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Watershed management in Sri Lanka's upcountry: a qualitative assessment with particular emphasis on the USAID reforestation project (Project No. 383 0055)

by

Tamara Rusinow
Graduate Student Intern
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1.0 Introduction

In recent years many Asian countries have been experiencing declining agricultural yields and reduced stream flow levels in upland areas, increased sedimentation of reservoirs and irrigation works and devastating natural disasters such as floods and landslides. Many of these problems have been blamed on unsuitable land use patterns and soil erosion in upland areas, and have prompted national governments and aid organizations to take a closer look at land use policies in general and watershed management in particular. Sri Lanka is no exception. Concern about the possible changes taking place in the water flow and sedimentation levels in the Mahaweli Ganga has been growing in recent years. Any changes in the hydraulic regime of this area could have far-reaching consequences, as this river basin and its new irrigation and human resettlement program have been the focus of large scale financial investments by the government of Sri Lanka and many donor organizations. Watershed management has thus become an important focus of research, new government policies and development programs.

2.0 What is a watershed?

The term watershed, which is used interchangeably with the terms catchment or drainage basin, refers to the upstream area of river basins which absorbs a large proportion of the local precipitation, stores it and releases it gradually to the rivers themselves. Its effectiveness in this respect depends to a very large extent on the type and structure of soils and vegetative cover found in the area (IMPSA, 1991). Although Sri Lanka contains 103 recognized river basins, the most important by far is the Mahaweli basin which, from its headwaters to the ocean covers an area of 10,327 sq km, or 16% of the islands area. The upper Mahaweli catchment area (UMCA), with which this paper is primarily concerned, encompasses 3,400 sq km which makes up the so called Wet and Intermediate Zones, and includes four major reservoirs (Kotmale, Victoria, Randengala and Rantembe), which are crucial to the countries's hydroelectric and irrigation capacity. A large proportion of Sri Lanka's agricultural produce is cultivated in this area, and just under one quarter of the countries rural population is concentrated in these two zones (Magrath and Doolette, 1990).

3.0 Who are the major land users in the Upper Mahaweli Catchment Area (UMCA)?

Sri Lanka's hill country is thought to have been sparsely populated throughout much of the islands history, when population centers were mainly concentrated in the coastal areas and dry zones. Invasions and occupation by the Dravidians, Portuguese, Dutch and lastly British, displaced many Sinhalese into the

upcountry. As a result population densities in this area grew and remain high even today. Much of the upcountry was later alienated by the British for plantations. Following the Crown Lands Encroachment Ordinance in 1840, any land that could not be documented as belonging to an individual, was claimed by the Crown. The colonial government thus controlled 90% of the land and subsequently cleared large areas of the upcountry of its natural forest cover in order to plant first coffee then later tea. This policy was continued by the GSL after independence (Bloch, 1988). In 1881, 81% of the island was covered by forests. By 1956 this area had been reduced to 44%, whilst aerial photographs showed that only 27% of the country was forested in 1983 (Fleming, 1991 quoting NARESA, 1991). The majority (about 80%) of the upcountry is still held by the government as state land. Large areas are under tea, plantation forest (mainly Pinus), and so called patana grasslands, whilst only comparatively small areas are held privately. Consequently there is a severe shortage of land in the Wet and Intermediate Zones, which the government has to a limited extent attempted to address with its Mahaweli irrigation and settlement schemes. Nevertheless, incidences of landlessness, microholdings (43% of all farms are 1 acre or less in size) and encroachment are very high (Bloch, 1988). Systems such as thattumaru and kattamaru, in which family members rotate access to a mutually inherited plot, allows many people to be economically sheltered by relatives. A large amount of underemployment is therefore absorbed in rural areas. This has undoubtedly contributed to the relatively slow farm to city migration found in Sri Lanka, but does not in the long term help reduce the severe land shortages experienced in many parts of the island (Thiesenhusen, 1990). The absence of any alternative sources of income, forces numerous small holders to cultivate marginal and steep lands with no legal tenure rights and little incentive to invest in labor or capital intensive conservation measures. The issue of land tenure rights, remains a complex but critical one, in regard to watershed management in Sri Lanka, and has been approached in many different ways by organizations attempting to address the problem of watershed degradation.

In summary, the land tenure arrangement in the UMCA, thus provide for four basic land user groups; 1.) government owned tea estates (currently the management of many estates is being handed over to the private sector); 2.) Forest Department on government owned plantations and grasslands; 3.) small holders with secure tenure; 4.) encroachers or farmers with insecure land tenure.

4.0 Why is watershed management needed in Sri Lanka?

Soil erosion, which is commonly blamed on irresponsible land use alone, is frequently cited as the greatest threat to watersheds, both in terms of upstream productivity and downstream siltation of reservoirs and waterways. Soil loss however, is a natural phenomenon. Indeed the highest observed rates of erosion

have been recorded in rainforest areas, which although free of human interference, are tectonically active and experience extremely high rainfall levels (Bruijnzeel, 1986). Clearly little can be done to halt this type of erosion. However, in regions with low to moderate rates of natural erosion, human activities such as deforestation, farming, mining, construction etc. can have a considerable impact on the land. While it is often difficult to distinguish between the two, natural, or so called tolerable rates of erosion are frequently defined for tropical countries. In Sri Lanka soil loss exceeding 10t/ha/yr is considered to be excessive (TAMS, 1980). Although a number of studies have attempted to study rates of erosion resulting from various land use practices in Sri Lanka, many are based on questionable techniques and prediction equations (Stocking, 1986). Nevertheless, erosion rates estimated from studies in tea estates (average 40t/ha/yr), tobacco (200t/ha/yr) and recently cleared chena land (mean 100t/ha/yr over 40 years) are very worrying. Moreover, the extent to which high erosion rates are affecting large areas of the upcountry, not just isolated plantations or smallholder's plots, is demonstrated by the land use planning study carried out by the Nuwara Eliya Integrated Rural Development Project (IRDP). The study concluded that erosion hazards are "high" to "very high" in 32% of the District, and that 49% of the plantation and 56% of the village sector experience "high" rates of soil loss (exceeding 10t/ha/yr) (Zijlstra, 1989).

Rates of erosion in Sri Lanka are clearly worrying, especially in the hill country, but as Stocking (1986) has pointed out, it is the potential impact that this erosion may have and not the actual quantity of soil lost which is important. Unfortunately, there is very little data available regarding the impacts of erosion in Sri Lanka. Many of the observations made by consultants have been quite anecdotal in nature. However, three major areas of concern have been identified by Stocking (1986).

4.1 Agricultural productivity

Erosion-induced yield declines have been observed in many agricultural systems. In general the causes are attributed to decreased soil depths, loss of organic material and nutrients, loss of soil moisture and decreased water-storage capacities (Doolette & Smyle, 1990). Sri Lanka is no exception in this. The low productivity of Sri Lanka's tea estates, is for instance to a large extent blamed on erosion and inadequate soil conservation. A number of estates in the Intermediate Zone have been abandoned, whilst others are run at a deficit by the government. The same can almost certainly be said of other forms of agriculture in these areas. Small holders (43% of whom farm one acre or less), tend to make less use of soil conservation methods than the large centrally managed estates, and thus it is likely that soil loss and yield declines are affecting these farmers too. This will particularly be the case in areas dominated by soils such as Luvisols, which have a concentrated nutrient distribution in the top soil and a critical water holding capacity. Any erosion to such soils will result in reduced yields. There are few figures

available regarding small holders and yields, but some anecdotal evidence was gathered from farmers in the Intermediate Zone many of whom complained of declining yields during the field trips which were carried out for this evaluation.

4.2 Landslides

The occurrence of land slides in recent years, and the resulting media coverage, has placed pressure on the GSL to stabilize the upcountry and reduce soil erosion. The NBRO (1986 - see Stocking 1986) has recorded a total of 136 recent landslide locations. The impacts of such occurrences vary, but are commonly felt more directly than other forms of soil erosion, as property, infrastructures and even human lives may be lost as a result of landslides.

4.3 Sedimentation of reservoirs, tanks and irrigation works

Once again the information available on sedimentation rates is inconclusive. A recent echo sounding survey of the Kotmale reservoir established that no measurable siltation had occurred during the first 7 years of the reservoirs life (Calder, 1991). Similarly, Stocking (1986) reported that there seemed to be no threat of sedimentation appreciably reducing the volume of stored water in the major reservoirs, within the lifespan of the works. Not all experts, however agree on this matter. NARESA (1991, quoted by Fleming, 1991), for instance estimated that the Polgolla Reservoir has experienced a 44% loss of capacity in the first 12 years of its life. This high figure is however, in part a result of urban erosion from the nearby city of Kandy, which makes for a rather exceptional case. Nevertheless, erosion under tobacco, vegetable and chena crops has been shown to be high (see section 4.1), and thus further studies are needed to determine how this soil loss may be affecting the major reservoirs in the Victoria complex.

These impacts and their potential seriousness are not static. Changes in legislation, development policy and ultimately land use patterns may alter the severity of the impacts experienced.

5.0 Are existing policies and legislation concerning watershed management adequate?

Currently there does not seem to be a need for new legislation to deal with watershed management in Sri Lanka. In fact the plethora of organizations currently in place, Stocking (1986) lists 12 ministries and 38 agencies involved with soil conservation, has hindered the progress of watershed management more than it has helped. In 1988, the Land Commission suggested that a new Watershed Management Authority be created. Such a move would however, most likely lead to further conflict, overlapping objectives and inefficiency. Existing legislation should, on the other hand be more productively streamlined, and cooperation between already existing authorities encouraged. Although the GSL

has clearly shown that they are aware of the need for a coherent policy and legislative base to deal with watersheds, this has not as yet been achieved (Stocking, 1986).

Land use planning is currently overseen by the LUPPD (the planning division of the MLIMD, Ministry of Lands Irrigation and Mahaweli Development), which was set up in the early 1980's in an effort to centralize the development of land use maps and identification of areas critical to watershed management (IMPSA, 1991).

6.0 Watershed management techniques

There are a large number of techniques which can be used in watershed management, and apart from legislative and institutional reforms to land use policies, most of them fall within the field of soil conservation. This includes both technical and non-technical measures which in aggregate form help to limit the rate of soil loss in the field and provide sustainable land use. Some measures may help prevent erosion whilst others may only control it, thus limiting the extent and timing of its impact. There are also techniques which are aimed at rehabilitating land after erosion has negatively impacted the land.

