the resource, the transaction function will be a monotonically increasing function of R since coordination costs are the only component of transactions cost and these fall as the private regime is approached; thus the private resource regime will be optimal. For a perfectly homogeneous group (" =0), the transaction function will be monotonically decreasing since it depends only on exclusion costs; open access will then be optimal. When there is both perfect homogeneity of the user group (" =0) and zero dependence on the resource ($=0), coordination and exclusion costs are zero for all regimes so regime selection becomes irrelevant.[27]

Optimal Resource Regime

More generally, the optimal resource regime is the one for which the value of the transaction function reaches its maximum. The first order condition for maximization is:

dG(R)/dR = 0 or R = "/("+$), (8)

and the second order condition at the point given by the first order condition is

d2G(R)/dR2 = - ("+$). (8a)

Therefore, for positive values of both the SEFs (" and $), R = "/("+$) defines the resource regime which maximizes the value of the transaction function. It indicates that for " > $, i.e., when heterogeneity of the user group is "greater than" that group's dependence on the resource, the optimal resource regime will be between a joint one (involving both the user group i.e., the community and the owner, probably the state) and a private one; for " < $, i.e., when the user group is relatively homogeneous and its dependence on the resource is high, the optimal regime will be between an open access and a joint regime.

The Impact of Social and Economic Factors on the Value of the Transaction Function

It is of interest to see how the value of the transaction function (proportion of the output available to the right holder) changes with the level of the SEFs, resource regime held constant. Consider, by way of illustration, a case involving values of "=0.8 and $=0.3, with R fixed at 0.3. The value of the transaction function for this level of R is 0.65. Note that the optimal value of R for this combination of " and $ is 0.73; with that regime the value of the transactions function would be 1. Now, if $ is changed to 0.4, and " remains unchanged, the optimal value of R becomes 0.66, and the value of the transactions function for R equal to 0.3 becomes 0.71. Thus with this increase in $ to 0.4, the optimal value of R moves closer to the fixed value of R (0.3) and the value of the transaction function increases. Similarly, if $ is changed to 0.5, the optimal R for "=0.8 and $=0.5 becomes 0.61, still closer to the fixed R=0.3, and the value of the transaction function increases to 0.75. Similarly, if $ is kept at the initial value of 0.3 and " is changed from 0.8 to 0.7, the optimal R (0.7) for these new values of " and $ is closer to the fixed value of 0.3 and the value of the transaction function increases from 0.65 to 0.71.

In general, if the change in the values of " or $ brings the given R closer to the optimal value of R, the value of the transaction function will increase; if it moves the actual R farther from the optimal R the value of transaction function will decrease.

SECTION IV
STATIC ECONOMIC ANALYSIS OF THE TOTAL PRODUCTION PROCESS

We now turn to an economic analysis of the total production process. The assumption of separability between the transformation and transaction functions has the value of simplicity, and the highly distinctive transformation

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27 A quirk of this particular function is that its value becomes zero at both R=1 and R=0. In this it misrepresents the reality we are portraying, but since it provides a valid picture asymptotically close to those limits it is useful. For a highly heterogeneous group (" close to 1) and negligible dependence ($ close to zero), the transaction function reaches its maximum close to R=1, but then falls precipitously to zero at R=1. Similarly it has its maximum close to R=0 for a highly homogeneous group, but the value falls precipitously to zero at R=0. Therefore, it is technically necessary to interpret the private resource regime as being represented by R =1- (a point very close to 1 but not exactly one), and the open access regime at R = 0+. Hence, in reality R varies from 0+ to 1- (as mentioned before), but for the sake of simplicity in the analysis we have taken the limits to be 0 to 1.

process of many non-renewable resources does suggest that the relation between the two functions may approximate separability. Non-separability comes closer to reflecting the facts in the case of renewable resources, however.

