

## Private Property Rights and Forest Preservation in Karnataka Western Ghats, India: Comment

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The hilly tract of Uttara Kannada district in the Western Ghats of India has been famous for its arecanut and spice orchards for several centuries. The cultivators have evolved complex horticultural practices to maintain productivity under conditions of high rainfall, hilly terrain, and leached soils. These practices include the intensive application of tree leaves as mulch and of leaf-mold and dung as manure, materials that are obtained directly or indirectly from the forests surrounding the orchards. Special forest privileges were granted to the arecanut orchard owners by the British in the 1890s for this purpose. The privileges, a rare compromise in state monopoly ownership of forest resources, allow arecanut cultivators to collect leaves, fuelwood, grass, and other products for personal use only. Specific forest plots, called *soppinabettas*, were demarcated, and rights to their use were unalienably linked to specific arecanut orchard plots (rather than vested in individuals). Recent concern over forest loss and degradation in the Western Ghats region has drawn attention to the conditions of the *soppinabettas* with their peculiar institutional form. Bhat and Huffaker (henceforth BH) constructed a bioeconomic model to predict whether the complete privatization of these forests will lead to their preservation. I present a brief critique of their effort.

### Framing the Question

To begin with, the question is ill-posed. BH state that "the government traditionally has given orchard owners exclusive right in the *soppinabetta* to prune trees for leaves" etc., but "[it] has left orchard owners to divide the *soppinabetta* lands among themselves by mutual agreement" (p. 376). BH seem to conclude that, in spite of the admittedly exclusive rights, the fact that ownership of the forest land still legally rests with the government is somehow leading to forest degradation (presumably through a "tragedy of the commons"). They then proceed to construct a model to predict what might happen if "ownership" of the

*soppinabettas* was transferred to the cultivators, without changing the "bundle of property rights," i.e., without granting rights to timber harvest or to the sale of any produce or of the land itself.

In fact, however, the latter is precisely the extant situation. Firstly, the government did not always assign *soppinabettas* communally. The extent of "common assignments" (i.e., more than one orchard plot being assigned to the same forest plot) varies significantly from village to village. Secondly, most of the commonly assigned forest plots have been divided by the households that have rights in them, typically two generations ago. Currently, "it appears that there is never any dispute about ownership or exploitation rights" (Mani, p. 30). Thirdly, the rights of individual *soppinabetta*-holders to fence off or otherwise to protect their forest plots, and to exclude others from harvesting the produce, have long been recognized (see Nugent; also Government of Bombay). Barring minor complaints about misallocation, there was no evidence during my field work in this region in 1989–91 that the *soppinabettas* suffer in general from the "tragedy of the commons."

Thus, the model of privatized *soppinabettas* presented by BH is not a model of a hypothetical situation, but in fact of what exists today, which places their analysis in quite a different light. On the one hand, it is no longer obvious that the question posed by BH is the most pertinent policy issue. BH motivate the need to "determine when private ownership by arecanut producers is a feasible preservationist strategy" by referring to the policy discussion in Gadgil (1987a). However, a perusal of this reference reveals that the "privatization" that Gadgil suggests is in the form of allocating additional rights to the *soppinabetta*-holders to harvest and sell timber. This is indeed the scenario that needs to be modeled, because it can also be argued that giving away the right to harvest timber will in fact lead to the rapid depletion of the lands. But this scenario has been explicitly omitted by BH (p. 376, col. 2, para. 2).

On the other hand, if one wishes to examine "the potential for foliage preservation under orchard production because it is the current use" (p. 376, col. 2, para. 2), the question of interest then is why certain *soppinabettas* appear degraded while others appear to be well-preserved, and why "private exclusive privileges have not necessarily played a preservative role" (Nadkarni et al.). It is then incumbent upon BH to show how their model explains the empirically observed condition of the *soppinabetta*

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forests. Unfortunately, BH present barely enough data to derive the parameter values. Model validation is not mentioned at all.

### Use of Empirical Data

In the mathematical statement of the model (pp. 376–77), BH clearly define variables  $B$  and  $R$  to be the foliage stock and foliage harvest rate respectively. However, in the calibration of the model (p. 383, col. 2), the values they use from Gadgil (1987a) pertain to stocks and flows of total tree biomass. Typically, foliage constitutes less than 5% of total above-ground biomass of trees in these forests (Rai and Proctor), while leaf production constitutes between 20% and 50% of total above-ground production (Satoo and Madgwick, pp. 106–08). In the case of harvested biomass, Gadgil (1987b, p. 38) reported its composition as lopped foliage (22%), leaf-litter (25%), grass (17%), fuelwood (27%), and small timber (9%).