6.1 Mechanical soil conservation

The majority of soil conservation programs instituted in the 1970's and 1980's were dominated by engineered systems. These systems were originally developed for large land holdings in temperate regions (Doolette & Smyle, 1990). A few of those most commonly found in Sri Lanka include:

6.1.1 Lock and spill drains

This is a specific type of graded drain which is usually built along contours and acts by capturing runoff in small stilling ponds, which allows the rain water to infiltrate slowly.

6.1.2 Stone walls

These are usually constructed along contours in fields or road sides and provide an irregular form of terracing.

6.1.3 Bench terraces

This involves the construction of large benches on steep slopes. Cultivation may be carried out on slightly downward or back sloping surfaces.

6.1.4 Bunds

These artificial embankments are constructed and graded so as to intercept rainfall and sediments and lead runoff away from the cultivated land.

These approaches are commonly used in the centrally managed tea estates, where conditions are most like those found in the temperate land holdings for which they were designed. Land is not in short supply and valuable topsoil can be sacrificed for the construction of bunds and terraces. Technical expertise for contour identification using theodolites and man power for the labor intensive construction of drains and terraces are also not

limiting factors on estates.

For the majority of small holders in Sri Lanka, who farm extremely small plots, in what is frequently steep and marginal land, these techniques are not really suitable. Consequently, farmers must be convinced of the large advantages such mechanical devices will bring them in order for them to invest so much time and effort into conserving soil on their land. There are many examples of development programs which initiated the construction of such structures by offering large incentives to the farmers, only to find that they were neglected as soon as subsidies were withdrawn. Farmers must be able to increase their yields quite substantially, or make greater profits from the cultivation of high value crops which they could not formally grow on their land, in order to compensate for the high unit cost of construction, continuous maintenance requirements, and loss of harvest from the land taken out of production (Carson, 1989; Magrath and Doolette, 1990).

6.2 Vegetative soil conservation

As recognition of the technical shortcomings of these traditional approaches has grown in recent years, more attention is being paid to vegetative systems of soil conservation. In many cases, farmers have been practicing such techniques for generations, but it is only recently that western "experts" are beginning to acknowledge their effectiveness. The great advantages of such methods is that they do not require machinery or engineering expertise, they often make use of locally available and accepted materials and the establishment is inexpensive and demands only modest amounts of labor input. Such techniques are therefore particularly applicable to small farmers, who do not have the necessary inputs required for mechanical systems. Small holders with out secure land tenure are highly unlikely to invest in expensive soil conservation structures on land that does not belong to them, but may be more inclined to develop low cost techniques if they improve yields substantially.

6.2.1 Cover crops

The deliberate choice of vegetative crops which grow rapidly and help provide a continuous ground cover which reduce the impact and erosivity of rain drops is one of the most effective means of reducing soil erosion in the tropics (Stocking, 1986). In Sri Lanka the creeping legume cover which is encouraged under coconut plantations and the replacement of old seedling tea with vegetatively propagated (VP) tea, are good examples of this kind of approach. Many small holders however, cannot afford to sacrifice much of their land to non-productive covercrops, but the cultivation of perennials such as coffee, spices, VP tea, fruit trees etc., can have a large effect on reducing erosion, whilst providing farmers with an income. The traditional Kandyan homegarden with its mixture of timber and fruit trees, as well as spices and occasionally vegetables, provides a multi layered canopy and can reduce soil erosion to neglible amounts. It may however, be difficult to encourage small farmers to plant such crops, as

they will have to wait a number of years before the trees begin showing returns.

6.2.2 Mulching

If continuous cover can not be established for financial or climatic/edaphic reasons, an alternative which works on very much the same principal, is mulching - covering the surface between crops with dead organic matter, such as crop residues, grass cuttings or tree branches. Loppings from nitrogen fixing trees (NFT) such as Gliricidiae sepium, which is popularly grown as field boundary markers in Sri Lanka, is often used for this purpose. The incorporation of organic manures, such as animal wastes, is also useful, and like the NFT's helps improve soil fertility as well as reducing erodibility.

6.2.3 Grass strips and trash bunding

The establishment of vegetative barriers along contours, is quickly gathering popularity as this technique has many distinct advantages over the traditional earth banks, bunds and drains, while fulfilling the same function of slowing down surface runoff and allowing sediments to settle out. Vegetative barriers require about one tenth of the space taken up by mechanical structures and no disturbance or removal of top soils is required. Runoff is slowed down and silts deposited behind the grass strips or hedges which over time allows the formation of a natural terrace without the waterlogging which sometimes occurs in drains and artificial terraces (Magrath and Doolette, 1991). The characteristics required of the vegetation used for such barriers includes: a root system which is aggressive and deep rather than laterally spreading; strong, dense leaves which are effective at intercepting runoff and rainfall, and yet are not attractive to livestock; resistance to drought and fire; sterile flowers; simple to propagate; perennial; able to mingle freely with neighboring grass clumps and no tendency to harbor agricultural pests. The plant which fits all these criteria and is thus currently being hailed as the new miracle grass, is vetiver grass, Vetiveria zizanioides (Magrath and Dollette, 1991). Vetiver is certainly gaining in popularity in Sri Lanka, where it is already familiar to much of the local population, because of the medicinal value of its roots. This is an advantage, as farmers are often wary of exotic species which agricultural experts have in the past tried to introduce. One should, however, always remain cautious of "miracle cures" and a reliance on a single species of plant should probably be avoided, as a sudden pest flare up or disease could jeopardize any program based on such a single solution approach. Weeping love grass (Elagrostis curvula), is another plant which is commonly used in Sri Lanka, particularly in tea estates. It is possible that a combination of these two species (eg in alternating rows of grass strips), might prove most satisfactory.

Trash bunding is a similar technique, but does not require the permanent establishment of grass strips. Instead, temporary vegetative barriers are created by laying or pegging dead grasses and crop residues in strips along the contours. This is a popular technique used in tea estates where Guatemala (Tripscceum laxum)

and Mana (Cymbopogon confertiflorus) are planted for one to two years and then placed on the contour when the new tea is planted.

6.2.4 Agro forestry and alley cropping

Although, Kandyan home gardens are popularly cited as good examples of agroforestry, combining woody perennials, multi purpose trees and some annual crops, this system is only practicable in certain agro-climatic zones. More research into other forms of agroforestry is needed in Sri Lanka, as such systems can help provide soil conservation and cash and subsistence crops which supply farmers with direct, quantifiable benefits.

Alley cropping, which also combines trees and agricultural crops on a farmers land, functions in a completely different manner. In fact alley cropping works on a similar basis as the vetiver system. A special form of this alley cropping technique, called SALT (sloping agricultural land technology), which was developed in the Philippines, seems to show particular promise in Sri Lanka. Hedgerows are established by planting two rows of woody perennials (frequently NFT's) about one meter apart, along the contour. Crop residues and grass cuttings, as well as rocks and any other suitable materials can then be placed in the gap once the hedge begins to grow. As soil is deposited behind the emerging hedgerows a natural terrace forms, and the farmers have the additional benefit of being able to utilize hedge cuttings as green mulch, animal fodder etc., depending on the species chosen. Agricultural crops of the farmers choice can be planted in between the SALT hedges.

There are many other forms of mechanical and vegetative soil conservation techniques practiced around the world, but it is not within the scope of this paper to discuss all of them. Consequently, only those methods commonly used in Sri Lanka, or which are felt to have significant value in the future are examined here.

6.3 Forestation as a tool for erosion prevention and soil rehabilitation

In Sri Lanka, one of the most popularly applied technologies for both soil conservation and soil rehabilitation in the UMCA has been reforestation. Vast areas of grasslands which are considered to be degraded (see Appendix section 5.1 for counter argument) and abandoned tea lands in Sri Lanka's Wet and Intermediate Zones have been planted with monocultures of Pinus caribaea and Pinus patula, and some Eucalyptus spp. The rationale behind this large scale operation (over 25,000 ha have officially been planted over the last three decades) is the thinking that forests provide a longterm barrier to soil erosion. The trees are believed to be effective in intercepting rain and reducing its impact, providing channels for infiltration through their root system and binding together soil on steep slopes. Forests are also in theory, relatively cost-effective to establish and do not require labor and capital intensive maintenance, if their function is watershed management. The choice of exotics such as Pinus, was made on the basis of their

rapid growth rates, ease of establishment, ability to compete with aggressive grass species and resistance to fire (Bandaratilake, 1988). Unfortunately, this reliance on monocultures appears to have brought about a number of initially unforeseen adverse effects, which may very well outweigh the advantages. The effects of pine forests on rainfall, streamflow and on-site erosion must be reassessed, as it now seems very likely that the plantations in many areas of the Intermediate Zone are not controlling erosion or maintaining water yields, as they were intended to do.

6.3.1 Forests and water yields

A commonly held belief about forests, is that the complex of tree roots, litter and soils acts like a sponge soaking up water during rain showers and releasing it gradually during dry spells. The high organic content of forest soils does indeed tend to increase the storage capacity of the land, but many researchers now believe that the majority of the water is consumed again by the trees (Bruijnzeel, 1986). Bosh and Hewlett (1982, quoted by Bruijnzeel, 1986), who reviewed 100 paired basin experiments throughout the world, concluded that no deliberate increase in vegetative cover has ever led to increased water yields - the reforestation of open land generally results in a decline in stream flow. Experiments with reforesting tropical grasslands with pines in Fiji and South Africa, have clearly shown that water yields are reduced (Bosh, 1979 - quoted by Bruijnzeel, 1986). It is likely therefore, that Sri Lanka's extensive reforestation efforts will have a similar effect. Calder (1991), has indeed calculated that afforestation of patanas in the Kandy region, will reduce river flows by the order of 200mm per year (or 2,000 cubic meters/ha/yr).

6.3.2 Forests and rainfall

Although in general afforestation would appear to reduce water yields, a number of high altitude areas in Sri Lanka may provide an exception to this principle. Certain areas in the island's high elevation Wet Zone, experience frequent cloud incidence. Horizontal precipitation, or cloud stripping, may therefore be an important source of water in these areas, which could compensate for, or exceed the rainfall interception loss from the forest (Calder, 1991). Although the effect is expected to be less important in closed forests (due to mutual sheltering, Bruijnzeel, 1986) than for isolated trees, preliminary results for fog interception under 15m pine trees in Horton Plains show that net rainfall levels are significantly increased (Calder, 1991). Prof. Gunawardena has identified major research objectives for future studies on this phenomenon and its potential importance to reforestation efforts in Sri Lanka (Gunawardena, 1991, and pers. comm., 1992). If the effect of cloud interception is indeed found to be significant, then reforestation in high altitudes where persistent fog belts occur may result in hydrological benefits, but further research is needed.

