Property Right , Risk of Eviction and Degradation of Common Pool Resources

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1. Introduction

There is evidence that development in many resource dependent countries has been synonymous with depletion/ degradation of their various natural resources. For example in Papua New Guinea the huge amount of development that has taken place on customary land (ie land owned by indigenous people) has been unsustainable as it involved continual depletion of both renewable and non renewable resources (Filer, 1996). In particular, mismanagement and depletion of renewable resources has been a central focus of public debate in that country. In a study on middle east and north Africa, it has been observed that population growth and urban development have led to land and water degradation which is harmful for resource productivity and food security (Cofie and DeVries, 2002). Renewable resources, mostly of common pool type support the basic subsistence of a majority of people in these countries . Thus for instance farm land, irrigation water, grazing lands, ground water, ponds and tanks all support production by farmers, herdsmen, fishermen, forest dwellers, landless squatters, etc. In many cases dependence on exploitation of these resources is extremely high. One effect is that the rate at which they are degrades/depleted means that they might soon fail to serve as the source of livelihood of these teeming millions. For example clearance of forest resources/grazing land in many regions is exceeding the regeneration rate of the natural resources (Mendelsohn , 1994). A study of some villages in Gujrat(India) found that the estimated proportion of trees on CPR land were around 1 to 15% of the total number of trees that prevailed a generation before (Iyenger, 1989). The status of CPR land was also found to have deteriorated over the said period.

The reason behind the degradation of various CPRs is often said to be the livelihood needs of poor people. This is reflected in the high rate at which these people discount the future stream of income compared to that at present. It is argued that poverty and

I am grateful to Prof. Charles Perrings for his comments and suggestions during the preparation of this paper. His insightful comments and careful scrutiny of an earlier version of the paper helped immensely to improve its quality.

liquidity constraints, tend to increase rates of time preference and so reduce incentives for investment and sustainable management of natural resources (Pender and Walker, 1990; Deaton, 1991; Holden , Shiferaw and Wik, 1998). Eventually future sustainability tends to be sacrificed at the alter of present exigency.

Apart from poverty , three basic dimensions can be identified which lie at the root of the present observed level of degradation of CPRs at different corners of the globe. The first is the misallocation of resources arising from market failure as well as regulations failure. Market failure involves reciprocal externalities in the harvesting of open access CPRs. For example, when a group of cattle herders graze their cattle on a piece of open access grazing land, each try to graze as many cattle as he wishes without regard to the impact of his exploitative grazing on others. As a result the grazing land tends to be depleted too rapidly relative to its natural rate of regeneration.

Regulations failure is exhibited through the implementation of environmentally perverse policies. For instance, coal subsidies in some developing countries have channelled resources to the mining sector and hence increased pollution above the efficient level. Exemption from taxation of virtually all agricultural income in Brazil is another glaring example of the failure of government policy to curb degradation of resources (Binswanger, 1991).

Second, resource degradation may be caused by a disproportionate human pressure on regenerative and assimilative capacity of the environment. This is also referred to as the problem of scale of human load relative to the carrying capacity of nature. Carrying capacity is not fixed and can be raised by investment in technology and exploration effort. But often the pace of human consumption of natural capital surpasses the rate of growth of carrying capacity of nature . This leads to the depletion / degradation of natural resources many of which may become irretrievable in future time horizon.

Third, there may arise the problem of property right failures. Property rights and the authority of village /community institutions is crucial to land titling, preservation of

forest lands, management of grazing lands and maintenance of biodiversity etc. It is this aspect of resource degradation that is considered in this paper.

A property right is defined as a set of actions and behaviours that the possessor may not be prevented from undertaking in relation to a benefit or income stream(Bromley, 1991, p 2-4). It involves a set of rules delineating the rights and duties of its holders as well as requiring other individuals to refrain from taking actions that infringes on the exercise of the right of the holder. Apart from private and state property regimes the dominant forms of property include community owned property (i.e common property) and open access property. Traditionally economists have argued in favour of private property (Demsetz ,1967; Furubotn and Pejovich,1972; Platteau, 1992). The superiority of private property is explained in terms of the combined presence of the authority and composition criteria in a single entity. However despite this, private management of CPRs is often viewed as undesirable from the point of view of social equity and distributional justice. Again resources under open access are prone to over use because of the reciprocal externalities associated with them. In order to avoid the tragedy involved with open access , it is desirable that state or community institutions regulate their uses to ensure sustainability.

Community management in various forms in different parts of the world has for long contributed to the sustained use of local common resources. Various case studies in recent times (Ostrom,1990, Wade,1988, Ngece, 2003) have revealed the great merits associated with common property rights exercised by site -specific well defined community. However often state appropriation of common property resources(forestry, grazing land etc) and the inability of the government machinery to undertake proper management in many cases has turned the traditional CPRs into open access resources. State intervention in land administration has often been harmful from the point of view of sustainability of the resource (Ault and Rutman, 1979; Bassett 1993). In the absence of unenforced or ill-enforced property right of the state, conditions resembling open access has crept in many of the local commons. Many tropical forests for example, are state property but in many cases the government fails to effectively implement access and conservation rules . As a sequel to this, the forests virtually degenerate into defacto open access as encroachment,

settlement and illegal logging go unchecked (Heltberg, 2001).This kind of situation persists in many poorly protected sanctuaries, national parks, forest reserves etc.

