Present and Prospective Uses of Tree Species in India's Semi-arid Tropics

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PRESENT AND PROSPECTIVE USES OF TREE SPECIES IN INDIA'S SEMI-ARID TROPICS

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To be successful, research on multipurpose tree species (MPTS) requires clear end-use objectives. Based largely on information from village studies in India's Semi-Arid Tropics, economic prospects of alternative MPTS end-use objectives are assessed, implications of current and prospective tree uses on villagers' welfare are discussed, and areas for future research are delineated. The most promising end uses include poles for small construction timber, fruit and fodder. The economic scope for using trees for mulch or village fuelwood is judged to be limited. More empirical research is needed on the optimal management of tree crops in sole stands, the consequences of rapid uptake of farm forestry systems, the demand for Leucaena, and the allocation of research resources to farm forestry and other economically important tree species vis-a-vis other commodities.

INTRODUCTION

This paper assesses, in a preliminary and intuitive manner, present and prospective end uses of tree species in India's semi-arid tropics (SAT). The material presented here draws heavily on Walker (1987). The assessment is limited in three respects: (1) its geographical focus is confined to several large production regions within India's SAT, (2) the evaluation does not center exclusively on multipurpose tree species (MPTS), and (3) the relevant literature has not been thoroughly reviewed. The assessment relies largely on longitudinal data from 10 villages representative of 5 broad soil, climatic, and cropping regions of India's SAT (See Figure 1). Table 1 lists the study villages and their salient features.

The paper is organized into three sections. Descriptive analytical information on end-use objectives is followed by a discussion of the implications of current and prospective tree uses on villagers' welfare. The paper concludes with a brief agenda for future research.

PRESENT AND PROSPECTIVE USES

To be successful, research on MPTS requires clear end-use objectives. Loppings for mulch or fodder, fruit, fuelwood for domestic use, wood for household construction, poles for commercial construction, commercial small timber for pulp, and wood for farm implements are only some of the potential end uses of trees in India's SAT. The demand for six end uses are evaluated here in ascending order of perceived prospects.

Figure 1 Areas identified for village selection in ICRISAT's Village-Level Studies.

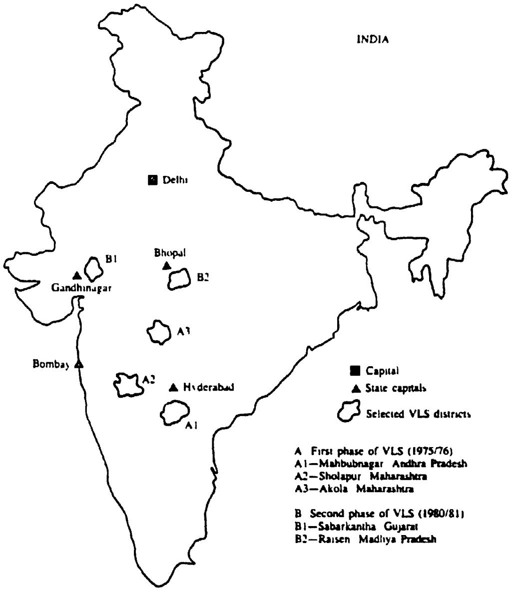


Table 1 Basic features of the study villages.

Characteristic features	State and village						
	Andhra Pradesh	Maharashtra		Gujarat		Madhya Pradesh	
	Aurepalle	Shirapur	Kanzara	Rampura	Boriya	Rampura Kalan	Papda
Soil type	Alfisols	Medium to deep Vertisols	Medium Vertisols	Sandy and sandy loam		Medium to deep Vertisols	
Annual rainfall (mm)	653	597	976	702	978	1350	
Average size of operational holding (ha)	4.0	4.8	4.6	2.2	1.4	5.1	5.4
Extent of inter cropping[2]	36	47	74	23	70	46	10
Area operated per pair of bullocks (ha)	4.8	11.8	8.0	3.8	4.2	5.3	6.3
Area under ICRISAT crops[2]	35	84	32	37	47	19	9
Irrigation	20	11	4	38	13	2	2
Intensity of cropping (%)	115	110	107	146	120	108	101
Postrainy season cropping	17	67	6	31	18	76	90

For the Madhya Pradesh villages rainfall data are taken from official records at a neighbouring town. For the other villages, daily data are recorded from rain gauge in the villages.

