Eucalyptus in Pakistan - Tanvir Ahmad

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ABSTRACT

Eucalypt introductions date back to 1843 but no substantial plantings were made to 1950. There was a further impetus in the 1970's and in 1985 in the motivation of farmers in fuelwood plantations. Eucalypts are mostly grown in irrigated plantations; in all some 10,000 ha are established. *E. camaldulensis* has proven most adaptable in all agro-ecological zones and is the most common species planted. The environment is characterised by extremes of temperature, low relative humidity, erratic and irregular rainfall; soil salinity is common. This species is especially favoured in the arid and semi-arid plains. Volume production is good. Regimes are tested for spacing and use of irrigation water. Strength properties of *E. camaldulensis* were intensively tested leading to its use in: particle and chipboard, pulp and paper, crossarms, fence posts, poles, fuelwood and charcoal. It is accepted and favoured by farmers. Alleleotrophic effects are minimal; water stress is tolerable. Pests and diseases are noted.

Key words: *Eucalyptus, E. camaldulensis*, Pakistan, social forestry, strength properties, utilisation, irrigation.

INTRODUCTION

Pakistan is an extratropical country between 24° to 37°N latitude and 61° to 75°E longitude. It has four provinces, i.e. Punjab, Sind, Baluchistan and North Western Frontier Province (NWFP) whereas the status of Kashmir is not yet decided. The north and north- western part of the country is hilly, but the central and southern part mostly consists of alluvial soils and a few deserts. Mean annual rainfall varies from 100 mm in the south to 1,500 mm in the north. The temperature varies from freezing point to 50°C. The important national forestry facts are given in Appendix 1.

HISTORY OF *EUCALYPTUS* PLANTING

Its first introduction in the sub-continent dates back to 1843 as single trees, arboreta and roadside plants. In 1900, when it was feared that fungal attack would cause severe loss to 'shisham' (*Dalbergia sisso*o)[3] in irrigated plantation, interest in *Eucalyptus* rose. However, no substantial areas were planted till 1950 as it was not considered a useful species due to shakes and cracks which developed in the cut wood. Efforts to test more *Eucalyptus* species revived with the arrival of Mr. G. Brockway, an Australian expert in 1955. Many foresters visited Australia in the quest of suitable species for climatic conditions obtaining in Pakistan. In the process, arboreta were established in the plains (Pirowala, Changa Manga, Mianwali, Chichawatni), and in hilly areas (Ghora Gali, etc.). Field trials on small scale were also conducted at Fort Munro, Pirowala, Changa Manga, Bani (Gujrat), Pakhowal, Jauharabad and Rakh Pirsabz.

Pryor (1967), an FAO consultant, assessed work here on *Eucalyptus*. In his opinion it was futile to test scores of species and suggested that future trials may be confined only to the following five species in order of merit: *Eucalyptus tereticornis; E. camaldulensis; E. microtheca; E. melanophloia* and *E. citriodora*. He further suggested that seed collection of these species should be made from pure stands or isolated trees available in Pakistan to minimize the chances of hybridization. In a study, "Past performance and future prospects for the use of *Eucalyptus* in Pakistan", he recorded (Appendix 2) the performance of species and localities where they are growing.

In the seventies the planting programme of *Eucalyptus* received a new impetus. Sheikh (1981a) found *Eucalyptus camaldulensis* could be raised without irrigation in the Peshawar zone when planted during the winter rains. (Mean annual rainfall of Peshawar is 400 mm of which 60% falls in winter). In 1985 the Social Forestry Project was started to motivate the farmers of seven districts (Attock, Rawalpindi, Jhelum, Gujrat, Khushab, Chakwal and Sialkot) of Punjab to raise fuelwood plantations mainly of *Eucalyptus* (Appendix 3).

PRESENT SITUATION

Eucalyptus is being grown in irrigated plantations of the Government land and on farm-lands of Punjab and Sindh. A recent survey shows about 200 million trees are planted in the Punjab on farmlands, mostly irrigated, of which *Eucalyptus* is 2.2%. Similarly a survey in NWFP Province found about 80 million trees were raised on farmlands, mostly irrigated, of which total *Eucalyptus* was 2.7 % (Amjad 1991, 1992). Under the Social Forestry Project, the farmers have raised 28 million trees since 1985. These trees if considered to be planted at 3 x 2 m, which is the conventional method, will cover an area of 16,800 ha, including 470 ha with *Eucalyptus*. The largest plantation of *Eucalyptus* in Pakistan is at Khipro (Sindh). *Eucalyptus camaldulensis* project planting commenced in 1973 to provide raw material to pulp and paper, chipboard and furniture industries. To date, about 3,500 ha have been planted.

