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Economics of wastelands afforestation in India, a review

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Abstract. India has vast tracts of wastelands. Afforestation of these wastelands is one of the many alternative uses of such lands. Given the scarcity of capital in India, it becomes imperative to determine the economics and financial feasibility of wastelands afforestation projects. The studies reviewed in this paper deal with cost and financial feasibility analysis of wastelands afforestation projects in India. The main rationale behind this review is to examine the prospects of increasing investments in the afforestation projects. This also has a global significance, since afforestation augments carbon sequestration, which has become an exigency in view of externalities associated with global warming. The study uses review of existing literature and regression analysis as analytical tools. The review reveals that reclamation of wastelands through afforestation is not an expensive venture in India. Afforestation projects are financially viable even when no environmental benefits are taken into consideration. The results of the study suggest that polluting companies/countries should explore the possibility of investing in afforestation in India to gain carbon credits economically, once the parties to the Kyoto Protocol to the United Nations Framework Convention on Climate Change decide to approve it. The studies reviewed reveal that researchers have used different sets of criteria for financial feasibility analysis of the afforestation projects. Almost all the studies have ignored non-market benefits of afforestation projects. Such methodological differences need to be addressed in view of the increasing importance of plantations as carbon sinks. Some socioeconomic issues like investment in tree crops vis-à-vis agricultural crops, preference for mixed plantation and wastelands development as a means of resource development have also emerged from this review.

Introduction

Afforestation has now emerged as an important instrument of solving the problems of scarcity of timber, fuelwood, fodder and other forest produces as well as reclamation of wastelands[1] in India. At the international level, the global warming

[1] For the purpose of this research, wasteland has been defined as "degraded land which can be brought under vegetative cover with reasonable effort [and cost], and which is currently under-utilised and land which is deteriorating for lack of proper water and soil management or on account of natural causes. Wasteland can result from inherent/imposed disabilities such as by location, environment, chemical and physical properties of the soil or financial or management constraints" (National Wastelands Development Board quoted in Gautam and Narayan (1988, p. 11)). This is a working definition of wasteland in India. Several estimates of the extent of wastelands in India have been made. The most commonly

phenomenon caused by emission of greenhouse gases (GHGs) necessitates to increase carbon sinks in the form of forest plantations. The Kyoto Protocol on Climate Change suggests protection and enhancement of sinks and reservoirs of GHGs by promotion of sustainable forest management practices, afforestation and reforestation.[2] According to Sampson and Sedjo (1997), tree plantation projects appear to be one of the more cost effective ways to increase terrestrial carbon storage. The polluting companies and governments can offset some of the emissions by investing in carbon sinks and, in lieu of that carbon credits would be issued corresponding to the amount of carbon sequestered. It is important in this context that by undertaking extensive afforestation projects, India can be in a win-win situation i.e., offsetting national carbon emissions and gaining by offsetting carbon emissions of polluting companies and other countries for a price.

Furthermore, forestry sector is vital to the Indian economy and need to be given special attention in terms of investments. There are a number of studies undertaken by social scientists to support this opinion. Three of these studies are summarized here (Lal 1992; Poffenberger 1995; Kadekodi and Ravindranath 1997). According to Poffenberger (1995), forests in India are critically important in meeting a wide diversity of needs for at least 50 million of the world's poorest tribal people. Moreover, many rural people depend on informal sector forest-based livelihoods. This is evident from the fact that forestry sector generates about 36 million person years of employment annually and is characterized by significant forward industrial linkages (Kadekodi and Ravindranath 1997). Lal (1992) estimated that in India forest dependent population actually requires 0.5 ha of forest land per capita, while mean availability is only 0.1 ha or one-fifth of that required.

Given this context, an implicit question arises: should investment in wastelands afforestation increase in India? To get an answer to this question, the present study poses two hypotheses. The first hypothesis is that afforestation projects are cost effective and financially feasible. The second hypothesis is that Indian investment in wastelands afforestation is too low. To resolve the hypotheses, this paper reviews the existing literature on the economics of wastelands afforestation projects in India as the major analytical tool. Regression analysis was also employed to know what the investment implications are. This analysis draws from the data generated from the review of studies on afforestation costs and financial feasibility of afforestation projects. The paper also brings forth the methodological issues in financial feasibility techniques used by the researchers for evaluating afforestation projects. Besides,

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accepted figure is 174.96 million hectares (m ha) estimated by National Commission on Agriculture in 1976 (Government of India 1976). Out of this, 37.36 m ha of wastelands has been treated till the end of 1993–94 (Government of India 1995). The estimate of treated wastelands does not give an idea about various means of reclaiming these wastelands. Nevertheless, an area of 20.18 m ha of degraded lands was afforested in India during 1952–1992 (ICFRE 2000). So it is evident that significant proportion of wastelands was reclaimed through tree plantation.

[2] Sink activities are specified in Article 3.3 of the "Kyoto Protocol to the United Nations Framework Convention on Climate Change" (for details, see http://www.unfccc.de/resource/convkp.html). In this paper, the term afforestation has been interchangeably used with plantation and reforestation.

it also reveals useful information and issues related to wastelands afforestation in India from socioeconomic viewpoint.

This paper is organized into five sections including this section. The second section on 'methods' describes the conceptual and empirical means employed to investigate the problem mentioned-above. Third section discusses the 'results' based on the review of studies and empirical analysis. Fourth section discusses the 'investment implications' by translating the results into a basis for estimating appropriate aggregate levels of investments in afforestation projects, followed by 'conclusions' in the last section.

Methods

This paper reviews literature on economics of afforestation projects undertaken in India during 1980s and 1990s together with recent literature.[3] During these past two decades, social forestry, farm forestry and community forestry[4] gained considerable momentum, and expenditure on tree plantation programmes dramatically increased in India. Moreover, the investments made by different departments of the Government of India and State Governments were coordinated. This is the rationale for reviewing the literature on economics of wastelands afforestation generated during the last two decades. It is also important to note that the existing literature on economics of wastelands afforestation in India is not very extensive. This paper altogether reviews thirty-eight studies and also a few related studies on theoretical issues of financial analysis of forestry projects (by Nautiyal (1988), Sharma et al. (1991), Bentley and Tewari (1997) etc.) are also analyzed.

Geographical representation and characterization of environmental conditions

In terms of geographical representation of the studies reviewed, there was not much diversity in the studies to cover different regions and various types of wastelands in India. India has been divided into fifteen agro-climatic regions based on homogeneity in rainfall, temperature, soil, topography, and water resources. However, for purpose of this study, India has broadly been divided into six regions/zones: Northern, Eastern, North-Eastern, Central, Western, and Southern covering twenty-nine states and six union territories as there are not many studies to represent

[3] This paper also reviews two important studies undertaken by Goswami and Singh (1976), Mathur et al. (1979) during 1970s on financial analysis of afforestation projects.

[4] Social forestry is the practice of forestry on lands outside the conventional forest area for the benefit of the rural and urban communities (Khanna 1987). Farm forestry is the practice of forestry in all its aspects on farms or village lands, generally integrated with other farm operations (Dwivedi 1992). Community forestry is the practice of forestry in the forest areas as well as non-forest areas with the people's participation.

environmental conditions of all the fifteen agro-climatic regions.[5] Various categories of wastelands in India which can be brought under the tree cover are: ravinous land, undulating upland, surface water logged land, salt affected land, land under shifting cultivation, degraded forest land, degraded pastures/grazing land, degraded non-forest plantation land, strip lands, sands and mining/industrial wastelands (National Wastelands Development Board 1986) and degraded farmlands. Table 1–3 give an idea about geographical representation and environmental conditions covered by the studies reviewed.

The studies on afforestation costs outlined in Table 1 reveals that some studies e.g., Singh (1985), Agarwala (1988), World Bank (1993a), Kadekodi (1995) have estimated afforestation cost (ha^{-1}) of wastelands/degraded lands in a generalized manner for the entire country. Whereas, other studies have specifically estimated cost incurred on afforestation of various types of degraded lands in different regions.

The studies on financial analysis of wastelands afforestation are presented in Table 2,3. These two tables reveal that there are more studies on wastelands from semi-arid and arid tropic regions (mostly from Western India) as compared to wastelands in other climatic regions. To present results of financial analysis of afforestation projects in a systematic manner, studies from semi-arid and arid regions are presented together in Table 2. As there are few studies on other types of wastelands in other climatic regions, these studies are collectively outlined in Table 3.

Most of the studies discussed in this paper (Table 1–3) are from Western (12) and Northern (7) region, whereas there are only three studies each from Central, Eastern and Southern region.[6] As mentioned above, ten studies summarized in Table 1 are not region specific. Notably, the author did not come across any study from the North-Eastern region in India.

Analysis of the studies reviewed in terms of representation of twenty-nine states in India revealed that more than 50% of the studies correspond to the States of Gujarat, Madhya Pradesh and Uttar Pradesh.[7] These three states were pioneers in launching social forestry programmes during 1980s. For that reason, a number of studies on economics of afforestation in these three states may have been undertaken by social scientists with the intention of popularizing afforestation programmes across India, which was the need of the time. This is evident from the fact that Gujarat, Madhya Pradesh and Uttar Pradesh accounted for 34.45% of 13.5 million

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[5] Northern region includes the States of Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttaranchal, Uttar Pradesh, and Delhi. Eastern region includes Orissa, West Bengal, Bihar, Jharkhand and Sikkim. North-Eastern region includes Arunachal Pradesh, Assam, Meghalaya, Nagaland, Manipur, Tripura and Mizoram. Central region includes Madhya Pradesh and Chhattisgarh. Western region includes Rajasthan, Gujarat, Maharashtra and Goa. Southern region includes Karnataka, Andhra Pradesh, Tamilnadu and Kerala. Six union territories have not been included in this classification as most of them are very small in geographical size.

[6] Studies by Sharma (1995), Singh and Bhattacharjee (1995) from Eastern region and study by Aziz (1995) from Southern region are not summarized in tables. These studies are referred to in the section on 'Results'.

