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BANK RESERVATIONS ON MAJOR NATURAL STREAMS IN MAHAWELI SYSTEM B

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Abstract

A survey was made of the existence, width, and floristic composition of stream reservations on the banks of two of the major natural streams in Mahaweli System B area in the dry zone. The Mahaweli Project is the biggest irrigation and settlement scheme in Sri Lanka. The surviving reservations were far smaller than prescribed in the relevant legislation The farmers had gradually encroached on the original reservations, especially for paddy cultivation. Some perennial crops like coconuts, mangoes, jak, and breadfruit had also been planted where the water table was higher, near the streams. Widening and straightening the streams to cope with the discharge water in the rainy season had also destroyed the natural vegetation, and there was very little of it left. The floristic survey found 32 species of woody plants along one stream, and 27 along the other; altogether there were 4 endemic species. Stricter legislation and more extension work are recommended.

Introduction

A large number of irrigation projects have been planned and implemented in Sri Lanka to provide water to the dry zone. Among these, the Mahaweli scheme has taken a very important place. This study was made in the part of the Mahaweli irrigated area known as System B.

In addition to the construction of the major headworks, a large number of natural streams were improved. Riverine forests form a very sensitive link in the ecosystem. They harbour a diverse community of fauna and flora. Natural forests in these environments play an important role in conservation of soil and water resources. Natural forest vegetation contributes to the stability of the banks by protecting the soil from splash erosion, by the interception of rainfall and dissipation of droplet energy, and by covering the surface with leaf litter. The roots of the trees help to hold the soil particles, thus preventing their loss in surface runoff. This is especially important in Mahaweli System B as the soils are structurally weak (Panapitiya, 1995). Organic matter from fallen leaves, twigs, dead roots, etc. when incorporated in the soil, improves the surface properties and so enhances infiltration and reduces surface run-off.

This in turn reduces the risks of rill and gully erosion. Natural forests on the banks also stabilize ground-water levels and stream flows. They also recycle part of the rainfall by interception and transpiration. They enhance the aesthetic value of the landscape. Riverine forests often act as natural corridors connecting core habitats of wildlife. They also improve the quality of life for local residents, by providing accessible natural areas for collecting useful plant species, such as those used in indigenous medicines and for animal consumption (Panapitiya, 1995).

Most of the natural streams in System B flow into wetlands called *villus*, which are very rich in wildlife. Some of the villus of System B are internationally known for their ecological importance. In fact, the entire flood plain bordering System B, comprising 38 villus, is listed as Site No. 13 in the Directory of Asian Wetlands (Panapitiya, 1995).

The roles played by the riverine forests have been neglected to a certain extent in most of the irrigation development projects. Despite the fact that the planners of these projects made arrangements to leave some reservations along the natural streams, most of these streams have only been considered as drainage outlets for excess irrigation runoff from the croplands. The ecological aspects have been overlooked.

Agricultural activities adjacent to riverbanks always have a negative effect on the riverine environment unless they are controlled and properly managed. Illegal encroachments into the reservations of natural streams are difficult to control as regular monitoring is difficult. Wetlands are usually treated by farmers as wastelands, and are either drained or filled in for other uses (Panapitiya, 1995). A watershed management survey by the Water Resources Board in Sri Lanka carried out in the 1960s revealed that in some areas in the hill country, more than 80% of the stream reservations were encroached and illicitly occupied. Similar tendencies were observed in the irrigation schemes in the dry zone (Panapitiya, 1995).

Hydrology and land use

A number of hydrological studies have been carried out, in relation to land use in the watersheds. These studies focus their attention on two main aspects: the effect of forest destruction, and the influence of planted or natural forests on the hydrology. They show clearly that runoff has increased as a result of the removal of natural forests. The flow patterns of the major rivers have also changed because of land-use changes. Increased floods during the rainy season and reduced dry-weather flow have been observed (FSMP, 1995). There are many studies showing that forest vegetation produces less surface runoff than most of the other uses. In the dry zone, active *chena* cultivation generates surface runoff amounting to 36 to 55% of the rainfall, whereas forest and scrub jungle produce less than 2% under same rainfall conditions. In a study in the Mahaweli watershed, the decline in crop yield over time due to soil erosion has been modelled using an exponential function (Sumaneratne & Somasiri, 1990, cited in FSMP, 1995).

