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PROJECT DESIGN AND RECOMMENDATIONS

for

REFORESTATION AND WATERSHED MANAGEMENT PROJECT IN SRI LANKA

Submitted to:

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Colombo, Sri Lanka

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July 1979

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WATERSHED REFORESTATION AND FUELWOOD DEVELOPMENT DESIGN FOR SRI LANKA

Contract No. AID/ASIA-C-1400
July 1979

Submitted to:

UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Colombo, Sri Lanka

Submitted by:

THE INTERNATIONAL SCIENCE AND TECHNOLOGY INSTITUTE, INC.
Washington, D.C.

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TABLE OF CONTENTS

I. Executive Summary and Recommendations 1

II. Project Background and Objectives 4

III. Technical Discussion 7

A. THE UPPER MAHAWELI REFORESTATION PROGRAM 7

1) Site Selection and Soils 7

2) Nursery Operations 8

3) Reforestation Species 11

4) Program Alternatives and Expected Rates of Return 12

5) National Agricultural Diversification and Settlement Authority (NADSA) 15

6) Program Costs 16

B. FUELWOOD DEVELOPMENT PROGRAM 16

1) Site Selection and Soils 18

2) Nursery Operations 19

3) Fuelwood Species 20

4) Plantation Alternatives and Rates of Return 21

5) Charcoal 23

6) Costs for Fuelwood Plantation 24

C. FOREST EXTENSION SERVICE 26

D. RESEARCH AND TRAINING 31

E. ENVIRONMENTAL IMPACTS OF THE PROGRAMS 37

F. BIBLIOGRAPHY 40

IV. Economic Analyses Summary 44

TABLE OF CONTENTS

ANNEXES

A. PERSPECTIVE ON DEFORESTATION IN SRI LANKA A-1

B. INSTITUTIONAL CONSIDERATIONS A-12

C. GENERAL ASSUMPTIONS AND MEASURES A-16

D. FUELWOOD PROJECT ANALYSIS A-23

* The GSL Proposal: Alternative 1 A-23

* Alternatives 2, 3, 4, and 5 A-25

* Return on Investment A-27

* The Charcoal Option A-28

* Project Costs and Benefits A-32

* Internal Economic Return A-33

E. REFORESTATION PROJECT ANALYSIS A-72

* The GSL Proposal: Alternative 1 A-72

* Alternatives 2 and 3 A-73

* Project Cost and Benefits A-73

* Internal Economic Return A-76

* Return on Investment A-76

F. ANALYSIS OF PROTECTIVE VALUE OF A WATERSHED A-99

G. MISCELLANEOUS DOCUMENTS AND ATTACHMENTS A-119

I. Executive Summary and Recommendations

Loss of forest resource has become a prime concern to Sri Lanka. This report describes two pilot programs designed to counter the downward trends in forest vegetation presently occuring on the island. One project consists of revegetating 15,000 acres in the Upper Catchment of the Mahaweli River while the other proposes the development of fuelwood plantations on 70,000 acres in the Sri Lankan Dry Zone. All demonstration areas were selected to avoid conflicting land-uses for agricultural production. An associated charcoal production demonstration, a forest extension service and various research programs are described.

Species of fast growing trees are incorporated into the planting designs. The economics of each program alternative has been analyzed from a conservative viewpoint to understate the benefits. Significantly increased production values can be expected if the programs are properly implemented, integrated and managed.

These associated projects should be considered as the minimum efforts necessary to illustrate some techniques available for soil and water conservation and proper forest maintenance. It is hoped that these demonstrations will act as catalyst for greatly expanded forest emphasis by USAID, the World Bank or other donors. Forests should represent an integral and invaluable asset to economic development in Sri Lanka.

The recommendations are to:

** Implement the proposed pilot projects to reforest 15,000 acres in the Upper Mahaweli Catchment, and to establish 70,000 acres in fuelwood plantations.

** Initiate a national reforestation program responsive to the need of the country.

** Strengthen the Forest Department to administer a national reforestation program with increased funding, training programs to improve technical capabilities, and organizational changes to enhance management.

** Conduct a new aerial survey to determine the remaining forest cover and future planting areas for reforestation.

** Establish a Forest Extension Service to promote community forestry and home fuelwood production.

** Commence a publicity program to advise the general public of the benefits derived from forests, and the utility of the simple home made stove to conserve fuelwood.

** Appoint a representative from the Forest Department as a member of the Mahaweli Development Board.

** Conduct a charcoal demonstration project in conjunction with one of the fuelwood plantations to test production techniques and market potential.

** Continue and expand the analysis of the protective value of a watershed to provide confirmation of the preliminary findings.

** Encourage the active involvement of the private sector in helping to meet national policy objectives of reforestation.

** Supply the Forest Department with small motorcycles to strengthen the ability to apprehend illicit felling for commercial purposes.

** Evaluate the economic and environmental impact of proposed forest removal by the Accelerated Mahaweli Development.

** Establish a review committee of USAID, Government of Sri Lanka and outside individuals to review the status and success of project implementation.

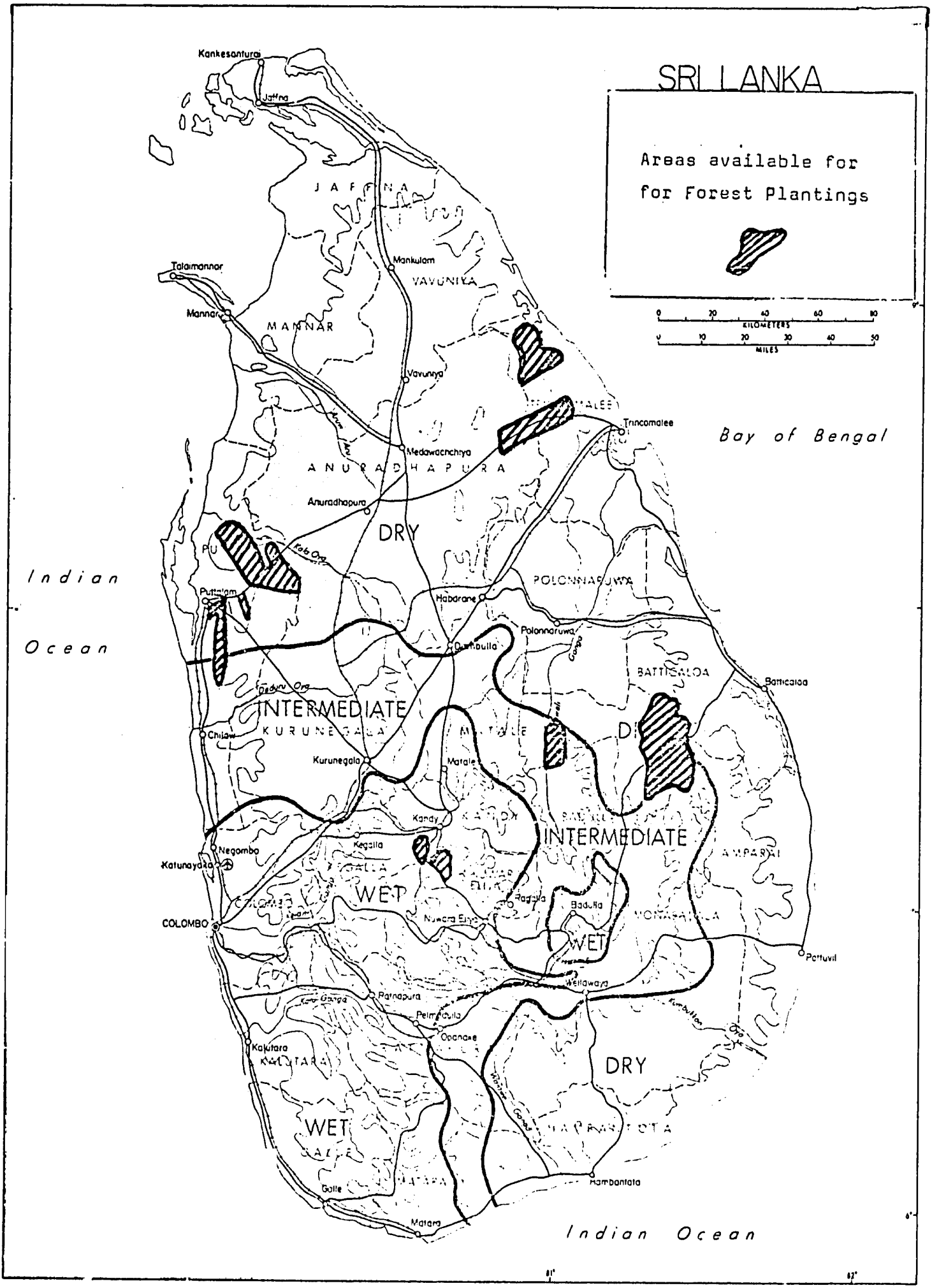
** Encourage other donors to assist in the goal of combating deforestation in Sri Lanka.

** Initiate research activities to improve the utilization of native tree species of Sri Lanka.

** Provide a non-govrenmental project management capability to assist in the co-ordination and implementations of reforestation activities funded by USAID.

** Alternative 3 of the reforestation program and Alternative 4 of the fuelwood program should be implemented. These two alternatives represent the most economically and environmentally sound management options of the alternatives analyzed.

** The reforestation/fuelwood development programs should be implemented in an integrated manner to realize the composite benefit of the management designs. This will avoid any adverse affects on the tree resource base itself as a result of commodity production and extraction.


SRI LANKA
Areas available for
for Forest Plantings
KILOMETERS
MILES
Kankesanturai
Jaffna
JAFFNA
Mankulam
VAVUNIYA
Talaimannar
Mannar
MANNAR
Vavuniya
Trincomalee
Bay of Bengal
Medawachchiya
ANURADHAPURA
Anuradhapura
DRY
Indian
Ocean
Puttalam
POLONNARUWA
Habarane
Polonnaruwa
Dambulla
BATTICALOA
Batticaloa
INTERMEDIATE
KURUNEGALA
Chilaw
Kurunegala
Matale
Kandy
INTERMEDIATE
Negombo
Katunayaka
Kegalla
WET
Ratnapura
Badulla
COLOMBO
WET
Pottuvil
Wellawaya
Ratnapura
Pelmadulla
Opanake
Kalutara
DRY
WET
Hambantota
Galle
Matara
Indian Ocean

II. Projects Background and Objectives

The impacts of deforestation are at first subtle and unperceived. The negative consequences are not realized until certain indicators appear. Siltation of rivers and tanks, shortages of wood products, or increases in energy costs are but the most obvious results of deterioration in the forest resource base. Long term modification of local climate, reduction of soil productivity, loss of economically important species and a variety of moderating environmental benefits are the less realized results of wholesale forest removal.

Sri Lanka is approaching a turning point with regard to its forests. The demonstation programs developed in this report are directed towards two primary consequences of deforestation in this nation - watershed degradation and reduction in fuelwood energy. It is hoped that these programs will serve as catalysts for expanded emphasis in forest development in the near future.

This report has been prepared from a technical perspective with accompanying economic analysis. The annexes to the report refer to specific economic elements of the various reforestation and fuelwood programs. The expected rates of return are summarized in the technical discussions.

The Government of Sri Lanka has recently re-emphasized the crucial importance of forests to the economic and environmental welfare of the nation. Annex G-1 is a summary of the Government of Sri Lanka's position. The accelerating of the Mahaweli Development schemes have brought forest conditions into more direct observation. Sri Lanka's forest events of the past 30 years can be summarized as follows. At the time of independence, approximately 50% of the island was covered in forest vegetation.

By 1956, when the first modern surveys were completed, 44% of Sri Lanka was forested. In the intervening twenty years, this figure has been reduced by 50% leaving today between 20 and 22% of the land surface in forest cover, the majority of which occurs in the dry zone. The rate of deforestation has been estimated at between 100,000 and 190,000 acres annually (See Annex A-1). During the same time period the efforts at reforestation have revegetated approximately 10,000 - 20,000 acres annually. This produces a deficit ratio ranging from 5 to 10: 1. Analysis indicated that in another 30 years there could be <u>no</u> forest cover in Sri Lanka.

The rate of deforestation does not include the estimates for forest removal as part of the Mahaweli system. In the next five years somewhere between 400,000 and 750,000 acres of existing forest will be removed to meet the objectives of the Mahaweli program. This represents up to 18% of the remaining forest resources of the nation. The consequences of such wholesale forest removal have not been addressed but cannot be considered entirely positive.

It is generally accepted that forests play a vital role in moderating the effects of climate and reducing the impacts of atmospheric pollution. Forests help in amileirating the effects of rain and wind, in checking soil erosion and controlling the water regime of the soil. However, a major problem in trying to evaluate the economic benefits of forests is to quantity in economic terms their protective role. This contrasts sharply with productive role which is generally analyzed in terms of timber or commercial values. The shortcomings of course is that it overlooks the protective role and may bias a decision in favor of exploitation, or tend to place a low priority on forest cover relative to other investments or development projects.

The protective role of forest cover is of undeniable importance in the Upper Mahaweli Catchment area where rainfall is high and the terrain generally steep. This report has placed qunatifiable values on the protective as well as the productive role of forests. This is expressed in terms of soil and water values for the protective role, and timber values for the productive role. (See Annex F).

The USAID demonstration program consists of watershed reforestation in two degraded locations in the Upper Mahaweli Catchment are totalling 15,000 acres and development of fuelwood plantations on approximately 70,000 acres in the dry zone. The demonstrations should be considered the absolute minimum necessary to illustrate various forest restoration techniques.

The need for a massive reforestation program is undenizble; the facts are compelling. A framework for a possible program responsive to the perceived needs of the country might include, at a minimum, the following:

(a) Cessation of any further reduction of forest cover to conserve the remaining 4.1 million acres of forest land.

(b) Reforestation of 100,000 acres of the 1.34 million acre Upper Mahaweli Catchment to partially replace the 114,000 acres lost since 1956.

(c) Reforestation of at least 400,000 acres or more for commercial timbering.

(d) Establishment of 250,000 acres in regenerative fuelwood plantations to supply urban, commercial and some rural fuelwood demand amounting to 100 million cubic feet per year.

(e) Establishment of a system of a village wood lots, hedgrows, etc., amounting to 400,000 acres to supply the rural demand for fuelwood.

If such a full scale program were implemented it could arrest the present trend of deforestation which appears to be nearing a crisis point. This would produce a forest cover of 5.3 acres. Translated into total area this means an increase of forested land from 20% to 33% of the nation.

The locations have been selected based on various criteria not the least of which was lack of competing land use. The sites are presently in various degraded conditions. In one location, the process of extreme soil depletion and desertification, has begun. Publicity programs and a forestry extension service will be required to expand the impact of these demonstrations. Increased revenues and a sustained committement to preservation of forest resources will be required if the benefits of these two demonstrations are to be widely appreciated. Expected benefits and results from these two pilot programs will include: soil erosion control, production of fiber for pulp, fuelwood, a charcoal conversion pilot, restored productivity to degraded sits and commodity timbers. Such benefits could be expanded elsewhere in the island through the influence of the Forest Extension Services.

Co-ordination between private industries, Government agencies, foreign donors and local people will be required. However, the most crucial element of success for these programs will be the committment of individuals to concentrate on positive solutions to this natural resource problem. Properly implemented, forest programs could become an intergral and invaluable link in the economic development on Sri Lanka.

III. TECHNICAL DISCUSSION

A. Upper Mahaweli Catchment Reforestation Program

1. Site Selection and Soils

The total acreage fo the Upper Mahaweli Catchment is approximately 1.3 million acres of which only 8% remains in forest cover. This amount is far from adequate to meet the minimum needs of soil conservation, fuelwood, water catchment and commidity timber. This USAID proposed program is designed to expand on the work begun by GSL.

In this demonstration of watershed conservation, the project sits cover an area approximately 15,000 acres. These locations will be reforested over a five year period. Two catchments were selected, Hatton and Dolosbage. (See Map 1). Each catchment shows high erosion potential, depletion of original forest cover or reduction of productive land. Elevations range from 3000 - 4000 feet. These acreages should represent a minimum goal for reforestation in these watersheds as substantially more land may be potentially available. Selection of additional planting areas must await the results of new aerial photography and the land use survey presently being conducted by the Government of Sri Lanka.

The soils in the Hatton and Dolosbage catchments are deep, well drained, reddish to yellowish, moderately fine textured and acid in character. The important properties related to forest use and management include:

* medium to very strong acidity
* compacted subsoil
* low base saturation
* low water availability
* low fertility
* variable erosion potential

For detailed soil description of each site See Table 1. A comparison of the Dry and Wet zone soils as shown in Table 2.

The total areas of patna will be identified with the use of LANDSAT imagery using digitized maps as the final product. From these maps the sites would be identified by the Forest Deparment that have been planted to trees leaving the remaining acreage as that available for planting.

The severly eroded lands includes primarily cropland that has lost its surface soil and a portion of its subsoil through sheet erosion and/or gully erosion. For the most part these lands with any significant contiguous acreage are the "degraded" tea lands. Such areas could readily be identified by a skilled photo interpreter using suitable aerial photos and incorporated into later reforestation.

2. Nusery Operations

Seedling production nurseries will need to be centered at Ginigathena and Rambukpitiya. At present, nurseries in adjoining areas can produce seedlings for planting 700 - 1000 acres per year. At this production level 3-4 nuseries should be sufficient. Annual production capacity of 3 to 3 1/2 million seedlings is necessary to meet the goals of reforesting 3000 acres annually. These sits have been located in easy access to the project catchment areas thus avoiding unnecessary transportation problems

With the exception of teak, all reforestation is presently accomplished utilizing tube containers. The plastic tubes 9" long are produced locally but can be manufactured to any dimension required. Generally, seedling survival increases with container length. Seedling Containers 10-15 inches in length would be ideal.

Containers with interior corrugations to prevent improper root developments are not yet used in Sri Lanka. The application of such containers system should be tested. The production of long verticle roots is often a major factor in the increased rate of seedling establishment. Bare root seedlings are not recommended in Sri Lanka due to increased handling difficulties. Because of post planting maintenance requirements, direct seedling of selected species is not a viable option. Forest Department Representatives believe competition from other species and the tendency of Sri Lankans to care for seedlings, require the use of containerized stock.

Table 1

SOILS INFORMATION FOR THE FUELWOOD AND UPPER MAHAWELI CATCHMENT PROGRAMS

Fuelwood Project Sites	Climate Temperature/ Precipitation	Physiography	Soils	Taxononic Class	Significant Soil Properties & Management	Fertilizer recommendations N-P-K
1. Lake Mundal (Puttalam Area)	45-50 June-Aug. very dry 81°F	gently rolling plains	Reddish-Brown Earths Non Calcic Brown Soils Low Humic Gley Soils	Rhodustalfs Haplustalfs Tropaqualfs	• Mod. Slow Infiltration • low available soil moisture • firm subsoils	Legumes: 0-20-5 0-20-5 + Dolomite (on non-calcic brown soils)
2. Puttalam Area	- do -	- do -	Reddish Brown Earths Low Humic Gley Soils	Rhodustalfs	• low fertility • gravelly subsoils	Non-legumes: 10-20-5 10-20-5 + dolomite (non-calcic brown-soils)
3. Trincomalee Area	55-60" June-Aug. very dry 81°F	- do -	- do -	Rhodustalfs Tropaqualfs	- do -	- do -
4. West of Batticaloa		- do -	Reddish-Brown Earths Non Calcic Brown Soils Immature Brown Looms Low Humic Gley Soils	Rhodustalfs Haplustalfs Dystropepts Tropaqualfs	- do -	- do -
5. System C	65-75" June-July very dry 81°F	Undulat[illegible] rolling hills	Reddish-Brown Earths Low Humic Gley Soils	Rhodustalfs Tropaqualfs	- do -	- do -
Upper Mahaweli Reforestation Sites						
1. Dolosbage Area	100-125" 70°F	Steep mountain terrain	Red-Yellow Podzolic soils	Rhodudults	• low pH (4.5-5.6) •• firm subsoils • low fertility	Legumes: 0-20-3 + Ca, Mg, and Boron Non-legumes 15-20-3 + Ca, Mg, and Boron
2. Hatton (Mt. Jean & Mt. Sebastian) Areas	125-150" 70°F	- do -	- do -	Rhodudults	• high erosion potential if exposed	- do -

Table 2

A COMPARISON OF DRY ZONE AND WET ZONE SITE CHARACTERISTICS

Site Location	Elevation Range	Precip. Average Annual (Inches)	Slope Characteristics	SOIL CHARACTERISTICS				
				Effective Depth	Moisture Stress	Soil Reaction	Fertilizer Required	Infiltration
Dry Zone	$<$200'	50 - 75	Flat to gently rolling plain, undissected, 0-8% slopes	Variable (20 - 60") based on depth to gravel layers or firm subsoil	2 - 4 months common	Medium Acid to Natural (pH 5.6 - 6.0) to neutral (pH 6.6 - 7.3)	Nitrogen and Phosphorous	Moderate to Medium Slow (may be limiting)
Wet Zone	3300 - 4000'	125-150	Steep to very steep mountainous lands 40 - 80% slopes	Usually deep to very deep ($>$ 36")	Usually $<$1 month	Very strongly Acid (pH 4.5 - 5.0) to medium Acid (pH 5.6 - 6.0)	Nitrogen and Phosphorous with some need for Calcium, (1) magnesium and occasionally the need for Molybdenum and Boron	Moderate (Usually not limiting)

NOTE: (1) This group of soils, Red-Yellow Podzolic, belong to the Order of Ultisols in the Taxonomic classification. This order is characterized by an appreciable amount of silicate clay but few bases. Removal of bases from this soil by leaching is an important consideration. Most of the bases are held in the vegetation and in the upper few centimeters of the soil. Base saturation in most Ultisols decreases with depth because the vegetation has cycled the bases.

Nursery practices are presently adequate to undertake the increased seedling production required for this project. It would be advisable to include approximately 1/4 humus material into the potting mixture. This will produce a more fertile growing medium and potentially better root development.

Efficiency of planting and post planting maintenance are essential if the rate of reforestation is to be successfully achieved. According to the Forest Department, the planter process presently requires up to 1/2 hour per seedling. Each planter carries approximately one dozen seedlings to a planting site. Some improvements in this system are required to meet even the minimum goals set for this demonstration. Small hand held power augers will substantially increase hole drilling efficiency. An illustration is shown in Annex G-2. Maintenance would be similar to a small chain saw motor. In even rock soils, a driller and five planters could plant nearly 1000 seedlings per hour utilizinf such tools. Tree bags worn around the waist will substantially increase each planters prese t carrying capacity. This will reduce the number of trips back to the nusery for seedlings. All nusery operations, maintenance and equipment costs for this reforestation effort are shown in Table 4.

3. Reforestation Species

The reforestation program proposed by the Government of Sri Lanka (GSL) considers the utilization of three tree species: Pinus, Eucalyptus and Albizia. The seasons for selections include relatively rapid growth, availability of seed material and past experience. Pertinent information on the various tree species is shown in Table 3. Pinus caribeae will be planted on the most degraded sites in the project area. Fire is a constant hazard until the young trees overtop the patna grasses. If possible, the use of Eucalyptus should be minimized. Considerable information now exists which illustrates that the oils contained within the leaves and bark interfere with the growth and reproduction of other plants. In zones of constant rainfall this characterisitc does not constitute a problem. However, the lands needing reforestation in the Upper Mahaweli Catchment are largely of a steep, non-plantation or degraded plantation character where extensive post-planting management will be limited. Additionally, Eucalyptus is susceptible to fire. Under these conditions the use of Eucalyptus could produce long term problems.

Albizia falcataria is presently grown on a small scale in the catchment area. It has been grown for fuelwood and construction material by the tea industry. The use of this species should be expanded on the appropriate sites in the project area. Albizia grows relatively fast, the roots fix nitrogen, the stumps will regenerate when cut (coppicing). The foliage will contribute to the build-up of humas. The wood can be used for fuel or for paper pulp.

Certain colonizing or succesional species are also suggested for incorporation into this reforestation project. The United States National Academy of Science has just completed an extensive global survey of such trees, many of which are grown in Sri Lanka. Most succesional species are intolerant of their own shade but create suitable micro-environments for regeneration of other species. They have been largely ignored by traditional forestry owing to the fact that few are prime timber species. For harsh site reforestation, however, such as in the Upper Catchment, they are ideally suited.

Calliandra is one leguminous species which could be utilized in this program. It is now growing on a minor scale in Sri Lanka. Elsewhere in Southwest Asia however, it has become a major source of fuelwood. Adequate supplies of selected seed material will be essential to establish the program. Once planted the reforestation areas can serve as seed sources for future expansion into other watershed areas. Calliandra can be grown on very short rotations, sometimes, as short as 18 months. Dense wood, coppicing from stumps and nitrogen fixation are other important attributes of this small tree. Additionally, the plant has been effectively used as a firebreak in Indonesia and could help to reduce fire induced losses inthe pine plantations.

Leucaena (ipil ipil) is another fast growing species which has attracted considerable attention in Sri Lanka. Unfortunately this tree will not perform well in the Upper Catchment areas. The elevations are either above the environmental tolerance or the soils are too acid for proper growth. Leucaena has utility in other parts of the island and is discussed under the fuelwood program.

4. Program Alternatives and Expected Rates of Return

Alternative 1

As originally proposed, the Government of Sri Lanka (GSL) would reforest principally with Pinus, Eucaplyptus and small amounts of Albizia. A total of 3,000 acres per year

Table 3

WATERSHED, REFORESTATION AND FUELWOOD PLANTATION SPECIES

Proposed Species	Elevation Limitations	Yield* In Tons/ Acre/Year	Rotation	B.T.U
Eucalyptus SPP	Under 5000'	4-5	10	NA
Pinus caribaea	Above 3000'	2-6	25	NA
Albyzia falcataria	Under 5000'	5-10	10-15	4250
(a) Alternative Selections				
Leucaena leucocephala (Ipil Ipil)	Under 3000'	9-12	5-7	6900 (wood) 1200 (Chrcl)
Calliandra callothyrsus	Under 5000'	1-5 10-18	1.5mos. 3yrs.	7800
Acacia mangium	Under 5000'	5-13	10yrs.	NA.
Acalia auricaliformis	Under 3000'	5-6	10yrs.	8800
Albyzia lebbek	Under 3000'	6-10	10yrs	8800
Sesbania grandiflora	Under 5000'	6-8	5yrs	5100

(a) Information sup
National Academ
Washington, D.C

* Assumes 45.15 $ft.^3$ = 1 Ton
Variation in yield dependent of specific site conditions.
All values represent minimum recorded yields.

is the planting goal. Under this alternative pines would be tapped for turpentine after the 12th year and harvested for pulp in the 25th year. Eucaplyptus and Albizia would be harvested between 10 and 15 years and used for fuel-wood or building materials. Given the anticipated yields the economic rate of return is calculated to range from 12 to 19%. Detailed analysis is given in Table E-11.

The GSL has determined that at least 50% of the Project areas are too degraded for anything other than pine. Alternatives 2 and 3, therefore, consider a yearly planting of 1500 acres each of pines.

Alternative 2

For reasons of reduced growth rates, lower biomass yields and soil depletion qualities, Eucalyptus would be replaced by Albizia on the remaining 1500 acres. The planting density would be increased from 8 feet on center to 6 feet. This will produce a denser stand of trees in less time. Significant increased in leaf litter and supression of the weedy grasses can be expected. The wood can be harvested in the 10th to 12 th year for fuel or pulp and the stumps will sprout. The expected economic rate of return has been calculated up to 25% depending on harvesting techniques. Detailed analysis is given in Table E-11.

Alternative 3

The alternative consists of utilizing Albizia as the canopy species and interplanting Calliandra as an understory. In this plan, the biomass yields are substantially increased as Calliadra wood can be harvested strating in the third season. In some situations, Albizia is susceptible to wind damage. Interplanting a small tree species will produce a more structurally sound plantation. A mixture of species is also more desirable as the potential exists for various positive synergistic influences affecting the growth performance of each other. The economic rate of return for this optimum has been calculated up to 30%. Detailed analysis is given in Table E-11.

Regardless of which reforestation alternative is finally implemented, the out plated saplings will require some initial fertilizer treatment. Except for the pine plantations, it is suggested that dolomite be added to each tree to provide the necessary calcium and magnesim. This will be of particular benefit to the broadleaft and and leguminous species. All species should respond well

to an N, P and K mixture. (0-20-3 + Ca+mg and boron for legumes, 15-20-3+ca+mg+boron for non-legumes).

Prior to conversion into tea or patna the forests in the Upper Catchment contained numerous species. Unfortunately, like native species from other environments, these trees tend to be slow growers, with limited reproduction and are generally intolerant of severe disturbances. In the Upper Catchment area species such as Terminalia, Michelia, and Careya were once common and in demand for various uses. If Alternative 2 or 3 is implemented the potential exists to begin restoration of some of these other important timber species. This will require a portion of the nuseries be devoted to propagation of such trees for later planting, perhaps after the third or fifth year.

The fast growing tree legumes will help produce favorable soil, light and micro environmental conditions for these less tolerant species. As these pioneer trees are short lived and cannot reporduce in their own shade, the more long lived hardwood species could replace the successional forest area once the watershed had been stabilized. Selectively removing the fuel or pulpwood could still be accomplished in this multi-purpose management approach.

Should this extended watershed reforestation approach be implemented, both short and long term economic and environmental benefits will result. Enrichment planting could serve as a model for the future. No economic evaluation of the costs for implementing this expanded design have been determined.

5. NADSA

The National Agricultural Diversification and Settlement Authority (NADSA) is a pilot demonstration program funded by the World Bank. NADSA is responsible for the restoration of diversified agriculture on abandoned tea lands in various locations in the Upper Mahaweli Catchment Area. The permanent settlement of 25,000 landless families on approximately 30,000 acres is the goal of NADSA. Expansion into other catchment areas has been discussed.

The first NADSA forest garden demonstration was begun in early 1979 near Peradeniya. The staff consists of three professionals training some 16 students who will expand the demonstration to other locations. The area presently under NADSA's implementation consists of rocky, bare or generally degraded tea lands. NADSA has estimated that approximately 14,000 acres will not be appropriate for crop diversification and would best be restored to a forest cover. Such forest cover would compliment the goals of this proposed re-forestation program. These lands have yet to be released to the Forest Deparment.

At the present time the degarded tea lands are planned for development under the NADSA program. However, it is felt that those lands in the severely "eroded" condition do not rank as good candidates for the development of diversified crops. The reason for this is the degree of erosion that has already occured. These sites have a significant lower potential for economic production. Many of the crops in the diversification program are quite demanding in their nutrient requirements. The problem is that positive responses to fertilizer and in some cases timing could be very low and perhaps ineffective. This is due to past loss as surface soil and organic matter. This is important as it concerns the cation exchange capacity (CEC). The low CEC affects the efficientcy of fertilizers plus decreases the affective soil-wate- relationship. These lands described as severely eroded would justfiably be best planted to forest species. The slight to moderate eroded lands could be utilized in the NADSA programs.

In this regard NADSA, the Forest Department and the proposed USAID demonstration program should be inter-related. A multi-purpose reforestation program will be a forest counter-part to the goals of NADA's diversified agriculture. On site co-ordination and dialogue with NADSA will be an essential.

The results of a national land use survey will not be completed until 1980. It has been suggested that 25-35% of the Upper Catchment area shold potentially be restored to a forest cover as compared to the present 8%. If such goals are to be realized the inner action between NADSA and the Forest Department must begin with these two demonstrations.

6. Program Costs

A summary of project costs for Alternative 3 are given in Table 4. They are scheduled over a five year period with a residual to cover the expenses thru the project life cycle.

The costs are based on the cost catalogues and figures presented in the GSL proposal with changes noted in Annex E. When appropriate the figures were increased by one third to cover the costs of reforesting 15,000 acres instead of 10,000 acres and an allowance was included to cover fertilizer as well as harvesting expenses.