In the technique, one year old plants are raised in polythene containers in the nursery. These are planted at 1.5 x 1.5 m spacing in trenches during February and March. Restocking of failures is carried out in 2nd and 3rd year of planting. Weedings are made twice in the first year and once in each of the 2nd, 3rd, and 4th years. The rotation of harvest is fixed at 8 years and trees are sold standing through open auction. The plantation is presently in arid areas affected by water logging and salinity. Another large *Eucalyptus* plantation is in Bahawalpur, of 4,123 ha. Bahawalpur plantation has a sandy loam soil with mean annual rainfall less than 200 mm, mostly received in summer. Summers are extremely hot and dry, with the maximum temperature to 45^{o}C. Winters are comparatively short but generally severe; lowest temperature is at freezing point.

A rough estimate that *Eucalyptus* plantings cover is about 10,000 ha. Of all *Eucalyptus* introduced in Pakistan to date, *E. camaldulensis* has proven most adaptable under all agro-ecological zones. Consequently, it has been planted more than other species; it is the prescribed species of all afforestation programmes. It is especially favoured in arid and semiarid plains as: single trees, in block and linear plantations and is raised with or without artificial irrigation. The existing growing stock of *Eucalyptus* is mostly of *E. camaldulensis* and its numerous hybrid forms, occurring naturally.

Eucalyptus camaldulensis:

Is the river red gum in Australia and sufaida or lachi in Pakistan. It is very large evergreen tree, the bark is usually not straight and is of red gum type, thick, smooth and patchy. The wood has light grey sap and reddish brown heart wood; it is hard and heavy. The species grows under a variety of ecological conditions associated with water courses, hence in the name river red gum. It exhibits a great deal of diversity in morphological features; is frost hardy and a light demander. The best growth in Pakistan is observed on exposed and disturbed sites. Though it coppices very well, this method is not practiced in plantation regeneration.

SILVICULTURE

Eucalyptus produce seed in September and October from five years age. Capsules, sun ripened open and shed seed in a week. Seed per kg of the five important species are: *E. microtheca,* 200,000; *E. camaldulensis,* 550,000; *E. citriodora*, 200,000; *E. melanopholia*, 250,000; *E. tereticornis*, 350,000. Seed remains viable for 1-2 years, but if air dried and kept in sealed containers at 1-4°C can remain viable for years.

Seed are sown at any time during the year in raised sandy beds. Germination starts within a week. When the seedlings are 5-7 cm high (after about one month), they are pricked out into polythene tubes. After six months the seedlings are ready for field transplanting. Plant cost is about paisa 25 (Sheikh, 1979).

GROWTH PROPERTIES

Height, diameter and volume growth

Figure 1. Average height, diameter and volume growth of thirteen provenances of *E. camaldulensis* at 10 years

Provenance	Height(m)	Diameter(cm)	Volume/ha/m^3/yr
Alice Spring (N.T.)	15.8	15.8	14.6
Tenant Creeks (N.T.)	11.3	10.4	5.5
Newcastle Waters Creek (N.T.)	11.9	12.4	8.1
Katherine (N.T.)	13.2	11.8	8.3
Fortescue River (W.A.)	14.0	15.2	13.5
Port Lincoln (S.A.)	14.5	16.3	15.4

Darlington Point (N.S.W.)	14.3	16.0	13.5
Silverton (N.S.W.)	12.9	14.2	10.3
Quilpie (Qld.)	14.2	13.4	10.3
East of Quilpie (Qld.)	14.0	15.2	12.3
Bullock Creek (Qld.)	14.4	13.8	9.4
Petford (Qld.)	15.8	13.7	11.3
Burma forest (Vict.)	11.7	13.2	9.4

The average height, diameter and volume of 13 provenances of *E. camaldulensis* grown in Changa Manga irrigated plantation are given in Figure 1. The plantation is characterized by extremes of temperatures, low relative humidity and erratic irregular rainfall of a mean of 378 mm; mean maximum temperature is 41°C and mean minimum temperature is 5.5°C. The plantation is irrigated (Siddiqui, 1984).

