Report

Gunnar Köhlin and Madelene Ostwald

Impact of Plantations on Forest Use and Forest Status in Orissa, India

In Orissa 100 thousand ha of village plantations were established from 1985 to 1992 as an aid project to support the subsistence needs of rural poor and to relieve heavy pressure on the natural forests. The aim of this paper is to examine the welfare and environmental effects of these village plantations. To do this, extensive data collection was needed which included both household utilization of different sources of biomass as well as remote-sensing information, to establish the status of the vegetation and it's spatial location *vis-a-vis* the users. The study shows that plantations have the potential for substantial welfare improvements for the target population, especially women, through increased consumption of biomass, decreased time for collection and decreased pressure on natural forests. However, interventions need to be very selective in order to be successful, with special consideration given to plantation location compared to natural forest.

Plantation where litter from the soil floor has been swept for fuel. Photo: M. Ostwald.

INTRODUCTION

In many poor areas of the world, dependency on forest products is great. Throughout India, increased pressure for timber, fuelwood, cropland, and commercial industry has had a direct impact on the livelihood of millions of rural households. Decreasing forest areas lead to environmental hazards such as erosion, sedimentation of rivers and flooding (1). The pressure on the forest resources in the area of interest for this study, Orissa, India, has increased dramatically (2). The direct dependency on the forests among poor people is often complex and important for their daily lives, e.g. through the use of forest products for fuel, food, building material, animal feed, and medicine (3).

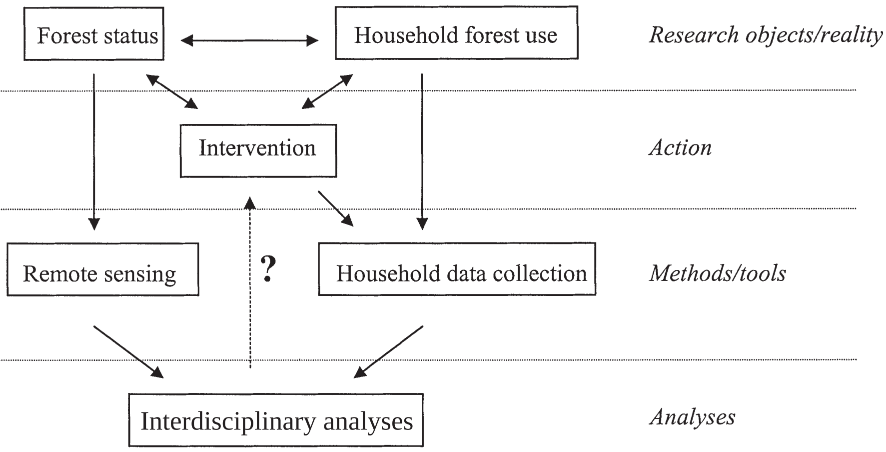
However, there have been a number of counteracting forces to the decreased forest resources in Orissa. Individual plantations have been supported by a farm forestry project. Community action has led to the establishment of protection of nearby natural forests. Forest plantations have been undertaken by a number of government agencies. The largest of these initiatives has been the Orissa Social Forestry Programme that initiated the establishment of more than 100 000 ha of village forest plantations during the period 1985 to 1992 (4).

The benefits from these plantations were not exactly what were expected. The fast-growing trees that were intended for fuelwood were often sold to the local paper and pulp mills while the leaves, which were either ignored as a resource or assumed to improve the humus layer, turned out to be of substantial benefit to the villagers. A very common practice is to sweep up leaves that have fallen from the trees for use as a fuel (5).

The aim of this paper is to examine the welfare effects of these village plantations through their impact on households' time allocation, fuel consumption, and pressure on natural forests. Since the interaction between households and forests is inherently interdisciplinary, the research has been conducted using both methodologies from environmental economics and physical geography. The study thus exemplifies the potential of combining physical information from remote sensing with economic analyses of household data, an approach that is of particular relevance to the interface between environment and development (6).

A conceptual model for the work is presented in Figure 1. The focus of the research is to understand the interaction between the status of the forest and the households' use of the forest in the case of a forest intervention, such as an aid project. In order

Figure 1. Conceptual model.