Sedimentation of water bodies

Sedimentation is a serious problem. There is concern that it will reduce the capacity of expensive hydro-power reservoirs and result in a reduction of their life span, loss of power, and environmental damage. The siltation of the smaller reservoirs has been very rapid compared with that of the larger ones. The Nuwara Eliya and Kandy lakes, Polgolla barrage, and Rantembe reservoir are some of the outstanding examples (unpublished survey reports of the Soil Conservation Division of the Department of Agriculture). The Polgolla barrage, commissioned in 1976, had lost 44% of its capacity by 1993. The annual rate of sedimentation of the larger reservoirs in the upper Mahaweli catchment is still low; it will take more than 100 years for the Victoria and Randenigala reservoirs to have their capacity reduced by 10% of the original one. However, the situation at Rentambe is alarming, with an 11% loss in capacity in just three years. Very approximate predictions indicate that this reservoir's capacity will be reduced to 56% in another 12 years. In the dry and intermediate zones, nearly all the minor tanks are silted to the extent that storage is reduced by about 30-35% (Dharmasena, 1992, cited in FSMP, 1995).

In irrigation systems, the drainage of excess water from the fields is a vital function in the operation of the system. Poor drainage causes waterlogging and the build up of salinity, resulting in crop damage and environmental hazards. The long-term sustainability of an irrigated agricultural system largely depends on the efficiency of the drainage.

Natural streams within an irrigation system play a very important role in draining out excess water. They are the main outlets for the secondary and tertiary drains that are laid out on the farms. If these outlet facilities do not function properly, the on-farm drains constructed above them cannot release water (Panapitiya, 1995).

Distorted stream hydrology and water loss

There are number of indicators for stream hydrology distortion. However, quantitative information on this aspect is quite meagre. Before the Kotmale reservoir was commissioned, between 1945 and 1985, the monthly river discharge at Peradeniya showed an increasing trend in the wet months, whereas in the dry months there was a decreasing trend, which indicated a rapidly changing flow regime and a reduced dry weather flow, even in a large river like the Mahaweli (Madduma Bandara & Kuruppuarachchi, 1989, cited in FSMP, 1995).

Policy and legislation in environmental protection

The need for environmental protection and management is duly recognized in the constitution of the Democratic Socialist Republic of Sri Lanka. Even long before the constitution was promulgated, several laws had been enacted which included scattered provisions relating to soil and water conservation. The Forest Ordinance of 1885 stated that reserved forests include stream reservations and reservations on the banks of rivers.

The State Land Ordinance of 1947 also says that state reservations and stream reservations are important, insofar as they are applicable to the protection of streams and their sources, etc. A significant law, but one which is difficult to implement under the present fragmented land use and land administration, is the Soil Conservation Act of 1951, which is intended to conserve the soil resources, prevent or mitigate soil erosion, and protect the land against floods and drought. Under Section 4, the Minister is empowered to make regulations applicable to areas declared as being erodible. It requires the owners of land to take measures designed to prevent or control soil erosion, such as the afforestation of stream sources and stream banks, and the reservation of prescribed widths of land along the banks of streams, free of cultivation, for the conservation of vegetation. Another significant piece of legislation is the National Environmental Act of 1980, which established the Central Environmental Authority (CEA) with the duty to recommend a national environmental policy and a set of criteria for protecting the environment. The Act specifies that the CEA will recommend soil conservation programmes, identify and protect critical watershed areas, etc. Yet another important law is the Water Resources Board Act of 1964, which includes very wide powers and provisions to ensure water conservation (Withanage, 1994).

Usually the width of the reservation due to be allocated for a particular stream depends on the stream width. According to the manual issued by the Ministry of Lands, in the case of a stream with a width of up to 15 feet [4.6 m], the reservation allocated will be 66 feet [20 m]. If the width is 15-50 feet [4.6-17.4 m] the width of the reservation will be 132 feet [40 m]. Likewise, in the Department of Agriculture the common practice is to allocate 1½ times the width of the stream for reservation. According to the Crown Land Ordinance, if the stream is up to 5 m wide, the width of reservation is 20m, if it is 5-15 m the reservation is 40 m, and if it is more than 15 m the reservation is 60 m.

Institutions responsible

The Ministry of Irrigation, Power and Energy, which includes the Irrigation Department, is directly concerned with the protection of irrigation infrastructure from sedimentation; the Water Resources Board is responsible for preparing comprehensive and integrated plans for water resources protection and utilization; the Ceylon Electricity Board (CEB) is concerned with the protection of hydro-power reservoirs from sedimentation; and the Mahaweli Authority is responsible for managing the upper Mahaweli watersheds for the long-term sustainability of the Mahaweli reservoirs.