6.3.3 Forests and on-site erosion

Another unfortunate misconception is that forests always reduce soil erosion. In fact trees by themselves provide little soil conservation benefits, except to the extent that they foster

an understorey (Magrath and Doolette, 1990). A well developed shrub, grass and litter layer protects the soil surface from the impact of raindrops, and permits higher rates of infiltration. Removal of this litter layer dramatically increases erosion. Thus even degraded forests with a dense undergrowth will have much lower levels of soil loss than a well managed plantation where the litter has been removed (in Indonesia the figures were found to be 5 and 40 t/ha/yr for degraded forest and teak plantations respectively, Carson, 1989). Plantations will therefore only reduce erosion if their canopies are open enough to allow undergrowth to become established and if fires can be avoided. Neither of these criteria apply to the majority of the pine plantations in Sri Lanka. Crown closure is achieved within 6 - 8 years in most plantations, and one of the main objectives of reforestation in this country has been the shading out of the patana grasses which are considered to be undesirable (see Appendix section 5.1).

Although Weil (1982) concluded that erosion in patanas was high and soil organic matter had been reduced by 37%, other consultants have found no evidence that rates of erosion under patana grasses are unacceptable (Calder, 1991). The soil erosion study which was set up in Wewethalawa by USAID, did in fact find that sediment production from 8 year old pine plantations was only 15 - 17% of that measured from patanas (Gunawardena, 1991). This site is however, a very exceptional one in Sri Lanka as rainfall levels are extremely high and the exclusion of fire has allowed some of the best understorey vegetation in the country to become established (Gunawardena, 1989). Subsequent to those experiments parts of Wewethalawa have experience fires and erosion has been quite severe in these areas (per. obsvn., 1992, see also Appendix section 6.3).

Fire is a persistent problem in the Wet and Intermediate Zones and the majority of plantations have a very poor or no litter layer or undergrowth. Pine litter, when it is allowed to accumulate, forms a thick mat of interwoven needles which protect the soil from the impact of rain drops. In its absence, however, the rain may cause even greater erosion than in patana grasslands (see Appendix section 6.3). In fact the larger raindrops that form through coalescence on the forest canopy will attain higher kinetic energy and thus greater erosivity potential than unintercepted rain outside a forest (Bruijnzeel, 1986). This point is only slowly being realized and brought to the attention of the Forest Department and many researchers in Sri Lanka. Gunawardena for instance clearly stated in a symposium held in 1989 on reforestation with pine that "there will be a high rate of erosion from burnt pine plantations, much higher than from the patana grass land... and.. would not recommend if the sole objective of planting <u>Pinus</u> is to protect watersheds".

7.0 How effective can reforestation and soil conservation be against land slides and sedimentation?

The root system of trees are ideally suited to providing slope stability in landslip-prone areas (Magrath and Doolette, 1990). Yet, for deep seated slides, there may be little that can be done to prevent them occurring. A number of researchers have concluded that geological processes, soil characteristics and basin and channel geometry may be important in determining the occurrence of large scale floods and land slides, and that soil conservation measures may have little or no impact on reducing their occurrence. In certain circumstances such measures may even serve to increase the likelihood of mass wasting taking place, by encouraging better infiltration rates (Stocking, 1985; Bruijnzeel, 1986).

Although there is some suggestion that reservoir capacities in the UMCA may be reduced by soil erosion in the future, it is unclear how far this process can be reversed by changes in land use (reforestation and rehabilitation). The time lag between such changes and a noticeable reduction in downstream siltation rates may have to be measured in decades or centuries rather than years as many government and aid officials optimistically hope. Uncertainties persist, because the process of erosion, deposition and re-mobilization of sediment particles in streambeds is still poorly understood (Bruijnzeel, 1986). Magrath and Doolette (1991) suggest that although the problems caused by sedimentation are indeed significant, it would be more effective in the short term, to address them in terms of appropriate dredging and operating practices as well as infrastructure modifications, rather than attempting to specify time frames within which land use changes in upstream areas will solve downstream problems. Nevertheless, concern about the short term and probably long term implications of continued soil erosion and watershed degradation in Sri Lanka's upcountry is well founded. Rehabilitating degraded watersheds in the future will be a far more capital and resource intensive operation than the conservation and sustainable management of catchments today.

8.0 Projects involved with watershed management

An evaluation of projects involved with watershed management was carried out between June and early September 1992. Although the major focus was the USAID funded project, a number of other programs were also visited and researched.

8.1 Reforestation and Watershed Management Project (RWMP)

One of the first projects to identify the need to examine watershed management issues was the Reforestation and Watershed Management Project (RWMP). The RWMP , was initiated in 1980 by the Forest Department (FD) with USAID's assistance, in an attempt to tackle the problems of erosion and reduced water yields. The objectives of the project were: a) reforestation of 24,000 acres

(10,000 ha) of catchment areas; b) Forestry Extension; c) Forestry Training and institutional strengthening of the FD; d) Forestry Research; e) Fire Control; f) Establishment of fuelwood plantations. The project was a bilateral loan and grant agreement between USAID and the GSL, and was completed in 1987 at a cost of $16.15 million.

Although the FD had been involved in reforesting certain areas of the upcountry since the 1970's, the original objectives were more closely linked to production forestry - growing trees to help meet the demands of the paper industry. By 1980, however, the FD had come to view the reforestation of the upcountry as a means to the end of halting soil erosion, reducing sediment buildup and securing dry season flow into the downstream reservoirs. This philosophy was supported by the USAID project and its consultants, and a laudable effort was made to pursue the goal of re- or afforesting large tracts of what was considered to be degraded grass and tea land. In retrospect, many of the premises on which the project was based, in particular the belief that forests invariably help secure water yields and reduce soil erosion, have since proved false (as was discussed in section 6.3) or overly optimistic. A fairly detailed evaluation of the project, based on two months of field work, interviews and literature reviews is given in Appendix 1. (The questions of land tenure and local impacts are examined in particular).

The major conclusions are as follows

a.) The choice of Pinus caribaea was not appropriate for many sites and watershed objectives are largely not being met:

- water yields have generally been reduced
- erosion has not been halted in many areas
- biodiversity of flora and fauna has been reduced

b.) The policy of planting up state land on traditional forestry lines with no local involvement, coupled with severe land shortages in the area resulted in:

- large scale encroachment
- large scale incendiarism
- loss of what was often considered to be communal land

Many mistakes were clearly made during this project, but at the time of its conception, now more than 12 years ago, the project was based on the accepted scientific thinking, that afforestation would benefit the watershed. Although the evaluation in Appendix 1 may appear to be very critical, it is important to realize that the RWMP was the first of its kind and can certainly be viewed as a significant first step towards watershed management. The attention of the GSL and many aid organizations was subsequently, for instance, more clearly focused on issues of watershed degradation. Yet it is disappointing to see how few lessons were drawn from USAID's mixed success. A number of the mistakes made in

the RWMP have been repeated many times over in subsequent project designs. Indeed many projects have persisted with the policy of planting pine trees. The ODA project currently in progress, is continuing to plant Pinus on sites selected by the FD, some of which are in areas of the Intermediate Zone where erosion under similar plantations has been severe. In part, the fault unfortunately again lies with RWMP, in that adequate evaluations of progress in the field were not carried out. Far more random site visits and concise M&E reports should have been prepared and made available to other projects. The opinions of local people who live and farm areas close to the plantations and who therefore usually have a good impression of what impacts local land use changes such as reforestation are having on their surroundings, should also have been consulted from the start of the RWMP and all subsequent projects.

8.2 Integrated Rural Development Programs (IRDP)

There are a number of IRDP's operating in the UMCA. Fundamentally each program is designed to tackle district level development problems across all sectors such as: agriculture, animal husbandry, health, welfare etc. The precise objectives of the programs are quite diverse and have often changed since their initial inception, but watershed management and forestry are frequently major components of the projects.

8.2.1 Ratnapura (funded by the Dutch government)

On its initiation in 1984, block forestation, similar to that carried out under the RWMP was an important component of the project. The emphasis however, has now shifted towards a more socially orientated program. Instead of the FD choosing sites and employing local labor only during the planting stages, village level organizations are now contracted and a series of meetings are held with the villagers in order to involve them in the planning and decision making process. The FD continues to choose which species should be planted and unfortunately persists in favoring fast-growing exotics, but more importance is now given to maintenance operations. Money is thus put aside for replanting and weeding for four years after the initial planting. One might optimistically therefore hope, that the community involvement will encourage higher survival rates and the protection of the forests against fire and encroachment through social consent. If fires can be discouraged, then natural regeneration of undergrowth may help provide protection against soil erosion, as well as furnishing the local population with fuelwood, livestock fodder, and other resources.

Agroforestry projects on steeply sloping chena lands, involving the use of various cash crops of the farmers choice and Acacia auriclaeformis in an alleycropping system, have also been launched. Initial survival rates appear to be good, but more evaluation surveys are needed (Skutsch, 1990; Wilson, pers. comm. 1992). This type of approach requires a significant amount of input in the form of discussion and consultations between the

farmers and extension workers. This may limit the number of families (in this case 20) which can be reached in a given time period and does not allow large acreages to be covered, but the technique appears to be quite promising if long term sustainability is of primary concern. The project management also seems to be learning from farmers (encouraging local input), who for instance, have expressed an interest in growing cinnamon in the long term rather than the cassava which had originally been suggested by the IRDP staff (Skutsch, 1990).

8.2.2 Matale (funded by the World Bank)

Once again large scale plantation forestry using exotic monocultures was pursued by this project between 1981 and 1986 when 8000 acres were officially planted. Although a target of 2300 acres per annum was at first envisaged, the project encountered heavy losses throughout and reported survival rates of less than 30% in many areas. The area considered effectively forested is now about 6400 acres. The reason for the high losses were considered to be incendiarism by chena cultivators and encroachers, and general disputes over land use (Skutsch, 1991). In other words very similar problems to those encountered by the RWMP were experienced here, and it is likely that little has been achieved in the way of soil conservation or watershed management.

8.2.3 Nuwara Eliya (funded by the Dutch Government)

Between 1980 and 1985, 3640 acres were planted with Pinus in this district. Again low survival rates caused mainly by fires, resulted in this activity being stopped. The project management remains highly critical of this kind of approach and the adverse ecological impacts the pine plantations have had in the District. It has therefore replaced the block forestry program with a "green sector strategy" whose major objective is the conservation of microcatchment areas. The project has a strong participatory element and focuses on soil conservation. One hundred families were initially targeted with a package of subsidies for the construction of mechanical conservation structures (stone walls, drains, earth bunds etc.). Standard national wages were paid for the work, of which one third was paid directly to the Thrift and Credit Societies to encourage farmers to make savings. The adoption rate for these packages was about 90%, despite the fact that the incentive payments were not really competitive in market terms and gave lower returns than farm laboring (Skutsch, 1990). Between 1984 and 1988, 300 acres were covered by this program. The land involved was mainly steep, rainfed chena plots and home gardens which was regularized prior to the initiation of the project. After completion of the soil conservation structures, farmers were also given tree seedlings of their choice (mainly minor export crops), and pepper vines. The majority of the trees were planted along the bunds and as home gardens around the farmers' houses (Skutsch, 1990).