Nonrenewable resources include energy supplies -oil, natural gas, and coal- and non-energy minerals, including copper, nickel, bauxite, and zinc. These resources are formed by geological processes that typically take millions of years, so we can view them for practical purposes as having a fixed stock of reserves. Local communities are normally not dependent on such non-renewable resources (such as coal, natural gas, etc.) so in such cases the options are limited to a state or a private regime. The very large scale of operations and sophisticated, costly technology constrains the choice of resource regime in the same direction. The full spectrum from open access to private regime is mainly relevant to renewable resources like forests, fish, pasture land, etc. Such resources are capable of growing and reproducing over economically relevant periods of time. The (absolute level of) growth depends both on the existing growing stock and its "yield" (growth rate), both of which are clearly affected by resource regime arrangements. Hence, the transformation and the transaction functions will in these cases work simultaneously (be non-separable), but it is helpful for heuristic purposes to consider the separability case as well[3].

SEPARABLE TRANSFORMATION AND TRANSACTION FUNCTIONS

Under separability the economic conditions for maximization of the transformation function and the transaction function are independent of each other and we may restrict our consideration to the transaction function only. If Q is the final product available to the legal right holder of the resource, then

Q = Q1.*R" (1-R)$.   (9)

The output Q is measured in the same physical units as Q1[4] The level of exclusion and coordination costs associated with the various regimes can be most simply expressed as the percent by which Q falls short of Q1. Also for simplicity, we assume that these costs are monotonically increasing, monotonically decreasing or a quadratic function of resource regime as the later variable moves from zero (open access) to one (private).

The "costs" associated with the various possible regimes take the form of expenditures of labour and capital to effect the exclusion and coordination functions and/or of output which, although produced, is not received by the right holder. With fixed input and output prices the former costs can be converted into the equivalent of output loss; the latter are naturally expressed in that way.

NON-SEPARABLE TRANSFORMATION AND TRANSACTION FUNCTIONS:

When the two relevant functions are non-separable, the amount of output Q resulting from a given input of L and K depends on the regime, as do the direct costs of exclusion and coordination and the leakage of output between the production process and the right holder. The characteristics of the physical production process are causally related either to the costs of coordination and/or exclusion and to the leakage between output produced and that received by the right holder. This is likely to make the relationship between regime and output or profitability somewhat more complicated than in the case of separability. The conditions for choice of the profit maximizing resource regime under the assumption of the specific technology, represented by the Cobb-Douglas function, are given in Appendix A.

CONCLUSIONS

The static analysis of this paper helps to formalize and elucidate the ways in which such socio-economic factors (SEFs) as degree of user group dependence on a resource and user group heterogeneity help to determine which resource regime, along a spectrum ranging from open access to private property, may be optimal under specific conditions. We have developed the concept of the transaction function to express the fact that different resource regimes face different costs of coordination and of exclusion. In the case of separable transaction and transformation functions, the optimal resource regime is determined by the effect of SEFs on the transaction function, while in case of non-separable transaction and transformation functions their effects on the physical production process is relevant as well.

Further research on the coordination and exclusion costs associated with different resource regimes is essential to provide a better feel for the likely range of circumstances under which community resource management may be optimal, and for ways in which those costs may be reduced in the context either of community management or competing management forms[5]. In the absence of the actual costs associated with the various resource regimes, it is not possible to demonstrate which regimes will be optimal under different socio-economic situations. But on the basis of what seem to us reasonable assumptions on the relative costs across possible forest management systems, we believe that the regimes identified as optimal in Table 2 (based on equation 8) for different combinations of two SEFs give interesting hints[28]. The results can be summarized as follows: R >= 0.75, for $ = 0.1 and " >=0.3; and for $ = 0.2 and " >= 0.6; and R =< 0.25 for $ >= 0.3 and " =0.1, and for $ >= 0.6, and "=0.2. For all other values of the two SEFs, the value of optimal R is less than 0.75 or greater than 0.25, which means some sort of joint management between government and communities. These results imply that only for a very small range of values of the two SEFs, particularly when the dependence of the user group on the resource is very small, will either a private or a state regime be optimal. In contrast, for a rather wide range of SEFs some sort of joint regime between state and community will be optimal. In the developing economies, the values of " and $ may often vary within the range of 0.4 to 0.6; for theses ranges of the two SEFs, the optimal R also varies within the range 0.4 to 0.6, implying that the optimal regime will often be some sort of joint one. The optimal degree of control of state or community in this regime will vary as per the value of two SEFs. If dependence is less i.e., $ is close to 0.4 and if heterogeneity is higher, i.e., " is close to 0.6, the state should have more control; on the other