B. Fuelwood Program

Over 94% of the people in Sri Lanka use wood for fuel. The present rate of deforestation and the demand for fuel wood accetuates the need to accommodate the supply with the demand. As part of the increased emphasis on the value of

Table 4

Watershed Reforestation Project

Summary Schedule of Costs for Alternatives 2 & 3

(Rs: Million)

Cost Elements	YEARS 1	2	3	4	5	6 - 30
Investment Costs -						
1. Equipment	3.9	4.7	3.1	3.8	0.3	
2. Office & Quarters	0.2	-				
3. Forestry College Buildings	1.0	-				
4. Surveys	0.07	-				
5. Nurseries	0.3	0.5	0.5	0.5	0.7	
6. Reforestation	-	1.7	3.3	3.3	4.2	
Sub-Total	5.5	6.9	6.9	7.6	5.2	
Operating Costs -						
1. Salaries & Travel	0.5	0.6	0.6	0.7	0.8	20.0
2. Stationery & Supplies	0.01	0.01	0.01	0.02	0.02	0.5
3. Fuel & Lubricants	0.1	0.1	0.1	0.1	0.1	2.5
4. Maintenance & Vehicles	0.02	0.06	0.06	0.07	0.08	2.0
5. Maintenance of Buildings	-	0.01	0.02	0.02	0.02	0.5
6. Maintenance of Plantations	-	-	0.1	0.2	0.3	19.5
7. Fertilizer	0.8	0.8	0.8	0.8	0.8	
8. Forest College Expenses	0.01	0.02	0.02	0.03	0.03	0.8
Sub-Total	1.5	1.6	1.8	2.0	2.1	45.8
Harvesting Costs	-	-	-	-	-	39.7 [a]
Supplemental Items -						
1. Training Awards	0.4	0.7	0.6	0.3	-	
2. Advisors	0.8	0.7	-	-	-	
3. Contingency	0.4	0.5	0.3	0.3	0.3	
Sub-Total	1.6	1.9	0.9	0.6	0.03	
TOTAL	8.6	10.4	9.6	10.2	7.3	85.5

NOTES: (a) Harvesting costs for alternative 3 are Rs: 41.6 and include Rs: 0.2 million in years 4 and 5.

forests, this proposed reforestation program will assist in the development of fuelwood plantations.

Extensive forest areas in the Sri Lankan Dry Zone have been reduced by slash and burn agriculture (chena) to an unproductive condition. Increased population pressure has reduced the normal time between fallow periods from 25 years to in some cases less than 10. This has created situations where soil fertility is restored to a fully productive condition. Chena cultivation of remaining forested land, including some previously reforested areas will continue to be a basic and most serious problem to any reforestation scheme.

The fuelwood program described below should represent a minimum effort in fuelwood planting. Involvement of the local villagers and resettled people will be discussed under the Forest Extension Service. Without the involvement of local people in the implementation of a national fuelwood program success may be greatly reduced.

1. Site Selection and Soils

Four areas have been selected for fuelwood plantations. Lack of land use conflicts and the proximity to the Mahaweli resettlement program were prime criteria for site suitability. The project locations are shown on Map 1 in the reforestation section. These areas include:

	Approximate Acreage
Puttalam Area	40,000 Acres
Trincomalee Area	40,000 Acres
Batticaloa Area	20,000 Acres
Mahaweli System C	10,000 acres (Potential)

Within these demonstration areas and elsewhere in the Mahaweli region there exist far in excess of 100,000 acres of similarity degrades lands. Such areas could be included in the fuelwood reforestation program as success is demonstrated.

Puttalam is the sriest of the four plantation areas and has the most severely smal.. damaged soils. The process of desertification has begun with xerophytic plants and weedy species now dominating a once forested landscape. In other locations grasses have invaded and totally cover the land. Natural tree regeneration is impossible under such conditions and areas of natural forest occur only as remanent patches in all the sites.

The soils at all sites except Mahaweli System C, have the the following characteristics:

* moderately slow infilteration rate
* low water availability for plant growth
* gravel layers in sub-soil
* low fertility

Complete soils analysis is shown in Table 1.
Erosion is not considered a serious problem at any of these sites owing to the virtually flat nature of the terrain. Moisture stress problems will occur due to the inherent soil structure. This will be pratically pronounced during months of May thru September.

The soils in System C vary somewhat from those of the other three sites owing to this area being located within the intermeidate zone. They are well to imperfectly drained, moderately fire textured with gravelly materials occuring on the tops of the rolling hills. Moisture stress may occur from June to August. Availability of lands in System C is pending planning decisions between the Forest Department and the Mahaweli Development Board. Comments regarding proposed forest development and soils suitability in this system are summarized in Annex G-3.

2. Nursery Operations

The project will require the construction of the seedling nuseries in five or six locations neat the planting areas.

Appropriate locations include Andigama, Mile 17 (Puttalam/ Anuradhapura Road); Pankulam, Debarawewa; Pulaveli; and Mahiyangana. Transportation access and availability of water were important considerations in selection of these locations.

At a minimum it is proposed that 7,000 acres be planted annually. The planting density of 1000-1200 plants to the acre will require that the nuseries produce upwards of 10 million seedlings a year. The level of production should be attainable utilizing existing nusery techniques. Nusery practices will be the same for all seedling production in the dry zone. Polyethelene tube containers used in the Upper Catchment reforestation will be used in the fuelwood program. If available, tubes of 10-15 inches in len-th should produce increased establishment success. Improved planting techniques and tools discussed under the Upper Catchment Reforestation are also appropriate to the fuel-wood program to increase planting efficiency.

3. Fuelwood Species

Leguminous tree species which have rapid growth and relatively dense wood have been selected for the fuelwood plantation. Among the potential attributes of such species include:

* Rapid growth
* Ability to supress weed competition
* Adaptability to a wide range of sites and soils
* Ability to coppice when completely harvested
* Palatable forage
* Nitrogen enrichment of soily by root nodules
* Copius seed production
* Inability to reprododuce under their own shade

The list of potential species is shown in Table 3 in the reforestation section. With the acception of the two Acacia species, the trees listed are presently grown in Sri Lanka but not in plantation culture. Their adaptability to intensive culture has been employed elsewhere in South East Asia.

All production values have been expressed in the minimum expected yields. Incorporated of proper planting and management could produce wood yields far in excess of those expressed.

Lucaena has been very successfully grown in portions of the Dry Zone. (The Puttalam area may be too dry for the proper cultivation of this species.) Six month old planting tests of selected cultivars have surpassed the expectations of the Forest Department. Some trees are already between 20 and 30 feet tall. It is also significant that nitrogen enrichment of the soil is visibly evident by a comparison of the planted and unplanted plots.

All species or combinations for this plantation program have been chosen to maximize wood production and to restore acceptable levels of soil fertility.

4. Plantation Alternatives and Rates of Return

Five plantation alternative are described for the fuelwood program. One alternative may be more appropriate to one site while another will be proper eleswhere. Management of the Puttalam plantations will require more effort as they are the driest of the program areas. Peletized fertlizer may be required.

Alternative 1

This alternative is proposed by the Government of Sri Lanka. Eucalyptus was suggested as the plantation species. Yearly production of four tons per acres on a 10 year rotation were expected. The Forest Department has commented t-at reduced performance has often occured due to variation in seed material. The expected rates of return from this plantation is 7.13%. Complete economic analysis is given in Annex D.

Alternative 2

In this alternative, one species of tree legume would be planted inthe fuelwood plantations. Possible candidate species include: Acacia auriculformis, Acacia mangium, Albizia lebbek or Sesbania grandiflora. On a 10 year rotation cultivated yields of 5-10 tons to the acre are expected. The rate of return from this plantation would be 7.74%.

Alternative 3

This alternative proposes the use of one species grown on a ten year rotation and another species interplanted on a five year rotation. Either Leucaena or Sesbania would be suitable as the five year rotation species. Sesbania is presently cultivated in Sri Lanaka as a minor food and fodder crop. Yields of 10 tons/acre or greater are expected. Seed supplies remain a primary limiting factor to expanded utilization of these or any of the other species.

This plan includes the additional benefit of producing a denser plantation. The closer an artificial plantation mimics natural forest conditions the less likelihood of adverse complications affecting performance. The expected rate of return is 18.76%.

Alternative 4

This plan utilizes two species, one of which is grown on a five year rotation and the second on a three year one. Calliandra is the suggested expected. In this plantation a dense stand of shrubs and trees would be produced. A complete covering of the landscape is possible. The taller species would not be so dense as to hinder the growth of the shorter Calliandra. The expected rate of return is 27.69%.

Alternative 5

This alternative is a variation of alternatives 1 and 2 utilizing one species, such as Leucaena, grown on a five year rotation. Yields ranging from 9 to 12 tons to the acre can be expected. It should be noted that yields exceeding 25 tons to the acre have been recorded in the Philippines and Mexico.

The yields expressed should therefore be considered conservative estimates. The rate of return for this alternative is calculated at 20.57%.

Regardless of which alternative is implemented, some fertilizer amendment will be required. All the soils in the plantation areas are deficient in nitrogen and phosphorus. This is exaggerated by low moisture availability for proper plant growth. A NPK fertilizer (0-20-5+ CA+Ma for legumes, 10-20-5+Ca+Mg for non-Legumes) is recommended to enhance plant development with emphasis on total root development.

The addition of phosphorus is particularly necessary to encourage root nodule formation on the leguminous species. If the leguminous trees are incorporated into the plantation programs, increases in soil nitrogen and organic matter can be expected from the constant leaf litter fall. Leaves of these species deteriorate rapidly during moist periods and can improve degraded soils.

The ability of the plantation sites to sustain wood production should not be overlooked. The continual cropping of trees for fuelwood could have negative impacts on soil structure, fertility and productivity, if the regenerative capacity is not maintained. This will be particularly true if Eucalyptus is used in monoculture plantations. As this species can deplete soil fertility, a multi-species approach is encouraged.

The fuelwood plantations could also serve the purpose of reforestation for future timber needs. The ability of the leguminous trees to out-compete weedy grasses and produce moderate environmental conditions (shade, increased soil nutrients and reduced temperature) could be highly advantageous for enrichment planting of native hardwoods. Such enrichment plantings were ateempted in the 1920's with high success, but were replaced by plantation cultivation in subsequent years. By the time the fuelwood has been completely harvested, the hardwood species would be well established. Such a planting program could begin in the third or fith year. A listing of selected species from the wet and dry zones are given in Annex G-4.

5. Charcoal

Charcoal represents an extremely viable option for certain sectors of the Sri Lanka economy. Tea drying, brick production, tobacco, steel, ceramics and various small industries presently utilize fuelwood or have begun conversion to oil. If charcoal were available such industries would utilize this resource.

Charcoal has approximately twice the heating (BTU) value of wood. While it is realized that the majority of home users will continue to use fuelwood for their domestic needs, conversion of fuelwood plantation trees into charcoal could help reduce the impact of deforestation on remaining natural forests.

A demonstration of charcoal production techniques has been included as part of the fuel plantation program.

The fuelwood plantations are capable of producing a surplus of several hundred thousand tons of fuelwood. This could be converted into charcoal to supply an estimated market demand for 140,000 tons of charcoal. The approximate market value of the charcoal Rs. 130 million and includes a profit potential in excess of 30%.

A charcoal market has some interesting implications for conserving forest cover, creating employment and conserving as well as earning foreign exchange. For instance just 15,705 acres are needed to produce wood to supply a charcoal market whereas it would take 21,330 acres to supply the same market with fuelwood. This represents a possible saving of forest cover of 5,625 acres per year.

The tea estates use fuel oil as well as fuelwood for tea drying. The JEDB estates indicate a current demand for as much as 8.7 million gallons of fuel oil at Rs. 5.35 per gallon. The unsubsidized price is Rs. 9.75 per gallon. This works out to a total economic cots of fuel oil of Rs. 169.6 million or US$ 10.6 million. The situation may be similar for other industries as well as the urban sector which uses kerosene as a substitute for fuelwood for cooking. The point is that a charcoal industry has the potential of freeing Sri Lanka from the need to import a certain amount of increasing expensive petroleum, and so represents the potential for a considerable saving in foreign exchange. Additionally, charcoal can be sold on the international market. The prevailing price is Rs. 1,600/-per ton FOB Colombo or US$ 100 per ton. This represents the potential for earning a substantial amount of foreign exchange.

6. COSTS FOR FUELWOOD PLANTATION

A summary of project costs for alternative 4 are given in Table 5. They are scheduled over a five year period with a residual to cover the expenses thru the project life cycle.

The costs are based on the cost catalogues and figures presented in the GSL proposal with changes noted in Annex D. Where appropriate the figures were increased to cover the costs of more densely planting the selected species, and an allowance was included to cover fertilizer as well as harvesting expenses.

A listing of supplemented items is also shown in the cost summary. It represents a package of items which are recommended as important for the success of the project, and are discussed in the appropriate sections of the text. The cost figures are best estimates of the probable cost of the item

Table 5

Fuelwood Project

Summary Schedule of Costs for Alternatives 3 and 4

(Rs: Million)

Cost Elements	YEARS 1	2	3	4	5	6 - 20	
Capital Costs (a) -							
1. Machinery	3.5						
2. Buildings	4.8	.11	.11	.11	.11	.11	(d)
3. Extra Equipment	.08						
Recurrent Costs -							
1. Salaries (a)	.95	.95	.95	.95	.95	4.8	(d)
2. Operating Costs (b)	9.2	9.2	9.2	9.2	9.2	46.0	(d)
Maintenance Costs (a)	-	1.02	1.98	1.98	1.98	9.9	(d)
Harvesting Costs (c)						32.8	(e)
Sub-Total	18.53	11.244	12.210	12.210	12.210	93.6	(f)
Supplemental Items -							
1. Project Management	3.75	3.75	3.75	3.75	3.75		
2. Forest Extension Service	3.4						
3. Charcoal Pilot Demonstration	1.5	3.0					
4. Seeds/Fertilizer	1.5	1.2	1.2	1.1	1.1		
5. Training Program	3.5	3.5	1.6	1.6	1.0		
6. Motor Bikes	.3						
7. Land Use Survey	.8	.3					
8. Communication Tools	.4	.23					
9. Tree Research Program	4.1	3.0	2.25	2.25	2.25		
Sub-Total	19.25	14.98	8.80	8.70	8.70		
TOTAL	37.78	26.22	21.01	20.91	20.91	93.6	

NOTES: (a) Costs as taken from GSL Proposal

(b) Including incremental costs for alternative 3 & 4: See Table D-7

(c) Costs as shown in Table O-2 for alternative 3 with Rs: 1.2 million/year for years 6-10 and Rs: 2.7 million/year for years 11-20.

(d) For just years 6-10.

(e) Harvest costs for alternative 4 are Rs: 33.8 with Rs: 9/year for years 4 & 5, and Rs: 2.1/year for years 6 to 20.

(f) Sub-Total is Rs: 94.0 million for alternative 4, or just Rs: 0.4 million more than alternative 3.

C. The Forest Extension Service

The importance of an overall fuelwood program to the Mahaweli Development Scheme should not be underestimated. As presently proposed, between 400,000 and 750,000 acres of forested land will be cleared under the Accelarated Mahaweli Development. This represents 18% of the remaining forest cover in Sri Lanka. The fuelwood plantation cannot be expected to entirely fill the total needs of wood for the settlers. In this regard a Forest Extension Service is considered an essential part of the fuelwood/reforestation demonstration. The incorporation of community forestry will have just as significant an impact on supplying wood and combating deforestation as charcoal production will help industries avoid expensive conversion to imported petroleum.

Agricultural extension information has been successfully applied elsewhere in Sri Lanka. A sample of an extension design is given in the accompanying figure. The adaption of extension activities

to forest species or agro-forest is relatively new, however. Traditionally forestry has considered forest products (pulp or lumber) as the primary benefits and ignored many "social" qualities of trees. The Extension Service could rectify this imbalance.

The proper design and incorporation of a forest extension program will be essential to the success of the proposed fuelwood program. This extension service will not only help to transmit tree management information (types, uses, cultivation practices) but also supply the seeds or seedlings to local farming communities and villagers.