[7] In the year 2000, the States of Chattisgarh and Uttaranchal were carved out from the States of Madhya Pradesha and Uttar Pradesh, respectively.

ha (m ha) afforestation undertaken during 1980–90 and 34.15% of 12.55 m ha afforestation undertaken during 1990–98 (ICFRE 2000). On the other hand, there was not any study characterizing the environmental conditions of North-Eastern region comprising seven states, which accounted for only 5.28% of 26.05 m ha afforestation undertaken in India during 1980–98.

The classification of the reviewed studies based on geographical representation suggests that maximum studies on economics of afforestation of wastelands undertaken in the last two decades represent arid conditions. For example, some of these studies characterize arid region of Gujarat, which constitutes around 26% of 19.6 million ha of the total geographical area of Gujarat. Apparently, this could be assigned to the fact that wastelands afforestation projects under various Government of India schemes have purposively been promoted in drought-prone arid region, which comprises around 12% of the country's total geographical area. Moreover, the forest area in arid region in India is less than 2% resulting in severe scarcity of fuelwood (Deb Roy et al. quoted in Pande et al. (1999)). For example, Gujarat has only 6.42% of its total geographical area under forest with per capita forest of 0.030 ha against national average of 0.075 ha (ICFRE 2000).

Further, the extent of various studies reviewed was limited to some categories of wastelands in India, as outlined in the beginning of this section. The author did not come across studies on economics of afforestation on surface water logged land, shifting cultivation area and sands and mining/industrial wastelands. Even amongst a few categories of wastelands referred to in this paper, there were not many studies to generalize the findings. The gist of this analysis is that the results based on this study do not represent in totality the environmental conditions of India in terms of geographical representation and various types of wastelands. This is one of the limitations of this study.

Method for securing comparable afforestation costs

The estimates of afforestation cost derived from the reviewed studies pertained to different years. To normalize the plantation costs to 2000–01 prices, an inflator based on All-India Consumer Price Index (CPI) for Agricultural Labourers (Base: 1986–87 = 100) was used, as shown below. This index was considered because the plantation activity is highly labour intensive. According to Pant (1984) about 70% of the investment in plantation goes towards wages and salaries of the labourers involved in plantation activities and rest of the investment is on material purchases. This is substantiated by Poffenberger (1995). According to Raj, 70–80% of total expenditure on afforestation work goes for payment of wages. Furthermore, various afforestation programmes and other rural development schemes like *Employment Assurance Scheme* (now *Sampoorna Gramin Rojgar Yojana*) covering afforestation activities currently underway in India always emphasize on providing employment opportunities to the people.

$$\text{Inflated afforestation cost}_{2000-01} = \text{Afforestation cost}_{\text{Year of estimation}} \times \left[\frac{\text{CPI}_{2000-01}}{\text{CPI}_{\text{Year of estimation}}}\right]$$

Table 1. Afforestation cost of various types of wastelands in different parts of India.

Study	Type of Wasteland	Afforestation cost Indian Rupees (Rs) ha^{-1}	Inflated afforestation cost (at 2000-2001 prices)* Rs ha^{-1}	US\$ ha^{-1}	Remarks
*Western India***					
Shah (1984)	Saline wastelands	8,000	27,631	605	Plantation of fuelwood and fodder species by
	Drought prone lands	9,000	31,085	680	Gujarat State Rural Development Corporation.
Rao (1987)	Arid wastelands	9,495	29,813	653	First year plantation cost of six species on (irrigated) degraded soils in village Moti Sindhodi in Kachchh.
Singh (1994)	Village common (grazing) land	942	4,779	105	Cost of establishing village woodlot including cost of supervision and protection in village Aslali.
Balooni (1998)	Degraded village common land	8,693	11,330	248	Joint forest management in village Soliya.
Balooni and Singh (1999)	Marginal private lands	14,841	19,343	423	Farm forestry in village Shankerpura.
Pande et al. (1999)	Community non-forest land unsuitable for cultivation	5,471	5,637	123	Watershed area partly owned by Forest Department.
Balooni and Singh (2001)	Totally degraded village common lands	13,523	17,625	386	Average cost of plantations undertaken by tree growers' co-operatives of Vatra, Sarnal and Navagambara.
Northern India					
Chaturvedi (1985)	Usar lands	10,000	34,472	755	Reclamation through plantation of fuelwood
	Ravines	5,000	17,236	377	species in Uttar Pradesh.
Central India					
Mishra (1993)	Wastelands in				Afforestation by tree growers' co-operatives in Madhya Pradesh.
	-Eastern region	9,000	15,022	329	Afforestation cost for first five years.
	-Western region	8,600	14,355	314	
Eastern India					
Malhotra and Poffenberger (1989)	Degraded forests with rootstocks	250	2,169	47	Active participation of local people in protection of regenerated forest in Arabari in West Bengal.
Southern India					
D'Silva and Nagnath (2002)	Degraded forests with rootstocks	497	567	12	Managed by forest protection group in village Behroonguda in Andhra Pradesh.
No-region specific					
Government of India (1984)	Ravines				In case of deep ravines, one-half of the
	-Shallow and medium	4,000	13,815	302	area was afforested by aerial seeding.
	-Deep	2,750	9,498	208	
Agarwala (1985)	Different types of wastelands	1,000 to 10,000***	18,960	415	Afforestation models of Bharatiya Agro-Industries Foundation, Dasholi Gram Swaraj Sangh; and CSWCRTI.
Singh (1985)	Degraded forest lands	4,000	13,789	302	Afforestation by forest department or any other government agency.
Agarwala (1988)	Different types of wastelands	5,000 to 7,000***	17,132	375	Afforestation cost for a period of three years.
Jhala and Pinto (1988)	Different types of wastelands	4,000	11,421	250	Average rainfed plantation cost for a period of three years.
Vohra (1989)	Different types of land	6,000 to 10,000***	20,294	444	Average plantation cost.
World Bank (1993a)	Different types of lands	18,000	30,045	658	Annual investment required for plantation during 1990s.
Kadekodi (1995)	Degraded village commons, forest and farmers' lands	10,000 to 15,000***	18,646	408	Social forestry projects.
Gupta and Varma (1997)	Ravines	10,500	12,505	274	Average plantation cost.
Haque (1997)	Different types of wastelands	15,000	17,865	391	Average plantation cost.
	Average cost		18,848	413	Total number of observations (N) = 25
	Standard deviation		8,919	195	
	Minimum		567	12	
	Maximum		34,472	755	

*US\$1 = Rs 45.68 in the year 2000–2001. **All studies are from the Gujarat State. ***For estimating average afforestation cost, middle value of the estimated range of afforestation cost has been considered.

Table 2. Financial analysis of wastelands afforestation in arid regions of Western and Central India.

	Tree species planted	Discounting rate (%)	Benefit cost ratio	Internal rate of return (%)	Annuity (Rs ha^{-1})	Pay back period (years)	Remarks
Western India							
Goswami and Singh (1976)	-*Dalbergia sissoo*	12	2.90	20		10	Deep ravines in Gujarat, afforestation covered elements of
	-*Dendrocalamus strictus*		1.06	12.45		11	risk and uncertainty in output, and involved heavy capital investment.
	-*Tectona grandis*		0.64	12		15	
Gupta and Mohan (1982)	-*Acacia tortilis*	11			362		In hot arid region in Rajasthan. Tree crops yielded positive net
	-*Albizia lebbek*				548		profits after paying for the costs of establishment and maintenance.
	-*Prosopis cineraria*				1,610		
	-*Prosopis juliflora*				950		
	-*Zizyphus sp.*				3,268		
Kishore et al. (1982)	Mixed afforestation (fuelwood and fodder species)	15	1.38	15		15	Narrow ravines in Vasad in Gujarat.
Bhatia (1984)	Intercropping of *Eucalyptus sp.* and Cotton			129 (I rotation)			In Gujarat. First year investment US$ 1700 ha^{-1} and total
				213 (successive			revenue after five years US$ 5900 ha^{-1}
				coppices)			
Shah (1984)	Bunding and plantation with	20 and 30		33.70			In Manipur village in Mehsana District of Gujarat. When costs were increased
	fuelwood and fodder species						by 10% and the returns reduced by 10% every year, internal rate of return was 31.2%.
Kalla (1988)	Afforestation of			> bank rate on		Belongs to	In Western Rajasthan. No mention of discount rates
				long term loans		medium run	used for the financial analysis. According to Kalla (1988)
	-alkali wastelands		1.63		1,580		different discounting rates were used.
	-sand dunes		1.85		703		
Singh (1994)	Community plantation of mixed tree species	15	1.73	28.71			In village Aslali in Ahmedabad
	on village grazing land						District in Gujarat.
Balooni and Singh (1999)	Farm forestry on marginal agricultural lands.	10	6.03	51.78	27,525		In village Shankerpura in Panchmahals District in Gujarat.
	Eucalyptus sp.						Financial analysis based on a sample of 20 households
							and excluding subsidy given to households.
Pande et al. (1999)	Afforestation of community land with *Eucalyptus tereticornis*	6	2.30	18		10	Navamota watershed in Sabarkantha District in Gujarat.
	Acacia nilotica and *Acacia tortilis*	10	1.10				Results of scenario I (complete protection from biotic interference).
Balooni and Singh (2001)	Afforestation of degraded community land with	Cashflows discounted at real interest rates					Villages in District Kheda in Gujarat.
	mixed tree species in village	prevailing during the respective years					Cash flows expressed in real terms discounted
							using real interest rates annum^{-1} based on interest rates on long-term
							loans for wasteland development projects during the project analysis period.
	-Vatra		9	63.1			
	-Samal		8.1	54.4			
	-Navagambara		8	66.3			
Central India							
Babu et al. (1984)	-*Acacia catechu*, *Prosopis juliflora* and	10	1.81	16.20			Deep ravines in Agra in Uttar Pradesh.
	miscellaneous species (I rotation)						
	-*Prosopis juliflora* and miscellaneous	10	1.61	27			
	species (II rotation)						

Table 3. Financial analysis of wastelands afforestation in other parts of India.