28 The suggested mathematical form of the transaction function generates results which are consistent with the existence of successful cases of common property resource management.

hand if dependence is higher i.e., $ is close to 0.6 and heterogeneity is lower, i.e., " is close to 0.4, the community should have more control.

Their quantitative imprecision notwithstanding, these results give some indication that in developing economies the state regime will frequently not be optimal for management of forest resources located near populated areas[29]. They do not, however, suggest that all the forests in these countries should be under joint resource regimes. Some large tracts are far from communities and no user group is dependent on them as a resource; these can be adequately managed under state or private regimes. On the other hand, in the economies where local communities are not directly dependent on forest resources and heterogeneity among the group is also quite common, a state, private or a joint regime (between the state and a private company) may be optimal. However, in the areas where forests are owned by private companies, but the local communities are heavily dependent on these forests (e.g for employment), a joint regime between the company and local communities may be optimal.

Table 2
Transaction Function Based Optimal Resource Regimes
for Different Socio Economic Factors

$ "	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0.1	½	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10
0.2	2/3	2/4	2/5	2/6	2/7	2/8	2/9	2/10	2/11
0.3	¾	3/5	3/6	3/7	3/8	3/9	3/10	3/11	3/12
0.4	4/5	4/6	4/7	4/8	4/9	4/10	4/11	4/12	4/13
0.5	5/6	5/7	5/8	5/9	5/10	5/11	5/12	5/13	5/14
0.6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15
0.7	7/8	7/9	7/10	7/11	7/12	7/13	7/14	7/15	7/16
0.8	8/9	8/10	8/11	8/12	8/13	8/14	8/15	8/16	8/17
0.9	9/10	9/11	9/12	9/13	9/14	9/15	9/16	9/17	9/18

As indicated in the introduction, the main concepts used here are general in nature and can be used in the analysis of optimal resource regimes for natural resources other than forests. They are: (i) a production function comprising transformation and transaction functions; (ii) two socio-economic factors -- heterogeneity and degree of dependence of the user group; and (iii) dependence of coordination and exclusion costs on the levels of heterogeneity and dependence, respectively.

The specific features of tropical forests and communities in developing countries have figured prominently in the above discussion. Tropical forests are very rich in biodiversity and produce a large number of non-timber forest products (NTFPs) such as fruits, leaves, seeds, flowers, gums, and tubers. Most of these NTFPs cannot be exploited at a commercial scale, due to high extraction costs, but do play a significant role in some rural economies. Neither private nor state regimes will use these products, management being mainly oriented towards timber production. In the case of community or joint regimes, the local user group will develop all the possible forest products. The argument for community or joint regimes for forest management in developing countries is thus similar to the nineteenth-century doctrine in favour of maintaining public access to locations essential as avenues of commerce, even at the expense of exclusive ownership rights. As Rose (1994) observes:

> It was, after all, the publicness of commerce- the increasing returns from greater and greater participation- that created the value of any roadway or waterway; and private owners were not permitted to capture the rents of commerce itself. In an odd Lockeanism, the public deserved access to these properties, because publicness, nonexclusive open access, created their highest value.

Similarly, community or joint regimes may create the highest value of those tropical forests which are surrounded by highly forest-dependent communities. Their advantage rests on a combination of low transaction costs and high value of resource.