As a by product to this, villagers from adjoining areas are enticed to illegally encroach on these resources . While the state enjoys the legal authority, these people deprived of customary rights suffer both from insecurity and partial and arbitrary enforcement of their remaining rights. This imperfect property right and associated risk of eviction from the CPR land is often viewed as the underlying factor responsible for unbridled degradation of forestry resources/grazing land etc. There exist many studies which support the view that security of tenure arrests degradation/depletion of natural resources while insecurity leads to mismanagement and their degradation. Many findings from Kenya, Ecuador , Indonesia, Southern Africa and other places support the importance of tenure security in influencing investment in land and checking depletion of natural resources (Southgate et al , 1991; Aihoon and Kirsten, 1994; Roth and Haase, 2000**;** Mwakubo,2002;Burkard and Ebersberger,2002).In certain studies it is stressed that deforestation and non sustaining agricultural practices are associated with incomplete or non enforced property right (Bedoya, 1987; Bromley and Cernea, 1989; Hanna and Munasinghe, 1995). According to Somnathan (1991), in central Himalayan region there happens to be rapid degradation of forest resources because of the prevalence of improper property rights. Local people are left in a condition of uncertainty about access to future benefits from forests. Owing to the loss of community control and regulation put on access to use of forestry resources, their motivation to sustainably manage the resources wither away where the future availability of the resource base is uncertain. In Kenya , government lands are often encroached on and occupied by groups of people in urban areas and forest reserves. These people lacking any security of tenure and registrable interest in occupied lands, often tend to overexploit and degrade the resources (Waiganjo and Ngugi, 2001). In a cross country study it has been observed that, there happens to be low agricultural yield and high rates of deforestation where tenure is insecure (Deacon, 1999). In disputed lands, titling schemes and land conflicts often lead to violence and increased deforestation. .In a study of Brazilian Amazon , it has been demonstrated that landless squatters and landowners often resort to violence as strategic decision to influence titling process (Alston, Libecap and Mueller, 1999). The issue of security in indigenous tenure system and its effects on

investment demand as land becomes scarce , has been examined in the context of sub-Saharan Africa (Sjaastad and Bromley, 1997).They argue that as the probability of eviction falls, likelihood of indigenous tenure providing higher investment incentive rises. Bohn and Deacon(2000) statistically demonstrated that increased risk of confiscation of forest rent tend to reduce forest cover. They however do not consider competing uses of land.

The nature of the land right is also closely related to the potential of land to serve as collateral for credit. However , even if there be access to credit, it can be surmised that ,the greater the perception of risk of eviction from untitled land, the greater is its use in obtaining high yielding but less sustainable quick returns than somewhat more durable but longer run returns. In fact in many newly settled regions, the community system often tends to be less secure as it is undermined by state acquisition of land rights. In such cases encroachment by the poor people often has to coexist together with some probability of eviction by the legal right holder at any time. This discourages the initiative of title-less settlers to maintain long lived assets like forests/grazing lands etc. The perception of risk of eviction also plays a crucial role with regard to sustainability of natural resources. In the surveyed literature the linking of an unenforced property right and that of risk of eviction with depletion of renewable resources has not been adequately examined in a theoretical framework covering competing uses of land. In order to understand the impact of improperly enforced property right on degradation pattern of a forest CPR , this paper utilises two models of the process.

In section 2 we consider a very simple model where ownership of private plot of land is combined together with resource extraction from a common forest land under improper property right structure (ie where property rights are not clearly defined). We seek to find out the conditions under which forest land resources in open access situation tend to be converted to agricultural land by private owners. In section 3 we consider a squatting model in newly settled/ encroached region with hardly any properly implemented property right on the land used for agricultural purposes as well as the CPR forest land used for resource extraction purposes. In this section we seek to derive the impact of changes in perception of risk of eviction from the encroached land on the degradation of the forested land resources, under certain conditions. Section 4 is devoted to concluding observations and policy prescriptions.

2. Conditions of forest depletion under open access situation

Under a weak property rights regime, or under weakly enforced state ownership of virtually open access forest resources, there is often found a tendency among private land owners to convert part of common forest resources into agricultural activities. In order to derive the conditions under which such clearing of forests for enlarging the land under agriculture is found to be profitable, we assume first that the forest area varies in its quality and potential in terms of serving as a source of value to the villagers . Thus the forest resource is assumed to be heterogonous in quality corresponding to variation in supply potential of fuel, fodder, fruits, latex, rattan , grazing land etc. The less the supply of these tangible benefits from the forest land , the less is its value and greater is the possibility of the forest land being considered as marginal .