Irrigation methods - spacing

Eucalyptus was introduced in Pakistan a century ago. Since then a conventional spacing of 3 x 2 m with trench irrigation has been used in planting. A study commenced in 1976 at five different sites to investigate spacing and irrigation. Two major treatments (trench and flow methods) and three minor treatments (spacings 1.5 x 1.5; 2.25 x 2.25 and 3 x 3 m) were adopted. Analysis of data indicates:

- Major treatments viz. trench and flood methods of irrigation did not have any effect on diameter and height of the trees.
- Diameter increased with the increase in spacing.
- Closest spaced trees gained more height as compared to wide spacings.
- Close spacing (1.5 x 1.5 m) produced 95 m^3 wood/ha and wider spacings, 2.25 x 2.25 and 3.0 x 3.0 m - 61 m^3/ha and 38 m^3/ha respectively at Chichawatni. The same trend was observed at Pirawala and Bahawalpur.
- Wider spacings were heavily infested with weeds compared to closer spacings.
- A first thinning was made at Chichawatni as the crop was congested in the 1.5 x 1.5 m spacing; 35 m^3 wood/ha was removed and 60 m^3/ha remained which was equal to the volume available in the 2.25 x 2.25 m spacing and about one and a half times that of in the 3.0 x 3.0 m spacing (38 m^3).

The study has given very important indications. It is recommended that for maximum volume production on a short rotation, *Eucalyptus camaldulensis* plantations should be raised at 1.5 x 1.5 m for pole, post and fuelwood production. If desired to be grown on longer rotation, these plantations can be thinned after 5 years to reduce competition and to enable the standing trees to gain diameter (Sheikh, 1984).

STRENGTH PROPERTIES

The strength properties of plantation grown *E. camaldulensis* wood in Changa Manga were determined according to British standard specification. The data for eucalypt wood is listed in Figure 2, along with the values for shisham (*Dalbergia sissoo*) and deodar (*Cedrus deodara*) for comparison purposes.

The data shows that with the exception of shearing strength, all other properties of *E. camaldulensis* wood are inferior to those of shisham. The reason for high shearing strength of eucalypt wood is the presence of sloping or interlocked grains which improves its shear strength. The mean values of eucalypt wood are 57-91% of the values for strength properties of shisham. On the other hand *Eucalyptus* properties are either comparable or superior to those of deodar. The exception is only modulus of elasticity. This suggests that *Eucalyptus* wood can be efficiently used for all purposes where deodar is presently employed. These uses include, joinery work, cross arms and construction purposes. Although deodar wood has high natural durability against insects and fungi, application of a suitable preservative treatment to eucalypt wood will provide sufficient protection against attack. Eucalypt wood can substitute for shisham in furniture manufacture provided slight modification are made in its design for lower strength. In general, *E. camaldulensis* wood can be regarded as fairly hard and strong and suitable for a number of uses.

Figure 2. Comparison of strength properties of E. camaldulensis with shisham and deodar

Property	Eucalyptus	shisham	deodar
Density (kg/m^3)	705	801	577
Modulus of rupture (kg/cm^2)	1,009	1,107	741
Modulus of elasticity (kg/cm^2)	77,788	117,767	102,158
Tensile strength perpendicular			
to grain: (kg/cm^2)	33	58	24
cleavage: (kg/cm)	32	-	-
Max. shearing strength parallel			
to grain: (kg/cm^2)	191	124	81
Max. compressive strength parallel			
to grain: (kg/cm^2)	397	609	431
Max. compressive strength parallel			
to grain at elastic limit: (kg/cm^2)	270	351	305
Impact bending strength per specimen (kg)	2.5	-	-
Hardness (kg)			
End	688	926	645
Side	599	883	447
Resistance to nail withdrawal (kg)	128	185	102
Resistance to screw withdrawal (kg)	262	364	231

UTILISATION

Particle board: While comparing the properties of commercial *Eucalyptus* particle board panels with the commercial board panels, it was observed that although former board is of lower density; its strength properties are better than the commercial panels. The low density in commercial panels is due to an inefficient chip spreading manufacture system. This system was good enough for the raw material used by the industry but it does not suit eucalypt chips. This is also the reason for the high density coefficient and water absorption values of commercial panels. From the preliminary results obtained, it is concluded that *E. camaldulensis* wood can produce particleboard of standard requirement provided some water repellent additive is added to the chips.

Figure 3. Crossarm potential of *eucalypt*

Property	Standard specifications of WAPDA*	*E. camaldulensis* wood
Density (kg/m^3)	512-576	705
Modulus of rupture (kg/cm^2)	478	1,009
Modulus of elasticity (kg/cm^2)	94,905	77,788
Maximum shearing strength parallel to grain (kg/cm^2)	77	191

* Water and Power Development Authority

Crossarms: The properties of eucalypt wood were superior to standard requirement for crossarms of deodar wood used on electric transmission poles, except for modulus of elasticity, as shown in Figure 3.