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29 In this context, some recent institutional shifts in forest management in India are described in appendix B.

APPENDIX A

PROFIT MAXIMIZATION UNDER NON-SEPARABLE TRANSFORMATION AND TRANSACTION FUNCTIONS

For simplicity, assume that only a given technology, represented by a Cobb-Douglas function, is available to the user group. We wish to identify the optimal combination of resource regime and physical inputs (labour and capital) for this technology. In this case profit can be expressed as:

Z = P.La.Kb.*.R" (1-R)$ - Pl.L - Pk.K- Pr(R) (1)

First order conditions for profit maximization are:

a.La-1.Kb.*.R" (1-R)$ = Plo (1a)

b.La.Kb-1.*.R" (1-R)$ = Pko (1b)

La.Kb.*.R" (1-R)$.[("/R)-($/(1-R))] = (MPr(R)/MR)/P (1c)

(MPr(R)/MR) is a marginal resource regime price, and we denote the ratio of the marginal resource regime price to the price of output (MPr(R)/MR)/P by Pro. Similarly, Plo and Pko are the prices of labour and capital, respectively, in relation to the price of output.

These three equations can be solved to obtain[30]:

*.R" (1-R)$.[("/R)-($/(1-R))]1-a-b =Pro.(Plo/a.Pro)a(Pko/b.Pro)b (1d)

Equation (1d), subject to the concavity conditions of the profit function, can be solved for R by any non-linear equation solution method. The value of R can be used to obtain the values of L and K. On simplification, the three first order conditions (1a, 1b, and 1c) will yield the standard marginal condition:

(MPPl / Pl) = (MPPk /Pk) = (MPPR / (MPr(R)/MR)) (2)

A slight difference in this equation from the standard marginal condition is noticeable. L and K represent the units of labour and capital used while R represents a particular resource regime. The prices of labour and capital are constant, hence, the Pl and Pk are average as well as marginal prices of labour and capital, respectively, while the price of the resource regime is a function of R, hence marginal price of R appears distinguishably. The equation can be interpreted as that the optimal condition will be given by the ratio of the marginal product and the marginal price of each input being the same.

The equation can be modified to:

(L.Pl/a) = (K.Pk/b) = [R.MPr(R)/MR] / [{" - ($.R/(1-R))}] (2a)

In a Cobb-Douglas function a and b represent the percent change in output due to a one percent change in the input (elasticity of output with respect to the respective inputs), and these are referred to as scale factors; accordingly, we refer to {" - ($.R/(1-R))} as a shadow scale factor of the resource regime. While a and b appear as powers of the two inputs labour (L) and capital (K), this shadow scale factor does not, nor does it have a constant value like a and b. The production function has two terms related to the resource regime, R and 1-R, which together with their powers " and $ produce the scale effect {" - ($.R/(1-R))}. Since this effect is not identical to that implicit in R{" - ($.R/(1-R))} we refer to it as the shadow scale factor. The shadow scale factor of the resource regime is resource regime dependent, hence the elasticity of output with respect to the resource regime varies across resource regimes, while the elasticity of output with respect to labour and capital is independent of the amount of these inputs used.

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30 On dividing (1a) by (1b)
K= (b/a).(Plo/Pko).L (1e)
On dividing (1c) by (1b)
K= (b.Pro/Pko)/[1/{("/R) - ($/(1-R))}] (1f)
On dividing (1c) by (1a)
L= (a.Pro/Plo)/[1/{("/R) - ($/(1-R))}] (1g)
On substituting the values of L and K from 1g, and 1f, in 1c, we get 1d.

Since, a and b are positive, {" - ($.R/(1-R))} should also be positive; which leads to optimal R < "/("+$). We know that for Pr(R)=0, the optimal R = "/("+$). Hence, in the presence of a positive price of resource regime, the optimal R will be less than optimal R in case zero price of resource regime.
The optimal condition can be expressed as the ratio of the input multiplied by its marginal price to the scale factor being the same for each factor.

