

**SUSTAINABLE SUPPLY OF FUELWOOD TO MEET SRI  
LANKA'S ENERGY NEEDS**

**EC DGIB CONTRACT: LKA/B7 - 6201/IB/970538(05)  
Tropical Forestry Budget Line B7 - 6201**

**PROJECT FINAL REPORT  
(including Project Administration Records for 2002)**

**March 2003**

**Ministry for Economic Reform, Science and Technology  
Colombo, Sri Lanka**

**Natural Resources Institute  
University of Greenwich, UK**

## **PROJECT FINAL REPORT**

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# **Project Final Report**

## **Section 1.      Introduction**

## ***a Outline***

This recently completed 5-year Project entitled ‘Sustainable Supply of Fuelwood to meet Sri Lanka’s Energy Needs’ commenced in January 1998. It has been affected through a contract under the EC Tropical Forest Budget Line B7-6201 between the European Commission DGIB and the Natural Resources Institute, University of Greenwich, UK who have also acted as technical consultants to the project.

The project activity has been predominantly located in Sri Lanka under the management of the Ministry for Economic Reform, Science and Technology (MERST, formerly MOST). They have worked in close liaison with NRI and the following Sri Lankan organizations: Department of Forestry, Coconut Research Institute, and Land Use Policy Planning Division.

The overall objective of the project has been to provide a sustainable supply of fuelwood to support Sri Lanka’s development in an environmentally sound manner. In order to do so the project has had the following specific objectives:

- To demonstrate the technical feasibility of short-rotation fuelwood plantations, particularly on degraded lands, as sources of energy for Sri Lanka.
- To enhance institutional capacity in Sri Lanka in the knowledge of fuelwood as a source of energy.

## ***b. Project Bar Chart and Logical Framework***

The bar chart and logical framework of project activities that have been followed are as indicated on annex 1 to this introduction. These documents describe the two major parallel threads of work pursued through this project for wood derived electricity or dendropwer. These activities have resulted in the

- implementation of short-rotation coppicing plantations, and
- production of studies oriented towards the generation of heat and electricity.

## ***c. Progress, previous reports & outline of current report structure***

The progress on this project prior to this report has been recorded through a series of Interim Reports submitted to the EC as a contractual requirement. These reports with an outline of their contents were as follows:

- First Set of Reports October 1998

Contained results of extensive literature survey with CD; selection of trial sites and species; initial forestry consultant visit; derivation of establishment criteria and rationale for overseas visits.

- Second Interim Report and Financial Statement for 1998                      March 1999  
  
Contained record of initial establishment work; Forestry consultancy visit report; First Year Financial Statement.
- Third Interim Report and Financial Statement for 1999                      April 2000  
  
Contained review report on European bioenergy facilities visited on Sri Lankan officers' study tour; update of establishment work at trial sites; joint report of Forestry and Biomass Energy consultants; Second Year Financial Statement.
- Fourth Interim Report and Financial Statement for 2000                      May 2001  
  
Contained NRI consultant report with trial site status information; review report on Indian bioenergy facilities visited on Sri Lankan officer's study tour; Third Year Financial Statement.
- Fifth Interim Report and Financial Statement for 2001                      September 2002  
  
Contained updated record of status at trial plantation sites; reports on progress in dissemination of information for production of heat and electricity from biomass in Sri Lanka, and on actual installations; land use planning information; Fourth Year Financial Statement.

The Financial Statements submitted each year to the EC have included audited accounts of project funds provided by the EC and disbursed by MERST in the execution of the project. Four such audit reports have been already submitted by the appointed auditors, KPMG, and the fifth and final year audit report is contained within the Project Administration Records for 2002 that are submitted together with this report.

Working liaison between project partners within Sri Lanka and EC Delegation Officials has been facilitated through regular Steering Committee Meetings under the Chairmanship of the Secretary, MERST. These meetings have been held on an annual or sometimes biannual basis and minutes have been included with the reports to the EC.

Key project outputs have been as follows (those that have been previously reported in earlier reports as indicated above are shown by italics):

- *literature review at inception of project to evaluate existing knowledge on fuel production through intensive short-rotation coppicing, including fuel harvesting, preparation, and storage*
- *site selection, establishment and long term monitoring results – covering location of trial sites, selection of species, experimental design and yield data measurements.*
- *visits to Europe and India to acquire information from existing production activities and energy conversion installations.*

- *status of available power generation systems – extent of dendropower uptake within period of project.*
- Land use planning for wider-scale application
- Roskilde University study – an outline of an external field study carried on the project in 1999/2000.
- summary with strategies for implementation of results

Project topics not previously reported as indicated above are covered within this report in **Section 2** entitled ‘Final Results of Project Activities’. This section comprises: long term monitoring and yield data measurements; land use planning for wider-scale application; Roskilde University Study; and a summary with strategies for implementation of results, including a proposal for a 3-year Project Extension.

Additionally, there is a **Section 3** of this report entitled ‘Project Administration Records for 2002’. This covers the following topics: ‘File Note Summary for Sri Lanka Fuelwood Project Visit - A C Hollingdale and R B Ridgway from 2<sup>nd</sup> – 22<sup>nd</sup> November 2002’ and ‘Financial Statement for 2002’.

#### ***d. Proposal for 3-year Project Extension***

Discussions have been held between NRI, MERST, and EC Delegation officials on the potential for funding of a 3-year extension to provide further inputs including monitoring of three existing fuelwood plantation trials. This need has arisen due to the limited time available to obtain representative yield data from the 11 sites in the current project.

The three sites identified for this exercise are: Mahailuppallama, Angunakolapalassa and Eastern University. Reasons for selecting these particular sites are:

- data collection activities would be supervised by competent research officials
- these sites are located near large areas of land available for energy plantations.

Further data would provide a more authentic basis for dendropower in Sri Lanka and needs to be viewed in the light of two aspects:

- i. a significant level of commercial interest in dendropower evident in Sri Lanka
- ii. availability of land for plantations, but the interest and willingness of farmers to grow fuelwood for this purpose in identified locations requires confirmation.

These important matters would be investigated by the focussed application of socio-economic skills for small-scale industrial developmental and economic smallholder forestry that would build upon the existing land use planning involvement. They would be best provided within the first year of any 3-year extension.

Overall, the proposed extension would include lines of inter-related work on: (i) site monitoring and data collection (ii) economic small-holder forestry (iii) small industry development for dendropower and (iv) continuation of land use planning aspects.

Such a proposal has been compiled together with this report and it is submitted as a separate document.

## ANNEX 1 to Section 1. Introduction

BAR CHART OF PROJECT ACTIVITY

### IMPLEMENTATION OF SHORT-ROTATION COPPICING PLANTATIONS

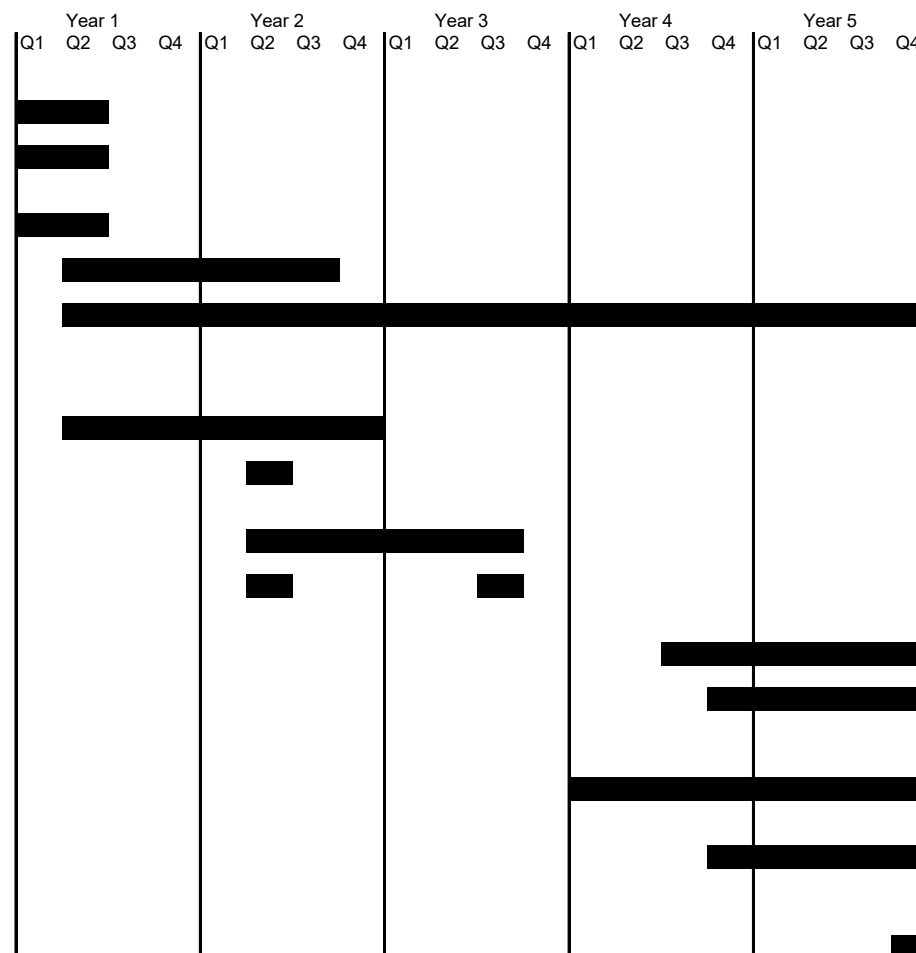
1. Review of information on intensive short-rotation coppicing
2. A visit to an identified country to review and assess practice of established energy plantations in intensive short rotation regime.
3. Selection of sites and species for trial plantations.
4. Establishment of trial plantations.
5. Longer-term monitoring of trial plantations.

### PRODUCTION OF STUDY ORIENTED TOWARDS THE GENERATION OF HEAT AND ELECTRICITY

1. Review of information on fuel harvesting, preparation, and storage.
2. Visit to EC countries to assess fuel handling technologies in use for their application in Sri Lanka.
3. Review information on technology for conversion of bio-fuels power.
4. Visit to power plants operating on bio-fuels in Europe and India to gain information on operational details and practices.
5. Evaluation of available power generation systems for their application.
6. Produce maps and data, using GIS and land planning studies, for wider-scale application of project results.
7. Selection of potential power station sites and evaluation of technical aspects of bio-fuels to power systems.
8. Integration of project work and development of strategies for wider-scale implementation of project results.

### ORGANISATION OF DISSEMINATION WORKSHOPS

1. Hold workshop in Sri Lanka to disseminate results of the project.



## Logical framework (revised version – January 2001)

| PROJECT STRUCTURE                                                                                                                                                                                                                                                                                                                             | RESULT INDICATOR                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | SOURCES AND MEANS OF VERIFICATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | ASSUMPTIONS, RISKS AND CONDITIONS                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>BROADER OBJECTIVES :</b> <ul style="list-style-type: none"> <li>Sustainable supply of fuelwood to support Sri Lanka's development in an environmentally sound manner.</li> </ul>                                                                                                                                                           | <ul style="list-style-type: none"> <li>Sustainable fuel supply from short-rotation energy plantations and their impact on land use, forest conservation and environmental issues.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                         | <ul style="list-style-type: none"> <li>Project reports and national statistical data.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <ul style="list-style-type: none"> <li>Projected yields of energy crops are achievable in wider-scale adoption</li> <li>Demand for power continues to grow and fuelwood remains dominant fuel for industry</li> <li>Socio-economic viability can be attained in the longer term</li> </ul>                                                                       |
| <b>SPECIFIC OBJECTIVES</b> <ul style="list-style-type: none"> <li>To demonstrate the technical feasibility of short-rotation fuelwood plantations, particularly on degraded lands, as sources of energy for Sri Lanka.</li> <li>To enhance institutional capacity in Sri Lanka in the knowledge of fuelwood as a source of energy.</li> </ul> | <ul style="list-style-type: none"> <li>11 x 3ha and 2 x 1ha of short-rotation coppicing plantation installed, enabling the project to determine the actual yield potential for energy systems in selected conditions.</li> <li>A technical study oriented towards the generation electricity from plantation grown fuelwood.</li> <li>Reports of studies identifying routes and actions required for wider-scale application of the results of the project.</li> </ul> <p>Successful completion of the project will demonstrate enhanced institutional capacity in Sri Lanka in the knowledge of fuelwood as a source of energy.</p> | <ul style="list-style-type: none"> <li>Data relating to establishment and longer-term monitoring of trial plantations.</li> <li>Reports, which in general will detail operations undertaken for each site in terms of: timing; extent of operations; inputs for the operations; outputs in terms of yields. The reports will also detail the methodologies used for the data collection. One report is to be produced by end-August 2000 detailing methodologies and plans to be used for subdivision of trial plots. Additionally reports will be produced annually beginning with November 2000. The first report will cover the period from the establishment phase to November 2000. The final report in November 2002 will also contain recommendations for any follow-up actions and species and silvicultural methods to be used in any subsequent trials.</li> <li>A report of a survey of power generation equipment available in Europe and India. The report will contain recommendation and details of equipment for field testing in Sri Lanka. The report to be produced by November 2000.</li> <li>Report detailing benefits of wider-scale adoption of the short-rotation fuelwood plantations taking into account: land availability; impact on forestry resources and environment; the yields determined in this project. This report will be completed in November 2002.</li> <li>Feedback from steering committee meetings and workshop.</li> </ul> | <ul style="list-style-type: none"> <li>Experimental yield data is of sufficient quality</li> <li>Required data and reports are provided by MOST to NRI on time and with sufficient detail.</li> <li>Unusual long-term local weather patterns do not occur during the project</li> <li>Political commitment for fuelwood energy in Sri Lanka continues</li> </ul> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                |                                                                                                     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| <p><b>OUTPUTS/ACTIVITIES</b></p> <p><b>IMPLEMENTATION OF SHORT-ROTATION COPPING PLANTATIONS</b></p> <ol style="list-style-type: none"> <li>1. Review of information on intensive short-rotation coppicing plantation regimes.</li> <li>2. A visit to an identified country to review and assess practice of established energy plantations in intensive short rotation regime.</li> <li>3. Selection of sites and species for trial plantations.</li> <li>4. Establishment of trial plantations.</li> <li>5. Longer-term monitoring of trial plantations.</li> </ol> <p><b>PRODUCTION OF STUDY ORIENTED TOWARDS THE GENERATION OF HEAT AND ELECTRICITY</b></p> <ol style="list-style-type: none"> <li>1. Review of information on fuel harvesting, preparation, and storage.</li> <li>2. Visit to EC countries to assess fuel handling technologies in use for their application in Sri Lanka.</li> <li>3. Review information on technologies for conversion of bio-fuels to power.</li> <li>4. Visit to power plants operating on bio-fuels in Europe and India to gain information on operational details and practices.</li> <li>5. Evaluation of available power generation systems for their application.</li> <li>6. Produce maps and data, using GIS and land planning studies, for wider-scale application of project results.</li> <li>7. Selection of potential power station sites and evaluation of technical aspects of bio-fuels to power systems.</li> <li>8. Integration of project work and development of strategies for wider- scale implementation of project results.</li> </ol> <p><b>ORGANISATION OF DISSEMINATION WORKSHOPS</b></p> <ol style="list-style-type: none"> <li>1. Hold workshop in Sri Lanka to disseminate results of the project.</li> </ol> | <p>Project reports and plantation sites</p>    | <p>High calibre staff identified for the project continue to be available</p>                       |
| <p><b>INPUTS</b></p> <p>Costs over five year period from:</p> <p>The E.C.</p> <p>Human resources</p> <ul style="list-style-type: none"> <li>Bio-energy experts and management</li> <li>Bio-energy expert</li> <li>Forestry and agronomy expert</li> <li>Land use planning expert</li> <li>Auditors</li> <li>Plantation labour</li> </ul> <p>Material resources</p> <ul style="list-style-type: none"> <li>Computers and printers</li> <li>Vehicle</li> <li>Plantation tools</li> <li>Fertiliser and chemicals</li> <li>Travel and subsistence</li> <li>Administration costs for audits</li> <li>Contingencies</li> </ul> <p>The recipients</p> <p>Human resources</p> <ul style="list-style-type: none"> <li>Project director</li> <li>Administrative director</li> <li>Bio-energy expert</li> <li>Forestry expert</li> <li>Agronomist</li> <li>Land use planning expert</li> <li>Drivers</li> </ul> <p>Material resources</p> <ul style="list-style-type: none"> <li>Project office</li> <li>Office materials</li> <li>Plantation land</li> <li>Vehicle</li> <li>Vehicle operating costs</li> <li>Seedlings and nursery facilities</li> <li>Training workshop</li> <li>Printing of reports</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p>Validated project accounts and receipts</p> | <p>Financial and manpower commitments in Sri Lanka are provided according to the project design</p> |

# **Project Final Report**

## **Section 2.      Final Results of Project Activities**

## a. Long term monitoring and yield data measurements

### Outline of Site Details

Outline details of plantation sites maintained in the project up to the end of 2002 are given in table 1. These comprise the ten-numbered sites, each of 3 ha area and all established at end 1998; plus one other site of 1 ha at the Eastern University, Batticaloa, established at end 2000. This amounts to 31 ha in total; with 24 ha at age 4 years; 6 ha at 3 years; and 1 ha at 2 years.

The plantation spacings on these sites were adjusted when some sub plots were thinned in 2001 to create a roughly equal mixture of 1m x 1m layout (designated S1) and 1m x 2m layout (designated S2). Around 14 species in total were planted with larger areas of *Acacia*, *Calliandra*, *Cassia*, *Gliricidia*, *Eucalyptus* and *Leucaena* (*Ipil Ipil*) varieties.

Extensive fire damage resulted in the abandonment of one 3 ha site (Site 3, Monaragala, dry zone, low country) in 2000. Fire in 2002 has also badly damaged site 6. One 1 ha trial site at Open University, Nawala was also abandoned soon after establishment in 2001 when it was discovered that the soil quality was much poorer than was first indicated. Fence damage and cattle grazing has also caused varying degrees of difficulty at some sites. Layout details and results from each site are provided later in this section of the report.

**Table 1.0** Table of established biomass trials at December 2002.

| Site Nos, Location<br>(Site ownership)                      | Zone                        | Principal Species (spacing)                                           | Establishment date |
|-------------------------------------------------------------|-----------------------------|-----------------------------------------------------------------------|--------------------|
| 1-Anamaduwa, Puttalam<br>(Forestry Department)              | Dry Zone, Low Country       | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)                          | end 98             |
| 2-Lunugamwehera, Hambantota<br>(Forestry Department)        | Dry Zone, Low Country       | Acacia (1x1 & 1x2)                                                    | end 98             |
| 4-Korakahawewa, Anuradhapura I<br>(Forestry Department)     | Dry Zone, Low Country       | Gliricidia (1x1 & 1x2)<br>Acacia (1x1 & 1x2)                          | end 98             |
| 5-Illuppankadawala Anuradhapura II<br>(Forestry Department) | Dry Zone, Low Country       | Gliricidia (1x1 & 1x2)                                                | end 98             |
| 6.Kanichiagalla, Polonnaruwa<br>(Forestry Department)       | Dry Zone, Low Country       | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)                          | end 98             |
| 7-Thalakolawewa, Kurunegala<br>(Forestry Department)        | Intermed. Zone, Low Country | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)<br>Eucalyptus (1x1, 1x2) | end 98             |
| 8.-Mahiyangana, Badulla<br>(Forestry Department)            | Intermed. Zone, Low Country | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)<br>Eucalyptus (1x1, 1x2) | end 98             |
| 9.-Kundasale, Kandy<br>(University of Peridina)             | Intermed. Zone, Mid Country | Calliandra (1x1, 1x2)<br>Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2) | end 98             |
| 11. Angunakolapelessa<br>(Regional Agric. Research Centre)  | Dry Zone, Low Country       | Cassia (1x1, 1x2)<br>Ipil Ipil (1x1, 1x2)<br>Gliricidia (1x1, 1x2)    | end 99             |
| 12. Maha Illuppallama<br>(Regional Agric. Research Centre)  | Dry Zone, Low Country       | Cassia (1x1, 1x2)<br>Ipil Ipil (1x1, 1x2)<br>Gliricidia (1x1, 1x2)    | end 99             |
| Eastern University, Batticaloa                              | Dry Zone, Low Country       | Gliricidia (1x1, 1x2)                                                 | end 2000           |

## Harvesting Procedure

Two different types of harvesting methodology have been adopted. In one method, termed as 'Annual' or 'One Year' Harvesting and designated H1, the main stem of the trees are cut at a height of 1 meter. These trees are harvested again in the same manner after an interval of 12 months. In the other method, termed as 'Continuous' Harvesting and designated H2, the main stems of the trees are cut at a height of 1.5 meters. New coppice shoots are allowed to grow and mature and once these reached a diameter of 25 mm, such branches are harvested at the base leaving 100 mm of stem.

The harvesting technique has evolved through the course of the trials and the most recent instructions (issued March 2001) differentiated slightly for species after a common pre-harvest pruning. Essentially harvesting was either was 'continuous' or 'annual'. Continuous was a regular (monthly or longer) pruning of single stems with a main stem height of 1.5m. Annual was a yearly pollarding or full cropping of all stems at 1m main stem height. This is described in more detail below.

*Pre-harvest Pruning:* All the established species should be treated with a uniform cut at a height of 1m or 1.5m (depending on the proposed subsequent harvesting regime) at the end of first year (around one year after planting but at a time with rains) to train the trees.

### *Acacia Auriculiformis*

Care is needed with the *first cut* since the regenerating ability of acacias (particularly matures stems where little or no branching below the cut end found) is extremely poor so maintenance of a few branches below the cut end is very important.

#### *Continuous Harvesting*

Pruning height should approx. be 1.5m but can be adjusted depending on the availability of branches. Branches below the cut end of the main stem should be kept intact. When trees with multiple stems are found take the most vigorous and straightest stem as the future main stem, all others should be cut off gradually at monthly intervals but depending on the maturity. (see sketch A & B)

#### *Annual Harvesting*

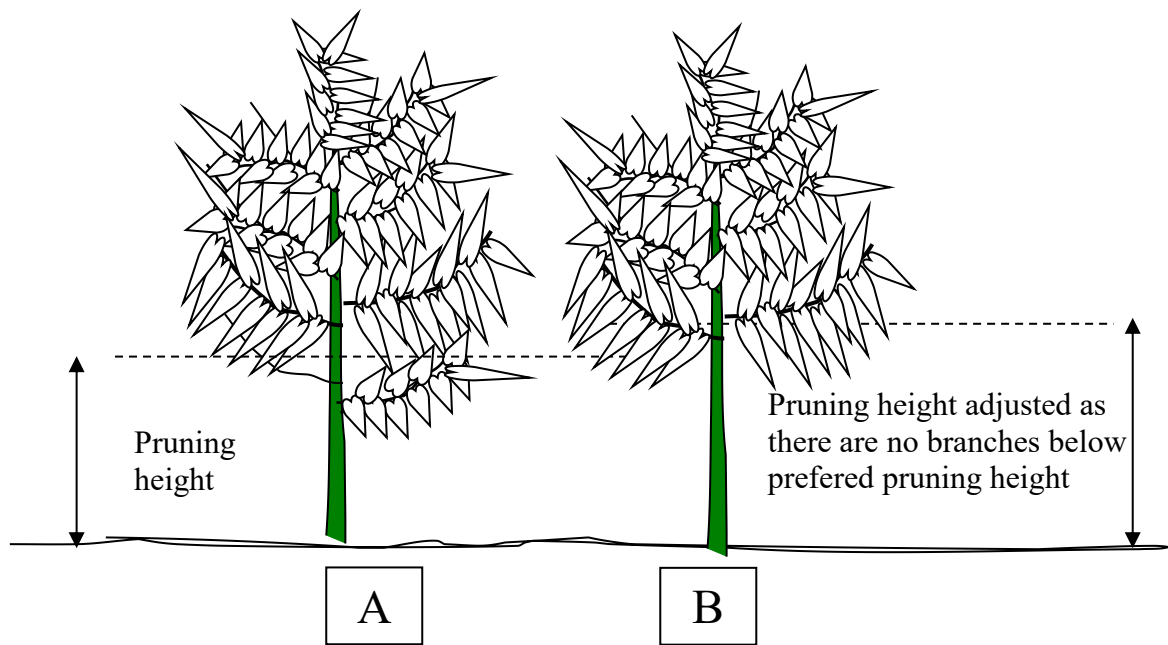
Similar to the above but pruning height should be at 1m.

### *Gliricidia sepium and other species*

Trees can be cut at desired heights even when there are no branches below the cut end.