Service life of *E. camaldulensis* crossarms was tested. Green logs were converted into 2.44 m x 12 cm x 2.5 cm size crossarms. They were carefully air seasoned to avoid development of defects. After seasoning, these were treated with 50:50 mixture of creosote and light diesel oil by the full cell process according to the Water and Power Development Authority (WAPDA) specifications; 41 treated crossarms were installed on 11 KW electric transmission poles along Jamrud road, Peshawar 1980 in collaboration with a local WAPDA office.

The crossarms were visually examined in June 1983 and checked for defects: spring, bowing, cupping, twisting, end splitting, surface checks, cell collapse (wash-board effect), insect attack, fungus attack and compression failure. They were graded according to the IUFRO Standard method for stake test. The result is shown in Figure 4.

Figure 4. Crossarm defect test

0 - Sound, no defect	0 %
1 - Slight, superficial defect; no effect on strength properties	26 %
2 - Evident defect but moderate; no effect on strength properties	47 %
3 - Severe defects	16 %
4 - Failure	11 %

Seasoning defects, when not severe, hardly affect the strength properties of the cross-arms, especially, since WAPDA specifications are based on a safety factor of 5. Some 73% of installed crossarms were found to be serviceable after almost 3 years of installation. There is considerable scope for improvement of their performance through proper seasoning.

Fence posts. Posts (40) each of *E. camaldulensis* and *Cupressus sempervirens* were treated with two preservatives - Tanalith C, (2.5% solution by weight) and Pentachlorophenol (5% solution by weight in diesel oil) and 5 posts of each species were taken as control. All fence posts were installed in 1978 in the Pakistan Forest Institute to determine service life. After one year, all the fence posts were examined for decay or at the ground level for beetle attack there. The result is shown in Figure 5.

Figure 5. Extent of damage on fence posts

Species	Preservatives	No. of posts damaged by attack	Sound	Fully	Partial
Eucalyptus camaldulensis	Pentachlorophenol	20	16	0	4
	Tanalith C	20	19	0	1
	Control	5	0	5	0
Cupressus sempervirens	Pentachlorophenol	20	18	0	2
	Tanalith C	20	20	0	2
	Control	5	0	5	0

The untreated posts of both the species were completely damaged by termites attack and had to be replaced after one year. In the case of Pentachlorophenol, 4 out of 20 posts of eucalypt and 2 out of 20 posts of cypress had partial termite attack at ground level. The reasons for this could either be mechanical to the treated outer surface during installation, providing entry for termites, or due to the leaching of the chemical during rain. In the Tanalith C treatment, none of the 40 posts of either species had any attack at ground level. However, in eucalypt Tanalith C treated, beetle attack above ground level was recorded in one post. The reason for this could again either be mechanical damage to the outer treated shell, or the presence of the insect in the wood prior to the treatment. The overall results indicate that both treatments had a significant effect in prolonging the life of posts of both species. Tanalith C gave better results than Pentachlorophenol. The cost of chemical per post for Tanalith C treatment is about Rs. 0.50 and for Pentachlorophenol about Rs. 2.00.

Firewood and charcoal. *Eucalyptus camaldulensis* is one of the principal eucalypts grown for fuelwood over the world. The wood of most eucalypts burns well when air dried and leaves little ash; it carbonizes easily, providing good charcoal. Charcoal yields more calories per kg than raw wood, about 7,900 calories per kg for charcoal against 4,700 calories for wood. Charcoal production, however, uses $1^1/4$ to 3 times as much wood to deliver the same amount of energy, as there is considerable loss of energy/heat during conversion into charcoal.

Eucalyptus camaldulensis is quite comparable in calorific value with the commonly preferred fuelwood species of shisham (*Dalbergia sissoo*) and kikar (*Acacia nilotica*). However, the former has slightly lower wood density than the latter; the density of eucalypt wood is 705 kg/m^3, shisham (*Dalbergia sissoo*) is 801 kg/m^3 and of kikar (*Acacia nilotica*) is 833 kg/m^3. On the other hand considering growth rate of these species, a hectare of eucalypt plantation could produce up to 10.86 tons of air dry of wood per annum which is more than that of shisham (*Dalbergia sissoo*) (5.21 tons of air dry wood per ha per annum) and kikar (*Acacia nilotica*) (10.08 tons of air dry wood per ha per annum).