Source	Place	Type of land/tree Species planted	Discounting rate (%)	Benefit cost ratio	Internal rate of return (%)	Pay back period (years)
Northern India						
Mathur et al. (1979)	Doon valley, Uttar Pradesh (now in Uttaranchal)	Wastelands along torrential streams.				
		-*Dalbergia sissoo* with *Chrysopogan fulvus*		2.75		
		-*Acacia catechu* with *Eulaliopsis binata*		3.43		
Kishore et al. (1983)	Shiwalik hills, Chandigarh	Sloppy land (9%) in watershed area. *Acacia catechu* and *Dalbergia sissoo*	8	1.79	16	11
Mathur et al. (1984)	Bijnore Division, Uttar Pradesh	Undulating land (forming watershed area of rivers Ganga and Ramganga). *Eucalyptus hybrid*	12, 15, 18 and 20	(at 12% discount rate)		
	-Jafrabad Block (9)			2.30	29.2	
	-Jafrabad Block (4)			4.28	38.5	
	-Mohanwali			5.08	49.12	
	-Barahapur			2.30	32.36	
Tewari and Singh (1984)	Ramganga, Uttar Pradesh	Ramgang river catchment area comprising community land.	5, 10, 15 and 20	(at 10% discount rate)		
		-*Grewia sp.*		1.63	17.27	
		-*Pinus sp.*		1.29	12.16	
		-*Pinus sp. and Grewia sp.*		1.34	12.58	
Chaturvedi (1985)	Uttar Pradesh	-Usar land (saline/alkali soils)		2.8		10
		-Ravines Fuelwood species		4		10
Babu and Arora (1985)	Doon valley, Uttar Pradesh	Wastelands,	10			
		-*Citrus lemon*		1.40		12
		-*Citrus reticulata*		2.13		10
Singh (1988)	Haryana	Agricultural land, *Eucalyptus sp.*	12	3.31		
Rana et al. (2000)	Upper-Swan catchment in Una District in Himachal Pradesh	Agro-forestry on eroded soils	12			
		-*Dalbergia sissoo*		2.59		
		-*Albizia lebbek*		1.97		
		-*Toona ciliata*		2.58		
		-*Grewia optiva*		2.35		
Central India						
Mishra (1993)	Madhya Pradesh	Rehabilitation of wastelands by tree growers' co-operatives*	15	1.13	16.27	
Southern India						
Nadkarni et al. (1992)	Karnataka	Social forestry projects in the village**	3, 5 and 8	(at 5% discount rate)		
		-Chinnambally		19	28.2	
		-Kabaka		28	53.3	
		-Sathenahally		4	21.9	
		-Siddapura		19	41	
		-Tadapally		15	30.3	

*Financial analysis (for a period of 26 yr) includes subsidy given to beneficiaries as a cost. **Net present value was positive for all the social forestry projects at the full value of returns. Costs include opportunity cost of grazing.

In Table 1, afforestation costs for the year of estimation and inflated costs at 2000–2001 prices for various types of wastelands in different parts of India are presented. However, only inflated afforestation costs at 2000–2001 prices have been used in the text to present results in a systematic manner.

Financial feasibility techniques

Review of studies on financial feasibility analysis of afforestation projects revealed that researchers have used a variety of techniques. These techniques are net present value (NPV), benefit cost ratio (BCR), internal rate of return (IRR), annuity, and pay back period (PBP); for details on these techniques, see Gittinger (1982), Nautiyal (1988), Singh (1994). In the context of wastelands afforestation projects, benefit cost analysis is an important tool to find out the feasibility of projects in terms of profits from such lands, which are lying barren and unused. Moreover, the results of financial analysis of afforestation on wastelands help the individuals, policy makers and implementing agencies like government organisations, non-governmental organisations and forest-based industries in their decision making process for future projects. Narayana and Babu (1990) suggested that the most important aspect of soil and water conservation activities like afforestation, water harvesting and storage etc. is to determine whether investment decisions on such projects are rational.

Costs and benefits classification

This section attempts to identity and classify major cost categories and benefits/outcomes of afforestation projects. This is essential, given the influence of costs and benefits of a project on the outcome of a financial analysis. The afforestation cost varies for different types of wastelands, e.g., ravine lands, saline lands, degraded forest lands, degraded village common lands. To justify the argument that conditions make a difference in the costs as well as in the benefits from afforestation, the investment in afforestation has been divided into the following three types.

Land productivity investment. These costs are presumably higher when soils are degraded and/or unstable. For example, Balooni and Singh (2001) found that expenditure on land development/soil and water conservation was 80% of the total expenditure on the community plantation undertaken by three tree growers' co-operative societies. These plantations were taken on totally degraded village common lands (ravines and saline lands) in Gujarat located in the arid region of India.

Growing stock investment. These presumably reflect the ecological potential; a combination of land, climatic and species capability. The impact of climatic capability on investment in plantation can be explained through a comparative analysis of two studies. Jhala and Pinto (1988) calculated that rainfed plantations need an investment of Rs 11,421 ha^{-1} in the initial three years, whereas Rao (1987) estimated the first year plantation cost on degraded soils provided with irrigation in arid region to be Rs 29,813 ha^{-1}(Table 1). On the other hand, choice of a species in an afforestation project is an important decision as reflected in the financial analysis of afforestation of community lands in Ramganga river catchment in Uttar Pradesh hills undertaken by Tewari and Singh (1984) (see section on 'Preference for mixed plantation').

Protection costs. These costs like fencing and policing are presumably higher where population pressures are more. For example, a large proportion of funds are spent on fencing and policing of community plantations on village common lands in India and other developing countries, in villages with a large proportion of households dependent on forests. Conversely, the major pre-requisite for the success of community plantations is a high level of people's involvement in the protection of the plantation sites. See section on 'Afforestation with people's participation' for studies on afforestation of village common lands with different forest management/ protection regimes.

In India, generally a large proportion of the afforestation expenditure is spent on enhancing land productivity and protection of plantation. This can be substantiated by the study undertaken by Gupta and Varma (1997) to estimate the afforestation cost of ravines. Afforestation cost was estimated to be Rs 12,505 ha^{-1}. The break-up of this plantation cost (ha^{-1}) activity-wise is: preparation of protection trench, inspection path and advance soil working - Rs 6,116, plantation work - Rs 3,424, first beating up (2nd year) - Rs 1,786, and second beating (3rd year) - Rs 1,179. Almost 50% of the plantation cost was spent on soil and water conservation works and protection of plantation.

Likewise afforestation costs, benefits/outcomes of afforestation projects varies for different types of wastelands and can make a difference in the benefit cost analysis. Moreover, inclusion/exclusion of benefits from an afforestation project could affect the benefit cost analysis. Compared to costs, the categorization of benefits/outcomes of an afforestation project is difficult, as discussed below.

Ideal classification of benefits. Ideally, the appraisal of an afforestation project or any other social project should include all the "direct, indirect, tangible and intangible benefits" (Singh 1994, p. 109); the same applies for costs also. Benefits of afforestation project could also be measured in terms of the "total economic value" (Georgiou et al. 1997, p. 24) of forest raised, comprising of direct use values, indirect use values, option value, bequest value and existence value. However, until recently no serious efforts were made to value and incorporate non-market benefits/ intangible benefits/indirect use values in the appraisal of projects concerning environmental resources[8]; this is a broad subject-matter, which is beyond the scope of this study. For such reasons, Nautiyal (1988) revealed that benefit cost analysis has been sparingly used in forestry projects analysis as the intended forestry projects generate non-market commodities. For example, the benefits of timber production from an afforestation project can be measured because market prices are observable;

[8] According to Smith (1993, p. 56), "Methods for valuing nonmarketed environmental resources were proposed forty-five years ago, but applications were slow to develop until the early 1970s. Dramatic progress has been realized in the last two-and-a-half decade as these applications have multiplied"; also see Smith (1987), Georigiou et al. (1997).

on the other hand conservation benefits and joint products of timber production are not observable. Despite this, Nautiyal (1988) has suggested that benefit cost analysis is the most appropriate tool for use in forestry project analysis due to its comprehensiveness and the avowed objective of taking various factors into account.

Quantitative and qualitative assessment of non-market benefits. Not a single study reviewed has included non-market benefits in the benefit cost appraisal. Although a few studies like Goswami and Singh (1976), Gupta and Mohan (1982), Singh (1994) discusses qualitative/quantitative (without monetary valuation) intangible returns of afforestation. Goswami and Singh (1976), while admitting that intangible benefits of afforestation can not be evaluated precisely, revealed that after reclamation of deep ravines through afforestation in Vasad in Gujarat, the run-off reduced from 155.9 mm in 1961 to 13.9 mm in 1968. This has a direct effect on reducing sedimentation of reservoirs and prevention of flooding in the rivers. Gupta and Mohan (1982) assessed the non-market returns as well as costs in qualitative terms to enhance results of economics of tree crops versus annual crops in hot arid regions of Gujarat and Rajasthan. This was done in order to get the necessary support from policy makers to facilitate the transition from annual to tree crops. Singh (1994) revealed that the establishment of community plantation in Aslali village in Gujarat resulted in indirect benefits like protection of soil from water and wind erosion, addition of organic matter to the soil and improvement in the microclimate.

Employment generation. Generally the emphasis of most of the studies reviewed is on final benefits like timber and intermediate benefits like grass, fuelwood, tree leaf fodder, and poles/small timber (from thinning). The employment generated from wastelands afforestation projects as a benefit has been described in few of the reviewed studies, e.g., Tewari and Singh (1984), Singh (1994), Balooni and Singh (1999). Balooni and Singh (1999) based on a study of twenty sample households/beneficiaries of a farm forestry programme estimated that plantations of *Eucalyptus sp.* on marginal agricultural lands (with no opportunity cost) in village Shankerpura located in a drought prone region in Gujarat created 1,120 workdays ha^{-1} $household^{-1}$ during 1982–93. This helped to reduce to some extent the seasonal migration of village population to nearby urban areas from 75% in 1975 to 3.5% in 1993; the local people also benefited from the irrigation scheme implemented during this period.