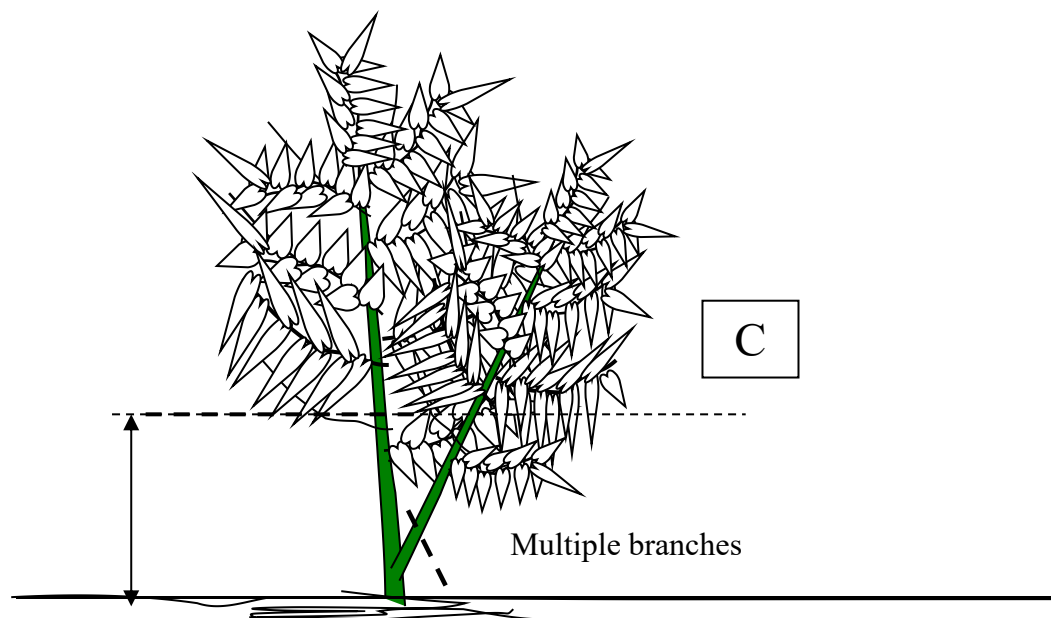
#### *Continuous Harvesting*

Similar to the pruning of acacia cutting height should be maintained at 1.5. Branches and multiple stems below the cut end should be left out but pruned out later at monthly intervals depending on the maturity.



### *Annual Harvesting*

Pruning height should be at 1m but branches and multiple stems below the cut end should be taken off leaving the most vigorous and straightest stem. (see sketch C)



## Site Layout of Plots and Yield Measurement Methodology

A split-plot design was adopted for the plantation trials to provide replications of species, spacing and harvesting regimes. The intentions for establishment were detailed in earlier reports and envisaged species (3 levels), spacing (2 levels) and harvesting regimes (3 levels) at each site. This generated  $3 \times 2 \times 3 = 18$  treatments in total. Original plot designs provided for this with sub-plots of 10m x 20m. Actual layouts at individual sites then had to be adjusted to local conditions and the number of treatments was restricted for different reasons at most sites. Thus establishment success with different species varied considerably. In some plots infilling of spaces was applied early on in the trials to improve establishment, and some other plots were abandoned.

At the time of first harvest, there was some thinning to enable what was predominantly 1m x 1m spacing to be made into a more representative mixture of 1m x 1m and 1m x 2m spacings. Also at that stage it was decided to reduce to only two harvesting regimes, e.g, the annual and continuous harvesting regimes H1 and H2 as described in the previous section. The separate site designs as harvested are indicated in the results later in this section.

Deriving results from these trials has involved generation and management of data for a very large number of trees. To facilitate this task, MERST decided that each site should be marked out in 5m x 5m areas and this was done with poles. Records were made of the number of trees in each area. Then, after each harvest, the aggregate weight of fresh wood harvested from that area was recorded together with the date of harvest. This basic aggregated data of viability and yield was entered onto separate spreadsheet files. The methodology to produce overall yield data for the particular sites involved consolidation of data by calculating an average yield per tree for each area. Conversion to dry matter yield was derived from measurements of water content of fresh harvested species at different sites.

From these measurements, a ‘probable annual yield at a given level of growth’ for each treatment was extrapolated for a hypothetical situation of all trees viable in whatever treatment was under consideration. This methodology gives a higher result than the actual physical yield of the trial but it reduces the variation that has been introduced by different levels of viability. Overall it was considered the best methodology for making comparisons and drawing conclusions from these trials.

This methodology may give high yield projections for situations where lower viability occurred, since those healthy trees remaining could flourish in less competitive environments. This was a contributory reason for the abandonment of certain sites. Site specific comments on these aspects are given later in the section.

At the Agricultural Research Centre sites, where better establishment techniques and supervision was possible and the viability levels were generally higher, a more direct method of yield calculation has been used.

The full yield data results for each site are contained within separate spreadsheets and these are provided in electronic form on the CD submitted with this report.

Summary yield data is presented later in this section of the report for each site, and these results need to be viewed in association with the notes on particular sites that follow.

### **Notes on Particular Plantation Sites**

#### *Site 1. Anamaduwa, Puttalam District*

For establishment, planting materials for gliricidia were initially obtained from the estate belonging to the Coconut Research Institute located at a distance of about 35 kilometers. This resulted in drying up and surface damage of planting materials during transport. Initial attempt to establish eucalyptus seedlings at the nearby nursery failed due to poor quality seeds. It was then decided to plant only gliricidia sepium and acasia. High results for continuous harvesting particularly under S1 spacing may be a reflection of the low viability of some plots at this site.

#### *Site 2. Lunugamwehara, Hambantota District*

Difficulties were experienced in establishment and management due to the site location near a wild life sanctuary. Frequently, wild elephants enter this plantation site damaging the barbed wire fence. Although the elephants themselves do not cause any damage to the trees, their entry into the site damages the protective fence, thus permitting wild cattle to enter the plantation. This resulted in completely destroying gliricidia trees. It was then decided to limit the site to the acasia plots only.

There was some labour dispute between the workforce and the supervisory staff. This resulted in deliberate damage to some part of the plantation by the labour force concerned. Although this matter was reported to the police, investigation could not proceed due to lack of evidence.

Due to prevailing drought in the location, most of the acasia trees did not withstand the annual and continuous harvesting treatments. It is observed that harvesting interval in this area should be decided up on the intensity of drought. This site is located in the driest district in the country, resulting in higher percentage of mortality of plants. Basing projected yield on those that remained has generated high figures.

#### *Site 4. Korakahawewa, Anuradhapura District (I)*

At establishment there were difficulties in obtaining adequate planting materials of gliricidia in the locality. Due to drying up and surface damage to planting materials, initial vacancies were very high. The survival rate of Casuarina equisetifolia was very poor due to site incompatibility so this species was abandoned.

This site also encountered a somewhat hostile labour force, demanding payment at much shorter intervals. Elephants and wild cattle also affected this area.

Due to a fire breakout in the site, a part of the plot was damaged. This resulted in lower quantities of harvested wood but adjusted yield data was high, especially for gliricidia under continuous harvesting.

*Site 5. Illuppankadawala, Anuradhapura District II*

Just prior to the scheduled establishment of plantation at this site, the farmer has introduced valuable cash crop at this site. It was therefore decided to limit this site only to gliricidia. At this site three spacings of 1m x 1m , 1m x 2m and 0.5m x 1m were introduced.(S1, S2 & S3). The high yield projections at this site for the dense spacings under continuous harvesting may be a consequence low viability.

This site also had difficulties in obtaining planting materials from the locality.

A part of the trees initially established were damaged by fire. Attempts made to replant this section were not successful due to poor timing.

This area was badly effected by gini grass weeds. This weed is very difficult to suppress and liable for fire during the drought season. Some harvestable trees were damaged by fire resulting prior to the final harvest.

*Site 6. Kanichiagalla, Polonnaruwa District*

This site encountered a fire early on over the major part of the plantation due to land clearing by military personnel. Filling of vacancies carried out in burnt areas was not very effective due to water logging, poor timing and unsuitable planting materials.

Another fire damaged most of the final harvestable materials. Yield projections on this site are from the limited remaining trees and results for acacia especially may not be typical of overall performance. However, it was observed that many of the trees damaged by fire could be still used to grow fuelwood as they were not completely destroyed. For gliricidia, new sprouts from the roots of the trees appeared after the rain and produced very healthy plantation.

*Site 7. Nikeweratiya (Thalakolawewa), Kurunagala District*

Attempts made to establish eucalyptus seedlings at the nearby nursery were not successful due to poor quality seeds. A part of the plots allocated for eucalyptus were successfully planted with gliricidia. Projected yields for continuous harvesting are high due to low viability and the short harvest intervals recorded and such figures are unlikely to be sustainable over longer trials.

*Site 8. Mahiyangana, Badulla District*

The soil in the South West part of the plantation was very hard. This resulted in the plantation process taking much longer period. This area is also badly effected by gini grass weeds.

The supervisors identified for this site did not accept the appointment. The farmer attached to the site effectively functioned as the supervisor.

The yield data at this site were low due to partial damage by fire, especially to acasia. Gliricidia performed well.

*Site 9. Kundasale, Kandy District*

The quality of the soil at this site was very heterogeneous from sub plot to sub plot. This resulted in significant variations in the survival and growth of trees in the different plots.

This is a university forestry department site, managed independently, and the degree of supervision on the recording of data at this site has been disputed by MERST regarding the dates of harvest. For this reason only partial yield data from this site is reported.

The monthly frequency of harvest for the continuous harvesting regime was too severe. Certain annual plots for gliricidia were visually very successful.

*Site 11. Angunakolapalassa, Hambantota District*

This site belongs to the Agricultural Department and was selected for the project after 1 year. Due to unavailability of acasia and the availability of casia siame seeds, this species was introduced at this site. Moreover as the supervisor at this site expressed confidence in establishing and maintaining ipil ipil at this site, this species too was also introduced.

Due to the drought prevailed at this location, the second year harvesting programme was suspended. This is reflected in the data tabulated. This site has been identified as one of the site for extended data collection.

*Site 12. Mahailluppallama, Anuradhapura District*

This site belongs to the Agricultural Department. This site was selected for the project after 1 year. Due to unavailability of acasia and the availability of casia siame seeds, these two species were introduced at this site. More over the supervisor at this site expressed confidence in establishing and maintaining ipil ipil at this site. This species too was introduced at this site.

*Eastern University, Batticaloa*

This site was introduced much later part in the project. One hectare of land was identified and only one species - gliricidia was planted at a spacing of 1m x 2m. Data collection at this site was based on random sample. Due to inconsistency in the data, it was decided to ignore the first set of data obtained for this site. It is proposed to continue to collect data at this site for a period of three years.

## SITE 1: Anamaduwa - LAYOUT AND RESULTS

### Layout of Anamaduwa

|      |            |      |            |      |
|------|------------|------|------------|------|
| H1S2 |            | H1S1 |            | H1S1 |
| H2S2 | Gliricidia | H2S1 | Gliricidia | H2S1 |
| H2S1 |            | H2S2 |            | H1S2 |
| H1S1 |            | H1S2 |            | H2S2 |
| H2S1 |            | H2S1 |            | H1S1 |
| H1S1 | Acasia - 2 | H1S1 | Gliricidia | H2S1 |
| H2S2 |            | H2S2 |            | H1S2 |
| H1S2 |            | H1S2 |            | H2S2 |
| H1S2 |            | H1S2 |            | H2S1 |
| H2S2 | Gliricidia | H2S2 | Acasia - 4 | H1S1 |
| H2S1 |            | H1S1 |            | H1S2 |
| H1S1 |            | H2S1 |            | H2S2 |

### Annual Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 15-Nov-98 | 15-Mar-01    | 06-Apr-01  | 16-Mar-02  |
| Test/Days | 822          | 852        | 1204       |
| H1S1      |              | 4426       | 8899       |
| H1S2      | 1429         | 2994       | 3778       |
| H1S1      |              | 4877       | 16459      |
| H1S2      | 2316         | 2637       | 6908       |

### Continuous Harvesting Yield Data

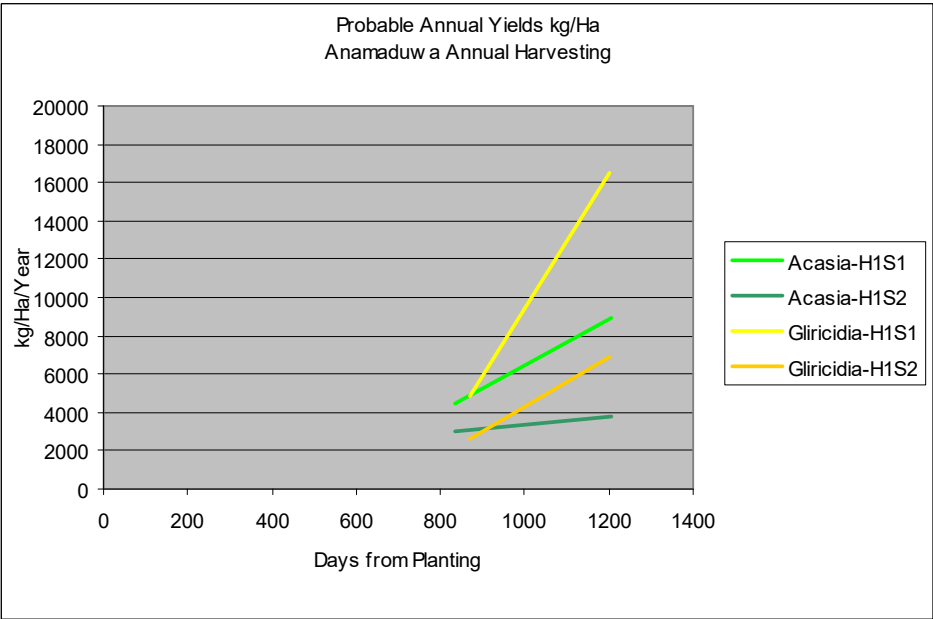
(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield (kg/ha/yr)

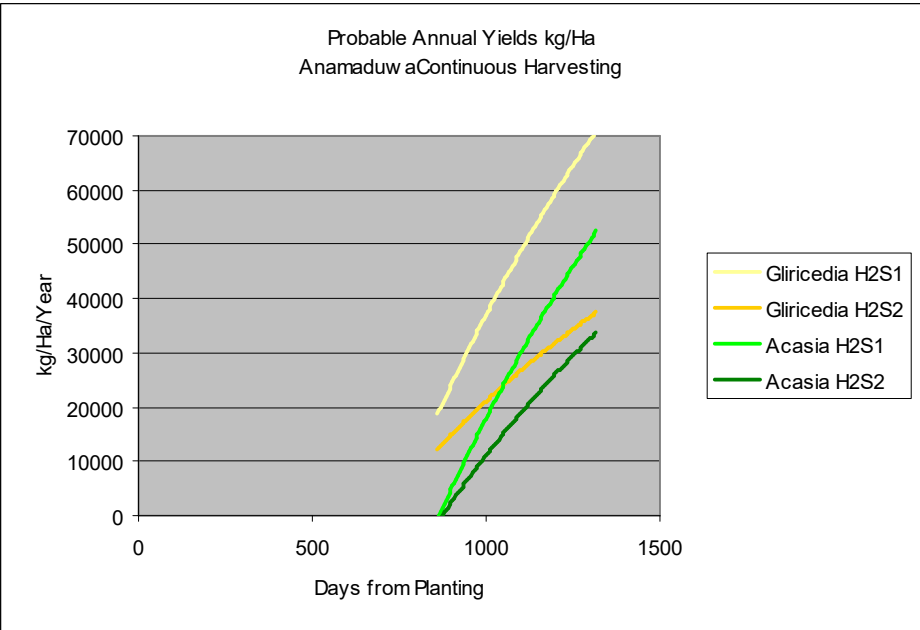
| Planted   | 1st       | 2nd       | 3rd       | 4th       | 5th       | 6th       | 7th       | 8th       | 9th       | 10th      |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 15-Nov-98 | 05-Apr-01 | 13-Oct-01 | 10-Dec-01 | 13-Jan-02 | 03-Feb-02 | 23-Mar-02 | 07-Apr-02 | 10-May-02 | 08-Jun-02 | 04-Jul-02 |
| Test/Days | 861       | 1053      | 1110      | 1143      | 1183      | 1211      | 1227      | 1261      | 1281      | 1317      |
| H2S1      | 3317      |           |           |           |           |           | 1866      | 62884     | 69871     | 53495     |
| H2S2      | 1558      |           |           |           |           |           | 1299      | 41923     | 39303     | 38211     |
| H2S1      | 1772      | 10082     | 90062     | 116101    | 55679     | 71588     | 57772     | 47771     | 42038     | 57325     |
| H2S2      | 685       | 4312      | 48399     | 81893     | 18744     | 35494     | 35660     | 23885     | 23647     | 25080     |

Site 1 (continued)

ANNUAL HARVESTING – YIELD TREND



CONTINUOUS HARVESTING – YIELD TREND



## SITE 2: Lunugamvihara – LAYOUT AND RESULTS

### Site plan

|                         |      |                         |      |                         |      |
|-------------------------|------|-------------------------|------|-------------------------|------|
|                         |      | H2S2<br>Acasia - plot 2 | H2S1 |                         |      |
|                         |      | H1S2                    | H1S1 |                         |      |
| H2S1<br>Acasia - plot 4 | H2S2 |                         |      |                         |      |
| H1S1                    | H1S2 |                         |      |                         |      |
|                         |      |                         |      | H1S2<br>Acacia - plot 9 | H2S2 |
|                         |      |                         |      | H1S1                    | H2S1 |

### Annual Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 15-Nov-98 |              | 09-May-01  | 04-Oct-02  |
| Test/Days |              | 905        | 1419       |
| H1S1      |              | 4552       | 33018      |
| H1S2      |              | 2116       | 17927      |

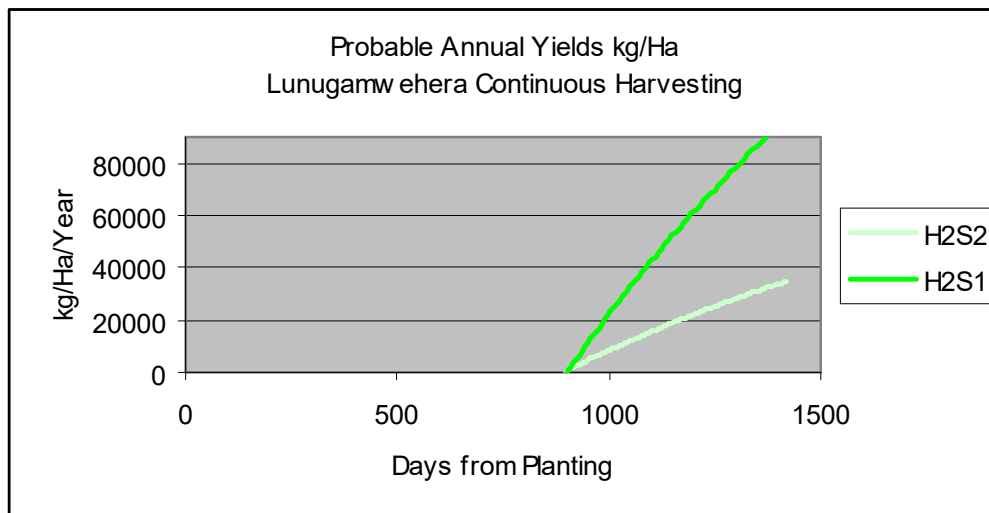
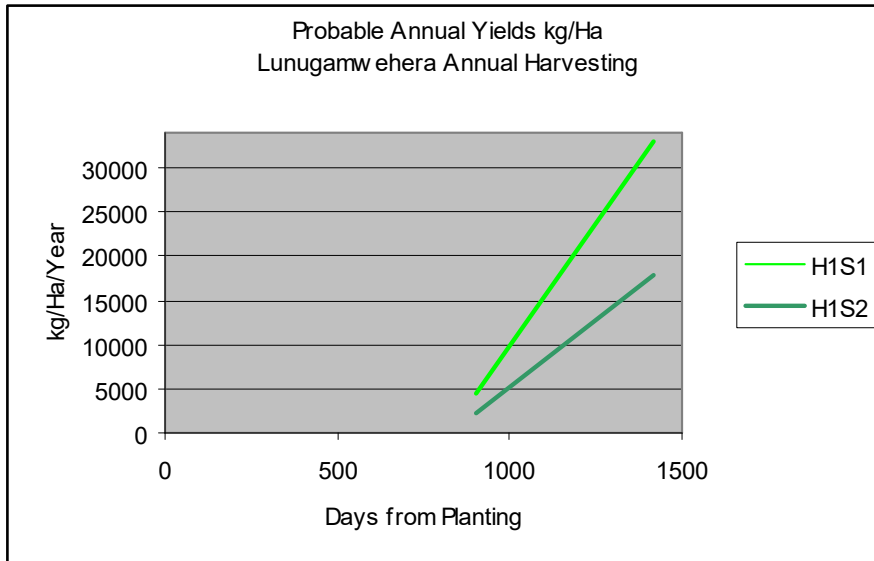
### Continuous Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

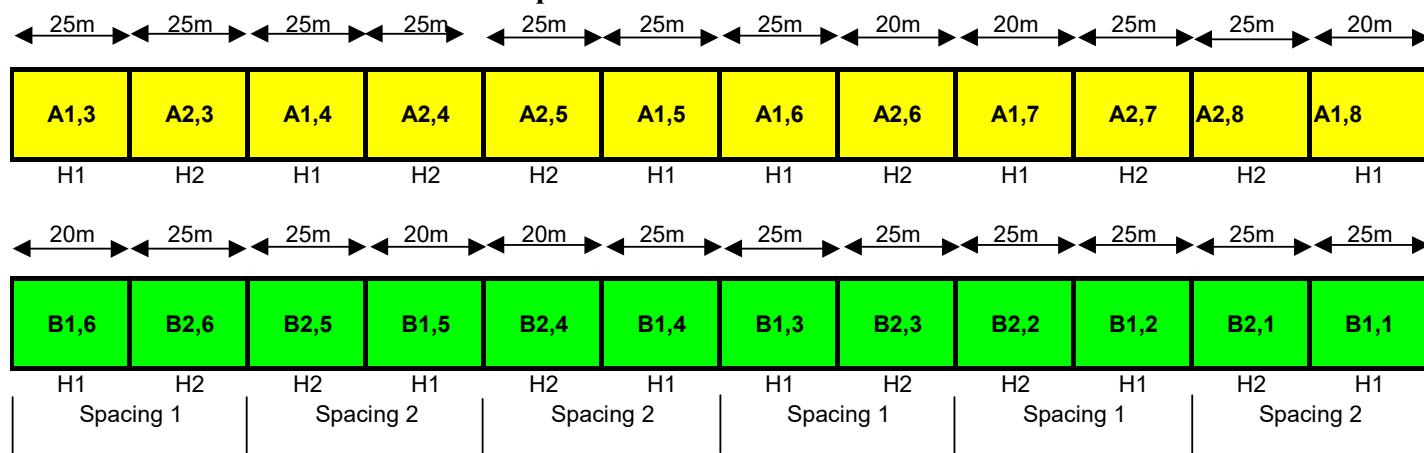
| Planted   | 1st       | 2nd       | 3rd       | 4th       |
|-----------|-----------|-----------|-----------|-----------|
| 15-Nov-98 | 02-May-01 | 21-Jan-02 | 10-Jun-02 | 05-Oct-02 |
| Test/Days | 898       | 1162      | 1302      | 1420      |
| H2S1      | 4808      | 22248     | 123656    | 79199     |
| H2S2      | 1395      | 8108      | 49740     | 24153     |

## Site 2 (continued)



## **SITE 4: Korakahawewa, Anuradhapura 1 – LAYOUT AND RESULTS**

### **Site plan**



A - Gliricidia  
B - Acasia

### **Annual Harvesting Yield Data**

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### **Probable Annual Yield at a given level of growth (kg/ha/yr)**

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 15-Nov-98 |              | 17-May-01  | 30-Apr-02  |
| Test/Days |              | 913        | 1261       |
| H1S1      |              | 1350       | 2665       |
| H1S2      |              | 945        | 1666       |
| H1S1      |              | 7711       | 14375      |
| H1S2      |              | 3084       | 5989       |