APPENDIX B

INSTITUTIONAL SHIFT IN FOREST MANAGEMENT IN INDIA

Up to the end of eighteenth century, forests in India belonged to the ruler of the territory but were open to use by everyone, with the exception of a few species which were proclaimed "Royal Trees" by the rulers (Stebbing 1922-27). In general, forests were considered an inexhaustible resource and their ecological importance was not yet recognised. This combination of attitudes and arrangements led to the rapid exploitation of forests in many areas; at the same time, many local communities continued to manage their natural resources including forests on a sustainable basis by regulating their use (Kant et al. 1991). At the beginning of the nineteenth century British rulers began to bring the forests under their control. In 1864, the first Inspector General of Forests was appointed, and it was decided to convert the forests into state property. Curtailment of the unrestricted right of access started with the Indian Forest Act 1878, which provided for the constitution of Reserved and Protected Forests. With the independence of the country, the remaining private forest areas in the country were converted to state property.

In the reserved forests, all rights of local people were abrogated, but in the protected forests some rights remained. The recognition of people's rights on `Forests as State Property' also changed with time. The forest policy (1952) of independent India accepted the concept of `Village Forest' to serve the needs of local population, but the operational emphasis remained on reserving the forests for national needs and excluding the local people from use as well as management. The process and consequences of this imposition have been less than smooth (Sarin 1993). Indian forest management history is replete with rebellions and uprisings by forest-dependent communities against the state's attempt to deprive them of their access to and control over local forest resources (Gadgil and Guha 1992, Guha 1989). As the situation deteriorated, the inherent difficulties associated with strict state custodial policies were realised at all levels of government. In some states such as West Bengal, Gujarat, and Harayana, forest officers began discussions with communities, encouraging them to organise and protect forest lands from further degradation. In other states like Orissa, Bihar, and Madhya Pradesh, local people took the initiative and started organising community based forest management systems. The Government of India recognised the need for change in the new National Forest Policy (1988). It stipulates: "the holders of customary rights and concessions in forest areas should be motivated to identify themselves with protection and development of forests from which they derive benefits." The Government of India followed up with directives to all state governments in 1990 regarding Joint Forest Management. As a result, since 1990 there has been a shift in forest management from state regimes and defacto open access regimes to community regimes and joint regimes. In Orissa and Bihar, about 200,000 hectares of forest are being managed by local communities under community regimes, while about 320,000 hectares in West Bengal state are being managed under joint regime (Sarin 1993). Similar efforts have been reported from eleven other states. These shifts of resource regime have greatly increased production efficiency. Two case studies, one of community and one of joint regime, illustrate this process.

Community Management of Rupabalia Reserved Forest in Orissa (Source: Kant et al. 1991). Rupabalia Reserved Forest is located in Dhenkanal district of Orissa. In the 1960's and 1970's industrialisation and the consequent urbanisation led to a tremendous increase in the demand for timber, leading to a large scale deforestation in the area. In search of forest produce, forest-dependent communities in the area started managing the state forests in the early 1980's. About 177 hectares (19% of the total forest area) are now being managed by communities. The eight villages on the periphery of Rupabalia hill divided the total forest area among themselves and started managing it. Normally, a local village organisation is responsible for such management. These organisations are governed by their own rules, which generally relate to: (i) the composition of village organisation and the duties of office-bearers; (ii) forest protection, extraction, and distribution of products; (iii) conflict resolution; and (iv) penalties for defaulters. The details of one village organisation (taken from the register of the Vejibolua village forest protection committee) serve to illustrate. Its rules, framed in 1992, can be grouped into two categories:

A. Rules related to the composition and functioning of the forest protection committee:

1. Any member (household) of the village can become a member of the committee.
2. Management of the forest will be looked after by an Executive Body which will have four members and five office bearers viz. President, Vice President, Secretary, Assistant Secretary, and Treasurer.
3. The office bearers and members of the Executive Body shall be selected by consensus. Duties of each office bearer are also given in these rules.