SUGGESTED ORGANIZATION CHART FOR AN INTENSIVE FOREST EXTENSION SERVICE

```
FOREST DEPARTMENT - (POLICY)
        |
        |----------SUBJECT MATTER SPECIALIST/TECHNICIAN
        |
DISTRICT EXTENSION OFFICE -(MANAGER)
        |
        |----------SUBJECT MATTER SPECIALIST/TECHNICIAN
        |
FOREST EXTENSION OFFICERS - (IMPLEMENTATION)
        |                   (Covers 5000 people in area)
        |
VILLAGE EXTENSION WORKERS - (IMPLEMENTATION)
                            (Covers 700-1000 individuals)
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Source: Benor & Harrision (]977)
Agricultural Research & Training Institute (ARTI) Colombo.

Nursery production practices in Sri Lanka and the nurseries planned for the fuelwood plantations could be utilized by the extension service. In this manner tree planting for community or home fuel consumption could be accomplished. Properly selected species (such as Leucaena, Sesbania or Calliandra) could supply necessary home fuelwood requirements. Additionally, forest extension agents could provide chena cultivators with seed materials to interplant with their crops thus potentially reducing some of the negative soils effects of slash and burn cultivation. By the end of the growing season, these legumes will have begun to develop a canopy.

If the forest extension workers are successful in introducing tree crops to the chena cultivators, the need to clear natural forest may be significantly reduced. Potentially, previously disturbed sites closer to homes and villages could be restored to reasonable productivity in less time than thru natural regeneration.

Any forest extension effort will require a variety of effective publicity or communication tools. 85% of Sri Lanka's population is literate and the newspapers are widely read. A recent ad placed by the Water Resources Board regarding ipil-ipil (Leucaena) resulted in over 10,000 requests for seed (See Annex G-5). Publicity tools such as tapes, posters, slide shows, brochures as well as technical information should all be part of these communication programs. Proper integration of this extension program into the agricultural planning for the Mahaweli seems obvious to avoid duplication of effort.

Success of the Forest Extension Service in this fuelwood program could be expanded to other areas of Sri Lanka as necessary. Information regarding the use and benefits of charcoal could be included, where appropriate.

D. Research and Training

The Forest Department is understaffed to handle all of its present and to be expanded responsibilities. Personnel training and upgrading research will be required to accomplish the various goals of the reforestation/fuelwood program.

In some instances, training and research can take a traditional perspective such as silviculture, forest ecology, soil conservation and plantation management techniques. However, the rate of forest deterioration will require new emphasis in applying scientific information.

The training requires can be divided into three categories: (1) short term (3-6 months) for refresher information, (2) four year academic and (3) one year traineeship for non-professional (forest guards). Non-professional training can be received at the Forest School at China Bay near Trincomalee. In the other instances, training would be given outside Sri Lanka. Emphasis on tropical forest biology is essential. A list of potential candidate schools and institutions

for both short and long term training programs is given in Annex G-6.

The District Forest Officer (DFO) is directly responsible for transfering technical information into field implementation and these individuals should be prime candidates for the 3-4 months short training. It is anticipated that half the training appointments will be short term in duration. Particularly, valuable will be the interaction between natural resource managers in other tropical areas such as Cost Rica, Hawaii, or the Philippines. New information can thus be transmitted and implemented in a more rapid manner. A collection of books and publications on recent advances in tropical biology should be added to the Forest College and Research Station at Peradeniya. Significant new applied research on tropical trees has been conducted in the past five years. This material would be beneficial for the implementation of the reforestation and fuelwood programs.

Research is critically needed into plant selection, propogation, improved establishment tech-

niques and improving rates of growth. Long term research priorities should therefore include:

* improvement of seed dormancy breaking techniques;
* improvement of seed cleaning and storage capabilities;
* selection and propogation of faster growing genotypes of selected species;
* application of plant tissue culture to important species where other forms of propogation are ineffective or special selections are required;
* application of computer storage of forest information and inventories to help planning and future planting or harvesting;
* methods of sustaining soil productivity under the influence of increased utilization or chena;
* integrated pest management and general entomology;
* increasing nursery production efficiency

Most of the native tree species of Sri Lanka require 60-150 years to reach maturity. Due to this characteristic, virtually all selection and development of the indegenious trees stopped over 30 years ago.

With the vast changes in plant biology in the past 10-15 years many of these species could be brought into productive use with proper management and research. Much of the tree flora of Sri Lanka is endemic. The consequences of deforestation could be the complete removal of the genetic resource base. This has indeed almost come to pass with Calemander, a valuable furniture hardwood. Only two guarded trees are specifically known and serve as seed stock for what little propogation has been attempted.

Another native Sri Lanka tree, Trema orientalis, should be investigated for future benefit. It occurs in both the wet and dry zones and is often one of the first colonizers of disturbances. Its wood is reported to be quite hard and the BTU value (5575) approaches Leucaena. This could potentially produce good charcoal. However, virtually nothing is known about its biology.

In conjunction with these efforts in forest biology, studies in soil planning and management should be increased.

Soils, hydrology and soil conservation should form the basis of any watershed program because of their inter-related nature.

The 'Benchmark' Soils Program developed by the University of Hawaii would be particularly valuable for soils trainees from Sri Lanka.

This program as one of its main functions is concerned with the collection and distribution of information regarding the response of soils to specific land use and management programs. The soils are identified at a designated level using the U.S. Scheme Soil Classification (7th Approximation). This program allows the distribution of established information on identical or similar soils wherever they occur throughout the world. This can avoid duplication in research that has been done or is in the process on similar sites in other countries. The one requirement is that the soils are keyed to the taxonomic classification schemes.

The information available through this program will include:

- The suitability of species to management practices, fertilizer responses, cover crop requirements and harvesting methods.

- Ability to determine watershed conditions as reflected in around water recharge, stream flows and changes in runoff and erosion.

- The impact of new planted tree cover on soil infilteration and permeability.

Additional areas for soil research should include:

* plant/soil/water relations
* long term effects of short cycle harvesting
* impact of fire on soil water repellency
* long term impact of pine planting on base saturation in soils
* total nitrogen gained by utilizing tree legumes for reforestation.

E.

Environmental Impacts of the Program:

The watershed reforestation and fuelwood plantation programs are designed to counter the negative consequences of deforestation. With this direction, the environmental impacts of the two projects should be entirely positive. As determined in this report, the rate of deforestation in Sri Lanka is presently proceeding at 5 to 10 times the rate of reforestation. The combined effect of the two projects will replant approximately 100,000 acres of presently degraded lands.

In the Upper Mahaweli Catchment reforestation areas, soils will be stabilized and returned to a higher productive condition, runoff intensity and the likelihood of landslides will be reduced. Potentially, local temperatures and wind velocities will be moderated by the new forest cover.

In the fuelwood growing areas, the soils will be improved by the nitrogen fixing root nodules of the leguminous trees. The leaf litter

will increase the humus content of the soils. This will increase the water infiltration rate and improve the present deficiencies in organic matter. Wind, dust and temperatures will all be ameliorated in the reforested areas. Additionally, habitat for wildlife and birds will potentially be increased if the replanted areas produce a natural appearing forest cover.

The Forest Extension Service will provide seedlings to villagers, local schools and farmers. This will extend the impact of the reforestation programs directly to the people who use the fuelwood for cooking. Reduction of dust and temperatures around homes and villages will have positive influence on the surroundings and living conditions of these rural people. No negative impacts to human health are known to occur from planting trees.

One negative impact could develop if the reforestation/fuelwood programs are not implemented in an integrated manner. Should harvesting of timber for charcoal be implemented without the

extensive replanting of trees, then the consequence could be an increased rate of deforestation on Sri Lanka. Utilization of one form of wood resource requires the careful maintenance of the resource base itself.

F.

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IV. ECONOMIC ANALYSES SUMMARY

Introduction:

Sri Lanka has approximately 4.1 million acres under forest cover. This cover is being rapidly removed at an estimated rate of 145,000 acres per year. If this trend continues there will be no forest cover remaining in approximately 28 years.

The GSL is proposing to increase its reforestation program. The plan is to reforest 15,000 acres of the Upper Mahaweli catchment in 5 years, and to establish 70,000 acres in fuelwood plantations in 10 years time. The purpose is to conserve the watershed which is vital to the Mahaweli irrigation project, and to provide fuelwood for the settlers who will farm the Mahaweli Development Area.

These pilot projects are intended to pave the way for a national program to reforest 100,000 acres in the upper Mahaweli catchment, and to establish 250,000 acres in fuelwood plantations. Additionally these projects will demonstrate the potential for a major conversion to charcoal to supply the energy needs of the tea plantations and to supplant fuelwood in the urban sector as the fuel for cooking. And these projects will foster the development of a forestry extension service to systematically promote the establishment of village fuelwood plots amounting to 400,000 acres.

Purpose:

The purpose of this report is an analysis of the economic viability of the projects proposed by the GSL. Each project will be analysed separately in general accordance with the guidlines suggested by the World Bank and the U.S. Agency for International Development. An internal economic return will be developed to assess the economic justification for each project.

Costs and Benefits:

The costs for the proposed projects amount to Rs. 353 million over the entirethe entire life cycle of the projects. Approximately 50% of the project funds are to be expended in the first five years. The cost per acre is Rs. 3,150/- for the fuelwood project and Rs.8,773/- for the reforestation project. The combined cost per acre is Rs. 4,142/-. A summary of the costs is given in figure 1 below and a schedule of expenditures by category for the first five years are shown in Tables 1-3.

Figure I
Reforestation & Fuelwood Project
Cost Summary

Project	Land area (000a)	COST			
		Total (Rs.Mln)	Per Acre (Rs)	Years 1-5 (Rs.Mln)	As %
Fuelwood Alternative 3 & 44	70	220.5	3150	126.9	58
Reforestation Alternative 2 & 3	15	131.6	8773	46.1	35
Total	85	352.1	4142	173.0	49

The benefits for the fuelwood project are based on the commercial wholesale value of firewood. Firewood will be given free to settlers; the surplus firewood could be sold to the tea plantations or urban sector The proceeds from the cash sale of firewood is sufficient to cover the entirety of the fuelwood project costs.

he benefits for the reforestation project have been calculated for the productive as well as protective role of forest cover. The productive benefits are based on the commercial value of timeber; the protective beenfits are based on the quantifiable values of a watershed. It is important to recognize that this will be one of the first instances that the value of a watershed has been quantified for inclusion in an

Table 1

Fuelwood & Reforestation Project

Cost Summary Schedule

(Rs.Million)

Cost Elements	Year 1	Year 2	Year 3	Year 4	Year 5	Others
Fuelwood Project (Alternatives 3 & 4)						
Capital	8.4	.11	.11	.11	.11	.11
Recurrent	10.3	10.3	10.3	10.3	10.3	50.8
Maintenance	-	1.02	1.98	1.98	1.98	1.98
Harvesting	-	-	-	-	-	32.8
Supplemental	19.25	14.98	8.80	8.70	8.70	-
Sub-Total	37.78	26.22	21.01	20.91	20.91	93.6
Reforestation Project (Alternatives 2 & 3)						
Investment	5.5	6.9	6.9	7.6	5.2	-
Operating	1.5	1.6	1.8	2.0	2.1	45.8
Harvesting	-	-	-	-	-	39.7 (a)
Supplemental	1.6	1.9	0.9	0.6	0.03	-
Sub-Total	8.6	10.4	9.6	10.2	7.3	85.5
TOTAL	46.4	36.6	30.6	31.1	28.2	179.1

NOTE: (a) Harvesting Costs for Alternative 3 are Rs: 41.6 and includes Rs: 0.2 million in years 4 and 5.

Table 2

Reforestation Project

Summary Schedule of Costs for Alternatives 2 & 3

(Rs: Million)

Cost Elements	YEARS 1	2	3	4	5	6 - 30
Investment Costs -						
1. Equipment	3.9	4.7	3.1	3.8	0.3	
2. Office & Quarters	0.2	-				
3. Forestry College Buildings	1.0	-				
4. Surveys	0.07	-				
5. Nurseries	0.3	0.5	0.5	0.5	0.7	
6. Reforestation	-	1.7	3.3	3.3	4.2	
Sub-Total	5.5	6.9	6.9	7.6	5.2	
Operating Costs -						
1. Salaries & Travel	0.5	0.6	0.6	0.7	0.8	20.0
2. Stationery & Supplies	0.01	0.01	0.01	0.02	0.02	0.5
3. Fuel & Lubricants	0.1	0.1	0.1	0.1	0.1	2.5
4. Maintenance & Vehicles	0.02	0.06	0.06	0.07	0.08	2.0
5. Maintenance of Buildings	-	0.01	0.02	0.02	0.02	0.5
6. Maintenance of Plantations	-	-	0.1	0.2	0.3	19.5
7. Fertilizer	0.8	0.8	0.8	0.8	0.8	
8. Forest College Expenses	0.01	0.02	0.02	0.03	0.03	0.8
Sub-Total	1.5	1.6	1.8	2.0	2.1	45.8
Harvesting Costs	-	-	-	-	-	39.7 (a)
Supplemental Items -						
1. Training Awards	0.4	0.7	0.6	0.3	-	
2. Advisors	0.8	0.7	-	-	-	
3. Contingency	0.4	0.5	0.3	0.3	0.3	
Sub-Total	1.6	1.9	0.9	0.6	0.03	
TOTAL	8.6	10.4	9.6	10.2	7.3	85.5

NOTES: (a) Harvesting costs for alternative 3 are Rs: 41.6 and include Rs: 0.2 million in years 4 and 5.

Table 3

Fuelwood Project

Summary Schedule of Costs for Alternatives 3 and 4

(Rs: Million)

Cost Elements	YEARS 1	2	3	4	5	6 - 20	
Capital Costs (a) -							
1. Machinery	3.5						
2. Buildings	4.8	.11	.11	.11	.11	.11	(d)
3. Extra Equipment	.08						
Recurrent Costs -							
1. Salaries (a)	.95	.95	.95	.95	.95	4.8	(d)
2. Operating Costs (b)	9.2	9.2	9.2	9.2	9.2	46.0	(d)
Maintenance Costs (a)	-	1.02	1.98	1.98	1.98	9.9	(d)
Harvesting Costs (c)						32.8	(e)
Sub-Total	18.53	11.244	12.210	12.210	12.210	93.6	(f)
Supplemental Items -							
1. Project Management	3.75	3.75	3.75	3.75	3.75		
2. Forest Extension Service	3.4						
3. Charcoal Pilot Demonstration	1.5	3.0					
4. Seeds/Fertilizer	1.5	1.2	1.2	1.1	1.1		
5. Training Program	3.5	3.5	1.6	1.6	1.0		
6. Motor Bikes	.3						
7. Land Use Survey	.8	.3					
8. Communication Tools	.4	.23					
9. Tree Research Program	4.1	3.0	2.25	2.25	2.25		
Sub-Total	19.25	14.98	8.80	8.70	8.70		
TOTAL	37.78	26.22	21.01	20.91	20.91	93.6	

NOTES: (a) Costs as taken from GSL Proposal

(b) Including incremental costs for alternative 3 & 4: See Table D-7

(c) Costs as shown in Table O-2 for alternative 3 with Rs: 1.2 million/year for years 6-10 and Rs: 2.7 million/year for years 11-20.

(d) For just years 6-10.

(e) Harvest costs for alternative 4 are Rs: 33.8 with Rs: 9/year for years 4 & 5, and Rs: 2.1/year for years 6 to 20.

(f) Sub-Total is Rs: 94.0 million for alternative 4, or just Rs: 0.4 million more than alternative 3.

Table 4

Fuelwood Project

Internal Economic Return (IER)

(Per Cent)

	Cash Basis	Accrual Basis
Alternative 1a	7.13	15.66
Alternative 1b	10.30	23.12
Alternative 1c	8.04	17.46
Alternative 1d	11.38	26.24
Alternative 2	7.74	20.07
Alternative 3	18.76	46.33
Alternative 4	27.69	62.51
Alternative 5	20.57	33.20

NOTES:

The rates of return are understated in that :

- all costs include a 10 per cent contingency factor.
- no allowance has been made for efficiencies in planting which will cut costs.
- yields for alternative 2-5 are the minimum reordered for the species selected, and so in practice should be higher.
- Rs: 75/ton is a conservative selling price; it could be as high as Rs: 100/ton wholesale.
- residual value of plantations on the 21st year for alternative 2-5 are not included in the benefit equation; the residual value is due to the fact that the species coppice and continue to produce useable wood without further costs.

CASH BASIS:

Valuation of timber or fuelwood at the time of actual or proposal harvest.

ACCRUAL BASIS:

Valuation of timber or fuelwood during the growth cycle of the tree and based on the yearly incremental value of the species.

economic analysis.

Internal Economic Return:

1. Fuelwood Project:

The rates of internal economic return for the fuelwood project range from 7 to 27 percent on a cash basis and 15 to 62 percent on an accrual basis. These rates are summarized for each alternative in table 5 and are a conservative representation of the probable rates of return. The alternatives which have the best rate of return are shown below in figure 2.

Figure 2
Fuelwood Project
Internal Economic Return
(Percent)

	Cash basis	Accrual basis
Alternative 2	18.76	46.33
Alternative 3	27.69	62.51

If supplemental costs of Rs. 33.6 million were spread equally over the first three years or at a rate of Rs. 11.2 million per year for alternative 2 and 3, the rates of return are still attractive as shown in figure 3 below.

Figure 3
Fuelwood Project
Internal Economic Return
(percent)

	Cash basis	Accrual basis
Alternative 2a	13.92	31.42
Alternative 3a	19.08	37.78

These rates of return are understated in that no allowance was made for inclusion of benefits attributable to the extra costs incurred.

2. Reforestation Project:

The rates of internal economic return for the reforestation project have been calculated with three different benefits assumptions. The first is a return which incorporates the complete value of all the timber; the second approach incorporates the full value of the timber as well as the watershed value of the forest cover. The third approach presumes a selective harvesting of timeber and excludes any watershed benefits.

The rates of internal economic return for the three alternatives range from 10 to 27 percent for the complete harvest approach. If the watershed benefits are included the rates of returns increase between 2 and 3 percentage points. For the selective harvest approach the rates of return vary from 5 to 19 percent. These are shown in table 6 and are a conservative representation of the probable rates of return.

The Charcoal Option:

The fuelwood plantations are capable of producing a surplus of several hundred thousand Tons of fuelwood. This could be converted into charcoal to supply an estimated market demand for 140,000 tons of charcoal. The approximate market value of the charcoal is Rs.130 million and includes a profit potential in excess of 30%.

A charcoal market has some interesting implications for conserving forest cover, creating employment and conserving as well as earning foreign exchange. For instance just 15,705 acres are needed to produce wood to supply a charcoal market whereas it would take 21,330 acres to supply the same market with fuelwood. This represents a possible saving of forest cover of 5,625 acres per year.

The tea estates use fuel oil as well as fuelwood for tea drying. The JEDB estates indicate a current demand for as much as 8.7 million gallons of fuel oil at Rs. 5.35 per gallon. The unsubsidized price

Table 5

Reforestation Project

Internal Economic Return

(Per Cent)

	Complete Harvest		Selective Harvest
	W/O Shed	W/Shed	W/O Shed
Alternative 1 (a)	10.07	12.21	4.95
(b)	17.47	19.51	12.52
Alternative 2 (a)	10.33	12.46	5.21
(b)	17.43	19.39	12.45
(c)	20.92	23.24	14.86
(d)	23.84	25.72	17.05
Alternative 3 (a)	15.34	18.34	8.66
(b)	20.98	23.35	14.47
(c)	24.84	26.96	16.19
(d)	27.53	30.08	19.37

NOTE:

(1) Complete assumes 100 per cent of the estimated value of the timber at harvest.

(2) Selective assumes 50 per cent of the value of the timber at harvest and represents the estimated cash value of selective cutting.

(3) W/O Shed defined as productive value of forest.

(4) W/Shed defined as combined productive value of forest and protective or watershed value of forest.

is Rs. 9.75 per gallon. This works out to a total economic cost of fuel oil of Rs. 169.6 million or US$ Lo.6 million. The situation may be similar for other industries as well as the urban sector which uses Kerosene as a substitute for fuelwood for cooking. The point is that a charcoal industry has the potential of freeing Sri Lanka from the need to import a certain amount of increasingly expensive Petroleum, and so represents the potential for a considerable saving in foreign exchange. Additionally, charcoal can be sold on the international market. The prevailing price is Rs. 1,600/- per ton FOB Colombo or US$ 100 per ton. This represents the potential for earning a substantial amount of foreign exchange.

A charcoal industry also will create employment. It will not be a total gain as the substitution of charcoal for fuelwood will also eliminate employment for some people currently engaged in the fuelwood market.

ANNEX A

Perspective on Deforestation in Sri Lanka

A. Introduction

Forests are of value to mankind. This is a statement of obvious truth, but honoured more or less in the breach. Until recently forests like water and other natural resources were taken for granted, and assumed to be of unlimited capacity to provide benefits to mankind. Now as this resource is preceived to be rapidly diminishing, there is world wide concern for the protection of the forest resources.

1. The value of a forest can be viewed in a number of ways. There is the productive value as measured in commercial timber, and the fuelwood value for cooking as well as other energy needs. These typically are the primary values ascribed to a forest, and used as the index of its worth to mankind. There also is the protective value which is less well understood, and frequently overlooked in exploitation of forests for commercial gain, and the conversion of forests to other uses such as agriculture, housing etc. The protective value can be viewed as including such elements as erosion control, flood control, watershed stabilization, clean water, wildlife habitat, recreation visual amenity and climate control. These values are of undeniable importance but difficult to quantify for inclusion in the traditional economic analysis.

In this economic analysis both the productive as well as protective value of a forest have been included. Primary emphasis will be placed on the productive values. However, where it is possible the protective values will be enumerated and quantified. In this regard it should be understood that the quantification of the protective values is exploratory and not rigorously definitive. Rather it is an attempt to point towards the viability of inclusion of the protective values in an economic analysis.

2. According to FAO, as shown in figure 1 below, 30% of the total land area of the earth was in forest cover in the early 1950's, with a per capita forest extent of 3.9 acres. Sri Lanka at that time was well above the world or Asia average with forests covering 55.6 percent of the land area. However, forest area per capita was one acre representing a high density of population well above the world average and on a par with the average for Asia.

By the mid 1970's, the world's forest areas had increased fractionally. This was due to vigorous afforestation efforts with China a notable example. However, due to a burgeoning population, the forest extent per capita has been reduced nearly 40 percent to 2.5 acres. In Sri Lanka the picture is more dismal with a depletion of 2.7 million acres of forest cover during the 20 year period, or at a rate of nearly one percent of the land area each year. Also there was a marked decrease in per capita forest cover by 50 percent to half an acre; this is well below the Asian per capita average of almost three quarters of an acre.

Figure I

Forest Area of the World, Asia & Sri Lanka for 1955 and 1973:

Location	Total Forest $\times 10^6$ acres		Total Land $\times 10^6$ acres	Forest as % of Land Area		Forest Area per Capita (a)	
	1955	1973	-	1955	1973	1955	1973
World	9478	9855	32621	30	30.2	3.9	2.5
Asia	1297	1403	6565	19.8	20.6	1.0	0.7
Sri Lanka	8724[a]	5930	15697	55.6	36.4	1.0	0.5

Note (a): Prior to aerial survey made in 1956 which showed 7.2 million acres

Source - World Forest Resources, FAO Publication, 1955 & 1973

B. Deforestation

In Sri Lanka, exploitation of the forests is a rather recent phenomen. When the country became independent, 50% of the land was forested. In 1956 the forest cover had been reduced to 7.2 million acres or 44% forest cover (Andrews 1961) and by 1976 this forest cover had been reduced by half according to estimates made by the Forest Department. Currently there is no accurate estimate of the remaining forest cover. The aerial survey made in 1956 was the last definitive assessment of forest cover.

In the absence of more definitive information, estimates of the rate of deforestation have been made using data from several sources. These calculations show a rate of deforestation ranging from 100,000 to 190,000 acres per year (see Tables A1 and A2). The implications are serious; by the close of the century there will be little forest cover left if any. As of the writing of this report, it is estimated that there are between 3 and 5.3 million acres under forest cover. A mid point of 4.1 million acres is probably an accurate estimate according to rigures compiled showing the protected lands of Sri Lanka (see table a-3).

The explanation for the deforestation is rather clear. Records of the State Timber Corporation show that commercial logging in the 1920's and 1930's extracted from 130,000 feet^3/year to 630,000 feet^3/year. After World war II this rate increased dramatically to 2,000,000 feet^3/year (Cabinet memo, 1978). Conversion of forest land for agricultural purposes also places pressure on the forests and has accelerated rapidly. During the period 1946 to 1966 agricultural lands increased from 3.2 to 4.1 million acres, an increase of nearly one million acres (Anonomous 1967). In the upper Mahaweli catchment there were 298,000 acres under forest cover in 1956; by 1975 forest land decreased to 114,000 acres (Perera 1975). Elsewhere clearing of forest land for agriculture increased as Sri Lanka moved from being able to domestically meet its food requirements to having to turn to outside sources to

TABLE A-1

LAND UNDER FOREST COVER [a]

(Acres Million)

Year	Estimated Forest Cover: Wijesinghe[b]	Forestry Dept.[c]	F A O[d]
1956	7.2	7.2	7.2
1966	6.5		
1970	6.1		6.1
1971	6.0		
1973			4.5
1976	5.4 *	3.6	4.2
1979	5.3 *	3.0 *	3.9 *
1986	4.8 *	1.7 *	2.8 *
1996	3.9 *	(.2)*	1.3 *
2005	3.0 *		(.3)*
* Estimates with Correlation coefficient of	-.87	- 1.0	-.93
	Acres/Year	Acres/Year	Acres/Year
Rate of deforestation	100,000	190,000	145,000

NOTES:

a) Includes forest pressures; does not include forests to be cleared by Mahaweli.
b) Wijesinghe, 1971
c) Sector Paper on Forestry, 1976
d) Dodd, 1979.

TABLE A-2

LAND UNDER FOREST COVER

(Acres Millions)

Zone	Total Area of Country	Forest Cover 56[a]	%	Forest cover 70[b]	%
Dry	10.40	6.212	60	5.280	51
Wet	3.77	.619	16	.557	15
Intermediate	2.15	.334	14	.284	13
Total	16.3	7.2	44	6.121	38

Source :

(a) Andrews, 1961

(b) Perera, 1973.

TABLE A-3

PROTECTED LANDS

With Forest Cover

	Area ('000 Acre)	% Total Land Area of Country
Forest Reserve	1,396	
Proposed Reserve	972	
	2,368[a]	
Forest Plantation	285[b]	
Total Forestry	2,653	16
Nature Reserve	161	
National Parks	741	
Jungle Corridors	86	
Sanctuaries	507	
Total Parks	1,495[c]	9
Grand Total	4,148	26

Source:

(a) Forest Department, Personal Communications June 1979

(b) Perera, 1979

(c) Dodd, 1979.

outside sources to supply enough food to feed everyone. The Mahaweli Project represents the Master Plan for food self sufficiency.

However in the process of bringing 900,000 acres under irrigation another 400,000 acres of forested land will be cleared by 1985. Pressure on forested land is also aggravated by the widespread chena system of agriculture; this is the slash and burn transient farmer who seeks a subsistence living. Further pressure on the forest cover is the illict timbering with 8000 cases reported in 1978 (Perera 1979). This is due to the shortfall of timber supplied by the State Timber Corporation which in 1979 is estimated to be 11.5 million cubic feet. This is based on a projected demand of 14 million cubic feet and a production capability of just 2.5 million cubic feet. This gap is to be filled with 500,000 feet^3 of imported timber, production from private home gardens, illicit felling or doing without. (State Timber Corporation Personal Communication, 1979).

Yet another major pressure on the forest cover has been the demand for fuelwood. Currently this demand is estimated to be 257 million cubic feet (5.7 million tons) per year and growing as population grows at 1.7% per year. This predicated primarily on the fact that 94% of the population use fuelwood for cooking; the calculations are shown in table A-4. To provide this volume of fuelwood it would now take fuelwood plantations of 642,000 acres assuming a yield of 2000 feet^3 per year with a five year rotation and the commitment of an additional 11,000 acres yearly to keep pace with the demands of a population growing at the rate of 1.7 percent per year. This effectively means a doubling of demand in just over 40 years.

It should be understood that not all of the current demand is actually in the form of wood harvested from trees for fuel wood; some of it is in the form of other burnable commodities such as coconut husks, wood scraps etc. The point is the magni-

TABLE A-4

FUELWOOD PROJECT

FUELWOOD DEMAND 1978

Sector		Population[b] (Millions)	Percent using[c] Firewood for cooking	Percapita[c] Consumption (feet^3/year)	Total Consumption (million feet^3/year	Market Value[d] of firewood (Rs. Millions)
Household[a]	(% Sector)					
Urban	(16%)	2.3	75.8	18	31.4	167.5
Rural	(72%)	10.3	97.9	18	131.5	(e)
Estate	(12%)	1.7	99.0	18	30.3	(e)
		14.3	94	18	243.2	167.5
Commercial						
JEDB : assuming total reliance on fuelwood					13.7	42.0
State Plantation					NA	
Industrial : from Ministry of Industries & Science					.1	.3
Other					NA	
					257.0	209.8

NOTE:

(a) Socio Economic Survey of Sri Lanka, 1969-1970
(b) World Bank Atlas, 1978; 13.8 million in 1976 with growth rate of 1.7%/year
(c) Towards an Energy Policy in Sri Lanka, 1978
(d) Based on Rs. 12/cwt of firewood with 1 cwt = 2.25 feet^3 solid or 3 feet^3 split
(e) Non monetary market
NA. Not available.

tude of the demand and the pressure that it places on the the forest cover.

Reduction of the fuelwood demand by conversion to an alternative energy source is unlikely as the most feasible substitute (kerosene) is subject to the world-wide oil problem, and vulnerable to arbitary OPEC price increases which in 1973 grabbed worldwide attention with five fold increases in the price of oil (Eckholm 1975). This trend is showing no signs of abatement with a standard barrel of OPEC oil reportedly fetching $ 35 on the Rotterdam market as of June 1979, more than double the official OPEC price of $14.55. (Ceylon Daily News, June 16, 1979). Conservation on the other hand may offer some hope in that use of stoves can cut consumption by as much as 50%; and conversion of wood to charcoal also shows the prospect of reducing the absolute demand for wood. One constant fact is that it takes a minimum amount of heat to cook which must in some form be supplied, and which will grow in aggregate uemand as the population base grows.

C. Reforestation

1. Present Program

In recognition of the fact that forest cover was rapidly being depleted, a reforestation program was initiated in the 1950's. Currently there are 280,000 acres under plantation, and plans for addition to these plantations at a rate of 20,000 acres per year.