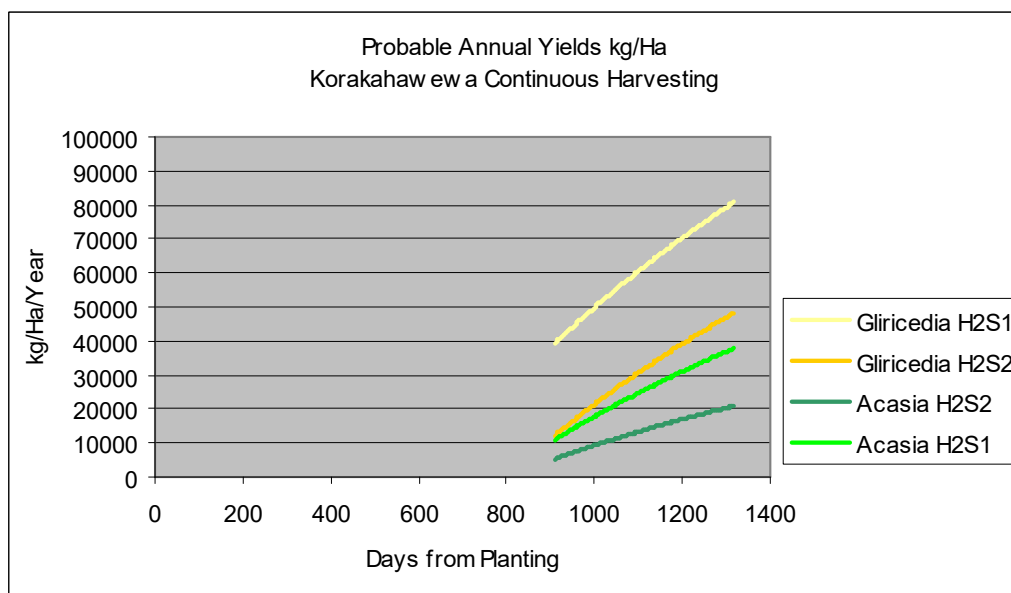
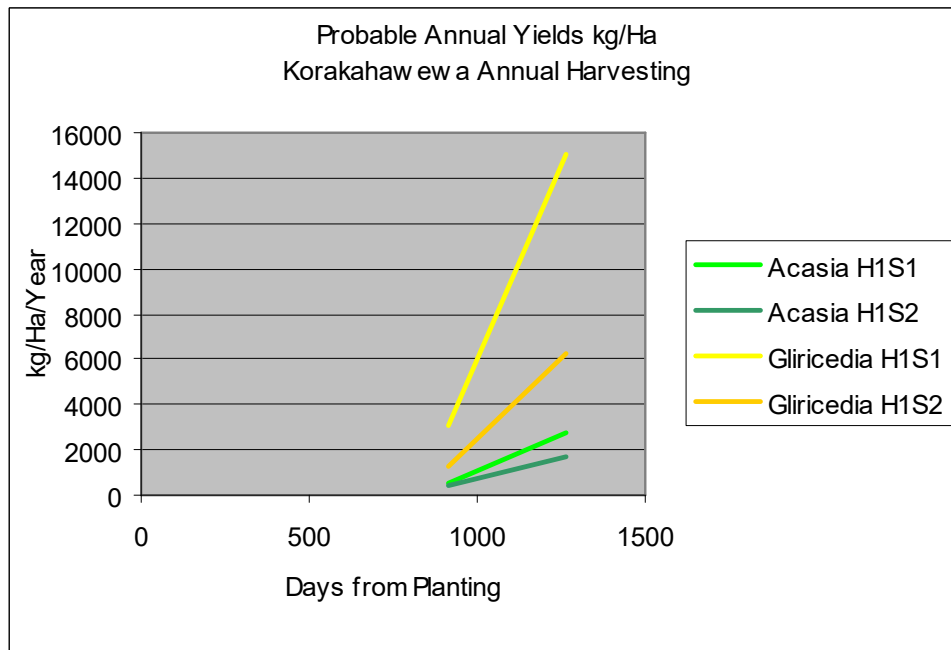
### **Continuous Harvesting Yield Data**

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### **Probable Annual Yield (kg/ha/yr)**

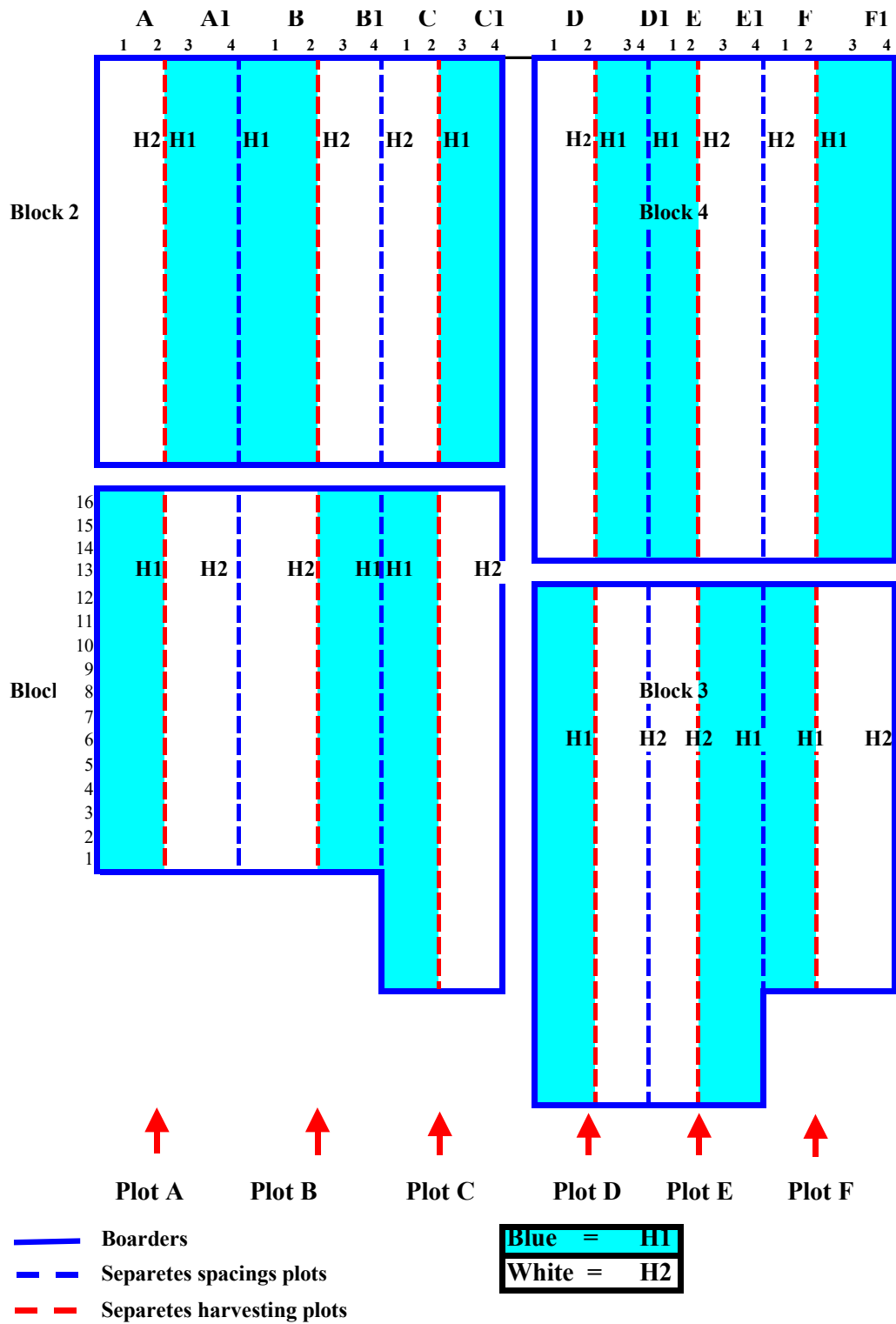
| Planted   | 1st       | 2nd       | 3rd       | 4th       | 5th       |
|-----------|-----------|-----------|-----------|-----------|-----------|
| 15-Nov-98 | 13-May-01 | 19-Jul-01 | 28-Mar-02 | 22-May-02 | 06-Jul-02 |
| Test/Days | 909       | 978       | 1228      | 1273      | 1318      |
| H2S1      | 1083      | 16487     | 5363      | 23975     | 33348     |
| H2S2      | 812       | 8243      | 3218      | 14385     | 16674     |
| H2S1      | 2926      | 57910     | 9307      | 51234     | 47978     |
| H2S2      | 860       | 22521     | 4654      | 27588     | 25703     |

Site 4 (continued)



# SITE 5: Illuppankadawala Anuradhapura II) – LAYOUT AND RESULTS

## Site plan (all gliricidia)



### Annual Harvesting Yield Data

(Note: Colour code for species with light shade = S1 mid shade =S2 & dark shade = S3)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 15-Nov-98 |              | 12-May-01  | 15-Jun-02  |
| Test/Days |              | 908        | 1307       |
| H1S1      |              | 7986       | 12643      |
| H1S2      |              | 4774       | 11260      |
| H1S3      |              | 15278      | 29237      |

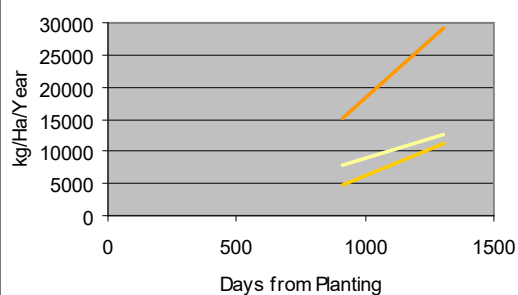
### Continuous Harvesting Yield Data

(Note: Colour code for species with light shade = S1 mid shade =S2 & dark shade = S3)

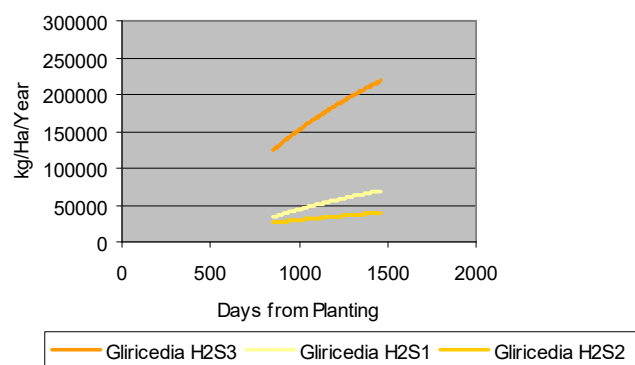
#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | 1st       | 2nd       | 3rd       | 4th       | 5th       | 6th       |
|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 15-Nov-98 | 18-Mar-01 | 20-Sep-01 | 14-Nov-01 | 05-Jul-02 | 03-Oct-02 | 15-Nov-02 |
| Test/Days | 853       | 1070.0    | 1094      | 1327      | 1418      | 1460      |
| H2S1      | 5360      | 19615     | 151075    | 16238     | 45041     | 94371     |
| H2S2      | 4066      | 10897     | 105096    | 8457      | 30316     | 45685     |
| H2S3      | 15894     | 42135     | 551752    | 31123     | 263317    | 184714    |

Probable Annual Yields kg/Ha  
Illuppankadaw ala Annual Harvesting



Probable Annual Yields kg/Ha  
Illuppankadaw ala Continuous Harvesting



## **SITE 6: Polonnaruwa - LAYOUT AND RESULTS**

### **Site Plan**

|                |                |      |                |
|----------------|----------------|------|----------------|
| H2S2           | H1S2           | H2S1 | H1S2           |
| 1 - Acasia     |                | H1S1 | 4 - Gliricidia |
|                |                | H2S2 | H2S2           |
| H2S1           | H1S1           | H1S2 | H1S1           |
| H1S1           | H2S1           | H1S1 | H2S2           |
| 2 - Gliricidia |                | H2S1 | 5 - Acasia     |
|                |                | H1S2 | H1S1           |
| H1S2           | H2S2           | H2S2 | H2S1           |
| H2S1           |                | H2S2 | H1S1           |
| H1S1           | 3 - Gliricidia | H1S2 | 6 - Gliricidia |
| H1S2           |                | H2S1 | H2S2           |
| H2S2           |                | H1S1 | H1S2           |
|                |                |      | 7 - Gliricidia |
|                |                |      | 8 - Gliricidia |
|                |                |      | 9 - Acasia     |

### **Annual Harvesting Yield Data**

(Note: Colour Code for species with light shades = S1 & dark shades = S2)

#### **Probable Annual Yield at a given level of growth (kg/ha/yr)**

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 15-Nov-98 | 12-Feb-01    | 23-May-01  | 03-Feb-02  |
| Test/Days | 819          | 919        | 1188       |
| H1S1      |              | 7874       | 84818      |
| H1S2      | 4358         | 3090       | 39908      |
| H1S1      |              | 9650       | 10718      |
| H1S2      | 4714         | 3900       | 11314      |

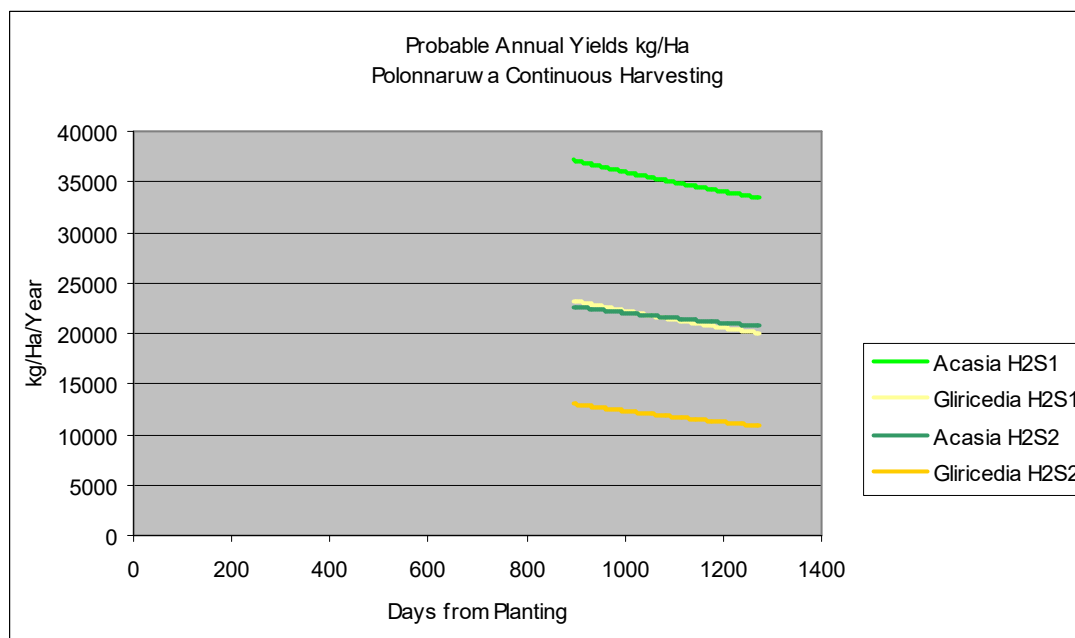
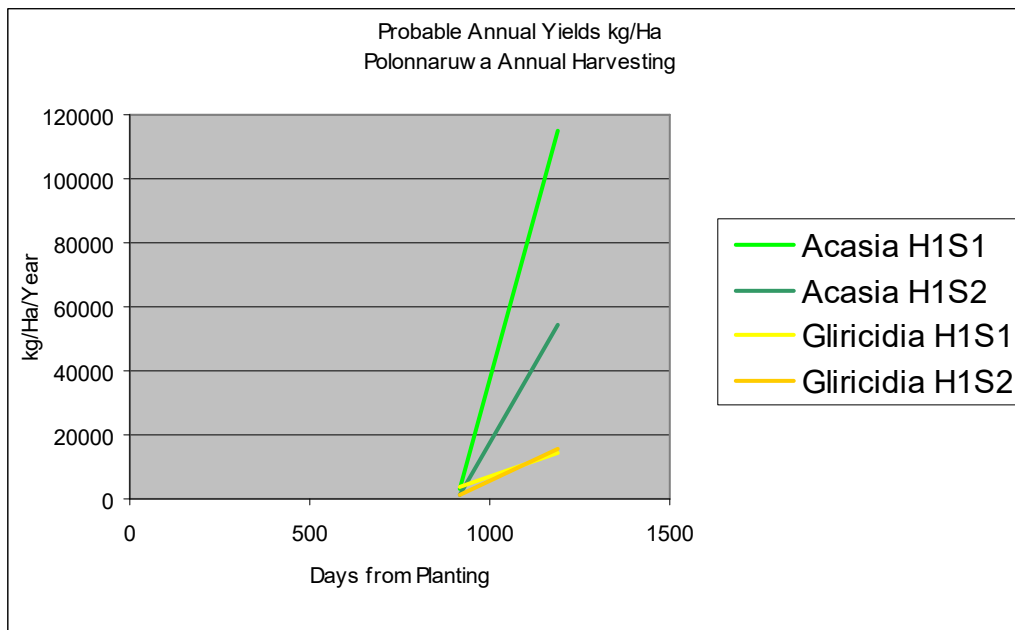
### **Continuous Harvesting Yield Data**

(Note: Colour Code for species with light shades = S1 & dark shades = S2)

#### **Probable Annual Yield at a given level of growth (kg/ha/yr)**

| Planted   | 1st       | 2nd       | 3rd       | 4th       |
|-----------|-----------|-----------|-----------|-----------|
| 15-Nov-98 | 05-Apr-01 | 13-Oct-01 | 10-Dec-01 | 13-Jan-02 |
| Test/Days | 894       | 959       | 1055      | 1273      |
| H2S1      | 8329      | 43401     | 77099     | 13955     |
| H2S2      | 3787      | 31428     | 41662     | 10710     |
| H2S1      | 5517      | 28425     | 33523     | 12610     |
| H2S2      | 3024      | 14886     | 20228     | 6143      |

Site 6 (continued)



## SITE 7: Nikeweratiya – LAYOUT AND RESULTS

### Site plan

|                    |      |                |      |      |      |      |      |
|--------------------|------|----------------|------|------|------|------|------|
| H2S1<br>1 - Acasia | H2S2 | H2S2           | H2S1 | H2S1 | H1S1 | H1S2 | H2S2 |
| H1S1               | H1S2 | H1S2           | H1S1 | H2S1 | H1S1 | H2S1 | H1S1 |
| 4 - Gliricidia     | H1S2 | H2S2           | H2S1 | H1S1 | H2S2 | H1S2 | H2S1 |
| H2S2               | H1S1 | 5 - Acasia     | H2S1 | H1S1 | H2S1 | H1S1 | H2S2 |
| 7 - Acasia         | H1S2 | H1S1           | H2S1 | H1S1 | H2S1 | H1S1 | H2S2 |
| H1S2               | H1S1 | 8 - Gliricidia | H2S1 | H1S1 | H1S2 | H2S2 | H1S1 |
| H1S2               | H1S1 | 9 - Gliricidia | H2S1 | H1S1 | H1S2 | H2S2 | H1S1 |

### Annual Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 07-Jan-99 |              | 28-Apr-01  | 28-Mar-02  |
| Test/Days |              | 860        | 1175       |
| H1S1      |              | 4951       | 8131       |
| H1S2      |              | 2301       | 2321       |
| H1S1      |              | 6539       | 8053       |
| H1S2      |              | 2697       | 3540       |
| H1S1      |              | 822        | 2567       |
| H1S2      |              | 447        | 1027       |

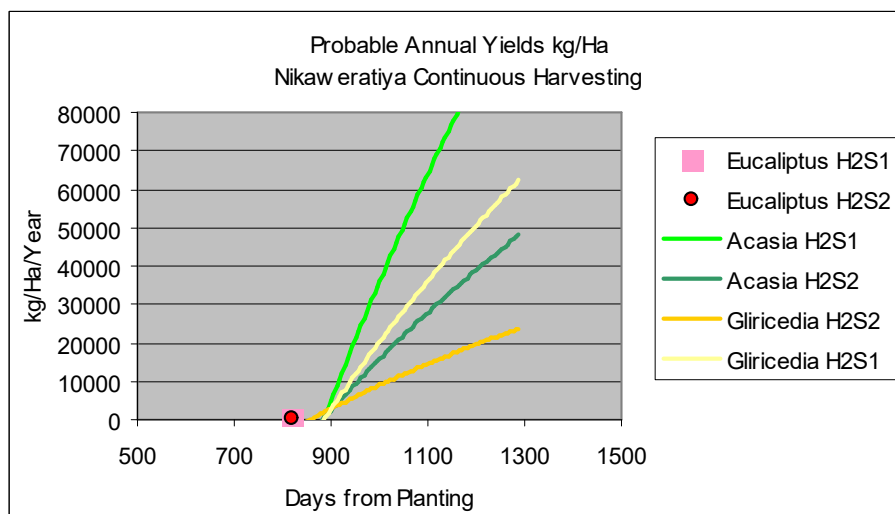
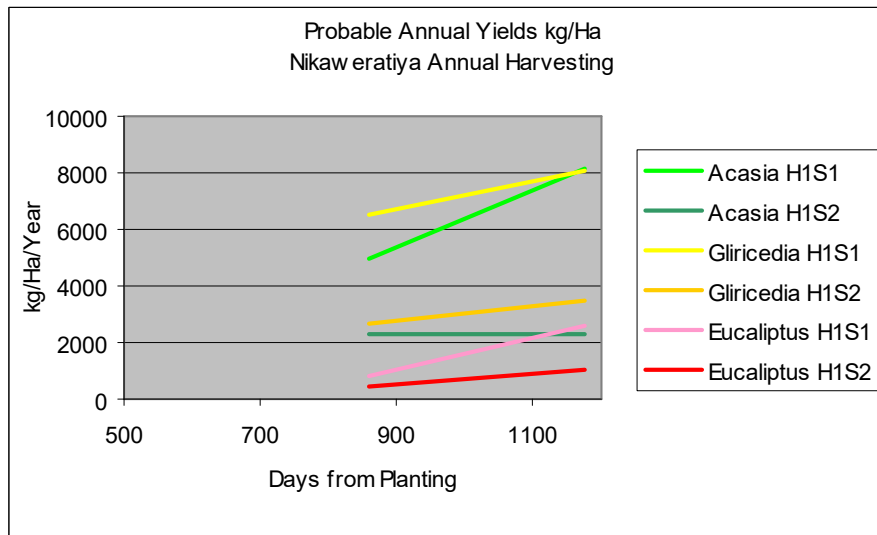
### Continuous Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted        | 1st       | 2nd       | 3rd       | 4th       | 5th       | 6th       | 7th       | 8th       |
|----------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 08-Jan-99      | 30-Apr-01 | 01-Nov-01 | 10-Jan-02 | 26-Feb-02 | 11-Apr-02 | 08-May-02 | 02-Jul-02 | 20-Jul-02 |
| Test/Days      | 816       | 1041      | 1098      | 1143      | 1187      | 1216      | 1270      | 1288      |
| Acasia H2S     | 4233      | 8794      | 41994     | 45038     | 39922     | 202850    |           |           |
| Acasia H2S     | 1845      | 3250      | 17892     | 22784     | 21514     | 82313     |           |           |
| Gliricidia H2S | 2342      | 8555      | 29040     | 35605     | 49097     | 31490     | 43529     | 115868    |
| Gliricidia H2S | 1241      | 2921      | 11746     | 19306     | 20522     | 20042     | 17686     | 32012     |
| Eucaliptus H2S | 716       |           |           |           |           |           |           |           |
| Eucaliptus H2S | 537       |           |           |           |           |           |           |           |

## Site 7 (continued)



## SITE 8: Mahiyangana– LAYOUT AND RESULTS

### Site plan

|                |                |                |      |      |                |      |      |      |
|----------------|----------------|----------------|------|------|----------------|------|------|------|
| H2S2           | H1S1           | H2             | H1S2 | H    | H2S2           | H1   | H1S1 | H2S1 |
| H1S2           |                |                |      |      |                |      |      |      |
| H1S1           | 7 - Gliricidia | 4 - Acasia     |      |      | 1 - Eucaliptus |      |      |      |
| H2S1           |                |                |      |      |                |      |      |      |
| H1S1           | H1S2           | H2S2           | H2S1 | H1S1 | H2             | H2S2 | H1S2 |      |
| 8 - Eucaliptus |                | 5 - Gliricidia |      |      | 2 - Acasia     |      |      |      |
| H2S1           | H2S2           | H1S2           | H1S1 |      |                |      |      |      |
| H2S1           | H1S1           | H1S2           | H2S2 | H1S1 |                |      |      |      |
| 9 - Acasia     |                | 6 - Eucaliptus |      |      | 3 - Gliricidia |      |      |      |
| H2S2           | H1S2           | H1S1           | H2S1 |      |                |      |      |      |

### Annual Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | Thinning Out | 1st Annual | 2nd Annual |
|-----------|--------------|------------|------------|
| 15-Nov-98 |              | 28-Jul-01  | 10-Jul-02  |
| Test/Days |              | 1023       | 1334       |
| H1S1      |              | 1724       | 1159       |
| H1S2      |              | 852        | 1171       |
| H1S1      |              | 4134       |            |
| H1S2      |              | 2143       |            |
| H1S1      |              | 4047       | 11413      |
| H1S2      |              | 1876       | 6472       |