It may be argued that the inconsistency between BH's mathematical statement and their calibration values can be easily resolved by redefining  $B$  and  $R$  to be total biomass stock and flow, and changing the value of  $q$  (fraction of harvest that is leaf mulch) from 90% to 47% (=22% + 25% from above). But given the unequal proportions of leafy matter in biomass stock, production, and harvest, this approach would not be correct. Instead, one must use the correct values for leafy biomass to reevaluate the expressions (22)–(24) of BH, whereupon one gets

$$(24a) \quad a_1 = a_0(8.97 \times 10^{-3}) + 5.44,$$

instead of  $a_0(9.44 \times 10^{-5}) + 0.111$ , and

$$(24b) \quad b = a_0(1.09 \times 10^{-6}) + 6.35 \times 10^{-4},$$

instead of  $a_0(5.45 \times 10^{-10}) + (3.79 \times 10^{-7})$ .

These differences are dramatic enough to warrant skepticism about BH's subsequent results.<sup>1</sup>

<sup>1</sup> Values used were as follows (modification of original value is given in brackets): 1.5 t/ha/yr (=50% of 3 t/ha/yr), 6 t/ha/yr (=30% of 20 t/ha/yr), 0.28 t/ha (=1% of 28 t/ha, because standing stock of foliage in a lopped *soppinabetta* is lower than in unlopped forest), and 20 t/ha (=5% of 400 t/ha, because 400 t/ha corresponds to unlopped forest). For  $a_0 = 500$ , one obtains  $a_1 = 9.927$  and  $b = 1.182 \times 10^{-3}$ , which gives  $\bar{B} = 50.7$  kg/acre and  $\bar{B} = 8347$  kg/acre. I did not repeat BH's numerical simulations with the new values, because I do not believe in the validity of the model itself, as explained later.

The problem is, however, further complicated by a possible error in Gadgil's estimate of 28 t/ha as typical total above-ground biomass (TAGB) in *soppinabetta*. A reworking of Gadgil's original data indicates that the TAGB is between 55 and 180 t/ha, depending upon the biomass estimation method used. Estimates of TAGB from my own larger sample of *soppinabetta* range from between 50 and 300 t/ha. The productivity values need to be similarly revised upwards (CES and KSCST, p. 44; Lélé, in preparation).

### Model Validation and Sensitivity Analysis

Any application of a mathematical model to a real-life problem must undergo calibration, validation, and sensitivity analysis. Only then can it be used for policy analysis. As pointed out above, the calibration of BH's model leaves much to be desired. Further, there is no attempt to validate the model by comparing its predictions with empirical data. Perhaps such validation was not thought to be possible because the authors were under the impression that the scenario they were modelling was a hypothetical one. But the absence of sensitivity analysis (beyond varying  $c_0$  and  $a_0$ , which could not be specified uniquely) is quite inexplicable.

An examination of the effect of changes in output (arecanut) or input (labor) prices is important in this case, where conflicting claims have been made about the causes of *soppinabetta* degradation and the role of such price changes. Arecanut prices rose at a nominal annual rate of about 7% between 1970–90 (Togar's Co-operative Sale Society, Sirsi, India: annual reports 1970–90). While Gadgil (1987b, p. 15) claims that this price rise is partly responsible for *soppinabetta* degradation (because of the careless lopping by laborers contracted by orchard owners as their cash incomes increased), Mani (p. 36) contends that it is increasing labor costs that has led to *soppinabetta* degradation. An examination of the effects of changes in output and input prices on the relative sizes of the optimality domains of continuous extraction versus resource extinction strategies would shed light on this matter.

### Fundamental Questions of Model Structure

BH must be complimented for having deviated from the conventional focus of bio-economic modellers on timber forestry and having attempted to model a problem that is far more pressing in many tropical regions—the use of forest products by local people as inputs to subsistence and commercial agriculture. In the process, however, they have inadvertently exposed the inapplicability of conventional renewable resource models—the logistic growth model and its variants (Clark, pp. 10–22)—to these problems. These models assume that the natural growth rate of the resource goes to zero at some finite stock level, BH's  $\bar{B}$ . In the case of timber, where net additions to the stock of living timber approach zero as the stand ages, the logistic growth model may be reasonable. However, in the case of the components of forest biomass production that are most used by villagers, viz., leaves, twigs, and deadwood, it does not apply. The reason is that natural death, which renders trees useless for timber (or, e.g., fish in fisheries useless for food), does not render other biomass in forests useless for human use (leaf litter can be used as mulch and manure, deadwood as fuel).