In recent years biological forms of soil conservation, such as SALT, have been favored over the mechanical solutions which were

promoted in the mid 1980's. The reasons for this shift in emphasis is mainly the perception by the management staff that this type of approach is more sustainable and ecologically sound (van Grootveld pers. comm., 1992). Initial assessments appear to show that these techniques are popular and readily accepted, but it is as yet too early to evaluate this program.

Landslide-prone areas have also been targeted by this IRDP. Two areas (50 and 200 acres respectively) have been planted with mixed forest (Calliandra, Gliricidia, Erythrina indica, etc.) and grasses.

8.3 The Overseas Development Administration's Project

This project is divided into three sub units. The Forest/Land Use Mapping Project (FORLUMP) was initiated in 1989, and is a joint venture between the ODA and the Mahaweli Authority. The main objective of this project is the production of 1:10,000 land use maps for the Upper Mahaweli catchment. These maps are to form the basis for land use planning activities and the management of watersheds and forests. Critical sub-catchments and areas susceptible to erosion will also be identified by the project and recommendations made on alternative land use practices which could be put into practice in order to reduce environmental degradation. Other activities currently being undertaken by the Kandy office include GIS studies and the analysis of sedimentation rates in reservoirs. In collaboration with the Forest Department in Colombo, FORLUMP is also mapping and monitoring forest cover in the entire country using satellite imagery.

The Forestry Management Project (FORMP), is working with the Forest Department in devising a management plan for the existing plantations, including those set up under the RWMP, and planting new sites to Pinus and other species. FORMP also work with the Forestry Research team (FORRI), who have carried out a review of the previous research which has been carried out in Sri Lanka, and are promoting new trials into underplanting, thinning regimes and optimal spacing.

The management, research (if the initiative can be maintained after ODA's departure), and mapping (if the maps are put to good use) efforts appear to be commendable , but it is disappointing to see that the project is continuing with a policy of planting Pinus, when its marketability is questionable and the adverse ecological impacts of planting these trees in the Intermediate Zone are now more clearly understood.

8.4 Community Forestry Project (CFP - funded by the Asian Development Bank)

The CFP which was completed in 1990 (2 years behind schedule), was the largest and most ambitious social forestry project carried out in Sri Lanka so far. The major objectives were to address the problem of declining forest resources by planting fuelwood plantations on a community basis, and to establish a community forestry division within the FD, to help supply seedlings and technical advice. On the whole, the project is regarded as a

failure, because the results indicate that the community was not really involved in the planning or monitoring phases, even though this was the explicit aim of the program. Once again, the block forestry component was judged to have been fairly successful. Nakarti (1991), however learned that achievements were mixed and that certain plantations planted exclusively to eucalyptus had purposefully been burnt by villagers, because they feared that these plantations would have a negative ecological impact on the area. This is a good reminder of the fact that local inhabitants may often appreciate the potential impact of local land use changes more than outside "experts" who visit the areas for a very limited time only. Moreover, the assumption made in the Project Plan, that villagers were experiencing a firewood shortage and would therefore welcome fast growing fuelwood trees, was found to be completely false. Farmers were quite aware of what trees (mainly slow growing multi-purpose species), they did wish to grow, but found it extremely difficult to obtain such seedlings and advice from a project which claimed to be "community based" (Nakarti, 1991).

8.5 Upper Mahaweli Watershed management project (UMWP - funded by GTZ)

The UMWP was initiated in 1987 as a joint venture between the German Gesellschaft fuer Technische Zusammenarbeit (GTZ), and the Mahaweli Authority of Sri Lanka (MASL). The project goal is the "balanced development of water, land and human resources on a sustainable basis" (GTZ project evaluation).

Although, at the projects inception, it was hoped that hydrological research would also be part of the program, this was later dropped. It was felt that no long-term research should be started unless the local authorities were able and willing to maintain the initiative after the donors departure. In part this decision was based on a review of other projects in particular the collapse of most of USAID's research projects after RWMP's completion (see Appendix section 4.4).

The project objectives today are to identify weak elements in the existing land use systems and to provide models for improvement, rather than actually implementing direct programs for watershed management. Demonstration plots thus form an important part of this program. One farm, demonstrating the benefits of combining animal husbandry and sericulture, is currently being supported by UMWP, and another farm is planned to show how perennial crops such as vegetables and tobacco can safely be grown on steeply sloping and nutrient deficient soils.

A tea estate near Nuwara Eliya, is also applying new soil conservation techniques, with the support of the GTZ project. The Somerset estate, which was visited during this evaluation, has been experimenting with vetiver hedges and SALT technologies for three years. Vetiver grasses have been planted along contour ditches in newly established VP tea, and along plot boundaries and paths. The grasses have become well established and in some areas one meter of soil has built up behind the new hedges. The management is also very satisfied with the fact that the hedges do not compete with

the tea for water, and yet survived this years severe drought very well.

SALT hedges have also been established in some fields. Elderberry (Sambucus javanica), wild sunflowers (Tithonia lithosperma), and the nitrogen fixing tree Calliandra calothrysus have been planted as double rows along the contours. Experiments are continuing to determine which species are best suited for the hedges - biomass production as well as drought resistance and root competition are important considerations.

Another important objective for the management of the Somerset Estate, is that the estate workers should also learn to apply and benefit from, these new technologies. A small project is therefore being designed to persuade the workers to establish hedge rows on their vegetable plots, and eventually to encourage them to use the hedge loppings to support stall-fed goats or other livestock. It remained unclear however, how much these ideas were being forced on the laborers in a top down fashion, or whether their input was being sought in the planning process.

The GTZ project recently decided to redirect its efforts of promoting soil conservation from mainly small holders to the estate sector and large scale farms. The justification for this move, is that these types of land use, cover vast areas of the hillcountry and thus a large proportion of vulnerable soils on steep slopes in Sri Lanka. If good soil conservation practices can be encouraged in a few estates and farms, then a sizeable number of acres can be protected. Consequently the UMWP project is working closely with the National Livestock Development Board (NLDB), to promote SALT in combination with animal husbandry, and the Tobacco Corporation, which has made a number of GTZ's recommendation mandatory for all its outgrowers (Mohn, pers. comm.,1992).

8.6 Project TEACUP (funded by CARE/USAID)

This project is specifically aimed at tea small holders who farm 1 acre or less. The objective of the program, which has been running for 4 years, is to mobilize farmers into groups to promote cooperation between them in the transportation and marketing of the tea, to help establish small nurseries producing VP tea and to promote awareness of the techniques available for soil conservation. The nurseries are provided with raw materials such as polythene bags, shade coverings and improved tea varieties in exchange for guarantees that seedlings will be sold to project participants at reduced rates for the first three years.
Establishing VP tea in place of the old seedling tea found on many of the farmers' plots will provide a good cover crop within a few years, and thus forms the first step in soil conversation. The small holders cannot however, afford to forgo any kind of harvest for 5 years as the large tea estates can when they establish first Mana grasses, then trash bunds and eventually the immature VP tea. Thus techniques have had to be evolved which allow the farmers to plant the new VP teas in small sections of their land or in between older tea plants in such a way that progressively more and more of the land is covered in productive VP tea. The small holders are

therefore being encouraged to establish other vegetative forms of soil conservation, such as vetiver grass strips, regular mulching with green manure and SALT hedges on their land. A recent field visit to one of the groups involved in the project, demonstrated how enthusiastically these techniques have been accepted by the participants, even though a number of them do not yet have secure tenure. The SALT hedges are established using Gliricidia sepium, which farmers have been employing as field boundary markers for generations, and which are therefore readily incorporated into the fields. The support of the farmers is further ensured by allowing them to be involved in all the decision making and planning. The CARE staff, in fact, act only in an advisory capacity. Thus the identification and pegging of the contour lines for the hedges and grass strips is for instance done by the farmers themselves, using simple A-frames rather than the complicated surveying equipment which require a knowledge of engineering principles. The hedges and grass strips although relatively new in the plots visited during this evaluation, were becoming well established and a build-up of soil behind the hedges could already be observed and was pointed out by the farmers themselves. The results of this project are very encouraging.

9.0 Lessons learned and conclusions

Many of the projects reviewed in this paper, emphasized rapid, highly visible activities such as reforesting large areas with plantations and constructing mechanical soil conservation structures. Such programs are popular with Sri Lankan government departments and the donor community because the achievements of these organizations are often evaluated on the basis of statistics, such as the number of acres planted or bench terraces constructed. This mentality has meant that in the past little attention was paid to survival rates of trees or maintenance of structures, as credit could often be taken again for replanting or rebuilding the same structures. The wishes and needs of local inhabitants who might wish to utilize the land differently, and the potential ecological impacts of such land use changes were also often ignored as a result of this "quota mentality".

A number of projects suffered unsatisfactory success rates, because the local populations either did not maintain the initiative of the programs adopted or purposefully destroyed them. This was particularly the case in all the block forestation projects which seldom found support amongst the local inhabitants, because they themselves had little to gain from the changes and at times were even negatively affected. Those projects such as TEACUP and IRDP Nuwara Eliya and Ratnapura, which are heavily participatory in nature appear to be far more successful in terms of adoption rates, than the larger RWMP and CFP for instance, but their scope of action are of course much smaller.

For future project designs, it should be possible to learn from the successes and shortcomings experienced by past programs.

Community participation would clearly appear to be the important key to the success of any conservation project. As Carson (1989), has stated "active participation by local farmers during the planning and implementation of conservation programs is essential if one is to achieve any lasting results". Techniques such as rapid rural appraisals (RRA's), and participatory rural appraisals (PRA's) should be used in defining the problems, needs and aspirations of the local population. Their perceptions regarding the dimensions and causes of local degradation should be sought along with that of government officials and technical experts.