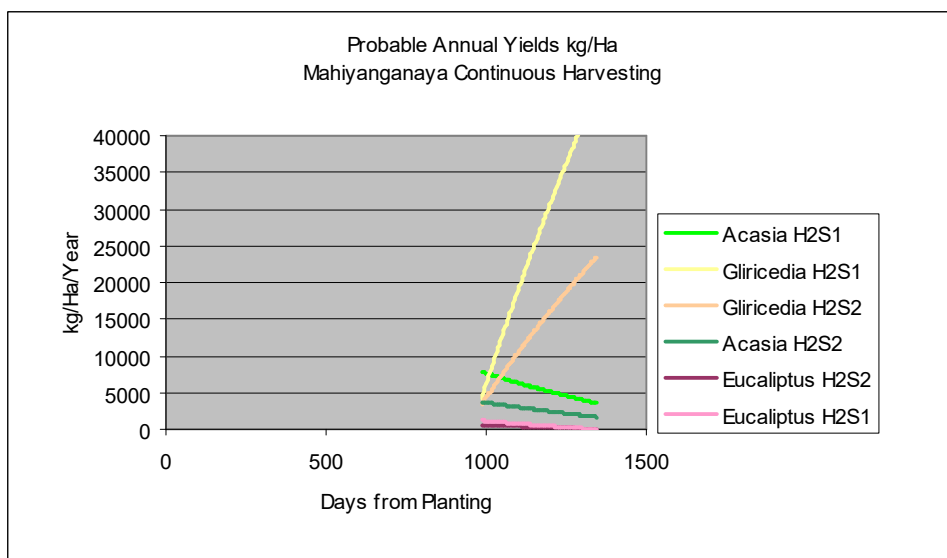
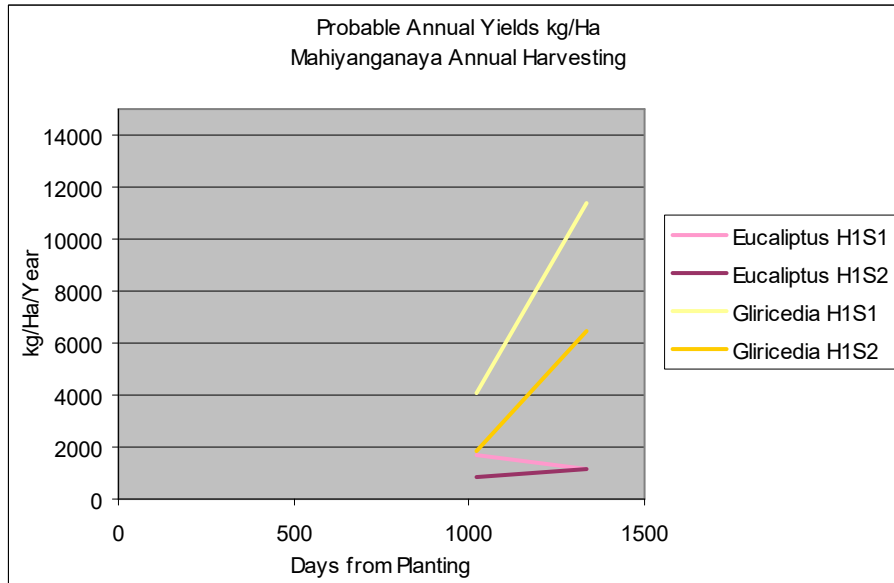
### Continuous Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield (kg/ha/yr)

| Planted      | 1st       | 2nd       | 3rd       | 4th       | 5th       | 6th       | 7th       |
|--------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 15-Nov-98    | 28-Jul-01 | 04-Nov-01 | 27-Jan-02 | 22-Mar-02 | 01-May-02 | 06-Jun-02 | 23-Jul-02 |
| Test/Days    | 986       | 1084      | 1168      | 1222      | 1262      | 1298      | 1345      |
| Acasia H2S   | 0         | 4239      | 32539     | 0         | 0         | 0         | 0         |
| Acasia H2S   | 0         | 2136      | 15302     | 0         | 0         | 0         | 0         |
| Gliricidia H | 3376      | 20523     | 15937     | 32823     | 50976     | 48491     | 34198     |
| Gliricidia H | 1673      | 13218     | 8795      | 18339     | 23059     | 26489     | 17015     |
| Eucaliptus   | 2203      | 0         | 0         | 0         | 0         | 0         | 1109      |
| Eucaliptus   | 1152      | 0         | 0         | 0         | 0         | 0         | 667       |

## Site 8 (continued)



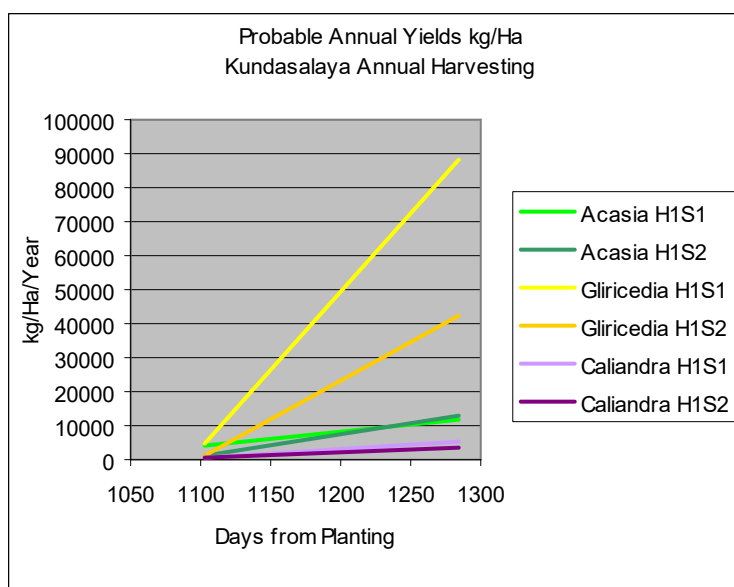
## SITE 9: Kundasala – LAYOUT AND RESULTS

Site layout

|      |                |                |               |                |
|------|----------------|----------------|---------------|----------------|
| H2S1 | H1S1           | H2S1           | H1S1          | H2S1           |
| H1S1 | 1 - Acasia     | 1 - Gliricidia | 1 - Caliandra |                |
| H1S2 |                |                |               |                |
| H2S2 | H1S2           | H2S2           | H1S2          | H2S2           |
|      | H2S2           | H1S2           | H1S2          | H2S2           |
|      | 2 - Caliandra  | 2 - Acasia     |               | H2S2           |
|      |                |                |               | H1S2           |
|      |                |                |               | 2 - Gliricidia |
|      | H2S1           | H1S1           | H1S1          | H2S1           |
|      |                |                |               | H1S1           |
|      |                |                |               | H2S1           |
|      | H1S2           | H2S2           | H2S2          | H1S2           |
|      | 3 - Gliricidia | 3 - Caliandra  |               | H2S2           |
|      |                |                |               | H1S2           |
|      |                |                |               | 3 - Acasia     |
|      | H1S1           | H2S1           | H2S1          | H1S1           |
|      |                |                |               | H2S1           |
|      |                |                |               | H1S1           |

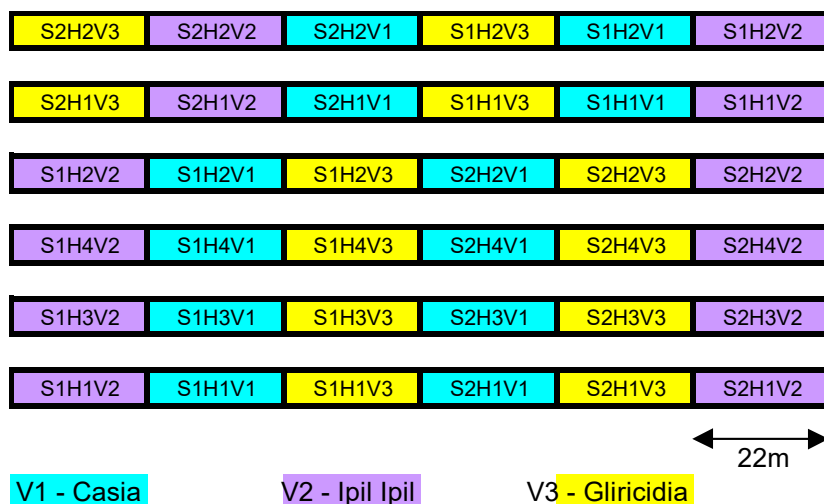
Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted         | Thinning Out | 1st Annual | 2nd Annual |
|-----------------|--------------|------------|------------|
| 15-Nov-98       |              | 07-Nov-01  | 27-Jun-02  |
| Test/Days       |              | 1103       | 1284       |
| Acasia H1S1     |              | 3897       | 12046      |
| Acasia H1S2     |              | 995        | 12832      |
| Gliricidia H1S1 |              | 4817       | 88481      |
| Gliricidia H1S2 |              | 1001       | 42319      |
| Caliandra H1S1  |              | 464        | 5271       |
| Caliandra H1S2  |              | 771        | 3377       |



## SITE 11: Angunakolapelessa – LAYOUT AND RESULTS

### Site plan



### Annual Harvesting Yield Data

(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield at a given level of growth (kg/ha/yr)

| Planted   | Thinning Out | 1st Annual |
|-----------|--------------|------------|
| 15-Nov-98 |              | 15-Mar-02  |
| Test/Days |              | 1223       |
| H1S1      |              | 6989       |
| H1S2      |              | 1761       |
| H1S1      |              | 2516       |
| H1S2      |              | 951        |
| H1S1      |              | 3475       |
| H1S2      |              | 2114       |

### Continuous Harvesting Yield Data

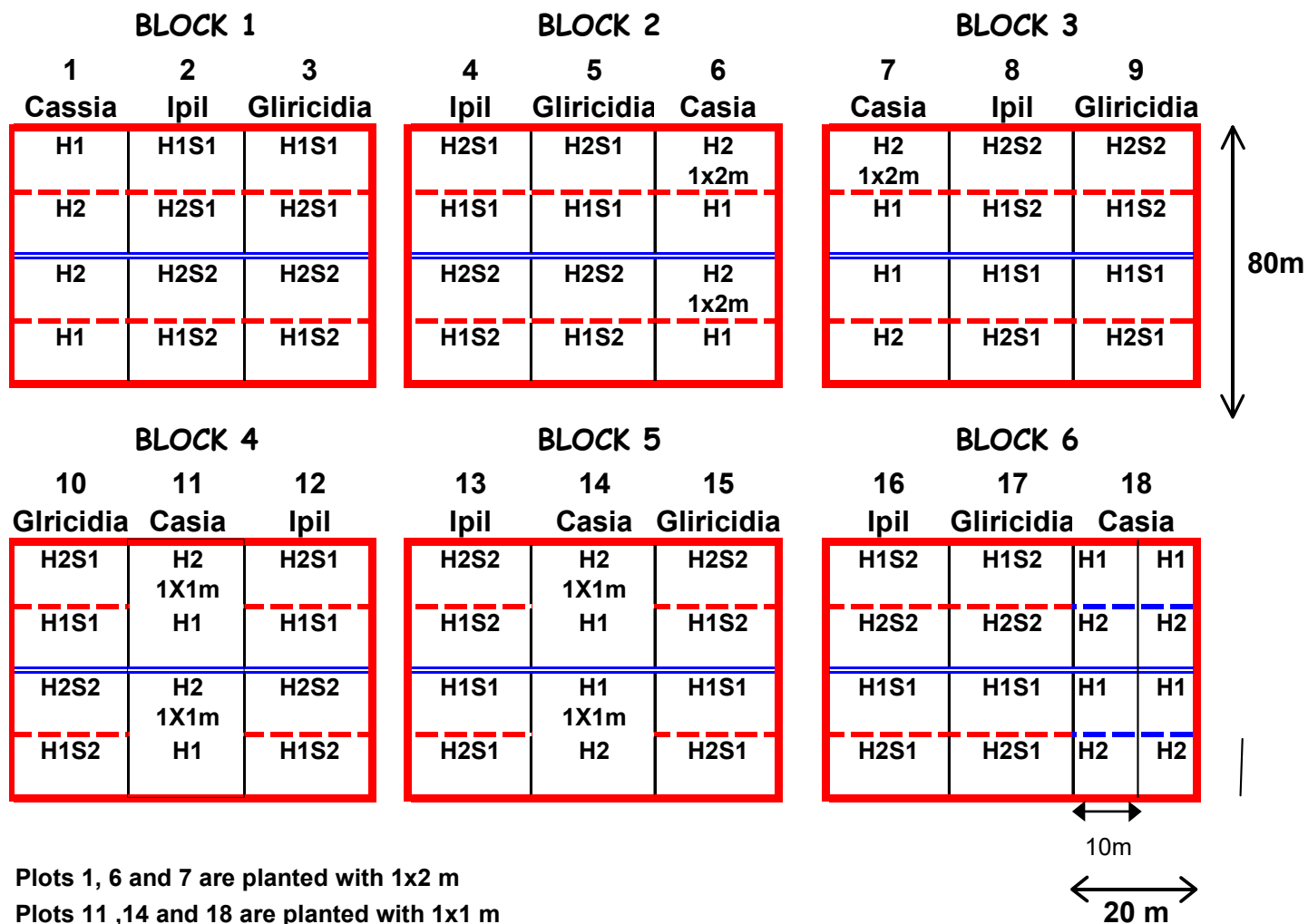
(Note: Colour code for species with light shades = S1 & dark shades = S2)

#### Probable Annual Yield (kg/ha/yr)

| Planted   | 1st       |
|-----------|-----------|
| 15-Nov-98 | 05-May-02 |
| Test/Days | 1269      |
| H1S1      | 3325      |
| H1S2      | 1216      |
| H1S1      | 1400      |
| H1S2      | 1164      |
| H1S1      | 2034      |
| H1S2      | 1468      |



## SITE 12: Mahailuppallama - LAYOUT AND RESULTS

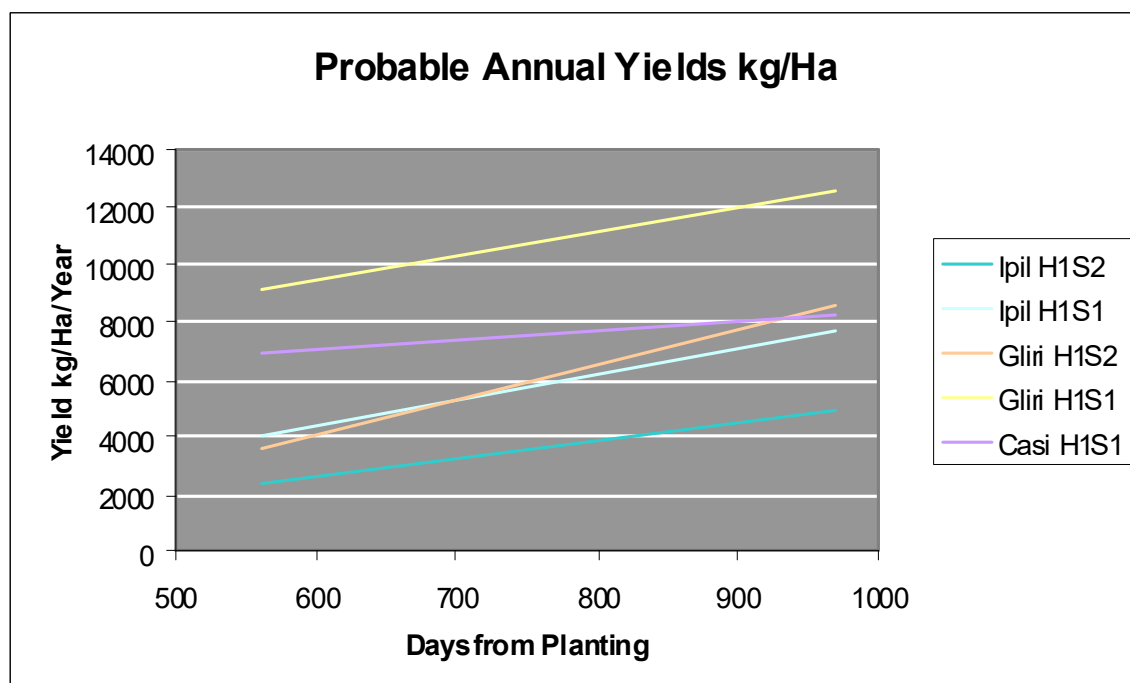


## Annual Harvesting Yield Data

( Note: Colour Code for species with light shades = S1 & dark shades = S2)

| Actual Yield Obtained (kg/ha) |              |            |            |            | Probable Annual Yield at a given level of growth (kg/ha/yr) |              |            |            |
|-------------------------------|--------------|------------|------------|------------|-------------------------------------------------------------|--------------|------------|------------|
| Planted                       | Thinning Out | 1st Annual | 2nd Annual |            | Planted                                                     | Thinning Out | 1st Annual | 2nd Annual |
| 01-Dec-99                     | 15-Jun-01    | 15-Jun-01  | 28-Jul-02  |            | 01-Dec-99                                                   | 15-Jun-01    | 15-Jun-01  | 28-Jul-02  |
| Test/Days                     | 562          | 562        | 970        |            | Test/Days                                                   | 562          | 562        | 970        |
| H1S2                          | 5266         | 3683       | 5461       | Gliricidia | H1S2                                                        | 3420         | 2392       | 4885       |
| H1S1                          |              | 6309       | 8606       | Gliricidia | H1S1                                                        |              | 4097       | 7699       |
| H1S2                          | 12280        | 5596       | 9603       | Cassia     | H1S2                                                        | 7975         | 3634       | 8591       |
| H1S1                          |              | 14062      | 14039      | Cassia     | H1S1                                                        |              | 9133       | 12559      |
| H1S1                          |              | 10638      | 9189       | Ipil Ipil  | H1S1                                                        |              | 6909       | 8221       |

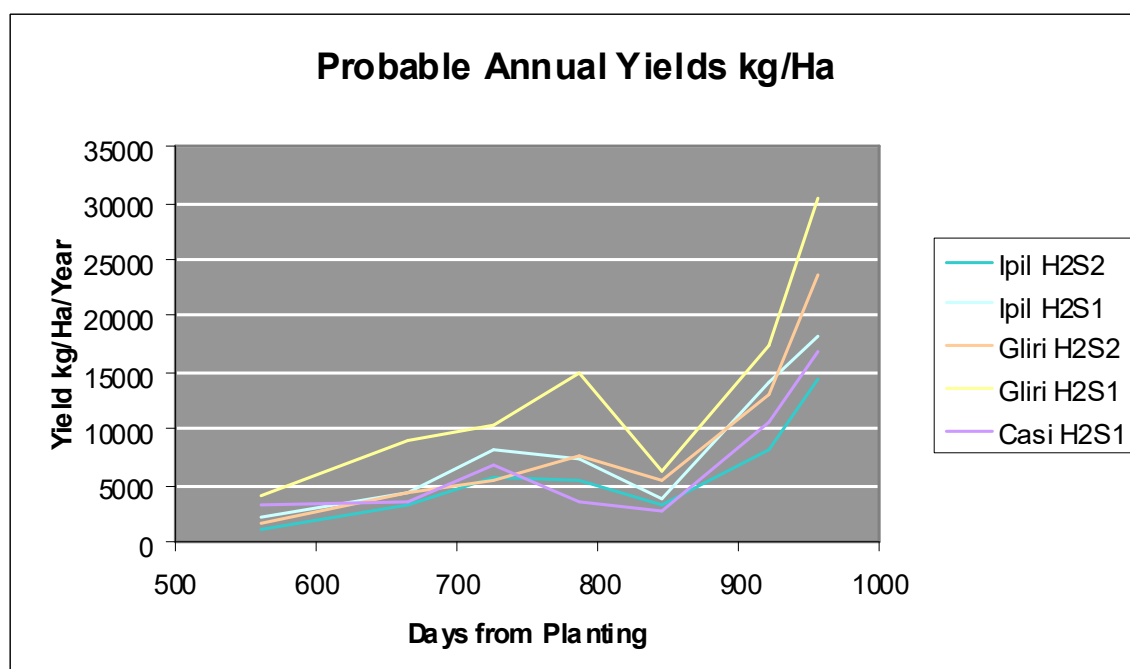
## Annual Harvesting - Yield Trend



## Continuous Harvesting Yield Data

|                                                                         |           |           |           |           |           |           |           |           |
|-------------------------------------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Actual<br>Yield<br>Obtained<br>(kg/ha)                                  | Planted   | 1st       | 2nd       | 3rd       | 4th       | 5th       | 6th       | 7th       |
|                                                                         | 01-Dec-99 | 15-Jun-01 | 26-Sep-01 | 26-Nov-01 | 25-Jan-02 | 25-Mar-02 | 09-Jun-02 | 13-Jul-02 |
|                                                                         | Test/Days | 562       | 665       | 726       | 786       | 845       | 921       | 955       |
|                                                                         | H2S2      | 1695      | 887       | 943       | 884       | 531       | 1675      | 1325      |
|                                                                         | H2S1      | 3590      | 1247      | 1386      | 1205      | 617       | 2928      | 1690      |
|                                                                         | H2S2      | 2454      | 1261      | 914       | 1256      | 904       | 2697      | 2206      |
|                                                                         | H2S1      | 6318      | 2570      | 1718      | 2453      | 1006      | 3647      | 2842      |
|                                                                         | H2S1      | 5243      | 1003      | 1141      | 587       | 442       | 2236      | 1580      |
|                                                                         | Days +    | 562       | 103       | 61        | 60        | 59        | 76        | 34        |
|                                                                         |           |           |           |           |           |           |           |           |
| Probable<br>Annual Yield<br>at a given level<br>of growth<br>(kg/ha/yr) | Planted   | 1st       | 2nd       | 3rd       | 4th       | 5th       | 6th       | 7th       |
|                                                                         | 01-Dec-99 | 15-Jun-01 | 26-Sep-01 | 26-Nov-01 | 25-Jan-02 | 25-Mar-02 | 09-Jun-02 | 13-Jul-02 |
|                                                                         | Test/Days | 562       | 665       | 726       | 786       | 845       | 921       | 955       |
|                                                                         | H2S2      | 1101      | 3143      | 5643      | 5378      | 3285      | 8044      | 14224     |
|                                                                         | H2S1      | 2332      | 4419      | 8293      | 7330      | 3817      | 14062     | 18143     |
|                                                                         | H2S2      | 1594      | 4469      | 5469      | 7641      | 5593      | 12953     | 23682     |
|                                                                         | H2S1      | 4103      | 9107      | 10280     | 14922     | 6224      | 17515     | 30510     |
|                                                                         | H2S1      | 3405      | 3554      | 6827      | 3571      | 2734      | 10739     | 16962     |
|                                                                         |           |           |           |           |           |           |           |           |
|                                                                         |           |           |           |           |           |           |           |           |

## Continuous Harvesting - Yield Trend



## ***b. Land use planning for wider scale application***

### **Land Use Notes on Visit to Sri Lanka Fuelwood Project on 3-15 November 2002**

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#### **1. Introduction**

The land use outputs from the Sri Lanka Fuelwood Project are:

- a. the listing of areas potentially suitable for fuelwood plantations,
- b. the commencement of identification of areas available for plantations, and
- c. an indication of the willingness of farmers to grow fuelwood.

#### **2. Listing of areas suitable for fuelwood plantations**

The base data of potentially suitable areas have been derived from four sets of data.

##### **2.1. Centre for Remote Sensing data**

The Centre for Remote Sensing land use survey of 1980-84 published 1:100,000 scale land use maps derived from air photo interpretation of (mostly) 1979-1981 air photos at 1:20,000-1:50,000 scale. The 25 maps cover each of the 25 districts of the country, and each contains statistics of the area coverage of different land uses in the district by DS Division (Divisional Secretary's Division - formerly termed Assistant Government Agent's Division). Sixteen categories of land use are mapped, of which three have been identified as potentially containing suitable areas for fuelwood plantations. These are:

- i. Sparsely used cropland: Chena (shifting cultivation), recently abandoned chena, sparsely used rainfed cropland (permanent dry cropping), neglected or abandoned tea, rubber and coconut lands, land under development.
- ii. Scrub land: Low growing vegetation with more than 50 percent scrub coverage, including trees with less than approximately 45 percent crown closure.

- iii. Grassland: Open park country with less than approximately 50 percent scrub coverage (damana and savannah), villus and other temporarily flooded land and patana (up-country grassland).

The CRS land use maps give the following area coverage in hectares by districts for the three land use types selected as potentially suitable for fuelwood plantations.

| <i>District</i> | <i>Sparsely used<br/>crop land</i> | <i>Scrub land</i> | <i>Grass land</i> | <i>Total</i>     |
|-----------------|------------------------------------|-------------------|-------------------|------------------|
| Jaffna          | 10,510                             | 6,810             | 10                | 17,330           |
| Kilinochchi     | 16,300                             | 10,230            | 420               | 26,950           |
| Vavuniya        | 40,150                             | 17,750            | 370               | 58,270           |
| Mullativu       | 22,400                             | 13,010            | 640               | 36,050           |
| Polonnaruwa     | 51,120                             | 40,600            | 10,750            | 102,470          |
| Hambantota      | 69,330                             | 39,970            | 1,950             | 111,250          |
| Ratnapura       | 101,570                            | 11,970            | 3,150             | 111,690          |
| Puttalam        | 58,700                             | 19,430            | 4,240             | 82,370           |
| Kurunagala      | 112,710                            | 7,280             | 120               | 120,110          |
| Badulla         | 84,430                             | 14,240            | 10,230            | 108,900          |
| Moneragala      | 186,330                            | 44,070            | 14,130            | 244,530          |
| Kandy           | 28,280                             | 12,110            | 6,010             | 46,400           |
| Nuwara Eliya    | 8,630                              | 9,880             | 7,560             | 26,070           |
| Galle           | 16,320                             | 960               | 910               | 18,190           |
| Matara          | 9,690                              | 0                 | 200               | 9,890            |
| Matale          | 45,600                             | 20,180            | 5,580             | 71,360           |
| Ampara          | 127,720                            | 33,410            | 3,030             | 164,160          |
| Colombo         | 750                                | 580               | 700               | 2,030            |
| Kalutara        | 14,840                             | 650               | 80                | 15,570           |
| Mannar          | 11,590                             | 22,410            | 3,680             | 37,680           |
| Anuradhapura    | 186,500                            | 103,790           | 1,720             | 292,010          |
| Batticaloa      | 38,920                             | 35,240            | 15,040            | 89,200           |
| Trincomalee     | 46,000                             | 33,230            | 260               | 79,490           |
| Gampaha         | 120                                | 740               | 200               | 1,060            |
| Kegalle         | 20                                 | 930               | 200               | 1,150            |
| <i>Totals</i>   | <i>1,288,530</i>                   | <i>499,470</i>    | <i>91,180</i>     | <i>1,879,180</i> |

The CRS maps and statistics act as a benchmark of the status of land use throughout the country in the early 1980s. However the data are now more than 20 years old, during which time land uses have changed significantly. The closed canopy forest cover alone fell from 27 percent of the country in 1982 to 23.9 percent in 1992. More up-to-date land use data are required to indicate what areas remain that are available and may be suitable for fuel wood plantations.