% of gross cropped area

More than 100% means that farmers take more than one crop a year on some portion of their area.

Tree Mulches

Much of the enthusiasm for using tree biomass as mulch stems from experience in Africa's humid and sub-humid tropics, where alley cropping has demonstrated advantages over conventional cropping in forest or bush fallows, usually on acidic and often heavily-leached soils (Kang *et al* 1981). These advantages derive largely from nutrient recycling and mulch incorporation on recently-cleared fallows. The comparative economic benefits from incorporating tree biomass as mulch have four possible sources (Sumberg *et al.* 1986, Hoekstra 1983):

1) cost of land clearing with conventional cropping and bush fallowing

2) progressive yield erosion under bush fallowing

3) scope for double-cropping a cereal in parts of Africa's SAT with a bimodal rainfall pattern

4) prohibitively expensive and/or unavailable fertilizer

Little if any economic advantage is conferred by these factors in India's SAT. Periodic fallowing is a luxury enjoyed by only the largest cultivator households who have extensive holdings of marginal land. Thus, land-clearing costs would not be charged against conventional cropping systems. Decline in yield erosion is not a significant factor in India's SAT, where fields have been under permanent cultivation for many years and where soil fertility is already low. For example, based on plot data and after accounting for technical progress, it would be difficult to show that yields have declined significantly since 1975 in the ICRISAT study villages. The problems of nutrient depletion and soil acidification are more acute in Africa's humid and sub-humid tropics, where bushfallowing is common, than in India's SAT, where permanent cultivation is the norm.

Opportunities to double-crop cereals are also rare in India's SAT. Furthermore, fertilizer availability, while still suffering from the occasional cyclical hiccup (Desai 1986), is adequate during most years and seasons, and the prospects are good that fertilizer will be increasingly available to SAT farmers.

The economics of substituting tree mulches, such as Leucaena prunings, for fertilizer warrants further discussion. Even a significant yield response to mulching may not be economical. Without significant change in soil structural properties or large nutrient carry-over effects, benefit from mulching should not be gauged by the increase in annual crop yields, but by the relative cost of fertilizer to achieve a similar response. Only benefits from mulching that cannot be gained by applying more fertilizer should be considered decisive. Under conditions of land scarcity, tree biomass is too precious to use as mulch when fertilizer is relatively cheap and readily available.

Currently, farmers do not apply tree biomass as mulch in any of the 10 study villages. The only example of mulching comes from the Sholapur villages, where farmers use sunhemp (*Crotalaria juncea*) as a mulch in the cultivation of irrigated table grapes – the most labor- and input-intensive cropping system in any of the villages. Economic sense dictates that mulches, when used, will be applied to the highest value cash crops.

Village Fuelwood

India's recent large investment in social forestry has generated valuable information on farmer demand for alternative end uses of trees. One message comes through clearly: farmers are reluctant to plant and harvest trees for sale as village firewood. The following reference applies generally to India's SAT:

> Gram panchayats (village governments) ...thought of their plantations on common land as being primarily for poles and small timbers with some consideration for fodder, but almost none for fuelwood. Typically their plans for distribution of the produce revolved around either auctioning off the wood and fodder, or selling them at concessional rates to local people. Even here the notion of the market prevailed. In short,... fuelwood – supposedly the first objective of social forestry – has in reality become its last objective. (Blair 1986, p. 1318)