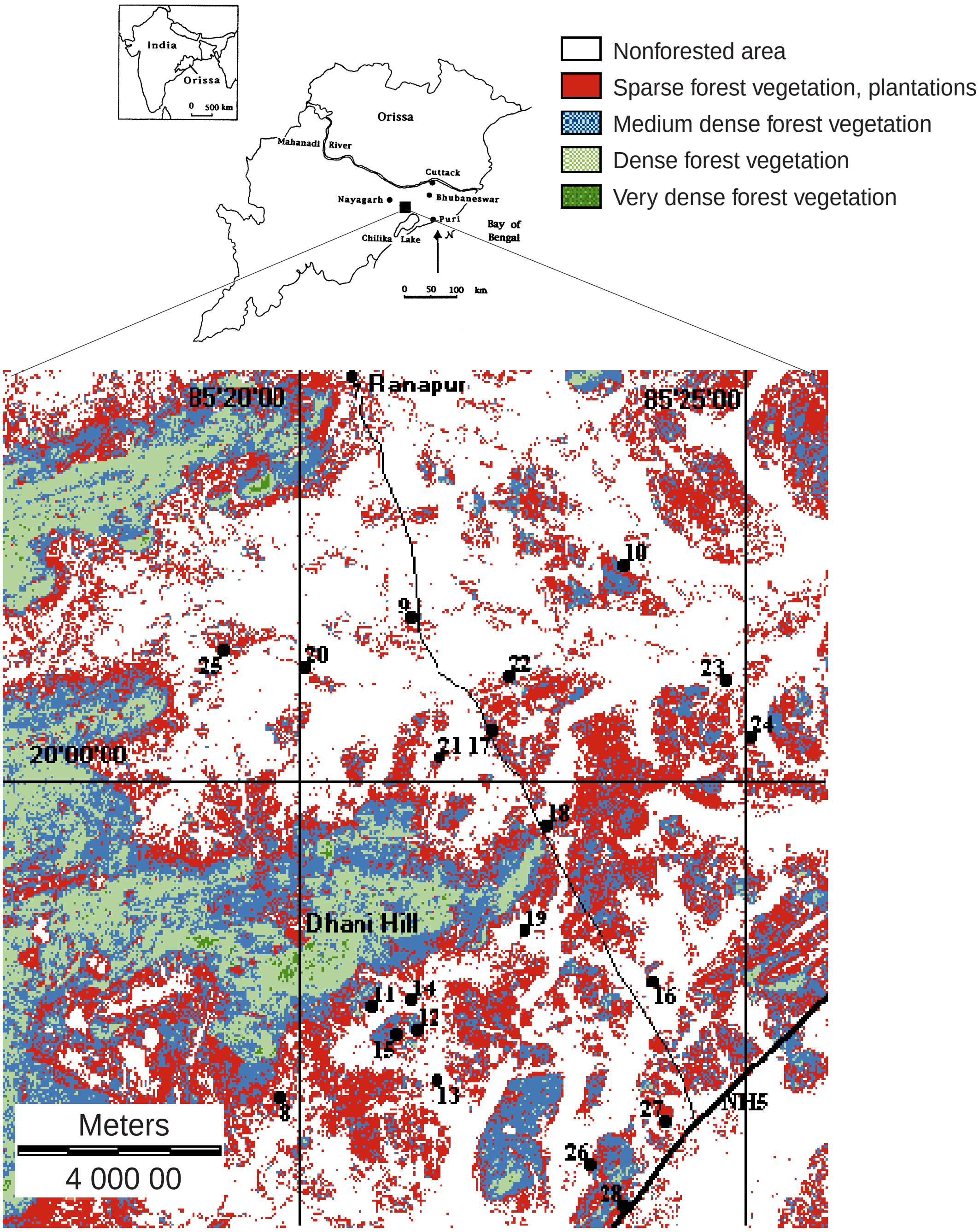


Figure 2. Study area.

to assess the status of the forest and its location compared to that of the household we use remote sensing. In order to identify household forest use and the household response to the intervention we use household data collection. The combined data can be used in an interdisciplinary analysis to evaluate the intervention and it has the potential to improve the efficiency of interventions both in terms of increased welfare for the population and improved status of the forest, if there is a feedback loop.