## 2.2. 1:50,000 topographical maps

The Land Use Policy Planning Division is abstracting land use data from Survey Department 1:50,000 scale topographical maps. There are 92 of these maps providing a complete coverage of the country, and 43 maps have to date been coloured to indicate areas of chena land, scrub land, forests, marsh and grassland. Area calculations will next be made of the extents of coverage of each of these land use types, as an indication of potentially available land for fuelwood plantations. The land use data given on the maps are derived from air

photo interpretation of air photos dated 1981-1987. Therefore the base data are only a few years more recent than those used to produce the CRS land use maps, and are 15-20 years before the present.

### 2.3. Forest Department survey

The Forest Department undertook an interpretation of satellite images and aerial photographs in 1992-94, in order to identify forested areas throughout the country. Three categories of forests were mapped, of which sparse forests and, particularly, degraded sparse forests are of interest to this project. Sparse forested areas are those where the closed canopy is less than 60 percent, and will include open forest, scrub land, regenerating chena and savanna land. Much of this sparse forest is degraded, where a loss of forest structure, productivity and ecological integrity has occurred, but where trees may still remain. The coverage in hectares of degraded sparsely forested areas by district in 1994 indicate the extent of this land use type.

| <i>District</i> | <i>Total area<br/>(in hectares)</i> | <i>Extent of<br/>degraded<br/>sparse forest</i> | <i>Percentage<br/>of district</i> |
|-----------------|-------------------------------------|-------------------------------------------------|-----------------------------------|
| Ampara          | 450,031                             | 34,243                                          | 8                                 |
| Anuradhapura    | 722,178                             | 98,022                                          | 14                                |
| Badulla         | 285,673                             | 18,097                                          | 6                                 |
| Batticaloa      | 263,983                             | 13,223                                          | 5                                 |
| Colombo         | 68,469                              | 0                                               | 0                                 |
| Galle           | 161,256                             | 373                                             | 0                                 |
| Gampaha         | 141,890                             | 0                                               | 0                                 |
| Hambantota      | 262,307                             | 49,569                                          | 19                                |
| Jaffna          | 107,848                             | 268                                             | 0                                 |
| Kalutara        | 164,391                             | 670                                             | 0                                 |
| Kandy           | 192,808                             | 2,033                                           | 0                                 |
| Kegalle         | 168,328                             | 221                                             | 0                                 |
| Kilinochchi     | 132,499                             | 3,927                                           | 3                                 |
| Kurunegala      | 489,787                             | 8,565                                           | 2                                 |
| Mannar          | 200,148                             | 9,644                                           | 5                                 |
| Matale          | 206,050                             | 6,442                                           | 3                                 |
| Matara          | 130,829                             | 723                                             | 1                                 |
| Moneragala      | 576,763                             | 45,735                                          | 8                                 |
| Mullaitivu      | 260,946                             | 12,950                                          | 5                                 |
| Nuwara Eliya    | 174,109                             | 589                                             | 0                                 |
| Polonnaruwa     | 344,988                             | 18,358                                          | 5                                 |
| Puttalam        | 315,485                             | 14,538                                          | 5                                 |
| Ratnapura       | 327,034                             | 1,616                                           | 0                                 |
| Trincomalee     | 267,991                             | 14,985                                          | 6                                 |
| Vavuniya        | 200,836                             | 14,525                                          | 7                                 |
| <i>Totals</i>   | <i>6,616,627</i>                    | <i>369,316</i>                                  | <i>6</i>                          |

When comparing the earlier data of the CRS mapping with the later data of the 1:50,000 topographical mapping and Forest Department mapping, care must be taken to note the exact areas covered by each map. Between the two sets of maps, some boundaries and names of DS Divisions have changed. The four main districts in which large extents of degraded sparse forest, and hence potentially available land for fuelwood plantations are located, are:

| <i>District</i>     | <i>Extent of degraded sparse forest</i> | <i>Percentage of district</i> |
|---------------------|-----------------------------------------|-------------------------------|
| <b>Anuradhapura</b> | 98,022                                  | 14                            |
| Hambantota          | 49,569                                  | 19                            |
| Moneragala          | 45,735                                  | 8                             |
| Ampara              | 34,234                                  | 8                             |

Together these districts contain more than 225,000 ha of land covered by degraded sparse forest.

#### 2.4 Other land use survey data

T. Somasekaran gives a total figure of 728,800 ha of sparsely used cropland, grassland and scrub covering the country in 1995 (from Land: some important facts. Ceylon Daily News 14 Nov 95). This is a decrease of approximately 1,150,000 ha or 250 percent in the coverage of these three land use types in about 15 years since the CRS land use mapping was undertaken, but double the extent of degraded sparse forest land identified by the Forest Department in 1994.

### **3. Identification of areas suitable for fuelwood plantations**

The identification on the ground of actual areas suitable for fuelwood plantations is proceeding more slowly, using material derived from the Land Bank Project and the completion of questionnaires by District Land Use Planning Officers.

#### 3.1. Land Bank Project

The main component of the ongoing government Land Bank Project that is relevant to the Fuelwood Project is the collecting of district-level data on many aspects of land use by Grama Niladharis (GNs) using 1:10,000 scale topographical maps. Details of important land use characteristics being collected at point locations with known land uses throughout the accessible part of the country are:

Name of the land

Total extent of land

Area of reserved land, if any

Area of encroachment, if any

Ownership status of land

Distance to main road, in km

Distance to single phase electricity line,, in km

Distance to three phase electricity line, in km

Nature of the terrain

Suitability for agriculture

Suitability for other purposes.

All data are entered into a computer by assigning a code to each item. Eg. 35. TERRAIN gives the nature of the ground surface, AGRI\_RANK gives the suitability of the land for agriculture, etc. The Land Bank Project is an ongoing exercise that can at best supply background information on the extent of suitable land for fuelwood plantations in areas that a GN has surveyed.

### 3.2. LUPPD questionnaire

The Land Use Policy Planning Division has commenced a field exercise specifically for the Fuelwood Project, in which its District Land Use Planning Officers (DLUPOs) collect primary data directly from small farmers in the field by using a questionnaire prepared by the LUPPD. Data have so far been collected from Anuradhapura, Matara, Moneragala, Nuwara Eliya and Polonnaruwa Districts, though only seven questionnaires have been completed in Anuradhapura District and the LUPPD was unable to state how many have been completed elsewhere.

In the questionnaire survey the DLUPO first identifies potentially available land for fuelwood plantations on a 1:50,000 topographical map. A farmer or, more preferably, a small community of farmers is visited who have some stake in the land that is uncultivated and usually under some form of bush or tree cover. This stake can be the collection of fuelwood, hunting, traversing between villages or similar activities. The following questions are then answered on the questionnaire with their direct involvement.

Location of land, by district, Divisional Secretary's Division (DS Division)

GN Division, Village name

Plan No, Lot No

Land ownership – private or state

Encroachments, if any

If location near forest or wildlife reserve

Natural resources of area – soil type, terrain, water availability, agro-ecological zone

Present land use – by category, extent, intensity

Socio-economic information – population data, no of families, major occupations, other income sources

Distances to motorable road, electricity line

Fuel wood presently grown in area, if any

Type of fuel wood, source of supply, distance to fuelwood source

Suitability for fuel wood cultivation

Parameters for suitability – land tenure, state or private land, land not suitable for housing, industrial use or agriculture

If degraded chena or scrub land in area

Availability of family labour

Willingness of farmers to cultivate fuel wood plantations

Families currently using fuel wood

Availability of transport

Non-availability/availability of electricity

Sketch plan of land area available for fuel wood plantation

Link to Land Bank database code.

This exercise is very thorough and, when compiled, provides valuable primary data on the availability of land for fuelwood plantations, its suitability and some indication of the willingness of the local farmers and villagers to participate in growing fuelwood on it. It is however very time consuming and cannot expect to deliver data on more than a small fraction of the country in the time available to the project.

### **4. The willingness of farmers to grow plantation fuel wood**

The information collected to date on land availability and suitability for fuel wood plantations in the country indicates clearly that there is no shortage of land for this purpose in the Dry Zone. The primary data being collected through questionnaires by the DLUPOs in five districts are being consolidated so that they are available to be included in the final project

report. From them an indication can be given of the answer to the more important question about the interest and willingness of the farmers to grow fuel wood for sale and use in power generation.

As most small farmers have access to no more than 1 ha of highland on which fuel wood trees can be grown by them, if they are to be involved in this land use they will need access to other land. A focus of work of the Forestry Department over the past 20 years has resulted in small farmers having increased capacities to produce trees on state forest land that has been leased out to them. Currently about 20,000 small farmers cultivate wood lots, with the largest concentrations being in districts that include Anuradhapura, Hambantota and Kurunegala. The large number of farmers involved indicates their willingness to grow plantation tree crops, where there is an economic return to them.

Taking this point further, the current policy of the Forestry Department for the forest plantation sub-sector is to raise forest plantations on degraded land, such as chena, abandoned tea estates, grass land and other derelict land wherever possible. In order to implement this forest plantation policy the private sector is being encouraged to become involved. This is partly in line with overall government policy to increase the role of the private sector in development activities, and partly to raise the growth and yield of forest plantations and the standard of their management and maintenance.

The identification of farmers, who are willing to grow fuel wood in plantations that they themselves manage, will best be undertaken through close community consultation with them. The aim is to design local forest management approaches that involve whoever are local farmers who will be involved at all of the plantation stages. Land use planning outputs that will indicate the willingness of the farmers for this work in any one area will include:

- i. maps that show the current and future land uses in the selected area and its surroundings
- ii. indication of the land that is suitable for fuel wood plantations, as identified specifically by the local community
- iii. areas within this land that will be under different forest management strategies, as identified by the community
- iv. a strategy for the implementation of the forest management plans that the community will endorse as their own
- v. operational guidelines to assist the community continue to raise the fuel wood in plantations as required by the Fuelwood Project and its successors.

## **5. ADB Sri Lanka Forest Resource Management Project final report July 1999**

The final report of this project has relevant and specific points to make in relation to the planning of fuelwood plantations within the national forest estate (NFE) and Forest Department (FD) land. They are given here as stated in the report.

### 5.1. Leasing of NFE/FD lands to NGO partners.

The Land Commissioner has authority to issue 50-year leases on surveyed, demarcated parcels with the NFE. With Cabinet approval he can issue 99-year leases. In order for this to happen, the Minister (of Forests) has to write to the Land Commissioner, laying out guidelines and procedures for the issuing of forestry leases to smallholders and private firms for forestry ventures on NFE/FD lands, for smallholder wood lots and commercial plantations.

### 5.2. Proposed Forest Classification.

The draft Forest Conservation Act proposes a 5-part classification system. Class IV forests within this classification are to be managed by local communities with state assistance and by

the non-state sector. Most other classes define the level of conservation that should be provided to the forest estate.

### 5.3. Community Forestry Project, completed in 1991.

This project aimed to supply the country with much needed fuel wood and timber, and supported a small social forestry component designed to pursue tree cultivation through community involvement. Tree planting by communities can conflict with peak agricultural activities and these need to be taken into consideration in scheduling and compensation provided to farmers for their labour and outputs. Individual farm households need immediate compensation for fuel wood supplied to buyers. Issuing leases to individual families rather than communities enhanced participation considerably. Awareness and motivational campaigns are necessary to strengthen community involvement in this type of project (smallholder fuel wood plantations), as well as greater community participation in project planning and monitoring.

### 5.4. Land allocation and usufruct rights for social forestry.

Beneficiaries of existing social forestry projects express concern that their land use permits with FD may not be legally binding; responsibilities and rights of ownership and the benefits from harvested crops are ambiguous; permits to grow the trees require annual renewal; lease conditions are inflexible, restrictive and strongly forestry biased. As a result beneficiaries have little incentive to derive income from social forestry rotations. Beneficiaries also remain uncertain about tree ownership; their rights to manage, harvest and market the tree products; access to market information and logistics.

## **6. Findings from recent ADB forestry projects in Sri Lanka.**

Community participation cannot be taken for granted, and will only be fully achieved when the community is involved from the planning to the implementation phases (in a fuel wood plantation). Communities need to have leases/permits prepared for them in a timely manner and extend over sufficient lengths of time. Participating families need to derive an annual benefit from growing trees. The FD needs to be given awareness training in participatory processes and gender issues.

The most successful component of participatory forestry projects has been farmer wood lots, with three important modifications. Leases must be granted to farmers for tree harvesting rights; wider spacing is needed between trees to allow farmers to intercrop where possible; and farmers should be given a say in tree selection.

The Reforestation and Watershed Management Project has provided fuel wood and alleviated poverty by reforesting 10,000 ha in the Mahaweli with closely spaced (1.8x1.8 m) eucalyptus and leucaena. However the quality of plantations has been low and growth minimal, and the whole exercise disappointing.

The private plantation estate sector is very receptive to new technologies, the transfer of knowledge and skills to improve productivity, to reduce costs and maximise values and return on investment in forest plantations.

The current land allocation and lease agreements for plantations are generally not clear and have been subject to different interpretations between FD and the Ministry of Lands. This undermines the confidence of potential investors in plantation forestry.

The FD cannot manage and protect forest resources without the active participation of small holder beneficiaries and development partners, including farmers, rural communities and

NGOs. Success in growing fuel wood has been directly proportional to participation by rural households. Those most likely to benefit are the most likely to have the greatest commitment to make more effective forest management succeed.

FD management and past projects have emphasised the need to increase tree cover by expanding the forest estate in the country. This has lead to a focus on the quantity and coverage of trees, rather than on quality management. As a result encroachment continues on natural forests and the performance of forest plantations is poor. A high proportion have failed or remain untended.

### ***c. Roskilde University Study***

#### **Outline**

Over the period October 2000 to July 2001 the Fuelwood Project was the focus of a field study by a team of four students from Roskilde University, Denmark. The terms of reference for their study as attached below were supplied to and agreed by the Ministry of Science and Technology.

The Fuelwood Project personnel gave assistance to the Roskilde student team in the execution of their project by: providing access to the ongoing Fuelwood Project activities, supplying them with information and contacts, accompanying them on site visits, and giving feed back on their analysis. The students' subsequent outputs were mainly in Danish and focussed towards their academic project requirements – nevertheless contact was maintained as it was considered that some feedback to the Fuelwood Project from their involvement would be worthwhile.

Recently a brief summary of their conclusions was prepared in consultation with them. This describes the notable issues that they examined and conclusions of interest to the project that came from their work.

#### **Conclusions from Student Project**

*Philosophical and conceptual aspects.* The team drew upon current industrialised-world development models with emphasis on dealing with risk to environment. They initially examined understandings of the term sustainable development and then recognised that English speakers (in the Fuelwood Project Team) did not fully share their Danish understanding of this term that implied it was the environmental constraints that must limit development. This realisation was indicative of the even wider differences that were recognised between the rationale for biomass energy or dendropower in Denmark compared to Sri Lanka, where provision of an adequate power capacity for development was the vital issue.

*Modelling activities.* The team entered into modelling activities in order to derive predicted electricity prices from dendropower in Sri Lanka. They found that all the basic data and information they needed to do this tended to originate from parties with an interest in the Fuelwood Project. Also, the team were not fully confident with the assumption implied by simple modelling that free market dynamics would create an assured supply of fuelwood for dendropower in Sri Lanka. Nevertheless, they concluded that Project estimates (currently at 6 Rupee/KWH) were not over optimistic.

*Wider consultation.* Interviews were carried out to examine the wider range of socio-economic and environmental issues, including biodiversity aspects. No overriding objections were identified and the overall conclusion was that the controlled cultivation proposals of the Fuelwood Project were acceptable though some aspects needed closer examination. It was recognised that implementation of dendropower in Sri Lanka would involve support for rural development against an increasing background pattern of urbanisation and centralisation. The team identified that adequate human resources and skills for such a programme were available within Sri Lanka.

#### ***d. Summary with strategies for implementation of results***

### **Summary with strategies for implementation of results**

#### **Introduction**

There are a number of related issues that have been addressed in the course of this project. These are reviewed in the following summary paper that gives a resume of the work done and the strategies that are being pursued to progress the increased use of fuelwood in Sri Lanka for heat and power applications.

#### **Power Requirements for Sri Lanka**

The pattern of hydroelectric generation in Sri Lanka during the past decade- and- a half is illustrated by the graph in figure 1 from a Study of the Energy- Generation published by the Central Electricity Board (CEB). This also shows the likely future needs of the country being met increasingly through thermal- generation systems as limited major hydro-generating sites remain available for exploitation.

As well as showing the demand for electrical energy in GWh (million kWh), the foreign- exchange requirements each year for imported fossil fuel (coal, oil or Natural Gas) based thermal generation are indicated. It is observed that within about ten years, the (foreign exchange) cost for such generation would absorb all of Sri Lanka's net foreign- exchange earnings from its major agricultural exports (tea, rubber and coconut), leaving very little for other vital imports such as for food and fuel for transportation.

This lack of revenue to import fuel for thermal generation of electricity is likely to be further aggravated if there is any continuation of the dramatic escalation in the rate of exchange - SL Rupees per US Dollar – that is also illustrated in the accompanying graph (fig.2; extracted from Central- Bank data over the past fifteen years). For this period the rate- of- exchange rose from less than Rs. 20 per Dollar in 1980 to over Rs.90 per Dollar by 2001. This scenario vividly demonstrates the need for Sri Lanka to develop its own sources of energy to meet the projected increases in demand.

While such alternatives as wind and solar- photo- voltaic are certainly important (and specially in specific isolated locations) it is clear that their contribution will be minimal in the context of the over- all electricity needs of the country. The capital cost of a wind power plant is 1.2 times the cost of hydro power plant. But more importantly, the annual plant factor of a wind power plant in Sri Lanka is only 17%, where as that of a hydro power plant is 50%. This has resulted in the cost of electricity from wind power plant in Sri Lanka is 3 times as expensive as the cost of electricity from hydro power. Similarly, the cost of electricity from solar photovoltaic is 12 times as the cost of electricity from hydro power. Therefore, the proposal to generate electricity from wind and PV to feed the national grid is not economically acceptable.

Fortunately fuel- wood farming offers a very viable alternative for production of an alternative indigenous fuel for thermal generation systems. The way this would be applied to

give an alternative fuel mix to the coal based projections of the CEEB is illustrated by figures 3 and 4. The purpose of this project has been to expand knowledge and experience of the key issues associated with this option.

## Environmental Factors

Use of wood as fuel for thermal generation of electricity no longer implies forests being chopped down and burned. Fuel-wood farming is a new form of agriculture by farmers specifically for fuel. It involves the quick growing, and coppicing of selected species of trees and it is being widely promoted in the United States, Scandinavia, Europe, India and elsewhere as an alternative to fossil and nuclear fueled thermal electricity-generating plants. This is because it offers a viable and economic way to generate power, but also in order to preserve the environment.

While fossil-fuelled (i.e. coal, oil and gas) generators continually emit CO<sub>2</sub> into the air, contributing to global warming, the CO<sub>2</sub> exhaust from wood-fuelled generators has been totally absorbed while the trees were growing. Thus it is a CO<sub>2</sub>-neutral and environmentally benign form of thermal power generation.

This form of growing trees for fuel-wood is often called Short Rotation Coppice (SRC) farming. In this method, the branches of the trees are periodically harvested, while allowing the main stem of the trees to grow and mature. After every harvest, new shoots appear near the cutting area and they grow into branches in due course. When these new branches reach maturity, they are harvested as fuel-wood.

The process of repeated harvest from a single tree could be maintained for many years in some variety of trees such as *Gliricidia* or *Leucena*. These particular species are nitrogen fixing trees and the establishment of SRC plantations with such species on degraded land previously used by shifting cultivators will upgrade the land and help prevent soil erosion.

## Land available.

Fuel-wood farming is particularly well suited to the humid-tropical region in which we live, and the growing of trees is a well proven form of agriculture. The uplands growing of the tree crops tea, rubber, coconut etc., has sustained Sri Lanka's economy for well over a century. Further, erosion from plantation lands is a tiny fraction of that from the short-term arable (cultivated) crops, often also grown on our hill-sides. The existing overall land use pattern is described in table 1.

**Table 1- Land use pattern in Sri Lanka**

| Land Use                | Area (ha. x 10 <sup>-3</sup> ) | Percentage  |
|-------------------------|--------------------------------|-------------|
| Natural Forest          | 1,678                          | 26%         |
| Forest Plantation       | 81                             | 1%          |
| Industrial Plantation   | 769                            | 12%         |
| Paddy Lands             | 799                            | 12%         |
| Sparsely used crop land | 1263                           | 20%         |
| Range scrub land        | 502                            | 8%          |
| Other                   | 1408                           | 21%         |
| <b>TOTAL</b>            | <b>6,500</b>                   | <b>100%</b> |

Forests still cover 1.7 million hectares or 26% of Sri Lanka, while plantation crops (tea, rubber, coconut, timber) occupy 0.85 million hectares or 13% of the land. Paddy lands occupy a further 0.8 million hectares or 12% of the country. But a further 1.7 million hectares of hitherto sparsely-utilised and scrub lands have been identified all over the country by the Land Use Policy Planning Unit. While inappropriate for the growing of food crops, most of this ecological terrain - which comprises around 28% of the total land area - is well suited to the farming of fuel-wood, multi-purpose trees and complementary arable crops.

The geographical distribution of land designated to industrial crops and as scrub land is illustrated in figures 5 and 6. It is important to note that scrub lands are located in dryer parts of the country and the location of trial plantation sites in this project has been chosen to include such locations.

## **Fuelwood Supply**

### *Species identified*

Fuel-wood tree-species with potential for 'Coppicing' have been identified through trials in this project for suitability to the various agro-climatic zones of the country. Most of these species are nitrogen-fixing and therefore of special benefit to the soil. 'Coppicing' is a term used to define the ability of certain trees to throw out a profusion of branches (coppices) from just below the level when 'lopped'. The coppiced branches are themselves lopped (harvested) when about one or two inches in diameter. This is the ideal size for use as fuel-wood in power plant systems, thereby minimising the need for size reduction of larger branches.

### *Tree Horticulture*

The most productive way of growing these fuel-wood trees is to plant them at high-density of about 1 or 2 meters apart. Planting of species that propagate from stems and from seedlings have both been tried in order to identify the most cost effective method.

Dense planting quickly provides canopy cover to shade out surface weed-growth. After 15 months of planting, the first harvest of branches could begin with the first lopping generally at about 1.0 to 1.5 metre off the ground. Green vegetation can be used for fodder or left on the ground as a mulch, and the lopped branches -- handled like sugar-cane - are left for a week or so on the ground to dry in the sun.

Within about six months or less (in the tropics) after harvest, fresh branches (coppices) would have grown radially and upwards from below the initial lopping of the tree and are ready for harvesting once again. By contrast, in the temperate, countries harvesting takes place annually and then only in the winter months. The coppicing cycle of re-growth, lopping and re-growth is continuous and is known to extend at least twenty five years. Need for added fertilizer is minimal and usually limited only to phosphate and potassium, the main nutrients removed from the soil with the fuelwood. The practice of returning the ashes after combustion of wood would reduce the need for such fertilizer applications. A mix of species is usually encouraged for environmental reasons as well as for the very much better growth which usually occurs. As disturbance is minimal, wildlife, - birds and small animals, quickly find an ideal home in such coppice plantations.

### *Trial Plantation Sites*

The actual location of the trial sites maintained in the project up to the end of 2002 is shown in figure 7 and some key details of these sites are provided in table 2.0. These comprise the

ten-numbered sites, each of 3 ha area and all established at end 1998; plus one other site of 1 ha at the Eastern University, Batticaloa, established at end 2000. This amounts to 31 ha in total; with 24 ha at age 4 years; 6 ha at 3 years; and 1 ha at 2 years.