Although the need for village fuelwood appears to be alarmingly high, the effective demand is surprisingly low This disparity between observers' expectations and farmers realities is easily explained (Blair 1986) Several studies have shown that about 90% of all fuel consumed by rural households is not purchased, but collected from common property resources or supplied by private crop residues or animal dung (Bowonder *et al* 1985, Jodha 1986) Women and children collect logs twigs, sticks, dung, and crop by-products. Men view the opportunity cost of that labor as insignificant. Thus in making decisions, men will choose to market tree crops to increase their cash income rather than grow trees as fuel, which they generally regard as free (Blair 1986) While this situation may be lamentable, and while the educational transition (Caldwell *et al* 1984) that is taking place in India's SAT may increase the opportunity cost of children's labor, investment in agroforestry research to increase village fuelwood consumption, in the near and medium-term future, is the economic equivalent of pushing on a string

Although casual empiricism suggests that fuelwood availability for the rural poor throughout India's SAT is deteriorating, proliferation of *Prosopis juliflora* over the last several decades – on village wastelands and along roadsides – has gone largely unnoticed Several survey indicate that fuelwood availability has increased over time with the productivity of highly-coppiced *Prosopis juliflora* on marginal open access land (D Hocking and K.P C Rao 1986, personal communication)

Some households in the drought-prone Mahbubnagar study villages now buy firewood, but their purchases amount to only about 1% of total village consumption expenditure In the Akola villages where biomass is more readily available only government employees purchase fuelwood In the Sholapur villages, households rely more heavily on dung as a source of cooking fuel Unless village purchasing power expands dramatically alternative fuel sources become much dearer and competing end uses such as pulp for paper and poles for construction become decidedly less attractive tree plantations for sale of village firewood will remain only a remote possibility

Vegetative Barriers and Shelterbelts

Vegetative barriers are grown to protect against soil losses from surface runoff, shelterbelts are designed to reduce the effects of wind erosion. With the exception of some districts in the northwest, wind erosion in India's SAT is not severe. The objective of shelterbelts makes them more suitable to Africa's SAT, where sand blasting often severely reduces millet yield

Species requirements for the use of trees as vegetative barriers are quite stringent at least partial tolerance to heavy browsing, limited competition with field crops, and a readily perceived economic value. Depending on location-specific conditions, grasses may be more cost-effective as vegetative barriers than trees.

Fodder

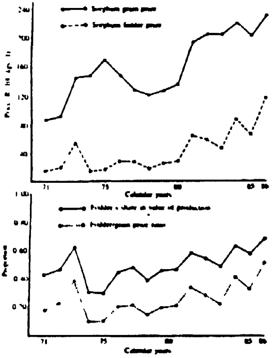
The use of trees for fodder shows considerably more economic promise Since 1980, the demand for fodder in India's SAT has clearly increased Fueled by demand for milk in urban areas and smaller towns, fodder prices have more than kept up with inflation.

Figure 2 illustrates that trend for the Sholapur market, the center of post-rainy season sorghum production in India's SAT

Since the severe drought in Maharashtra in 1972-73 sorghum fodder prices have increased steadily from about Rs. 15 per quintal of 100 kg in 1975 to Rs. 115 per quintal [1] Growth in sorghum fodder prices in Sholapur started well before the 1986 drought. Between the periods 1971-75 and 1982-86, the fodder/grain price ratios have almost doubled from 0.20 to 0.36 (lower graph, Figure 2). Based on grain and fodder yield data for post-rainy season sorghum, fodder's share in value of production has also advanced steadily since 1975. Similar trends of rising fodder/grain price ratios are evident in all of the study villages in the 1980's.

The impact of the rapidly increasing demand for fodder on the adoption of fodder species is unknown. Tree fodder is rarely marketed, and price information is scarce. As a result of social and farm forestry extension programs, a handful of farmers in several villages are now harvesting

Figure 2. Wholesale prices, ratios, and shares for sorghum fodder and grain in the Sholapur market from 1971-86.