In light of the estimated rate of deforestation of 100 to 190,000 acres per year, the reforestation effort of 20,000 acres per year can be said to be less than adequate. In effect, reduction of the total forest cover (deforestation) is taking place at a rate of up to one percent per year where as reforestation is proceeding now at a rate of one tenth of a percent (.01%) per year.

2. Current Need

The need for a massive reforestation program is undeniable; the facts are compelling. A framework for a possible program responsive to the perceived needs of the country might include at a minimum the following :

a) cessation of any further reduction of forest cover to conserve the remaining 4.1 million acres of forest land;

b) reforestation of 100,000 acres of the 1.34 million acre Mahaweli Catchment to partially replace the 114,000 acres lost since 1956;

c) Reforestation of at least 400,000 acres or more for commercial timbering;

d) establishment of 250,000 acres in regenerative fuelwood plantations to supply urban, commercial and some rural fuelwood demands amounting to 100 million cubic feet per year;

e) establishment of a system of village wood lots, hedgerows etc amounting to 400,000 acres to supply the rural demand for fuelwood.

If this program were to be implemented it would arrest the present trend of deforestation which appears to be nearing a crisis point, and move the country to a forest cover of 5.3 million acres. This would mean an increase of forested land from 25% to 33% of the country. Coincidentally, it should be noted that the Report of the Land Utilization Committee (1968) recommended that 5.3 million acres remain under forest cover.

3. Proposed Projects

In response to the obvious need for a major reforestation program, two pilot projects have been proposed by the Government of Sri Lanka (GSL). They include a 15,000 acre five year project

for the upper Mahaweli Catchment, and a 70,000 acre 10 year fuelwood plantation project.

They are scheduled to commence by early 1980 and should represent the start of a long range nationwide program to reforest 1.2 million acres. The actual site determination aside from the pilot project acreage, might best await the results in mid 1980 of the planned aerial survey and land capability analysis.

ANNEX B

Institutional Considerations

Perspective

The World Bank projects an increase in foreign aid disbursement for Sri Lanka from $ 241 million in 1979 to $ 529 million by 1983. The Bank indicated that the projected high level of aid disbursements is distorted on account of the Acclerated Mahaweli Program, for which expenditure will be peaking in 1983/84.

The Bank states there is a strong case for a substantial increase in aid to Sri Lanka in support of its medium term development program. This positive assessment of the investment climate in Sri Lanka is further substantiated by the recent decision of a consortium of commercial banks to extend substantial credit to the country on very favourable terms.

However, the donor community consider Sri Lanka's absorptive capacity to be constrained by weaknesses in planning and implementation capability. Despite the ongoing multilateral and bilateral technical assistance programs, there is an urgent need to improve the staffing level and training within some government agencies. This need is particularly apparent in the case of the Forest Department. If the proposed reforestation and fuelwood projects are to be effectively implemented this constraint needs to be addressed.

Government Sector

The Forest Department will be the government agency charged with the primary responsibility for implementing the proposed projects. The Forest Department is situated in the newly reorganized Ministry of Lands and Land Development. The Forest Department's Budget is shown in figure 1.

Figure 1

Forest Department Budgets
(Rs. Million)

Expenditure Category		Actual 1977	Estimate 1978	Estimate 1979
Recruitment		6.3	7.0	8.4
Capital		11.0	14.9	17.8
	TOTAL	17.3	21.9	26.2

The expenditure for both projects amount to Rs. 44.6 million in the first year, or 170 percent of the entire departments annual budget for 1979. The planned expenditure over the first five years amount to Rs. 173 million. The significant fact is the magnitude of the proposed budget expenditure in relation to the Forest Departments current level of budgetary activity.

The Forest Department reports a severe strain on the present staff to accomplish the workload currently assigned. The sizeable additional workload represnted by the proposed projects will further strain a fully burdened Department.

The Forest Department is fully cognizant of the possible problems which may be occassioned in the implementation of the proposed projects, and looks upon this situation as an opportunity to basically strengthen its operations. The first requirement would be a Ministerial statement of priority for the reforestation program. This should be backed with the budgetary resources needed by the Forest Department, and will permit the Forest Department to appropriately augment its staff as well as equipment. Training of the present as well as new staff is vital for a successful reforestation program. This need is more fully addressed in another section of this report.

The second requirement is an internal realignment or responsibility within the Forest Department to facilitate project implementation. It is suggested that the Senior Assistant Conservation of Forests be delegated the primary responsibility for the projects. In this regard, his office should be expanded to include a project management section, a communication/publicity office and a research section. The project management section should co-ordinate the implementation of the proposed projects, pilot programs and future project activities. The communications office should mount a publicity compaign to inform and educate the general public about the reforestation program. The Research Section should undertake necessary research work related to a reforestation program.

Private Sector

If a major reforestation program is to be mounted, then the participation of the Private Sector is needed. A communications campaign backed with the forestry extension service described in another part of this report is essential to mobilize the support of the general public. Additionally there is a good opportunity to involve various private firms in the reforestation program. Examples would be the planting of trees on a contract basis and a charcoal production as well as distribution facility. By involving private companies the Forest Department can effectively expand its capability to implement a major forestation program.

Project management is also an activity which is vital to the success of a major reforestation program. It is suggested that the donor agency contract with a private firm to provide a project management capability to supplement the efforts of the Forest Departments newly organized Project Management Office. The tragedy of developmented assistance is frequently the inability to link project design, technical assistance, funding and administrative structure into a program which achieves the objectives of the projects.

Provision of a project management capability should be viewed as an integral part of the investment process; - it should provide co-ordination, liason and a sense of momentum.

ANNEX C

1. General Assumption and Measures

The focus of this report is an economic analysis of the proposed fuelwood and reforestation projects. Economic analysis is defined as the total returns or profitability for the whole society of all the resources committed to the project regardless of who in the society contributes them and regardless of who in the society benefits.

This report does not include a financial analysis. However, several aspects of a financial analysis have been prepapred and are presented in sections called return on investment.

In an economic analysis taxes and subsidies are treated as transfer payments. Taxes are considered a part of the total project benefit which is transferred to the Scoiety as a whole, and are not treated as a cost. Conversely a subsidy is a cost to society since it is an expenditure of resources which the economy incurs to operate this project. Fertilizer and fuel oil are the two subsidized items which are a direct factor in the proposed projects. However, both items are relatively insignificant in terms of the total project, and will have negligible impact on the rates of (see figure 1 below). For simplicity both items are shown in the project budgets without adjustments for the subsidy.

Figure 1

Fertilizer Subsidy

(Rs. million)

Project	Total Cost	Market Price	Subsidy at 50%
Fuelwood	7.6	3.8	3.8
Reforestation	8.0	4.0	4.0

In an economic analysis, interest on capital is not separated out and deducted from gross returns since it is part of the total return to capital available to the society as a whole. Thus in this report no adjustments or provision need be made to treat interest on capital.

Shadow prices are an issue in any economic analysis. For various reasons, markets are imperfect. Because imperfections exist, the use of market prices may introduce a significant error into an economic analysis of a project. To avoid error, a shadow price is uded to reflect the "true" value of a commodity r service. In agricultural and forestry projects such as the ones under consideration in this report, the World Bank considers the use of shadow rather than market prices to be appropriate in just three areas (Gittinger 1972). These are for foreign exchange, for commodities which are important in world markets, and for unskilled agricultural labour. In the first two cases, there seems to be no need in the present Sri Lankan context to consider shadow printing. In the case of labour, traditional theory would suggest a cost of zero in light of prevailing high rates of unemployment in the rural sector. However, this report will cost labour at the prevailing wage rates which will serve to understate the prospective rates of returns. As will be shown subsequently, this will pose no probelm as the rates of return are quite ample despite a conservative approach to valuation of costs and benefits.

Basic Data

Land Area : 16.3 million acres

Population :

* Size : 13.8 million in mid 1976
* Growth rate : 1.7% (1970-76)

GNP at market prices (1976)

* Amount US$ 2,590 million
* Per capita US$ 190

Currency Rupee = 100 cents; exchange rate June 1979,
US$ 1 = Rs. 15.45

Main Towns: Population in '000 1973

Colombo	618
Dehiwela-Mount Lavinia	136
Jaffna	112
Kandy	94
Galle	73

Climate : Tropical

Language: Sinhala, Tamil

Employment:

There are no reliable, comprehensive employment statistics. The increases of unemployment is shown by the upward trend in the number of people registering at the labour exchange for employment. These figures have risen annually since 1953.

The 1973 labour force participation rate survey of the Central Bank puts the number of unemployed at 793,000. Current unofficial estimates put it at 1.4 million.

Currency:

The unit of currency is in rupee which is divided into 100 cents. The exchange rate is allowed to float. The Central Bank announces new exchange rates against major currencies on a daily basis. Currently the rupee stands at Rs. 15.45 to the US Dollar.

Wages and Prices:

Information on changes in the general level of wages is not available. But although wages are low compared with those paid in developed economies, unit labour costs are relatively high owing to low productivity.

Some indication of wage movements can be gained from the indices of minimum wage rates shown in the following table. The table also demonstrates the erosion of wages by the rise in the

cost of living, although it is generally known that the Colombo consumer price index (which is the only official indicator of cost of living changes) plays price increases down but does not entirely conceal them.

Wages and Prices:
(1952 = 100)

	1973	1974	1975	1976	1977
Minimum Wage Rates					
Agriculture:					
at current values	168.1	210.0	241.2	246.4	310.2
in real terms[a]	101.5	113.0	121.6	122.8	152.6
industry & commerce:					
at current values	199.7	235.8	275.2	282.3	304.0
in real terms[a]	120.7	126.9	138.7	140.7	149.6
Civil Service:					
at current values	180.1	202.8	224.2	237.2	308.8
in real terms[a]	108.8	109.2	113.0	118.2	151.9
Cost of living	165.4	185.8	198.3	200.7	203.2

a : Adjusted according to cost of living changes

b : Consumer prices in Colombo

Source : Review of the Economy, Central Bank of Ceylon.

Average Household Income

According to a Department of Cencus and Statistics Survey taken in 1969, eighty percent (80%) of the householder in Sri Lanka receive incomes of less than Rs. 400/- a month. Nearly 20% of the households receive an average income of over Rs. 400/- a month; only 2% have incomes exceeding Rs. 1000/- a month.

An average household consists of 5.8 persons with 1.7 income receivers. Over 50% of the households have one income receiver and only 15% more than three income receivers.

Household incomes shown by sector are given in figure 1, and type of income in figure 2 below.

Figure 1
Average Annual Household Income

(Rs. Annual)

	All island	Urban	Rural	Estate
Average:				
Household Income (Rs)	3564	5700	3252	2448

Source: Socio Economic Survey of Sri Lanka 1969 - 70

Figure 2
Type of Income

(Rs. bi-monthly)

	Urban	Rural	Estate	All island
Income in kind	92	131	46	109
Money income	540	335	191	346
Total Income	632	466	237	455

Source: Central Bank of Ceylon 1974.

2. Definition and Measures

The working definitions and units of measurement used in this report are stated below for common reference.

Cash basis: Valuation of timber or fuelwood at the time of actual or proposed harvest.

Accrual Basis: Valuation of timber or fuelwood during the growth cycle of the tree and based on the yearly incremental value of the species in question.

Cost of Land: Assumed to be free in all cases as it is government owned.

Taxes: Taxes are a transfer payment and considered to be a part of total project benefit.

Subsidies: Fertilizer and fuel oil are subsidized at the following rates according to the Ceylon Petroleum Corporation and Ceylon Fertilizer Corporation.

* Kerosene : 64%
* Heavy Diesel : 43%
* Fertilizer : 50%
* Gasoline 0

Prices: Current market prices are used unless otherwise noted.

Inflation: All prices for either cost or benefits are assumed to rise uniformly by the same proportion and will therefore not change their relative values.

Salvage Value: The residual value of a stand of trees at the end of the project life cycle.

Wood: Wet weight at harvest is assumed unless otherwise stated.

- One (1) ton of logs =45 feet^3(1.7 yd^3) or 20 c.w.t. with 1 cwt = 2.25 feet^3
- One (1) ton of firewood billets = 59 feet^3 (2.2 yd^3) with 1 cwt = 3 ft^3

Ton: One ton (long) = 1.016 metric tons = 2240 lbs = 20 cwt.

Firewood Consumption: 2.4 tons per household of six or 18 feet^3 per person per year using 45 feet^3 to a ton (Sanpras 1978).

Firewood Measure: A stocked yd^3 is .67 yd^3 of wood and .33 yd^3 of air space.

Firewood Costs:

- Worked in forest and transported by headload upto 1 mile and stocked in cubic yards is paid at Rs. 6/cubic yard;
- Transport by 5 ton lorry costs Rs. 1.70 per ton per mile ;
- Price in Colombo:
  Wholesale - Rs. 5/cwt or Rs. 100/ton or Rs. 45/yd^3
  Retail - Rs. 12/cwt or Rs. 240/ton or Rs. 108/yd^3

Characteristics & Productivity of Wood & Charcoal

Type of fuel	Energy Content BTU / lb	Household Efficiency (%)	Value/Efficiency per pound
Wood	6,970	7.5	523
Charcoal	12,980	27.5	3570

ANNEX D

Fuel Wood Project Analysis

1. The GSL Proposal: Alternative 1 (a,b,c&d)

The purpose of the proposed fuelwood project is the establishment of fuelwood plantations to mee the future fuelwood requirements of the settlers in the Mahaweli Development Area. The GSL estimates that approximately 900,000 acres are to be placed under irrigation with 2.5 acres alloted to a family, and assumes 4 members per family unit. This would mean about 1.4 million settlers (900,000 ÷ 25 x 4) and a projected fuelwood demand of 14 million feet^3 per year assuming per capita consumption of 10 feet^3.

Other sources indicate that a typical family has 6 members per family unit and a consumption rate of 18 feet^3 per person (Sankar 1978). If this is the case the demand for fuelwood will be considerably greater than estimated by the GSL and could range as high as 39 million feet^3 per year. In order to consider these possibilities this report will assess demandscenarios for family units with four and six members and consuption rates of 10 feet^3/ person and 18 feet^3/ person. For future reference GSL's proposal will be labeled alternative 1 and will be defined as shown in Figure 1 below.

Figure 1
Demand Scenarios

Alternative	Family Unic (members)	Consuption Rate (feet^3/person)	Total Consumption (million feet^3)
1 a	4	10	14
1 b	4	18	22
1 c	6	10	25
1 d	6	18	39

On the supply side of equation, the GSL contemplates 70,000 acres of fuelwood plantations to provide 14 million feet^3 per year of firewood. This assumes planting 7000 acres per year in

Eucalyptus or Casuarine with planting on 8 foot centres and a 10 year rotation. The yield is projectd to be 200 feet^3 per acre per year or 2000 feet^3 per acre at harvest. For valuation purposes it is estimated by the GSL that there are 50 feet^3 per tons, and that a ton of fuelwood is worth on an average of Rs. 75 wholesale. Other sources suggest 45 feet^3 per ton and an average wholesale value of Rs. 1000 per ton (Sankar 1978, Spot Prices Table D-1 and Colombo Wood Dealer-attachment D-1). In order to take there variations into account the following information shown in figure 2 below will be factored into alternative 1.

Figure 2

Supply Scenarios

Alternative	Feet^3/ Ton	Gross Volume (million feet^3)	Gross weight (tons 000)	Price/ ton (Rs)	Total value (Rs.million)
1 a	50	14	280	75	21
1 b	50	14	280	100	28
1 c	45	14	311	75	23
1 d	45	14	311	100	31

The cost figures presented in the GSL proposal seem to be reasonable, and have been adopted as the cost basis for the analysis of the proposal with addition of two extra items; they are Rs. 80,000 for planting equipment and an allowance for harvesting costs. In total the costs for the GSL fuelwood proposal assuming various scenarios and a project life cycle of 20 years range from Rs.109.7 million for alternative 1a & 1b and Rs. 111 million for alternative 1c & 1d. The detailed cost figures may be found in the GSL's Fuel Wood Proposal, 1979 and Table 2 for harvesting costs.

Depending on the demand scenario and tonnage yield from the plantations, there may <u>not</u> be enough fuelwood for the settlers.

The shortfall may range from 8 million cubic feet to as much as 25 million cubic feet per year. These figures would suggest the need to establish a much larger fuelwood plantation, vary the species planted to obtain a greater yield per acre and persuade the settlers to adopt conservation measures such as the use of stoves to use fuel more efficiently. Additionally it should be possible to encourage the establishment of village wood lots to supplement the fuelwood supplied by the plantations.

2. Alternatives 2,3,4 and 5

In order to provide an adequate supply of fuelwood to the Mahaweli settlers under the various demand scenarios, the mix of species planted has been varied. This is represented in the following analysis as alternatives 2,3,4 and 5. The details of the species mix and probable yield per acre is shown in tables D-3 and D-4 for all of the alternatives and desceibed more technically in another section of this report.

The results are dramatic. Under alternative 3 and 4 the supply of fuelwood is now adequate to meet the demands of the settlers under nearly all conditions. As shown in Table D-5 alternatives 3 and 4 provide an annual surplus ranging from 33,000 to 333,000 tons; whereas, the yield for the species mix for alternative 1, shows a uniform shortfall in most instances ranging upto 500,000 tons per year. And if the settlers could be persuaded to uniformly adopt the use of a simple home made clay and stone stove, alternatives 3 and 4 provide a surplus under all demand conditions; Over a project life cycle of 20 years the surplus yield ranges from 830,000 tons to 4,730,000 tons (see table D-6).

The implications are obvious. Alternatives 3 and 4 are adequate in most instances to supply the needs of the settlers and to yield a surplus for other uses. Widespread

adoption of the use of a stove as a conservative practice greatly increases the surplus wood available for other uses. Establishment of village wood lots would further increase the surplus, or counter profligacy of wood consumption including non-use of a stove.

The costs for alternative 2,3,4 and 5 are somewhat more than those shown in the GSL Fuelwood Proposal. The increases are reflected in higher operating costs of Rs. 2.9 million per year due to more densely spacing the trees, and a greater number of trees to be planted. (see table D-7). Also there are higher harvesting costs due to the fact that more trees are actually harvested.

The cost figures are probably overstated in that no provision has been made to reflect the efficiencies from the use of better planting tools and seedling bags. Also there is a contingency factor of 10% to cover unforseen expenses which may or may not actually materialize.

The benefits are probably understated in that tonnage yield per acre is the lowest yield figure for the species selected. In some instances this may be as much as 50% lower than the optimum recorded yield (see table D-3). Also, an allowance has been made for the residual value of the unharvested timber at the end of the project life cycle. The residual is due to the fact that the species selected naturally regenerate (coppice) after cutting, and so are ready to be harvested again on the 21st year.

The assumptions for alternatives 2,3,4 and 5 are the same as the ones used for alternative 1 (a,b,c. and d). Total plantation size is 70,000 acres with a project life cycle of 20 years. A ton of wood is valued at Rs.75 and is equivalent in volume to 45 feet^3.

A sensitivity analysis of the alternatives has been omitted in light of the fact that cost values are overstated and benefits are understated. In fact the economic rate of return for the most promising alternatives (e.g. alternatives 3 and 4) remains attractive even with the addition of extra costs spaced evenly over the first three years amcunting to Rs. 33.6 million, and no corresponding inclusion of benefits which might flow from the extra expenditures. These figures will be presented in the subsequent section which covers the economic rate of return analysis.

3. Return on Investment

The surplus wood from the fuelwood plantations can make a substantial cash contribution to the overall project costs. For example, alternative 3 with a 20 year project life cycle can cover upto 95% of the total project costs, and with a 30 year project life cycle alternative 3 is capable of returning 128% of the total project costs; that is a net return on investment of 28%. The calculations are shown in tables D-8, D-9 and D-10. All values are computed as net present worth at a discount rate of 10%.

As shown in D-5 and D-6 it is unlikely that there would be a surplus of wood under alternative 1 (a,b,c and d). Also alternatives 2 and 5 may provide a surplus of wood but not of the volume or with the certainity which will be the case with alternatives 3 and 4. The contribution towards total cost for all of the alternatives for a 20 and 30 project life cycle is shown in Tables D-8 and D-10.

The assumption is that the urban sector and the tea plantations would be cash customers for fuelwood. The urban sector currently purchases about 30 million feet^3 per year of fuelwood. The tea estates currently use fuelwood for tea drying. The JEDG Tea Plantations estimate an annual demand of 13.7 million feet^3 and project an increase by 1982 to 14.6

million feet^3. JEDB currently pays Rs. 83 yd^3 or about Rs. 183 per ton (JEDB letter of May 28, 1979 shown as an attachment to this annex). The State Plantations Corporation also consumes a large volume of fuelwood for tea drying but as of the writing of this report no consumption figures were available.

4. The Charcoal Option

The surplus wood from the fuelwood plantation could also provide the basis for the establishment of a charcoal industry. For instance alternative 3 might yield a minimum of 113,000 tons of wood per year to as much as 473,000 tons of wood per year (Table D-6).

The State Timber Corporation (STC) is currently considering a wood charcoal project to supply the needs of the State Steel Corporation. Pilot projects to convert suitable wood to charcoal have commenced at Yakkure and in the Southern area of the forest. In each case two charcoal pits were made and the charcoal produced was found to be of good quality. Data from Yakkure are given below (Anomomous 1978, Annex R).

Charge per pit	:	24 cu. yds.[a] or 18.35/m^3 of firewood billets. Firewood from 147 ha at 45 m^3/ ha is needed for 10 years operation.
Charcoal Output	:	2 tons per pit per charge of 18% efficiency.[b]
Production	:	5 days per charge so 6 charges per month per pit. 12 tons per month for 6 months proposed working per annum gives 72 tons p.a. per pit.

Costs	:	1 pit, brick-lined, metal cover (the most expensive item) Rs. 3,000/-.
Operation	:	Firewood supply, 6 men per 2 pits, water, firing and bagging: Rs. 500/- per charge

(a) 24 yd^3 x 27 = 648 $ft.^3$ ÷ 59 $ft.^3$ = 11 tons input

(b) $\frac{\text{output}}{\text{input}} = \frac{2}{11}$ = 18% efficiency

			Rs.
Annual Costs	:	Depreciation of pit	300
		Interest on 60% of the capital (Rs. 1,800 at 10%)	180
		Operation of 72 charges at Rs. 500 per charge	36,000
			36,480
		Repairs, miscellaneous etc. at 10%	3,650
		Say	40,000
		with 72 tons p.a. at kiln	Rs 555 per ton at kiln
		Transport cost of 5 ton lorry at Rs. 1.70 per ton-mile to Colombo 310 miles (STC return empty)	Rs. 527
		Cost delivered at Colombo	Rs.1082 per ton
		Transport cost if return loaded	263
		At Colombo (return journey loaded)	Rs. 818 per ton

The results of STC's pilot project serve to show production viability and establish an initial cost basis for a ton of charcoal of Rs. 555/ton at the pit. Production efficiency is low with a computed 18 percent but could most likely be improved to 20-25 percent depending on experience and capital investment. The State Timber Corporation has recently estimated a cost figure of Rs. 450/ton for the production of 360 tons of charcoal (Muttish 1978).

The utility of charcoal as a fuel medium is well known as is its relative advantage compared to wood. Namely: charcoal is competitive with wood because of its low weight to heat energy output. The energy characteristics of firewood, charcoal and kerosene are compared in Table D-11. This shows a unit of wood converted to charcoal to have nearly twice the heat value of that same unit of wood used as wood; and, charcoal has 6.8 times as much heat energy as the equivalent weight in wood. Thus the key to charcoal economics is the conversion efficiencies at the production site, and transportation costs.

Additionally, and attractive feature of charcoal is the ease with which it can be produced. The bulk of the charcoal produced in the world is made in kilns. The simplest earth kilns are simple indeed and require little investment and no specialized skills. Higher conversion efficiencies can be obtained by producing charcoal in retorts. Retorts can also permit gas and distillable by-products to be captured for sale as well as the charcoal. However, the capital cost of retorts may be relatively high, and require further substantial investment in generating, refining as well as storage equipment to make use of the by-products (Jongura 1978).

For Sri Lanka it would appear that charcoal holds great promise. For example, a quick comparison of the relative profitability of wood versus charcoal shows charcoal to be more profitable by a substantial margin. The figures are given in Table D 12 and indicate the profit from charcoal to be 32 percent comapred to just 20 percent for wood If better kiln efficiencies or other economies were achieved, then charcoal would be even more profitable.

For instance if the Rs. 450/ton kiln price for charcoal cited above is used in the analysis presented in Table D-12, then the profit on charcoal jumps to 40 percent or double that for wood. The key however is the transportation distance and costs. This example uses 50 miles (or 100 miles roundtrip) at a prevailing rate of Rs.1.7 per ton per mile. A rough breakdown

analysis (Table D-13) shows charcoal to be competitive with wood at about 45 miles and perhaps even 30 miles if the heat efficiency of charcoal is a primary consideration.

As shown in Table D-14 a large potential market for charcoal already exists in Sri Lanka. The demand could be as much as 140,000 tons with an approximate market value of Rs. 130 million. This is predicted on the known consumption needs of fuel for tea drying and the current urban market for fuelwood for cooking. It is also dependent on an adequate as well as reliable source of fuelwood.

One prospective customer (JEDB) has a potential need for 32,400 tons of charcoal annually. This could be supplied at a total cost of Rs. 30.6 million at a profit of 30 per cent. This assumes Rs. 945/ton and a transport distance of 100 miles. EDB currently pays Rs. 1244 for the fuelwood equivalent of one tone of charcoal. This is based on Rs. 183/ton of fuelwood (x 6.8 heat efficiency factor of charcoal = Rs. 1244) with JEDB's current purchase price of Rs.83/yd^3 for fuelwood (x 2.2 yd^3 = Rs. 183/ton). See Table D-14 and attached letter from JEDB dated May 28, 1979.

As was shown previously, the fuelwood plantations are capable of producing a surplus of several hundred thousand tons of fuelwood. This falls far short of the 948,000 tons of fuelwood potentially needed for conversion to charcoal (Table D-14) but does represent a substantial base; and, the surplus yield from the fuel wood plantations are a conservative estimate.

A charcoal market also has some interesting implications for conserving forest cover; creating employment and conserving as well as earning foreign exchange. For instance just 15,705 acres are needed to produce wood to supply a charcoal market whereas it would take 21,330 acres to supply the same market with fuelwood. This represents a possible saving of forest cover of 5,625 acres per year (Table D-15).

If charcoal is promoted as the energy source for household cooking in the urban sector, it prospectively will supplement fuelwood as well as kerosene. This may have pricing policy implications for kerosene which is used for cooking by 23 per cent of the urban sector, two per cent of the rural sector and one per cent of the estate sector (Sanpsar 1978). The point is that kerosene is heavily subsidized and is paid for with foreign exchange. The GSL may wish to reconsider the wisdom of continuing the subsidies and also examine the possible foreign exchange savings of persuading the public to switch to charcoal.

It is known that the tea estates use fuel oil as well as fuelwood for tea drying. The use of fuel oil is based on the relative availability and price of fuelwood. The JEDB estates indicate a current demand for as much as 8.7 million gallons of fuel oil at Rs. 5.35 per gallon. The unsubsidized price is Rs. 9.75/gallon. This works out to a total economic cost of fuel oil of Rs. 169.6 million. The situation may be similar for other industries as well as the urban sector which uses kerosene as a substitute for fuelwood for cooking. The point is that a charcoal industry has the potential of freeing Sri Lanka from the need to import a certain amount of hydro carbons, and so represents the potential for a considerable saving in foreign exchange. Additionally, charcoal can be sold on the international market. The prevailing price is Rs. 1,600/-per ton FOB Colombo or US$ 100/ton. This represents the potential for earning a substantial amount of foreign exchange.

A charcoal industry also will create employment. It will not be a total gain as the substitution of charcoal for fuelwood will also eliminate employment for some people currently in the fuelwood market.

5. Project Costs and Benefits

The projected project costs range from Rs. 109.7 to Rs. 159.9 million depending on the alternative selected and assuming a 20 year project life cycle. A summary of the cost figures is shown in Table D-16. A more detailed breakdown of costs can be found in the GSL Fuelwood Proposal 1978.

A cost per ton calculation has been made. It shows a range of Rs. 21.3 per ton for alternative 4 to Rs. 39.2 per ton for alternatives 1(a) and 1(b) (Table D-17). These calculations do not include the additional items mentioned above.

Project benefits are based on an average wholesale value of Rs. 75 per ton for fuelwood. This would be an economic benefit as it is not assumed that the Mahaweli settlers would actually purchase fuelwood. Traditionally the rural sector has gathered