In Sri Lanka it is important to identify exactly which land user group a program will target. Highly visible results and larger impacts in terms of reductions in total soil loss from watersheds may be achieved if the estate sector and agrarian corporations are targeted (e.g. UMWP), but grass roots programs which work with small holders (e.g. TEACUP) may instead benefit a greater number of people. Clearly the aims of any watershed management project must be clearly defined. Is the objective to minimize absolute erosion rates and soil loss in Sri Lankan watersheds, to help improve the living standards of small farmers in a sustainable manner, to maximize agricultural production in the hillcountry, or to permit the utilization of formally unproductive land for forestry and other exploitative uses? Watershed management cannot be pursued with one single approach. Moreover, there is no one technology that applied in isolation will achieve any of the objectives listed above. Within any watershed there will be a number of treatments appropriate to addressing the problems defined in an interactive planning process. A list of eligible treatments can be compiled for each project depending on the exact aims of the program. Projects which promote single-solution, structural approaches to soil conservation and reforestation should be strongly discouraged. Instead, more importance should be placed in developing socioeconomically and ecologically appropriate technologies, especially vegetative forms of soil conservation. These ideas are summarized in the table on page 19A.

Target Group	Small holders with secure land tenure	Small holders without secure land tenure	Estate sector	Statelands (plantations)
Problems encountered by target groups and causes of degradation.	Declining yields, Loss of topsoil, Reliance on single crops.	Declining yields, Loss of topsoil, No secure tenure and thus little incentive to farm land in sustainable manner, Shortened fallow periods for chena land.	Declining yields, Heavy erosion in areas with old seedling tea and during initial replanting with VP tea, Rising costs of fertilizer inputs.	Fires, Encroachment, General dislike amongst villagers, Heavy erosion in some areas.
Possible solutions and techniques which can be applied.	Encourage vegetative soil conservation strategies which: -use simple methods which can be applied by farmers; -use locally acceptable materials and species; -do not involve increased risks to the farmers; -do not radically change farming practices or landuse; -are easy to maintain; -bring immediate benefits through increased yields or other income. Encourage diversification of farmers' income bases, through animal husbandry or new perennial crops.	Help secure tenure in exchange for sustainable land use and conservation farming as outlined in previous column.	Encourage vegetative soil conservation which: -do not involve an increased risk to the management; -can be applied as an integral part of the traditional management system and the mechanical soil conservation structures already in place. Encourage the use of green manures and mulch in place of increased fertilizer inputs.	Underplant existing (protection) plantations with multi-purpose trees and shrubs, Encourage local inhabitants to protect trees by social consent in exchange for legal rights to forest byproducts and grazing land. Continue the policy of reforestation only in high altitude sites with potential for fog interception, using ecologically suitable species

APPENDIX

1.0 Introduction

The Reforestation and Watershed Management Project (RWMP), was commenced in 1980 by the Forest Department (FD) with USAID's assistance, in an attempt to tackle the problems of erosion and reduced water yields. The objectives of the project were: a) reforestation of 24,000 acres (10,000 ha) of catchment areas; b) Forestry Extension; c) Forestry Training and institutional strengthening of the FD; d) Forestry Research; e) Fire Control; f) Establishment of fuelwood plantations. The project was a bilateral loan and grants agreement between USAID and the GSL, and was completed in 1987 at a cost of $16.15 million.

The aim of this appendix is to assess how successful the reforestation of the catchment area has been five years after completion of RWMP, and what impacts these land use changes have had on the local population.

2.0 Methodology

In order to try and gain insights into the views of a wide spectrum of people affected by, or involved with the plantations initiated by USAID, informal interviews rather than set questionnaires were used in this assessment. In many cases no clear target group was identified for interviews, instead plantations were visited and persons found close by or in the forests were approached. In this way it was possible to talk to: school teachers, tea estate workers, estate superintendents, farmers, casual laborers, "encroachers", schoolchildren, people cutting wood illicitly, shopkeepers and others. It is hoped that this fairly random approach to selecting respondents will have provided a wide and unbiased selection of opinions. In addition to these interviews, more formal contacts were pursued with the FD and other organizations. District and range forest officers were approached, as were organizations currently involved in assisting the FD in managing existing plantations (eg the Overseas Development Association - ODA), and in planning new watershed reforestation efforts (eg. ODA, Integrated Rural Development Programs - IRDP's, and Janasaviya).

Personal (qualitative) observations of the condition of forests and undergrowth, underplanting trials, fire damage etc. were made during site visits. Once again, a wide spectrum of sites in different areas, districts and rainfall zones were visited, in order to minimize sampling biases.

3.0 Discussion

3.1 Targets of reforestation effort

The official objectives of the reforestation effort, as summarized in the Revised Implementation Plan (1981) were: "to

ensure the protection of the watersheds against erosion; to control the quality, quantity and timing of water flows from catchment basins and ultimately to provide protection forests". It was concluded that 25,300 acres of upper Mahaweli catchment area had been reforested by 1988, which constituted a 20% increase in stabilized ground cover (Completion Report, 1987).

3.2 Choice of species

The choice of tree species used to reforest the upper Mahaweli catchment area was made by the FD in 1978. Pinus patula (at elevations above 1223m) and Pinus caribaea were selected as trees showing a remarkable ability to successfully establish and grow under the adverse conditions of these areas (Bandaratilake, 1988). This decision was subsequently supported by the USAID sponsored technical consultants; "Pinus is clearly the optimal species to be planted to achieve the objectives of watershed management" (Brister, 1985). It was however recognized in the original Project Report that more mixed species forests would harbor a greater variety of wildlife and resist diseases, pests and fires better than the initial mono-cultures of pine. The need to investigate multispecies and enrichment planting techniques was emphasized.

3.3 Choice of Sites

The choice of sites for reforestation was made by the FD. The aim was to plant up any degraded land in the upcountry belonging to the government. Abandoned tea lands and patanas were particularly targeted. Patana is a collective term used for grasslands dominated by mana (Cymbopogon spp), and iluk (Imperata cylindrica) grasses, which tend to grow in clumps (Gunawardena, 1988). Some patanas may have a very dense cover of these grasses, along with a few dispersed ferns (eg. Dicranopteric linearis) and fire resistant trees, whilst others are characterized by a less extensive cover of vegetation and greater expanses of bare soil. There is some controversy surrounding the question of whether these areas are natural or man made.

The actual site preparation and planting was carried out by laborers hired locally at each site by the FD. The RWMP provided a set amount of money per acre and consultants visited on site nurseries and some plantations to give technical advice.

4.0 Shortcomings

4.1 Lack of maps

Although the original Project Paper included a program which aimed to develop national forestry baseline maps, this was later dropped in the Project Paper Amendment, because the UNDP agreed to finance this work. The ODA is now running a forestry land use mapping project (FORLMP), but unfortunately no adequate maps were drawn up of the locations and acreage of plantations set up under RWMP between 1980 and 1988. This has made it extremely difficult for organizations interested in evaluating the project or in

setting up management plans for the plantations, to function efficiently. Even identifying sites to visit during this assessment was problematic, as few people could say with certainty exactly which sites had been planted under RWMP. The field sketches provided by the technical consultants of the sites used for fertilizer and spacing trials, agroforestry demonstration plots, hydrology research etc. were also extremely poor, and it was virtually impossible to find the majority of these sites. It would have been much more useful if the technical reports had been written in such a way that people other than those directly involved with the project during its conception, could visit sites and follow the methods/practices used, if they were found to be successful.

4.2 Marketability

The Project Paper (1980, p24), originally proposed that 30% of the pines planted should be left as protection forest, whilst the balance was to be harvested for pulpwood or tapped for oleoresins from the 7th - 15th year, then harvested for pulpwood or firewood. Becoming self-sufficient in the production of longfibre pulpwood was one of the FD's major objectives in the 1970's, when large amounts of foreign exchange were being spent on its import. This challenge was to be met with pine plantations including ones grown under RWMP. Unfortunately, the market for this pulp was not thoroughly investigated and various political and bureaucratic hurdles seem to have impeded its development. Too many organizations were and still are, involved in handling these forest resources. The FD produces the wood products, but puts the contracts for their removal, transport and marketing up for tender. Although the State Timber Corporation handles some of this, a large proportion of the produce remains under-utilized. In a number of sites visited including Wewathalawa, Galamuda and Massgolla, pine trees which have been felled for thinning purposes are left to rot in the forest. In these and other sites, trees marked for thinning have not even been cut, although systematic thinning is known to increase yields in Pinus (Brister, 1985). On one tea estate near Hunasgiriya the superintendent explained that he had made inquiries into the possibility of buying some of the pine trees felled by the FD in a nearby plantation, to use as fence posts on his estate. The request was denied on the grounds that the FD could not market the wood. As no contractor was subsequently found either, the wood is rotting in neatly stacked piles by the edge of the forest. The marketability and utility value of pines should have been investigated more extensively before and during the RWMP.

4.3 Survivorship not adequately evaluated

The evaluation of tree survivorship in the plantations was not given adequate attention in the Project Paper. Subsequently very few plantations were visited by consultants on a regular basis. The progress made by nurseries, on the other hand, was carefully monitored and consultants visited these regularly throughout the period of the project, giving technical advice and suggestions for

improvements. Although a regular supply of healthy seedlings was essential to this project, the actual planting and maintenance of trees in the field was no less important and should have been paid equal attention both in terms of financial investment and technical expertise.

A few consultants who did visit field sites near established nurseries reported excellent survival rates of 90% or more for Pinus, but others recognized that there "are no reliable figures...verbal reports range from 50 to 95%... Observations in the field indicate that survival may be lower" (May, 1981). The causes of plantation failures during the early stages of the project varied. Steinbeck (1982) reported that in one area of Eucalyptus camaldulensis plantation he visited with FD personnel, no signs of planting hole preparation, planting or polythene bags could be found. May (1981) described a variety of causes including stem wilt or die back, white grub worms, inappropriate site selection (eg. impoverished soils, and poor accessibility for laborers and seedling supplies), poor planting etc.

Survival rates of plantations established by other organizations have also varied greatly. The Norwegian funded IRDP in Hambantota reported an overall survival rate of only 26%. Some plantations were totally lost, whilst others did as well as 80-90%. The World Bank funded program in Matale, and the Dutch funded IRDP in Nuwara Eliya, both dropped their block forestry projects after a few years, due to the low success rates (Skutsch, 1990). The primary cause of low survival, according to Skutsch (1990), was lack of sufficient maintenance, particularly weeding. Fire also was and continues to be a major hazard in many areas, and will be discussed in greater detail in section 5.4. Drought, termites, grazing and damage by free ranging cattle, wild boars and porcupines, illegal felling and encroachment have also all taken their toll.