DATA AND METHODS

Study Area

The state of Orissa is mainly rural with more than 80% of the population working in the agricultural sector. The study area, between Ranapur in Nayagarh district and the Bay of Bengal (Fig. 2), is characterized by plains with paddy fields crossed by two mountain ridges; the Eastern Gaths. These two ridges are 1–5 km wide, rising approximately 500 m above the plains and are the main area of natural forest. Since independence, the coastal belt of Orissa experienced rapid population growth. From 1961–1991 the population in 10 villages in the study area grew by 140% (7). The forest has been intensively used, predominantly for local consumption, which has decreased both the size and status of forests.

An analysis of human interaction with forest resources demands detailed data on household collection patterns as well as data on forest stocks and forest location vis-a-vis the households. This information can then be used in econometric analyses to explain factors affecting the choice of source of biomass, the im-

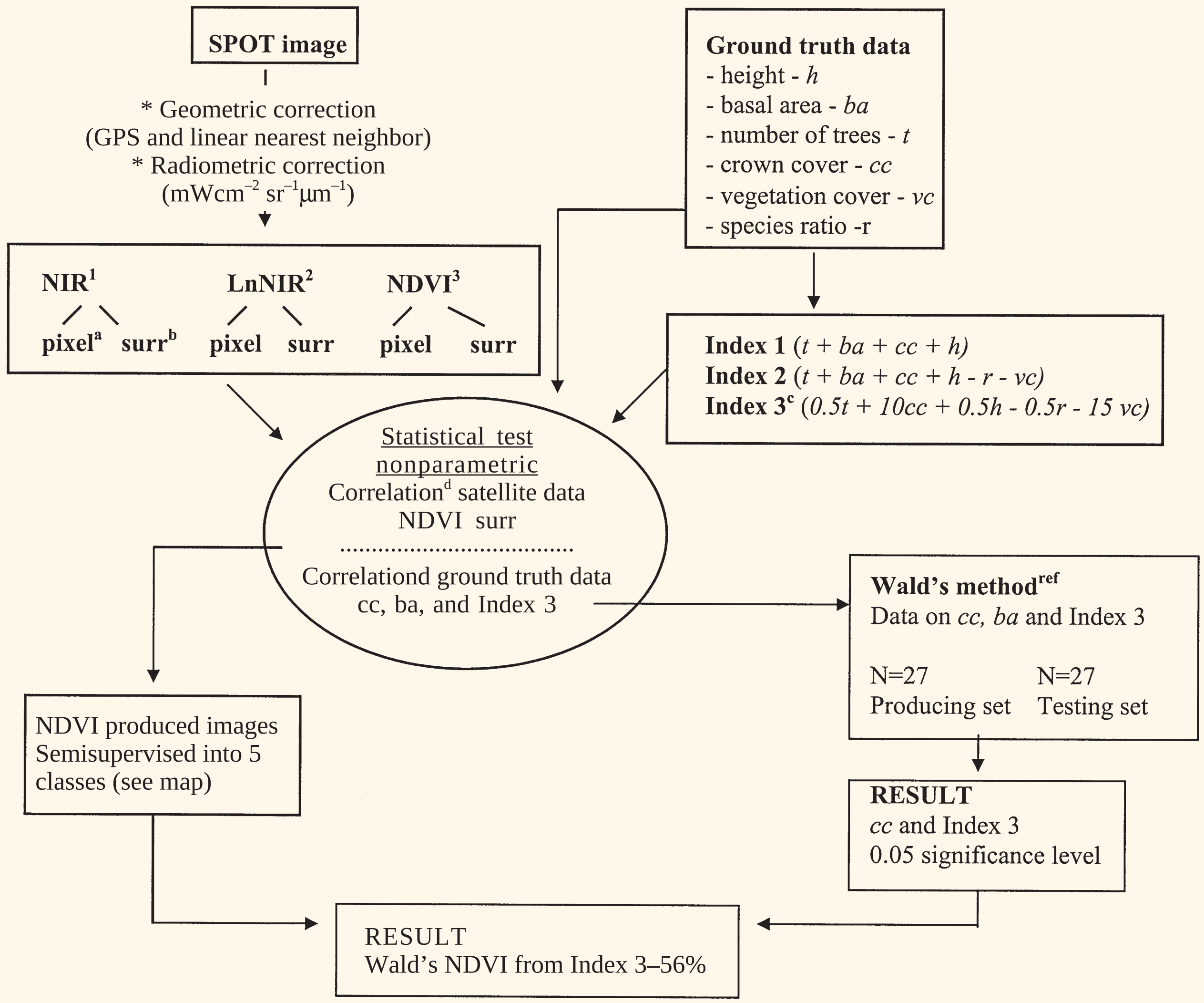


Figure 3. Flow chart over the development of vegetation classes based on SPOT satellite image.

[1] Near infra-red spectral band from satellite image
[2] Natural logarithm on near infra-red spectral band
[3] Normalized difference vegetation index = (NIR – red band)/(NIR + red band)
[a] One satellite pixel from the point of field observation
[b] Mean of 28 surrounding satellite pixels from the central one
[c] Weighted parameters produced from multivariate analyses followed by trial and error
[d] With significance level < 0.05 with Spearman Rank test (21, 22)

pact of plantations on household time allocation, and pressure on the natural forest.

Household Data Collection

Household interviews were conducted in 22 villages around Dhani Hill Reserved Forest (Fig. 2). The villages were randomly sampled and include villages with and without village woodlots (VWL) at different distances to the Reserved Forest. Professional interviewers, who received special training for this survey, conducted 743 interviews. The questionnaire included detailed questions regarding forest use as well as supplementary household data. Fuel use was determined based on recall over four seasons and specified by kind and source. Separate questions were posed regarding the collection in VWL and in natural forest with details of who collected, where they collected, quantity per trip, number of trips and time to get to the source of fuel as well as the time to collect.

Remote Sensing of Forest Status

A geographical information system (GIS) with information on the location of the studied villages in relation to different sources of woody biomass was developed. All villages and reference sites in the vegetation area were identified in the GIS through the use of handheld GPS.