Here we consider a very simple model similar to the type used by Parks(1995) in explaining irrational land uses. We assume that the representative individual owner of land has a stock of land resources T_t at time t, which is put to agricultural operation. The land owner's benefit at time t from maintaining aforesaid landstock T_t for agricultural purposes is given by $\pi_A(T_t)$. Benefits from forest collection activities at time t is given by $\pi_F(R_t)$ where R_t stands for the forest stock while environmental benefits that may be derived from the forest stock is indicated by $\pi_E(R_t)$.Clearance of marginal forest land for agriculture is assumed to involve certain cost of C_t per unit of deforested land while the amount of deforested land is indicated by f_t.

Now the land owner is assumed to maximise the present value of net benefits from extraction of both agriculture and forest related activities by choosing the optimum level of deforested land to be converted to agriculture. So he maximises

$$\int_0^\infty [\pi_A(T_t) + \pi_F(R_t) + \pi_E(R_t) - C_t f_t] e^{-rt} dt \quad \text{by choosing } f_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

subject to the following land and forest resource dynamics

$$dT_t / dt = f_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$dR_t/ dt= - f_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The current value Hamiltonian of the aforesaid problem stated in linear control variable f_t stands as

$$H = \pi_A(T_t) + \pi_F(R_t) + \pi_E(R_t) - C_t f_t + \lambda_{Tt} f_t - \lambda_{Ft} f_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where λ_{Tt} , λ_{Ft} indicate shadow prices of land and forest resource respectively at year t. Applying the maximum principle we have

$f_t = f_{max}$, if $\partial H/\partial f_t = - C_t + \lambda_{Tt} - \lambda_{Ft} > 0$, ……..(5)

$f_t = 0$,if $\partial H/\partial f_t = - C_t + \lambda_{Tt} - \lambda_{Ft} < 0$, ……(6)

and $f_t = f_t^*$ if $\partial H/\partial f_t = - C_t + \lambda_{Tt} - \lambda_{Ft} = 0$, ……...(7)

Implication is that if the net shadow value of a unit of land $-C_t + \lambda_{Tt,}$ after conversion, exceeds the opportunity cost of forest land λ_{Ft} , then all the forest land at the margin tends to be cleared for agriculture. There is no basis for the re-conversion to agriculture if the reverse inequality holds. There is often found a tendency among landowners in village areas to consider the immediate benefits from agriculture to be at a premium value compared to the scattered benefits that may be available from heterogeneous qualities of forest land . And if the available tangible benefits from forest are perceived to be of little value compared to that in agriculture, all the forest land tend to be cleared very quickly despite its function as carbon sequestrator, maintenance of bio-diversity, stabilisation of the impact of storms, habitat of diverse fauna etc. This involves a bang-bang solution due to the linearity of the Hamiltonian on f_t.

The last case ie $f_t = f_t^*$ becomes relevant when conversion of forest lands(considered as an aggregate entity) to agriculture takes place only upto a certain level where the net shadow value of an additional unit in agriculture equals the marginal opportunity cost for some unit of forest land at time t. In order to understand the steady state condition for forest conversion we consider the adjoint equation in the form

$$d\lambda_{Tt}/dt = r\lambda_{Tt} - \partial H/\partial T_t = r\lambda_{Tt} - \partial \pi_A /\partial T_{t.} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

and $d\lambda_{Ft}/dt = r\lambda_{Ft} - \partial H/\partial R_t = r\lambda_{Ft} - [\partial \pi_F/\partial R_t + \partial \pi_E/\partial R_t]$

or $r(\lambda_{Tt} - C_t) = [\partial \pi_F/\partial R_t + \partial \pi_E/\partial R_t] + d\lambda_{Ft}/dt$ ……..(9)

as $\lambda_{Ft} = \lambda_{Tt} - C_t$ when $\partial H/\partial f_t = 0$.

At the steady state shadow value of agricultural land does not change so that we have $d\lambda_{Tt}/dt = 0$ implying

$r\lambda_{Tt} = \partial \pi_A/\partial T_t$.

Putting this value in equation (9) we get

$\partial \pi_A/\partial T_t - rC_t = \partial \pi_F/\partial R_t + \partial \pi_E/\partial R_t + d\lambda_{Ft}/dt$ ……(10)

In the steady state however, opportunity cost of forest land does not change so that optimal condition for deforestation at steady state appears as

$\partial \pi_A/\partial T_t - rC_t = \partial \pi_F/\partial R_t + \partial \pi_E/\partial R_t$ ……(11)