A qualitative evaluation of plantation success was made during this assessment. The figures quoted in the Completion Report and field sketch maps of the USAID plantation (provided by the Kandy forestry office) were compared with 1:20,000 maps. These maps, which were drawn up by the FD, are based on aerial photograph interpretations and show the age and height class of plantations. A number of plantations are clearly smaller than the field sketches show and a few are not visible on the photographs at all.
Site visits also provided evidence of stunted tree growth and failed plantations.

These observations suggest that the figures given in the Completion Report should not be taken as absolute - some areas have had to be replanted and a number of plantations never became fully established. These figures, at best give a measure of effort rather than acreage that can be found on a map. Greater accuracy could have been achieved if the RWMP had initiated a system of plantation survival counts and regular updating to record sample surveys, stand development, prescription and inspection activities during the early stages of the project (Brister, 1982). Such data would have been extremely useful to any organizations hoping to

subsequently carry out forestry work and to the FD itself.

The ODA/FD mapping project is hoping to be able to provide realistic figures on the extent of pine plantations presently found in Sri Lanka. FORLMP is planning to calculate the acreage of land covered by pine, from its satellite interpretations in the near future. As stated above, the success of the reforestation effort of RWMP should not be evaluated simply by comparing the new FORLMP figures with the acreage that was officially planted under the project. This would lead to misconceptions about how the plantations had been managed since the conclusion of RWMP. If it is recognized that fewer acres were actually established during the course of the project, then the success rate of the plantations 5 years after the completion of the RWMP will not seem so disappointing.

4.4 Breakdown of research initiatives

One of USAID's major objectives was to encourage new research initiatives in forestry, nursery techniques, hydrology, and related fields. The Completion Report included five pages of research projects proposed and initiated under the RWMP. One notable success, was the development of taper, volume, yield and site index functions for P.caribaea plantations in Sri Lanka, which are currently being used by the FD.

Another important project was set up to determine the effects of reforesting abandoned tea lands with pine trees. Flumes and sediment samplers were established in four experimental catchments in order to measure runoff and sediment production. A research consultant completed a preliminary study on the rainfall/runoff data collected over three years, and forestry staff were provided training to enable them to carry out data collection and analysis, after his departure. The results from this experiment, although situated in one of the best Pinus plantations in the country (Gunawardena, 1988), could have provided some important insights into the effectiveness of pines for watershed management. Unfortunately, the experiments have been terminated. Two sets of recording equipment appear to have been stolen, whilst the others are being stored by the Forestry Department. The flumes are still in place, and although somewhat overgrown, could be made operational again with a minimum of effort.

Unfortunately most of the other projects were never started, and many were dropped soon after the completion of the project. As mentioned in section 4.2 it was not even possible to find the fertilizer and spacings trial plots set up by the consultants, and it is clear that the follow up measurements were never taken after the consultants left.

The blame for these failures can not be attributed to any one particular cause. Some of the proposed projects were over-ambitious, requiring more financial or manpower input than the FD could afford. Other projects were abandoned as personnel who were associated with the experiments were moved to new posts or locations. In fact the rapid turnover and relocation of staff caused problems throughout the project, especially where

specialized training was concerned (Steinbeck, 1981; Completion Report, 1987). The civil disturbances which occurred between 1987 and 1989 were particularly severe in the areas covered by the RWMP and clearly affected some of the research and planting efforts (Completion Report, 1987,p30).

The results from many of these projects, had they been fully implemented, would have been of immeasurable benefit to the FD and ODA who are now trying to develop management plans for the plantations.

5.0 Impacts and local feelings towards Pinus

5.1 Land tenure issues

As mentioned in section 3.3 the land chosen by the FD for reforestation was mainly abandoned tea land or patanas. These uncultivated lands which the British claimed as Crown lands during the colonial period, were turned over to the government on independence and are state property. They are also considered to be barren and degraded. A former Conservator of the Forests, who was instrumental in promoting the widespread establishment of Pinus, described these areas as, " eyesores .. of denuded, degraded, eroded lands" (W.Perera, 1988). The FD therefore set forth in the 1960's, to green these areas with pines (Vivekanandan, 1988). Unfortunately, little attention was paid to the wishes of the local population, nor was any attempt made to find out whether, and if so how, these lands were being utilized by local residents. Many areas, especially the abandoned tea estates, were indeed badly degraded, drained of all nutrients, susceptible to erosion and unsuitable for any sort of human activity. But other areas, especially the patanas, played a fundamental role in the lives of the local village communities. Many patanas, even today, are extensively used by villagers for: cattle grazing and collecting firewood, cow dung, medicinal herbs and grasses for thatching. Cattle are kept at fairly low densities and limited fires, which do not damage the root stock of the plants, may be set in order to encourage fresh growth for grazing (Starkloff, pers comm, 1992). Although possibly created by humans, these patanas have provided a self sustaining system of low productivity land use for many hundreds of years. Knox, described this type of system 300 years ago (Starkloff, pers comm, 1992). Unfortunately, this was not taken into consideration by the officials who decided to use these lands for block forestation. This has led to conflicts in some localities, where villagers perceive the pine forests as a threat.

In one area, close to the village of Ulapane, a former DFO pointed out a plantation of Pinus which had failed after a long battle between the villagers, who wanted to use the land for their own purposes, and the FD who repeatedly tried to plant pine trees.

On another site visit to a village near Galaha, a family whose house was situated on the edge of a pine plantation was interviewed. The family of nine had been given 1/2 acre of land by the government in the 1970's, to build a house on. Subsequently the FD had decided to plant pine trees on what had formerly been

tea land. As the entire area was considered to be state land, most of the 1/2 acre plot was also planted with pines, although this was against the wishes of the family.

People at a number of sites also described how entire households, considered to be encroachers, had been moved off the land prior to planting, and foundation stones and clearings were still visible in a few sites.

Not everyone interviewed however, was quite as negative about the impacts made by the forestation efforts. A middle aged man near the village of Imboolpitya, explained that he had been moved off his land prior to the planting of Pinus, but that he had been given another plot of fertile land nearby, with which he was satisfied. Nevertheless, a general feeling of mistrust and anger was evident amongst many villagers.

5.2 Local Input

The RWMP was carried out along traditional or "classical " forestry lines, and involved no local participation . The majority of people questioned, said that they had not been informed as to the purpose of the plantations, nor been consulted about species or site selection. The only input local villagers were allowed was that of paid labor. The temporary employment opportunities were mainly directed towards the landless and poorer sections of the community, but little extension work was carried out. Villagers had gathered more information about the alleged function and subsequent shortcomings of pine trees from the local press than from the FD, who had made little effort to promote an awareness for the need for soil conservation in the areas being reforested. Many people nevertheless, had some very imaginative ideas of how the land could have been environmentally enhanced and used more constructively. Several members of a farmer's organization in the village of Dwatagas have, for instance, proposed to the Mahaweli Authority, that the land under what remains of a pine plantation, be planted up with timber and fuelwood tress by and for the local community (Allison and Sawyer, 1992).

5.3 Encroachment

There is a general shortage of land in the Wet Zone, where large scale alienation of land for tea and rubber plantations took place during the colonial period (Bloch, 1988). As mentioned in section 5.1, people also considered many of the areas claimed by the FD for reforestation, to be common land. It is thus hardly surprising that large scale encroachment of the forests is occurring in some areas. Three general types of encroachment were identified during site visits.

[A] Encroachment for land

Pinus plantations which are close to roads, and thus easily accessible, are particularly vulnerable to encroachment by landless families. A number of such sites were visited throughout the assessment. In most cases the families which ranged in size from 3 to 11 members, were casual laborers, who do not have enough money

to buy land. Most people clear a small area of about 1/8 acre, in order to build simple mud and wattle huts, and do not carry out any agriculture, although small vegetable patches and very small tree gardens (mostly bananas, jak and coffee) may be established once the family feels they are safe from eviction. The fear of eviction, however, keeps many people from building more permanent housing or investing time and effort into the upkeep of gardens or the removal of waste. Many houses are situated on steep paths, with no access to water supplies or sanitary facilities, and severe erosion of the land around the huts is not uncommon.

On one site visit to a small village near Galaha, we were fortunate enough to witness an attempt by 100 Tamil estate worker families, to encroach on an area of pine plantation. The workers had been advised by their local politician to stake their claim on the land prior to the upcoming visit by senior politicians. The families had started clearing 1/4 acre plots, constructing temporary shelters and planting banana trees. Although the sites they had chosen were 1/2 a mile from the nearest source of water, whilst the linehouses are equipped with standpipes and pit latrines, the workers were adamant about their wish to possess their own land and to have more than one room to live in. On a later visit to the same area, it was found that the workers had been forced to return to the linehouses.

Encroachment for land use of a less drastic nature, namely for grazing livestock, was also observed in many sites. Cattle and waterbuffalo were found tethered near the periphery of plantations where grasses are able to grow. This "encroachment" is probably a substitute for the once extensive use of the former patanas for cattle grazing (see section 5.1). Indeed, the one farmer we were able to locate, who owned one of the cows, explained that he could only afford to keep one animal whereas his father had kept three, and that his standard of living was subsequently lower than previously. On the whole this type of encroachment is the least destructive, and may even benefit the forests as the animals provide some natural fertilizer.

[B] Encroachment for fuelwood

About 75% of the population in Sri Lanka depend on fuelwood for their day to day cooking needs. The abundance of home gardens and forested lands, often gives the false impression that firewood is readily available. In actual fact many villagers (especially women) spend 1.5 - 3 hours per day collecting fuel (Allison and Sawyer, 1992). One major source of this firewood is government plantations.

Although villagers are apparently permitted to collect dead wood from state land, some confusion persists as to the exact legality of this action. There was evidence of fuelwood gathering at virtually every site visited and sites closer to villages and/or roads were more heavily utilized. Allison and Sawyer (1992) also reported that a large number of people, especially those living on poor tea land where tea prunings are meager, depend heavily on pine as firewood. The thin lower branches of trees had been cut in most

plantations and few branches or dead limbs were found in the accessible sites, despite the fact that Pinus is not considered to be very good for cooking. The high resin content produces a lot of sparks (Jayasekera, 1988) and cooking pots become coated with resinous soot.

Although it was not always possible to discern whether trees were being cut for timber or fuelwood purposes, evidence of ringbarking and deliberate cutting of live trees was also plentiful. Occasionally the trees had been lopped off at breast height, and yet had continued to grow. Although these new trees would not be suitable as timber trees, this remarkable ability to regenerate gives some indication as to why Pinus caribaea, were chosen for the reforestation of inhospitable sites.