Leucaena for fodder. When asked why, farmers responded that they prize Leucaena dry fodder more highly than sorghum dry fodder. But they rarely offer reliable information on how they intend to incorporate Leucaena into their farming systems. Economic questions remain concerning the ability of Leucaena to replace or complement other stovers, particularly sorghum straw; and the relative attractiveness of poles and fodder as end use objectives.

Fruit

In response to expanding market opportunities, a few farmers in several of the study villages are planting small orchards around productive dug wells. In the transition to fruit trees, the farmer often consolidates his activities around an assured irrigation source and plants one species before diversifying to others. Leucaena and other tree species often find a home in these orchards because they can be protected from browsing with the associated high level of management. Area under fruit tree plantation should continue to increase in several of the study villages.

Pulp, Poles, and Small Timber

Poles for construction and pulpwood for paper will most likely continue to offer the brightest prospects as end uses. Farm forestry systems – primarily using eucalypts and casuarina – are expanding rapidly in large regions of India's SAT. The area under eucalypt plantation is increasing, although farmers in the study villages have not benefitted from the farm forestry revolution nearly as much as growers in other regions. Some have planted eucalypts in marginal dryland fields, while others have sown them in more productive irrigated fields. In general, the seedlings planted on marginal dryland have suffered high mortality whereas those under irrigation have prospered

TREES AND THE VILLAGERS' WELFARE

Income

Scattered trees in farmers' fields figure prominently in India's dryland agricultural landscape. Common species include *Acacia nilotica* (babul), *Annona squamosa* (custard apple), *Azadirachta indica* (neem), *Mangifera indica* (mango), *Melia azedarach* (bakain), and *Tamarindus indica* (tamarind) Tree counts in the study villages yield average densities ranging from 1-7 trees/ha^{-1} In general, tree densities on private land have been too low to contribute substantially to village income

But trees can be important revenue earners in geographical pockets of India's SAT Of the study villages, the outstanding example is Aurepalle, which has about 2,000 productive toddy palm trees. The milky juice of the palm fruit is fermented and sold as palm liquor or toddy Toddy tapping, a traditional caste occupation, engages about one quarter of the village population (Rao 1983) The toddy trade accounted for about 15% of total village income from 1975-84 and has gradually increased in importance in this decade.

Equity

The complexity of agroforestry systems featuring MPTS is sometimes cited as an advantage to resource-poor small farmers. It is maintained that these farmers are accustomed to complex intercropping systems, that they have more time for farm management, and that they rely less on hired labor (Bentley *et al* 1984) Most likely, however, this advantage of complexity will not prevail in adoption behavior Competition between woody perennials and annuals for soil moisture, which reduces the yields of annuals, severely constrains the potential of intercropping at narrow spacing in India's SAT (ICRISAT Annual Report 1985, p. 304) Other factors also indicate that large farmers will be the first to adopt the systems.

Two factors determine the differential consequences of tree species on small farm households *vis-a-vis* large farm households. (1) the pattern of adoption by the two groups, and (2) adoption s impact on the demand for casual labor Observers often overlook the importance of the latter issue In the study villages small farm households derive 30-50% of their income from earnings as casual agricultural labor

The relatively low demand for labor of eucalypts is responsible to a great extent, for their surge in popularity In the tightening labor markets of the past decade large farmers, particularly absentee landlords, find such systems attractive

Farm forestry systems can hurt rural casual labor in another respect. After planting, the management of these systems usually responds to seasonal labor fluctuations with greater flexibility than annual croppings systems, which are more bound to seasons. This reduced seasonality in labor demand does not favor landless labor and small farm households, which find seasonal peaks in labor demand economically desirable except where mechanization is imminent.

The comparatively low labor use intensity of farm forestry systems also has implications for differential adoption behavior between large and small farm households Low labor use intensity means that small farm households have less scope for exploiting their advantage compared to large farm households, of a lower opportunity cost in supplying labor

The long-term nature of farm forestry systems may also favor early adoption by larger farmers who may be more willing to forgo consumption today in order to enhance tomorrow's consumption.