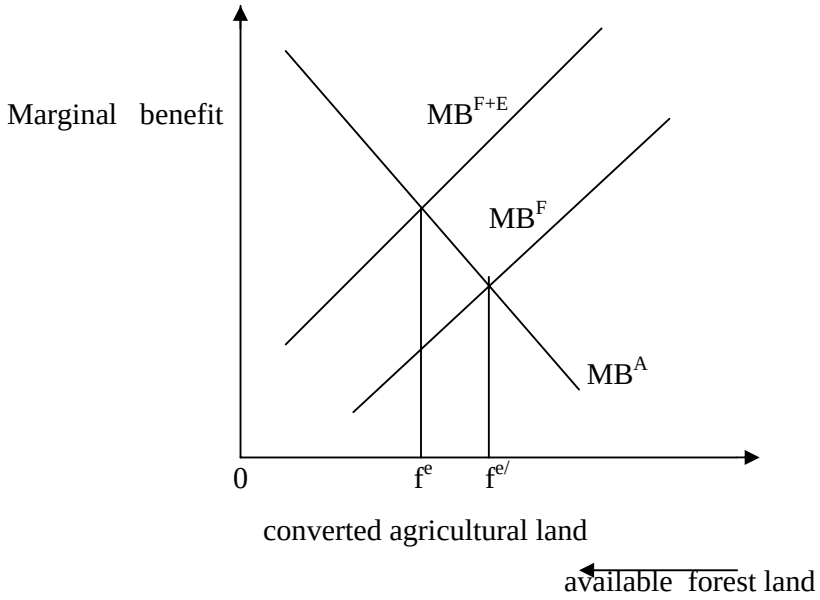
The implication is that net marginal benefit from land in agriculture should be equal to the marginal benefit from forest land .

This condition is akin to that stated by Hartwick (1992) where he suggested that the use of any piece of land will be determined by the relative magnitudes of net benefits from land in agriculture and that of land in forestry, comprising both timber and non – timber benefits. Following the basic logic of this argument, we can say that so long as the net marginal benefits from agriculture exceed the combined marginal benefits from forest collection activities and environmental benefit, deforestation would continue to occur and the socially efficient rate of conversion to agriculture at any time t occurs when the aforesaid marginal benefits from land converted to agriculture and that of forest land are equated , as expressed in the last equation.

It might reasonably be expected that the marginal forest collection benefits and environmental benefits would go up as the remaining forest land resources becomes smaller and smaller . This is likely to lessen the rate of conversion of forest land to

agriculture. But this effect might be countered by a rise in the value of marginal net benefit from land converted to agriculture resulting from higher pressure on agriculture associated with an increasing population and higher incomes. If the process is repeated period after period, this might eventually result in all the forest land being converted to agriculture. Moreover, given the fact that environmental benefits (being non marketable in nature) are often not perceived and hence tend to be neglected , the likelihood of all the forest land being converted to agriculture is all the more strengthened. This view comes closer to the bang bang solution implied in $f_t = f_{max.}$

The fact that non-consideration of environmental benefit of forest land leads to speedy and larger scale conversion of forest resources to agricultural land, can be demonstrated by the following diagram. We may reasonably assume that as conversion of forest to agricultural land rises, the marginal benefit of remaining forest rises and vice versa. Symmetrically with rise in converted agricultural land its net marginal benefit falls and vice versa. In the following diagram converted agricultural land is measured along the horizontal axis while available forest resources are measured along the reverse direction of the horizontal axis. The more forest land is converted to agriculture, the less is the available forest .



Accordingly the net marginal benefit schedule of land converted to agriculture(MB^A) is downward sloping one while the marginal benefit schedule of available forest MB^{F+E}(composed of both forest collection benefits and environmental benefit) land is

an upward one as the axis has been defined . For simplicity the marginal benefit schedules are represented by straight lines.

The socially optimal allocation of forest land at any time period t requires that marginal benefits from forest collection activities and the environmental benefit from forest land taken together coincides with the marginal net benefits of land converted to agricultural production. In the diagram this occurs at point f^e on the horizontal axis. However if the component of opportunity cost associated with allocating land to agriculture in terms of foregone environmental benefit of forest land is not taken into account , then the MB^{F+E} curve shifts down to MB^F (without the environmental benefit component) . As a result the new equilibrium through intersection of MB^A and MB^F occurs to the right of the old equilibrium, at a point (say)$f^{e/}$, indicating that more of forest land is converted to agriculture .The underlying reason is that exclusion of environmental benefits from forest lands lowers the marginal benefit of forest . In order to establish the optimum condition marginal net benefit of converted agricultural land needs to be lowered which requires conversion of more forest land for agricultural purposes(because of the assumption of diminishing marginal benefits). The greater the degree of marginal environmental benefit and its non consideration, the greater will be the rate of deforestation. Besides this if the MB^A curve be relatively flatter (resulting from a slower rate of decrease of marginal net benefit of land converted to agriculture), then also deforestation is likely to occur at a higher rate.

3. Impact of risk of eviction on land use

Let us now consider a number of people who try to settle as squatters in a forest and adjoining land. Each is supposed to make a choice regarding encroaching a portion of the land for individual agricultural activities assuming that other squatters would also act in a similar manner. The rest of the forest land is then exploited as common pool resources . The entire encroached land is assumed to be legally owned by the state or by some landed authority, but due to lax administration it is defacto treated as open access. However although the settlers encroach on this forest land , they always have to carry out their operations under the threat of being caught and evicted from the piece of land they utilise for agriculture as well as for forest collection purposes.