The moisture content in freshly cut wood of *Eucalyptus* is round 80% and it weighs about 850 to 900 kg per m^3 green. It will lose half of its moisture by air drying for 8 weeks in an average dry season which lowers its weight and leaves the wood a good fuel. This has the additional advantage of ease of transporting the lighter material.

SOCIAL ASPECTS OF *EUCALYPTUS* PLANTING

Pakistan is basically an agricultural country. About 20 million ha (25% of total land area) consists of 4 million individual farms averaging 4.7 ha in size. Farmers prefer to grow multipurpose trees that give fuelwood, fodder, fruits and do not adversely affect agricultural production. The following is a common dialogue which occurs between the farmer and the forest officer during the motivation for planting trees:

Qes. Why shall I plant trees with agriculture crop when it would damage the crop and reduce the yield? The trees send their root system in competition with agriculture crop, cast their shade on the young crops and house birds to attack the crops at grain stage.

Ans. Nobody is asking you to raise trees in competition with agriculture crops. Trees shall be raised on such lands which generally are not fit for raising agri-crops. They can also be raised around agriculture fields, and with agri-crop if it is compatible with the agriculture crop. If properly spaced and planted in appropriate directions, the trees will not damage agriculture crops. Not all birds damage crops, many birds which eat some grain also eat a lot of insect larvae. The Chinese had to import a lot of insecticide after the complete elimination of spar-rows. If birds or trees become too numerous some can be harvested for the farmer's benefit.

Choice of species. This is great interest to and by farmers. Eucalypts has been accepted by the farmers mainly because of its phreatophytic qualities and fast growth. Although efforts are on record for encouraging indigenous species by the field staff, the glamour of *Eucalyptus* seems to caught the public. The trend in favour of *Eucalyptus* has been gradual from 1985 to 1990 as can be seen in the following Figure 6.

Figure 6. Yearwise % of plants planted by farmers

Species	1985	1986	1987	1988	1990
Acacia nilotica	24	26	20	10	3
Acacia modesta	20	10	7	5	2
E. camaldulensis	50	60	70	82	93
Melia azadarach	1	-	-	1	-
Hybrid poplar	2	1	1	1	1
Fruit trees	1	1	1	-	-
other species	2	2	1	1	1

Source: Chaudry, 1989

Eucalyptus has been accepted by almost all farmers for farmland planting. NGOs, such as Agha Khan Rural Support Programme (AKRSP) and Pakistan Foundation of Environmental Conservation (PFEC), do not advocate any particular kind of tree, but do advocate increasing the number of trees. The only apprehension of the farmers who have raised *Eucalyptus* in large number on their fields is that there is no proper marketing system that pays back to them: the money invested with reasonable profit. Hopefully the industries will soon start purchasing eucalypt wood as raw material for pulp, paper, plywood and safety match boxes. In fact, two industries have come forth with encouraging results (Appendix 4 & 5).

ECOLOGICAL ASPECTS

Allelopathy. Malik (1993) studied the allelopathic effect of three *Eucalyptus* species on the growth of french bean (*Phaseolus vulgaris*) and sweet pea (*Pisum sativum*). It was found that leaf leachate of *Eucalyptus* had no significant allelopathic effect on all the growth parameters of french beans. However, the growth of sweet pea was significantly reduced due to allelopathy. The maximum effect was decayed leaves of *E. citriodora* followed by *E. camaldulensis* and *E. tereticornis* (Figure 7).

Khattak (198l) also observed differences in yield in wheat crops grown between rows of *Dalbergia sissoo, Eucalyptus citriodora, Populus deltoides* and *Salmalia malbaricum*. Wheat yield was higher with *Dalbergia sissoo* than other three species (Figure 8).

Figure 7. Allelopathic effect

Growth parameters	Control		*E.camaldulensis*		*E. citriodora*		*E.tereticornis*	
	Peas	Bean	Peas	Bean	Peas	Bean	Peas	Bean
No. of pods	4.74	11.5	2.19	4.5	2.13	6.4	2.41	11.3
Weight of pods (g/plant)	15.58	47.11	6.24	15.46	5.30	38.20	7.54	51.1
Biomass (g/plant)	16.13	266.0	6.07	150.5	4.8	204.8	6.7	248.0
Shoot biomass (g/Plant)	16.12	257.3	6.36	145.9	4.6	195.7	6.4	241.0
Shoot length (cm)	39.62	40.47	26.38	33.35	31.78	36.51	31.96	42.2
Root Biomass (g/Plant)	0.47	8.18	0.34	4.61	0.23	6.05	1.44	7.0
Root length (cm)	9.8	17.0	8.1	11.8	9.1	16.3	9.7	13.1
No. of leaves/plant	52.0	94.0	30.0	73.0	23.0	75.0	32.0	74.0
No. of branches	19.0	50.0	14.0	37.0	10.0	34.0	14.0	35.0
No.of nodules	0.6	2.4	0.08	2.9	0.02	2.7	0.2	2.6
Survival %	86.4	100.0	83.5	90.0	89.3	95.0	82.4	93.0
Seed Germination %	80.0	100.0	86.0	100.0	86.0	83.0	80.0	93.0