Given the above context, while drawing results of benefit cost analysis based on such studies for investment decisions, due consideration need to be given to indirect benefits/costs.

Results

Average cost of wastelands afforestation

The estimates of cost of wastelands afforestation per hectare (ha^{-1}) based on the findings of studies are presented in Table 1. A few select studies have been reviewed below to give some idea about afforestation cost in India. These studies have estimated afforestation cost for the entire country in a generalized way rather than for regions.

Agarwala (1985) analyzed three successful wastelands afforestation models developed by the Bharatiya Agro-Industries Foundation, Dasholi Gram Swaraj Sangh and Central Soil and Water Conservation Research and Training Institute (Sukhomajri). Agarwala estimated the average cost of afforestaton based on these three models to be Rs 18,960 ($415) ha^{-1} (US$ 1 = Rs 45.68 in 2000–2001). Singh (1985) estimated that afforestation by the forest department or any other government agency using hired labour, expensive fencing and paid supervisory staff would cost nearly Rs 13,789 ha^{-1}. Vohra (1989) estimated the afforestation cost of wastelands for the entire country between Rs 15,220 to Rs 25,367 ha^{-1}, whereas the World Bank (1993a) estimated the average plantation cost ha^{-1} in Asia including India to be Rs 22,391 ($670). According to Kadekodi (1995), in India, annually about 2 million ha of village commons, degraded forest department land, government land and farmers land are planted under various afforestation programmes. Kadekodi estimated the afforestation cost of these various types of degraded lands is in the range of Rs 14,917 to Rs 22,375 ha^{-1}.

It was not possible to find the average cost of afforestation for each region in India and for various types of wastelands due to lack of many studies. So an average afforestation cost for the entire country was estimated based on twenty-five estimates/observations (N) from twenty-one studies. The studies reviewed evidently revealed that the wastelands afforestation in India is not an expensive proposition. The average plantation cost ha^{-1} at 2000–2001 prices was found to be Rs 18,848 ($413). On the other hand, Read (1996) estimated the global average cost of reforestration to be $1,074 ha^{-1}, which is more than double the above-mentioned estimate for India.

Further, it is important to note that estimated average cost based on review of literature has focused mainly on afforestation of wastelands, wherein lot of investment in the form of soil and water conservation has to be undertaken before taking up plantations. On the other hand, in some studies the afforestation costs are estimated for the first few years, whereas in others they have been estimated for a longer time horizon. Nevertheless, results of the comparative average plantation costs for India and global clearly suggests that polluting companies and governments can invest in afforestation projects in India to gain carbon credits economically. The investment decision will also depend on the value of potential sequestered carbon in such plantations.

Table 1 reveals that owing to different climatic conditions and types of wastelands, there is a wide variation in the plantation cost across India. The afforestation cost ha^{-1} varied from Rs 567 ($12) to Rs 34,472 ($755) depending on the type of wastelands and the extent of degradation. The standard deviation was found to be Rs 8,919. However, the results based on twenty-one studies could not give a good relationship between afforestation costs and environmental conditions. Besides, most of the studies analyzed characterize relatively dry regions i.e., the span of environmental conditions is restricted. Due to these limitations on data sources, plausible arguments could not be made. On the cost side, it can be argued that plantation efforts on bad sites cost more than good, and heavily used sites cost more than unused sites. On the benefit side, it can be argued that, everything else being equal, wetter sites with better soils produce more than the drier and poorer sites.

Afforestation with people's participation. Even though a relationship could not be established between afforestation costs and environmental conditions, a few studies well reflect that the afforestation cost in case of degraded forest lands/village common lands with natural rootstock is drastically reduced under the participatory plantation/management regime. For example, Malhotra and Poffenberger (1989) estimated cost of regenerating degraded forest lands in Arabari in West Bengal to be only Rs 2,169 ha^{-1} ($47). Here, it was the joint responsibility of the forest department – *de jure* owners, and village people – *de facto* users for protection of the regenerated forest. In fact the cooperation between forest department and local people for regeneration and protection of degraded forest lands in Arabari as an experiment by some forest department officials led to the emergence of joint forest management (JFM) programme in India. For details on JFM programme in India, see Bahuguna (2001).

A recent study of a successful JFM programme in Behroonguda in Andhra Pradesh revealed that regeneration of degraded forest lands with rootstock through protection incurred an annual cost of Rs 567 ha^{-1} ($12) as compared to establishment cost of Rs 4,859 ha^{-1} for new plantation in the same area (D'Silva and Nagnath 2002). That is, afforestation of degraded forest lands with natural rootstock is cheaper than afforestation of totally degraded forest lands or barren lands. This is also evident from the case of community plantation taken under the JFM programme in village Soliya in Gujarat. In Soliya, the rehabilitation cost of degraded forest lands with natural rootstock was one-sixth of the afforestation cost of degraded wastelands without natural rootstock (Balooni 1998).

There is economic reasoning in rehabilitation of degraded forest lands through JFM in India as active people's participation in the plantation activities and management reduces the protection costs drastically vis-à-vis forest department/government undertaking rehabilitation of degraded forest lands at its own. This fact is corroborated in a study by Singh (1994). Singh analyzed the village woodlot/community plantation raised under the social forestry programme by forest department in Aslali village in Gujarat. The study revealed that the plantation was protected in multiple ways as forest department was responsible for the management of community plantation not the village people i.e., afforestation without people's participation. These methods were: cattle proof trenching, live-fencing of thorny bushes/plants, closing the planted area to grazing for five years, patrolling by forest department officials; and patrolling by a paid watchman employed by the village panchayat/council. The plantation cost was found to be Rs 4,779 ha^{-1} ($105), which is high as compared to afforestation with people's participation as discussed above.

In short, on the cost side, afforestation in India is not very expensive as evident from the review of studies.

Financial feasibility of wastelands afforestation projects

The results of financial analysis of afforestation projects based on twenty-one studies are described in this section. The results of these studies are summarized in Table 2,3. Here it is important to point out that researchers have invariably employed different sets of criteria for computing the financial feasibility of afforestation projects. These criteria are application of discount rate and time horizon/ project duration, and inclusion/exclusion of opportunity cost of afforested land in the financial feasibility analysis. This complexity in methodology makes it difficult to compare financial feasibility of different types of afforestation. Hence, it is essential to describe these criteria before discussing the financial feasibility of afforestation projects; opportunity cost of afforested land is discussed later. Some issues like investment in tree crops vis-à-vis agricultural crops, *Eucalyptus* as a plantation species and preference for mixed plantation emerging from the reviewed studies are also discussed in this section.

Inconsistent application of discount rate. Among various factors affecting the results of financial analysis of any project, the selection of discount rate used for analysis is crucial. It was observed that discount rate varied across these studies. In fact, the selection of discount rate is a subject of major debate in natural resource economics; for details, see Lober and Gracy (1997). The discount rate used for the financial analysis in the studies reviewed varied from 3% in case of Nadkarni et al. (1992) to 30% in case of Shah (1984). Most of these studies have not given any justification for choosing a particular discount rate used for the project analysis. A number of researchers used a discount rate of around 10% for the financial analysis. For example, 8% by Kishore et al. (1983), 10% by Babu et al. (1984), Balooni and Singh (1999), 11% by Gupta and Mohan (1982), and 12% by Goswami and Singh (1976), Singh (1988). These researchers may have equated the discounting rate to the market rate of return or more specifically lending rate of financial institutions, reflecting the private discount rate. However, Tewari and Singh (1984) (5%), and Nadkarni et al. (1992) (3% and 5%) used discount rates that reflected a social discount rate.

Nadkarni et al. (1992) carried out economic and financial feasibility analysis of five randomly selected social forestry projects in Karnataka, using NPV, BCR and IRR criteria on the basis of direct benefits only. Nadkarni et al. found that social forestry is quite economically and financially worthwhile for investing additional resources, and that much of degraded lands in India could be put to productive use at economic rates of return. Nadkarni et al. (1992) justified the use of social discount rate as social forestry is undertaken for benefit of a community or communities (see 'Footnote 4' for the definition of social forestry). Tewari and Singh (1984) also justified this using 5% discount rate for the financial analysis of afforestation of community land, a common property resource in Ramganga catchment in Uttar Pradesh (now in the State of Uttaranchal). The importance of using appropriate discount rate for financial analysis is highlighted in a study undertaken by Sharma (1995). Sharma found that *Casuarina equisetifolia* plantations on coastal sandy areas in Orissa under a social forestry project were financially viable (in terms of NPV) at 3% and 5% discount rates for 12 yr as well as 18 yr rotation. However, these plantations were not financially viable at the discount rates of 7%.

Sharma et al. (1991) estimated social discount rate for India to be 2% based on an inter-temporal social utility model using an annual growth rate of per capita consumption of 1.5%. By this standard, even the social discount rate of 3% used by Nadkarni et al. (1992) is on the higher side. The selection of the social discount rate is justified on the grounds that there are many positive externalities generated from the afforestation projects, which do not enter into the market and have public-good effects like soil and water conservation, and amelioration of the microclimate. Despite this, some studies analyzing social/community afforestation projects have used a very high discount rate. For example, Kishore et al. (1983) used 8% discount rate for the analysis of afforestation of a watershed area in Shiwalik hills in Chandigarh in Northern India. Use of a high discount rate of 30% by Shah (1984) for the project analysis of a plantation on wastelands under a social development project is not warranted.

A few of these studies, for example, Gupta and Mohan (1982), Singh (1988), Rana et al. (2000), have confined to financial analysis of farm forestry/agro-forestry undertaken at a small scale on private wastelands justifying the use of a higher/private discount rate. Gupta and Mohan (1982) worked out the financial viability of tree crops growing in wastelands in the hot arid zones of Rajasthan. They worked out the economics of tree crops at 11% discount rate, which was the lending rate of the financial institutions. Singh (1988) calculated the BCR at 12% discount rate for *Eucalyptus sp.* plantation on farmlands in Haryana. Rana et al. (2000) used 12% discount rate for benefit-cost analysis of plantations established under the agro-forestry system in Himachal Pradesh as farmers were getting funds for this purpose at the same rate. As the rate of time preference for individuals is high as compared to the society, the discount rate used for private investment (e.g., farm forestry) differs from that chosen for social investment (e.g., community forestry); according to Nautiyal (1988), traditionally the choice of discount rate depended upon the risk, pure rate of time preference, and inflation. However, Herbohn et al. (2000) have argued that a lower rate such as 3 or 4% is more appropriate for assessing farm forestry activities to allow for the important non-wood benefits landholders receive from farm forestry.