Relatively low and unseasonal labor-use intensity and potential differences in time preferences indicate that large farm households will participate more actively in the farm forestry revolution. In the green revolution, large farmers adopted first but small farmers soon caught up (Herdt 1987) Such differences in the diffusion of farm forestry systems though are more likely to endure

Much of the preceding discussion is speculative and addresses short-term equity objectives. One particularly neglected longer-term question centers on the consumption and investment behavior of large farmers who have profited handsomely from the early adoption of such systems. Do they consume and invest in ways that are conducive to local regional and national economic growth? the answer is yes, then the foregoing discussion loses much of its importance Another relevant issue concerns the degree to which small and marginal farmers who instead of producing for their subsistence needs or leasing their land to others have planted eucalypts and have channelled their energies to more specialized, profitable (and often off-farm) activities. Few of these issues have received the empirical attention that they deserve

With fruit trees, the labor consequences will likely be more benign and perhaps decidedly beneficial But fruit crop production requires greater management skills than farm forestry systems that use eucalypts. If the study villages are any indication, such management skills are scarce in India's SAT

While it is still too early to judge the impact of farm forestry on the labor market, the question of who adopts first has an obvious initial answer those who adopt early in the study villages come from the ranks of the most progressive large farmers. Some of these farmers may have inherited little or no land but by the time they planted trees in their fields they had relatively more land than others in the village

Nutrition

Tree products can influence nutrition indirectly through income, or directly through consumption. Although tree products directly contribute little to the overall nutritional status of the study villages, they contribute proportionately more to the intake of those nutrients, such as B-caroten and ascorbic acid, characterized by the largest deficiencies. Even so, tree products only contribute 5-15% of the total intake of these vitamins.

Risk Benefits

Risk benefits are those supplied by institutional or technological means that allow risk-averse decision makers to reduce fluctuations in income. This, in turn, reduces variability in consumption (Newbery and Stiglitz 1981). Because trees are often assumed as being more drought-tolerant than annual crops, it is only natural to suppose that tree products would be prized highly in low income years. Farmers could also cut trees for sale to compensate for these years of low income. But this common sense observation may not carry much force in the SAT of India.

If tree production also drops sharply in low income years, or if resource-poor households have access to fairly efficient means of risk adjustment, benefits are likely to be small. For example, farmers in the study villages seldom part with land to mitigate income variability (Cain 1981). Moreover, with the exception of the Sholapur villages (where the fodder costs of maintaining livestock rises sharply during prolonged drought), asset disposal is not the preferred first or even second line of defense to adjust to income risk. The risk adjustment measure preferred by the overwhelming majority of households is consumption credit. Farmers will not be enticed to cut down trees that they have planted until sources of consumption credit are exhausted, or until public works schemes are no longer locally available.

RESEARCH IMPLICATIONS

What do these points imply for MPTS research in India's semi-arid regions? First, more research should be directed to study optimal management of tree crops, particularly *Leucaena leucocephala* in sole stands for end uses such as fodder and poles. The main interaction between trees and annuals will most likely be the income generation taking place at the household level. Donor interest in agroforestry has, perhaps, obscured this emerging empirical truth. Unless strong complementary effects can be found, more proximal or field-level interactions will either be economically unimportant or too location-specific for general research.

This author believes that the research establishment may have been slow to respond to the needs of the rapidly expanding farm forestry systems. Tree species in these systems, as well as indigenous species such as toddy palms, may be discriminated against in the allocation of research resources. An assessment of research resource allocation on tree species in general and farm forestry species in particular should rank high on the research agenda, although adequate data may not be available at this time. The emphasis on agroforestry research has to some extent directed experimental attention away from farm forestry systems already adopted by farmers in favor of new systems that farmers do not now plant, and which they may not reasonably hope to plant in the immediate future.