Figure 8. Effect of some tree species on crop yield

Species Grain Yield (kg/ha)	1979	1980
Shisham	2,762	1,991
Semul	2,609	1,802
Eucalyptus	2,563	1,590
Poplar	1,700	1,532

Water stress. Saturation deficit and water stress in dry and wet season was studied for three species (Repp *et al*., 1967). The result is shown in Figure 9.

Figure 9. Water stress

Species	Dry Season		Wet Season	
	Saturation deficit (%)	Water stress (%)	Saturation deficit (%)	Water stress (%)
Olea ferrugenia	25.9	37	29.7	42.0
E. tereticornis	25.5	40	42.8	68.0
Pinus roxburghii	l4.l	-	5.4	-

In comparing *Olea* with *Eucalyptus*, the saturation deficit of the later is higher than that of *Olea* during the dry and the rainy season. Since *Eucalyptus* has a lower dehydration tolerance too, it is percentally under greater water stress than *Olea*. However, as the water stress of the *Eucalyptus* does not yet reach the critical point (63-65%), it may be said *Eucalyptus* can still stand ecological stress conditions without actual damage.

EUCALYPT PESTS AND DISEASES

Eucalyptus plants are highly susceptible to termites in the first two years after planting. The Forest Entomologist, Pakistan Forest Institute, recommends use of Heptachlor, Chloradane and Dieldrin, 5 cc per plant in 1/2 gallon of water at the time of planting, mixing the insecticide in the soil.

The following important diseases of eucalypts have been detected in Pakistan. Names of the causal agents and control measures are also given in Figure 10.

Figure 10. Disease of *Eucalyptus* spp. and their control

Leaf spot	(*Alternaria alternata*)
Control:	Spraying with Zerlate at the rate of 2.lbs./100 gallon of water/acre.
Leaf spot	(*Cercospora eucalypti*)
Control:	Spraying with Formate at the rate of 2.lbs./100 gallons of water/acre.

Root Disease	(*Ganoderma lucidum*)
Control:	Sanitation, mixed cropping with semal, Paper mulberry and *Ailanthus.*
Gummosis	Exudation of gum from the stem caused by injuries.
Control:	Injuries be avoided.

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APPENDIX 1

Some national facts of forestry of Pakistan

1	Total Land Area	87.98 million ha
2	Population (total) Population (Rural) Population (Urban)	114 million 81 million (71%) 33 million (29%)
3	Population Growth Rate	3.1 %/year
4	Forest Area (Controlled by Forest Dept)	4.26m. ha (4.8%)
5	Range Area (Controlled by Forest Dept)	6.41m. ha (7.2%)
6	Watershed Area	35.192m. ha
7	Annual Import of Pulp & Paper	$ 100 million
8	Fuelwood consumption (@ 0.2 m^3 per capita)	22.8 mill.m^3
9	Timber consumption (@ 0.024 m^3 per capita)	2.7 mill.m^3
10	State owned Forest Area	60%
11	Private owned Forest Area	40%

12	Irrigated Plantations Area	2,26,000 ha
13	Timber protection from state forest	0.492 mil m^3 (18%)
14	Timber protection from Farmland	1.117 mil m^3 (41%)
15	Timber Imported	1.118 mil m^3 (41%)
16	Firewood production from state forest	2.28 mil m^3 (10%)
17	Firewood production from Farmland	20.54 mil m^3 (90%)