B. Rules related to forest management:

1. The members only will have equal rights on the forest. If any outsider wants some produce from the forest, the office bearers can give permission for the same.
2. Each member will protect the forest on the days allotted to him. If any member fails to do so, he will be required to compensate for that day by two days of patrolling duty.
3. On receiving information regarding theft in the forest, the Palia (the man who is supposed to be on patrolling duty on that day) has to go to the forest. If he does not do so without adequate reason, he will be required to give Rs. 1 as fine, and will have to apologise in front of all the members.
4. A member can go to the forest for collection of material allotted to him only after paying the money as per the scheduled rates to the concerned office-bearer. If somebody violates this rule, he will have to forfeit the material along with a fine of Rs. 2.
5. Each member is entitled to equal amount of material from the forest. If somebody requires more material, he will have to take the permission from the committee and will have to pay twice the scheduled rates.
6. If any one wants to give his share to another person, he can do so at double the rate and after taking the committee's consent.
7. Forest produce can be collected only from the area decided by the committee. If someone collects from any other area, he would have to pay a fine of Rs. 2.
8. No one can sell any forest produce from the protected patch of forest to outsider.

These rules have been amended by the committee from time to time to meet the new requirements/challenges faced by the village. Community based forest management of Rupabalia forest has resulted in increased production of all forest produce. Before community management, dwellers used to get fuelwood from a forest distant from the village. The cost of getting this fuelwood was about Rs. 100-120 per cartload. Now, except for two villages which have young forests, each household in all villages gets two to three cartloads of fuelwood through cleaning of forest patches every year at a very nominal cost of Rs. 2 to 5 per cartload. In all villages, headloads are also allowed. Production of non-timber forest products such as fruits of Bel, Aonla, and Baheda have also increased significantly. The regeneration of forests has increased employment opportunities for the poor. According to the tribal people of some villages, they get full employment for 45 days in the Kendu leaf season and 15 days in the Sal seed season, earning Rs 15-20 per day. Opportunities of leaf plate making and Chatai (mat) making have also increased. In addition to fuelwood and non-timber forest products, poles are now available for house construction. The success of this community based forest management has been attributed to: (i) the high dependence of the local populace on forests for fuelwood and construction material; (ii) the almost uniform dependence of all sections of the society on forests for fuelwood and construction material (economic homogeneity); (iii) common expectations and mutual trust leading to similar views with respect to resource management.

A joint regime from West Bengal: The Sitarampur Forest Protection Committee (Source: Malhotra and Poffenberger 1991): The committee, located in East Midnapore district, is comprised of two villages: Metal and Sitarampur. Three hundred hectares of state forest were allocated to it for protection. A forest official (Range Officer) was instrumental in the committees' formation in 1986. Through a number of meetings with the villagers, and in the presence of the village headman (Pradhan), he convinced them to cooperate with the forest department in protecting the forest.The details of the program and the rights and duties of both parties (government and

community) were worked out. All ninety nine households (except six absentee households) are members of the committee. The committee members select their officials, the president, secretary, treasurer, and 12 governing body members.

In this committee, three persons go on patrol duty daily. When a problem arises other members assist the patrol. Each member is supposed to do one day's duty per month. In an emergency, members can fill in for each other, but if they miss duty they are fined Rs.12/. If an FPC member breaks the rules, he is warned and fined depending upon the nature of offence, though this has seldom been necessary. In the case of a non-member offender, he is warned on the first offence, but on the second he is handed over to the Forest Range Officer for legal action. Since its formation, FPC has worked well. After it took over the management, the condition of the forest has improved markedly. Previously, the forest was totally degraded and villagers were not getting anything from it. During the establishment of the committee, employment was generated by the forest department, and once the forest began recovering, villagers have been able to collect a growing number of non-timber forest products along with a regular supply of dry leaves and twigs for fuelwood. The villagers also acquire considerable income from cutting the unwanted multiple shoots of Sal trees; the timing of this activity coincides with a period of employment scarcity and it is especially appreciated. Since this job is quite popular, opportunities are generally given on a rotation basis to member families. Multi-shoot cutting also provides fuelwood for six months to villagers. On average, after the creation of the FPC, families have earned Rs.245 per month from forest products and forest related activities as compared to nothing before FPC formation.