Absence of legal ownership right has impact on how they alter their decision regarding use of forest land for agricultural purposes. We suppose , however, that peoples' decisions are affected by their perceptions of the risk of eviction from the encroached land.

In order to have an understanding of this, we consider a formalised model. We assume that there are n squatters each of whom choose certain portion of the defacto open access land (its area being given as $\underline{R}$)for personal agricultural operation purposes(assuming that others will do similarly) and the residual land is utilised as CPR for having some annual services flow in the form of grazing land benefits. To be specific let us denote the choice of land by the ith squatter for agricultural purposes as T_i . Each household also employs part of his endowed labour $\underline{L}$ in the agricultural operation . Let this amount of labour employed in agriculture be denoted by the residual $\underline{L} - L_i$ where L_i stands for the participatory labour that the ith squatter employs for the upkeep of the grazing land with the expectation of earning something more per unit of goat. ΣT_i is the total land used for agriculture by the n settlers. Hence $\underline{R} - \Sigma T_i$ is the land left as CPR grazing land. It is assumed further that the ith squatter has g_i units of livestock which involves a rearing cost of amount c per unit. The value earned per goat is denoted by $f(g, \underline{R} - \Sigma T_i)$, where $g = \Sigma g_i$ and $fg < 0$, implying that as the total number of goats grazed rises, value earned per unit falls possibly because of reduced availability of grass per goat and loss of benefits offered by the herd . Furthermore, $f_{\underline{R} - \Sigma Ti} > 0$, implying that as the residual area left for grazing ie $(\underline{R} - \Sigma T_i)$ rises , value earned per unit of goat increases with increased availability of the feed for the goats and their better health and offered benefits. Hence gross revenue earned by grazing g_i number of goats in the CPR land is given by $f(g, \underline{R} - \Sigma T_i) g_i$.

It is also assumed that each individual squatter believes that putting some participatory labour into the maintenance of the grazing land would add value to the rearing of goat. He counts this value addition from participatory labour on the assumption that others also similarly would put forth some labour for the upkeep of the grazing land. Thus the ith squatter believes the aggregate amount of participatory labour to be ΣL_i. Let now θ_i be the parameter representing the ith squatter's

perception of additional value earned from each goat per unit application of joint participatory labour ΣL_i. Thus from grazing g_i number of goats he expects to get additional value to the tune of $(\theta_i \Sigma L_i.)\ g_i$. It is further assumed that application of unit level of participatory labour involves some opportunity cost at the rate of w. Hence the total cost involved in rearing g_i number of goats and offering L_i units of participatory labour amounts to $cg_i + wL_i$. Therefore the ith squatter's net revenue derived from the CPR grazing land at time t appears to be

$$f(g_t, \underline{R} - \Sigma T_{it})\ g_{it} + (\theta_i \Sigma L_{it}.)\ g_{it} - cg_{it} - wL_{it}.$$

There may be another benefit derived from the CPR land in the form of environmental benefit. This is assumed to be a function of the number of goats grazed and the land remaining for grazing, and is denoted as $E(g_t, \underline{R} - \Sigma T_{it})$ where $E_g < 0$, $E_{\underline{R} - \Sigma Ti} > 0$.

Besides this the revenue that the ith squatter derives from the agricultural land is assumed to be a function of the amount of land T_i and the amount of labour employed therein and is written as $A_i (T_i, \underline{L} - L_i)$. At this point we consider three possible cases regarding the nature of agricultural operation. Case (I) Despite the lack of permanent land use rights, farmers may undertake long term investment in land resources, converting rain fed land into paddy terraces, or implementing erosion control measures etc. This has been observed in mountainous regions of northern Vietnam and Thailand where undertaking this better management/investments tend to increase farmer's perceived tenure security (Neef, 2001). This has the effect of raising land productivity at a rate (say) β over time. Case (II) It might be other way round. Often agricultural operation is carried on in an exploitative manner in order to reap as much harvest as possible within a short period. This is particularly relevant in case of many tropical forest areas which have been a prey to rapid influx of landless peasants. The landless migrant poor , driven by the subsistence motive often carry out slash and burn agricultural operation with farming techniques ill suited to the forest. Ignorant of the traditional sustainable cycle, they pursue continuous cropping detrimental to soil fertility and nutrient and as a result productivity continuously decays at a rate (say) β over time. After incorporating this productivity impact the net revenue benefit from agriculture for the ith squatter at time t is given by $A_i (T_{it}, \underline{L} - L_{it})e^{\beta t}$. where $\beta > 0$ for

case (I) and $\beta < 0$ for case (II). There might be a case (III) when productivity is constant ie $\beta = 0$, but it is not realistic and for analytical purposes we are concerned here with cases (I) and (II).