fuelwood as a free good; it is doubtful that fuelwood could actually be sold to these settlers. The price for a typical households yearly requirements of fuelwood (2.4 tons) is Rs. 180 at wholesale. This represents 6 per cent of rural houslholds income which averages Rs. 3252 (Perera 1973). Moreover fuelwood would be generally available for the taking (legal or illegal) in nearby forested land.

As indicated in a preceding section, the surplus of fuelwood under some of the alternatives could be sold for cash or converted into charcoal. If sold for cash, the proceeds from the sale of fuelwood could make a substantial contribution to tota project costs. In fact in several cases the sale of the surplus fuelwood would cover all project costs and even yield an attractiv return on money invested.

6. Internal Economic Return

The rates of internal economic return (IER) for the fuelwood project range from 7 to 27 percent on a cash basis and 15 to 62 percent on an accrual basis valuation. These rates are summarized in Table D-18 and are a conservative representation of probable rates of return for the options described in Sections 1 and 2 of this annex. The detailed display of cost, benefits and net benefits spread over the project life cycle are shown in Tables D-19 to D-26.

Alternative 2 and 3 show the most attractive rates of return, they are given in figure 1 below:

Figure 1
Internal Economic Return
(Perera)

		Cash Basis	Accrual Basis
Alternative	2	18.76	46.33
Alternative	3	27.69	62.51

If additional costs of Rs. 33.6 million were spread equally over the first three years or at a rate of Rs. 11.2 million per year for alternatives 2 and 3, the rates of return are still attractive as shown in figure 2 below:

Figure 2
Internal Economic Return
(Percent)

		Cash Basis	Accrual Basis
Alternative	2a	13.92	31.42
Alternative	3a	19.08	37.78

These rates of return are understated in that no allowance was made for the inclusion of benefits attributable to the extra costs incurred.

TABLE D-1.

FUELWOOD PROJECT

SPOT PRICES FOR FIREWOOD

	Jungle Firewood	Slash Firewood (a)
COLOMBO depots	-	5/= per C.W.T. (b)
KURUNEGALA depots	25/= per Cu.Yd.	12/= per Cu. Yd.
KANDY depots	18/= per Cu.Yd.	12/= per Cu.Yd.
JAFFNA depots	120/- per ton	12/= per Cu.Yd.
ANURADHAPURA depots	22/= per Cu.yd.	12/- per Cu. Yd.
NUWARA-ELIYA depots	31.50 per Cu.Yd.	-
MATARA depots	30/= per Cu.Yd.	12/= to 19.50 per Cu.Yd.
RATNAPURA Depots	15/= per Cu.Yd.	12/= per Cu.Yd.
BATTICALOA Depots	20/= per Cu.Yd.	12/= per Cu.Yd.
BADULLA Depots	30/= per Cu.Yd.	12/= per Cu.Yd.
AMPARAI Depots	30/= per Cu.Yd.	12/= per Cu.Yd.
GALLE Depots	-	19.50 per Cu.Yd.

Note :

(a) Off Cuts from Sawmill

(b) Rs. 45 per yd^3

Source:

State Timber Corporation: Informal communication from M.S. Ranatunga 5/18/79.

TABLE D.2

FUELWOOD PROJECT

HARVESTING COSTS

Harvest Tons/a	x	Total Acres	÷	Yd^3/ Ton	=	Total Yd^3	x	Cost/Yd^3 Rs	=	Total Cost Rs. Million
40		7000		2.2		127,273		9.7		1.235
44		7000		2.2		141,364		9.7		1.371
55		7000		2.2		175,000		9.7		1.698
50		7000		2.2		159,091		9.7		1.543
37.5		7000		2.2		119,318		9.7		1.157
30		7000		2.2		95,455		9.7		0.926
45		7000		2.2		143,182		9.7		1.389

Note : Cost of Harvest

Cutting & Converting	=	Rs. 7.20/Yd^3
Transport to road	=	Rs. 2.50/Yd^3
		Rs. 9.7

Source : State Timber Corporation

Table D.3
Fuelwood Project
Summary of Yearly Production of Selected Species

Species	Yearly Production (In Tons/Acre)	Yearly Production (Low Average Est)	Rotation
Alternative 1a - 1d[a]			
Eucalyptus/Casuarina			
A/B @ 50 feet^3 = 1 ton	4.0 T/A	4.0 T/A	10 years
C/D @ 45 feet^3 = 1 ton	4.4 T/A	4.4 T/A	10 years
Alternative No. 2[b] [c]			
Species A	5.6 T/A		
Species B	5.13 T/A		
Species C	6.10 T/A	5.5 T/A	10 years
Species D	6.9 T/A		
Alternative No. 3			
Species A	5.6 T/A	5 T/A	
Species D or	6.8 T/A		10 years
Species E	9.12 T/A	7.5 T/A	5 years
Alternative No. 4			
Species F	10-18 T/A	10 T/A	
Species D	6-8 T/A		3 years
Species E	9-12 T/A	7.5 T/A	5 years
Alternative No. 5			
Species E	9-12 T/A	9 T/A	5 years

Species A: Acacia Auricaliformis

Species B: Acacia Mangium

Species C: Albizia lebbek

Species D: Sesbania Grandiflora

Species E: Leucaena Leucocephala

Species F: Calliandra Callothyrsus

(a) Information provided by Government of Sri Lanka 1978.

(b) Data supplied by National Academy of Science 1979.

(c) All calculations based on 45.15 feet^3 = 1 Ton.

Table D-4

Fuelwood Project

Tonnage Yield for Project Alternatives
(ton/acre at harvest)

Year	Alt 1W/Species A & B	Alt 1W/Species C & D	Alt 2W/Species A, B, C, or D.	Alt 3W/Species A	Alt 3W/Species B & C	Alt 3W/Species Tot:	Alt 4W/Species A	Alt 4W/Species B & C	Alt 4W/Species Tot:	Alt 5W/species A
1										
2										
3										
4										
5							30 (b)		30	
6									30	
7					37.5 (e)	37.5		37.5 (g)	67.5	45 (h)
8					37.5 (e)	37.5		37.5 (g)	67.5	45 (h)
9					37.5 (e)	37.5		37.5 (g)	67.5	45 (h)
10					37.5 (e)	37.5		37.5 (g)	67.5	45 (h)
11	40 (a)	44 (b)	55 (c)	50 (d)	37.5 (e)	87.5		37.5 (g)	67.5	45 (h)
to	40 (a)	44 (b)	55 (c)	50 (d)	37.5 (e)	87.5		37.5 (g)	67.5	45 (h)
20	40 (a)	44 (b)	55 (c)	50 (d)	37.5 (e)	87.5		37.5 (g)	67.5	45 (h)
Total:	400	440	550	500	562	1,062	510	562	1.072	675

Assumptions: (1) Harvest tonnage uses minimal recorded tonnage yield per acre for species selected
∴ Actual yield may be much greater

(2) 45 ft^3 ≐ 1 ton except in calculations for GSL Proposals A & B

Notes-

(a) 4.0 t/a/yr with 10 yr rotation
(b) 4.4 " " " "
(c) 5.5 " " " "
(d) 5.0 " " " "

(e) 7.5 t/a/yr with 5 year rotation
(f) 10.0 " " 3 " "
(g) 7.5 " " 5 " "
(h) 9.0 " " 5 " "

Table D.5
Fuelwood Project
Yearly Supply of Fuelwood for Families to be Resettled

	Supply[a] Yield/ Year	Demand[b] [c] Household of 4 10 ft³/ Person	Demand Household of 4 18 ft³/ Person	Demand Household of 6 10 ft³/ Person	Demand Household of 6 18 ft³/ Person	Balance Household of 4 10 ft³/ Person	Balance Household of 4 18 ft³/ Person	Balance Household of 6 10 ft³/ Person	Balance Household of 6 18 ft³/ Person
Alternative 1 a	280	280	500	440	780	0	(220)	(160)	(500)
1 b	280	280	500	440	780	0	(220)	(160)	(500)
1 c	311	280	500	440	780	31	(189)	(129)	(469)
1 d	311	280	500	440	780	31	(189)	(129)	(469)
Alternative 2	385	280	500	440	780	105	(115)	(55)	(395)
Alternative 3	613	280	500	440	780	333	113	173	(167)
Alternative 4	473	280	500	440	780	193	(27)	33	(307)
Alternative 5	315	280	500	440	780	35	(185)	(125)	(465)

NOTE:

(a) For simplicity of comparison, values are at harvest on 10th year, for all yields however, all 3, 4 & 5 have yields beginning in the 5th year for all 3 & 5, and the 3rd year for all 4. Thus yields for all 3, 4 & 5 are under-statements of actual value.

(b) The proposal assumes household size of 4 and consumption of 10 ft³/person; other sources indicate household size of 6 and consumption of 18 ft³/person. Therefore :

Total Acres		Acres/ Family		Total Families
900,000	÷	2.5	=	360,000

Thus:

Population Millions
1.4
2.2

Population in Millions with 4/Family	6/Family
1.4	2.2

Consumption (Millions ft³) 10ft³/person	18ft³/person
14	25
22	39

(c) Calculations use 50 ft³/ = 1 ton

(d) Brackets indicate a negative number

Table D-6

Fuelwood Project

Surplus Wood from Plantation Available for Sale.

for Sale - Assuming 20 year project cycle

	Household of Four (4)							
	No Use of Stove				Use of Stove			
	$10ft^3$/Person Surplus Wood		$18ft^3$/Person Surplus Wood		$5ft^3$/Person Surplus Wood		$9ft^3$/Person Surplus Wood	
	tons 000	value Rs.Mln	tons 000	value Rs.Mln	tons 000	value Rs.Mln	tons 000	value Rs.Mln
Alternative 2	1050	18.7	(a)	-	2450	43.6	1350	23.9
Alternative 3	3330	59.2	1130	20.1	4730	84.1	3630	64.4
Alternative 4	1930	34.4	(a)	-	3330	59.2	2230	39.6
Alternative 5	350	6.2	(a)	-	1750	31.0	650	11.6
	Household of Six (6)							
Alternative 2	(a)	-	(a)	-	1650	29.4	(a)	-
Alternative 3	1730	30.8	(a)	-	3930	69.9	2230	39.6
Alternative 4	330	5.9	(a)	-	2530	45.0	830	14.7
Alternative 5	(a)	-	(a)	-	950	16.8	(a)	-

Notes:

(a) No surplus wood available

(b) Surplus defined as wood available after needs of settlers is satisfied.

(c) Assumes stove cuts fuel use in half

(d) Sale is at plantation for Rs.75/ton

(e) Value of wood defined as net present worth using discount rate of 10%.

(f) Stove is simple clay stove design fabricated by householder.

Table D.7
Fuelwood Project

Incremental Costs for Fuelwood Alternatives 1-4

Operation Cost

1.	Survey & demarcation of annual area of 7000 acres Rs.	5,000
2.	Raising of 8.4 million tubed plants including cost of seeds, polythene bags, fertilizer etc. at -/50 cts. per tubed plant	4,200,000
3.	Clearing secondary growth of jungle and burning of debris at Rs. 200/- per acre	1,400,000
4.	Lining & staking at an espacement of 6' x 6' spacing at Rs. 30/- per acre	210,000
5.	Digging holes (18" deep and 9" diameter) 1200 holes per acre at -/14 cts per hole (i.e. Rs. 168/- per acre)	1,176,000
6.	Planting 1200 plants per acre including head-load transport, filling of vacancies within 4 weeks of initial planting and weeding wherever necessary at Rs. 150/- per acre (@ Rs. 0.125/plant)	1,050,000
7.	Cost of road construction - 12 miles of 14 ft. wide jeepable track at Rs. 3,000/- per mile	36,000
8.	Cost of fuel and servicing of vehicles and equipment	250,000
9.	Office stationery & requisites	5,000
	TOTAL : Rs.	8,332,000
	10% Contingencies on operating cost only : Rs.	833,200
	TOTAL COST : Rs.	9,165,200

Costs as stated in Original Proposal	Rs.	6,194,100
Increased Costs	Rs.	2,971,100

Table D- 8
Fuelwood Project
Net Present Worth of Surplus Wood
Shown as Percent of total Project Cost
Assuming 20 Year Project Cycle

	Total Cost of Project (Rs. Mln)	Value of Surplus Wood as % of Project Cost — No use of Stove: 10 ft^3/Person (%)	No use of Stove: 18 ft^3/Person (%)	Use of Stove: 5ft^3/Person (%)	Use of Stove: 9ft^3/Person (%)
Household of Four (4)					
Alternative 2	83.7	22	(a)	52	29
Alternative 3	88.7	67	23	95	73
Alternative 4	90.5	38	(a)	65	44
Alternative 5	86.2	7	(a)	36	13
Household of Six (6)					
Alternative 2	83.7	(a)	(a)	35	(a)
Alternative 3	88.7	35	(a)	79	45
Alternative 4	90.5	7	(a)	50	16
Alternative 5	86.2	(a)	(a)	19	(a)

NOTE

(a) No surplus wood available

(b) Surplus defined as wood available after needs of Mahaweli settlers have been supplied - eg - wood given free.

(c) Cost is total cost of project for all expenses from years 1 to 30

(d) Discount rate of 10%

(e) Stove is simple clay and stone design fabricated by householder.

Table D-9

Fuelwood Project

Surplus Wood from Plantation

Available for Sale

Assuming 30 year Project Cycle

		Household of Four (4)							
		No Use of Stove				Use of Stove			
		$10ft^3$/Person Surplus Wood		$18ft^3$/Person Surplus Wood		$5ft^3$/Person Surplus Wood		$9ft^3$/Person Surplus Wood	
		Tons (000)	Value Rs.Mln	Tons (000)	Value Rs.Mln	Tons (000)	Value Rs.Mln	Tons (000)	Value Rs.Mln
Alternative	2	2100	25.9	(a)	-	4900	60.4	2700	33.2
Alternative	3	6660	82.1	2260	27.9	9460	116.5	7260	89.3
Alternative	4	3860	47.6	(a)	-	6660	82.1	4460	54.8
Alternative	5	700	8.5	(a)	-	3500	43.0	1300	16.1
		Household of Six (6)							
Alternative	2	(a)	-	(a)	-	3300	40.7	(a)	-
Alternative	3	3460	42.7	(a)	-	7860	96.8	4460	54.8
Alternative	4	660	8.2	(a)	-	5060	62.4	1660	20.4
Alternative	5	(a)	-	(a)	-	1900	23.3	(a)	-

Notes

(a) No Surplus Wood available

(b) Surplus defined as wood available after needs of Mahaweli settlers have been supplied - eg - wood given free.

(c) Cost is total cost of project for all expenses from years 1 to 30

(d) Discount rate of 10%

(e) Stove is simple clay and stone design fabricated by householder

Table D-10
Fuelwood Project
Net Present Worth of Surplus Wood
Shown as Percent of total Project Cost
Assuming 20 Year Project Cycle

Value of Surplus Wood as % of Project Cost

	Total Cost of Project (Rs. Mln)	No use of Stove $10ft^3$ /Person %	No use of Stove $18ft^3$ /Person %	Use of Stove $5ft^3$ /Person %	Use of Stove $9ft^3$ /Person %
Household of Four (4)					
Alternative 2	85.3	30	(a)	71	39
Alternative 3	91.1	90	31	128	98
Alternative 4	92.5	51	(a)	89	59
Alternative 5	87.5	.10	(a)	49	18
Household of Six (6)					
Alternative 2	85.3	(a)	(a)	48	(a)
Alternative 3	91.1	47	(a)	106	60
Alternative 4	92.5	9	(a)	67	22
Alternative 5	87.5	(a)	(a)	27	(a)

NOTE
(a) No surplus wood available.
(b) Surplus defined as wood available after needs of Mahaweli
(c) Cost of total cost of project for all expenses from years 1 to 30.
(d) Discount rate of 10%.

TABLE D - 11

FUELWOOD PROJECT

CHARACTERISTICS & PRODUCTIVITY OF SELECTED FUELS

TYPE OF FUEL	ENERGY CONTENT BTU/LB	HOUSEHOLD EFFICIENCY (%)	VALUE EFFICIENCY BTU/LB
Firewood (a)	6,970	7.5	523
Charcoal (b)	12,980	27.5	3570 (c)
Kerosene	18,910	42.5	8037

SOURCES : (1) Leucaene, National Academy of Sciences 1977

(2) Wood Processing & utilization at the village level, S.A. Draper, Nov 1977.

NOTE :

(a) Leucaena (dry)

(b) From Leucaena

(c) Effective yield from 1 lb. of wood assuming 80/70% shrinkage in charcoaling process: 3570 x .20/.30 = 714/1071 BTU or 1.4 - 2.0 efficiency of firewood/lb. Advantages including: low weight, no storage problem, less volume, minimal smoke, steady heat, high BTU/lb (6.8 more than firewood)

Table D.12

Fuelwood Project

Comparison of Profitability of Wood and Charcoal

	Wood Needed Tons	Cost of Wood (RS) [a]	Charcoaling Cost (RS) [b]	Selling Price (RS) [c]	Transport 100 miles (RS) [d]	Total Cost (RS)	Market Price (RS) [e]	Profit (RS)	Profit (%)
Wood	5	107		375	850	1225	1200	243	20
Charcoal	5 [b]	107	555	930	170	1100	1219	387	32

(a) Cost of wood Rs: 9.7 yd^3 x 2.2 yd^3/tin x 5 tons = Rs: 107/-

(b) Wood needed to make 1 ton of charcoal assuming 80 per cent shrinkage

(c) Assumes Rs: 268/- profit for both wood and charcoal

(d) Transport Rs: 17/ton per mile

(e) Wood at Rs: 240/ton and charcoal Rs: 1200/metric ton or Rs: 1219/ton

(f) Coal figures from State Timber Corporation Pilot Project at Yakkure using kiln process : 18% efficiency.

Table D-13
Fuelwood Project
Breakeven Analysis

Wood (V) Charcoal

Distance	Wood 5 tons (Rs) (a)	Wood 6.8 tons (Rs.) (b)	Charcoal 1 ton (Rs) (c)
25	425	578	640
30	510	693	657
35	595	809	674
40	680	-	691
45	765	-	708
50	850	-	725

Assumptions

(1) Wood is free in all cases
(2) Charcoal costs Rs. 555/ton at the kiln
(3) Transportation by 5 ton lorry is Rs. 1.7/ton mile
(4) Delivery assumes roundtrip by truck
(5) Charcoal/wood relationship

	Input of wood	Shrinkage	Output	Heat value per unit	Total value
Charcoal	5 tons	0.2	1 ton	3570	3570
Wood	5 tons	1.0	5 ton	523	2615

NOTE :

(a) Assumes simple relationship of 5 tons wood = 1 ton charcoal
(b) Assumes it takes 6.8 tons of wood to equal 1 ton of charcoal
(c) Charcoal: 1ton is equivalent to 5 - 6.8 tons of wood.

TABLE D - 14

FUELWOOD PROJECT

CHARCOAL MARKET

CUSTOMER	(a)(b) FUELWOOD DEMAND Mln ft^3	tons 000	(c) CHARCOAL Equivalent tons 000	(d) CHARCOAL VALUE MARKET (Rs. Mln)
J.E.D.B.	13	220	32.4	30.6
State Plantations Corporation	13	220	32.4	30.6
Urban Sector	30	508	74.7	70.6
TOTAL:	56	948	139.5	131.8

NOTES :

(a) Estimated

(b) Assumes 59 ft^3 = 1 ton

(c) Assumes charcoal is 6.8 more heat efficient than fuelwood per pound.

(d) Assumes production cost of Rs. 450/ton wood cost of Rs.9.7/yd^3, transportation distance of 100 miles @ Rs.1.7/ton/mile and 30% profit. Therefore, selling price of Rs. 945/ton.

Table D-15
Fuelwood Project
Land Requirements for Charcoal Market

Customer	Charcoal Demand (tons '000s)	(a) Wood needed to produce charcoal (tons'000s)	(b) Land needed to produce wood for charcoal (acres)	(c) Land needed to produce fuelwood equivalent (acres)	Forest conserved by use of charcoal (acres)
JEDB	32.4	162	3645	4950	1305
State Plantations Corporation	32.4	162	3645	4950	1305
Urban Sector	74.7	374	8415	11.430	3015
Total	139.5	698	15,705	21,330	5625

NOTES:

(a) Assumes conversion rates of 5.1 on 20% efficiency at the kiln

(b) Assumes 45 ft^3 = 1 ton, and 2000 ft^3 / acre production

(c) Assumes wood equivalent factor of 6.8; 45 ft^3 = 1 ton and 2000 ft^3 / acre

Table D-16
Fuelwood Project
Summary Schedule of Project Expenditures (a)
(Rs: '000s)

Capital Cost	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th to 10th Year
1. Machinery, vehicles, equipment	3483	-	-	-	-	-
2. Buildings, etc	4793	110	110	110	110	110
3. Extra equipment (b)	80					
Recurrent Costs						
1. Salaries, allowances etc.	950	950	950	950	950	4750
2. Operating costs						
- alternatives 1a to 1d	6194	6194	6194	6194	6194	30,771
- increment for alternatives 2-5 (c)	2971	2971	2971	2971	2971	14,855
Maintenance		1019	1985	1985	1985	9,924
Harvesting Cost (d)	←	1200 to	2700	→		

NOTES

(a) Cost figures excepted from GSL Fuelwood Proposal, 1978
(b) Suggested by AID Forestry Design Team
(c) Additional to GSL Proposal costs for alternative 1a -1d; shown in table D-7
(d) Vary depending on the plantation yield; shown in Table D-2

Table D-16a

Fuelwood Project

Additional items for inclusion in Project
(Rs. Mln)

Item	Years 1	2	3	4	5
Project Management	3.75	3.75	3.75	3.75	3.75
Forest Extension Service	3.4				
Charcoal pilot Demo.	1.5	3.0			
Seeds/Fertilizer	1.5	1.2	1.2	1.1	1.1
Training Program	3.5	3.5	.84	.84	.84
Motor bikes	.3				
Land Use Survey	.4				
Communication tools	.4	0.23			
Tree Research Program	4.1	3.0	2.25	2.25	2.25
Total	19.25	14.98	8.80	8.70	8.70

Table D-17
Fuelwood Project

Total cost & yield of alternatives

	Total cost 20 year period (Rs.million)	Total harvest Yield (Million Tons)	Cost/Ton Rs.
Alternative 1a	109.7	2.8	39.2
Alternative 1b	109.7	2.8	39.2
Alternative 1c	111.0	3.1	35.8
Alternative 1d	111.0	3.1	35.8
Alternative 2	143.9	3.9	36.9
Alternative 3	159.6	7.4	21.6
Alternative 4	159.9	7.5	21.3
Alternative 5	147.6	4.7	31.5

NOTE

There is a residual value for alternatives 2-5 due to the natural regeneration of the species planted. Thus on the 21 to 30th years harvesting could continue.

Table D-18
Fuelwood Project
Internal Economic Return (IER)

(Per Cent)

		Cash Basis	Accrual Basis
Alternative	1a	7.13	15.16
Alternative	1b	10.30	23.12
Alternative 1	1c	8.04	17.46
Alternative	1d	11.38	26.24
Alternative	2	7.74	20.07
Alternative	3	18.76	46.33
Alternative	4	27.69	62.51
Alternative	5	20.57	33.20

NOTES:
The rates of return are understated in that:

- all costs include a 10% contingency factor;
- no allowance has been made for efficiencies in planting which will cut costs;
- yields for alternative 2-5 are the minimum recorded for the species selected, and so in practice should be higher;
- Rs.75/ton is a conservative selling price; it could be as high as Rs.100/ton wholesale;
- residual value of plantations on the 21st year for alternative 2-5 are not included in the benefit equation; the residual value is due to the fact that the species coppice and continue to produce useable wood without further costs.

Cash Basis: Valuation of timber or fuelwood at the time of actual or proposed harvest.

Accrual Basis: Valuation of timber or fuelwood during the growth cycle of the tree and based on the yearly incremental value of the species.

T A B L E D.19

Fuelwood Project

Alternative 1(a)

(Rs Million)

Year	Cost		Benefit		Net Benefit	
	G S L	A I D	Cash	Accrual	Cash	Accrual
1	12.256	3.245	0	0	-15.6	- 15.6
2	8.273			2.1	- 8.3	- 6.2
3	9.239			4.2	- 9.3	- 5.0
4	9.239			6.3	- 9.3	- 3.0
5	9.239			8.4	- 9.3	- 1.0
6	9.198			10.5	- 9.2	1.3
7	9.088			12.6	- 9.1	3.5
8	9.088			14.7	- 9.1	5.6
9	9.088			16.8	- 9.1	7.7
10	9.088			18.9	- 9.1	9.8
11	1.235		21.0	21.0	19.8	19.8
12	1.235		21.0	18.9	19.8	17.7
13	1.235		21.0	16.8	19.8	15.6
14	1.235		21.0	14.7	19.8	13.5
15	1.235		21.0	12.6	19.8	11.4
16	1.235		21.0	10.5	19.8	9.3
17	1.235		21.0	8.4	19.8	7.2
18	1.235		21.0	6.3	19.8	5.1
19	1.235		21.0	4.2	19.8	3.0
20	1.235		21.0	2.1	19.8	.8
TOTAL	106.15	3.245	210	210	100.6	100.6

Assumptions :

1. Plantation o 70,000 Acre with 10 year rotation using Eucalyptus a J Casuarina on 8 feet centre.

2. 50 feet ^{3} = 1 Ton; Rs. 75/Ton; Yield of 14 Million feet ^{3}/Year = 280 Thousand Ton/Year x Rs. 75 = Rs. 21 Million/Year.

TABLE D.20

FUELWOOD PROJECT

ALTERNATIVE 1(b)

(Rs. Million)

Year	Cost G S L	Cost A I D	Benefit Cash	Benefit Accrual	Net Benefit Cash	Net Benefit Accrual
1	12.256	3.245	0	0	-15.6	-15.6
2	8.273			2.8	- 8.3	- 5.5
3	9.239			5.6	- 9.3	- 3.7
4	9.239			8.4	- 9.3	- 0.9
5	9.239			11.2	- 9.3	1.9
6	9.198			14.0	- 9.3	4.7
7	9.088			16.8	- 9.2	7.6
8	9.088			19.6	- 9.1	10.5
9	9.088			22.4	- 9.1	13.3
10	9.088			25.2	- 9.1	16.1
11	1.235		28	28.0	26.8	26.8
12	1.235		28	25.2	26.8	24.0
13	1.235		28	22.4	26.8	21.2
14	1.235		28	19.6	26.8	18.4
15	1.235		28	16.8	26.8	15.6
16	1.235		28	14.0	26.8	12.8
17	1.235		28	11.2	26.8	10.0
18	1.235		28	8.4	26.8	7.2
19	1.235		28	5.6	26.8	4.4
20	1.235		28	2.8	26.8	1.6
Total	106.15	3.245	280	280	170.6	170.6

Assumptions: (1) Plantation of 70,000 acres with 10 year rotation using Eucalyptus and Casuarina on 8 feet centre.

(2) 50 feet^3 = 1 ton; Rs: 100/ton; Yield of 14 million feet^3/year = 280 thousandton/year x Rs: 100 = Rs: 28 million/year.

Table D.21

FUELWOOD PROJECT

ALTERNATIVE 1(c)

(Rs. Million)

Year	COST GSL	COST AID	BENEFIT Cash	BENEFIT Accrual	NET BENEFIT Cash	NET BENEFIT Accrual
1	12.256	3.245		0	-15.6	-15.6
2	8.273			2.3	- 8.3	- 6.0
3	9.239			4.6	- 9.3	- 4.7
4	9.239			6.9	- 9.3	- 2.4
5	9.239			9.2	- 9.3	- 0.1
6	9.198			11.5	- 9.2	2.3
7	9.088			13.8	- 9.1	4.7
8	9.088			16.1	- 9.1	7.0
9	9.088			18.4	- 9.1	9.3
10	9.088			20.7	- 9.1	11.6
11	1.371		23	23.0	21.6	21.6
12	1.371		23	20.7	21.6	19.3
13	1.371		23	18.4	21.6	17.0
14	1.371		23	16.1	21.6	14.7
15	1.371		23	13.8	21.6	12.4
16	1.371		23	11.5	21.6	10.1
17	1.371		23	9.2	21.6	7.8
18	1.371		23	6.9	21.6	5.5
19	1.371		23	4.6	21.6	3.2
20	1.371		23	2.3	21.6	0.9
Total	107.51	3.245	230	230	119.3	119.3

Assumptions: (1) Plantation of 70,000 acres with 10 year rotation using Eucalyptus and Casuarina on 8 feet centre.

(2) 45 feet^3 = 1 ton; Rs: 75/ton: Yield of 14 million feet^3/year = 311 thousand ton/year x Rs: 75 = Rs: 23 million/year.

Table D.22

FUELWOOD PROJECT

ALTERNATIVE 1(d):

(Rs. Million)

Year	COST G.S.L.	COST AID	BENEFIT Net	BENEFIT Accrual	NET BENEFIT Cash	NET BENEFIT Accrual
1	12.256	3.245	31	0	-15.6	-15.6
2	8.273			3.1	- 8.3	- 5.2
3	9.239			6.2	- 9.3	- 3.1
4	9.239			9.3	- 9.3	0
5	9.239			12.4	- 9.3	3.1
6	9.198			15.5	- 9.2	6.3
7	9.088			18.6	- 9.1	9.5
8	9.088			21.7	- 9.1	12.6
9	9.088			24.8	- 9.1	15.7
10	9.088			27.9	- 9.1	18.8
11	1.371		31	31.0	29.6	29.6
12	1.371		31	27.9	29.6	26.5
13	1.371		31	24.8	29.6	23.4
14	1.371		31	21.7	29.6	20.3
15	1.371		31	18.6	29.6	17.2
16	1.371		31	15.5	29.6	14.1
17	1.371		31	12.4	29.6	11.0
18	1.371		31	9.3	29.6	7.9
19	1.371		31	6.2	29.6	4.8
20	1.371		31	3.1	29.6	1.7
Total	107.51	3.245	310	310	199.3	199.3

Assumptions: (1) Plantation of 70,000 acres with 10 year rotation using Eucalyptus and Casuarina on 8 feet centre.

(2) 45 feet^3 = 1 ton; Rs: 100/ton; yield of 14 million feet^3/year = 311thousand/ton year x Rs: 100 = Rs: 31 million/year.

TABLE D-23

FUELWOOD PROJECT

ALTERNATIVE NO.2

(Rs.Million)

Year	Cost		Benefit		Net Benefit	
	G S L	A I D	Cash	Accrual	Cash	Accrual
1	15.227	3.245		0	-18.5	-18.5
2	11.244			6.6	-11.2	- 4.6
3	12.210			13.2	-12.2	1.0
4	12.210			19.8	-12.2	7.6
5	12.210			26.4	12.2	14.2
6	13.326		19.7	33.0	6.4	19.7
7	13.216		19.7	39.6	6.3	26.4
8	13.216		19.7	46.2	6.3	33.0
9	13.216		19.7	52.8	6.3	39.6
10	13.216		19.7	59.4	6.3	46.2
11	2.700		45.9	66.0	43.2	63.3
12			45.9	66.0	43.2	63.3
13			45.9	66.0	43.2	63.3
14			45.9	66.0	43.2	63.3
15			45.9	66.0	43.2	63.3
16			45.9	66.0	43.2	63.3
17			45.9	66.0	43.2	63.3
18			45.9	66.0	43.2	63.3
19			45.9	66.0	43.2	63.3
20			45.9	66.0	43.2	63.3
Total	156.3	3.245	557.5	957.0	397.9	797.6

ASSUMPTIONS:

(1) Plantation of 70,000 acres with 10 year rotation for species A and 5 year rotation for species B/C.
(2) 45 ft 3 = 1 ton: Rs.75/ton
(3) Yield of 612,500 tons/year x Rs.75 = 45.9 million/year.
(4) Harvest cost included beginning on 6th year

T A B L E D.24

FUELWOOD PROJECT

ALTERNATIVE NO.2

(Rs. Million)

Year	Cost		Benefit		Net Benefit	
	G S L	A I D	Cash	Accrual	Cash	Accrual
1	15.227	3.245		0	- 18.5	- 18.5
2	11.244			2.9	- 11.2	- 8.3
3	12.210			5.8	- 12.2	- 6.4
4	12.210			8.7	- 12.2	- 3.5
5	12.210			11.6	- 12.2	- 0.6
6	12.169			14.5	- 12.2	2.3
7	12.059			17.4	- 12.1	5.3
8	12.059			20.3	- 12.1	8.2
9	12.059			23.2	- 12.1	11.1
10	12.059			26.1	- 12.1	14.0
11	1.698		28.9	28.9	27.2	27.2
12	1.698		28.9	28.9	27.2	27.2
13	1.698		28.9	28.9	27.2	27.2
14	1.698		28.9	28.9	27.2	27.2
15	1.698		28.9	28.9	27.2	27.2
16	1.698		28.9	28.9	27.2	27.2
17	1.698		28.9	28.9	27.2	27.2
18	1.698		28.9	28.9	27.2	27.2
19	1.698		28.9	28.9	27.2	27.2
20	1.698		28.9	28.9	27.2	27.2
Total	140.6	3.245	289	419.5	145.1	275.6

Assumptions:

1. Plantation of 70,000 acres with 10 year rotation
2. 45 feet^3 = 1 ton; Rs. 75/ton
3. Yield of 385,000 tons/year x Rs. 75 = Rs. 28.9 million
4. Harvest costs included beginning on the 11th year.

T A B L E D.25

FUELWOOD PROJECT

ALTERNATIVE NO.4

(Rs. Million)

Year	Cost		Benefit		Net Benefit	
	G S L	A I D	Cash	Accrual	Cash	Accrual
1	15.227	3.245		0	- 18.5	- 18.5
2	11.244			9.2	- 11.2	- 2.0
3	12.210			18.4	- 12.2	6.2
4	13.136		15.7	27.6	2.6	14.5
5	13.136		15.7	36.8	2.6	23.7
6	14.252		35.4	46.0	21.1	31.7
7	14.142		35.4	55.2	21.3	41.1
8	14.142		35.4	64.4	21.3	50.3
9	14.142		35.4	73.6	21.3	59.5
10	14.142		35.4	82.8	21.3	68.7
11	2.083		35.4	92.0	33.3	89.9
12	2.083		35.4	92.0	33.3	89.9
13	2.083		35.4	92.0	33.3	89.9
14	2.083		35.4	92.0	33.3	89.9
15	2.083		35.4	92.0	33.3	89.9
16	2.083		35.4	92.0	33.3	89.9
17	2.083		35.4	92.0	33.3	89.9
18	2.083		35.4	92.0	33.3	89.9
19	2.083		35.4	92.0	33.3	89.9
20	2.083		35.4	92.0	33.3	89.9
Total	156.6	3.245	562.4	1334	402.5	1174.1

Assumptions :

1. Plantation of 70,000 Acres with 3 year rotation for species A and 5 year rotation for species B & C.
2. 45 feet^3 = 1 ton; Rs. 75/ton
3. Yield of 472,500 tons/year x Rs. 75 = Rs. 35.4 million/year
4. Harvest costs included beginning on the fourth year.

T A B L E D.26

FUELWOOD PROJECT

ALTERNATIVE NO.5

(Rs. Million)

Year	Cost		Benefit		Net Benefit	
	G S L	A I D	Cash	Accrual	Cash	Accrual
1	15.227	3.245		0	- 18.5	- 18.5
2	11.244			4.7	- 11.2	- 6.5
3	12.210			9.4	- 12.2	- 2.8
4	12.210			14.1	- 12.2	1.9
5	12.210			18.8	- 12.2	6.6
6	13.558		23.6	23.6	10.0	10.0
7	13.448		23.6	28.2	10.1	14.7
8	13.448		23.6	32.9	10.1	19.4
9	13.448		23.6	37.6	10.1	24.1
10	13.448		23.6	42.3	10.1	28.8
11	1.389		23.6	47.0	45.6	45.6
12	1.389		23.6	47.0	45.6	45.6
13	1.389		23.6	47.0	45.6	45.6
14	1.389		23.6	47.0	45.6	45.6
15	1.389		23.6	47.0	45.6	45.6
16	1.389		23.6	47.0	45.6	45.6
17	1.389		23.6	47.0	45.6	45.6
18	1.389		23.6	47.0	45.6	45.6
19	1.389		23.6	47.0	45.6	45.6
20	1.389		23.6	47.0	45.6	45.6
Total	144.34	3.245	354	681.6	206.2	533.8

Assumption

1. Plantation of 70,000 acres with 5 year rotation
2. 45 feet^3 = 1 ton; Rs. 75/ton
3. Yield of 315,000 tons/year x Rs. 75 = Rs. 23.6 million/year
4. Harvest costs included beginning on the sixth year.

COLOMBO WOOD DEALER

A gentleman who wishes to remain anonymous is one of about 50 wholesale/ retail dealers in firewood, operating in the City of Colombo.

He has been in this business for over thirty years and has considerable knowledge and experience of the firewood trade.

The timber he deals in is mainly rubber wood, which he obtains from rubber estates 45 miles away in the Matugama-Agalawatte area, which lies in the Kalutara district.

There are no depots as such from where he buys his wood, but he has regular suppliers - transporters, who buy rubber wood on tender from estates, and transport the logs to dealers, in Colombo.

According to this gentleman, a rubber tree is ready to be cut down when it is over 20 years old. The trees on Government owned estates are offered for sale on tender, and the successful tenderer has to cut down the trees, cut them to convenient size and take them away from the estate.

In the past few years, the Government's Hardboard Corporation takes the bottom 4 foot length of all trees cut which have a diameter of over 18 inches. These logs are used for making compressed boards etc. The rest of the tree belongs to the successful tenderer.

The dealer estimates one tree to provide enough logs to fill a five-ton lorry - 115 cwts of firewood timber.

One truck load of such timber, this gentleman buys today for Rs: 750/-. That is what he pays to the transporter and the truck load is delivered to his shop for that price. Last year he paid Rs: 650/- for a truck load. Five years ago the price was Rs: 300/- and 5 years before that he was charged only Rs: 175/- for a truck load of wood.

Having had the wood delivered to him, the dealer has to pay his workmen for stacking, splitting and sawing the timber and in addition he has other expenses of a more confidential nature like greasing fire-brigade officials' and other palms. He naturally, was reticent on this aspect of his expenses.

Today he sells his cut firewood at Rs: 12/- for a hundred-weight, delivered at your door by handcart. His delivery charges are included in his selling price and he makes no reduction if you provide your own transport. Last year his selling price was 50 cents more than half today's price. Five years ago he sold a hundred-weight for Rs: 2/50 and ten years ago firewood was only half that price.

Annex - D

Attachment 2

ජනවසම

ජනතා වතු සංවර්ධන මණ්ඩලය
ஜனதா பெருந்தோட்ட அபிவிருத்திச் சபை
JANATHA ESTATES DEVELOPMENT BOARD

මගේ අංකය / எனது இல. / My No. } GM/TRI/211

ඔබේ අංකය / உமது இல. / Your No. }

දුරකථන අංකය / தொலைபேசி எண் / Telephone No. } 20901-5

තැ. පෙ. අංකය / த. பெ. எண் / P. O. Box } 1753

55/75, { වෝක්ස්හෝල් වීදිය, කොළඹ 2. / வொக்ஸ்ஹோல் லேன், கொழும்பு 2. / Vauxhall Lane, Colombo 2.

28th May, 1979.

Stephen L. Keiley, Esqr.,
Resources Development Corporation,
C/o.Finco Ltd.,
49/16, Iceland Building,
Colombo 3.

Dear Sir,

I refer to the discussion we had at our office recently and attach hereto a statement indicating the fuel requirements for tea drying in our Organisation based upon the requirements of firewood and liquid fuel for Tea Driers.

We have written to Dr. R.L.de Silva of the Tea Research Institute of Sri Lanka who is presently working from the Sri Lanka Tea Board Office at No.563, Galle Road, Colombo 3, telephone No.87814 or 83687, to enquire whether charcoal could be utilised. As soon as we hear from him we shall get in touch with you. Meanwhile, we enclose a schedule of a programme of reafforestation prepared by our Crop Diversification Division for estates that have been visited by the Manager of that Division. The present programme covers 5,265 acres. This figure could perhaps be doubled after he has had an opportunity of visiting the rest of the plantations that come under our management. Please do not hesitate to get in touch with us if you need further information for the feasibility study that you are doing.

Yours faithfully,
JANATHA ESTATES DEVELOPMENT BOARD,

K.D.W.Ratnayaka,
General Manager.

encl.

cc. Dr. R.L.de Silva
cc. J.K.Gnanaratnam,Esqr.Manager
Crop Diversification Division,
J.E.D.B. Kandy.

kdwr:cw

FUEL REQUIREMENTS

T E A :		1979	1980	1981	1982
Estimated Crop - (Kgs) ..		92 M	94 M	96 M	99 M
- (lbs) ..		202.82 M	207.23 M	211.64 M	218.25 M
FIREWOOD :					
(a) Requirements based at 1 cu.yd.per 400 lbs.Crop	(yds).	507,050	518,075	529,100	545,625
(b) Cost of above at Rs.83/- per yard	(Rs.)	42 M	43 M	44 M	45 M
LIQUID FUEL :					
(a) Requirements based at (i) 35 lbs. per gallon for withering (ii)70 " " " " firing	(Gls)	8.69 M	8.89 M	9.07 M	9.35 M
(b) Cost of above at Rs.5/35 per gallon	(Rs.)	46½ M	47½ M	48½ M	50 M

GWC/UHW
24/5/79

PROGRAMME OF REAFFORESTATION

REGION	TOTAL EXTENT ACRES	1978	1979	1980	1981	1982	1983	1984
Badulla	832½	-	170	185	177	161	127	12½
Hatton	228	-	80	90	58	-	-	-
Kegalle	31½	-	18½	13	-	-	-	-
Nawalapitiya	3374	150	1290	1204	605	75	-	-
Kandy	849	5	283	166	148	70	70	107
		155	1841½	1658	988	306	197	119½
GRAND TOTAL								5,265

These figures relate to estates which have been so far visited by the Manager, Crop Diversification Division and there will be so many other extents available on estates of the regions.

M E M O

To : Mr. Steve Keiley

From : Cecil Wikramanayake

Date : June 15, 1979

Subject : WOOD CHARCOAL

Wood charcoal exports have been quite small in the past five years, and the last consignment exported was in 1978, a mere 660 tons which fetched an average price of Rs: 1,600/- per metric ton. Mr. Rajan Yatawara, an Executive at M/s. Hayleys Limited, one of the oldest firms in Colombo delaing with rubber and rubber product exports, and now handling the export of charcoal, both wood and coconut, was most helpful with facts and figures relating to wood and coconut charcoal. Mr. Yatawara is considered an authority on the subject, in the private sector.

Mr. Yatawara said that while there was very little activity in the field of wood charcoal, coconut charcoal had been exported in large quantities over the years - an average of 25 to 30 thousand tons per year at prices around Rs: 1,000/- per ton, FOB Colombo. The current price of coconut charcoal is $ 155 per metric ton FOB Colombo, and the chief buyers are the United States of America and Japan, but most of the coconut shell charcoal exported is used for industrial purposes other than for fuel.

In 1977, Sri Lanka exported 1276 tons of coconut charcoal at an average price of Rs: 722/- per ton and the previous year 1235 tons were exported at an average price of Rs: 530/- per ton. Comparative figures for the export of wood charcoal are in the annexed table prepared by Mr. Yatawara.