The plantation spacings on these sites were adjusted when some sub plots were thinned in 2001 to create a roughly equal mixture of 1m x 1m layout (designated S1) and 1m x 2m layout (designated S2). Around 14 species in total were planted with larger areas of *Acacia*, *Calliandra*, *Cassia*, *Gliricidia*, *Eucalyptus* and *Leucaena (Ipil Ipil)* varieties.

**Table 2.0** Table of established biomass trials at December 2002.

| Site Nos, Location<br>(Site ownership)                         | Zone                           | Principal Species<br>(spacing)                                        | Establishment date |
|----------------------------------------------------------------|--------------------------------|-----------------------------------------------------------------------|--------------------|
| 1-Anamaduwa, Puttalam<br>(Forestry Department)                 | Dry Zone, Low Country          | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)                          | end 98             |
| 2-Lunugamwehera,<br>Hambantota<br>(Forestry Department)        | Dry Zone, Low Country          | Acacia (1x1 & 1x2)                                                    | end 98             |
| 4-Korakahawewa,<br>Anuradhapura I<br>(Forestry Department)     | Dry Zone, Low Country          | Gliricidia (1x1 & 1x2)<br>Acacia (1x1 & 1x2)                          | end 98             |
| 5-Illuppankadawala<br>Anuradhapura II (Forestry<br>Department) | Dry Zone, Low Country          | Gliricidia (1x1 & 1x2)                                                | end 98             |
| 6.Kanichiagalla, Polonnaruwa<br>(Forestry Department)          | Dry Zone, Low Country          | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)                          | end 98             |
| 7-Thalakolawewa,<br>Kurunegala<br>(Forestry Department)        | Intermed. Zone, Low<br>Country | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)<br>Eucalyptus (1x1, 1x2) | end 98             |
| 8.-Mahiyangana, Badulla<br>(Forestry Department)               | Intermed. Zone, Low<br>Country | Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2)<br>Eucalyptus (1x1, 1x2) | end 98             |
| 9.-Kundasale, Kandy<br>(University of Peradeniya)              | Intermed. Zone, Mid<br>Country | Calliandra (1x1, 1x2)<br>Acacia (1x1 & 1x2)<br>Gliricidia (1x1 & 1x2) | end 98             |
| 11. Angunakolapelessa<br>(Regional Agric. Research<br>Centre)  | Dry Zone, Low Country          | Cassia (1x1,1x2)<br>Ipil Ipil (1x1, 1x2)<br>Gliricidia (1x1, 1x2)     | end 99             |
| 12. Maha Illuppallama<br>(Regional Agric. Research<br>Centre)  | Dry Zone, Low Country          | Cassia (1x1, 1x2)<br>Ipil Ipil (1x1, 1x2)<br>Gliricidia (1x1, 1x2)    | end 99             |
| Eastern University, Batticaloa                                 | Dry Zone, Low Country          | Gliricidia (1x1, 1x2)                                                 | end 2000           |

### ***Yield***

While under moderately favourable conditions one hectare of SRC- farming could yield well over 25 tonnes of dry- matter per year, a more conservative yield figure may be taken as 20 tonnes/ha/yr. Now, considering just 500,000 hectares, (one third of the total scrub terrain,) this land could conservatively produce 10- million tonnes of fuel- wood annually -- and on a continuing basis. This quantity of wood, when used to generate electricity could generate

10,000 GWh of electricity annually and equivalent to nearly twice known hydropower potential.

## Pricing

In energy value, 4 tonnes of fuel wood is approximately equivalent to 2 tonnes of coal or 1 tonne of oil. Market price of fuelwood in Sri Lanka is in the range of Rs. 1500 per tonne and at current prices of fossil fuel, the energy- equivalent price of fuel- wood is significantly cheaper. If the price for imported oil or coal continues to escalate, the price for domestically grown fuel- wood becomes increasingly more attractive. A rough and convenient figure for the electrical- energy which may be produced on a sustainable basis from SRC fuel- wood farming is about 0.4 kW (kilowatt) per hectare. A 1 MW power plant would require a plantation area of 2 km x 2 km.

Wood based electricity generating stations (perhaps between 1 to 20 MW is size) are usually located throughout the country and in proximity to both the energy- plantations as well as to the consumers. Transmission and distribution losses are thereby minimized. However, large fossil- fuel- based power stations necessarily have to be located around the coast. This involves costly transmission lines and extensive losses in distribution of the energy inland. Inevitably, the delivered cost of fossil- fuel- based energy will proportionately increase, thus off setting any initial cost advantage.

The table below gives a cost comparison of a large (1000 MW) coal based power station if constructed in the West Coast Sri Lanka and that of a 500 kW wood based power station located in the dry zone.

| <b>Cost</b>                | <b>Coal</b> | <b>Wood</b> |
|----------------------------|-------------|-------------|
| Capital (US\$/kW)          | 2000        | 500         |
| Life span (years)          | 25          | 15          |
| Annuity (US / kWh)         | 3.5         | 1.0         |
| Fuel (US / kWh)            | 2.0         | 1.5         |
| Operational (US / kWh)     | 1.0         | 2.5         |
| Trans. & Distr. (US / kWh) | 2.0         | 1.0         |
| Total (US / kWh)           | 8.5         | 6.0         |

**Table 3. Cost Comparison of Electricity Generation from Coal and Wood**

From the above analysis, it is clear that the construction of large numbers of small-sized wood-based power plants near the load centres is a better option than constructing large centralized coal-based power plants. The type of installation patterns that are envisaged are shown in figure 8.

## Conversion Technologies

Wood can be used as fuel for heat applications and in power generation. Heat applications for industrial process heat may be linked with electricity generation in combined heat and power

(CHP) systems. At present woodfuel is the primary thermal energy source for local industries. Nevertheless, nearly 25% of petroleum imports to Sri Lanka are used by industries to produce steam or hot air for drying applications. Wood fuel could easily replace imported petroleum in these applications.

To produce electricity from wood fuel, there are primarily two technological options available. In one option, wood fuel is combusted in a boiler to raise steam at high temperature and pressure, very similar to traditional oil or coal fired systems. High-pressure steam is used to drive turbo alternators to produce electrical power. This technology of using biofuels for electricity production has been extensively used all over the world, including Sri Lanka for many years. In Sri Lanka, all sugar industries use this technology to produce all the electrical and motive power needs of all the sugar factories.

A second method of converting wood into electricity is through a process known as gasification. In this method, wood is partially combusted to produce a combustible gas. This gas is first cleaned and used as fuel to drive internal combustion engines, very similar to driving motor vehicles on LPG. This method of electricity generation is more suitable for smaller scale of operation. The specific cost of the gasification based technology is very much lower than for conventional steam systems. Systems manufactured in India or China would cost only US\$ 500/ kW for complete system including land and buildings. This half of traditional large-scale coal based system, excluding coal-unloading facilities such as breakwater, jetties etc. However, in small-scale power generation systems, the operating costs are higher.

The advantage of biofuel based power generation over other renewable energy technology is that fuel required for energy production could be stored in adequate quantities to ensure uninterrupted operation throughout the year.

## **Promotion of Technology**

### ***Employment Potential***

Fuel-wood farming could provide a viable and local source of income. 3 hectares of land conveyed to a family for growing fuel wood would conservatively produce 60 tonnes of fuel-wood annually, and at the present delivered price of Rs.1,500 per tonne this represents an annual income of nearly Rs.90,000 a year for what would really be part-time work. It would not interfere with the seasonal time needed for paddy cultivation or for remunerative work in local industry. Overall, if 500,000 hectares (a third of the total scrub land available) could be brought into fuelwood productivity, it would generate a remunerative 'base' employment for 150,000 rural families and promote rural development in the country.

### ***Governmental Initiatives***

The Ministry of Science and Technology initiated this project in 1998 to determine the optimum parameters for the establishment and management of SRC (Short Rotation Coppice) energy plantations under local, dry-zone conditions as described above. Based on the experience from this project the following initial recommendations have already been made to try and foster adoption of the technology in Sri Lanka:

1. Best species suitable for dry zone conditions are *Gliricidia sepium*, *Leucena leucocephala*, *Casia sieme* and *Acacia auriculiformis*.
2. Best spacing: 1m x 2 m.
3. Best harvesting method: Train the trees to develop a single straight stem to a height of 1.5 meters. Trim the top at this height when the diameter reaches 25mm. Many number of branches will sprout just below the cut and grow . Once a branch reaches a diameter of 25 mm, cut that branch. At any time a branch reaches a diameter of 25 mm cut it off. Do not cut the main stem. Allow the main stem to grow and mature.
4. First harvest could commence 15 months from the time of planting.
5. Average annual yield: 20 tonnes/hectare/year (moisture free basis).

Additionally, the Ministry of Science and Technology has taken steps to import two gasifiers from India, one for industrial thermal applications and the other for electricity production. These will be installed in the next few months. These installations will serve as demonstration facilities to encourage the private sector to adopt these technologies on a wider scale. The technology has been promoted in various other ways through:

- articles in the vernacular newspapers
- release of a document titled “Modern Biomass Energy for Sri Lanka”
- by publicity at many national professional gatherings such as the Institution of Engineers, Sri Lanka.
- through formation of an association called “ Bio Energy Association of Sri Lanka - BEASL”.

Private sector institutions and the Government officials responsible for National Planning expressed the view that it is necessary to demonstrate the technical viability of generating electricity, using wood from SRC plantations. The MOST therefore decided to promote the construction of a facility to demonstrate this technology. As this existing EU-funded Fuelwood Project does not include the establishment of a facility to demonstrate the conversion technology, it was decided to utilise local funds to support this initiative.

MOST also had discussion with the Renewable Energy unit of the local World Bank office. The renewable energy funding programme introduced by the World Bank a decade ago did not include biomass energy although it included micro hydro, solar PV and wind based electricity production. MOST has convinced the World Bank that biomass energy should be included. In fact in the recently introduced funding scheme (called RERED- Renewable Energy for Rural Economic Development) by the World Bank biomass energy has been included. Under this scheme, up to 80% of the initial capital cost of renewable energy (such as micro hydro, biomass, wind and solar PV) based electricity project would be funded on a loan basis. Interest payable is close to commercial bank rates. A total US\$ 135 million will be available for this scheme. More over, the GEF will provide an additional grant component of US\$ 400 per kW for “Off-Grid” projects – non-grid connected rural community projects. The GEF/ World Bank have ear marked US\$ 400,000 as grant component for biomass energy projects.

#### *Private Sector Initiatives*

Following this publicity of the Fuelwood Project many private sector institutions made inquiries. Some of them visited the energy plantation plots and were impressed the visual growth rate of SRC trees. Amongst these, the following two institutions showed firm commitments to establish SRC plantations and energy conversion facilities on a commercial basis: The Ceylon Tobacco Co. Ltd. (CTC) , and the Lanka Transformers Ltd. (LTL). Many

plantation management companies also showed interest in the establishment of SRC plantations.

Two demonstration facilities have been now established: one for the generation of electricity and the other to produce industrial thermal energy from coppice fuelwood. The electricity generating facility with a capacity of 35 kW is located at Sapugaskanda at the premises of LTL, about 5 km from Colombo. The thermal energy facility with a capacity of 2.5 million kJ/ hr is located at Badelgama in an activated carbon manufacturing facility. These facilities have been operating on a regular basis for several months. At the electricity generating facility, quantitative measurements are being taken on the consumption of wood and the generation of electricity.

The electricity generating facility consists of a down draught gasifier, water scrubber, gas filters, water coolers and a spark-ignition type IC engine-generator assembly. The thermal energy facility consists of a down draught gasifier without cleaning equipment. All the equipment is purchased from an Indian manufacturer ANKUR. These two facilities have arranged to purchase coppice fuelwood from the public at the prevailing fuelwood market price of Rs. 1500 per tonne (at 20% moisture). Whatever fuelwood harvested from the trial plantation plots are being transported to the facility at LTL. The cost of transport is born by MOST's local funds. LTL pays the market price of Rs. 1500 per tonne. Electricity generated is utilised to meet a part of the electricity demand at the LTL site for production of galvanized iron products. MOST does not charge for the use of the capital expended.

Many interested parties have visited these sites in the recent past and based on the performance of this demonstration facility at LTL, CTC and LTL have decided to establish a joint commercial type electricity generating facility with a capacity of 500 kW at Walapane in the Central Province. The CTC will establish SRC plantations and will supply all fuel requirements and LTL will install commission and operate the power generating facility. These two Companies have travelled to India and have visited many SRC plantation sites and gasifier based electricity and thermal energy producing facilities. Electricity generated from this facility will be sold to the national electric utility at the usual tariff formulated for small power producers. The 500 kW power plant is expected to be commissioned in March 2003.

The CTC has initiated action to get their traditional tobacco farmers to establish *Gliricidia sepium* in their plantations. The Company has established around 100 acres of *Gliricidia* SRC plantations under their own management. A copy of the promotion leaflet issued by CTC is attached as figure 8.

## **Other issues**

### ***Regional and Global Situation***

Wood is used as an industrial fuel in many parts of the world for industrial process heat applications and electricity generation for many years. United States of America generates over 6000 MW of electrical power using wood fuel. Other industrialized countries using wood fuel for such applications are Sweden, Finland, Austria etc. As the use of wood fuel for energy production is found to be carbon neutral, a number of industrialized countries have recently started applying this technology for electricity generation. Notable examples are, Denmark, the United Kingdom and the Netherlands.

In Asia the use of wood based electricity generation is already very extensive with over 2,500 MW of existing installed capacity.

### ***National Programme***

National benefits of developing a biofuel based energy system instead of imported fossil fuel systems are as follows:

1. Savings in foreign exchange.
2. Employment to many rural agricultural workers.
3. Upgrading of degraded land.
4. Lower capital cost in developing the energy sector.
5. Drastic reduction in the capital cost of transmission and distribution network expansion, as generating plants is erected very close to load centres.
6. Finances required for power generation could be generated locally by a modest increase in the tariff.
7. Investments are required in small chunks in a gradual and uniform manner.
8. Many auxiliary benefits such as increased agricultural production particularly milk.

However, to meet the increasing demand for thermal based electrical energy from fuelwood with the energy mix for the next 13 years as given in Fig. 5, large areas of land would need to be converted into plantations and many power plants erected. There would need to be a continuing commitment from the government and that would be best achieved by establishing an institution dedicated to these tasks.

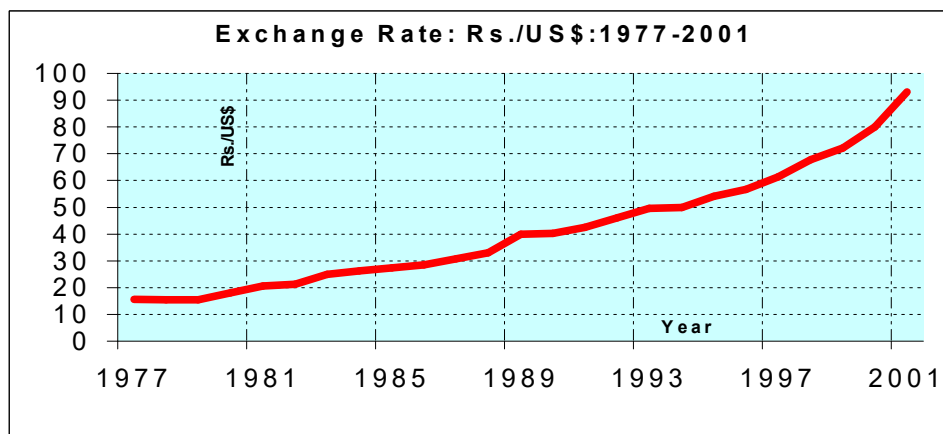
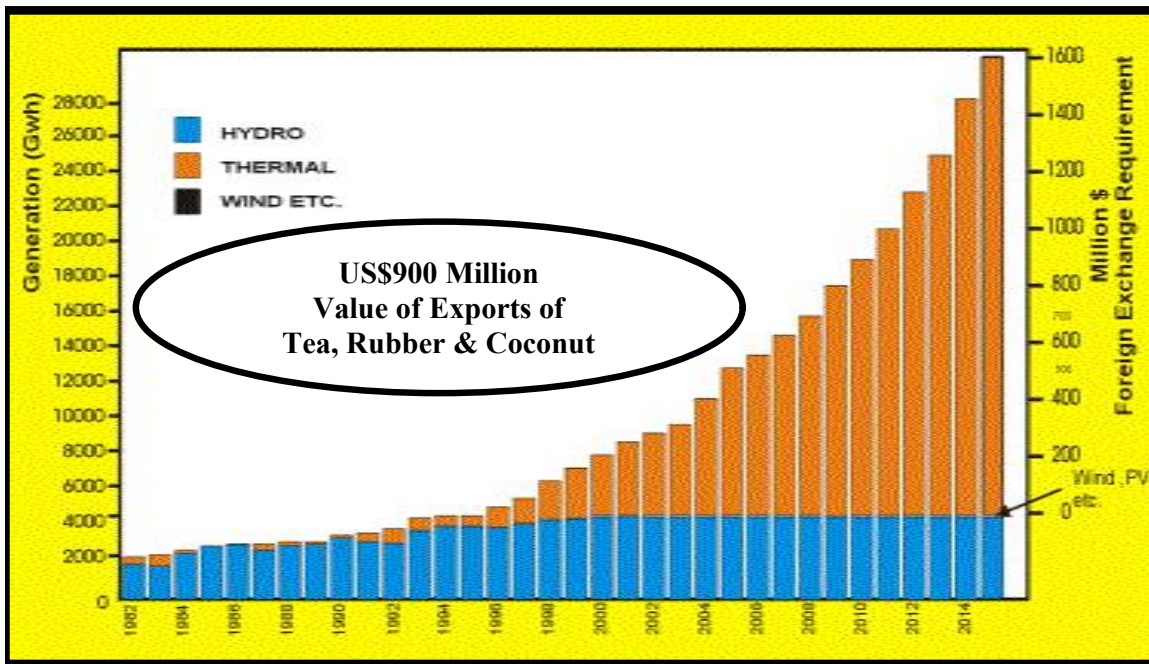
### ***Funding***

The establishment of energy plantations in the degraded land in the dry zone would cost about Rs. 50,000 per hectare. The cost of this should be borne by the government from the money allocated annually for poverty alleviation. It should be noted that once the plantation is established, the plantations could be blocked out into 3-hectare plots to be managed by a farmer family. Each family could earn an income in the range of Rs. 60,000 to 90,000 per year from each 3-hectare plot. Each farmer family need to spend only 50% of their working time in these plantations. They could devote the balance time in traditional agricultural activity.

The power generating facilities should be established and operated on a strictly commercial basis by the private sector. Funds for these should be raised by the private sector in the normal manner. However, the government could assist the private sector by obtaining grants provided by various agencies for environmentally sound technologies. One such source is Clean Development Mechanism. An annual outright grant of about US\$30,000 to 60,000 could be obtained for each MW of Renewable Energy based base-load power plants.

Fig. 1. Electrical Energy Demand and Foreign Exchange Requirements

Fig. 2 Depreciation of S.L.Rs. with respect to US\$



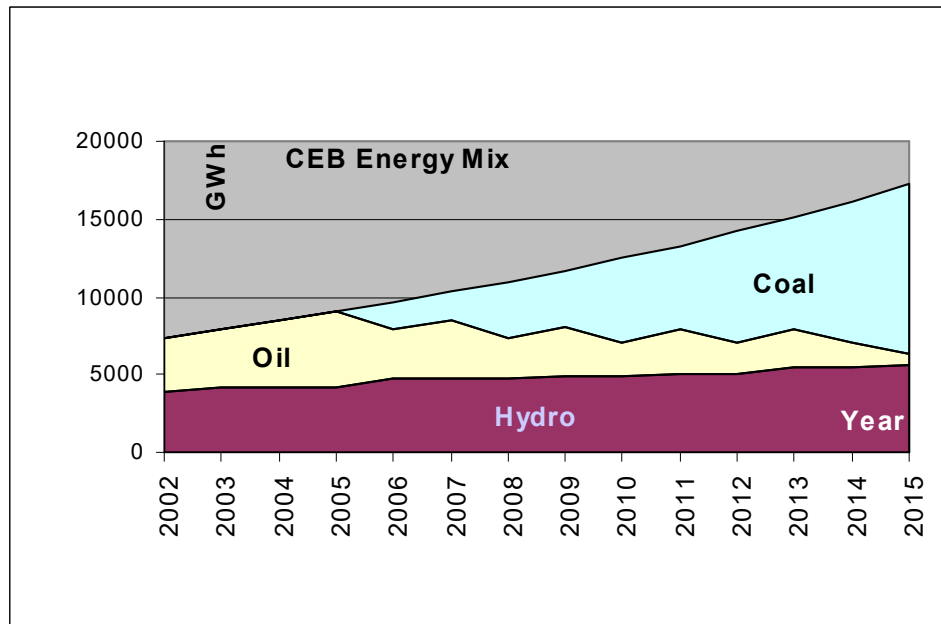


Fig. 3. CEB Energy Mix

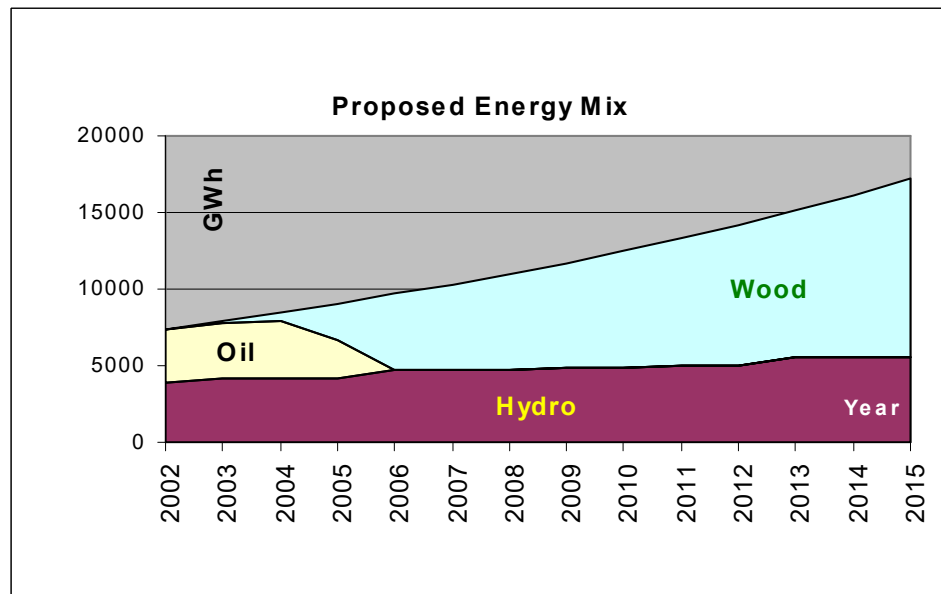


Fig. 4. Proposed Energy Mix

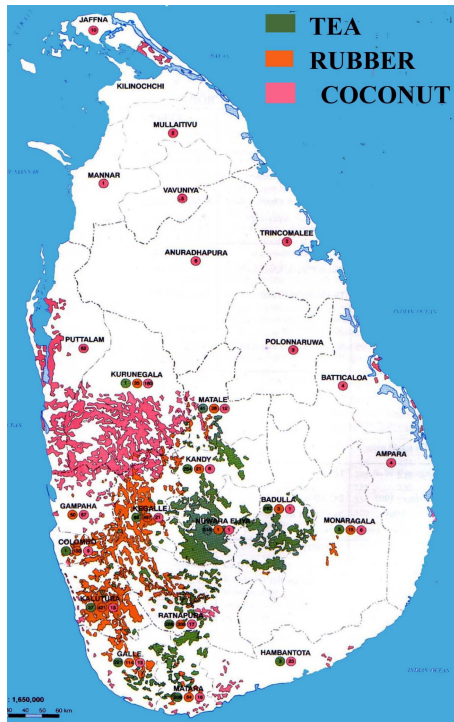
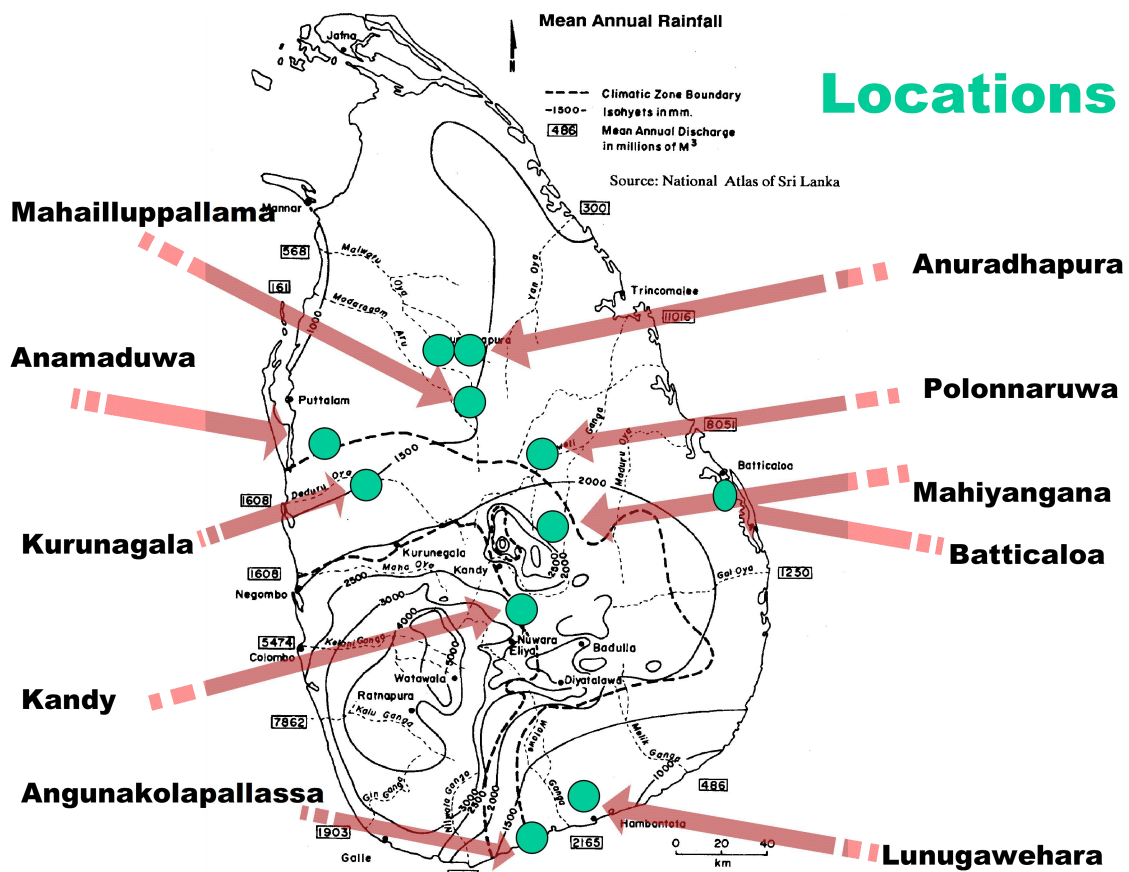