These two case studies indicate that a shift in resource regime from state regime/ defacto open access regime to community or joint regime can lead to increased production from forests. In the first case, the user group is highly dependent on the resource and quite homogeneous in its views on resource management, so a community regime is optimal. In the second case, the user group is dependent on the resource, but homogeneity of views on resource management appears not to have been as high as in the first case. Hence, the user group itself was not able to develop a community regime, and joint regime seems to be the correct choice.

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COMMUNITY MANAGEMENT:
AN OPTIMAL RESOURCE REGIME FOR TROPICAL FORESTS

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COMMUNITY MANAGEMENT: AN OPTIMAL RESOURCE REGIME FOR TROPICAL FORESTS?

Abstract: The economic theory of natural resource management has its roots in the conventional economic theory of commons that overlooked the role of the institutional structures and the associated transaction costs. Hence, it has not been able to explain the outcomes of the cases of successful management of natural resources, such as forests, as common property. The possible economic optimality of community regimes has been recognised in the empirical literature, but it has not yet been incorporated in production models that would help to elucidate the reasons for its relatively superior performance in selected contexts. In this paper, we incorporate institutional structure into a static analysis of optimal resource management regimes which aims to correct this neglect. Resource regime is included as one variable input in natural resource production models that leads to determine global optimum resource regime. The other specific features of this paper are: i) a continuous array of possibilities varying from open access at one extreme to private regime at the other rather than just the two extreme options of state and private regimes; (ii) the socio-economic characteristics of the resource's "user group" as the main determinant of the relative efficiency of different regimes; and (iii) a specific mathematical form for the transaction function, in order to facilitate empirical studies in this area. Static models for general separable and non-separable transformation and transaction functions are discussed. The possibility of different resource regimes being optimal in different socio- economic conditions is highlighted.

Key Words: Resource management, Resource regime, Socio-economic factor, Static model, Transaction function, and Transformation function.

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1. For simplicity, we incorporate the productive potential of the natural resource under the factor "capital".

2.Given the indivisibility of tropical forests, "private regime" implies management by a large enterprise, not the ownership of small plots of trees by individuals. Hence, private regime_implies total exclusion of any local community which could be a potential user group.

3. In the case of non-renewable resources, though there is a fixed stock which is not capable of being affected by any artificial transformation process, the quantity retrievable for use is related to the transformation process. Hence, if we look at the transformation process in this broader perspective, the transformation and the transaction function will be non-separable even for such non-renewable resources. The issue is one of degree and our only point is that the interaction between the two functions is likely to be more intense in the case of renewable resources.

4. The resource regime variable is different from the variables corresponding to the physical inputs capital and labour. Physical inputs are assumed to be homogeneous, and the number attached to them represents the quantity used. Differences across resource regimes are not necessarily or generally interpretable as comparable to quantitative differences in a physical input, though in this case we are assuming that they can be thought of as qualitative differences which are related to different levels of underlying SEFs.

The concept of the resource regime price is perhaps more artificial, since "resource regime" is not traded in the market as physical inputs are. But, the design, implementation, and monitoring of different resource regimes have different costs. We define the "price" of a particular resource regime as the total costs (the sum of exclusion and coordination costs) of the regime. Regime price thus varies with the value of the regime variable R.

5. A solid understanding not only of the cost and productivity features of alternate resource regimes but also of the dynamics – the process of evolution of resource regimes is necessary for effective policy making, especially when community involvement in management is a serious option. Kant and berry (1998) presents a more detailed discussion of it..