Useful tree biomass production is thus no longer just net addition to above ground biomass of trees, i.e.,  $\Delta(TAGB)$ , but is  $= \Delta(TAGB) + \text{litterfall}$ .<sup>2</sup> The second term, which includes dead leaves, twigs, branches and trees, probably peaks at maximum stand age (Satoo and Madgwick, p.100), at which point  $TAGB$  is also at its maximum. While total useful production may peak at some intermediate  $TAGB$  level, it will never go to zero. More important, in the particular case of leaf mulch from *soppinabetta* forests, total leaf production increases monotonically with  $TAGB$ , or with tree density and basal area.

Does this then mean that arecanut cultivators ought to maintain their *soppinabettas* at or near climax vegetation? No, because there is at least one other key link between forests and arecanut productivity that was ignored by B and H: the grass—livestock—manure link. Arecanut cultivators maintain a number of cattle and buffaloes, at least in part for the dung they provide that can be used as manure for the orchards. Grass from the *soppinabettas* forms a major source of fodder for these animals. Grass production, however, is negatively correlated with tree canopy cover (and therefore with  $TAGB$ , assuming unchanging tree architecture; see Satoo and Madgwick, p. 91). Thus, the *soppinabetta*-user must trade-off the benefits from mulch against those from manure when choosing what tree density and crown cover to maintain in the *soppinabetta*.<sup>3</sup> A static model of farmer choice in these circumstances can be easily formulated, and is found to give reasonable results (Lélé 1993).

What then about the dynamic aspects? The negative feedback between leaf harvest/collection and leaf production is quite tenuous and long-term. On the one hand, the litter collection component of leaf biomass harvest has no short-term impacts on future production. Long-term impacts occur through changes in the nutrient cycle, soil structure, and hydrology, but they are poorly understood. Dynamic models of such effects in tropical forests are rare and quite complex (e.g., Bossel and Schafer). On the other hand, lopping too may have no effect or even have a positive effect on leaf production in the following year (Rob-

inson). In any case, the conventional logistic growth model is quite inappropriate.

### Concluding Remarks

The above arguments are not meant to insist that no reasonable bio-economic model can ever be built to represent the behavior of arecanut cultivators in Uttara Kannada. They are, however, meant to highlight the problems associated with constructing models from theory without a reality-check. My observations in the Karnataka Western Ghats region suggest that, on the one hand, the redefinition of what is useful production in a forest renders conventional dynamic models inapplicable, and on the other hand, the nature and complexity of socio-economic conditions (such as highly imperfect fodder, fuel, land and credit markets, and people's belief in transferring real productive assets to future generations that amount to an allocation of inter-generational property rights) may render the control-theoretic NPV-maximization approach at least infeasible, and probably inappropriate, for the problem at hand, i.e., to understand why *soppinabettas* are used, maintained and transformed the way they are. Static methods like benefit-cost analysis, while perhaps unfashionable, are likely to be more useful in answering the currently pressing policy questions, such as whether the present structure of privileges in the *soppinabettas* provides a "sufficient" incentive for arecanut cultivators to incur the costs of protecting and maintaining these forests.

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<sup>2</sup>  $\Delta(TAGB)$  would be the same as BH's  $\dot{B}$  if B represented total above-ground tree biomass.

<sup>3</sup> It has been estimated that about 5 tonnes (by fresh weight) of dung are used each year in the manure applied to 1 ha of arecanut orchard, and in producing these 5 tonnes the livestock consumed about 20 tonnes fodder and concentrates, of which 7 tonnes of grass came from the *soppinabettas* per year (CES and KSCST, p. 36).

Note that the effect of lopping of green foliage and twigs on useful production and on the partitioning of that useful production is a complicating factor. While to a casual observer, the lopping of trees in *soppinabettas* is for leaf mulch, in fact, however, it is more likely to be related to the demand for fuelwood. The fact that virtually all the cultivators who have recently installed biogas plants (which then provide all of their cooking energy needs) have stopped or dramatically reduced lopping in their *soppinabettas* lands, and are relying mostly on leaf-litter collected from the forest floor (Lélé, 1991), lends support to this interpretation.

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