Mr. Yatawara said that any efforts to produce more wood charcoal from hardwood timbers or timbers with little ash content would be most welcome, and wood charcoal would have a ready market, particularly among the tea plantations, the industrialists and the urban domestic consumer. The rural domestic consumer, he felt, would not go for wood charcoal because he would have to buy it, whereas at present, most rural folk simply collect their firewood, free of cost, from the nearby forests.

Whether it would be economical to have large areas of forest devoted exclusively for the production of wood charcoal was another matter, Mr. Yatawara said. He was of the view that moving labour from, say, the south of Sri Lanka to the Mahaweli basin, to work on the preparation of wood charcoal would not be a good proposition, unless there were other incentives, like cultivation of chena crops, as is done at present, to keep such labour in that area.

One of the chief users of charcoal as fuel,is the Ilmenite Corporation, which now uses coconut shell charcoal, around 500 tons a year. This Corporation would be able to take in at least 150 tons of wood charcoal a month, but only for about six to eight months of the year. But with the extension of its plant, the Ilmenite factory at Pullmudai would be able to take 2000 tons of wood charcoal a year, increasing it gradually to about double that quantity.

I also spoke to Mr. Abeysiri of the Steel Corporation at Aturugiriya, about 10 miles out of Colombo. He said the Corporation does not use anthracite for firing, but uses coconut shell charcoal and fuel oil. He said he had been informed that the Forest Department had promised to allocate about 20,000 acres for the growing of timbers suitable for high quality charcoal and he was looking forward to this promise reaching fulfilment. The Steel Corporation had three projects under way, which would require a considerable quantity of wood charcoal, particularly for its pig-iron project, which, he said, involved 40,000 tons of sponge-iron for which they would require 400 to 500 kilos of charcoal per ton.

SRI LANKA WOOD CHARCOAL EXPORTS : JANUARY TO JUNE 1978

	Yugoslavia		Kuwait		Dubai		Bharain		Netherlands		Total		
	Qty	Av/Mt	Qty	Av/Mt	Qty	Av/Mt	Qty	Av/Mt	Qty	Av/Mt	Qty	Av/Mt	W.T.
Ceylon Trading Co.	340	1405.47	-	-	-	-	-	-	-	-	340	1405.47	51.52
Adamjee Lukmanjee Co.Ltd.	-	-	50	1596.68	-	-	-	-	-	-	50	1596.68	7.58
Jafferjee Bros.	-	-	-	-	50	1200.15	-	-	-	-	50	1200.15	7.58
Haran Engineering Works	-	-	-	-	-	-	-	-	20	636.00	20	636.00	3.03
Samson & Sons	-	-	-	-	150	2435.03	-	-	-	-	150	2435.03	22.73
Renuka Enterprises Ltd.	-	-	-	-	-	-	50	1234.25	-	-	50	1234.25	7.58
TOTAL	340	1405.47	50	1596.68	200	2126.25	50	1234.25	20	636.00	660	1602.11	
% WEIGHT		51.52		7.58		30.30		7.58		3.03			100.00

Quantity : Metric Tons

Value : F.O.B. excluding FEECs in Rupees

Source : Mr. Rajan Yatarawa of M/s. Hayleys Ltd., Deans Road, Colombo 10.

Ceylon Daily News

SATURDAY, JUNE 16 1979

Other measures to conserve fuel

Petroleum products except kerosene up in price

Filling stations closed during weekends from July 1

The Government increased the price of all petroleum products except kerosene from midnight yesterday and announced other measures to conserve fuel.

The price of petrol was raised from Rs. 20 a gallon to Rs. 30. The price of auto-diesel was raised to Rs. 10/50 per gallon, while the prices of industrial diesels and furnace oils were also increased.

The government has also decided on the following measures :—

- All filling stations will be closed on Saturdays and Sundays. This will be effective not immediately but from July 1, 1979.
- Motor races to be banned until further notice.
- Ceiling to be imposed on officials enjoying the privilege of private travel in official vehicles.

US $ 12/70 per barrel f.o.b. or Ceylon Rs. 197 per barrel f.o.b. The purchase price today ranges between US $ 14.05 (Ceylon Rs. 220) to US $ 21.09 (Ceylon Rs. 330) per barrel f.o.b. In fact some shipments are purchased at a price which is 66 per cent more than that paid in December, 1978.

Steep increase in demand since late 1977 is another cause for increased losses. Most of the petroleum products were sold below cost and with the increase in demand the losses also increased.

The Refinery can no longer refine all our requirements necessary to meet the increased demand. The Corporation has been compelled to import refined products like kerosene and diesel at prices very much higher than the locally refined kerosene and diesel. In fact, the selling prices of imported kerosene and diesel, if sold without any profit to the Ceylon Petroleum Corporation will be kerosene — Rs. 14 per gallon and Diesel — Rs. 18 per gallon.

Freight costs have also doubled over last year.

As stated earlier, the present loss of the Ceylon Petroleum Corporation is Rs. 98 million per month. Except for petrol, which is sold at a profit, all other products, including kerosene and diesel, are sold at a loss. The present loss on kerosene and diesel each month is Rs. 49 million and Rs. 65 million respectively. In fact, the loss on each gallon of locally refined kerosene is Rs. 6.33 and on imported kerosene Rs. 10.26. Loss on each gallon of locally refined diesel is Rs. 4.45 and on imported auto-diesel, Rs. 9.52.

Ceylon Daily News

Annex D

Attachment 4(b)

The English Daily with the largest circulation in Sri Lanka

Sri Lanka VOL. 64 NO. 141 THURSDAY, JUNE 14, 1979 14 PAGES

● CPC spokesman explains

Over past 6 years oil price hike here was only 300%

● World prices went up 800%

(by Winston de Valliere)

Oil prices have increased by a staggering 800 per cent over the six years from Rs. 270 a tonne in 1973 to over Rs. 2000 a tonne.

"Yet the price increase of oil in Sri Lanka over the same period has been only about 300 per cent", an official spokesman said yesterday.

He was commenting on the sharp increase in petroleum products (except kerosene) effected last night along with several other measures, including a ban on motor races and the closure of filling stations on week-ends, to conserve oil fuel and to contain heavy losses incurred by the Petroleum Corporation.

One of the main causes of the heavy losses was the fact that most of the petroleum products were sold below cost.

These moves have been decided on in a bid to contain the spiralling losses sustained by the Ceylon Petroleum Corporation which now stand at an estimated Rs. 98 million a month, in the wake of recent O.P.E.C. oil price hikes and to conserve present stocks of petroleum products, the official said.

The Organisation of Petroleum Exporting countries meets in Geneva on June 26 to discuss a further revision of oil prices and according to the Paris based Organisation for Economic Co-operation and Development (O.E.C.D.) a revision of prices upto 20 per cent, above those obtaining in December last year, is predicted.

In view of expected further price increases in the course of this year, this vital decision has been taken to contain inflation and a resulting stagggered growth rate in the wake of O.P.E.C. price hikes.

The heavy reliance on petroleum products for industrial and agricultural activity is evidenced by the spiralling consumption figures with the growth rate.

While sustaining subsidy losses mounting from Rs. 30 million in 1975 to Rs. 78 million in 1976, Rs. 179 million in 1977 and Rs. 377 million in 1978, the loss to the Petroleum Corporation estimated for 1979 is in the region of Rs. 98 million a month. This loss is expected to rise still further if the expected June 26 OPEC price increase becomes a reality, thus placing the crude oil price at US $ 17 per barrel.

As at June 1 the prices of Arabian light, medium and heavy crude oils stood at US $ 14.55, $14.05 and $13.6[illegible]

(Continued on Page 3)

Over...

(Continued from Page 1)

respectively, while Iranian varieties sold at U.S. $ 45.43 for light and 34.69 for heavy crude. Basrah light crude sold at US $ 34.17 per barrel. These prices reflect an increase of an average of over nine percent and more in some cases.

The C.P.C. loses Rs. 550 million on the kerosene oil subsidy and an estimated Rs. 250 million on the diesel oil subsidy alone. Reckoning the expected OPEC price hike in the course of this year combined with factors like the estimated 33 per cent industrial growth rate and population growth the maintaining of subsidies at present levels will push the C.P.C. losses in the course of the next twelve months to well above the Rs. 1250 million mark.

While the whole world prices kerosene oil well above those of petrol and diesel oil, Sri Lanka stands alone in not only selling kerosene oil at a price far below those levels, but also at a subsidised rate. What remains underscored is not that the poor are benefited by this subsidy, but that the rich and upper-middle-class households and industrialists benefit most through this subsidy. Industrialists about Rs. 150 million or more alone benefit to the tune of anually through the kerosene oil subsidy.

Calculated at the rate of 33 per cent industrial growth, Industrialists stand to profit further by the kerosene oil and diesel oil subsidy contributing still further to the C.P.C. losses and draining the country's resources still further exposing a need for a revision of the implementation of the subsidy schemes.

While O.E.C.D. countries are assured of a feed-back of a good portion of their estimated additional 40 million dollar oil bill through exports to O.P.E.C. countries, Sri Lanka and other Asian and African countries are not in a position to ensure such feed-back through sophisticated methods of protectionism by way of increasing the cost of exports to O.P.E.C. countries, which import increasingly more commodities from the O.E.C.D. group.

The answer lies in conservation, a shift to alternate indigenous power and stepping up production of refined products by maximum purchases of crude oil at existing rates. Perhaps the last named could be negotiated through international development funding programs of the O.P.E.C. countries.

Ceylon Daily News

SATURDAY JUNE 16, 1979

Annex D

Attachment 5

$ 8.6 m IFC loan for private sector firm

The International Finance Corporation (IFC), an affiliate of the World Bank, yesterday granted a loan of 8.6 million dollars (Rs. 138 million) to Ceylon Synthetic Textile Mills Ltd.

This is the first loan ever granted by the World Bank to a private sector industrial organisation in Sri Lanka.

Mr. A. Y. S. Gnanam, Chairman and Managing Director of Synthetic Textile Mills, said that with this loan the company would expand its production, doubling its suiting fabric and saree material capacity. The increased textiles, whilst meeting local demands which substantially exceed domestic production, would save approximately 2 million dollars (Rs. 30 million) in foreign exchange to the country.

The IFC loan would also mean that the company's expanded project would employ an additional 600 people. The company had plans to set up, for the first time in this country, shuttle-less looms in the expanded project. That would not only increase production but enable local consumers to purchase textiles of world class quality.

Mr. A. Tharmaratnam, representative of IFC, and its attorney Mr. C. Knight, who signed the loan agreement with Mr. Gnanam, said that the IFC had in addition to granting Synthetic Textiles Mills the loan also brought into the company's expanded project the financial participation of organisations in Belgium and the Netherlands.

They said that Societe Belge D'Investment International was matching the IFC financial participation with 1.2 million dollars while the Netherlands Finance Company for Developing Countries was providing 1.31 million dollars in loans and 500,000 dollars in equity.

Local participation includes a loan from the Development Finance Corporation of Ceylon for 500,000 dollars and a 125,000 dollars equivalent investment while the Bank

(Continued on Page 3)
(Picture on Page 3)

$ 8.6 m...

(Continued from Page 1)

of Ceylon was lending 1.2 million dollars.

The expansion of the company's project financed with these loans will be implemented at the company's plant site in Colombo while equipment will be obtained from Europe, India and Japan. Mr. Gnanam said that the company hoped to go into full production by the end of next year and has plans for a second phase in the expansion to provide additional weaving capacity.

The IFC representatives said that the IFC which was set up in 1956 as an affiliate of the World Bank handles investment grants to private sector organisations of member countries of the bank. While the Synthetic Textile Mills loan of the IFC was the first direct loan investment to a private sector industrial organisation, the IFC had earlier brought investment into Sri Lanka by a loan to the Bank of Ceylon and an equity investment in the Development Finance Corporation of Ceylon.

They said that the two criteria which the IFC had in mind when a private sector organisation made an application for IFC investment were whether the investment would help the recipient country to raise its economic standards and, secondly, whether the investment was being made to a viable project.

The IFC representatives said the Synthetic Textile Mills satisfied both these criteria. The IFC had been informed that the company would broadbase its share capital shortly by offering shares to the public to the tune of Rs. 6 million. Synthetic Textile Mills currently had 400 shareholders on its books and the IFC regarded the company as a satisfactorily broad-based organisation, they said.

ANNEX E

REFORESTATION PROJECT ANALYSIS

1. The GSL Proposal: Alternative 1.

The purpose of the proposed reforestation project is the conservation of land and water by improving vegative cover on the steep and eroding land in the Upper Mahaweli Catchment. The project is to constitute an initial contribution to the national objective of reforestation of the mountain catchments of Sri Lanka.

The project is designed to reforest 15,000 acres over a peirod of 5 years on the sites described in another section of this report. It is intended that this project represent the start of a National Programme to reforest at least 100,000 acres in the Upper Mahaweli Catchment.

The GSL proposes the planting of Pinus Caribaea and Eucalyptus on the project sites over a period of 5 years. Reforestation at the rate of 1500 acres per year of Pinus Caribaea with a 25 year rotation, and 1500 acres per year of Eucalyptus with a 10 year roation is contemplated. Upon completion of this project 15,000 acres should be reforested.

The GSL proposal is defined as alternative 1 in this report. The approach and cost figures presented in the GSL proposal have been adopted. Additional cost figures have been included to cover the second replanting of Eucalyptus in years 11 to 15, maintenance of the reforested areas for 30 years, and harvesting expenses. The provision of funds for the construction of cold storage facilities and rehabilitation of tea areas has been deleted from the project with the concurrence of the GSL.

Estimates of the yield of pulp and timber from the reforested areas planted in Pinus Caribaea vary from 2220 ft/acre to 7388 ft/acre (table E-1). This variation in yield is handled in this analysis by assessing a high and low yield option.

Alternative 1 (a) considers the low yield possiblity. Alternative 1 (b) considers the high yield possibility. The yield of Eucalyptus seems to be constant at 4 tons per acre for use as firewood, and so will be included at this rate in both alternatives 1(a) and (b).

2. Alternative 2 and 3

Variations of the GSL proposal are considered under alternatives 2 and 3. The purpose, sites and extent of lands to be reforested remain the same. The differences are the planting of Albizia and Calliandra instead of Eucalyptus; the rationale for this substitution is given in the technical section of this report.

Due to the proposed higher planting densities for Albizia and Calliandra, the costs need to be increased, and have been adjusted accordingly in the cost schedule for these alternatives. It should be noted that since both Albizia and Calliandra regenerate naturally (coppice) there is no need to include a replanting cost as was the case with Eucalyptus which does not coppice. The yield figures for Albizia and Calliandra are shown in Table E-2. The minimum recorded yields for these species have been selected for this report. This represents an understatement of possibly as much as 50% of the probable yield.

Calliandra will be planted for use as firewood. Albizia an be used for firewood or for pulp. This factor necessitates consideration of both options in assessing benefits. A display of the various options is shown in table E-3; this table summaries the factors included for alternatives 1,2, and 3.

3. Project Cost & Benefits

The projected costs range from Rs. 111.3 to Rs. 127.6 million depending on the alternative selected and assuming a project life cycle of 30 years. A summary of the cost figures is shown in Table E-4 and Table E-5.

Project benefits are based on current market prices. The benefits are calculated for both the productive as well as the protective role of a forest. Productive is defined as the commercial or timber value of a forest; protective is defined as the watershed value of a forest. The productive or timber benefits are shown in tables E6 to E9. The protective or watershed benefits are discussed briefly in this section and in more detail in annex F to this report.

Protective or Watershed Values

It is generally accepted that forests play a vital role in moderating the effects of climate and reducing the noxious impact of pollution in the atmosphere. Forests help in amelorating the effects of rain and wind, in checking soil erosion and controlling the water regime of the soil. However, a major problem in trying to evaluate the economic benefits of forests is to quantify in economic terms their protective role. This contrasts sharply with productive role which is generally analyzed in terms of timber or commercial values. The shortcoming of course is that it overlooks the protective role and may bias a decision in favour of exploitations, or tend to place a low priority on forest cover relative to other investments or developmental projects.

The protective role of forest cover is of undeniable importance in the Upper Mahaweli Catchment area where rainfall is high and the terrain generally steep. This report has placed quantifiable values on the protective as well as the productive role of Forests. This is expressed in terms of soil and water values for the protective role, and timber values for the productive role.

It should be understood that the delineation of protective values is tentative. The intent is to make a first cut at remedying an obvious omission of traditional economic analysis in the project assessment process. It should be noted that productive and protective values are shown separately in the project analysis. It is clear that the reforestation project can be amply justified on traditional

grounds with the use of just the productive values; the additional of the protective values is supplementary and serves to increase the rates of return.

The approach has been to demonstrate that there is a definite co-relation between deforestation and the rate and amount of water runoff as well as soil erosion. With this point established the next task was to place specific watershed values on an acre of forest cover. The values which have been established are shown in figures 1 below; the supporting analysis is shown in Annex F.

Figure 1
Watershed Values
(per acre)

1.	Water	Rs. 958 per acre
2.	Soil	Rs 732 per acre
	Watershed (1 + 2)	Rs. 1690 per acre

These values have been incorporated in the economic analysis for the 15,000 acres which will be reforested. This means the addition of R. 5 million for each 3000 acre section which is reforested. This supplemental benefit has been scheduled at a rate of Rs. 0.5 million per year with the presumption of yearly incremental value, and full value as of 10 years growth (Table E-10). The result is an increase of the internal economic return of approximately 2 percentage points. For instance the internal economic return for alternative 1(a) increases from Lo.07 percent to 12.21 percent. If the full value of the watershed benefit is carried forward for each 3000 acre section after the 10th year of growth, the internal economic return is increased approximately 8.5 percentage points. For alternative 1(a) the value would be 18.91 percent.

Both the values established for the watershed benefit and the scheduling of the values are open for debate. Whether or

not the full value of the watershed benefit should be carried forward after the 10th year of growth is also open to question. Another matter which should be examined is the stage at which a reforestation effort achieves the critical mass; that is the period when the whole is greater than the sum of the parts and should be valued accordingly. The important point is not the finite correctness of the values derived, but rather the principle of the inclusion of a watershed value in an economic analysis.

4. The Internal Economic Return

The rates of internal economic return for the reforestation project have been calculated with three different benefits assumptions. The first is a return which incorporates the complete value of all the timber; the second approach incorporates the full value of the timber as well as the watershed value of the forest cover. The third approach presumes a selection harvesting of timber and excludes any watershed benefits.

The rates of internal economic return for alternatives 1-3 range from 10 to 27 percent for the complete harves approach. If the watershed benefits are included the rates of return increase between 2 and 3 percentage points. For the selective harves approach, the rates of return vary from 5 to 19 percent. These rates are summarized in table E11 and are a conservative representation of the probable rates of return for the options described in sections 1 and 2 of this annex. The detailed display of costs, benefits and net benefits spread over the project life cycle are shown in tables E12 to E21.

5. Return on Investment

Inspection of the rates of return (table E-11) shows a positive net present worth in almost all cases assuming a discount rate of 10 percent. This means there is a satisfactory return on investment in all but three instances; namely alternative 1(a), 2(a) and 3(a) using the selective cutting approach. Net present worth for the three benefit valuation approaches is shown below in

figure 1 as a range from low (alternative 1a) to high (alternative 3d).

Figure 1

Net Present Worth

Using 10% Discount rate

(Rs. Mln)

	Complete (100%) Harvest		Selective (50%) Harvest
	Without watershed benefits	with watershed benefits	Without watershed benefits
Alternative 1(a)	0.4	11	- 20
Alternative 3(d)	188	199	74

Table E.1.

Reforestation Project

Yield from 1500 a of Pinus Cariboea

(ft $^3/_a$)

According to FAO Estimates [a]

Year	10	15	20	25	Total
Pulp	500	214	143	529	1386
Timber	-	357	572	5073	6002
Total	500	571	715	5602	7388

According to Forest Department Estimates (a)

Year	150	171	215	1683	2220

Source:

(a) Ahmed, 1975: Class I Land

(b) Land & Water Conservation Project:
The Upper Mahaweli Catchment (1978-83)

Note: Scheduling of yield based on data from FAO

T A B L E E.2

Reforestation Project

Upper Mahaweli Catchment Reforestation Options

(15,000 Acre Program)

Alternative No. 1	Yield	Rotation
1500 acres Pinus	yielding 2 T/A	25 years
1500 Eucalyptus	yielding 4 T/A	10 years
Alternative No. 2[a]		
1500 acres Pinus	2 T/A	25 years
1500 acres Albizia	5-7 T/A	10 years
Alternative No. 3[a]		
1500 acres Pinus.	2 T/A	25 years
1500 acres Albizia	5-7 T/A	10 years
+ Calliandra	10-18 T/A)	3 years

NOTE:

(a) It is unlikely that either species will be totally harvested (clear cut)

TABLE E-3

Reforestation Project

Various Planting Options

		Pinus Caribaea 7500 Acres yielding 2200 ft^3/a	Pinus Caribaea 7500 Acres yielding 7388 ft^3/a	Eucalyptus 7500 acres for firewood	Albizia 7500 acres for firewood	Albizia 7500 acres for pulp	Calliandra 7500 acres for firewood
Alternative 1	(a)	X		X			
	(b)		X	X			
Alternative 2	(a)	X			X		
	(b)		X		X		
	(c)	X				X	
	(d)		X			X	
Alternative 3	(a)	X			X		X
	(b)		X		X		X
	(c)	X				X	X
	(d)		X			X	X

TABLE E.4

Reforestation Project

Summary Schedule of Costs for Alternative 1

(Rs: Million)

Cost Elements	Years 1	2	3	4	5	6 - 30
Investment Costs -						
1. Equipment	2.9	3.5	2.4	2.9	0.3	
2. Office & Quarters	.2					
3. Forestry & College Building	1.0					
4. Surveys	0.05					
5. Nurseries	0.3	0.4	0.4	0.4	0.5	
6. Reforestation	-	1.0	2.0	2.0	2.5	
Sub-Total	4.5	4.9	4.8	5.3	3.3	
Operating Costs -						
1. Salaries & Travel	0.4	0.4	0.5	0.5	0.6	15.0
2. Stationery & Supplies	0.01	0.01	0.01	0.01	0.01	.3
3. Fuel & Lubricants	0.08	0.08	0.08	0.08	0.09	2.3
4. Maintenance of Vehicles	0.02	0.06	0.07	0.07	0.08	2.0
5. Maintenance of Buildings	-	0.01	0.02	0.02	0.02	0.5
6. Maintenance of Plantation	-	-	0.1	0.15	0.2	19.5
7. Fertilizer	0.8	0.8	0.8	0.8	0.8	
8. Forest College Expenses	0.01	0.02	0.02	0.03	0.03	0.8
Sub-Total	1.3	1.4	1.4	1.7	1.6	40.4
Harvesting Costs	-	-	-	-	-	39.5
Supplemental Items -						
1. Training Awards	0.4	0.7	0.6	0.3	-	
2. Advisors	0.8	0.7	-	-	-	
3. Contingency	0.4	0.5	0.3	0.3	0.03	
Sub-Total	1.6	1.9	0.9	0.6	0.03	
TOTAL	7.4	8.2	7.3	7.6	4.9	79.9

Table E.5

Reforestation Project

Summary Schedule of Costs for Alternatives 2 & 3

(Rs: Million)

Cost Elements	YEARS 1	2	3	4	5	6 - 30
Investment Costs -						
1. Equipment (a)(c)	3.9	4.7	3.1	3.8	0.3	
2. Office Quarters	0.2	-	-	-	-	
3. Forest College Buildings	1.0	-	-	-	-	
4. Surveys (a)	0.07					
5. Nurseries (a)	0.3	0.5	0.5	0.5	0.7	
6. Reforestation (b)	-	1.7	3.3	3.3	4.2	
	5.5	6.9	6.9	7.6	5.2	
Operating Costs -						
1. Salaries & Travel (a)	0.5	0.6	0.6	0.7	0.8	20.0
2. Stationery & Supplies (a)	0.01	0.01	0.01	0.02	0.02	0.5
3. Fuel & Lubricants	0.1	0.1	0.1	0.1	0.1	2.5
4. Maintenance of Vehicles	0.02	0.06	0.06	0.07	0.08	2.0
5. Maintenance of Buildings	-	0.01	0.02	0.02	0.02	0.5
6. Maintenance of Plantations (a)	-	-	0.1	0.2	0.3	19.5
7. Fertilizer	0.8	0.8	0.8	0.8	0.8	
8. Forest College Expenses	0.01	0.02	0.02	0.03	0.03	0.8
Sub-Total	1.5	1.6	1.8	2.0	2.1	45.8
Harvesting Costs	-	-	-	-	-	39.7 (a)
Supplemental Items (c) -						
1. Training Awards	0.4	0.7	0.6	0.3	-	
2. Advisors	0.8	0.7	-	-	-	
3. Contingency	0.4	0.5	0.3	0.3	0.03	
Sub-Total	1.6	1.9	0.9	0.6	0.03	
TOTAL	8.6	10.4	9.6	10.2	7.3	85.5

NOTES: (a) Increased 1/3 from alternative 1 (GSL Proposal)

(b) Increased 1/4 from alternative 1 (GSL Proposal)

(c) Includes items budgeted for donors in GSL Proposal

Table E-6

Reforestation Project

Benefits and Harvest Costs for 1500 a of Pinus Caribaea

(Rs. Mln)

According to FAO Estimates[a]

Year	10	15	20	25	Total
Pulp	10.1	5.4	4.4	19.4	39.3
Timber	-	7.9	13.5	158.3	179.7
	10.1	13.3	17.9	177.7	219.0

According to Forest Department Estimates [b] [c]

Year	3.0	4.0	5.4	53.4	65.8

Harvest Costs [a] [d]

Year	.5	.6	.7	5.5	7.3

Source:

(a) Ahmed, 1975

(b) Land & Water Conservation Project: The Upper Mahaweli Catchment (1978-83)

(c) Scheduling based on FAO data

(d) Excludes annual maintenance costs

Table E.7

Reforestation Project

Benefits and Harvest Costs for 1500 a of Eucalyptus

(Rs. Mln)

Years[a]	Gross Returns[b]	Harvest Cost[c][d]	Net Return
11	4.5	.3	4.2
12	4.5	.3	4.2
13	4.5	.3	4.2
14	4.5	.3	4.2
15	4.5	.3	4.2
21	4.5	.3	4.2
22	4.5	.3	4.2
23	4.5	.3	4.2
24	4.5	.3	4.2
25	4.5	.3	4.2
Total	45.0	3.0	42.0

Note:

(a) Rotation of 10 Years

(b) Yield of 4 t/a x 10 yrs - 40 tons/a x 1500 a - 60,000 tons

(c) Price of Rs.75/ton

(d) Harvest Cost: 60,000 tons ÷ 2.2 yd^3/ton x Rs.9.7/yd^3 - Rs264,546

Table E.8

Reforestation Project

Benefits & Harvest Costs from 1500 a of Albysia

(Rs. Mln)

Year	Gross Return All Pulp	Gross Return All Fuelwood	Harvest Costs
11	45.6	5.6	.3
12	45.6	5.6	.3
13	45.6	5.6	.3
14	45.6	5.6	.3
15	45.6	5.6	.3
21	45.6	5.6	.3
22	45.6	5.6	.3
23	45.6	5.6	.3
24	45.6	5.6	.3
25	45.6	5.6	.3
30 (e)	68.4	8.4	.2
Total	524.4	64.4	3.2

Note:

(a) Rotation of :

(b) Yield of 5 t/a x 10 Yrs = 50 tons/a x 1500 = 75,000 tons

(c) Price of Rs.75/ton for fuelwood

(d) Price of Rs.13.5/ft^3 for pulp x 45ft^3/ton x 75,000 ton = 45.6

(e) Harvest Cost: 75,000 tons ÷ 2.2 yd ¾ x Rs.9.7/yd^3 = Rs 330,682

(f) Residual value of standing timber

Table - E.9

Reforestation Project

Benefits & Harvest Costs for 1500 a of Calliandra & Albysia

Year	Calliandra as Fuelwood	Albyzia Fuelwood	Albyzia Pulp	Harvest Cost Calliandra & Albyzia
4	3.4			.1
5	3.4			.1
6	3.4			.1
7	3.4			.1
8	6.8			.1
9	3.4			.1
10	3.4			.1
11	3.4	5.6	45.6	.3
12	6.8	5.6	45.6	.4
13	3.4	5.6	45.6	.3
14	3.4	5.6	45.6	.3
15	3.4	5.6	45.6	.3
16	6.8			.2
17	3.4			.1
18	3.4			.1
19	3.4			.1
20	6.8			.2
21	3.4	5.6	45.6	.3
22	3.4	5.6	45.6	.3
23	3.4	5.6	45.6	.3
24	6.8	5.6	45.6	.4
25	3.4	5.6	45.6	.3
26	3.4			.1
27	3.4			.1
28	6.8			.2
29	3.4			.1
30 (g)	17.0	8.4	64.4	*

Note: * excluded to correct for rounding bias

(a) Rotation of 3 yrs for Calliandra & 10 yrs for Albyzia

(b) Calliandra Yield of 10 T/a x 3 yrs - 30 tons/a x 1500 - 45,000

(c) Albyzia yield of 5 t/a x 10 yrs - 50 tons/a x 1500 - 75,000

(d) Price of Rs 75/ton for fuelwood; Rs.135 ft^3 as Pulp

(e) Harvest Cost: 45,000 tons ÷ 2.2 yd^3/ton x Rs.9.7/yd^3 - Rs198,410

(f) Harvest Cost: 75,000 tons ÷2.2 yd^3/ton x Rs.9.7/yd^3 - Rs330,682

(g) Residual value of standing timber

T A B L E E 10

Reforestation Project

Scheduling of Watershed Values

Year	Section[a] 1	2	3	4	5	Total
2	.5					.5
3	.5	.5				1.0
4	.5	.5	.5			1.5
5	.5	.5	.5	.5		2.0
6	.5	.5	.5	.5	.5	2.5
7	.5	.5	.5	.5	.5	2.5
8	.5	.5	.5	.5	.5	2.5
9	.5	.5	.5	.5	.5	2.5
10	.5	.5	.5	.5	.5	2.5
11	.5	.5	.5	.5	.5	2.5
12		.5	.5	.5	.5	2.0
13			.5	.5	.5	1.5
14				.5	.5	1.0
15					.5	.5
Total	5.0	5.0	5.0	5.0	5.0	25

NOTE:

(a) Section is defined as 3000 acre unit.

Table E.11

Reforestation Project

Internal Economic Return

(Per Cent)

		Complete Harvest		Selective Harvest
		W/O Shed	W/Shed	W/O Shed
Alternative 1	(a)	10.07	12.21	4.95
	(b)	17.47	19.51	12.52
Alternative 2	(a)	10.33	12.46	5.21
	(b)	17.43	19.39	12.45
	(c)	20.92	23.24	14.86
	(d)	23.84	25.72	17.05
Alternative 3	(a)	15.34	18.34	8.66
	(b)	20.98	23.35	14.47
	(c)	24.84	26.96	16.19
	(d)	27.53	30.08	19.37

NOTE: (1) Complete assumes 100 per cent of the estimated value of the timber at harvest.

(2) Selective assumes 50 per cent of the value of the timber at harvest and represents the estimated cash value of selective cutting.

(3) W/O Shed defined as productive value of forest.

(4) W/Shed defined as combined productive value of forest and protective or watershed value of forest.

TABLE E.12
Reforestation Project
Alternative No.1 (a)
(Rs. Mln)

Year	Cost: Invest-ment	Cost: Ope-rating	Cost: Donor	Benefits: Pine	Benefits: Euca-lyptus	Benefits: Shed	Net Benefits: Complete W/O Shed	Net Benefits: Complete W/Shed	Net Benefits: Selective W/O Shed
1	2.6	.7	4.6				-7.9	- 7.9	-7.9
2	3.0	.8	5.4			0.5	-9.2	- 8.7	-9.2
3	4.0	1.0	3.2			1.0	-8.2	- 7.2	-8.2
4	4.1	1.1	3.5			1.5	-8.7	- 7.2	-8.7
5	4.0	1.2	0.3			2.0	-5.5	- 3.5	-5.5
6		1.3				2.5	-1.3	1.2	-1.3
7		1.3				2.5	-1.3	1.2	-1.3
8		1.3				2.5	-1.3	1.2	-1.3
9		1.3				2.5	-1.3	1.2	-1.3
10		1.8		3.0		2.5	1.2	1.3	0.3
11		2.0		3.0	4.5	2.5	5.5	8.0	1.8
12		2.0		3.0	4.5	2.0	5.5	7.5	1.8
13		2.1		3.0	4.5	1.5	5.4	6.9	1.7
14		2.2		3.0	4.5	1.0	5.3	6.3	1.6
15		2.7		4.0	4.5	0.5	5.8	6.3	1.6
16		1.3		4.0			2.7	2.7	0.7
17		1.3		4.0			2.7	2.7	0.7
18		1.3		4.0			2.7	2.7	0.7
19		1.3		4.0			2.7	2.7	0.7
20		2.0		5.4			3.4	3.4	0.7
21		1.6		5.4	4.5		8.3	8.3	3.4
22		1.6		5.4	4.5		8.3	8.3	3.4
23		1.6		5.4	4.5		8.3	8.3	3.4
24		1.6		5.4	4.5		8.3	8.3	3.4
25		7.1		53.4	4.5		50.8	50.8	21.9
26		6.8		53.4			46.6	46.6	19.9
27		6.8		53.4			46.6	46.6	19.9
28		6.8		53.4			46.6	46.6	19.9
29		6.8		53.4			46.6	46.6	19.9
30		-		-			-	-	-

Note: (a) Costs from GSL Proposal adjusted to 15,000 a (table)

(b) Maintenance Costs of Rs.1.3 Mln/Yr included for years 6-30

(c) Harvest costs included from tables E.6 and E.7.

(d) Shed represents watershed value; see table E.10.

(e) Eucalyptus requires replanting years 11-15

(f) Pinus yield of 2220 ft^3/a w/25 yr rotation

(g) Complete defined as 100% of estimated value of timber at harvest

(h) Selective defined as 50% of the value of timber at harvest represents the estimated cash value of selective cutting

TABLE E13

Reforestation Project
Alternative No. 1 (b)
(Rs. Million)

Year	Costs: Invest ment	Costs: Opera- ting	Costs: Donor	Benefits: Pine	Benefits: Eucal- yptus	Benefits: Shed	Net Benefits: Complete w/o shed	Net Benefits: Selective w/shed	Net Benefits: Selective w/o shed
1	2.6	.7	4.6				- 7.9	- 7.9	- 7.9
2	3.0	.8	5.4			0.5	- 9.2	- 8.7	- 9.2
3	4.0	1.0	3.2			1.0	- 8.2	- 7.2	- 8.2
4	4.1	1.1	3.5			1.5	- 8.7	- 7.2	- 8.7
5	4.0	1.2	0.3			2.0	- 5.5	- 3.5	- 5.5
6		1.3				2.5	- 1.3	- 1.2	- 1.3
7		1.3				2.5	- 1.3	1.2	- 1.3
8		1.3				2.5	- 1.3	1.2	- 1.3
9		1.3				2.5	- 1.3	1.2	- 1.3
10		1.8	10.1			2.5	8.3	10.8	3.5
11		2.0	10.1	4.5		2.5	12.6	15.1	5.5
12		2.0	10.1	4.5		2.0	12.6	14.6	5.5
13		2.1	10.1	4.5		1.5	12.6	14.1	5.5
14		2.2	10.1	4.5		1.0	12.4	13.4	5.4
15		2.7	13.3	4.5		0.5	15.1	15.6	6.3
16		1.3	13.3				12.0	12.0	5.3
17		1.3	13.3				12.0	12.0	5.3