To overcome the problem of choosing one appropriate discount rate for the financial analysis and to provide for the sensitivity analysis, Mathur et al. (1984), Nadkarni et al. (1992), Tewari and Singh (1984) used a set of discount rates for the analysis, for details see Table 3. On the other hand, given a situation where there are different types of tree species for plantation and a set of discount rates used for the financial analysis, the choice of choosing the appropriate or most desired plantation type is a cumbersome exercise. Tewari and Singh (1984) confronted this situation in the financial analysis of afforestation of community land with three different types of plantations. The study by Tewari and Singh inferred that to make a choice at different discount rates, the decision-maker should assign some weights to outcomes and then choose the type of plantation having the highest combined weighted value.

Tewari and Singh assigned weights to the income (60%) and employment (40%) goals, the weights reflecting local community's preferences.

As the discounting rate employed in various studies was not consistent, it was not possible to use NPV as a financial indicator to compare/rank different types of afforestation projects with different rotations and management regimes in terms of their financial viability. Similarly, using BCR criterion would give misleading results for ranking various types of afforestation projects in different environmental conditions with cashflows of varying magnitudes. These drawbacks were overlooked in the present study, as the objective of this study is not to rank the various types of afforestation projects but to judge the feasibility of expanding investments in afforestation projects in India. However, it was observed that mostly BCR along with IRR were used as financial indicators in most of the studies reviewed. For this reason, NPV estimated in few studies have not been collated in Table 2,3.

Different time horizon/project duration. Differences were also found in the selection of the time horizon/period for which the financial analysis were carried out. Selection of the time horizon also has a direct bearing on the financial indicators. For example, the time horizon was 15 yr in the case of Goswami and Singh (1976), Shah (1984), and 50 yr in the case of Kishore et al. (1983). Nevertheless, selection of time horizon also depends on the species planted. To illustrate, time horizon used in the case of financial analysis of afforestation with *Eucalyptus sp.* having a short economic rotation has to be small compared to afforestation with *Pinus sp.* having a long economic rotation. Balooni and Singh (1999), Tewari and Singh (1984) used a time horizon of 10 yr and 70 yr for the financial feasibility analysis of *Eucalyptus sp.* and *Pinus sp.*, respectively. Das (1984) suggested that since the prevention of degradation or the restoration of degraded lands continue to yield dividends over a considerable period, a time horizon of 10–20 yr is considered suitable for working out cost effectiveness.

Internal rate of return vis-à-vis market interest rate. One of the most commonly used financial indicators for the viability of a project is IRR, which should be more than the interest rate payable on invested money. In almost all the studies, the IRR computed was either equal or more than the prevailing market interest rate in India justifying the financial viability of afforestation projects. IRR varied from 12% (Goswami and Singh 1976) to 129% (Bhatia 1984). However, comparison of IRRs estimated from afforestation projects with interest rates offered by the financial institutions on long term deposits will not always present the correct picture. As the interest rate charged by moneylenders or informal institutions in rural India vary across the country; all the financial institutions in India under the regulation of Reserve Bank of India such as scheduled commercial banks offer loans for almost similar interest rate, which currently is around 11 to 12%. For example, Gupta and Mohan (1982) found out that the market rate of interest prevailing in the semi-arid areas in India was much higher, commonly varying between 24% and 36%. In such cases, the afforestation undertaken on private wastelands with an IRR around 15–20% would not be financially feasible; perhaps it is not common that farmers take loans for tree plantation at very high interest rates from informal financial institutions. However, in such cases, an economic analysis of wastelands afforestation including all the direct, indirect benefit streams should pass the tests of profitability. These results based on IRR clearly illustrate the scope of successful plantation forestry on degraded lands. Besides, carbon emission trading has the potential of bringing forward the financial break-even point and thus improving IRR to the forest growers' (Lamb 2000).

Pay back period. Closely linked to time horizon of the financial analysis is the pay back period (PBP), one of the financial indicators. PBP conveys information about the rate at which the uncertainty associated with a project is resolved; the shorter the PBP, the faster is the uncertainty associated with the project resolved and vice versa (Chandra 1987). The studies reviewed revealed that PBP was between 10 yr as in the case of Goswami and Singh (1976), Chaturvedi (1985) and 15 yr as in the case of Kishore et al. (1982). Thus high PBP for investment in the wastelands afforestation projects shows that uncertainty associated with these projects is not resolved early. National Bank for Agriculture and Rural Development in India (its activities discussed later in the section on 'Investment implications') stipulates that repayment of loan taken for farm forestry plantation on private land should be paid back within 10 yr. This repayment schedule is possible in case of farm forestry but not for community forestry projects undertaken on degraded common lands. Balooni (1998) suggested that the repayment period should differ in the case of community plantations raised on degraded lands and preferably repayment of loans taken for community plantations should start only from the 10th year onwards and be over by the 16th year. The results of studies undertaken by Goswami and Singh (1976), Kishore et al. (1982, 1983) substantiate this suggestion as they computed the PBP between 10 to 15 yr for community plantations on degraded lands. Venkataraman (1984), Mishra (1993) emphasized that financial institutions should adhere to a repayment period of 13 to 20 yr for wastelands afforestation projects.

Investment in tree crops vis-à-vis agricultural crops. It has been found that in some locations growing tree crops on degraded farmland is economically more beneficial than growing agriculture crops alone, whereas in other locations the converse may be true. Hence, choice of converting a degraded farmland into a forest land is not an easy proposition and has to be carefully judged on economic grounds.

Singh (1988) found that BCR for crops grown on agricultural land was less than the BCR for *Eucalyptus sp.* grown on the same land showing higher returns for the latter. Singh calculated the BCR at 12% discount rate for 12-year-old *Eucalyptus sp.* plantation on farmlands in Haryana to be 3.31 as against only 1.17 for paddy-wheat crop rotation and 1.09 for sugarcane planted in the same area. Balooni and Singh (1999) carried out the financial feasibility of *Eucalyptus sp.* plantation undertaken on marginal agricultural lands in Gujarat. This analysis excluded subsidy given by a non-governmental organization to farmers. Balooni and Singh estimated the BCR to be 6.03 and IRR of 51.78% for 11 yr old plantations; the results are based on overall average figures for twenty households/farmers. Bhatia (1984) found that inter-cropping of *Eucalyptus sp.* and cotton yielded IRR of 129% for the first rotation and was estimated to increase to 213% for successive coppice crops in Gujarat.

These three studies revealed an important finding that inter-cropping and farm forestry on agricultural lands is a better proposition than plantation of trees alone from the financial point of view. However, according to Balooni and Singh (1999), it may not be economically desirable for a farmer to plant trees on good lands which have very high opportunity cost in terms of value of agricultural production foregone. Perhaps, tree planting may be profitable for a farmer in a region prone to recurring droughts and having unproductive soil, which is not fit for growing agricultural crops. For example, Aziz (1995) examined the economics of *Eucalyptus* cultivation on marginal land vis-à-vis economics of annual crops on the same lands in a cluster of villages in Kolar District, a drought-prone area in Karnataka. It was found that it is more remunerative for the farmer to raise *Eucalyptus* than annual crops like *ragi*, *jowar* (millets) as the paid-out cost return per unit of land from *Eucalyptus* was more than four times that of an annual crop.

Similarly, Singh and Bhattacharjee (1995) found that *Eucalyptus* plantation was more profitable use of marginal farmlands vis-à-vis agricultural crops like rice, potato and mustard in Nepura village in the Midnapur District in West Bengal. These marginal farmlands/*patta* lands were allotted to farmers under land-reforms programme of the Government of West Bengal. Singh and Bhattacharjee found that gross returns from *Eucalyptus* were about 17% higher than those obtained from crop cultivation on marginal farmlands. Positive yields from *Eucalyptus* plantation vis-à-vis agriculture have also been reported from other parts of the World. For example, Haltia and Keipi (1997) reported that Brazilian forestry yields greater benefits than cattle raising, especially in case of *Eucalyptus grandis*.

The above discussion implies that it is necessary to undertake a comparative financial feasibility study before converting marginal agricultural lands into forests. At the same time it is also important to financially analyze other alternatives of using marginal agricultural lands like growing horticultural crops. Cultivation of horticultural crops on wastelands is an attractive proposition. For example, Babu and Arora (1985) worked out the economic feasibility of the plantation of horticultural crops, *Citrus lemon* and *Citrus reticulata* on wastelands of Doon valley in Uttaranchal. BCR and PBP at 10% discount rate were calculated to be 1.40 and 12 yr, and 2.13 and 10 yr, respectively for *Citrus lemon* and *Citrus reticulata*.

In the context of above discussion, importance of opportunity cost of land in the financial analysis of forestry projects and *Eucalyptus* as an important plantation species in India has emerged, which have been discussed below.

Opportunity cost of afforested land. Opportunity cost of afforested land gains significance in the financial analysis as it affects the tree plantation investment decisions. According to Haltia and Keipi (1997) it makes sense to put agricultural land for forestry use if the social opportunity cost of agricultural land is less than or equal to the marginal value of land in forestry production minus the associated costs of conversion. Haltia and Keipi further stated that afforestation is justified only if the discounted net benefits from afforestation exceed the discounted net benefits of the next best use of land. Keeping in view such a significance of opportunity cost of land, it was found that all the studies reviewed on financial analysis except the study undertaken by Nadkarni et al. (1992) have not factored opportunity cost of afforested land into the financial analysis. Nadkarni et al. (1992) included among costs, the opportunity cost of afforested land in the form of the grazing opportunity foregone. So excluding opportunity cost of land from the financial analysis was one of the methodological drawbacks of studies reviewed.