On the face of these facts, it is apparent that most of the reservations allocated for the streams have been or are being destroyed. In improving the carrying capacity of natural streams, engineers consider only the hydraulic engineering aspects of the problem. In some cases all the riverine forest vegetation has been removed at the construction stage. Stream paths have been straightened, resulting in high stream-flow velocities that cause erosion. All the natural wetlands associated with streams have also been destroyed. In addition to this, most of the reservations allocated for the streams have been encroached by farmers, who are cultivating right up to the stream banks, and have destroyed the

bank-stabilizing tree cover (Panapitiya, personnel communication). Therefore there is a need to study and quantify the effect of this unplanned development, in order to take necessary mitigatory action to correct the situation.

Under the Mahaweli Agricultural and Rural Development Program (MARD) of the Ministry of Irrigation, Power and Energy in Sri Lanka, which is funded by USAID, both environmental and social factors are taken into consideration in addition to pure hydraulic engineering aspects. A pilot project was started in June 1993 to reforest about 16 km of riparian land on either side of the Kuda Oya, which is a left bank tributary of the Maduru Oya, immediately downstream from the Pimburattawa tank, with the objective of enhancing the natural biodiversity in the largely agricultural landscape, by restoring native dry-zone riparian forest vegetation. This project was planned as a community forestry project with the active participation of neighbouring farmers.

An effort was made under the same programme to plant bamboos along the Menik Ela, which is a natural stream flowing from the Maduru-Oya to Handapan Villu (a wetland). The planting was carried out by the farmers of the neighbouring area. They were also encouraged to set up bamboo nurseries and arrangements were made for the seedlings to be bought by the MARD Project (Panapitiya, 1995).

Objectives of the study

The present study aimed:

- To survey the remaining stream reservations in and around some of the major natural streams in Mahaweli System B, and compare the present situation with that at the beginning of the Mahaweli Irrigation Project (with the help of the available maps) to get an idea of the rate of degradation of the reservations and the riverine vegetation in them.

- To study the floristic composition in the existing stream reservations.

Study site and methods

Study site

The study site was in the dry zone, in Manampitiya, Polonnaruwa District, in the Mahaweli System B. This area lies between the Maduru-Oya reservoir and the world famous Handapan Villu, an area rich in biodiversity. Prior to the Mahaweli Project, it was under natural forest, and there were many natural streams to discharge the rainwater. The area was intermittently cultivated by the local inhabitants, under the *chena* system. In 1983 the land was cleared for housing and cultivation and to provide irrigation facilities under the Mahaweli Project. However, even after these human interferences, some natural streams existed which acted as a drainage system for removal of excess water from both the irrigation supply and the rainfall.

Two natural streams, the Menik Ela and the Mahaulpotha Ela, were selected for the present study. They link the Maduru-Oya reservoir to the Handapan villu. The total area is about 6000 ha. Most of the study area is flat. The mean annual temperature ranges from 27 to 30°C. The mean annual rainfall is about 1200 mm, with a pronounced dry period of about 5 months. Most of the rainfall comes from the north-east monsoon. The rocks are well weathered undifferentiated paragneisses; and well layered and compositionally variable gneisses, containing, biotite and sillimanite, and occasionally garnets.

Experimental procedure

The width of the two streams was measured at 50-m intervals, working downwards in the direction of flow. At each point, on both sides, measurements were made of the distance from the edge of the stream to the closest paddy fields, or to any other land-use type. In all, 216 measurements were taken. They were compared with the width of the reservation allocated in the irrigation maps at the start of the Mahaweli Project in 1983. From this comparison the amount and rate of encroachment were calculated.

Transects oriented on the environmental gradient, i.e arranged in a zigzag manner to cut the stream perpendicularly on each bank, were used to assess the floristic richness of the riparian vegetation. Plots of 5 × 100 m were aligned along the transects at 150-m intervals. A record was made of the family, species, dbh, and endemicity of woody perennials with a dbh of 10 cm or more. Any unidentified samples were taken to the National Herbarium in Peradeniya for identification.

Stand variables

Relative density, relative frequency, and relative basal area were calculated by the formulas given below. The importance value index was calculated from these three parameters to find the species dominance of the reserve.