A vegetation index was produced based on a SPOT satellite image obtained on 29 December 1994 (228/309) and ground observation. The methods used and the process involved in developing and choosing the index are presented in a flow chart (Fig. 3) and in Ostwald (8). Field observations were carried out during 1996 and 1997. The evaluation of the method showed that the highest accuracy was 56% from Index 3, which is a weighted index based on number of trees, crown cover, tree height, ratio of heterogeneity of species and ground vegetation cover. The image enhancement that proved most feasible was the normalized difference vegetation index (NDVI) based on mean spectral values from visited site and adjacent areas (pixels) up to 60 m.

A canopy approaching 100% closure will reach a point of saturation. This means that even though the biomass will grow with age under a totally closed canopy this is not detected by the data collected by the satellite image (9). However, this also means that the method is suitable for analyses of forests in the state of regeneration, which is the case for the study area.

The vegetation classes are shown in Figure 2, which shows 4 classes of forest vegetation varying from plantation to dense mature natural forest. In socioeconomic analyses of forest use there is often a lack of relevant exogenous variables of resource stocks. In this case, it was possible to both produce indices of vegetation surrounding the villages and distances from villages to vegetation of a certain status. Especially the latter is used in the following analysis. However, forests with high amounts of species are more difficult to interpret due to the variety of height, leaf structure, deciduous behavior, growth patterns, etc. (10).

RESULTS

The Impact of Plantations on Time Spent Collecting Fuel

Several results could be drawn from the material (11). Let us start with fuel collection patterns and how these have been affected by the introduction of VWL. In the literature, it is generally assumed that women bear the brunt of the burden in regard to fuel collection (12, 13). Table 1 reports participation in fuel collection by different categories of household labor, and indicates a greater participation by men than women. This holds for collection in both natural forest and in VWL. In fact, with the introduction of VWL, men not only become involved in fuel collection more often, they also spend more time than women collecting. Not only that, female participation in collecting in natural forests also decreases with the introduction of VWL. It is striking that the only really significant change in time allocation is that women in villages with VWL spend less time collecting in natural forests.