Preference for Eucalyptus as a plantation species. Studies on economics of farm forestry undertaken by Bhatia (1984), Singh (1988), Aziz (1995), Singh and Bhattacharjee (1995), Balooni and Singh (1999) invariably highlight the importance of *Eucalyptus*, an exotic plantation species. Further these studies suggest *Eucalyptus* plantation as a financially viable alternative income generating activity on farm-lands. Even the *Eucalyptus* plantation undertaken on degraded non-farm lands was found to be financially viable. For example, Mathur et al. (1984) found that *Eucalyptus hybrid* plantations in the undulating area forming watershed of two rivers in Bijnore Plantation Division in Uttar Pradesh were financially viable. Mathur estimated that a nine years old *Eucalyptus* plantation undertaken on 25 ha in 'sandy plain' soil type (in Compartment 9 in Jafrabad Block) yielded an IRR of 29.2% and BCR of 2.30 at 12% discounting rate and 1.52 at 20% discounting rate. All these studies analyzed financial feasibility of *Eucalyptus* plantations, which were undertaken during late 1970s and early 1980s. This was the golden era of *Eucalyptus* in India. Moreover, *Eucalyptus* and other exotic fast growing species are preferred for plantation in tropics. Abod and Siddiqui (1999) based on a review of forty-five reforestation projects in the tropics revealed that 95% of these projects used exotic species. However, preference for *Eucalyptus* as a plantation species in India withered due to overproduction and subsequently to the collapse of its market during date 1980s (Dewees and Saxena 1997). It was also brought down by the controversies concerning adverse ecological impacts of *Eucalyptus* (Abbasi and Vinithan 1997).

Preference for mixed plantation. The composition of tree species planted under various afforestation projects is very important particularly to those focussing on rehabilitation of village common lands. There is high dependence on forests for various timber as well as non-timber forest products (NTFPs) in rural India. For example, the share of fuelwood is 30% of the total energy use in India (Ravindranath and Hall 1995). Similarly, there is high dependence on forests for fodder from trees for cattle and other forest products. Over 3,000 plant species produce economically significant products and thus are integral components of local economies in India (Tewari and Campbell 1997). According to Jodha (1997), rural poor in dry tropical regions in India receive bulk of their fuel supplies and fodder from village common lands; products of the commons account for 14 to 23% of rural household income. Jodha's estimation is based on a study of eighty villages from seven states in India. So from the socioeconomic point of view the afforestation projects in developing countries should not focus on timber production alone unlike developed countries like Canada and Finland involved in paper and pulp production on a very large scale. This is also supported by the fact that out of forty-five reforestation projects in tropics reviewed by Abod and Siddiqui (1999), only 20% of the projects chose species for timber production alone. Besides, mixed plantation compared to monoculture tree plantation is fast gaining importance as a measure to maintain/enhance species diversity. This is also the need of the time as aggregate areas of forest reserves, a major avenue of biodiversity conservation for protection of native species are limited, particularly in wet tropical regions leading to attention towards protecting biodiversity outside reserves, which can be achieved by restoring degraded lands (Harrison et al. 2000).

The studies reviewed on the financial feasibility of mixed plantations on wastelands were found to be profitable. Mathur et al. (1979) reported that an experiment was undertaken in 1959–60 to utilize wastelands (river terraces) along the torrential streams of Doon valley in Uttaranchal by way of raising two fuel tree species *Dalbergia sisso* and *Acacia catechu* along with fodder grass species *Chrysopogan fulvus* and *Eulaliopsis binata*. BCR for *Dalbergia sissoo* with *Chrysopogan fulvus* and *Acacia catechu* with *Eulaliopsis binata* were found to be 2.75 and 3.43, respectively. Kishore et al. (1982) carried out the economic evaluation of mixed afforestation, consisting of fuel and fodder species in deep and narrow ravines at Vasad in Gujarat. Project life of 15 yr was considered with a discount rate of 15% for the calculation of feasibility parameters. The BCR, IRR, and PBP were worked out to be 1.38, 15% and 15 yr, respectively. Shah (1984) worked out the economics of wasteland development project undertaken on 100 ha of wasteland of fuelwood and fodder species in Gujarat. The works involved bunding and plantation. The IRR of the project with 15 yr time frame was found to be 33.7%.

Tewari and Singh (1984) analysed the financial feasibility of three types of plantations, *Grewia sp.*, *Pinus roxburghii*, and a mixed plantation of these two species. *Grewia* is multipurpose tree species yielding a number of benefits like fodder, fuelwood and fibre, and *Pinus* yields benefits like timber, resin and fuelwood. Tewari and Singh recommended mixed plantation of *Grewia* and *Pinus* on the community lands as *Grewia sp.* would provide benefits in the short run and *Pinus* in the long run. Tewari and Singh found that this mixed plantation was financially feasible at 5% and at 10% discount rate in terms of both BCR and NPV. However, NPV was negative at 15% discount rate.

In the ongoing community plantation programmes in India, added emphasis is given on growing fodder grass species with tree species. This strategy specifically helps those households in rural areas who traditionally rear cattle. For example, Balooni and Singh (2001) reported that out of 40 ha of degraded village common land afforested by Vatra Tree Growers' Co-operative Society in village Vatra in Gujarat, 2 ha was raised only for grass production. This was done to meet the requirement of *rabaris* community-grazers by profession, as a compensation for the lost opportunity to graze their cattle in the village common land, a traditional property right of *rabaris*.

Afforestation of vast extent of ravines and arid wastelands. In this section the results of financial analysis of afforestation of ravine and arid lands have been summarized as these two categories constitute a large proportion of land available for plantation in India. Some ravine lands also fall in the category of arid lands. It has been estimated that around 4.32 million ha of land in India falls in the category of ravine wastelands. Ravines are network of gullies with steep sides and are very deep, and more than nine meters wide (Gautam and Narayan 1988). Studies reviewed on financial feasibility of afforestation on ravine lands cover the states of Gujarat and Uttar Pradesh. The analysis of four studies by Goswami and Singh

(1976), Kishore et al. (1982), Babu et al. (1984), Chaturvedi (1985) revealed that the BCR was found to be more than one except in case of Goswami and Singh (1976). The IRR and PBPs were found to be in the range of 12 to 27% and 10 to 15 yr, respectively. A higher return from afforestation suggests that such projects on ravine lands are bankable. The arid region of India covers about 31 million ha (Malhotra and Kalla 1990); some ravine lands fall in this region. By virtue of its geographic situation, the arid region in India is beset with numerous problems like frequent droughts, which need special attention. Most of the land in this region falls in the category of wastelands. The financial analysis of five studies covering two states of Rajasthan and Gujarat in Western India revealed that afforestation projects in this region were financially feasible (Table 2). So afforestation of these wastelands is one of the alternatives to rehabilitate them. This is further upheld by the fact that the land-use pattern in arid region has traditionally been guided by the conservation-oriented motives (Malhotra and Kalla 1990).

Wastelands development, a means of resource development. The overall analysis of the studies reviewed on financial analysis of afforestation on different types of wastelands in different parts of India suggestes that afforestation is one of the alternatives to rehabilitate such lands and is also financially feasible. The results of financial analysis of most of the afforestation projects in terms of BCR, IRR and PBP were found to be conforming to the guidelines suggested in theory. The main focus of this paper was to review literature on financial evaluation of wastelands afforestation projects. However, in the context of the developing country like India, wastelands afforestation projects need not only be judged from the financial point of view. Rather reclamation and rehabilitation of wastelands by afforestation are means of resource development to benefit the poor by generating employment and enhancing the availability of forest products. According to Bentley and Tewari (1997) many projects are designed to benefit certain groups relative to others, contrary to Kaldor-Hicks standard[9] for a successful project. They substantiated this by giving example of social forestry programmes and other resource development and management schemes designed especially to benefit the rural poor in India. For example, the Government of India has earmarked a minimum of 25% of anti-poverty funds for afforestation programmes. An area of 0.82 million ha was afforested during 1989–97 under the *Jawahar Gram Samridhi Yojana* (now *Sampoorna Gramin Rojgar Yojana*), a development programme in India (ICFRE 2000); this programme aims at providing employment to at least one person in a family living below poverty line in rural areas for 50 to 100 d in a year. Bentley and Tewari (1997) suggested that it is logical to use distributional weights for evaluating wastelands rehabilitation projects for skewing benefits towards the poor as this approach makes these projects appear economically efficient even if it only covers part of its costs (for details, see Bentley and Tewari (1997, pp. 245–250)). Factoring these suggestions into the studies reviewed in this paper would make wastelands afforestation projects economically efficient.

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[9] According to Kaldor-Hicks, "In any choice situation, select the policy alternative that produces the greatest net benefit" (Gramlich quoted in Bentely and Tewari (1997, p. 231)).

Investment implications

Financial viability of afforestation undertaken in a large scale

The analysis of studies in the preceding sections revealed that wastelands afforestation projects are cost effective and are also financially viable. Based on these studies, can we generalize that afforestation undertaken on a large scale in India is financially feasible? To answer this question, an attempt was made to find out empirical relationship between financial feasibility indicators – BCR and IRR, and the afforested area. A simplified linear analysis model between the financial feasibility indicator (y) and afforested area (x) based on the collated information from the review of studies was estimated using regression analysis. There were eighteen observations (N) each in the case of BCR and IRR. Observations on BCR and IRR from only those studies were employed, which used both these techniques simultaneously. Observations failing this condition were dropped from the regression analysis. The results of this analysis are shown in Figure 1,2.