Combining these three types of benefits on the basis of the aforesaid statements, the ith squatter's present value of net revenues over an infinite time horizon stands as

$$\int_0^\infty (A_i (T_{it}, \underline{L} - L_{it})e^{\beta t})e^{-rt}dt + \int_0^\infty [f(g_t, \underline{R} - \Sigma T_{it}) g_{it} + (\theta_i \Sigma L_{it.}) g_{it} - cg_{it} - wL_{it.}] e^{-rt} dt$$

$$+ \int_0^\infty E(g_t, \underline{R} - \Sigma T_{it}) e^{-rt} dt , \qquad \text{where r is the discount rate.}$$

But the squatter being not a legal settler, always perceives some amount of risk of being evicted at any time by the legal authority. And the perception of this risk element is not a static one, it might vary depending on various associated circumstances. Let us for the moment assume that the probability of being evicted is perceived to be α. Hence the squatter expects net revenues from both of the aforesaid activities with a probability of $1- \alpha$. And following the analysis of Mendelsohn (1994), this probability at time t is assumed to take the form $(1 - \alpha)^t = e^{- \delta t}$ (say), with the implication that $\delta = - \log (1 - \alpha)$. α being a probability lies between 0 and 1 , so δ always assumes a positive value.

Given this eviction factor δ, the risk burdened present value of aggregate net benefits for the ith squatter takes the form

$$\int_0^\infty (A_i (T_{it}, \underline{L} - L_{it})e^{\beta t}) e^{-\delta t} e^{-rt} dt$$

$$+ \int_0^\infty [f(g_t, \underline{R} - \Sigma T_{it}) g_{it} + (\theta_i \Sigma L_{it.}) g_{it} - cg_{it} - wL_{it.}] e^{-\delta t} e^{-rt} dt$$

$$+ \int_0^\infty E(g_t, \underline{R} - \Sigma T_{it}) e^{-\delta t} e^{-rt} dt$$

$$= A_i (T_{it}, \underline{L} - L_{it})/(r + \delta - \beta) + [f(g_t, \underline{R} - \Sigma T_{it}) g_{it} + (\theta_i \Sigma L_{it.}) g_{it} - cg_{it} - wL_{it.}]/(r + \delta)$$

$+ E(g_t, \underline{R} - \Sigma T_{it}) /(r + \delta)$

(For the case of $\beta > 0$, the denominator of the first term in the above expression is finite under the condition that $(r + \delta) > \beta$ ie when productivity rises at a rate smaller than the combined effect of $r + \delta$. In reality the rate of productivity increase through poor farmers' moderate investment efforts is likely to be very small. In case of $\beta < 0$ the expression holds unconditionally).

The ith settler is assumed to maximise the risk adjusted aggregate net revenue with respect to choice of three strategic variables T_i, L_i and g_i , treating the others' choice of the same as given. Thus on the basis of the following problem

Max

$$\pi_i = A_i (T_{it}, \underline{L} - L_{it})/(r+\delta - \beta) + [f(g_t, \underline{R} - \Sigma T_{it}) g_{it} + (\theta_i \Sigma L_{it}.) g_{it} - cg_{it} - wL_{it}.]/(r + \delta)$$
$$+ E(g_t, \underline{R} - \Sigma T_{it}) /(r + \delta) \quad \ldots\ldots(12)$$

we have the following 1st order conditions (omitting the suffix t)

$$\partial\pi_i/\partial T_i = A_{i\,Ti} / (r+\delta - \beta) - f_{x.}\ g_i /(r + \delta) - E_x/(r + \delta) = 0 \quad \text{where } x = \underline{R} - \Sigma T_{it} \text{ ------(13)}$$

$$\partial\pi_i/\partial L_i = - A_{izi} / (r + \delta - \beta) + (\theta_i .\ g_i - w) /(r + \delta) = 0 \text{ where } z_i = \underline{L} - L_{it} \text{ -----------(14)}$$

$$\text{and } \partial\pi_i/\partial g_i = [f_g g_i + f (.) + \theta_i \Sigma L_{it}. - c + E_g] /(r + \delta) = 0 \text{ ----------------------------(15)}$$

All the above three equations are valid for i =1 to n. Optimum Nash-Equilibrium (N-E) values of T_i, L_i and g_i (for i = 1 to n) can be found out by solving these equations simultaneously.

In order to have an understanding of the impact of perceived changes in the risk of eviction from the encroached land, on the shift in use pattern of forest land resources and allocation of endowed labour between contending uses of agriculture and maintenance of grazing land, we consider the first two equations.