Illegal felling activities were observed in two sites. An old man was seen to be uprooting the stumps of pine trees felled by the FD during their thinning operations near Shamrock. He explained that the wood was to be sold as firewood in the town of Nawalapitiya. This activity, although representing an income source for the man, is extremely destructive. The impact of removing the root system which would normally aid water infiltration, help hold together the soil and recycle nutrients is potentially far more severe than the straightforward felling of trees.

[C] Encroachment for timber

The other incident of illicit felling activity was observed in Wewethalawa. In this case Alstonia macrophylla were being removed by a group of about 5 men who planned to sell the wood as timber. The men were unwilling to be photographed and quite evasive when asked questions. They were doubtlessly worried that they might be reported or even prosecuted. Allison and Sawyer (1992) experienced similar problems when they tried to quantify the extent to which villagers used FD plantations for timber and fuelwood supplies. Their study revealed that although only 16 out of 64 households admitted taking pine trees, many more had cut timber in the forest in order to construct housing.

A laborer on the Blackwater tea estate, made an interesting observation concerning the inclination of different groups towards taking timber illegally. He claimed that the estate workers were more likely to cut timber illicitly, than the colony (or landless) people who had been involved with the planting of the trees, and felt a certain amount of pride in their achievement. If the worker is correct, then even block forestry projects may produce a certain amount of local support and protection, but it is not clear how common this is or how strong the sense of custody towards the forest is.

5.4 Fires

Every plantation visited during this assessment showed signs of fire damage. The majority of plantations had been burnt between February and May of this year. Although the upcountry had experienced an unusually severe drought in 1992, fires are common

in every dry season. Certain areas in the drier zones may even endure two fires a year (Sanders, 1985). In some of the younger (4 - 8 year old) plantations visited, the fires had not only scorched the ground and base of the pines, but also the tops of the trees. Nevertheless the plantations were making a remarkable comeback with the onset of the rains. Most of the trees were putting out new tufts of green foliage and only a few had succumbed entirely. The thick barked pines seem to tolerate fires better than many broadleaved species, the remains of which were found in a few sites.

Pinus caribaea, was chosen for reforestation in part because of its fire resistance. The patanas which had formerly dominated these areas were considered to be a fire-climax (A.Perera, 1988, quoting Rosayro, 1945) and it was thought that reforestation would help solve this problem. It is now clear however, that fires occur just as readily, if not more so, under pine. A carpet of pine needles provides an ideal fuel for the rapid spread of ground fires. The resinous needles which tend to be loosely packed, contain volatile inflammable compounds and have a low moisture content (A.Perera, 1988).

Fires in pine plantations may also have far more severe ecological consequences than fires which occur in grasslands, as the majority of nutrients in conifers is stored in the living tree itself and in the needles. The standing litter content in pine forests is thus ten times higher than that in patanas (Perera, 1987). Nutrients which had accumulated in the litter are lost in a number of ways. They may be released directly to the atmosphere through volatilization, or returned to the soil in a highly mobile form, which can not be adequately utilized because there is no understorey vegetation. Leaching and erosion may then occur when the wet season brings heavy rains, as the canopy has been opened up and there is no carpet of needles or any undergrowth to check the kinetic energy in the rain drops. Fires also form a hydrophobic ash layer (A.Perera, 1988 quoting Viro, 1974) which will further impede infiltration and help create overland flow and erosion. Recurring fires will thus deplete forests of nutrients and increase erosion progressively (A.Perera, 1988).

Because of the drastic ecological impacts fires can have on forests, an important aim of this assessment was to investigate some of the causes behind the fires. This was quite a difficult task as the only people willing to really talk about such issues were the FD, whose job it is to prosecute arsonists. Indeed, although some fires may start accidentally or naturally as a result of lightning, the majority appear to be purposefully set.

On asking villagers how fires had started in the various plantations we visited, the usual evasive answer was that young boys had been playing a prank or that motorists had carelessly thrown a cigarette out of the window. It was clear that no one wanted to appropriate blame, although we had tried to make it clear that we were not connected with the FD. A few other indications of possible causes were gathered from casual conversations. A major complaint about the pine forests, which was repeated a number of

times, was that the carpet of needles is very difficult to walk on when it accumulates, and carrying produce or goods through the forests becomes dangerous. Although this may seem quite trivial to an outside observer, if the forest is not held in very high regard by the local population, this would be a good enough reason to set fire to the needles and thus the forest.

A range officer for the FD provided other clues as to the causes of some fires. He cited incidents where hunters had ignited certain areas of forest in order to flush out wild boars. The range officer also showed us a self styled lighter briquette made from tightly bound coconut fibers which can smolder for hours. He had confiscated it off a villager who begrudged the fact that he had been caught and prosecuted for taking timber illegally. Fires are thus set out of spite towards the FD, and occasionally for fun.

A laborer at one of the tea estates further described how fires may be set in order to clear undergrowth so that villagers can move more freely through the forests when cutting timber or collecting firewood. Another problem for the plantations near his estate was the railway line workers, who he claimed, set the vegetation along the tracks ablaze, instead of clearing it by hand as they had been contracted to do. The fires spread more than two miles uphill from the tracks during the dry season.

The root cause of these fires however, seems to me, to be a lack of respect of the plantations in general. Villagers can not benefit from the presence of the trees, as they have no legal rights to any forest products, and they may feel that their presence has robbed them of their former multi-faceted use of the patanas, which were considered to be common land. Wood (1991) supports this reasoning and points out that fires are far more frequent and more damaging in FD plantations than they are in areas reforested through village initiatives. I therefore strongly disagree with Sanders (1985), who argued that as a result of the wide spread tendency to burn plantations, any reforestation effort with native species will be doomed to failure, because they are less fire resistant than Pinus caribaea. It is not simply a question of what species are chosen, but whether the local population can appreciate that the forests constitute a valuable resource.

Instead of appreciating the social causes behind the fires, the general feeling in Sri Lanka seems to be that the only way to solve the problem is to prosecute arsonists and physically prevent or put out fires as they occur. This philosophy was also advocated by the USAID-sponsored technical consultants (Walker, 1982; Dixon, 1983). The FD is however, financially severely constrained, and subsequently physical fire barriers and other precautionary measures are only partially put into practice. Many tea estates that border pine plantations, subsequently use their own labor to construct fire strips. One estate superintendent, however, admitted that since both the plantations and the tea estates belong to the government, and he is not held accountable for the damages, little is done to contain the fires. Once again it is evident that the current land tenure system provides little incentive for

protecting plantations.

It seems clear that the most suitable solution to the problem of incendiarism, is to make forests an accessible resource. If local inhabitants are given unequivocal rights to forest thinnings or other products, it may be possible to place the protection of the trees directly in their hands (Wood, 1988).

6.0 Ecological Problems with Pinus

There has been considerable debate in the past few years, both within scientific circles and the general population, concerning the ecological suitability of Pinus for forestation. Ecological aspects of pine are important, because many of the plantations initiated under the RWMP were established for watershed protection. The major criticisms focus on three main issues:

1.) pine plantations are biological deserts; indigenous birds and insects avoid them.
2.) absence of undergrowth;
3.) reduced water yields

Interestingly these were also the most commonly voiced objections villagers had against the plantations.

6.1 Biological desserts

Pinus caribaea has only been grown extensively in Sri Lanka for the last 30 years. Consequently very few native animal species are adapted to these exotics. The pines do not provide fruit, seeds or foliage that are similar to anything found naturally on the island and thus provide few animals with habitat or sources of food. A. Perera (1988) found that the number of frugivorous birds found was significantly lower in pine plantations than in patanas, and only a fraction of that found in natural broad leaved forests. This disparity was particularly evident when walking through pine forests. In small patches of grassland, in the stream gullies which support native tree species, and along the forest edge and road sides, birds, insects and the occasional small rodent were commonly seen, whereas the pine forests remained eerily silent. It is no wonder then, that this unnaturally sterile landscape is unpopular with many Sri Lankans, from school children in villages to taxi drivers in Colombo.

6.1 Lack of undergrowth

The argument that Pinus caribaea plantations never support any understorey vegetation is unfounded. In one or two sites visited a whole range of indigenous species were found to be regenerating naturally. In Wewethalawa, one of the highest rainfall areas in Sri Lanka, broad leaved successional trees have become so well established that the pines are partially obscured and a variety of canopy layers similar to that found in climax forests are forming. A. Perera (1988), has found that some plantations actually show an enhanced floral composition after introducing pines. This is however, more the exception than the rule. The vast majority of

sites visited, had little or no undergrowth, instead the ground was either completely bare or covered with a layer of needles and ashes with occasional fire resistant species such as guava (Psidium guajava) and lantana (Lantana camara).

The detrimental effects that fires can have on pine plantations has already been discussed in section 5.4. Most indigenous plants cannot tolerate the fierce ground fires which pines tend to encourage and will thus be destroyed. As fires occur annually in many sites this is not conducive to the establishment of successional plant species.

Although fires are probably the most important cause of undergrowth retardation under pines, other factors must also be taken into account.

Low light intensity is often cited as an inhibitory factor. Pines can indeed form a closed canopy in the short space of 6 - 8 years, and the shade intolerant patana grasses die back. However, this dearth should be temporary as shade tolerant species invade the undergrowth (A. Perera, 1988).

Another common hypotheses is that pine needles acidify the soil. Bongarten (1982), a consultant under the RWMP, did indeed find soil Ph values to be fairly low under pines, but no lower than those measured in adjacent patana grass lands. This observation is supported by A. Perera (1988), and Gunatilleke (1988) - soils in the high rainfall regions of Sri Lanka appear to be highly leached and quite acidic regardless of the vegetational cover. The litter layer does however, affect natural regeneration under pines, by blocking dispersed seeds from contacting mineral soil and impairing seedling emergence (A. Perera, 1988). This factor is particularly crucial in pine plantations, because the exogenous seed input from native species is very low to begin with. In part this is due to the fact that natural forests are dwindling in size and the number of mature, seed-bearing trees have been drastically reduced. The other major constraint is the dearth of frugivorous birds or other seed dispersers found in pine forests (see section 6.1). The majority of secondary tree species found in the plantation are therefore wind dispersed varieties (A. Perera, 1988).

Lastly, it must be remembered that Pinus caribaea was chosen for reforesting upcountry areas, because of its ability to grow well on poor sites: Pines may be able to draw on nutrients which lie in deeper layers of soil, and are thus inaccessible to other forms of understorey vegetation. The nutrients accumulated by the pines are subsequently also not made available to other plants because of the slow decomposition rates of the needles.