Relative frequency = total frequency of a species ÷ total frequency of all species

Relative density = number of individuals of a species ÷ total number of individuals of all species

Basal area = $\pi d^2/4$ (d = dbh)

Relative basal area = total basal area of a species ÷ total basal area of all species

Importance value index = relative density + relative basal area + relative frequency

Note was taken of the erosion of the banks and the siltation of the stream, as well as of any special features on the banks.

A socio-economic survey was conducted along the two streams. The farmers living there were made aware of the study and their ideas were gathered, with regard to encroachment into the stream reser-vations, their own economic status, and about protecting the stream for long-term sustainability. An effort was made to correlate the amount of encroachment to the age of the stream.

Data analysis

The data gathered on the stream reservations were categorized according to stream width, into two groups: 5-15 m and > 15m. The reservation widths were divided into ranges 0-5, 5-10, 10-15 m ... etc. The frequency of each width class in both right and left bank reservations was assessed. The mean and mode values were taken for the existing reservations according to the two stream width groups.

Results and discussion

Stream reservations

The existing stream reservations on both right and left side of the stream and the frequency of occurrence of each width class are shown in Figs. 1-4

Very little tree-covered land was found along these streams. As is apparent from Figs. 1-4, the surviving reservations are very small and not at all adequate. They are far less than is prescribed by the Crown Lands Ordinance. The farmers who had been settled on either side of the streams had gradually encroached on the reservations for their paddy cultivation. In some instances there were other perennial crops like coconut, mango, jak, or breadfruit which had been planted where the water table was higher near the streams. Along both of the streams studied, the right bank was more encroached than the left. This was because more families had been settled on the right banks. High rates of soil erosion and bank erosion were seen along both streams, due to the encroachments on the reservations. The water had eroded the banks, thus changing stream dimensions considerably. Heavy siltation was also observed in the streams, which was reducing their carrying capacity. The adjoining Maduru Oya reservoir and the Handapan Villu must also be affected by the heavy erosion and siltation of the streams. Although they were supposed to provide a corridor for migrating animals from Handapan Villu and the Maduru-Oya reservoir area, the present naked, treeless banks do not seem to qualify for this function at all.