From equation (13) we get

$A_{i\,Ti}/(r+\delta-\beta) = f_{x.}\ g_i/(r+\delta) + E_x/(r+\delta)$

Or $A_{i\,Ti}/(f_{x.}g_i + E_x) = [1 - \beta/(r+\delta)]$ …… (16)

Now in order to get the impact of marginal changes in the value of the eviction factor δ on the value of T_i we treat the values of g_i and L_i fixed at their Nash equilibrium levels g_i^* and L_i^* respectively and evaluating at this level we get,

$\partial T_i/\partial\delta = \{\beta/(r+\delta)^2\}.(f_{x.}g_i^* + E_x)^2 / [\ A_{i\,Ti\,Ti}\ .\ (f_{x.}g_i^* + E_x) - A_{i\,Ti}\ .(\ f_{x\,Ti}\ .g_i^* + E_{xTi})]$ ..(17)

Here we assume $A_{i\,Ti} > 0$, $f_x > 0$, $A_{i\,Ti\,Ti} < 0$ because of the assumption of diminishing marginal benefits from agricultural land and $f_{x\,Ti} > 0$ as rise in T_i decreases $\underline{R}- \Sigma\, T_{it} = x$ and raises f_x , where f_{xx} is assumed to be negative. Similarly $E_x > 0$ and $E_{xTi} > 0$ since rise in T_i decreases $\underline{R}- \Sigma\, T_{it} = x$ and increases E_x while it is assumed that $E_{xx} < 0$.

Therefore in case of $\beta > 0$, $\partial T_i/\partial\delta < 0$, indicating that as perception of risk of eviction increases, agricultural land is reconverted to forest and vice versa. So in this case as the settlers put more investment in managing agricultural land , they perceive less risk of eviction by the authority and feel encouraged to convert more forest/ grazing land.

On the other hand in case of slash and burn agriculture where $\beta < 0$, $\partial T_i/\partial\delta > 0$.The implication is that as the risk of eviction is perceived to rise (through a rise in the value of the eviction factor δ) , the amount of land in agriculture ie T_i increases through conversion of more forest grazing land for agricultural purposes . The result is a reduction in CPR land and its degradation arising from attempts to earn quick returns from converting CPR land into an exploitative activity like agriculture.

Again from equation (14) we have

$A_{i\,zi}/(r+\delta-\beta) = (\theta_i\ .\ g_i - w)/(r+\delta)$

or $A_{i\,zi} = (\theta_i . g_i - w)[1 - \beta/ (r +\delta)]$ ……(18)

Now evaluating the impact of a marginal change in the eviction factor δ on L_i while treating the values of g_i and T_i fixed at their Nash equilibrium levels , we get on differentiation with respect to δ,

$A_{i\,ziLi} . \partial L_i/\partial\delta = (\theta_i . g_i^* - w) . \beta/ (r +\delta)^2$

or $\partial L_i/\partial\delta = [(\theta_i . g_i^* - w)/ A_{i\,ziLi}]. [\beta/ (r +\delta)^2]$ ……(19)

In case of forest squatters, w is the opportunity cost of participatory labour in the absence of major wage earning occupations. It is assumed to be very low and hence $\theta_i.g_i^*$ can reasonably be taken to be greater than w. Again A_{izi} ie marginal benefit of agriculture due to labour is positive and assuming diminishing marginal benefit ie $A_{i\,zizi} < 0$, it can be asserted that as L_i rises z_i falls and so $A_{izi\,Li} > 0$.

When $\beta > 0$, $\partial L_i/\partial\delta > 0$, indicating that with a rise in eviction risk ,labour is shifted away from agriculture to be employed in participatory management of grazing land and vice versa. Thus it can be said that in case of $\beta > 0$, a fall in the risk of eviction is associated with converting grazing land resources to agricultural land at given(N-E) level of labour employment and cattle population while more labour is put into agricultural operations if the quantity of agricultural land and cattle are kept fixed at N-E level. Usually it is expected that under such circumstances migrant settlers will resort to clearing of forest /grazing land for agricultural purposes, rather than to employ more labour into the same tract of land which just lowers productivity.

The greater the investment efforts by the settlers, the less is the perception of risk of eviction on their part and more likely is the degradation of forest resources/ grazing land .On the basis of empirical evidence Besley(1995) states that farmers often make strategic investment so that the probability of eviction is reduced. It is only when fully secured tenure is given to poor migrant farmers, that the risk factor vanishes, and their investment efforts do not involve degradation of forest grazing land . However the case of increasing productivity is relatively rare , more likely in case of tropical forest squatters is the case of decaying agricultural productivity ie $\beta < 0$.

In this case $\partial L_i/\partial\delta < 0$. Thus with rise in risk of eviction , reflected by increase in the eviction factor δ , there is a fall in the allocation of labour to maintain grazing land. Given the endowed labour $\underline{L}$, it implies an increment in labour employed in exploitative agricultural operations. The implication of perception of an increased risk of eviction (as indicated by a rise in eviction factor δ) is that land converted to agriculture (T_i) rises at given (N-E) level of labour employment and cattle size , and if T_i and cattle size are taken to be fixed at N-E level, then labour is shifted away from participatory management of grazing land to agricultural operations. Thus grazing land is either depleted or tends to be ill-managed with increased risk of eviction .

The first kind of change is more likely to occur as settlers, threatened with increased risk, try to extract as much crop output as possible in a short time by putting more land into agriculture. In this context it might be noted that certain factors are often at work which lead to perception of increased risk of eviction over time. For instance with rising population pressure , the first settlers might be increasingly contested and challenged by later arrivals who try to evict them and grab the resource base. Again rising land values or falling eviction costs may persuade the settlers that their tenure is less secure.