6.3 Reduced water yields and increased erosion

Farmers and villagers who lived close to pine plantations, throughout the UMCA, consistently expressed their opinion that water yields had decreased since the establishment of the trees. In many cases we were taken to see wells and streams which had dried out completely in the dry season of the past few years - something that had not previously occurred in the living memory of any of the villagers. These assertions were confirmed by a number

of tea estate managers. In one case the superintendent's bungalow had recently been deprived of water in April and there was a growing concern that the factory might soon also be strained by the fast maturing pines, which had been planted on the hills surrounding the house and factory. These observations would seem to support findings in other tropical countries concerning plantations and water yields, and seriously undermine the rationale of planting pines in order to safeguard water flows to downstream reservoirs.

The field trips for this evaluation were carried out in the rainy season, and thus few streams were dry. In fact many field visits were made during heavy downpours, and consequently it was possible to observe, in a very qualitative manner, the effects the rainfall had on erosion. In numerous areas, streams flowing out of plantations were heavily laden with silt, whereas adjacent streams emerging from small riverine forests were crystal clear.

The fact that a very large number of pine plantations (those that had experienced numerous fires and supported no litter layer or undergrowth) lacked any topsoil what so ever, gives even clearer evidence that soil erosion is taking place at quite a phenomenal rate. A villager near Bandarawela described the ground under pines as covered in "boulders which were maturing", in a conversation with an advisor from the Nuwara Eliya IRDP. The maturing boulders and heavily quartz laden gravel found in pine plantations bear witness to the fact that soil is being washed down stream. In a few areas the pine trees were visibly bending near the base. Clearly the entire slope is failing in such plantations, and the trees are not fulfilling their role of stabilizing the soils. Moreover, patana lands growing adjacent to a Massgolla pine forest, and even patches of grass within the plantation were found to support an humiferous A horizon which was completely absent under the pines. Although more research is perhaps needed in this field, it is clear that care should be taken before general statements concerning the erosion hazard under grasses versus that under pine trees is made.

7.0 Where go we go from here?

7.1 Underplanting

If watersheds are to be protected for the sake of reducing soil erosion and sediment build up in reservoirs, then the best solution to the ecological problems created by the pine plantations may be to encourage their conversion to mixed species plantations or natural broadleaved forests. The conversion of parts of the Wewethalawa plantation to a semi-natural forest with multiple canopy layers is a promising indicator that this can and will occur in Sri Lanka, given the right circumstances. The most important factors to consider will probably be soil fertility (is the soil already so badly degraded that huge inputs will be needed to allow anything to grow?), and fire.

Some encouraging first steps have already been taken by the FD, in an effort to address these problems. The department has

started underplanting trials in a number of locations. Single species and mixes species trials are in progress, and more research as to thinning regimes and fertilizer applications are planned in conjunction with FORRI. A variety of broad leaved trees such as: Alastonia spp., Syzygium spp., Dipterocarpus spp., mahogany, teak, tuna, kaya, coffee etc., have been planted. Unfortunately, these efforts are mainly confined to timber species, on land which is strictly controlled by the FD, and requires large inputs of fertilizers and thinning and weeding activities. It is therefore questionable how applicable these methods will be on a large scale, especially as little is being done to address the social causes of fires and encroachment which jeopardize the existence of many plantations. One site in Wewethalawa, for instance, which had successfully been underplanted with mahogany in 1988, had recently succumbed to fire, which killed virtually all of the broad leaved trees. Although these experiments at silvicultural manipulations to develop mixed species plantations are laudable, and should be encouraged, more effort is needed to persuade the FD to move away from traditional forestry practices in plantations which are critical to watershed protection.

Underplanting pine forests with multi-purpose trees, shrubs and grasses, to which the local population is allowed access, will encourage the plantations to be protected by social consent. Costs of establishing such species, may be reduced if local residents are encouraged to provide the labor for thinning and planting operations, in exchange for the by-products and guarantees for future utilization. Although this may seem to be an over-ambitious goal, the annual loss of biocapital through fires and encroachment in present plantations and the rates of soil loss and watershed degradation currently taking place will surely be more costly to the government in the long run unless radical changes are made in the way plantations are managed. On a number of field visits villagers independently suggested that better use could be made of pine plantations if they were allowed to underplant with trees of their own choice. In the village of Dwatagas such a proposal had even been forwarded to the Mahaweli Authority by a local farmers' organization (Allison & Sawyer, 1991). This is an encouraging sign that programs aimed at promoting village utilization and protection of plantations would be welcomed by many communities.

7.2 Oleoresin tapping

Another strategy may be to make better use of the pine plantations which already exist. This could for instance, involve encouraging the use of pine trees for oleoresin tapping at a local level. The Nuwara Eliya IRDP has carried out some initial trials on a village level, but concluded that current extraction practices will have to be improved upon if such enterprises are to made economically viable (van Grootveld, pers. comm., 1992). Nevertheless, slaughter tapping before thinning and felling operations and more sustainable longterm tapping could give the pines a greater value to rural communities, and thus encourage their protection. It should also result in a more productive use

of the available biocapital than the current system of timber marketing is achieving. Oleoresin tapping could, of course, be carried out along side programs aimed at underplanting or gradually converting plantations to mixed forests.

References

Allison, G. & Sawyer, J., (1992). Socio-economic survey of Maswela and Dwatagas villages in the Kotmale region. Unpublished Draft. Oxford University.

Bandaratilake, H.M., (1989). Development of pine plantations in Sri Lanka. Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds. H.P.M. Gunasena et al. Univ. Peradeniya/Brit. High Comm./ODA, pp 10-18.

Bloch P.C., (1988). Land tenure issues in Sri Lanka: a brief overview. Draft report prepared for USAID, Colombo.

Bongarten, B., (1982). End-of-Tour Report. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Brister, G.H., (1982). End-of-Tour Report. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Brister, G.H., (1985). Yield tables for pine plantations in Sri Lanka. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Brown, N.P., (1990). Social forestry in Ratnapura, time to reassess? In: Multipurpose Tree Species in Sri Lanka: Research and Development. Edt. H.P.M. Gunasena. Proc 2nd regional workshop on multi purpose trees, Kandy, Sri Lanka.

Bruijnzeel, P.S., (1986). Environmental impacts of (de) forestation in the humid tropics - a watershed perspective. Wallaceana
46: pp 3 - 13.

Calder, I.R., (1991). Sri Lankan Link Programme - Hydrology component. Draft Tour Report ODG 90\14.

Carson, B., (1989). Soil conservation strategies for upland areas of Indonesia. Occasional Paper No. 9 of the East-West Environment and Policy Institute, Honolulu.

Completion Report (1987). Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Dixon, M. (1983). End-of-Tour Report: Fire Management. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Dollette, J.B. & Smyle, J.W., (1990). Soil and moisture conservation technologies: review of literature. In: Watershed Development in Asia - Strategies and Technologies. Eds. J.B. Dollette & W.B. Magrath. World Bank Technical Paper No. 127. Washington, D.C.

Fleming, W.M., (1991). Watershed management Policies for Sri Lanka. IMPSA Staff working paper No. 7.3.

Gunatilleke, N., (1988). Soil and nutrient cycling under Pinus. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds H.P.M. Gunasena et al. Univ. Peradeniya/Brit. High Comm./ODA, pp 38-46.

Gunawardena, E.R.N., (1983). Hydrological and soil erosion studies on Pinus in Sri Lanka. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds H.P.M. Gunasena et al. Univ. Peradeniya/Brit. High Comm./ODA, pp 46-54.

Gunawardena, E.R.N., (1990). Priorities in forest hydrology research in the uplands. In: Multi purpose trees species in Sri Lanka: research and development, Proc. 2nd regional workshop on multi purpose trees. Edt. H.P.M. Gunasena. Kandy, Sri Lanka.

IMPSA (1991). Sustainable and productive resource management: Macro policies for land and water resources. Policy Paper No 7, Colombo, Sri Lanka.

Jayasekera, K.P., (1988). Utilization of pines in Sri Lanka. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds H.P.M. Gunasena et al. Univ. Peradeniya/Brit. High Comm./ODA, pp 61-70.

Magrath, W.B. & Dollette, J.B., (1990). Strategic issue in watershed development. In: Watershed Development in Asia - Strategies and Technologies. Eds. J.B. Dollette & W.B. Magrath. World Bank Technical Paper No. 127. Washington, D.C.

May, J.T., (1981). End-of-Tour Report, and supplement: Nursery and Silviculture. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Nakarti, K., (1991). Community based natural resource management in Sri Lanka: an NGO perspective. Draft report for the Natural Resources and Environment Policy Project.

Perera, W. R.H., (1988). History of Pinus plantations in Sri Lanka. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds. H.P.M. Gunasena et al., Univ. Peradeniya/Brit. High Comm./ODA, pp 6-10.

Perera, A.H., (1988). Ecological issue on pines in Sri Lanka. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds H.P.M. Gunasena, et al. univ. Peradeniya/Brit. High Comm./ODA, pp 56-61.

Project Paper (1980). Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Revised Implementation Plan (1981). Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Sanders, J.F. (1985). End-of-Tour Report: Research. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Steinbeck, K., (1982). End-of-Tour Report 82-5: Nursery and silviculture. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Skutsch, M.M., (1990). Social forestry in integrated rural development planning - Sri Lanka. Regional Wood Energy Dev. Progr. in Asia. GCP/RAS/131/NET Field Document No. 24.

Smyle, J.W., (1987). End-of-Tour Report. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Stocking, M.A., (1986). Soil conservation in land use planning. Consultants report 3 to UMPD/FAO Project SRL/84/032.

TAMS (Tippets-Abbett-McCarthy-Stratton), (1980). Environmental assessment: accelerated Mahaweli development program. A consultants report for USAID, Sri Lanka.

Thiesenhusen W.C., (1990). Sri Lanka: Strife, development , and the environment. Draft report, Univ. Wisconsin-Madison.

Vivekanandan, K., (1988). Provenance research on Pinus caribaea. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds. H,P.M. Gunasena et al. Univ. Peradeniya/Brit. High Comm./ODA, pp 19-29.

Walker, G.D., (1982). End-of-Tour Report: Forestry Extension. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Weil, R.R., (1982). Soils of the Upper Mahaweli. Upper Mahaweli Reforestation and Watershed Management Project in Sri Lanka. USAID Project 383-0055.

Wood, P.J., (1988). An overview of the status of tropical pines relevant to Sri Lankan conditions. In: Proc. Symp. Reforestation with Pinus in Sri Lanka. Eds. H,P.M. Gunasena et al. Univ. Peradeniya/Brit. High Comm./ODA, pp 1-6.

Zijlstra, P.J., (1989). The need for land use improvement in the Nuwara Eliya District. Integr. Rural Dev. Proj., N'Elyia, Sri Lanka