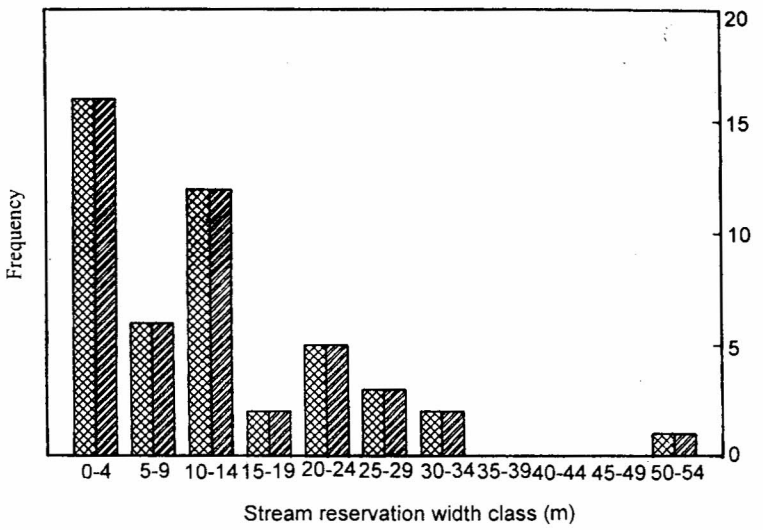

Figure 1: Existing reservations on left side Stream bank-Stream width 5-15m

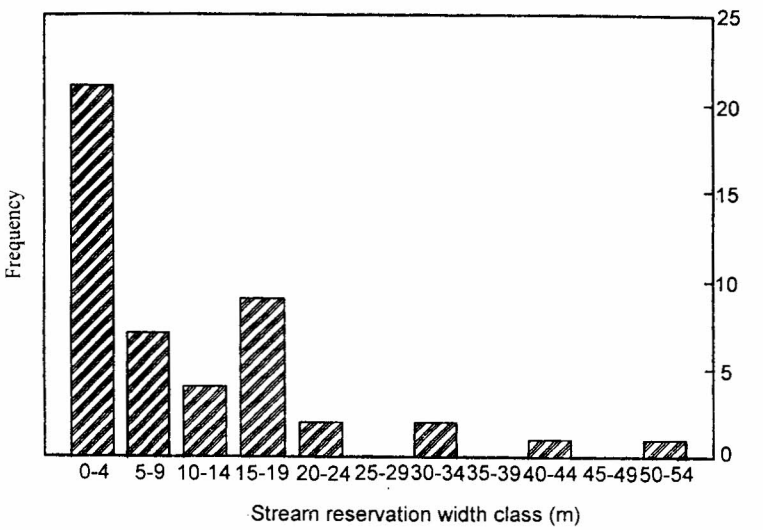

Figure 2: Existing reservations on right side Stream width 5-15m

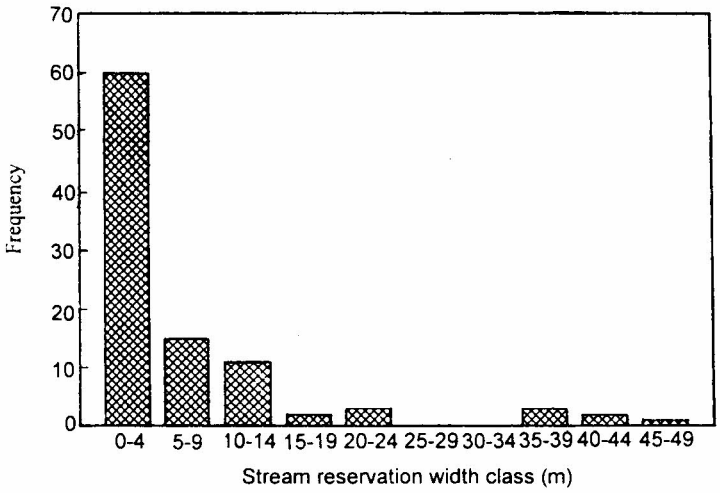

Figure 3: Existing reservations on right bank Stream width over 15m

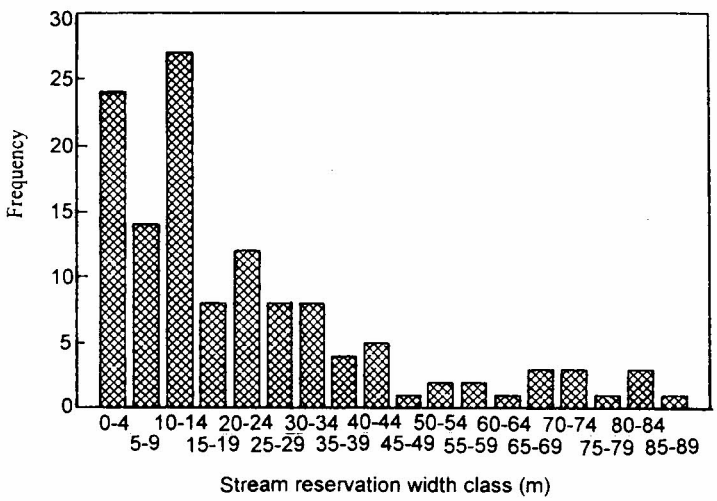

Figure 4: Existing reservations on left bank Stream width over 15m

It was noted in the literature survey that different reservation widths were prescribed by each department concerned with irrigation. For example, in the Crown Lands Ordinance the reservation width for a stream up to 15 m wide is 40 m, while the practice of the Department of Agriculture is to allocate 1½ times the width of the stream.

There was very little natural vegetation left on the banks. Information supplied by the irrigation engineers of the Mahaweli System B (personnel communication, 1995) was that after the natural forest had been cleared for the construction of the irrigation facilities, the streams had to be widened at intervals to cope with the discharge rate and so to prevent the adjoining paddy fields being flooded during the rainy season. This had to be done as there was no natural vegetation to absorb the rain water and prevent floods. The farmers in the adjoining areas were not very happy at this widening of the streams as they did not wish to lose any piece of cultivable land. However, they also dreaded the flooding.

Although stream reservations had been allocated according to the width of the stream, the following factors should also influence the area of reservation: soil type (some soil types are very fragile compared with others), topography, geology, floristic and faunistic richness, climate, adjacent land use, etc.

Floristics of the present riverine vegetation

In the survey, all woody vegetation with dbh >10cm was sampled. Alongside the Menik Ela the sample included 249 individuals while there were 158 alongside the Mahaulpotha Ela. The number of species was respectively 32 and 28. In all there were four endemic species. The tree species are listed in Table 1.