In the area of economics research, priority should be given to the consequences of rapid uptake of farm forestry systems. Research should also explore reasons for the slow development of tree fodder markets in the SAT of India By studying the Leucaena leafmeal markets that have developed in some countries in Southeast Asia, F/FRED s regional research network could improve understanding of the evolution of such markets

With the threat of an infestation by the Leucaena psyllid a study of the demand for Leucaena seed and seedlings in India s SAT may be timely Before investing in research to control this pest the demand for Leucaena should be ascertained

Finally more information is needed concerning the relative demand for MPTS and single-purpose trees Under what conditions is multiplicity of purposes an advantage? An analogy can be drawn to multipurpose wheeled tool carriers, in which several research institutes including ICRISAT have made a considerable investment In a forthcoming book, Paul Starkey argues persuasively that farmers want single-purpose implements and equipment Investing in a multipurpose implement for example involves more risk because in the event of machine breakdown *all* of the machine s multiple operations cease Perhaps work in this area has already been done Such research would enhance our understanding of when and where multipurpose trees best suit the farming systems of resource-poor households in semi-arid regions

DISCUSSION

How applicable to arid regions are statements made regarding demand for fuelwood and windbreaks in SAT? While an increase in fuelwood demand for semi-arid regions may not take place until the future it is a more immediate concern in arid regions

Large farmers may adopt agroforestry systems more quickly than small farmers Donors have focused on adoption by small farmers not necessarily for optimum productivity but for reasons of equity

REFERENCES

Bentley W R. R.C Chambers and B P Gh ldyal 1984 Agroforestry A complex system for resource-poor farmers. Paper given at the Indian Society of Agricultural Scientists Satellite Session on Agroforestry Indian Institute of Technology Ranchi, Bihar January 2 1984

Blair H W 1986 Social forestry time to modify goals? Economic and Political Weekly 21(30) 1317 1321

Bowonder B N Rao Prakash B. Dasgupta, and S S R. Prasad 1985. Energy use in eight communities in India. World Development 13(12) 1283-1296

Cain M. 1981 Risk and insurance perspective on fertility and agrarian change in India and Bangladesh Population and Development Review 7(3) 435-474

Caldwell J C P H Reddy and P Caldwell 1984 Education transition in rural South India. Population and Development Review 11(1) 29-51

Desai, G.M 1986. Policies for growth in fertilizer consumption the next stage Economic and Political Weekly 21(21) 928-9

Herdt, R.W 1987 A retrospective view of technological and other changes in Philippine rice farming 1965-1982. Economi Development and Cultural Change 35(2) 329-349

Hoekstra, D.A. 1984 An economic analysis of a simulated alley cropping system for semi-arid conditions using microcom Agroforestry Systems 1(4) 335-345.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) 1988. Page 304 in Annual Report 1988. Patancheru Andhra Pradesh 502 324 India

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) 1987 Pages 309 in Annual Report 1986 Patancheru, Andhra Pradesh 502 324 India

Kang B.T G.F Wilson L. Sipkens 1981 Alley cropping maize (Zea Mays L.) and leucaena (Leucaena leucocephala lam) Southern Nigeria Plant and Soil 63 165-179

Mohan Rao Y 1983 Toddy tapping and selling in Aurepalle Mimeo ICRISAT Economics Program Patancheru Andhra Pradesh

Newbery D M G and J E Stiglitz 1981 The theory of price stabilization a study in the economics of risk Oxford Clarendon Press

Sumberg J.E. J McIntire C Okali and A Atta Krah 1985. Economic analysis of alley farming with small ruminants ILCA Bulletin October 1987 International Livestock Centre for Africa. Addis Ababa, Ethiopia (Forthcoming)

Walker T S. 1987 Economic prospects for agroforestry interventions in India s SAT Implications for research resource allocation at ICRISAT Economics Group Progress Report No 79 Resource Management Program ICRISAT