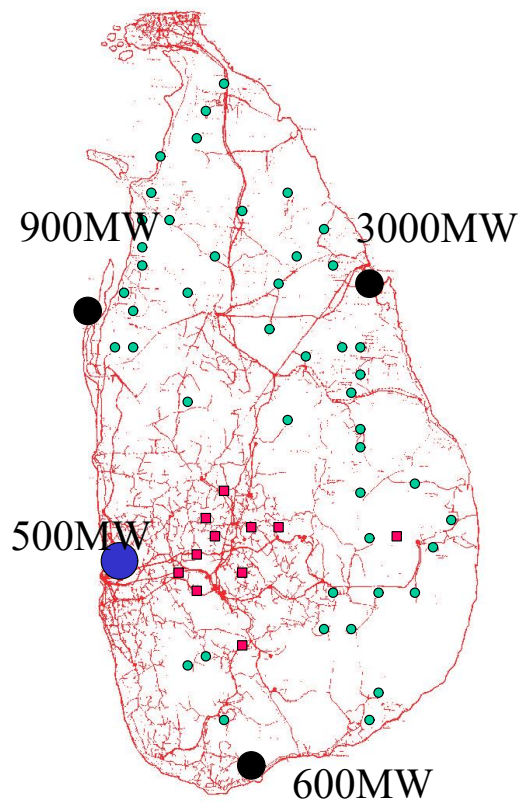
Figure 5 – Location of industrial plantations



Figure 6 – Location of scrub lands

Figure 7 – Location of trial sites





***Centralization***  
**Few Large Plants**  
**with extensive**  
**transmission**

***Decentralization***  
**Many small plants**  
**0.2 to 10 MW,**  
**with minimal**  
**transmission**

Figure 8 – Options for power station installations

Overleaf

Figure 9 – Copy of promotion brochure issued by Ceylon Tobacco Company

## **Project Final Report**

### **Section 3. Project Administration Records For 2002**

***FILE NOTE SUMMARY FOR SRI LANKA FUELWOOD PROJECT VISIT  
A C Hollingdale and R B Ridgway from 2<sup>nd</sup> – 22<sup>nd</sup> November 2002***

**Outline Itinery**

|           |                                                                                                                                |
|-----------|--------------------------------------------------------------------------------------------------------------------------------|
| 2/3 Nov   | ACH & RBR travel to Sri Lanka                                                                                                  |
| 4 Nov am  | Meeting with PG Joseph, MERST                                                                                                  |
| 4 Nov pm  | Meeting with Upul Karunaratne, KPMG Audit Manager.                                                                             |
| 5 Nov     | At MERST Offices. Meeting at Energy Conservation Fund.                                                                         |
| 6 Nov am  | Meeting LUPPD office                                                                                                           |
| 6 Nov pm  | Meeting Mr Miguelez, EC Delegation<br>Meeting Ms Gayathree Jayasinghe, IWMRI                                                   |
| 7 Nov     | Field visit to: Ray Wijewardene coconut estate, <u>Nikkeweratiya</u> plantation site, <u>Anamaduwa</u> plantation site.        |
| 8 Nov am  | Steering Committee Meeting                                                                                                     |
| 8 Nov pm  | Travel to Anuradhapura                                                                                                         |
| 9 Nov     | Field visits to three planations at <u>Anuradhapura 1</u> , <u>Anuradhapura 2</u> and <u>Mahailluppallama</u>                  |
| 10 Nov    | Travel to Colombo                                                                                                              |
| 11 Nov    | At MERST Offices                                                                                                               |
| 12 Nov am | At NPLP Office, Dr Percy Silva and Mr Denzil Senanayake                                                                        |
| 12 Nov pm | At MERST Offices                                                                                                               |
| 13 Nov am | Site visits, Lanka Transformer and Haycarb installations                                                                       |
| 13 Nov pm | Meeting Mr Miguelez, EC                                                                                                        |
| 14 Nov    | RBR meeting with LUPPD, Mr J. Jayasinghe, Director<br>ACH travel to Eastern University, Batticaloa via <u>Polonnaruwa</u> site |
| 15 Nov    | RBR return to UK<br>ACH site visit at <u>Batticaloa</u> and return Colombo                                                     |
| 16/17 Nov | Rest days                                                                                                                      |
| 18 Nov    | At MERST Offices                                                                                                               |
| 19 Nov    | Poya Day, pm Travel to Kandy                                                                                                   |
| 20 Nov am | Visit to <u>Kundasale</u> site                                                                                                 |
| 20 Nov pm | Return journey to Colombo. Meeting with Mr Miquelez, EC Delegation.<br>Meeting at Energy Conservation Fund.                    |
| 21 Nov    | ACH return to UK                                                                                                               |

Plantation sites at eight locations as underlined in the above itinerary were visited. Records of plots visited with some observations are provided in the table below. The project's other three sites at Lunugamvihara, Mahiyangana and Angunakolapalassa were previously viewed in 2001.

Results from harvesting trials and other conditions on sites indicate that it would be valuable to continue trials at Mahailluppallama, Angunakolapalassa and Eastern University, Batticaloa. In addition, Kundasale site has also been well managed and could generate more useful yield data. Arrangements for 3-year extension to monitor further site trials were discussed with MOST and EC during the visit.

### Plantation Visit Details

| Site/plot                      | Species    | Age | 1 <sup>st</sup> Har. | 2 <sup>nd</sup> Har. | Spacing | NOTES                                                           |
|--------------------------------|------------|-----|----------------------|----------------------|---------|-----------------------------------------------------------------|
| <b><u>Nikkeweratiya</u></b>    |            |     |                      |                      |         | Supervisor:-<br>Samantha Bandara                                |
| 9                              | Acacia     | 4   | 3/01                 | 3/02                 | 1x1     | Recent elephant<br>damage                                       |
| 9                              | Acacia     | 4   | 3/01                 | Contin.              |         |                                                                 |
| 3                              | Eucalyptus | 4   | 3/01                 | 3/02                 |         |                                                                 |
| 2                              | Gliricidia | 4   | 3/01                 | 3/02                 |         |                                                                 |
| 7                              | Gliricidia | 4   | 3/01                 | Cont                 |         |                                                                 |
|                                |            |     |                      |                      |         |                                                                 |
| <b><u>Anamaduwa</u></b>        |            |     |                      |                      |         | Supervisor:-<br>Manjula Sampathi                                |
| 4                              | Acacia     | 4   | 4/01                 | Cont                 | 1x1     | Good establishment<br>overall                                   |
| 4                              | Acacia     | 4   | 4/01                 | Cont                 | 1x2     |                                                                 |
| 4                              | Acacia     | 4   | 3/01                 | 3/02                 | 1x2     |                                                                 |
| 6                              | Gliricidia | 4   | 3/01                 | 3/02                 | 1x1     |                                                                 |
| 6                              | Gliricidia | 4   | 3/01                 | Cont                 | 1x1     |                                                                 |
| 8                              | Gliricidia | 4   | 3/01                 | 3/02                 | 1x2     |                                                                 |
|                                |            |     |                      |                      |         |                                                                 |
| <b><u>Anuradhapura 1</u></b>   |            |     |                      |                      |         | Supervisor:-B P<br>Dhammike Senevirathna                        |
| A 2.8                          | Gliricidia | 4   | 3/01                 | cont                 | 1x2     | Elephant and cattle<br>damage, site<br>waterlogged              |
| A 2.7                          | Gliricidia | 4   | 3/01                 | cont                 | 1x2     |                                                                 |
|                                | Acacia     | 4   | 5/01                 | 5/02                 |         |                                                                 |
|                                | Casuarina  |     |                      |                      |         |                                                                 |
|                                |            |     |                      |                      |         |                                                                 |
| <b><u>Anuradhapura 2</u></b>   |            |     |                      |                      |         | Supervisor:-<br>Mr Rathnyake                                    |
|                                | Gliricidia | 4   | 3/01                 | 6/02                 | 1x0.5   |                                                                 |
|                                | Gliricidia | 4   | 3/01                 | cont                 | 1x0.5   |                                                                 |
|                                | Gliricidia | 4   | 3/01                 | 6/02                 | 1x2     |                                                                 |
|                                | Gliricidia | 4   | 3/01                 | cont                 | 1x2     |                                                                 |
|                                |            |     |                      |                      |         |                                                                 |
| <b><u>Mahailluppallama</u></b> |            |     |                      |                      |         | Supervisor:-<br>G Gunawardelana                                 |
|                                | Cassia     | 3   | 6/01                 | 7/02                 | 1x1     | High survival and<br>good overall canopy<br>cover for all plots |
|                                | Ipil Ipil  | 3   | 6/01                 | 7/02                 | 1x1     |                                                                 |
|                                | Gliricidia | 3   | 6/01                 | 7/02                 | 1x1     |                                                                 |
|                                | Ipil Ipil  | 3   | 6/01                 | cont                 | 1x1     |                                                                 |
|                                | Ipil Ipil  | 3   | 6/01                 | cont                 | 1x2     |                                                                 |
|                                | Gliricidia | 3   | 6/01                 | cont                 | 1x2     |                                                                 |
|                                | Cassia     | 3   | 6/01                 | 7/02                 | 1x2     |                                                                 |
|                                | Cassia     | 3   | 6/01                 | cont                 | 1x1     | Insect damage on<br>plot                                        |

|                                                       |            |   |      |      |     |                                         |
|-------------------------------------------------------|------------|---|------|------|-----|-----------------------------------------|
| <b><u>Polonnaruwa</u></b>                             |            |   |      |      |     | Supervisor:-<br>Sandya Kumuduni         |
| 1                                                     | Acacia     | 3 | 3/01 | cont | 2x1 | Extensive site fire<br>damage in Aug 02 |
| 2                                                     | Gliricidia | 3 | 3/01 | cont | 2x1 |                                         |
| 1                                                     | Acacia     | 3 | 3/01 | cont | 2x1 |                                         |
| 3                                                     | Gliricidia | 3 | 3/01 | cont | 2x1 |                                         |
|                                                       |            |   |      |      |     |                                         |
| <b><u>Eastern University<br/>Batticaloa (1ha)</u></b> |            |   |      |      |     | Supervisor:<br>vacant                   |
|                                                       | Gliricidia | 2 | 2/02 | cont | 2x1 | Not fully established                   |
|                                                       |            |   |      |      |     |                                         |
| <b><u>Kundasale</u></b>                               |            |   |      |      |     | Supervisor:<br>Mr Amarakon              |
| 1                                                     | Acacia     | 4 | 2/01 | cont | 2x1 | Some good plots                         |
| 1                                                     | Gliricidia | 4 | 2/01 | 2/02 | 2x1 |                                         |
| 1                                                     | Calliandra | 4 | 2/01 | cont | 2x1 |                                         |
| 2                                                     | Calliandra | 4 | 2/01 | 2/02 | 1x1 |                                         |
| 3                                                     | Gliricidia | 4 | 2/01 | cont | 1x2 | Too frequent pruning                    |
| 3                                                     | Gliricidia | 4 | 2/01 | 2/02 | 1x2 | Vigorous regrowth                       |

**Key outcomes from visit were that:**

- Work on project plantations has been sustained
- Steering Committee has maintained active support for project
- Significant level of commercial interest in dendropower evident in Sri Lanka
- There is no shortage of land for dendropower plantations, but the interest and willingness of farmers to grow fuelwood for this purpose in identified locations requires confirmation
- Agreed with MERST that NRI would submit requests for (i) 3 month no-cost time extension and (ii) contract budget virement
- Payment of MERST advance of 18k euro for 2002 expenditure was to be progressed
- Project Final Report and Cost Statements to be completed asap

**Additionally, it was ascertained that:**

- Need exists for 3-year continuation of plantation monitoring at 3 or 4 sites
- MERST are willing to participate in an extension request with a degree of NRI involvement to provide land planning, economic forestry and small scale industrial enterprise expertise.
- EC will receive such a request as a non-competitive call on the Tropical Forest Budget line
- Extension request to be submitted with Final Report

**Minutes of the Meeting of the Steering Committee on "Sustainable Supply of Fuel-wood to Meet Sri Lanka's Energy Needs" Subsidiary Contract: LKA/B7-6201/CB/97/0538105 held at the Auditorium of the Ministry of Economic Reform, Science and Technology on 8 November 2002 at 10.00 a.m.**

**Present, -**

1. Mr. G Hewagama, Secretary, Ministry of Economic Reform, Science & Technology.
2. Mr M D D Peiris, Advisor, MERST.
- Dr.Ray Wijewardene, Director, NERD Centre.
3. Prof K.K.Y.W. Perera, Chairman, Energy Conservation Fund.
4. Mr Alec Hollingdale, Natural Resources Institute, UK.
5. Dr R B Ridgway, Natural Resources Institute, UK.
6. Mr. Sarath Fernando, Conservator General of Forest, Forestry Department.
7. Mr. P Subasinghe, Assistant Secretary, MERST.
8. Mr G D Rupasinghe, Chief Accountant, MERST.
9. Mr S K Shanmugasundaram, Accountant (Payment), MERST.
10. Mrs C Kulatunga, Deputy Director, National Planning Dept.
11. Dr Jayantha Gunertilake, Head Agronomy Division, Coconut Research Institute.
12. Mr H Wickramasinghe, Director (Project), Energy Conservation Fund.
13. Mr. H A Vimal Nadeera, Project Engineer, Energy Conservation Fund.
14. Mr J Jayasinghe, Director, Land Use Policy Planning Division.
15. Mr.N.R.Meemaduwa, Director General, MERST.
16. Mr Borja Miguelez, Delegation of European Commission.
17. Mr P G Joseph, Director, Alternative Energy Division, MERST.
18. Mrs. W.A.S.Mahawewa, Director (Planning), MERST.

1 Mr Hewagama welcomed members to the meeting. This then continued in line with the agenda items and as reported below.

2. Dr Ray Wijewardene gave a power point display on dendropower potential in Sri Lanka as an introduction to the meeting (see attached).

Mr Peiris opened discussion on particularly important aspects that he identified as technology dissemination, plantation management model and institutional uptake. He was of the view that CEB prefers few larger power plants to many smaller ones. Some discussion also ensued on the quality of tree cover when related to energy crops.

Dr. Gunetilleke explained that the 30-hectare Gliricidia SRC plantations under coconut at the Research Centre at Pallama is functioning on a commercial basis supplying coppice wood to an industrial unit. He proposed to expand the SRC plantation with the revenue obtained by the sale of coppice wood.

3. Mr Joseph followed with another presentation on the objectives and present status of the project (see attached)

4. Mr Wickremasinghe gave a summary of the yield calculations being performed at each site with detail from the site at Mahailluppalla. (see attached)

5. Dr Ridgway indicated his previous long-term work in Sri Lanka at the inception of the LUPPD and more recently in other cooperative activities. The work that was being currently carried out for this project was then outlined in a power point display presented by Mr Jayasinghe (see attached).

6. Mr Hollingdale commented on the financial status of the project. He pointed out that the financial statement for Year 4 of the project had been presented with the recent interim report. This had indicated that there was significant underspend on certain headings and those with responsibilities had been advised. With less than two months remaining before the end-date of the project it could be appropriate to obtain items to help with dissemination of results from remaining funds under equipment headings. Such items discussed were multi media projector, digital camera, GPS instrument and laptop computer; but speedy action was necessary to purchase any such items. All remaining reimbursable expenditure for the project would need to be included in the final audit for the year ending 31 December 2002. Approval would be sought from the EC for a project advance ahead of the final report submission in the same manner as in the previous year. A request for a short time allowance to complete the final report had been addressed to the EC.

7. Mr Joseph outlined the type of future activities that had been discussed earlier in the year with the EC and which MERST had subsequently progressed to the extent of obtaining approval for counterpart funding. These comprised a 3-year plantation site monitoring on three of the present project sites, a demonstration facility for 500kW Dendropower system, and a 250kW Wave Energy Demonstration Project.

Mr. Miguelez advised that he is awaiting response from Brussels on these issues and on issues connected with the completion of the project.

#### 8. Discussion

Prof. Perera emphasised the need to continue the project for a further period until the out come of the projects are adequately implemented. He informed the members that a request made by the Biomass Energy Association for the inclusion of a Capacity Charge in the Power Purchase Tariff for small power projects has been granted for the initial projects. He also pointed out that modern technology has made it possible to incorporate large numbers small power plants in to the national electricity grid.

**Steering Committee Meeting of Fuelwood Project**  
**8<sup>th</sup> November, 2002**

**Agenda**

1. Welcome Address  
*Mr. G.Hewagama*  
*Secretary, Ministry for Economic Reform, Science and Technology*
2. Background to the project  
*Vidya Jothi Dr. Ray Wijewardene*  
*Director, NERD Centre*
3. Objectives and present status of project  
*Mr. P.G.Joseph*  
*Director, Alternative Energy Division,*  
*Ministry for Economic Reform, Science and Technology*
4. Summary of yield measurements  
*Mr. H.Wickremasinghe*  
*Director (Projects)*  
*Energy Conservation Fund*
5. Land use issues  
*Dr. R.Ridgway*  
*Natural Resources Institute, UK and*  
*Mr. J.Jayasinghe*  
*Director, Land Use Policy Planning Division*
6. Financial position of project  
*Mr. A.C.Hollingdale*  
*Natural Resources Institute, UK*
7. Future activities  
*Mr.A.C.Hollingdale*  
*Natural Resources Institute, UK and*  
*Mr.P.G.Joseph*  
*Director, Alternative Energy Division, Ministry for Economic Reform, Science and Technology*
8. Discussion & Conclusion

## **Attachments to Steering Committee Meeting Minutes**

The following printout of slides from four power point presentations made to the meeting were attached to the meeting minutes

### **Growing Our Own Energy**

***Vidya Jothi Dr. Ray Wijewardene***

***Director, NERD Centre***

### **Sustainable Supply of Fuel-wood to Meet Sri Lanka's Energy Needs - objectives and present status of the project**

***Mr P G Joseph***

***Director, Alternative Energy Division, MERST.***

### **Fuel Wood Yields from Dedicated Plantation at Maha-Illuppallama**

***Mr. H.Wickremasinghe***

***Director (Projects)***

***Energy Conservation Fund***

### **Land use issues ; Fuel Wood Project – Field Survey Questionnaire**

***Mr. J.Jayasinghe***

***Director, Land Use Policy Planning Division***

## ***Financial Statement for 2002/3***

Essential papers relating to the financial management of the project are attached. These comprise the following items:

1. Complete updated NRI Cost Statements for year 5 of project.
2. KPMG Audit Report for Year 5

Matters of note arising from this information are as follows:

### **NRI Cost Statements**

A full record of costs incurred by NRI in Year 5 of the project is detailed in the attached table. These follow the required format of EC Annex III tables and are for the Financial Year 2002/03.

Staff costs are derived from times logged by participating staff on NRI's project management accounting records, although only a proportion of these costs are being charged to this EC project. These charged times have then been converted to Euro at the charge rates agreed in the contract. This final year charge includes some staff time logged to the project from earlier years but not previously charged to the project.

Details of non-staff costs have been extracted from NRI's project management accounting records for this period of the project. These have been converted to euro using monthly exchange rates according to EC instructions.

### **Payments made to MOST this year**

Audited costs incurred by the Ministry of Science and Technology (MOST) in Sri Lanka in the calendar year ending 31 December 2002 and were approved and paid during the past year. In addition an advance payment of project costs for the year 2002 was made during this year.

### **Project Time Extension Request**

In view of the need for compilation of full results for the Final Report it was necessary for the project to seek a short time extension for submission of the Final Report. This was agreed by the EC without any change to the formal completion date of 4<sup>th</sup> January 2003. Some costs that have unavoidably fallen after this date are included within the financial year Cost Statement for 2002/3, notably those subject to completion of the KPMG year 5 audit report. However, all project costs that have been incurred have now been provided either within the current financial year Cost Statement or those submitted for earlier years.

**NATURAL RESOURCES INSTITUTE**

**STATEMENT OF EXPENDITURE  
FOR THE YEAR ENDED  
31<sup>ST</sup> DECEMBER 2002.**

## **REPORT OF THE AUDITORS**

### **TO THE NATURAL RESOURCES INSTITUTE**

We have audited the statement of Expenditure for the year ended 31<sup>st</sup> December 2002 together with the notes.

#### **BASIS OF OPINION**

We conducted our audit in accordance with the Sri Lanka Auditing Standards, which require that we plan and perform the audit to obtain reasonable assurance about whether the said Expenditure Statement is free of material misstatements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the said Expenditure Statement, assessing the accounting principles used and significant estimates made by the Project Team, evaluating the overall presentation of the financial statements, and determining whether the said Expenditure Statement are prepared in accordance with the Sri Lanka Accounting Standards. We have obtained all the information and explanations, which to the best of our Knowledge and belief were necessary for the purpose of our audit. We therefore believe that our audit provides a reasonable basis for our opinion.

#### **OPINION**

In our opinion, so far as appears from our examination, the Project Team maintained proper books of account for the year ended 31<sup>st</sup> December 2002, and to the best of our information and according to the explanation given to us, the said Expenditure Statement and notes thereto, which are in agreement with the said books have been prepared and presented in accordance with the generally accepted accounting principles.

#### **CHARTERED ACCOUNTANTS**

Colombo.

11<sup>th</sup> February 2003.

**Natural Resources Institute**  
**Expenditure Statement**

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*For the Year Ended 31st December*

|                                                                                   | Notes | 2002<br>Rs.      | 2001<br>Rs.      |
|-----------------------------------------------------------------------------------|-------|------------------|------------------|
| Expenditure incurred by the Ministry of Science & Technology on Trial Plots       | 1     | 1,216,793        | 1,194,061        |
| Expenditure incurred by the Post Graduate Institute of Agriculture on Trial Plots | 2     | 206,264          | 300,000          |
| Expenditure incurred by the Agriculture Research Institute on Trial Plots         | 3     | 455,855          | 322,443          |
| Expenditure incurred by the Eastern University on setting up Fuelwood Plant       | 4     | 100,800          | 31,570           |
| Expenditure Incurred by the Open University on setting up Fuelwood Plant          | 5     | 25,000           | 67,960           |
| Vehicles Hired                                                                    |       | 83,825           | -                |
| Purchase of Multimedia and Digital Camera                                         | 6     | 384,000          | -                |
| <b>Total Expense for the Year</b>                                                 |       | <b>2,472,537</b> | <b>1,916,034</b> |
| Funds Receivable / ( Overpayment ) for the Previous Year                          |       | -1,926,896       | 9,231            |
| <b>Balance to be reimbursed from the budget</b>                                   |       | <b>545,641</b>   | <b>1,925,265</b> |

**Natural Resources Institute**  
**Notes To The Expenditure Statement**

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1. Expenditure incurred by the Forest Department was verified by us and found to be satisfactory. It should be noted that verification of the above amount was done on a sample basis.

| Division                        | Plantation<br>Labour<br>Cost<br>Rs. | Plantation<br>Tools &<br>Materials<br>Rs. | Supervision<br>Cost<br>Rs. | Total<br>2002<br>Rs. | Total<br>2001<br>Rs. |
|---------------------------------|-------------------------------------|-------------------------------------------|----------------------------|----------------------|----------------------|
| <b><u>Forest Department</u></b> |                                     |                                           |                            |                      |                      |
| Anuradhapura                    | 190,396                             | 24,845                                    | 176,000                    | 391,241              | 340,551              |
| Badulla                         | 105,422                             | -                                         | -                          | 105,422              | 101,443              |
| Hambantota                      | 27,419                              | 10,395                                    | 96,000                     | 133,814              | 114,738              |
| Kurunagala                      | 119,016                             | 8,787                                     | 96,000                     | 223,803              | 169,989              |
| Pollonnaruwa                    | 38,891                              | -                                         | 96,000                     | 134,891              | 191,572              |
| Puttalam                        | 121,239                             | -                                         | 96,000                     | 217,239              | 186,963              |
| <b><u>Other Expenses</u></b>    |                                     |                                           |                            |                      |                      |
| Operating Cost                  | -                                   | -                                         | -                          | 10,383               | 15,448               |
| Fertiliser & Chemicals          | -                                   | -                                         | -                          | -                    | 73,357               |
| <b>Total</b>                    | <b>602,382</b>                      | <b>44,027</b>                             | <b>560,000</b>             | <b>1,216,793</b>     | <b>1,194,061</b>     |

## 1.2 Supervision Cost

Six Supervisors were appointed by the steering committee, Two for Anuradhapura and One each for the others for Rs.8,000/- per month from January 2002. But there was no supervisor in Anuradhapura for the months of May and April 2002.