18		1.3	13.3				12.0	12.0	5.3
19		1.3	13.3				12.0	12.0	5.3
20		2.0	17.9				15.9	15.9	7.0
21		1.6	17.9	4.5			20.8	20.8	9.7
22		1.6	17.9	4.5			20.8	20.8	9.7
23		1.6	17.9	4.5			20.8	20.8	9.7
24		1.6	17.9	4.5			20.8	20.8	9.7
25		7.1	177.7	4.5			175.1	175.1	82.0
26		6.8	177.7				170.9	170.9	82.1
27		6.8	177.7				170.9	170.9	82.1
28		6.8	177.7				170.9	170.9	82.1
29		6.8	177.7				170.9	170.9	82.1
30		-	-				-	-	-

Note: (a) Costs from GSL Proposal adjusted to 15,000 acres (table E5).
(b) Maintenance Costs of Rs. 1.3 mln/Yr included for years 6-30.
(c) Harvest costs included from tables E6 and E7.
(d) Shed represents watershed value -: see E10.
(e) Eucalyptus requires replanting years 11-15.
(f) Pinus yield of 7388 ft3/a w/25 yr rotation.
(g) Complete defined as 100% of estimated value of timber at harvest.
(h) Selective defined as 50% of the value of timber at harvest & represents the estimated cash value of selective cutting.

Table E.14
Reforestation Project
Alternative 2 (a)
(Rs. Mln)

Year	Cost: Investment	Cost: Operating	Cost: Donor	Benefits: Pine	Benefits: Albyzia	Benefits: Shed	Net Benefits: Complete W/O Shed	Net Benefits: Complete W/Shed	Net Benefits: Selective W/O Shed
1	2.6	.7	4.6				-7.9	-7.9	-7.9
2	3.3	.8	5.4			0.5	-9.5	-9.0	-9.5
3	4.6	1.0	3.2			1.0	-8.8	-7.8	-8.8
4	4.8	1.1	3.5			1.5	-9.4	-7.9	-9.4
5	4.9	1.2	0.3			2.0	-6.4	-4.4	-6.4
6		1.3				2.5	-1.3	1.2	-1.3
7		1.3				2.5	-1.3	1.2	-1.3
8		1.3				2.5	-1.3	1.2	-1.3
9		1.3				2.5	-1.3	1.2	-1.3
10		1.8		3.0		2.5	1.2	3.7	0.3
11		1.6		3.0	5.6	2.5	7.0	9.5	2.7
12		1.6		3.0	5.6	2.0	7.0	9.0	2.7
13		1.6		3.0	5.6	1.5	7.0	8.5	2.7
14		1.6		3.0	5.6	1.0	7.0	8.0	2.7
15		2.1		4.0	5.6	0.5	7.5	8.0	2.7
16		1.3		4.0			2.7	2.7	0.7
17		1.3		4.0			2.7	2.7	0.7
18		1.3		4.0			2.7	2.7	0.7
19		1.3		4.0			2.7	2.7	0.7
20		2.0		5.4			3.4	3.4	0.7
21		1.6		5.4	5.6		9.4	9.4	3.9
22		1.6		5.4	5.6		9.4	9.4	3.9
23		1.6		5.4	5.6		9.4	9.4	3.9
24		1.6		5.4	5.6		9.4	9.4	3.9
25		7.1		53.4	5.6		51.9	41.9	22.4
26		6.8		53.4			46.6	46.6	19.9
27		6.8		53.4			46.6	46.6	19.9
28		6.8		53.4			46.6	46.6	19.9
29		6.8		53.4			46.6	46.6	19.9
30		1.5		-	8.4		6.9	6.9	2.7

Note: (a) Cost from GSL Proposal adjusted to 15,000 acres (table E.5)

(b) Maintenance Costs of Rs.1.3 Mln/Yr included for years 6-30

(c) Harvest Costs included from tables E.6 and E.8.

(d) Shed represents watershed value; see E.10.

(e) Albyzia used for fuelwood

(f) Pinus Yield of 2220 ft ^{3}/a w/25 yr rotation

(g) Complete defined as 100% of estimated value of timber at harvest

(h) Selective defined as 50% of the value of timber at harvest and represents the estimated cash value of selective cutting

Table E.15
Reforestation Project
Alternative No.2 (b)
(Rs. Mln)

Year	Cost: Invest-ment	Cost: Ope-rating	Donor	Benefits: Pine	Benefits: Albyzia	Benefits: Shed	Net Benefits: Complete W/O Shed	Net Benefits: Complete w/Shed	Net Benefits: Selective W/O Shed
1	2.6	.7	4.6				- 7.9	-7.9	-7.9
2	3.3	.8	5.4			0.5	- 9.5	-9.0	-9.5
3	4.6	1.0	3.2			1.0	- 8.8	-7.8	-8.8
4	4.8	1.1	3.5			1.5	- 9.4	-7.9	-9.4
5	4.9	1.2	0.3			2.0	- 6.4	-4.4	-6.4
6		1.3				2.5	- 1.3	1.2	-1.3
7		1.3				2.5	- 1.3	1.2	-1.3
8		1.3				2.5	- 1.3	1.2	-1.3
9		1.3				2.5	- 1.3	1.2	-1.3
10		1.8		10.1		2.5	8.3	10.8	3.5
11		1.6		10.1	5.6	2.5	14.1	16.6	6.3
12		1.6		10.1	5.6	2.0	14.1	16.1	6.3
13		1.6		10.1	5.6	1.5	14.1	15.6	6.3
14		1.6		10.1	5.6	1.0	14.1	15.1	6.3
15		2.1		13.3	5.6	0.5	16.8	17.3	7.4
16		1.3		13.3			12.0	12.0	5.4
17		1.3		13.3			12.0	12.0	5.4
18		1.3		13.3			12.0	12.0	5.4
19		1.3		13.3			12.0	12.0	5.4
20		2.0		17.9			15.9	15.9	7.0
21		1.6		17.9	5.6		21.9	21.9	10.2
22		1.6		17.9	5.6		21.9	21.9	10.2
23		1.6		17.9	5.6		21.9	21.9	10.2
24		1.6		17.9	5.6		21.9	21.9	10.2
25		7.1		177.7	5.6		176.2	176.2	84.6
26		6.8		177.7			170.9	170.9	82.1
27		6.8		177.7			170.9	170.9	82.1
28		6.8		177.7			170.9	170.9	82.1
29		6.8		177.7			170.9	170.9	82.1
30		1.5			8.4		6.9	6.9	2.7

Note: (a) Cost from GSL Proposal adjusted to 15,000 acres (table E.5).

(b) Maintenance Costs of Rs.1.3 mln/Yr included for years 6-30

(c) Harvest Costs included from tables E.6 and E.8.

(d) Shed represents watershed value; see E.10.

(e) Albyzia used for fuelwood

(f) Pinus Yield of 7388 ft ^{3}/a w/25 yr rotation

(g) Complete defined as 100% of estimated value of timber at harvest

(h) Selective defined as 50% of the value of timber at harvest and represents the estimated cash value of selective cutting

TABLE E.16

Reforestation Project

Alternative 2(C)

(Rs. Millions)

Year	Costs: Investment	Costs: Operating	Costs: Donor	Benefits: Pine	Benefits: Albizia	Benefits: Shed	Net Benefits Complete: w/o shed	Net Benefits Complete: w/shed	Net Benefits Selective: w/o shed
1	2.6	.7	4.6				- 7.9	- 7.9	- 7.9
2	3.3	.8	5.4			0.5	- 9.5	- 9.0	- 9.5
3	4.6	1.0	3.2			1.0	- 8.8	- 7.8	- 8.8
4	4.8	1.1	3.5			1.5	- 9.4	- 7.9	- 9.4
5	4.9	1.2	0.3			2.0	- 6.4	- 4.4	- 6.4
6		1.3				2.5	- 1.3	1.2	- 1.3
7		1.3				2.5	- 1.3	1.2	- 1.3
8		1.3				2.5	- 1.3	1.2	- 1.3
9		1.3				2.5	- 1.3	1.2	- 1.3
10		1.8		3.0		2.5	1.2	1.3	- 0.3
11		1.6		3.0	45.6	2.5	47.0	49.5	22.7
12		1.6		3.0	45.6	2.0	47.0	49.5	22.7
13		1.6		3.0	45.6	1.5	47.0	48.5	22.7
14		1.6		3.0	45.6	1.0	47.0	48.0	22.7
15		2.1		4.0	45.6	0.5	47.5	48.0	47.5
16		1.3		4.0			2.7	2.7	0.7
17		1.3		4.0			2.7	2.7	0.7
18		1.3		4.0			2.7	2.7	0.7
19		1.3		4.0			2.7	2.7	0.7
20		2.0		5.4			3.4	3.4	0.7
21		1.6		5.4	45.6		49.4	49.4	23.9
22		1.6		5.4	45.6		49.4	49.4	23.9
23		1.6		5.4	45.6		49.4	49.4	23.9
24		1.6		5.4	45.6		49.4	49.4	23.9
25		7.1		53.4	45.6		91.9	91.9	42.4
26		6.8		53.4			46.6	46.6	19.9
27		6.8		53.4			46.6	46.6	19.9
28		6.8		53.4			46.6	46.6	19.9
29		6.8		53.4			46.6	46.6	19.9
30		1.5		-	68.4		66.9	66.9	32.7

Notes: a) Costs from GSL Proposal adjusted to 15,000 acres (table E.5)
b) Maintenance costs of Rs. 1.3 million/year included for years 6-30
c) Harvest costs included from tables E.6, E.8.
d) Shed represents watershed value ; see E.10.
e) Albizia used for pulp
f) Pinus yield of 2220 feet 3/a with 25 year rotation
g) Complete defined as 100% of estimated value of timber at harvest
h) Selective defined as 50% of the value of timber at harvest and represents the estimated cash value of selective cutting.

Table E.17
Reforestation Project
Alternative No. 2 (d)
(Rs. Mln)

Year	Cost: Invest-ment	Cost: Ope-rating	Donor	Benefits: Pine	Benefits: Albyzia	Benefits: Shed	Net Benefits: Complete W/O Shed	Net Benefits: Complete W/Shed	Net Benefits: Selective W/O Shed
1	2.6	.7	4.6			0.5	-7.9	-7.9	-7.9
2	3.3	.8	5.4			0.5	-9.5	-9.0	-9.5
3	4.6	1.0	3.2			1.0	-8.8	-7.8	-8.8
4	4.8	1.1	3.5			1.5	-9.4	-7.9	-9.4
5	4.9	1.2	0.3			2.0	-6.4	-6.4	-6.4
6		1.3				2.5	-1.3	1.2	-1.3
7		1.3				2.5	-1.3	1.2	-1.3
8		1.3				2.5	-1.3	1.2	-1.3
9		1.3				2.5	-1.3	1.2	-1.3
10		1.8		10.1		2.5	8.3	9.8	3.3
11		1.6		10.1	45.6	2.5	54.1	56.6	26.3
12		1.6		10.1	45.6	2.0	54.1	56.1	26.3
13		1.6		10.1	45.6	1.5	54.1	55.6	26.3
14		1.6		10.1	45.6	1.0	54.1	55.1	26.3
15		2.1		13.3	45.6	0.5	56.8	57.3	27.4
16		1.3		13.3			12.0	12.0	5.4
17		1.3		13.3			12.0	12.0	5.4
18		1.3		13.3			12.0	12.0	5.4
19		1.3		13.3			12.0	12.0	5.4
20		2.0		17.9			15.9	15.9	6.9
21		1.6		17.9	45.6		61.9	61.9	30.2
22		1.6		17.9	45.6		61.9	61.9	30.2
23		1.6		17.9	45.6		61.9	61.9	30.2
24		1.6		17.9	45.6		61.9	61.9	30.2
25		7.1		177.7	45.6		61.9	61.9	30.2
26		6.8		177.7			170.9	170.9	82.1
27		6.8		177.7			170.9	170.9	82.1
28		6.8		177.7			170.9	170.9	82.1
29		6.8		177.7			170.9	170.9	82.1
30		6.5		-	68.4		66.9	66.9	32.7

Note:
(a) Cost from GSL Proposal adjusted to 15,000 acres (table E.5)
(b) Maintenance Costs of Rs.1.3 mln/Yr included for years 6-30
(c) Harvest Costs included from tables E.6 and E.8.
(d) Shed represents watershed value; see E.10.
(e) Albyzia used for pulp
(f) Pinus Yield of 7388 ft ^{3}/a w/25 yr rotation
(g) Complete defined as 100% of estimated value of timber at harvest
(h) Selective defined as 50% of the value of timber at harvest and represents the estimated cash value of selective cutting

TABLE E18

Reforestation Project
Alternative No. 3 (a)
(Rs. Million)

Year	Costs: Invest ment	Costs: Opera- ting	Costs: Donor	Benefits: Pine	Benefits: Albi- zia	Benefits: Calli- andra	Benefits: Shed	Net Benefits: Complete w/o shed	Net Benefits: Selective w/ shed	Net Benefits: Selective w/o shed
1	2.6	.7	4.6					- 7.9	- 7.9	- 7.9
2	3.3	.8	5.4				0.5	- 9.5	- 9.0	- 9.5
3	4.6	1.0	3.2				1.0	- 8.8	- 7.8	- 8.8
4	4.8	1.3	3.5			3.4	1.5	- 6.2	- 4.7	- 7.9
5	4.9	1.4	0.3			3.4	2.0	- 3.2	- 1.2	- 4.9
6		1.5				3.4	2.5	1.9	4.4	0.2
7		1.5				3.4	2.5	1.9	4.4	0.2
8		1.5				6.8	2.5	5.3	7.8	1.9
9		1.5				3.4	2.5	1.9	4.4	0.2
10		2.0		3.0		3.4	2.5	4.4	6.9	1.2
11		1.9		3.0	5.6	3.4	2.5	10.1	12.6	4.1
12		2.1		3.0	5.6	6.8	2.0	13.3	15.3	5.6
13		1.9		3.0	5.6	3.4	1.5	10.1	11.6	4.1
14		1.9		3.0	5.6	3.4	1.0	10.1	11.1	4.1
15		2.5		4.0	5.6	3.4	0.5	10.5	11.0	4.0
16		1.7		4.0		6.8		9.1	9.1	3.7
17		1.5		4.0		3.4		5.9	5.9	2.2
18		1.5		4.0		3.4		5.9	5.9	2.2
19		1.5		4.0		3.4		5.9	5.9	2.2
20		2.4		5.4		6.8		9.8	9.8	3.7
21		1.9		5.4	5.6	3.4		12.5	12.5	5.3
22		1.9		5.4	5.6	3.4		12.5	12.5	5.3
23		1.9		5.4	5.6	3.4		12 5	12.5	5.3
24		2.1		5.4	5.6	6.8		15.7	15.7	6.8
25		7.4		53.4	5.6	3.4		55.0	55.0	23.8
26		1.5		53.4		3.4		55.3	55.3	26.9
27		1.5		53.4		3.4		55.3	55.3	26.9
28		1.8		53.4		6.8		58.4	58.4	.28.3
29		1.5		53.4		3.4		55.3	55.3	26.9
30		-		-	8.4	17.0		25.4	25.4	12.7

Note: (a) Costs from GSL Proposal adjusted to 15,000 acres (table E5)
(b) Maintenance Costs of Rs. 1.3 mln/Yr included for years 6-30
(c) Harvest costs included from tables E6, E8 and E9.
(d) Shed represents watershed value -: see E10.
(e) Albizia and Calliandra used for fuelwood.
(f) Pinus yield of 2220 ft3/a w/25 yr rotation.
(g) Complete defined as 100% of estimated value of timber at harvest.
(h) Selective defined as 50% of the value of timber at harvest & represents the estimated cash value of selective cutting.

TABLE E 19

Reforestation Project
Alternative No. 3 (b)
(Rs. Million)

Year	Costs: Invest ment	Costs: Opera- ting	Costs: Donor	Benefits: Pine	Benefits: Albi- zia	Benefits: Calli- andra	Benefits: Shed	Net Benefits: Complete w/o shed	Net Benefits: Complete w/shed	Net Benefits: Selective w/o shed
1	2.6	.7	4.6					- 7.9	- 7.9	- 7.9
2	3.3	.8	5.4				0.5	- 9.5	- 9.0	- 9.5
3	4.6	1.0	3.2				1.0	- 8.8	- 8.8	- 8.8
4	4.8	1.3	3.5			3.4	2.0	- 6.2	- 4.2	- 7.9
5	4.9	1.4	0.3			3.4	2.5	- 3.2	- 0.9	- 4.9
6		1.5				3.4	2.5	1.9	4.4	0.2
7		1.5				3.4	2.5	1.9	4.4	0.2
8		1.5				6.8	2.5	5.3	7.8	1.9
9		1.5				3.4	2.5	1.9	4.4	0.2
10		2.0		10.1		3.4	2.5	11.5	14.0	4.8
11		1.9		10.1	5.6	3.4	2.5	17.2	19.7	7.7
12		2.1		10.1	5.6	6.8	2.0	20.4	22.4	9.2
13		1.9		10.1	5.6	3.4	1.5	17.2	18.7	7.7
14		1.9		10.1	5.6	3.4	1.0	17.2	18.2	7.7
15		2.5		13.3	5.6	3.4	0.5	19.8	20.3	8.7
16		1.7		13.3		6.8		18.4	18.4	8.4
17		1.5		13.3		3.4		15.2	15.2	6.9
18		1.5		13.3		3.4		15.2	15.2	6.9
19		1.5		13.3		3.4		15.2	15.2	6.9
20		2.4		17.9		6.8		22.3	22.3	9.9
21		1.9		17.9	5.6	3.4		25.0	25.0	11.6
22		1.9		17.9	5.6	3.4		25.0	25.0	11.6
23		1.9		17.9	5.6	3.4		25.0	25.0	11.6
24		2.1		17.9	5.6	6.8		28.2	28.2	13.1
25		7.4		177.7	5.6	3.4		179.3	179.3	86.0
26		1.5		177.7		3.4		179.6	179.6	89.1
27		1.5		177.7		3.4		179.6	179.6	89.1
28		1.8		177.7		6.8		182.7	182.7	90.1
29		1.5		177.7		3.4		179.6	179.6	89.1
30		*			8.4	17.0		25.4	25.4	12.7

Note: (a) Costs from GSL Proposal adjusted to 15,000 acres (table E5)
(b) Maintenance Costs of Rs. 1.3 mln/Yr included for years 6-30
(c) Harvest costs included from tables E6, E8 and E9.
(d) Shed represents watershed value -:' See E10.
(e) Albizia and Calliandra used for fuelwood.
(f) Pinus yield of 7388 ft3/a w/25 yr rotation.
(g) Complete defined as 100% of estimated value of timber at harvest.
(h) Selective defined as 50% of the value of timber at harvest & represents the estimated cash value of selective cutting.
* Excluded to correct for rounding bias.

TABLE E20

Reforestation Project
Alternative 3(c)
(Rs. Million)

Year	Costs: Invest ment	Costs: Opera-ting	Costs: Donor	Benefits: Pine	Benefits: Albi-zia	Benefits: Calli-andra	Benefits: Shed	Net Benefits: Complete w/o shed	Net Benefits: Selective w/shed	Net Benefits: Selective w/o shed
1	2.6	.7	4.6					- 7.9	- 7.9	- 7.9
2	3.3	.8	5.4				0.5	- 9.5	- 9.0	- 9.5
3	4.6	1.0	3.2				1.0	- 8.8	- 7.8	- 8.8
4	4.8	1.3	3.5			3.4	1.5	- 6.2	- 4.7	- 7.9
5	4.9	1.4	0.3			3.4	2.0	- 3.2	- 1.2	- 4.9
6		1.5				3.4	2.5	1.9	0.6	0.2
7		1.5				3.4	2.5	1.9	3.4	0.2
8		1.5				6.8	2.5	5.3	7.8	1.9
9.		1.5				3.4	2.5	1.9	4.4	0.2
10		2.0		3.0		3.4	2.5	4.4	6.9	1.2
11		1.9		3.0	45.6	3.4	2.5	50.1	52.6	24.1
12		2.1		3.0	45.6	6.8	2.0	53.3	55.3	25.6
13		1.9		3.0	45.6	3.4	1.5	50.1	51.6	24.1
14		1.9		3.0	45.6	3.4	1.0	50.1	51.1	24.1
15		2.5		4.0	45.6	3.4	0.5	50.5	51.0	24.0
16		1.7		4.0		6.8		9.[illegible]	9.1	3.7
17		1.5		4.0		3.4		5.9	5.9	2.2
18		1.5		4.0		3.4		5.9	5.9	2.2
19		1.5		4.0		3.4		5.9	5.9	2.2
20		2.4		5.4		6.8		9.8	9.8	3.7
21		1.9		5.4	45.6	3.4		52.5	52.5	25.3
22		1.9		5.4	45.6	3.4		52.5	52.5	25.3
23		1.9		5.4	45.6	3.4		52.5	52.5	25.3
24		2.1		5.4	45.6	6.8		55.7	55.7	26.8
25		7.4		53.4	45.6	3.4		95.0	95.0	43.8
26		1.5		53.4		3.4		55.3	55.3	26.9
27		1.5		53.4		3.4		55.3	55.3	26.9
28		1.8		53.4		6.8		58.4	58.4	28.3
29		1.5		53.4		3.4		55.3	55.3	26.9
30						17.0		25.4	25.4	8.5

Note: (a) Costs from GSL Proposal adjusted to 15,000 acres (table E5).
(b) Maintenance Costs Rs. 1.3 mln/Yr included for years 6-30.
(c) Harvest costs included from tables E6, E8 and E9.
(d) Shed represents watershed value -: see E10.
(e) Albizia used for Pulp and Calliander for fuelwood.
(f) Pinus yield of 2220 ft3/a w/25 yr rotation
(g) Complete defined as 100% of estimated value of timber at harvest.
(h) Selective defined as 50% of the value of timber at harvest & represents the estimated cash value of selective cutting.

TABLE E 21

Reforestation Project
Alternative No. 3 (d)
(Rs. Million)

Year	Costs: Investment	Costs: Operating	Costs: Donor	Benefits: Pine	Benefits: Albizia	Benefits: Calliandra	Benefits: Shed	Net Benefits: Complete w/o shed	Net Benefits: Selective w/shed	Net Benefits: Selective w/o shed
1	2.6	.7	4.6					- 7.9	- 7.9	- 7.9
2	3.3	.8	5.4				0.5	- 9.5	- 9.0	- 9.[illegible]
3	4.6	1.0	3.2				1.0	- 8.8	- 7.8	- 8.8
4	4.8	1.3	3.5			3.4	1.5	- 6.2	- 4.7	- 7.9
5	4.9	1.4	0.3			3.4	2.0	- 3.2	- 1.2	- 4.9
6		1.5				3.4	2.5	1.9	4.4	0.2
7		1.5				3.4	2.5	1.9	4.4	0.2
8		1.5				6.8	2.5	5.3	7.8	1.9
9		1.5				3.4	2.5	1.9	4.4	0.2
10		2.0		10.1		3.4	2.5	11.5	14.0	4.8
11		1.9		10.1	45.6	3.4	2.5	57.2	59.7	27.7
12		2.1		10.1	45.6	6.8	2.0	60.4	62.4	31.3
13		1.9		10.1	45.6	3.4	1.5	57.2	58.7	27.7
14		1.9		10.1	45.6	3.4	1.0	57.2	58.2	27.7
15		2.5		13.3	45.6	3.4	0.5	59.8	60.3	28.7
16		1.7		13.3		6.8		18.4	18.4	8.4
17		1.5		13.3		3.4		15.2	15.2	6.9
18		1.5		13.3		3.4		15.2	15.2	6.9
19		1.5		13.3		3.4		15.2	15.2	6.9
20		2.4		17.9		6.8		22.3	22.3	9.9
21		1.9		17.9	45.6	3.4		65.0	65.0	31.6
22		1.9		17.9	45.6	3.4		65.0	65.0	31.6
23		1.9		17.9	45.6	3.4		65.0	65.0	31.6
24		2.1		17.9	45.6	6.8		68.2	68.2	33.1
25		7.4		177.7	45.6	3.4		219.3	219.3	106.0
26		1.5		177.7		3.4		179.6	179.6	89.1
27		1.5		177.7		3.4		179.6	179.6	89.1
28		1.8		177.7		6.8		182.7	182.7	90.1
29		1.5		177.7		3.4		179.6	179.6	89.1
30					8.4	17.0		25.4	25.4	12.7

Note: (a) Costs from GSL Proposal adjusted to 15,000 acres (table E5).
(b) Maintenance Costs Rs. 1.3 mln/Yr included for years 6-30.
(c) Harvest costs included from tables E6, E8 and E9.
(d) Shed represents watershed value -: see E10.
(e) Albizia used for pulp and Calliandra for fuelwood.
(f) Pinus yield of 7388 ft3/a w/25 yr quotation.
(g) Complete defined as 100% of estimated value of timber at harvest.
(h) Selective defined as 50% of the value of timber at harvest & represents the estimated cash value of selective cutting.

ANNEX F

ANALYSIS OF PROTECTIVE VALUE OF A WATERSHED

Introduction:

The effectiveness of a watershed in minimizing soil erosion and the stabilization of flows depends on several factors. These include primarily: (a) the physical and chemical properties of soil, (b) the gradient of the physical landscape, (c) the kind of rain, and (d) the use and management of landscape. Unfortunately there is little that can be done to control the soil erosion due to natural phenomenan as indicated by the first three factors; it is only in the case of the latter that effective policies can influence and control soil erosion at least to some extent.

The most serious threats to effective watershed management come from the inconsiderate clearing of forest cover and land uses which do not conform to the physical landscape and characteristics of the watershed. These practices invariably increase the rate of run-off from watershed by exposing the soils to the natural elements. This in turn increases the momentum of rapid soil erosion processes.

It is, therefore, apparent that there is a close relationship between the vegetative cover and the soil erosion in any watershed. A change in the vegetative cover affects soil erosion through changes in the rate of run-off. Soil erosion, in turn, affects agricultural production, the volume of water in the river, flood levels in the downstream, the water-retaining capacity of the soils etc. If these relationships can be quantified, an economic assessment of soil erosion can be made which in turn can be related to changes in the vegetative cover of the watershed.

Significance of the Analysis

The ecological soundness of the upper Mahaweli catchment area is critically important to economic development at both national and regional levels. This region consists of an economic system which brings foreign exchange to the country as well as providing employment in large numbers to the unskilled labour force. The upper Mahaweli catchment also supplies nearly 50% of the water to the Mahaweli river system which provides the main source of water supply to the irrigable lands under the accelerated Mahaweli Development Project. Any changes in the physical characteristics of the upper Mahaweli will undoubtedly have effects on the economic systems of the upper catchment itself as well as on the lands where the Mahaweli system provides water for irrigation.

The evidence of soil erosion in the upper Mahaweli catchment is apparent from the gullying of the lands in the watershed as well as from visual observations of sediment levels in the stream. Approximately 1.3 million acres in extent, the upper Mahaweli was completely covered with natural forest a few centuries ago. At present, the

region is largely used for commercial agriculture plus subsistence agriculture and homegardening associated with settlements in the region. This trend appears to be still continuing at a considerable rate, which is clearly reflected in the reduction of forest cover from 298,000 acres in 1958 to 114,000 in 1975.

The purpose of this study is to analyse the effects of the changes in physical characteristics of the upper Mahaweli, in particular, to examine the effects of the reduction of forest cover on the rate of run-off and soil erosion. Furthermore, an attempt is also made to provide an economic assessment of deforestation by quantifying, as far as possible, the volume of run-off and soil erosion. However, this study is not based on direct empirical investigation. Rather it is based on extrapolation of available data in published reports and documents. The analyses therefore, captures only the broad trends that result from deforestation in the upper Mahaweli Catchment.

Methodology

The only two sets of time series data available for this study were run-off and rain-fall. This limitation compelled the analysis to be dependent on several assumptions. These assumptions will be dis - cussed in the relevant sections of the text.

The study estimates the values of several variables which constitute part of the protective value of a watershed. Following is a brief outline of the methodology used in arriving at estimates of these variables.

(a) Run-off from Upper Catchment

Simple regression and correlation techniques were used to establish the relationship between rainfall and run-off. A comparison of run-off was also made between the estimated value for the upper Mahaweli Catchment and the values based on the probability of run-off from catchment areas, given the catchment characteristics.

(b) Soil Erosion: The soil content of run-off water was measured by applying the conversion factor of .5 acre foot per square mile. The conversion factor suggested in the Mahaweli Ganga Irrigation and Hydropower survey was 1 acre foot per square mile. This figure was, however, not used in order to avoid probable over-estimation of the effects of deforestation. The measurement of soil erosion was then translated into monetary values by calculating the effects of loss of soils on agricultural development.

(c) The Value of Water in the Mahaweli system: The past flood peak levels in the Mahaweli system indicated a change in the flood level. Assuming that the annual flow of water in the Mahaweli system shows similar trends, an economic assessment was made to analyse the effects of changes in the annual water flow.

Rainfall and Run-off Relationship:

Time series data on rainfall (independent variable) and run-off (dependent variable) for five stations (Morape, Watawela, Hollbrook, Talawakelle and Peradeniya) were collected from the records of the Department of Irrigation and were used to run five separate regression analyses. The values of regression coefficients, correlation coefficients and the coefficients of determination are indicated in table I.

As can be seen from table I, the relationship between run-off and rainfall, indicated by the correlation coefficient (r), is fairly good for Hollbrook, Watawela and Peradeniya. As for other stations the (r) values indicate a relatively poor relationship.

The correlation between rainfall and run-off alone is not sufficient to provide the link between the run-off and deforestation. Even to provide an indirect link, in the absence of land use data, a few steps are needed. First, the trends in rate of run-off must be examined overtime. Secondly, the degree of run-off in the upper catchment during the recent past must be observed. If these two factors show anomalies, then these exceptions must be analysed in terms of changes in the vegetative cover in the upper Mahaweli Catchment.

Trends in Rate of Run-Off:

The residuals of the regression analyses provide the basis to examine the trends in rate of run-off in the upper Mahaweli Catchment. The residuals are the difference between the observed and the predicted values. A minus residual value indicates a lower run-off rate than expected and a positive value indicates a run-off above the level expected on the basis of the rainfall - run-off relationship.

The residuals of the five stations are indicated in table II. In 4 stations, the residuals show a systematic distribution with minus residual values at the early years of the time series and positive values towards the end of the period. In otherwords, an increasing trend in the rate of run-off in the upper catchment is indicated by the residual distributions of Peradeniya, Watawela, Hollbrook and Talawakelle. This suggests that some other factor besides rainfall has had an increasing influence on the rate of run-off.

A Comparison between the Observed values and the values based on Probability:

The amount of run-off largely depends on the slope, vegetative cover, and the soil characteristics of the watershed. These factors, known as the catchment characteristics, affect the relationship between rainfall and run-off and also influence the regional variation in run-off within the catchment area. If these factors are known and can be measured, the amount of run-off from a watershed can be estimated by using values based on probabilities, expressed as percentages shown in table III.

Alternatively, if the rate of run-off is known, a description of catchment characteristics can be made in broad terms by comparison with values in table III. In additiin, it two characteristics of the catchment are know, as well as the rate of run-off, then the other characteristics can be found from table III which most nearly fits the rate of run-off.

Table III shows that the lowest run-off in any catchment area is around 25%. This refers to heavy grass cover (10) on deep, well drained soils (10) and very flat to gentle slope (5). On the other hand the highest rate of run-off is around 95% which refers to bare eroded cover (25) on impervious surface (50) and mountainous slope (25). Furthermore, the table III reveals the extent to which the removal of forest cover could affect the rate of run-off in a catchment area. About 25% of the rate of run-off is determined by the slope characteristics, and there is very little that can be done to control the run-off due to slope variation. Out of the balance, there is a minimum rate of which is around 20%. Therefore, at least 55% of the rate of run-off depends on the characteristics of cover and the soil type and drainage. This means that by modifying the vegetative cover, the rate of run-off changes directly by 15% and indirectly by 40% as a result of changes in soil erosion associated with the rate of run-off.

In order to make an assessment of the rate of run-off in the upper Catchment in terms of probabilities given in table III, the pro - portion of the rain which becomes run-off has been calculated for all five stations. This has been done by using the following formula:

$$C = \frac{\overline{Y}}{\overline{X}} \times 100$$

C = Proportion of the rain which becomes run-off expressed as a percentage.

$\overline{Y}$ = Mean annual run-off in inches.

$\overline{X}$ = Mean annual rainfall in inches.

The values for C for the five stations are as follows:

Morape - 67%

Watawela - 30%

Hollbrook - 58%

Talawakelle - 55%

Peradeniya - 63%

In comparison with the probabilities of run-off in Table III, it can be seen that the rate of run-off, except Watawala, has reached critical levels. For example, taking the slope characteristic to be hilly or steep gives a run-off value of 20%, while the moderately impervious soil gives a run-off value of 20%. These two characteristic together account approximately 40% of the run-off in the upper catchment. The difference between this value and the calculated values for five station, therefore, refers to the cover characteristics of the upper catchment. Accordingly, the corresponding values of cover characteristics for Morape, Holbrook, Talawakelle and Peradeniya are 27%, 18%, 15% and 23%, respectively. With reference to the values of cover characteristics in table III, these values indicate cover characteristics from medium grass cover to bare or eroded cover. In the case of Morape and Peradeniya in particular, the run-off values indicate an alarming situation which obviously requires immediate attention.

The effects of deforestion on run-off:

So far, the analysis, was concentrated on the rate of run-off in the upper Mahaweli catchment. First, the rainfall and run-off relationship was established. Secondly, the rate of run-off over time was considered and thirdly, the rate of run-off was compared with the values of probabilities based on catchment characteristics. Next step is, therefore, to relate the run-off to deforestation trends in the upper catchment.

Unfortunately, it is not possible to establish the direct relationship between deforestation and run-off due to lack of time series data either on land use change or the reduction in forest cover. However, it is possible to establish the relationship between the two variables indirectly. To show this indirect relationship, the run-off and rain-fall indices were preapred for Peradeniya, Walawala and Hollbrook. These indices were not preapred for Morape and Talawakelle because of the poor relationship between rain-fall and run-off reflected in the low correlation coefficients.

In all three stations the base year was the year when the first set of data was available, The selection of the base year in this manner created one serious problem, i.e. the values in the index are dependent upon the base year value. Therefore, the final outcome as well as the interpretation of results are to a great extent determined by the base year of value. Unfortunately, there is no other method which is superior to the above method. Table IV is prepared based on the values of rain-fall and run-off indices for Peradeniya, Watawala and Hollbrook. The values shown are the average changes in rain-fall and run-off. For example, the rainfall in Peradeniya has increased by 20% per annum during 1945-1976, where as the run-off has increased by 52% per annum.

In order to determine the run-off due to deforestation, it was necessary to separate the normal run-off from the run-off due to deforestation. This was determined by calculating the expected run-off given rain-fall, using the b coefficients of the earlier regression equations. The difference between the run-off and the expected run-off due to rainfall was taken as the run-off resulting from deforestation. These values are indicated in Table V.

According to the table, the run-off has increased by 52% and the increase in run-off due to reduction of forest cover is 33%. As the ratio of run-off due to reduction of forest cover to total run-off is around 63% for Peradeniya and 20% for Walawela. This means that, a reduction of forest cover by 1% increases the run-off volume by .63% for Peradeniya and .20% for Watawela.

Run-off and Soil Erosion:

The soil erosion due to run off varies from place to place depending upon the vegetative cover. The higher the vegetative cover the lower the soil erosion and vice versa. A relatively small change in plant cover could result in a large difference in soil erosion. Therefore, there is a considerable regional variation in soil erosion within a catchment area which is not reflected in the relationship between the rain-fall and run-off. To identify these variations, the data on land use change over time is needed, and it must be correlated with the rain-fall and run-off.

In the absence of these data, an attempt is made to calculate the annual volume of soil erosion based on assumptions. One assumption used in design by the Department of Irrigation is that the annual sediment discharge is equal to .5 acre foot per square mile. The soil erosion has been estimated by using the above conversion factor, and the results are shown in Table VI.

Deforestation and Soil Erosion:

The estimate of the soil erosion in the upper catchment was made on the assumption that the excess run-off of Peradeniya, which was considered to be due to deforestation, reflects the run-off characteristic in the entire Mahaweli upper catchment. Although, this makes the study less accurate, the extent of catchment area at Peradeniya which is about 1/2 of the entire upper Mahaweli catchment, and the lower conversion factor used to estimate the soil volume will probably reduce any inaccuracy in the estimate.

Table VII gives estimated values of soil loss for Peradeniya and the upper Mahaweli catchment. These estimates were derived by first separating the increased run-off (i.e. 52%) from the total run-off and from that again separating the volume of run-off due to

deforestation (i.e. 33% ÷ 52% = 63%). The conversion factor of .5 acre foot per square mile was then applied to obtain the soil loss and it has been expressed in terms of acreage in the table.

The soil loss has been calculated in terms of three categories, i.e. (a) acre feet of soil (b) acre plow layer of soil, and (c) acre inch of soil. The first category assumes that the soil erosion is concentrated to an extent of 1 foot of soil; the second assumes 6 inches of soil while the third assumes only 1 inch of soil.

Economic Assessment of soil erosion:

The most serious affect of soil erosion is on the land use. As a consequence of soil erosion, the changes in land uses become inevitable and the changes are often from good agricultural uses to an agricultural use with lower productivity . Occasionally, soil erosion affects land use to an extreme extent, e.g. in the first category in Table VIII that the land becomes a complete wasteland.

Obviously there is an economic loss resulting from changes in one agricultural type to another, The main cause of this economic loss is the soil erosion and, as this study shows, this in turn is caused by deforestation. Therefore, the economic loss resulting form changes in agricultural type must be directly linked to the effects of deforestation.

Table VIII shows the economic loss due to deforestation in the upper catchment. The economic loss has been calculated with reference to the three categories indicated in Table VII. In calculating the economic loss, the following assumptions were made:

(1) First category: In this category the soil has been removed to an extent of 1 foot of soil. Consequently, the land becomes a wasteland. Therefore, the loss is equal to the higher per acre value, i.e. about Rs.15,000/-.

(2) Second category: The acreage indicated in this category has been obtained by assuming that the soil has been removed up to 6 inches. As a result, the agricultural type changes from highly productive agricultural type, to one with low agricultural type. E.g. changing from tea cultivation to chena. The loss is therefore, equal to the difference in the two types. This difference was assumed to be around Rs.12,000/-.