The evidence appears to support this view. Dorner and Thiensenhusen(1992) found that in many parts of the world deforestation has often been the offshoot of tenure insecurity suffered by settlers. They indicated that the threat of a land reform in Paraguay in 1980s and rising risk of eviction over time resulted in rapid deforestation by land settlers who apprehended that forested area might be proclaimed as unproductive. According to Gould's study (2002) a large part of forest land in the highlands of Philippines is cultivated by slash and burn process. He finds that pressure of migrant settlers and population growth associated with land competition and increased risk of eviction have resulted in increased deforestation and land degradation because of shifting cultivation. At present many states do not recognise the use of land for grazing as a productive land use and abstain from conferring rights to the users. Hence users fear being driven out of the use of the grazing land. On the contrary , use of land for agricultural purposes is often considered as a valid form of land use and is conferred a stronger user right. Driven by this consideration squatters

often feel encouraged to convert forest/grazing land to agriculture so as to minimise the risk of eviction. Assurance of unhindered access to grazing land over a reasonably long period of time and recognition of the act of grazing as a valid form of land use, which confers rights to users , would increase the security felt by the herdsmen over the resources. This would also slow the process of conversion of grazing land into agricultural land . Thus for $\beta < 0$, it can generally be observed that weakly defined ownership and associated increased threat of eviction tend to accentuate the conversion of the forest resources/ grazing land into non capital intensive exploitative subsistence type agriculture and loss of diverse benefits offered by the natural resources.

4. Conclusions and policy prescriptions

This paper supports the findings of a substantial body of literature that security of tenure matters. The steady state optimal level of deforestation requires that marginal benefit from land in agriculture should be equal to the marginal benefit from forest land, where benefits include both forest collection and environmental benefits. Conversion of open access forest land to agriculture will continue so long as the former benefit exceeds the latter. And in cases where environmental benefits tend to be neglected , deforestation rates will be higher. The crux of the problem lies in the absence of proper titling to the forest resources. In its absence private holders of agricultural land under the aforesaid conditions, tend to deplete the unprotected forest land for private benefit. One solution to this is the following. This can be avoided by devolution of power to local community groups, empowering them to take protective management of the forest resource and enforce controls regarding terms of access and its use by different stakeholders. The group should be composed of representatives of all the neighbouring beneficiaries who would have a joint stake in its management and who must be motivated to take care of its environmental benefit aspect as well. Besides this co- management on the basis of convention between local community and the government or joint participatory management may be another viable option for sound management of the common pool resources like forestry (Poffenberger, 1990;Saxena 1999).

In the case of squatters in unprotected public land, there often exists the risk of eviction from the encroached land by the legal authority. There are two possible cases in the de facto open access land ($\beta > 0$, $\beta < 0$). So long as the risk of eviction exists, degradation of forest/grazing land is likely to occur over time. The specific nature of variation in perceived risk of eviction over time in the respective cases leads to increased depletion/mismanagement of forest/grazing land . This can be avoided by eliminating the risk factor in the perception of settlers and by establishing security of tenure. To this purpose government can divide the land into small but economically meaningful pieces and hand them over to the settlers with full right of cultivation , or it may adopt a less generous option by just leasing out the land pieces to them for a reasonably long period of time. In case land be very limited in quantity , instead of giving a piece of land to an individual ,co-operative may be formed of a number of settlers , which may be granted the right to cultivate a carefully chosen piece of land.

In case land resources are scarce and of considerable value (as in peri urban areas) , they are likely to be subject to high competition, increasing insecurity and land disputes. In such cases parcels of the high value land could be sold in the financial market. This would of course exacerbate the equity aspect by attracting only the wealthier farmers to purchase this land rights The revenue generated for the government could, in principle, be used to enable landless settlers to buy land elsewhere. This would serve the double purpose of establishing security of tenure on high value land and thus ending land conflict while enabling rehabilitation of the poor squatters elsewhere and putting an end to their risk of eviction. When secured property rights to an asset , be it forest resources or agricultural land , in the sense of right of use and right of control are established , the concerned settler/farmer feels inclined to take action influencing productivity of the asset and regulating behaviour of others in such a way that the asset is sustained over time. This view is broadly supported by Moench(1991) in a study on the state of Kerala (India), where he has argued that in order to check the deforestation in Kerala , land titling is most desirable in the absence of other institutional mechanism. On a summary basis of micro level economic and ethnographic studies Godoy et al (1996), conclude about the high association among tenure security, high yield farming and light deforestation .

Of course security of tenure alone will not solve all problems relating to land management and deforestation. Unless there are policies aimed at reducing the pressure of population and poverty, decreasing migration across regions, enlarging scope of employment in non -farm sector as well as bringing in attitudinal changes to value the remaining forest resources at a high rate, mere titling may not guarantee sustained long –term management of land and forest conservation. Nevertheless land titling, though not sufficient , is necessary for inducing capital investment in land improvement, tree planting, forest conservation etc and this is the first step to preserve common pool natural resources .

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