APPENDIX 2

EUCALYPTUS SPECIES IN PAKISTAN

Species	**Locality**	**Comments**
E. algeriansis	West Kundian (arid)	Not thrifty
E. astoingens	Wide spread (sub humid)	Mostly thrifty
E. bicostata	Ghora Gali	Fair growth
E. bigalerita	Miani (arid)	Fair
E. botryoides	Miani (arid)	Poor
E. brockwayi	Peshawar (semi arid)	Not thrifty
E. camaldulensis	Wide spread	Vigorous and thrifty
E. citriodora	Wide spread	Vigorous and thrifty. Some frost damage.
E. cladocalyx	Koha Lassan, Miani, (arid)	Not good form not fully thrifty
Peshawar. (semi arid)	Moderate	
E. olelandi	-do-	
E. confertifolia	Miani(arid)	Not healthy
E. crebra	Chichawatni (arid)	Thrifty
E. decepta	Changa Manga Main Road	Fair, dead wood in the crown
E. diversicolor	Peshawar (semi arid)	Fair
E. dundasi	Peshawar (semi arid)	Not thrifty
E. erythronema	Ismat Park, Jauharabad (arid)	Fair
E. falcata	West Kundian (arid, semi arid)	Poor
E. gomphocephala	Peshawar, Miani (arid)	Fair
E. grandis	Daphar, Miani (arid) and	Fair
Peshawar (semi arid)	Fair	
E. hemiphloia	Changa Manga (Prob.= *E. microcarpa*) Miani, Q'land	Good
E. longicornis	Peshawar (semi arid)	Poor
E. maculata	Miani (arid)	Good, rather slow
E. melanophloia	Common	Thrifty
E. melliodora	Daphar, (arid) Ghora Gali (sub humid)	Slow, fair,
E. microcorys	Miani (arid)	Poor, not thrifty
E. microtheca	Common (arid)	Very thrifty
E. occidentalis	Miani, Peshawar (semi arid)	Moderate
E. oleosa	Peshawar, (semi arid)	Not thrifty, poor
E. platyphylla	Miani (arid)	Poor
E. polyanthemes	Landi Kotal (Hill Semi arid)	Thrifty, moderate growth
E. polycarpa	Miani. (arid)	Fair, slow
E. populifolia	Miani (mixed with (arid) *E. hemiphloia*)	Good
E. salmonophloia	Peshawar (semi arid) W. Kundian (arid)	Poor
E. slaubris	Peshawar (semi arid) Miani (arid)	Moderate growth, thrifty
E. siderophloia	Miani (arid)	Poor

E. sideroxylon	Koha Lassan, Peshawar (semi arid)	Good, thrifty
E. stricklandii	W. Kundian (arid), Peshawar (semi arid)	Moderate, not thrifty
E. tereticornis	Common	Excellent, vigorous, thrifty
E. tesselaris	Miani (arid)	Not vigorous
E. torquata	Kohala Lassan, Miani (arid)	Moderate, reasonably thrifty

Note Mean annual rainfall Arid= less than 200 mm
Semi arid= 200-500 mm
Subhumid= 500-1000 mm
Humid = more than 1000 mm

APPENDIX 3

SOCIAL FORESTRY PROJECTS

Social forestry activities, in one form or another, began in Punjab in 1950 to promote tree plantations in the private sector when the “Celebration of tree planting week” started twice a year, i.e. in spring and monsoon seasons. Saplings were distributed to land owners, and other Government Departments and Agencies. It continued year after year until it was realized that to make it more meaningful and instrumental, infrastructure was needed for organizing and monitoring this programme. Accordingly, a nucleus organization was created under a development scheme in 1975-74 called “Promotion of Tree Plantation in the Punjab”. Its main object was to organize the hitherto sporadic tree planting campaigns on a scientific basis and also to provide technical guidance to the private land owners. This project continued till 1983-84 when a larger, and better conceived scheme called “Farm Forestry Pilot Project” was inducted in six selected districts, i.e. Bahawalpur, Bhakhar, Multan, Jhang, Jhelum and Mianwali. Forest nurseries were raised all over the Punjab Province and seedlings distributed to the farmers. As the aims and objectives of these two schemes were identical, therefore, these were amalgamated into a larger project and redesignated as “Farm/Promotion of tree plantation in the Punjab”.

Satisfied with the performance of these two projects and because of an unprecedented response of the people, particularly the farming community, the Punjab Government decided to launch still another scheme titled “Social Forestry in the Punjab” over the period 1985-86 to 1987-88. It aimed at establishing and maintaining woodlots and compact plantations in private farm lands in addition to raising nurseries. It was followed by yet another project “Afforestation of marginal private lands in irrigated tracts of the Punjab” for a period of four years. In order to provide polythene plants to the farmers another project the “Raising of plants for saline and marginal private farmlands in irrigated tracts of the Punjab” was approved with effect from 1986-87 for a period of three years.