(3) Third category: Since the soil loss is 1 inch, the effects of soil erosion on agricultural production is not that serious. The land can be improved to obtain the productivity through appropriate land control measures. The cost of this control measures has been calculated to be around Rs.750/-. This figure includes the estimates of labor cost for land preparation and manuring plus the cost of manuring.

The first row in Table VIII indicates the total loss according to each category, while the second row indicates the loss in terms of reduction of 1 acre of forest cover. The values in row 2 were derived by dividing the total loss in each category by the annual average reduction of forest cover which is estimated to be around 8736 acres per annum based on 1958 to 1975 figures.

The run-off water which carries soil from the upper catchment area bring soils as bed load to the down stream and deposits at least part of the soil along the river banks and low elevated areas in the lower catchment area. This has both desirable and undesirable effects. Increased productivity as a result of these deposits is a desirable effect while the loss of productivity due to the deposits of silt and the loss of agricultural lands due to water logging are the undesirable effects. If it can be assumed that the desirable and undesirable effects are roughly equal, then the effects in the lower catchment area resulting from soil erosion from the upper catchment area balance out and under this assumption, the soil erosion effects the agricultural production only in the upper catchment area.

Deforestation and the Annual flow of water in the Mahaweli system:

The examination of flood levels at Peradeniya, indicated in Annex A of the Mahaweli Ganga Development Program Implementation Strategy Study Part 1, revealed a declining trend of flood levels over time, According to this source, the 1,000 year flood peak was 210,000 ft^3 the 100 year peak was 146,000 ft^3 and the 20 year oeak was 106,000 ft^3. The flood level of the 100 year peak was 30% lower in relation to the 1,000 year peak while the 20 year peak was 27% lower in relation to the 100 year peak and 77% lower in relation to the 1,000 year peak. However, it is not known when these flood peaks occured.

The same study has observed fluctuation in the rainfall cycle, during recent years. The index for Peradeniya calculated for in the analysis, also indicated a reduction in annual rainfall overtime with high positive values about the mean annual rainfall distributed towards the beginning of the time series. Perhaps the fluctuations in rainfall is related to the vegetative cover through changes in evapotranspiration.

If the lowering of flood peak level is a continuing trend and the lowering of water level is common throughout the year, then this phenomenon will have serious consequences on agricultural development on the lower catchment area, because the annual water supply for irrigable lands under the accelerated Mahaweli scheme depends on the annual flow of water in the Mahaweli system. The Mahaweli Project estimates that the annual flow of water from Mahaweli which amounts to 5,956,000 acre feet per annum will provide irrigation for 700,000 acres of paddy or 1,300,000 acres of other crops for which the water requirement is lower than paddy, e.g. groundnuts, sugar, etc. This will give the per acre requirement of water as 8.5 acre feet for paddy and 4.5 acre feet for other crops.

The accelerated Mahaweli Project plays a vital role in the economic devleopment process of the country, Therefore, if there is a tendency to lower the volume of water in the Mahaweli system, the consequences will undoubtedly be to reduce the economic progress through the loss of agricultural production. In order to examine the possible consequences of lowering the water level, it was assumed that past trends will continue with a reduction of water volume by .27% per annum, which is the average annual reduction calculated from data on flood peak levels.

The reduction in water volume by .27% per annum will reduce the water by 16,081 acre feet per annum. This reduction will reduce the supply of water to 1888 acres under paddy or 3565 acres under other crops per annum. If the entire reduction is on paddy, the agricultural loss is equal to the gross income from paddy for 1888 acres, which is approximately around Rs.6,025,760 (see Table IX). On the other hand, if the reduction is entirely on the other crops, the loss is approximately around Rs.10,694,000. If this loss is related to the deforestation in the upper catchment, a one acre reduction of forest ocver reduces paddy income by Rs.688/- or Rs.1,224/- in the case of other crops.

Conclusion:

Although this study is based on several assumptions, there is substantial evidence to indicate that the deforestation in the upper catchment area has seriosu economic implications. As shown in the summary of economic losses in Table X, the deforestation has a soil value in the upper catchment calculated with reference to the changes in agricultural type. It also has a water value in the lower catchment due to possible reduction of annual water volume.

REFERENCES

1. Hudson, N.W., Field Engineering for Agricultural Development, Oxford University, Press, 1975

2. Nedeco, Mahaweli Ganga Development Program, Annex A. October 1978.

3. UNDP/FAO, Mahaweli Ganga Irrigation and Hydropower Survey, Volume 1, 1968

4. Weatherly, Paul and Arnold, John(Jr.) Environmental Assessment of Stage II of the Mahaweli Ganga Development Project. September 1977

TABLE I

Values of regression coefficients, correlation coefficients and the Coefficients of determination:

Station	$Y = a + bx$	Correlation Coefficient (r) Coefficient of determination (r^2)	Mean of Annual rainfall $\overline{X}$, and Runoff $\overline{Y}$	Ratio expressed as a % $\overline{Y}/\overline{X} \times 100$
Morape	a = 46.8756 b = .2569	r = .4664 r^2 = .2175	$\overline{X}$ = 110.01 $\overline{Y}$ = 74.14	67%
Watawela	a = 8.5519 b = .25378	r = .7524 r^2 = .5661	$\overline{X}$ = 159.86 $\overline{Y}$ = 49.12	30%
Hollbrook	a = -28.3734 b = .88847	r = .6827 r^2 = .46610	$\overline{X}$ = 93.11 $\overline{Y}$ = 54.35	58%
Talawakelle	a = 28.704 b = .2709	r = .4536 r^2 = .2058	$\overline{X}$ = 99.64 $\overline{Y}$ = 55.69	55%
Peradeniya	a = -33.158 b = .9367	r = .85815 r^2 = .7364	$\overline{X}$ = 110.80 $\overline{Y}$ = 70.63	63%

TABLE II

The distribution of residuals of the selected stations:

	Peradeniya	Morape	Watawela	Hollbrook	Talawakelle
1945	- 7.0				
46	- 13.11				
47	- 15.42				
48	- 13.57				
49	- 2.72				
50	- 9.96	1.17			
51	- 3.79	.88			
52	9.85	22.61			
53	- 0.85	- 8.536			
54	- 2.15	1.21			
55	2.75	13.71			31.85
56	.88	12.48			1.42
57	4.98	1.586			- 12.95
58	10.65	9.77	- 1.86		- 4.45
59	- 0.42	4.81	7.6		- 1.1
60	12.09	- .28	- .23	- 1.26	- 4.39
61	8.49	9.347	- 3.31	- 12.37	- 1.67
62	- 7.93	- 1.97	- 4.59	4.36	- 11.24
63	- 10.07	- 11.86	- 4.91	- 1.32	- 6.73
64	9.59	- 3.92	- 1.22	- 6.02	- 7.16
65	- .52	- 16.70	- 1.92	- 6.37	- 10.32
66	- 4.39	- 27.06	- .31	- 10.28	- 2.89
67	6.9	- 5.23	- 4.97	3.68	21.75
68	8.28	10.68	1.29	- 3.22	3.02
69	5.82	7.902	5.15	- 3.79	4.12
70	4.56	- 6.9518	5.66	4.15	12.07
71	4.30	7.0074	14.04	- 7.19	8.47
72	3.52	- 6.33	2.99	10.32	2.98
73	- 3.45	- 9.587	- .66	8.28	23.34
74	- 3.45	4.633	- 14.09	15.33	- 23.13
75	- 16.60	7.75	5.91	21.99	- 11.47
76	13.22	- 8.85	12.78	- 11.04	- 11.75
77	6.71	- 22.33		30.66	
78	1.08				

TABLE III

Run-off Probabilities:

Cover		Soil type and drainage		Slope	
Heavy Grass	10	Deep, well drained soils	10	Flat to gentle	5
Scrub or Medium) Grass)	10	Deep, moderately pervious	20	Moderate	10
Cultivate lands	20	Fair Permeability	25	Rolling	15
Bare	25	Shallow soils	30	Hilly or steep	20
		Medium heavy clays or rocky surfaces	40	Mountains	25
		Impervious surfaces	50		

Source:

Field Engineering for Agricultural Developments, P.44

TABLE 1V

Run-off and Rainfall relationship overtime

	Run-off	Rain-fall
Peradeniya	+ 52%	+ 20%
Watawela	+ 21.5%	+ 14.0%
Hollbrook	+ 9.5%	+ 12.5%

TABLE V

Observed Run-off and Estimated Run-off based on time series data

	Run-off	Estimated Run-off	Run-off due to deforestation
Peradeniya	52%	18.7%	33.3%
Watawela	21.5%	3.5%	18.0%
Hollbrook	9.5%	11.1%	-

T A B L E VI:

Estimated soil erosion of Selected Stations

	Acre feet of soil	Acre plow layer of soil	Acre inch of soil
Watawela	37.5	75	450
Talawakelle	145	290	1740
Peradeniya	554	1108	6688
Norape	277	554	3324
Hollbrook	60	120	720

TABLE VII

Estimated soil erosion from the Upper Mahaweli Catchment

	Peradeniya	Upper Catchment
Extent of the Area	709120	1,300,000
Acre feet of soil	214	400
Acre plow layer of soil	428	800
Acre inch of soil	2568	4800

TABLE VIII

Estimated Economic Loss due to Deforestation

	First Category [1]	Second Category [2]	Third Category [3]
Economic loss	Rs.6,000,000	9,600,000	3,600,000
Per Acre of forest cover	Rs. 686,000	[illegible] 000	412,000

1 Acre foot of soil

2 Acre Plow layer of soil

3 Acre inch of soil

TABLE IX

ECONOMIC LOSS IN AGRICULTURE DUE TO CHANGES IN ANNUAL WATER VOLUME

	Acreage	Average income Per acre (Rs.)	Total loss Per annum (Assuming two seasons Rs.)	Loss interms of 1 acre of forest cover (Rs.)
Paddy [1]	1888	1600	6,041,600	688
Others [2]	3565	1500	10,695,000	1224
Average				956

1 Paddy average income = 40 Bushels per acre x Rs.40/- per bushel

2 Others " " = Average of Chillies, Ground-nut, Sugar and Vegetables

TABLE XI

SUMMARY OF ECONOMIC LOSSES

Upper Catchment soil value			Lower Catchment water value	
Category	1	Rs. 686	Paddy	Rs. 688
Category	2	Rs. 1098	Others	Rs. 1224
Category	3	Rs. 412		
Average		Rs. 732	Average	Rs. 956

Annex G 1

දුරකථන/தொலைபேசி/Telephone

අමාත්‍යවරයා அமைச்சர் Minister	31161
නියෝජ්‍ය අමාත්‍යවරයා பிரதி அமைச்சர் Deputy Minister	33496
ලේකම් காரியதரிசி Secretary	35392
පෞද්ගලික ලේකම් சொந்தக் காரியதரிசி Private Secretary	33380
කාර්යාලය அலுவலகம் Office	31350

ඉඩම් හා ඉඩම් සංවර්ධන අමාත්‍යාංශය
காணி, காணி அபிவிருத்தி அமைச்சு
MINISTRY OF LANDS & LAND DEVELOPMENT

මගේ අංකය / எனது இல. / My No. .....

ඔබේ අංකය / உமது இல. / Your No. .....

තැ. පෙ. / த. பெ. / P. O. Box 512

500, ටී. බී. ජයා මාවත
500, டீ. பீ. ஜயா மாவத்த
500, T. B. JAYA MAWATHA

කොළඹ 10/கொழும்பு 10/Colombo 10.

21st May, 1979.

Dr. Hugh Bollinger,
Team Leader,
USAID Team,
Havelock Tourist Inn,
Colombo.

Dear Dr. Bollinger,

I am sending herewith a note on the Government Policy on the Forestry Sector. Also you will find enclosed a copy of the Forest Department programme.

Yours faithfully,

S. B. Baudusena

S.B. Baudusena
Deputy Director (Development)
for Secretary,
Ministry of Lands & Land Development.

GOVERNMENT POLICY ON THE FORESTRY SECTOR

Backbround

1. In 1958 Sri Lanka had a forest cover of around 8 million acres equivalent to 50% of the total land area. Within two decades of 'development' the forest cover has been reduced to around 25%. The Wet Zone of Sri Lanka where the catchment areas of the country's major rivers feeding the massive irrigation net works is located, has a forest cover of only 9% of its total land area. Frequest in-roads are being made to this very minimal forest cover due to pressure from local interests. With the implementation of the Accelerated Mahaweli Programme, over a million acres of forest land will be cleared within the next 5 years, further reducing the available forest cover.

2. Pressure on forest in the immediate future

In the next few years there will be an unprecedent pressure on the remaining forests particularly in the more populated areas for

i) fuel wood - 94% of households in Sri Lanka still use fire wood for cooking purposes and the demand for this is likely to increase with the price escalations of kerosene and other fossil fuels.

ii) Building and furniture industry - the present annual demand for sawn timber is in the region of 10 million cubic feet while the local supply at best would be 2-4 million cubic feet. While the balance is expected to be imported, there is no doubt that through illicit fellings and exploitation of private timber resources inroads would be made into the available forest cover.

iii) Settlement - with the increase in population, villate forests are being encroached upon for village expansion and other forms of settlement.

3. Policy

The Government is fully aware of the seriousness and the magnitude of the problem and hence embarked upon a policy on conservation and afforestation.

i) Conservation - Government has laiddown a policy of moratorium on felling of jungles. By conservation Government expects to bring a balance in the ecology. It is expected that the adverse effects of de-forestation on weather patterns and the environment would minimise.

ii) Afforestation - Hand in hand with the conservation Government has decided that the afforestation too should take place.

a) Afforestation in the catchment areas in the major rivers and irrigation systems

Programmes for planting up the Upper Mahaweli catchment area with foreign assistance and to plant up ravines, gullies in the plantation areas through the State Plantation Corporation and the private estates and through voluntary organisations has already been initiated. Action on other river basins too will betaken up.

b) Afforestation for fuel wood

A programme has already been initiated to establish 7000 acres of fuel wood in the Mahaweli Development Area. Under this programme it is expected to plant 70,000 acres during a period of 10 years.

iii) Home Gardens - For reasons of economy and convenience it is essential that fuel wood is made available as close to the consumer as possible. Hence a programme to grow Ipil Ipil in home gardens all over the island is being initiated to meet the impending shortage of fuel wood in rural areas, evoking public consciousness and awareness. Apart from co-ordinating the above activities there is a need to evoke public consciousness for a more positive realization of the inter-dependence and indispensability of forests for

productivity and environment development. There is a need for a nation-wide programme to bring about the desired social controls and management into this planting effort.

a) Publicity campaign by mass-media Newspapers, Radio, Films and by Television;
b) Tree Planting Campaign;
c) Participation of villagers through R.D.SS., Tembles, Schools andother voluntary organisations.

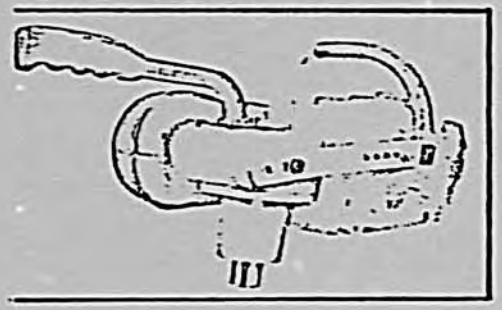
iv. Development of Technology - A Committee has already been appointed to examine and recommend ways and means to prevent wasteful use of timber in the buildings and the furniture industries and to rationalise and optimse their utilisation.

ANNEX G 2

Mike

ANNEX G-2

SPECIAL!
Auger Planting Equipment



CANNON TREEPLANTERS
THE DH-2 "W-SERIES"

- Approximately half the R.P.M.s of the Standard model.
- Works very well in rock and clay soils.
- Leaves all soil withing 6" from the perimeter of the hole.
- Advise 1.8 Cu. In. saw or larger.

$195 SALE
REG. $219.95

Available at sale price for Homelite, McCulloch, and Stihl chain saws only. (16 tooth sprocket—3/8 pitch drive chain.)

CALL TOLL FREE 1-800-345-0597
OR WRITE FOR FREE CATALOG

AUGER PLANTING EQUIPMENT SALE

We're specialists! We design, manufacture, and sell more reforestation equipment and supplies than anyone in the world. Planting hoes, dibbles, containerized planting gear, treebags, and tree packing systems. Cannon auger gearboxes, carbide augers, special planting shovels, KEC planting bars, Vexar® tubing, brush clearing tools, and your custom tool manufacturing.

That's our business. If you're involved in reforestation, we've got the tools you need, when you need them!

International Reforestation Suppliers
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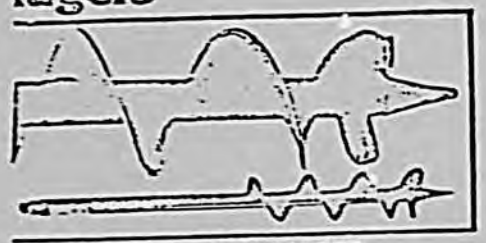
ATTENTION: REFORESTATION PERSONNEL

Augers



STANDARD "1000" AUGER

The Standard 1000 Auger offers all the same features as the Carbide 1000 except that only the tip and cutting edge are carbide treated. Designed to fit the Cannon Gear box.

$112.95

- Designed for better soil conditions

CARBIDE "1000" AUGER

This is the longest lasting, high production, low maintenance auger on the market! Designed to fit the Cannon Gearbox.

- Continuous carbide treatment, not just coated or hard-faced, but silver soldered to moly-chrome steel for maximum wear and protection in even the most severe soil conditions.
- Replaceable tip is milled to protect carbide from breaking off.
- When field tested against the leading Augers, the Carbide 1000 Auger outlasted the others 10 to 1.
- Cutting edge is carbide tipped on all three sides with two full rows of carbide.
- This is one piece of solid equipment! No more expensive tips to replace or take in for daily hard-facing. Down time means money!
- Shop and compare our low price!

SALE PRICE **$174.95**
REG. $185.00

THE INT-REF SCALPING TOOL

Designed specifically for hand scalping and site preparation.

- Scalping edge is a full 9" wide.
- Buy the Scalper complete or just the blade and bolt it on to your planting hoe handle casting.

$23.95
(Blade only $14.50)

Treebags

Introducing the all new EASY RIDER multi-component treebag!

THE BASIC BAG

This is the best bag we've ever built! All of our new components fit our basic bag—just add them on!

- Made of Neoprene coated nylon that is puncture and tear resistant, abrasion resistant, impervious to oil and grease, and stays soft and pliable at low temperatures.
- Fully double stitched with 16 ounce Dacron bonded polyester thread—NO GLUE OR WELDING.
- Double thickness bottom.
- Super stitched at all stress points.
- Separate split containers with the same capacity as the old conventional design, but a much easier ride on the hip.
- New stay open corners.
- 2" nylon webbing with a breaking strength of six thousand pounds.
- Non-slip buckles.
- Available in two sizes: Regular, 9" X 9½" X 13" (each compartment), or Deep, 9" 9½" x 15" (each compartment).

$16.95

SHOULDER HARNESS SYSTEM

Designed exclusively for us by a leading backpack manufacturer, this new harness will help distribute the weight of your trees equally between your shoulders and hips.

- Features Cordura covered 3/8" polyethylene shoulder pads.
- Fully adjustable 2" webbing.
- Fastens quickly to our basic bag.
- D-rings on back for quick attachment of our new auxiliary bag.

$10.00

HIP PAD

For maximum hip comfort this 5" X 9" X 3/8" Cordura covered polyethylene foam pad loops easily through basic bag belting. All part of the EASY RIDER treebag from International Reforestation Suppliers.

$1.95

DOUBLE COMPARTMENT DIVIDER BAG

This is a bag design that has been around for quite some time. We have many customers who prefer this design and many more who like the split bag design. Now the choice is yours!

- Can be used with or without our Shoulder Harness system and Hip Pad
- Available in two sizes: regular 9" X 9½" X 13" (each compartment), deep 9" X 9½" x 15" (each compartment)

THE PLUG PACKER

Because of such great demand, tremendous capacity, and room for empties, we're re-introducing the Plug Packer. Using the same fine construction qualities of our Easy Rider multi-component treebag, attach our shoulder harness system and you've got one of the best packing units available.

- 300-8" plug capacity with the right side bag for empties
- Dimensions (each compartment) 8" X 11" - 15" deep
- 3 separated compartments that ride easier on the hip

$22.95

TREEBAG INSULATION INSERT

When inserted in our Double Compartment Divider Treebag the insulation insert will:

- Increase production by extending your tree planting day.
- Decrease seedling mortality due to heat and moisture loss from within the treebag.

Now you can maintain the original temperature and moisture content by surrounding seedlings with a ½" thick polyurethane open cell foam liner. The foam liner is covered by a vinyl polyester mesh for rugged long lasting strength.

You will find the same high quality construction in this insulation insert that goes into all of our tree bags and accessories.

Insulation Liner Dimensions: two 15" X 9" X 9½" compartments fastened together.

$15.50 each

Complete with Treebag $29.95

MEMORANDUM

TO: Dr. James Bonner

FROM: ISTI Forestry Team

DATE: June 15, 1979

RE: Deforestation plans in Mahaweli System C

The Forestry Team and the Sri Lankan Conservator of Forests toured System C for possible fuelwood plantation sites. We feel the following observations are appropriate even though this area is somewhat outside our direct project responsibility.

System C of the Mahaweli Development consists of approximately 200,000 acres (85,000 ha). At present only the lower half of the system has been developed. Much of this area is depleted chena, grassland or paddy. Beyond Ulhitiya Oya (the remaining 1/2 of System C), the land is completely forested. No roads or trails lead into this region and no permanent settlements are known. As presently planned, the upper section of System C will be opened for development starting sometime this year with completion of the development by 1983.

The systematic plan calls for clear cutting the majority of this forested area. If 70,000 acres (30,000 ha) are converted into other uses this will represent approximately 2% of the nations remaining forest cover.

Sri Lanka's forests are already under severe pressure certainly beyond the sustainable levels of biological productivity. Demand comes from many factors including fuelwood gathering, illicit felling, commercial uses, and fires. We estimate the decrease in forest cover at approximately 145,000 acres per year. If this trend continues, there will be no remaining forest on the island in 28 years.

In commercial terms, the wood from System C represents :

* 144 million feet^3 of timber (or)
* 3.2 million tons of wood
* 55 per cent of the nations annual consumptions of fuelwood
* Rs: 240 million at wholesale for fuelwood
* 14 times the nations annual shortfall of needed timber

Currently there is an annual shortage of 10 million feet^3 of lumber. This gap is being filled by imported timber and illicit felling.

There is a good potential commercial market for charcoal. The timber from System C could be converted into 640,000 tons of charcoal to service this market. It could sell at Rs: 945/ton over a distance of 100 miles at a 30 per cent profit. A commercial customer (JEDB) has an annual requirement of 32,000 tons of a fuel such as charcoal for tea drying. Currently, JEDB is paying Rs: 1244 for the fuelwood equivalent of one ton of charcoal. The State Plantations Corporation may have a similar requirement as may the State Steel Corporation.

There is also a potential urban market of upto 74,000 tons of charcoal per year as a fuel for cooking. In Colombo the fuelwood equivalent of one ton of charcoal sells for Rs: 1.632, or nearly 70 per cent more than a ton of charcoal. Prospectively there are beneficial foreign exchange implications for the charcoal which could be produced from wood harvested in System C. On the international market it will earn foreign exchange. The current price is Rs: 1600/ton (US$ 100) F.O.B. Colombo. As a substitute for fuel oil it will save foreign exchange. For example, JEDB could use up to 8.7 million gallons of fuel oil per year at a cost of US$ 15 million. Charcoal could help conserve or minimise this foreign exchange expenditure.

During a previous assignment in Sri Lanka (1970), our Soil Scientist had the opportunity to review the field operations and to discuss sugar production problems on the Kantalai Sugar Plantation near Trincomalee. Most of their problems were related to inherent soil conditions including: internal drainage, poor fertility levels, root zone limitation, low moisture availability, and to some extent associated tillage problems. These conditions produced less than satisfactory growth in the sugarcane.

Soil suitability deserves particular emphasis when planning for sugarcane. Given the opportunity, cane will develop proper root distribution to a depth of 5-6 feet. Gravelly layers, firm-in-place subsoils and fluctuating water tables within the root zone can greatly influence root growth and more importantly the tonages of sugar produced.

Regarding System C of the Mahaweli development, our concern is that some of the soils (perhaps upwards of 60 per cent) have similar characteristics and qualities to the soil at Kantalai. In System C these gravelly upland soils are being considered for sugarcane. It is felt that the best use for these types of soils would be to remain in forest cover.

We feel it a realistic suggestion that forest removal be minimized on these marginally productive soils. The settlers will require wood for various uses and this will need to come from somewhere. The forest plantations presently being planned cannot be expected to fill the gaps in the short term. In areas of System C already developed or the result of chena cultivation, fast growing tree species could be utilized for appropriate reforestation. According to the Conservator, these areas have not as yet been released to the Forest Department.

One final comment relates to wildlife planning. The NEDECO consulting group is suggesting a series of wildlife corridors between the various Mahaweli developments and some of Sri Lankas national parks. Properly designed forest plantations or areas of remaining forest could assist in conserving this resource which itself is being reduced to smaller and smaller forested areas. Wildlife tourism is rapidly increasing in Sri Lanka and the opportunity exists to incorporate wildlife concerns into the Mahaweli economic development plan.

We hope this information will be of assistance to your program. Background data and various calculations will appear in the appendix of our project document.

ISTI FORESTRY TEAM
Dr. Hugh Bollinger, Ph.D.
Team Leader.

We suggest c.c. to the following people :

David Thomas, World Bank
John Kreuze, NEDECO
Brian Duncan, Hunting Surveys
J. Erichson/Evans, US/AID
Conservator of Forests
Secretary, Lands & Land Development

SELECTED IMPORTANT INDIGENOUS TREE SPECIES OF SRI LANKA

	Scientific Name	Common Name
Wet Zone	Artocarpus nobilis	Del
	Depterocarpus zeylanicus	Hora
	Diospyros quaesita	Calamander
	Garcinia terpnophylla	Kokatiya
	Pericopsis mooniana	Nedun
	Alstonia scholaris	Rukattana
	Calophyllum bracteatum	Walu
Dry Zone	Chloroxylon sewietenia	Satin
	Pterocarpus marsupium	Gammalu
	Berrya cordifolia	Halmilla
	Mitragyne parvifolia	Halamba
	Chukrassia velutina	Hulanhik
	Diospyros ebenum	Ebony
	Marilkara hexandra	Palu
	Alseodaphne semecarpifolia	Ranai
	Albizia odoratissima	Suriyamara
Intermediate Zone/Montane	Michelia champaca	Gini-sapu
	Careya arboresens	Kahata
	Terminalia belerica	Bulu
	Calophyllum walker	Hill Kina

Annex G 5

IPIL-IPIL

AN

Leucaena - Leucocephala

EXCELLENT **FERTILIZER**

PROBLEM

The raw materials of most of the chemical fertilizers that we use today are mined and therefore they are not renewable. During the past decade the cost of all chemical fertilizers has increased many times and it is very likely that future increases are going to be still more painful.

It was the GRAND DESIGN of NATURE to FEED a PLANT to a PLANT. This was how the natural ecosystems were supposed to maintain their perfect equilibrium. In fact many farmers did use organic manure to fertilise their crops and some still do notably, the Jaffna farmer.

It is well known that the application of inorganic fertilizers has contributed to the increase productivity of land. But what is less known are the ill-effects caused to the soil structure and the environmental factors within a given system and that these items are not debited in the final evaluation formulae of the efficacy of inorganic fertilizers. Furthermore, it has now been calculated that modern technology with ample use of fertilizers REQUIRES NEARLY SIX CALORIES OF ENERGY TO PRODUCE ONE NUTRIENT CALORY. This situation, we all will agree is counter-productive in the Final Analysis specially in view of the fact that most of the energy used is NON RENEWABLE.

POSSIBLE SOLUTIONS

While NO attempt should be made to discourage the use of inorganic fertilizers all ATTEMPTS SHOULD BE TAKEN TO ENCOURAGE THE USE OF ORGANIC FERTILIZERS. This practice is not anything new to our farmers and they would take to it, if suitable sources of organic material is made available to them.

METHOD

IPIL IPIL a fast growing leguminous plant could be one of the many plants that could be propagated as a source of organic manure. It has the following desirable qualities:

(1) It can be continuously harvested once in three months or earlier to coincide with your cropping calendar.

(2) It has the special capacity to produce its own fertilizer — nitrogen

(3) It has a very deep root system with very few laterals while most of our agricultural crops including coconut have a superficial root system. This means that IPIL IPIL will not compete with other agricultural crops (in mixed plantation) but would bring up Nutrients from deep down and fix them in the leaves. This is one of its greatest assets. The nutrient content of its leaves are very high. It has been calculated that FIVE bags of IPIL IPIL leaves has the same nutrient as a bag of common mixed inorganic fertilizer.

A number of prominent research institutes including — International Rice Research Institute (IRRI) have conducted comprehensive research projects to assess the efficacy of IPIL IPIL as a fertilizer and they have documented very favourable results.

The WATER RESOURCES BOARD is now calling upon all public and private sector institutions to organise a Nursery Programme during the coming rainy season in October in order to encourage the cultivation of this plant. A pound of seed with reasonable germination would yield about 7000 plants. Please write to us early giving your seed requirement, so that we can make suitable arrangement for their procurement.

WE DO NOT HAVE ANY SEED NOW IN STOCK FOR DISTRIBUTION

IPIL IPIL
Water Resources Board
P. O. Box 34
Colombo.

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2. Forest Research Institute
Kepong, Selargor
MALAYSIA.

3. Department of Tropical Silviculture
Agricultural University
Wageningen, The Netherlands.

4. College of Forestry
University of the Philippines at Los Banos College
Laguna
PHILIPPINES.

5. Institute of Pacific Island Forestry
U.S. Forest Service
1151 Punchbowl St.
Honolulu, Hawaii 96813
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6. Plant Resources Center (Forestry Department)
CATIE (Research & Training Centre for Tropical Agriculture)
Turriabba, Costa Rica.

7. University of Florida
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8. Colegio Superior de Agricultura Tropical
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9. Institute of Tropical Forestry
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10. Tropical Science Center
Apartado Postal 2959
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11. Mayaguez Institute of Tropical Agriculture
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12. Los Angeles State and County Arboretum
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13. Institute for Mycorrhizal Research and Development
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14. Mycorrhizal Division
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16. Department of Communication
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Table 1

SOILS INFORMATION FOR THE FUELWOOD AND UPPER MAHAWELI CATCHMENT PROGRAMS

Fuelwood Project Sites	Climate Temperature Precipitation	Physiography	Soils	Taxonomic Class	Significant Soil Properties & Management	Fertilizer recommendations N-P-K
1. Lake Mundal (Puttalam Area)	45-50 June-Aug. very dry 81°F	gently rolling plains	Reddish-Brown Earths Non Calcic Brown Soils Low Humic Gley Soils	Rhodustalfs Haplustalfs Tropaqualfs	• Mod. Slow Infiltration • low available soil moisture • firm subsoils	Legumes: 0-20-5 0-20-5 + Dolomite (on non-calcic brown soils)
2. Puttalam Area	- do -	- do -	Reddish Brown Earths Low Humic Gley Soils	Rhodustalfs	• low fertility • gravelly subsoils	Non-legumes: 10-20-5 10-20-5 + dolomite (non-calcic brown-soils)
3. Trincomalee Area	55-60" June-Aug. very dry 81°F	- do -	- do -	Rhodustalfs Tropaqualfs	- do -	- do -
4. West of Batticaloa		- do -	Reddish-Brown Earths Non Calcic Brown Soils Immature Brown Looms Low Humic Gley Soils	Rhodustalfs Haplustalfs Dystropepts Tropaqualfs	- do -	- do -
5. System C	65-75" June-July very dry 81°F	Undulating & rolling hills	Reddish-Brown Earths Low Humic Gley Soils	Rhodustalfs Tropaqualfs	- do -	- do -
Upper Mahaweli Reforestation Sites						
1. Dolosbage Area	100-125" 70°F	Steep mountain terrain	Red-Yellow Podzolic soils	Rhodudults	• low pH (4.5-5.6) • firm subsoils • low fertility	Legumes: 0-20-3 + Ca, Mg, and Boron Non-legumes 15-20-3 + Ca, Mg, and Boron
2. Hatton (Mt.Jean & Mt. Sebastian)Areas	125-150" 70°F	- do -	- do -	Rhodudults	• high erosion potential if exposed	- do -

PROGRAMME OF REAFFORESTATION

REGION	TOTAL EXTENT ACRES	1978	1979	1980	1981	1982	1983	1984
Badulla	832½	-	170	185	177	161	127	12½
Hatton	228	-	80	90	58	-	-	-
Kegalle	31½	-	18½	13	-	-	-	-
Nawalapitiya	3374	150	1290	1204	605	75	-	-
Kandy	849	5	283	166	148	70	70	107
		155	1841½	1658	988	306	197	119½

GRAND TOTAL 5,265 acres.

These figures relate to estates which have been so far visited by the Manager, Crop Diversification Division and there will be so many other extents available on estates of the regions.