In the case of BCR, the coefficient of afforested area was found to be positive (0.017) (Figure 1). However, it was not statistically significant. The R^2 value was 0.048 signifying a poor line of fit rather suggesting no relationship between BCR and afforested area. So using BCR criterion, it could not be drawn from the present analysis that afforested area undertaken in large scale will be financially viable. Nevertheless, all the observations (N = 18) on BCR were more than 1, except one

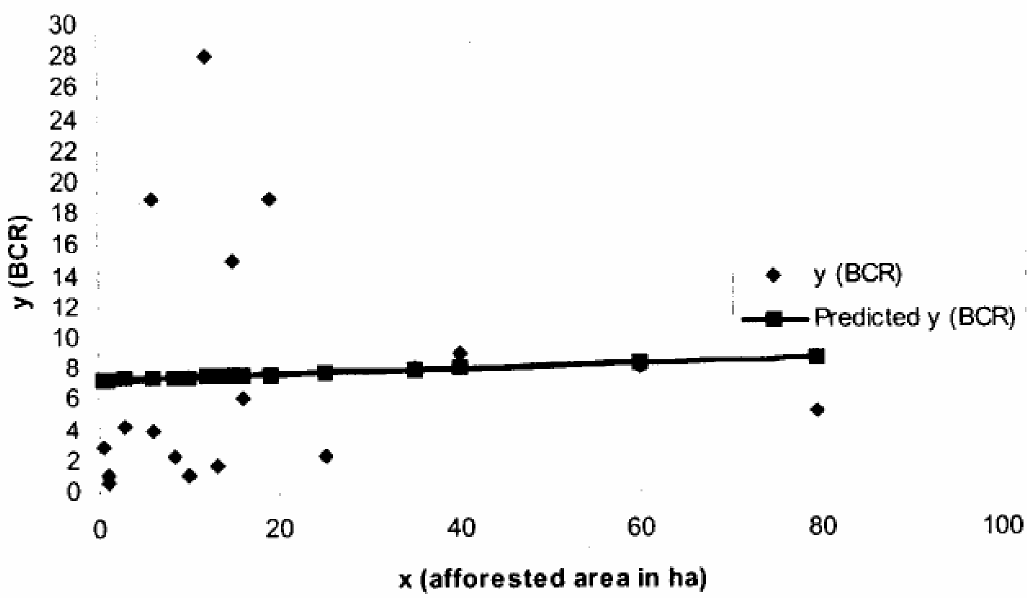

Figure 1. Line fit plot of benefit cost ratio (y) on afforested area (x) (Note: The graph is an illustration of a simplified linear model).

R^2 = 0.048, F-statistic = 0.037, Observations = 18

	Coefficient	S.E.	t-statistics	P-value
Intercept	7.306	2.552	2.862	0.01129
Afforested wastelands (x)	0.017	0.089	0.192	0.84982

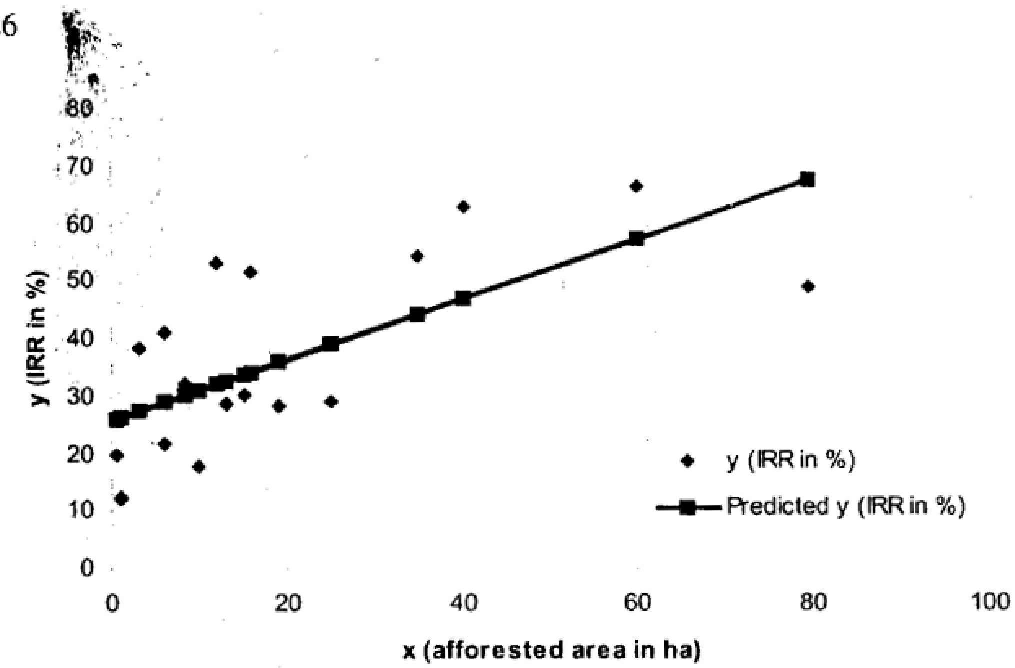

Figure 2. Line fit plot of internal rate of return (y) on afforested area (x) (Note: The graph is an illustration of a simplified linear model).

R^2 = 0.45, F-statistic = 13.29, Observations = 18

	Coefficient	S.E.	t-statistics	P-value
Intercept	25.891	4.138	6.257	1.145E-05
Afforested wastelands (x)	0.526*	0.144	3.645	0.00217

*Significant at 1% level

observation (0.64). BCR more than 1 signifies that afforestation projects were financially viable, whereas if BCR is equal to or more than 1.2, it is an economically sound project. Kalla (1988), Narayana and Babu (1990) suggested that for an economically sound project, the BCR should not be less than 1.2. This condition was also satisfied in fifteen observations. The reason for the lack of statistically significant relationship between BCR and afforested area may be attributed to the fact that the observations based on the studies reviewed have used different discount rates for discounting the cash flows for the purpose of financial feasibility analysis; this has already been discussed in detail in the section 'Inconsistent application of discount rate'. Figure 1 reveals that four observations on BCR (more than 14) have deviated much from the 'line fit plot'. These observations based on the study of Nadkarni et al. (1992) were computed using a discount rate of 5%. On the other hand, for rest of the observations on BCR used for the analysis, a discount rate of 10–15% was used. Given such inconsistency in the methodology for computing BCR in different studies, IRR, which is independent of discount rate, would better describe the relationship under examination.

The relationship between IRR and afforested land was found to be positive with coefficient value of 0.526 and statistically significant at 1% level (t-statistics = 3.645), even though it was not a good line of fit as the R^2 value was calculated to be 0.45 (Figure 2). For all the observations (N = 18), IRR was more than 12%

indicating that all the afforestation projects accrued more returns than the prevailing market rate of return in India.

Before generalizing the outcome of the empirical analysis presented above, it is important to highlight that most of the studies analyzed the economics of afforestation projects undertaken on degraded private lands/forests/village common lands less than 80 ha of area. This is substantiated by the fact that 64.5% of private area operated in India is between 1 ha to 10 ha, 13.5% below 1 ha, and only 20.1% above 10 ha (Central Statistical Organisation 1998). On the other hand, by and large, plantations on village common lands or degraded forest lands in India are undertaken on small-scale at the same time, even if the area available for afforestation is large in the same location. As mostly plantations are spread over a period of three to five years, such a plantation strategy helps in generating employment to landless and marginal farmers (having landholding less than 1 ha) in rural India. Many of the government development schemes for providing more employment opportunities in rural areas are linked to afforestation programmes, already discussed in the preceding section. For example, tree growers' cooperative societies in the villages of Vatra, Sarnal and Navagmbara in Gujarat undertook plantations during 1987 to 1991 on degraded village commons with an area of 40 ha, 35 ha and 60 ha, respectively resulting in generating employment to its members mostly belonging to landless and marginal category of farmers for four years (Balooni and Singh 2001). Besides, there are hassles in getting large areas for afforestation due to lack of systematic information about the ownership, present use, and extent of degradation of wastelands in India (Romm 1981a, 1981b).[10]

Given this context, we can not expect studies on financial analysis of afforestation on large areas of private and village/government owned degraded lands. Conversely, it is difficult to estimate the financial viability of all the afforested areas in a year or during a particular period, say 1.72 million ha of land afforested during 1990–91 or 7.95 million ha of land afforested during the Eighth Five Year Plan (1992–97) in India. Also, it can not be projected whether afforestation of 84 million ha of available wastelands for tree plantation (discussed later) in the coming years will be financially viable or unviable in India. But a generalization based on the review of literature and the results of regression analysis for IRR (y) and afforested area (x) could be that 'afforestation projects are financially viable' in India with the presumption that afforestation is undertaken on a small-scale in one location and that all such locations constitute a large afforested area in India every year.

Level of investments in afforestation in India

Given that afforestation projects are financially viable in India, do we need to enhance investment in afforestation projects? Conversely, are Indian investments in

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[10] In the last decade, concrete measures have been undertaken to improve the availability of grassroot level data for preparing action plans at district level for reclamation of wastelands through afforestation, soil conservation and land management practices.

wastelands afforestation too low? To answer these questions, an attempt was made to estimate how much financial resources are required to rehabilitate wastelands in India through tree plantation.

The methodology used for estimation is summarized here. The overall estimate of investment required is the summation of estimates of investment required to afforest three categories of wastelands based on their ownership. Chambers et al. (1989) estimated that 84 million ha of wastelands in cultivated lands, as strips and boundaries, degraded forest land and uncultivated degraded lands, are available for tree growing in India. Chambers et al have further categorized these different types of wastelands according to their ownership as private owned wastelands, wastelands owned by forest department, and wastelands owned by revenue department and other departments (Table 4). The latter two categories fall in the category of common lands. A perusal of the Table 4 reveals that a different tree plantation model was used for rehabilitation of each category of wasteland. These three tree plantation models are based on authors' own studies (Balooni 1998; Balooni and Singh 1999, 2001). The selection of a specific tree plantation model for a particular type of wasteland was based on their relative success and possibility of replication of the model as revealed by these three studies.

It was assumed that 2% of the 84 million ha of wastelands available for plantation, i.e., 1.68 million ha, would be undertaken for afforestation per annum. This assumption was based on the fact that during 1985–1999, on an average 1.64 million ha of area was afforested per annum, which includes afforestation in three categories of wastelands as mentioned above. Hence the assumed afforestation rate per annum used for the analysis is achievable in India given the accomplishments in the recent past. The estimates of investments required for wastelands afforestation at rather conservative afforestation costs revealed that the present rate of investments in afforestation programmes in India is not sufficient vis-à-vis the extent of wastelands and the objective of bringing more area under forest cover in India.