This result also holds if we look at total time devoted to collection in the household. All categories spend less time on fuelwood collection when VWL are available. However, the largest and most significant change is for women who, on average, decrease their weekly collection time by more than 10 hrs in those households involved in collection. This is a remarkable aid project accomplishment since it is difficult to bring benefits to a group that is as systematically marginalized as the women in Orissa. Discussions with the females who helped in interviewing during the fieldwork reinforce the picture of a project that benefits women. Women were very happy with the plantations since they made fuel more readily accessible. The benefits have also been shown in a study regarding gender differences in forest protection (14). VWLs also involved the men in collecting fuelwood for the household purposes.

The Impact of Plantations on Biofuel Consumption

In Table 2, consumption data are used to analyze the sources of biomass consumption in villages with and without VWL. The plantations seem to have a number of impacts on the fuel consumption patterns in the villages. A common objective of most social forestry projects is to increase availability of fuel and thus increase consumption of a basic need closely related to nutrition and general well-being. The fulfilment of this objective is indicated by the reported higher consumption of fuels in villages with VWL (significant at the 5% level).

The consumption of fuel from natural forests is almost identical for the two groups. This would suggest that there is no reduced pressure on the natural forest as a result of the plantations of VWL. A more sophisticated multivariate analysis actually shows that VWL decrease the pressure on natural forests, as will be shown below.

The significantly higher consumption from private sources in villages with VWL is due to the implementation of the other main component of the Orissa social forestry program, farm forestry, i.e. distribution of free seedlings to households, mainly in villages carrying out VWL plantations.

Villages with VWL are significantly less dependent on market purchases of fuel. This is an often forgotten benefit from plantation projects. Reduced market purchases save scarce cash for those with limited availability of fuel sources. In addition, it reduces the pressure on the natural forest from "headloaders" who use the forest to supply urban markets.

Estimation of Welfare and Environmental Impacts of Plantations

A number of welfare and environmental impacts of VWL can be estimated based on the data described here. Table 3 gives a summary of 3 different methods to assess the impact of VWL in 15 villages around Dhani Hill Reserve Forest (Fig. 2). The names of the villages are found in the first column. The second column gives a monetary measure of the value of time saved due to the increased availability of biomass from VWL. By as-

Table 1. Participation and time for collection in VWL and NF.

	Collection in VWL (N = 494)			Collection in forest: Without VWL (N = 248)			Collection in forest: With VWL (N = 494)			Two sample t-test
	%	hrs per week[b]	STD	% (a)	hrs per week[b]	STD	% (a)	hrs per week[b]	STD	
Total	50	4.7	4.6	53	23.6	39.7	49	15.6	2.32	– 2.32**
Men	33	3.9	4.1	38	10.2	14.3	42	8.3	9.5	– 1.37
Women	22	3.2	3.1	18	20	22.6	14	12.8	15.3	– 2.03**
Boys	10	2.9	3	2	5.5	2.8	3	5.4	8.5	– 0.02
Girls	10	3.2	3.4	2	5.8	3.7	1	7.8	8.5	0.48

***, **, * indicate significance at the 1, 5 and 10% levels, respectively.
a) Percent of households (N) that have someone in the mentioned category collecting from that source.
b) Average collection time by respective household category from specified source. Note that this is the average for those households that collect.

Table 2. Consumption of fuels from different sources with and without plantations.

	Without VWL (N=242)		With VWL (N=490)		Two sample t-test
	^{a}kg yr^{-1}	STD	^{a}kg yr^{-1}	STD	
Total consumption	4200	3790	4800	3620	2.06**
From NF	1080	2240	1030	2410	– 0.27
From VWL	21	190	1200	2140	8.60***
From Private	530	1900	1120	2440	3.28***
From Village forest	830	1610	970	1840	0.98
From Market	1740	3370	480	1420	– 7.11***

***, **, * indicate significance at the 1, 5 and 10 % levels, respectively.
Average consumption per household in kg leaf equivalents per year

Table 3. Comparison of values due to VWL.