**Natural Resources Institute**

**Notes To The Expenditure Statement**

2. Expenditure incurred by the Post Graduate Institute of Agriculture (PGIA) was verified by us and found to be satisfactory.

| <b>Division</b>              | <b>Plantation<br/>Labour Cost<br/>Rs.</b> | <b>Plantation<br/>Tools &amp;<br/>Materials<br/>Rs.</b> | <b>Supervision<br/>of Labour<br/>Rs.</b> | <b>Total<br/>2002<br/>Rs.</b> | <b>Total 2001<br/>Rs.</b> |
|------------------------------|-------------------------------------------|---------------------------------------------------------|------------------------------------------|-------------------------------|---------------------------|
| Kundasale                    | 146,405                                   | 59,859                                                  | -                                        | 206,264                       | 157,482                   |
| <b><u>Other Expenses</u></b> |                                           |                                                         |                                          |                               |                           |
| Operating Cost               | -                                         | -                                                       | -                                        | -                             | 41,539                    |
| Advance Payments             | -                                         | -                                                       | -                                        | -                             | 45,479                    |
| Supervision of labour        | -                                         | -                                                       | -                                        | -                             | 55,500                    |
| <b>Total</b>                 | <b>146,405</b>                            | <b>59,859</b>                                           | <b>-</b>                                 | <b>206,264</b>                | <b>300,000</b>            |

3. Expenditure incurred by the Agriculture Research Institute was verified by us and found to be satisfactory.

| <b>Division</b>                  | <b>Plantation<br/>Labour Cost<br/>Rs.</b> | <b>Plantation<br/>Tools &amp;<br/>Materials<br/>Rs.</b> | <b>Supervision<br/>of Labour<br/>Rs.</b> | <b>Total<br/>2002<br/>Rs.</b> | <b>Total 2001<br/>Rs.</b> |
|----------------------------------|-------------------------------------------|---------------------------------------------------------|------------------------------------------|-------------------------------|---------------------------|
| Maha Illupallama                 | 263,065                                   | -                                                       | 48,000                                   | 311,065                       | 178,568                   |
| Agunakulapalassa                 | 108,790                                   | -                                                       | 36,000                                   | 144,790                       | 67,875                    |
| <b><u>Other Expenses</u></b>     |                                           |                                                         |                                          |                               |                           |
| Supervision &<br>Co - Ordination | -                                         | -                                                       | -                                        | -                             | 76,000                    |
| <b>Total</b>                     | <b>371,855</b>                            | <b>-</b>                                                | <b>84,000</b>                            | <b>455,855</b>                | <b>322,443</b>            |

**Natural Resources Institute**  
**Notes To The Expenditure Statement**

- 4 Total Expenses for the year was Rs.100,800/-. We verified this payment and it was found to be satisfactory.

| Division                     | Plantation<br>Labour Cost<br>Rs. | Plantation<br>Tools &<br>Materials<br>Rs. | Total<br>2002<br>Rs. | Total<br>2001<br>Rs. |
|------------------------------|----------------------------------|-------------------------------------------|----------------------|----------------------|
| Batticaloa                   | 88,000                           | 12,800                                    | 100,800              | 94,570               |
| <b><u>Other Expenses</u></b> |                                  |                                           |                      |                      |
| Supervision of Labour        | -                                | -                                         | -                    | 12,000               |
| Advance Payment              | -                                | -                                         | -                    | (75,000)             |
| <b>Total</b>                 | <b>88,000</b>                    | <b>12,800</b>                             | <b>100,800</b>       | <b>31,570</b>        |

- 5 The expenses for the year was Rs. 25,000/-.

| Division     | Plantation<br>Labour Cost<br>Rs. | Plantation<br>Tools &<br>Materials<br>Rs. | Total<br>2002<br>Rs. | Total<br>2001<br>Rs. |
|--------------|----------------------------------|-------------------------------------------|----------------------|----------------------|
| Nawala       | 25,000                           | -                                         | 25,000               | 67,960               |
| <b>Total</b> | <b>25,000</b>                    | <b>-</b>                                  | <b>25,000</b>        | <b>67,960</b>        |

- 6 As per agreement Purchase of Digital Camera and Multimedia Projector for the year 2002.

| Description          | 2002<br>Rs.    | 2001<br>Rs. |
|----------------------|----------------|-------------|
| Digital Camera       | 85,200         | -           |
| Multimedia projector | 298,800        | -           |
| <b>Total</b>         | <b>384,000</b> | <b>-</b>    |

## Expenditure - 2002

### Maha-liuppallama

| Date       | Description                                              | Amount           | Labour           | Item |
|------------|----------------------------------------------------------|------------------|------------------|------|
| 02.01.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 02.02.2002 | Manuwal weeding, Continuous Harvesting                   | 16950.00         | 16950.00         |      |
| 19.01.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 19.02.2002 | Manuwal weeding, Continuous Harvesting                   |                  |                  |      |
|            | Marking of mini plots                                    | 9750.00          | 9750.00          |      |
| 25.03.2002 | Maintenance of Fence & Roads                             | 2115.00          | 2115.00          |      |
| 25.03.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 18.04.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 05.05.2002 | Continuous Harvesting, & Internal Transport of fire wood | 19975.00         | 19975.00         |      |
| 30.05.2002 | Manuwal weeding, Loading & Unloading Firewood            | 42770.00         | 42770.00         |      |
| 17.05.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 12.06.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 03.07.2002 | Continuous Harvesting                                    | 41830.00         | 41830.00         |      |
| 02.08.2002 | Continuous Harvesting & Yearly Harvesting                | 48645.00         | 48645.00         |      |
| 16.07.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 26.08.2002 | Continuous Harvesting & Internal Transport of fire wood  | 43665.00         | 43665.00         |      |
| 16.09.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 03.10.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 29.10.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 29.10.2002 | Continuous Harvesting                                    | 13160.00         | 13160.00         |      |
| 21.11.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 21.12.2002 | Supervision Charges                                      | 4000.00          | 4000.00          |      |
| 24.10.2002 | Continuous Harvesting                                    | 24205.00         | 24205.00         |      |
| 31.12.2002 | Total                                                    | <b>311065.00</b> | <b>311065.00</b> |      |

### Angunakolapalassa

| Date       | Description                                            | Amount           | Labour           | Item |
|------------|--------------------------------------------------------|------------------|------------------|------|
| 02.01.2002 | Thinning out, manuwal weeding, planting of Casia       | 9225.00          | 9225.00          |      |
| 02.01.2002 | Supervision Charges                                    | 4000.00          | 4000.00          |      |
| 19.02.2002 | Open of fire belt, manuwal weeding                     | 10500.00         | 10500.00         |      |
| 25.03.2002 | Supervision Charges                                    | 4000.00          | 4000.00          |      |
| 18.04.2002 | Supervision Charges                                    | 4000.00          | 4000.00          |      |
| 18.04.2002 | Harvesting of Acasia & Gliricidia                      | 12510.00         | 12510.00         |      |
| 16.05.2002 | Harvesting                                             | 8225.00          | 8225.00          |      |
| 26.06.2002 | Harvesting                                             | 6580.00          | 6580.00          |      |
| 16.07.2002 | Harvesting                                             | 14500.00         | 14500.00         |      |
| 26.08.2002 | Open of fire belt, manuwal weeding                     | 20250.00         | 20250.00         |      |
| 16.09.2002 | Construction of fence & Internal Transport of firewood | 15250.00         | 15250.00         |      |
| 21.11.2002 | Supervision Charges                                    | 4000.00          | 4000.00          |      |
|            | Supervision Charges                                    | 4000.00          | 4000.00          |      |
|            | Supervision Charges                                    | 4000.00          | 4000.00          |      |
|            | Supervision Charges                                    | 4000.00          | 4000.00          |      |
|            | Supervision Charges                                    | 4000.00          | 4000.00          |      |
|            | Supervision Charges                                    | 4000.00          | 4000.00          |      |
| 24.12.2002 | Marking of Sample plots                                | 1500.00          | 1500.00          |      |
| 29.12.2002 | Internal transport Lording Marking                     | 10250.00         | 10250.00         |      |
| 31.12.2002 | Total                                                  | <b>144790.00</b> | <b>144790.00</b> |      |

### Nikaweratiya

| Date       | Description                                                       | Amount           | Labour           | Item           |
|------------|-------------------------------------------------------------------|------------------|------------------|----------------|
| 01.01.2002 | Purchasing of Gliricidia stems, Accasia Seedlings, Transport Cost | 8787.00          |                  | 8787.00        |
| 01.01.2002 | Harvesting of Accasia & Gliricidia                                | 6498.00          | 6498.00          |                |
| 01.01.2002 | Planting of Gliricidia & Accasia                                  | 7011.00          | 7011.00          |                |
| 13.02.2002 | Slashing out of weeds, remove of plants                           | 9405.00          | 9405.00          |                |
| 03.05.2002 | Internal transport One year harvesting                            | 11457.00         | 11457.00         |                |
| 16.05.2002 | Continuous harvesting                                             | 12996.00         | 12996.00         |                |
| 11.10.2002 | Continuous harvesting Accasia Gliricidia Eucaplitus               | 35055.00         | 35055.00         |                |
| 29.10.2002 | Continuous harvesting & internal transport                        | 13851.00         | 13851.00         |                |
| 21.11.2002 | Continuous harvesting & internal transport of firewood            | 15219.00         | 15219.00         |                |
| 17.12.2002 | Continuous harvesting                                             | 7524.00          | 7524.00          |                |
| 31.12.2002 | Supervisor Salary                                                 | 96000.00         | 96000.00         |                |
| 31.12.2002 | Total                                                             | <b>223803.00</b> | <b>215016.00</b> | <b>8787.00</b> |

### Anamaduwa

| Date       | Description                                           | Amount           | Labour           | Item           |
|------------|-------------------------------------------------------|------------------|------------------|----------------|
| 02.01.2002 | Countinous Harvesting Maintenace of road              | 1368.00          | 1368.00          |                |
| 01.01.2002 | Expenses Tel calls/Fax                                | 244.00           |                  | 244.00         |
| 13.02.2002 | Countinous Harvesting                                 | 855.00           | 855.00           |                |
| 13.02.2002 | Expenses Tel calls/Fax                                | 311.50           |                  | 311.50         |
| 19.02.2002 | Removing of new sprouts, Slashing out of weeds        | 9405.00          | 9405.00          |                |
| 06.03.2002 | Internal Transport of firewoods Loading the firewoods | 2223.00          | 2223.00          |                |
| 25.03.2002 | Expenses Tel calls/Fax                                | 415.00           |                  | 415.00         |
| 25.03.2002 | One Year harvesting of acasia Gliricigia              | 11286.00         | 11286.00         |                |
| 14.03.2002 | One Year harvesting                                   | 8037.00          | 8037.00          |                |
| 03.05.2002 | Expenses Tel calls/Fax                                | 360.00           |                  | 360.00         |
| 03.05.2002 | Countinous Harvesting                                 | 13851.00         | 13851.00         |                |
| 23.05.2002 | Countinous Harvesting                                 | 5814.00          | 5814.00          |                |
| 12.06.2002 | Weeding and Countinous harvesting                     | 16245.00         | 16245.00         |                |
| 18.07.2002 | Expenses Tel calls/Fax                                | 323.50           |                  | 323.50         |
| 10.07.2002 | Countinous Harvesting                                 | 6156.00          | 6156.00          |                |
| 26.08.2002 | Opening of firewood                                   | 9405.00          | 9405.00          |                |
| 16.09.2002 | Expenses Tel calls/Fax                                | 341.00           |                  | 341.00         |
| 16.09.2002 | Weeding and Countinous harvesting                     | 12141.00         | 12141.00         |                |
| 23.09.2002 | Countinous Harvesting                                 | 10431.00         | 10431.00         |                |
| 10.10.2002 | Expenses Tel calls/Fax                                | 1028.00          |                  | 1028.00        |
| 21.11.2002 | Weeding and Countinous harvesting                     | 14022.00         | 14022.00         |                |
| 17.12.2002 | Expenses Tel calls/Fax                                | 606.50           |                  | 606.50         |
| 31.12.2002 | Supervisor Salary                                     | 96000.00         | 96000.00         |                |
| 31.12.2002 | Total                                                 | <b>220868.50</b> | <b>217239.00</b> | <b>3629.50</b> |

### Mahiyanganaya ( Baddulla )

| Date       | Description                                    | Amount           | Labour           | Item |
|------------|------------------------------------------------|------------------|------------------|------|
| 17.01.2002 | Harvesting Acasia                              | 6070.50          | 6070.50          |      |
| 01.02.2002 | Cutting of Gliricidia and plantening           | 6754.50          | 6754.50          |      |
| 13.02.2002 | Countinous Harvesting                          | 11371.50         | 11371.50         |      |
| 23.05.2002 | Countinous Harvesting                          | 16245.00         | 16245.00         |      |
| 18.06.2002 | Slashing out of weeds                          |                  |                  |      |
|            | Countinous Harvesting                          | 7011.00          | 7011.00          |      |
| 12.06.2002 | Slashing out of weeds                          |                  |                  |      |
|            | Countinous Harvesting                          | 18297.00         | 18297.00         |      |
| 03.07.2002 | Opening of firewood                            | 11628.00         | 11628.00         |      |
| 16.09.2002 | Harvesting and Internal Transport<br>fire wood | 13680.00         | 13680.00         |      |
| 17.12.2002 | Countinous Harvesting & Yearly Harvesting      | 14364.00         | 14364.00         |      |
| 31.12.2002 | Total                                          | <b>105421.50</b> | <b>105421.50</b> |      |

### ANURADHAPURA -II

| Date       | Description                                              | Amount           | Labour           | Item           |
|------------|----------------------------------------------------------|------------------|------------------|----------------|
| 09.01.2002 | Perchesing of Gliricidia stamps                          | 8000.00          |                  | 8000.00        |
| 13.02.2002 | Countinuous Harvesting                                   |                  |                  |                |
|            | Maintenance of the fence                                 |                  |                  |                |
|            | Slashing out of weeds                                    | 8037.00          | 8037.00          |                |
| 13.02.2002 | Planting of Giiricidia stamps                            |                  |                  |                |
|            | Countinuous Harvesting                                   |                  |                  |                |
|            | Transport of Gliricidia stamps                           | 4018.50          | 4018.50          |                |
| 15.01.2002 | Planting of Giiricidia stamps                            | 2137.50          | 2137.50          |                |
| 13.02.2002 | Expenses Tel:Calls/Fax                                   | 303.50           |                  | 303.50         |
| 14.02.2002 | Advance for vacancy filling                              | 7524.00          | 7524.00          |                |
| 25.03.2002 | Advance for weeding                                      | 7011.00          | 7011.00          |                |
| 16.05.2002 | Advance for Harvesting                                   | 8122.50          | 8122.50          |                |
| 18.06.2002 | Countinuous Harvesting                                   |                  |                  |                |
|            | One year Harvesting                                      | 17100.00         | 17100.00         |                |
| 12.06.2002 | Slashing out of weeds                                    | 5814.00          | 5814.00          |                |
| 02.08.2002 | Slashing out of weeds                                    | 8892.00          | 8892.00          |                |
| 26.08.2002 | Internal transport of firewood bundaling<br>and loarding | 13427.00         | 13427.00         |                |
| 21.11.2002 | Continuous harvesting                                    | 9576.00          | 9576.00          |                |
| 29.10.2002 | Continuous harvesting                                    | 15390.00         | 15390.00         |                |
| 31.12.2002 | Superviser Salary                                        | 80000.00         | 80000.00         |                |
| 31.12.2002 | Total                                                    | <b>195353.00</b> | <b>187049.50</b> | <b>8303.50</b> |

## Anuradhapura I

| Date       | Description                                        | Amount           | Labour          | Item            |
|------------|----------------------------------------------------|------------------|-----------------|-----------------|
| 01.01.2002 | Expenses for telephone calls                       | 213.00           |                 | 213.00          |
| 01.01.2002 | Transport for Gliricidia stems                     | 2803.62          |                 | 2803.62         |
| 02.01.2002 | Planting of Gliricidia stems slashing out of weeds | 5130.00          | 5130.00         |                 |
| 02.01.2002 | Slashing out of weeds. Planting Casia              | 4617.00          | 4617.00         |                 |
| 03.01.2002 | Advance for planting Casurina                      | 6000.00          | 6000.00         |                 |
| 17.01.2002 | Expenses for Telephone Calls                       | 245.00           |                 | 245.00          |
| 15.02.2002 | Planting of Gliricidia stems slashing out of weeds | 8037.00          | 8037.00         |                 |
| 13.02.2002 | Perchasing of seedling                             | 4525.00          |                 | 4525.00         |
| 13.02.2002 | Slashing out of weeds. Planting of Acasia          | 6498.00          | 6498.00         |                 |
| 25.03.2002 | Perchasing of seedling                             | 12000.00         |                 | 12000.00        |
| 02.04.2002 | Countinuous Harversting Slashing of weed           | 10773.00         | 10773.00        |                 |
| 03.05.2002 | One Year Harvesting                                |                  |                 |                 |
|            | Slashing out of weeds.                             | 15907.00         | 15907.00        |                 |
| 25.06.2002 | Advance for weeding                                | 8122.50          | 8122.50         |                 |
| 26.08.2002 | Harvesting and internal transport                  | 16074.00         | 16074.00        |                 |
| 24.08.2002 | Internal transport                                 | 1539.00          | 1539.00         |                 |
| 03.10.2002 | Expenses for Telephone Calls                       |                  |                 |                 |
|            | Perchasing Quarries                                | 2508.00          | 2188.00         | 320             |
| 31.12.2002 | Superviser Salary                                  | 96000.00         |                 |                 |
| 31.12.2002 | Total                                              | <b>200992.12</b> | <b>84885.50</b> | <b>20106.62</b> |

## POLONNARUWA

| Date       | Description                                   | Amount           | Labour           | Item           |
|------------|-----------------------------------------------|------------------|------------------|----------------|
| 01.01.2002 | Expenses for Telephone Calls                  | 399.00           |                  | 399.00         |
| 06.03.2002 | Slashing out of weeds. Planting of Gliricidia | 5814.00          | 5814.00          |                |
| 07.03.2002 | Advance for vacancy filling                   | 8205.00          | 8205.00          |                |
| 25.03.2002 | Expenses for Telephone Calls                  | 252.00           |                  | 252.00         |
| 23.05.2002 | One Year Harvesting                           |                  |                  |                |
|            | Slashing out of weeds.                        | 6156.00          | 6156.00          |                |
| 16.05.2002 | Expenses for Telephone Calls                  | 250.00           |                  | 250.00         |
| 12.06.2002 | One Year Harvesting                           |                  |                  |                |
|            | Slashing out of weeds.                        | 6837.50          | 6837.50          |                |
| 08.07.2002 | Advance for Harvesting                        | 4959.00          | 4959.00          |                |
| 16.07.2002 | Expenses for Telephone Calls                  | 250.00           |                  | 250.00         |
| 16.09.2002 | Harvesting                                    | 6919.00          | 6919.00          |                |
| 10.10.2002 | Expenses for Telephone Calls                  | 250.00           |                  | 250.00         |
| 21.11.2002 | Expenses for Telephone Calls                  | 250.00           |                  | 250.00         |
| 31.12.2002 | Superviser Salary                             | 96000.00         | 96000.00         |                |
| 31.12.2002 | Total                                         | <b>136541.50</b> | <b>134890.50</b> | <b>1651.00</b> |

### LUNUGAMVHERA

| Date       | Description                                | Amount           | Labour           | Item            |
|------------|--------------------------------------------|------------------|------------------|-----------------|
| 09.01.2002 | Slashing out of weeds. Planting of Acasia  | 8951.50          | 8951.50          |                 |
| 09.01.2002 | Perchasing of black Polythin               |                  |                  |                 |
|            | Preparation of bags filling soil           | 10395.00         |                  | 10395.00        |
| 06.03.2002 | Up rooting of death plant                  |                  |                  |                 |
|            | Countinuous Harversting                    | 5130.00          | 5130.00          |                 |
| 03.03.2002 | Opening of firewood                        |                  |                  |                 |
|            | Internal transport and firewood            | 4445.00          | 4445.00          |                 |
| 21.11.2002 | Countinuous Harversting & Early Harvesting | 8892.00          | 8892.00          |                 |
| 31.12.2002 | Superviser Salary                          | 96000.00         | 96000.00         |                 |
| 31.12.2002 | Total                                      | <b>133813.50</b> | <b>123418.50</b> | <b>10395.00</b> |

### KUNDASALAYA

| Date       | Description          | Amount           | Labour | Item |
|------------|----------------------|------------------|--------|------|
| 01.01.2002 | Balance forward      | 45479.49         |        |      |
| 04.05.2002 | Check Number-573683  | 200000.00        |        |      |
| 31.12.2002 | Amount received back | -39215.00        |        |      |
| 31.12.2002 | Total                | <b>206264.49</b> |        |      |

### EASTEN UNIVERSITY

| Date       | Description                                 | Amount           | Labour          | Item            |
|------------|---------------------------------------------|------------------|-----------------|-----------------|
| 01.01.2002 | Cost of re-planting                         | 4000.00          | 4000.00         |                 |
| 31.12.2002 | After care                                  | 10000.00         | 10000.00        |                 |
|            | Cattle Manure                               | 5000.00          |                 | 5000.00         |
|            | Cost of weedicides                          | 7800.00          |                 | 7800.00         |
|            | Cost of Labour (lopping,spreding & bundling | 50000.00         | 50000.00        |                 |
|            | Co-ordinating Charges                       | 24000.00         | 24000.00        |                 |
| 31.12.2002 | Totals                                      | <b>100800.00</b> | <b>88000.00</b> | <b>12800.00</b> |

### OPEN UNIVERSITY

| Date       | Description                      | Amount          | Labour | Item |
|------------|----------------------------------|-----------------|--------|------|
| 11.02.2002 | Advance Payment Cheque no.571348 | 25000.00        |        |      |
| 31.12.2002 | Total                            | <b>25000.00</b> |        |      |

## OTHER EXPENDETURE

| Date       | Description                        | Amount           | Labour | Item             |
|------------|------------------------------------|------------------|--------|------------------|
| 23.12.2002 | Vehical for hiring                 |                  |        |                  |
|            | High level travels and Tours (pvt) |                  |        |                  |
|            | Ch No-613980                       | 74645.00         |        | 74645.00         |
| 26.12.2002 | Vehical for hiring                 |                  |        |                  |
|            | High level travels and Tours (pvt) | 9180.20          |        | 9180.20          |
|            | Digital Camera                     | 85200.00         |        | 85200.00         |
|            | Multimedia Projector               | 298800.00        |        | 298800.00        |
| 31.12.2002 | Total                              | <b>467825.20</b> |        | <b>467825.20</b> |

## Summary of Expenditure-2002

| Date       | Name of Site      | Amount(Rs)        |
|------------|-------------------|-------------------|
| 31.12.2002 | Maha-Iluppallama  | <b>311065.00</b>  |
|            | Agunakolapalassa  | <b>144790.00</b>  |
|            | Nikawaratiya      | <b>223803.00</b>  |
|            | Anamaduwa         | <b>220868.50</b>  |
|            | Mahiyanganaya     | <b>105421.50</b>  |
|            | Anuradhapura-1    | <b>200992.12</b>  |
|            | Anuradhapura-11   | <b>195353.00</b>  |
|            | Polonnaruwa       | <b>136541.50</b>  |
|            | Lunugamwehera     | <b>133813.50</b>  |
|            | Kandasalaya       | <b>206264.49</b>  |
|            | Easten Uniuersity | <b>100800.00</b>  |
|            | Open University   | <b>25000.00</b>   |
|            | Other Expenditure | <b>467825.20</b>  |
| 31.12.2002 | Total             | <b>2472537.81</b> |