An amount of around Rs 26 billion (US$ 575 million) at 2000–2001 prices was estimated to be required for afforestation of 1.68 million ha of wastelands available for tree planting annum [1]. This estimate of investment required for afforestation is markedly higher than expenditure of Rs 13 billion incurred on afforestation of 1.72 million ha during the year 1991–92 (ICFRE 2000)[11] and somewhat higher than Rs 24.15 billion, the total approved outlay for environment and forest put together for the year 1999–2000 in India (http://www.Indianstat.com); both the investment figures have been inflated to 2000–2001 prices.

Under-investment in afforestation as revealed by the present analysis is in conjunction with concerns raised by researchers. Jhala and Pinto (1988), Vohra (1989), Rao and Singh (1990), Kalla (1988), Joshi et al. (1997) pointed out that the present level of financial resources available for wastelands afforestation programmes is inadequate given the extent of wastelands in India. Also reinvestment in the forestry sector in India has been considerably less than the contribution to the

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[11] Year-wise data on investment on afforestation by the Government of India during the recent years is not available.

Table 4. Estimates of investment required for afforestation in India in 2000–2001 (at 2000–2001 prices).

Particulars	Private owned Wastelands	Wastelands owned by Forest Department	Wastelands owned by Revenue Department and other Departments	All
Wastelands available for afforestation* (in million ha)	35	36	13	84
Afforestation cost ha^{-1} (in Rs)	19,343	11,330	17,625	
Study	Balooni and Singh (1999)	Balooni (1998)	Balooni and Singh (2001)	
Tree plantation model	Farm forestry	Community plantation-joint forest management	Community plantation-tree growers' co-operatives	
Afforestation @ 2% per annum of the available wastelands for tree planting (in million ha)	0.70	0.72	0.26	1.68
Investment required				
-in Rs million	13,540	8,158	4,583	26,280
-in US$ million (US$=Rs 45.68)	296	179	100	575

*Source: Chambers et al. (1989).

state treasury (World Bank 1993b). While this is not the cause of concern, not enough funds have been made available to manage the forest resources properly or to rehabilitate the degraded areas. The investments in the forestry sector including afforestation projects have been abysmally low during the first six Five Year Plans implemented during 1951 to 1985, varying from 0.39% to 0.71% of the total public sector outlay. The low investments in the forestry sector in the past had dual effects as it resulted in low forest production as well as low investment in the afforestation projects. It was only during the Seventh Plan (1985–1990) that the forestry sector outlay was more than 1% of the total public sector outlay. During the Eight Plan (1992–97), the forestry sector outlay was 1.13% of the total public sector outlay (Figure 3). This increase is mainly due to a number of afforestation projects taken up during this period. When comparing investments in forestry sector with agriculture, it was found that forestry sector/uncultivated lands get very low priority in development plans. This is evident from the fact that before 1980s, the share of forestry was less than 1% of the total development outlay/budget, whereas agriculture got between 20 and 24% (Saxena 1991). In recent years, investment in forestry sector has further been reduced as a proportion of the total outlay. The forestry sector outlay in the Ninth Plan (1997–2002) is 0.84%.

All these findings suggest that there is an urgent need to enhance investments in wastelands afforestation by the Government of India and to encourage private sector investments in afforestation programmes.[12] There is also scope to tap the financial resources available from various international environmental agreements. The estimates of investment required for wastelands afforestation presented in Table 4 also give an abstraction of the funds required for specific plantation programmes like farm forestry on privately owned marginal/degraded farmlands, and communi-

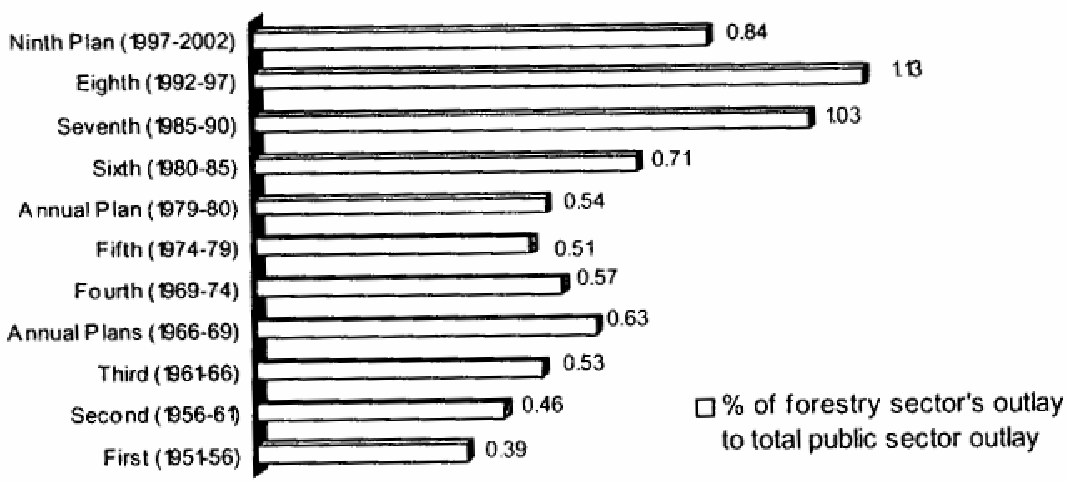

Figure 3. Plan-wise outlays in forestry sector as compared to total public sector outlays in India during 1951–2002 (Note: The graph is based on ICFRE (2000, p. 212)).

[12] Private sector involvement in tree plantation in India was meager till recently due to highly subsided raw material provided to the forest-based industries from the government owned forests.

ty forestry on degraded forest lands and non-forest lands owned by various government departments in India.

Issues hampering wastelands afforestation

The review of studies done in this paper paints a positive picture for undertaking afforestation on wastelands on economic grounds. Mostly, these studies represent the case of those afforestation projects, which have been contemplated successfully. However, the wastelands afforestation in India is hassled by many constraints. In this section, some of these constraints have been briefly described.

The first and foremost constraint is the lack of funds available for afforestation of wastelands, which has emerged from the discussion in the preceding section. Long gestation periods also do not motivate farmers to take up tree plantation adventures. For example, the on-going afforestation programmes in India suggest that salt-affected soils can be effectively managed by planting *Acacia nilotica*, *Prosopis juliflora*, *Casuarina equisetifolia*, *Sesbania egyptia*, and various *Eucalyptus* species as all these species give better results with low establishment costs (Joshi et al. 1997). However, Joshi found that farmers seldom plant trees on fields with problem soils as the minimum gestation period of 7 to 10 yr is too long for poor farmers to wait.

The institutional financing in this area of development in India is miniscule (Balooni and Singh 1994; National Wastelands Development Board 1995). Results of financial feasibility analysis of afforestation projects evidently revealed that they are worth financing by the financial institutions as IRR from these plantations is more than the prevailing interest rate on long-term loans; at present the interest rate on long term loans of more than Rs 200,000 for wastelands development is around 11 to 12%. For example, National Bank for Agriculture and Rural Development (NABARD), an apex development bank in India provides refinance facilities to financial institutions like scheduled commercial banks, state cooperative banks, state land development banks and regional rural banks in respect of the loans advanced by them to individuals and organizations for undertaking tree plantations and other forestry activities. Balooni and Singh (1994) found that the forestry schemes constituted only 0.61% of the total number of schemes sanctioned and accounted for only 1.64% of the cumulative disbursements made by NABARD during 1982–92. The same trend has prevailed in the recent years also.

It has been found that a number of constraints like the long term nature of afforestation projects, downgrading of afforestation programmes in terms of the political priorities (Venkataraman 1984), inaccessibility to bank finance, credit unworthiness of farmers owing to previous debts (Lobo et al. 1987), resource crunch and lack of infrastructure with lending banks (Singh 1993), and lack of interaction between financial institutions or aid agencies mostly with the unorganized poor (Sreenivasan 1992) come in the way of financing the afforestation projects. There are also a number of other constraints at the grassroots level affecting financing of afforestation programmes in India; for details, see Balooni (1998). These constraints need to be overcome for the promotion of wastelands afforestation in India in order to bring a large extent of wastelands under tree cover.

Conclusions

The lessons drawn from the various studies reviewed in this paper reveal that a large area of wastelands lying unutilized in India and in other countries can be successfully and economically reclaimed by taking up afforestation activities. The wasteland afforestation has been found to be a financially viable venture even when no environmental benefits are taken into consideration. Overall review of studies on the cost of wastelands afforestation suggests that reclamation of wastelands through afforestation is not an expensive venture in India. It was found that afforestation of degraded forest lands with natural rootstock was cheaper than afforestation of totally degraded forest lands or barren lands. So about 15.5 million ha of degraded forest lands with natural rootstock in India (Government of India 2001) can be regenerated cost-effectively with people's participation in their protection and management under the ongoing joint forest management (JFM) programmes in India.

The estimates of investments required for wastelands afforestation at conservative afforestation costs revealed that the present level of investments in afforestation programmes in India is not adequate. On this front and on economic grounds, India should endeavor to undertake compensatory plantation on behalf of the polluting companies and nations obliged to reduce the emissions of GHGs by investing in carbon sinks as proposed by Kyoto Protocol on Climate Change; the Government of India has recently (August 2002) decided to ratify the Kyoto Protocol. It is expected that the Clean Development Mechanism under the Kyoto Protocol (see 'Footnote 2') would accelerate investments in the establishment of new forest plantations. In India there is vast scope for implementing afforestation programmes in regions, which are not yet brought within the fold of tree plantation schemes and where there is acute shortage of fuelwood, timber and other forest produce.

The policy makers and researchers should also be cautious while choosing the discount rate for the financial analysis of afforestation projects, which has a direct bearing on the financial results and therefore investment decisions. Besides, various methodological issues in the feasibility analysis of afforestation projects need to be addressed by the researchers in view of ever increasing importance of plantations as carbon sinks and source of other environment services. Including environmental benefits of afforestation projects in financial analysis will be the best tool to overcome economic biases in investing in these projects.

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