Village name	Value of time based on wood price (Rs ha^{-1} yr^{-1})	Decreased collection in NF (kg ha^{-1} yr^{-1})	Village WTP (Rs ha^{-1} yr^{-1})	Km to NF
Nakithana	780	1500	4200	0.3
Raipada	840	2500	4100	0.5
Kadamjhola	170	420	1000	0.8
Kiapalla	0	0	1300	0.8
Krushnapur	2100	5900	3700	1.0
Chandapur	770	1200	17 500	1.5
Arjunpur	3200	3000	3400	1.8
Kerendatangi	2800	1800	10 000	1.8
Champapedi	12 300	4100		2.0
Mayurjhelia	2600	950	9400	2.2
Hariharpur	890	90	2300	2.2
Balarampur	770	1400	1300	2.8
Khandisi	16 300	3200	9000	3.0
Patharbandha	10 600	100	3700	5.0
Narasinghpur	11 500	1800	13 400	5.0
Average	3866	1800	5500	

suming that the household could use the time saved for collection and sale of fuel, a monetary value of the time saved due to VWL is established. This measure is based on information on household marginal productivity in fuel collection—estimated quantity collected per time unit for the last unit collected—and the market price of fuel. The information is aggregated to the village level and is presented in terms of rupees per year for each ha of VWL established in a village.

Table 2 (Col. 3) presents the estimated annual reduction in collection in natural forests due to the establishment of VWL. The decreased pressure is estimated through an analysis of how VWL affect the time spent collecting in natural forests. It turned out that availability of VWL reduced the probability of households going to the natural forest. It also decreased the time spent collecting in natural forests. The econometric analysis made it possible for us to quantify how the increased accessibility of VWL—expressed as the marginal product for collection in VWL—affected the time spent in the natural forest on the margin. In order to obtain the change in quantity collected the change in time spent collecting in the forest was multiplied with the marginal product (kg hr^{-1}) for collection in the forest. The estimated reduction in collection in the natural forest varied greatly between villages. In one village, Champapedi, the reduction amounted to 25% of present collection in the natural forest. The aggregate reduction for the studied villages was roughly 300 tonnes of biomass per year, or approximately 10% of current collection in the forest. The estimated decreased collection in the natural forest was about a third of actual collection in VWL. This defies any simplistic notion of a one-to-one relationship between collection in VWL and reduced collection in natural forest.

The questionnaire also included questions regarding the willingness-to-pay (WTP) for a new plantation. This included all the perceived values of a new plantation, although the respondents in this case were asked to disregard the final harvest value. In Table 3 (Col. 4) the responses are expressed as the total sum that the households in each village would be willing to pay per ha and year.

Spatial Variation in Impacts of Plantations

Table 3 is sorted by ascending distance to the natural forest to facilitate a discussion on the relationship between the estimated values and the distance to natural forest. In a multivariate analysis of collection by different household categories it was found that the distance to natural forest, as classified through remote sensing, affected collection in both natural forest and VWL. We can therefore expect that distance also affects the estimated time saving from utilization of VWL instead of natural forest. In Table 3, the trend is that the value of time saved tends to increase with distance. With longer distance to the forest, households have more to gain by collection from VWL. The factors driving these results include both the increased collection in VWL with increased distance to the forest and the longer time it takes to collect from the forest for those who live further away.

The reduction in pressure on the forest due to the establishment of VWL is also affected by distance to the forest. Plotting the decreased pressure against distance to forest shows a quadratic trend, with the most significant impact achieved if plantations are located about 2 km away from the forest. This is also substantiated by multivariate analysis of the decision to collect in the forest and the amount collected. The intuition behind this is that plantations that are located very close to the forest do not affect collection behavior. People will continue to go to the natural forest. The opposite is the case far away from the forest; people would not have gone to the forest in any case but would instead have solved their fuel needs by other means. It is only at a medium range that plantations can effectively change collection behavior away from collection in the natural forest.

Households further away from the forest collect more in VWL, and save more time because of this than households closer to the forest. One would therefore expect them also to have a higher willingness-to-pay for new plantations. Indeed, an econometric analysis of the bid function shows that distance to natural forest has a positive marginal effect significant at the 5% level. This trend can also be found in Table 3, although the variation is great between villages due to a number of other factors. Other factors that are important for the value people put on a new plantation include their reliance on market purchases of fuel and the extent of their previous experience of plantations. These factors, together with the increased interest with increasing distance from natural forest indicate that community plantations are most appreciated in towns at some distance from forests, which would strengthen the case for another tradition in forest interventions, viz peri-urban fuelwood plantations. Such interventions could be very beneficial from the perspective of the society due to their environmental impacts. There might therefore be a case for subsidizing such plantations. Whether this would be commercially viable would depend on the availability of open-access sources of biomass and the collection and transport costs for these alternatives.