Social forestry received a great impetus when the Punjab Chief Minister decided to institute a series of prizes at Provincial, Divisional and District levels for the tree growers. It envisages engendering a competitive spirit in various groups of population for undertaking afforestation on their private lands on self-help basis. The Prizes to be awarded on the basis of evaluation include Suzuki Car, sponsorship for Haj/Umra, free trips to New York and South Asia besides cash prizes at Divisional and District levels. Other incentives such as subsidized tree cultivation in private lands, essay, poetry and slogan competitions played a key role in invoking a love for trees in this Province.

An ambitious Social Forestry Project is currently under way in Pakistan, i.e. Forestry Planning and Development Project. It is a joint effort of the Government of Pakistan’s Ministry of Food, Agriculture and Cooperatives and the USAID. It is being implemented in four Provinces of the country and the over all aim is to expand tree planting and production of fuelwood, fodder and timber on privately owned farmlands in the country. The specific objectives of the projects are:

- To develop long term plans to increase the contribution of forest resources to National development;
- To design, evaluate, and implement effective forestry development projects;
- To develop and execute a programme of research for improving farm forestry systems that produce fuelwood, fodder and timber while enhancing agricultural productivity;
- To establish a professional training programme in farm forestry techniques; and
- To establish a field programme to demonstrate the viability of farm forestry systems.

APPENDIX 4

PRELIMINARY REPORT *E. CAMALDULENSIS* PULP AND PAPER MAKING TRIAL

Gerald G. Wire, Pulp and Paper consultant

Adamjee Paper and Board Mills carried out trial production of pulp and paper from *Eucalyptus camaldulensis* at its Nowshera, Pakistan mill 8-9 January 1991. About 35 tons of round wood was purchased from six tree farmers. This was shipped to the mill in truck loads of 125 to 250 mounds from districts of 50 km to over 135 km. The wood supply was supplemented from Adamjee plantings adjacent the mill. The wood was hand debarked and chipped with a KMW chipper. Chips wet bulk was 400 kg/cm; moist was 46%.

The pulp was made by soda processing in the mill's rotary batch digester. Satisfactory bleachable pulp was made from the first batch. It was CEH bleached to 76% brightness and was of satisfactory strength, cleanliness, and other characteristics. Production was without any extra ordinary events such as excessive screening, foam, washer difficulties, etc.

Writing paper was made on the fourdrinier paper machine from 50 % lickin (cotton) pulp plus normal additives as standard furnish, without prior shutdown or wash up. The change over caused an immediate break at the wet end, probably from light weight, however, upon wet end adjustments, paper went through the machine satisfactorily. Within about ten minutes it was on the reel. About 10 tons of paper were made, running at normal speed for the grade/weight. The paper produced was deemed at specification, mullin was 110% to 130% of specification.

Extensive evaluation of this trial is under way from both technical, manufacturing and commercial standpoints. A more substantial report will be available in the near future. However, Adamjee has indicted that the results are sufficiently satisfactory and commercially promising to continue and accelerate purchase of *Eucalyptus* as an added resource for pulp and paper manufacture.

We realize that Adamjee has certain unique circumstances and that aspects of this trial and processing may not be suitable to other Pakistan mills. Neither do we believe this to represent the best for optimum *Eucalyptus* pulp production. Still, these were good methods, and provide evidence of viability for the acquisition, shipping, handling and processing of this wood, within the existing mill facilities, and production of satisfactory product.

APPENDIX 5

EUCALYPTUS CHIPBOARD

Pakistan Chipboard (Pvt) Ltd., Jhelum, uses 100% Mango (*Mangifera indica*) wood as raw material for its Chipboard. A mill scale test to make chipboard from *Eucalyptus* wood was conducted in the mill on 17 December 1991 in the presence of a number of farmers and project staff including a group of ten farmers from Skardu in the Northern area, who have planted trees under the Agha Khan Rural Support Programme. The initial results are very encouraging, for the same amount of raw material the output of chipboard is expected to be 10% more, where as the consumption of bonding agents etc. may be up to 5% less than for Mango wood (approximate values). The raw board weight, board density and the raw material moisture content of the chipboard produced, was found to be within the range that is generally accepted in Pakistan.

Final laboratory analyses is in hand, however the experience of the mill staff is positive. They indicated that *Eucalyptus* chipboard is lighter in color and has smoother surface finish, and the process produces less dust and gives a cleaner smell during the process of manufacturing the board. The mill management indicated its willingness to purchase *Eucalyptus* wood of 2.5 inches to 10 inches diameter for approximately the same price that it pays for mango wood.

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[3]: Another favoured plantation species is 'babul' or 'kikar' (*Acacia nilotica*), plantation of which started in 1891.