SUMMARY OF RESULTS

To sum up the policy implications of this study we note:
i) village plantations in social forestry projects have the potential for substantial welfare improvements for the target population, especially women;
ii) welfare improvements can come about through increased consumption of biomass, decreased time for collection, decreased pressure on natural forests or through sale of the harvest;

iii) benefits from plantations vary dramatically between villages and the benefits are not necessarily closely correlated with each other. This implies that interventions need to be selective in order to be successful;
iv) given the limited sample and the focus on time saving and decreased pressure on the natural forest, this study indicates that, as a rule of thumb, village woodlots are more beneficial further away from the natural forest, where biomass is scarce and market purchases of fuel are common. This is not to say that many of the plantations without these characteristics have been failures. On the contrary, the combined benefits for many of the plantations would pass a rigorous social cost-benefit analysis.

DISCUSSION

Social forestry projects peaked in the 1980s. Since then many projects have been discontinued for a number of reasons such as administrative overload, poor survival rates, unintended distributional impacts or undesirable market responses (15, 16). However, seldom has the decision to discontinue a project been based on welfare analyses. In effect, surprisingly little research is being carried out on forestry intervention projects in developing countries. It has been claimed that whatever learning there is, this is not sufficiently taken into account in new projects (17).

It has been demonstrated here and elsewhere that forestry interventions can have positive impacts on both rural welfare and the vegetative status of the forest (18). We have also seen that collection patterns are sensitive to distance to and status of different sources of biomass. It is therefore almost impossible to study man-forest interactions without socioeconomic and physical data. The need for more holistic analyses when studying forest use and vegetation status is increasing with the increasing complexity (19). In this case, the economic analysis of plantation intervention was greatly improved by the introduction of variables describing vegetation status and the location of forest resources relative to the surveyed households.

Unfortunately, this spatial dimension does not seem to have been given enough attention in project implementation. GIS is a promising tool for geographical planning and so is the vegetation index method based on satellite imagery that can be very useful in following the process of vegetation change over both time and space (20). However, for it to be useful for forestry interventions in rural areas in developing countries, it needs substantial data collection both in terms of physical ground-truthing and socioeconomic variables. Physical variables are needed in order to develop vegetation indices that are reliable in describing actual vegetative status, and socioeconomic variables are needed to describe patterns of resource utilization. Furthermore, it demands analytical skills that are not always consistently available. Still, if there is knowledge that it is possible to generalize from, then the investments in this kind of applied interdisciplinary research have the potential to pay-off rapidly in terms of increasing success rates and the positive welfare implications of forest-intervention projects.

The challenge is to strengthen the link between interdisciplinary research and interventions so that the question mark in Figure 2 can be erased and the expected efficiency gains are made possible. Unfortunately, this may prove difficult. There is little incentive in academia for researchers to work with application of their results. More surprisingly, there is little interest in, and understanding of, applied research among implementing consultants and ministry staff in developing countries.

One way out of this deadlock is to pinpoint successful examples. The most promising way to generate these good examples is to apply aid-supported research to actual development projects, which was the case for the research presented here.

References and Notes

1. Poffenberger, M. and McGean, B. 1996. Village Voices, Forest Choices. Oxford University Press, pp. 1–13.
2. Singh, N.M. and Singh, K.K. 1993. Forest protection by communities in Orissa—a new green revolution. Forest Trees People 19, 16–20.
3. Jha, L.K. 1996. Forestry for Rural Development. APH publishing Corporation, New Delhi, 199 pp.
4. Chaffey, D., Aziz, A., Djurfeldt, G., Haldin, G., Köhlin, G., Paranjape, J., Sunder, S.S., Svanqvist, N. and Tejwani, K.G. 1992. An Evaluation of the SIDA supported Social Forestry Projects in Tamil Nadu and Orissa, India, 231 pp. Sida, Stockholm, Sweden.
5. Jonsson, Ö. 1995. Regular and Intensive Sweeping for Leaves—A Minor Forest Produce or a Major Forest Problem. Swedish University of Agricultural Sciences. Working paper 283, 26 pp.
6. El-Swaify, S.A. and Evans, D.O. 1999. Sustaining the Global Farm: Strategic Issues, Principles, and Approaches. Prepared for the 10th International Soil Conservation Organization Conference, Purdue University, USA, 60 pp.
7. Orissa Population Census 1997. Census Records 1961–1991. Census Office, Bhubaneswar.
8. Ostwald, M. 1999. Feasibility of Estimating Degrees of Regeneration in Tropical Dry Forest through Ground Truth Data, SPOT and GIS. Report available at Earth Sciences Centre, Göteborg University. Sweden.
9. Ardö, J. 1998. Remote Sensing of Forest Decline in the Czech Republic, PhD Thesis 135 Lund University, Sweden, 136 pp.
10. Jusoff, K. and Manaf, M.R.A. 1995. Satellite remote sensing of deforestation in the Sungai Buloh Forest Reserve, Peninsula Malaysia. Int. J. Remote Sens.16, 1981–1997.
11. This section draws heavily on the following unpublished PhD Thesis: Köhlin, G. 1998. The Value of Social Forestry in Orissa, India. Dept. of Economy, Göteborg University, Sweden, 83, 133 pp.
12. Kumar, S.K. and Hotchkiss, D. 1988. Consequences of Deforestation for Women's Time Allocation, Agricultural Production, and Nutrition in Hill Areas of Nepal. Research Report 69, International Food Policy Research Institute, Washington, DC.
13. Cecelski, E. 1987. Energy and Rural Women's Work: Crisis, Response and Policy Alternatives, ILO. Int. Labor Rev. 126, 41–64.
14. Ostwald, M. and Baral. R. Local forest protection, gender and caste—Dhani Hill, Orissa, India. Geogr. Ann. Serie B. (In print).
15. Chambers, R., Saxena N.C. and Shah, T. 1989. To the Hands of the Poor. Oxford & IBH Publishing Company, New Delhi.
16. Saxena, N.C. 1994. Forestry Programmes in India. Mimeo, Sida, New Delhi. India.
17. Persson, R. 1997. Det skogliga biståndet. Sida, Stockholm, Sweden. 15 pp. (In Swedish).
18. Ravindranath, N.H., Mohan Nayak, M., Hiriyur, R.S. and Dinesh, C.R. 1991. The status and use of tree biomass in a semi-arid village ecosystem. Biomass Bioenergy 1, 9–16.
19. El-Swaify, S.A. and Evans, D.O. 1999. Sustaining the Global Farm: Strategic Issues, Principles, and Approaches. Prepared for the 10th International Soil Conservation Organization Conference, Purdue University, USA, 60 pp.
20. Ostwald, M., Jusoff, K. and Lindqvist, S. 2000. Detecting local protection efforts in forest vegetation change in Orissa, India using NOAA AVHRR data. J. Tropical Forest Sci. 12, 778–793.
21. Ardö, J. 1992. Volume quantification of coniferous forest compartments using spectral radiance recorded by Landsat Thematic Mapper. Int. J. Remote Sens. 13, 1779–1786.
22. Curran, P.J. and Hay, A.M. 1986. The importance of measurement error for certain procedures in remote sensing at optical wavelengths. Photogram. Eng. Remote Sens. 52, 229–241.

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Gunnar Köhlin is a researcher at the Environmental Economics Unit, Göteborg University. He has experience from development assistance and academic work. His research focuses on welfare and environmental impacts of aid projects. His address: Environmental Economics Unit, Department of Economics, Göteborg University, Box 640, SE-405 30 Göteborg, Sweden.
E-mail: gunnar.kohlin@economics.gu.se

Madelene Ostwald has a PhD in physical geography from Göteborg University. Her research focuses on biophysical effects and social outcome of local protection of natural forest in Orissa, India. Her address: Physical Geography, Department of Earth Sciences, Göteborg University, Box 460, SE-405 30 Göteborg, Sweden.
E-mail: madelene@gvc.gu.se