The flora varied from typical dry-zone to wet-zone species depending on the height of the bank, soil type, and soil-moisture content. When the stream was deep cut the banks were dry and tree species adapted to the dry zone could be found. When the stream was narrow, the banks were wetter, and any vegetation present included tree species from both the wet and the dry zones.

Table 1 : Floristic composition and important value indices of woody perennials > 10 cm dbh

Sample area	Plot no.	Family	Botanical name	Local name	IVI
Menik Ela					
Near	1	Combretaceae	*Terminalia arjuna*	kumbuk	1.321
Handapan		Euphorbiaceae	*Croton laccifer*	keppitiya	0.631
Villu. Bank		Sapotaceae	*Madhuca*	mee	0.553
very wet and		Sterculiaceae	*longifolia*	wetakeiya	0.510
stream very		Rubiaceae	*Pandanus*	rathmal	0.450

wide		Verbenaceae	*odoratissimus*	nambada	0.423
		Palmae	*Ixora grandis*	thal	0.203
		Fabaceae	*Vitex leucoxylon*	kumburu	0.193
			Borassus	wel	
			flabellifer		
			Caesalpinia		
			bonduc		
The soil is	2	Fabaceae	*Croton laccifer*	maila	1.015
both wet and		Sapotaceae	*Manilkara*	palu	1.050
dry		Rubiaceae	*hexandra*	ahu	0.305
		Rutaceae	*Morinda clitoria*	walkarapinc	0.281
		Boraginaceae	*Micromelium*	ha	0.246
		Rutaceae	*minutum**	lolu	0.212
		Fabaceae	*Cordia dichotama*	unknown	0.177
			Canthium	nilkaturodu	
			coromandelicum		
			Clitoria ternatae		
The stream	3	Verbenaceae	*Vitex altissima*	milla	0.956
bank is high		Melastomatace	*Memecylon*	kuratiya	0.812
and therefore		ae	*rostrum**	andara	0.501
more dry. The		Fabaceae	*Dichrostachys*	ahela	0.458
stream is		Leguminosae	*cineria*	bolpana	0.425
deep.		Rutaceae	*Cassia fistula*	davul	0.399
		Lauraceae	*Glycosmis*	kurundu	0.389
		Euphorbiaceae	*angustifolia*	daluk	0.298
		Rutaceae	*Neolitsea cassia*	burutha	0.257
		Euphorbiaceae	*Euphorbia*	heen endaru	0.168
		Fabaceae	*antiquorum*	kalawel	0.168
		Sapindaceae	*Chloroxylon*	kon	0.168
		Asclerpiadeae	*swietenia*	wara	
			Ricinus communist		
			Derris parviflora		
			Schleichera oleosa		
			Calotropis		
			gigantea		
The stream	4	Combretaceae	*Terminalia arjuna*	kumbuk	1.186
bank is both		Melastomatace	*Memecylon*	kuratiya	0.933
wet and dry		ae	*rostrum**	mee	0.720
		Sapotaceae	*Madhuca*	bolpana	0.475
		Rutaceae	*longifolia*	hurimara	0.381
		Leguminosae	*Glycosmis*	eraminiya	0.372
		Rhamnaceae	*angustifolia*	ehela	0.316
		Leguminosae	*Albizia*	karapincha	0.286
		Rutaceae	*odoratissima*	halmilla	0.172

		Tiliaceae	*Ziziphus nepeca**	bokalawel	0.160
		Leguminosae	*Cassia fistula*		
			Murraya koenigii		
			Berrya cordifolia		
			Derris scandens		
Mahaulpotha Ela					
The stream bank is dry	1	Melastomatace ae	*Memecylon rostrum**	kuratiya	0.831
				ahetu	0.724
		Moraceae	*Ficus tsiela*	milla	0.632
		Verbenaceae	*Vitex altissima*	eraminiya	0.426
		Rhamnaceae	*Ziziphus nepeca**	hurimara	0.364
		Leguminosae	*Albizia*	kudumiris	0.363
		Hydrocaritacea e	*odoratissima*	ketakela	0.307
			Thalassia	kirikon	0.243
		Euphorbiaceae	*hemprichii*	pupula	0.243
		Miliaceae	*Bridelia retusa*	siyambala	0.236
		Compositae	*Walsura tsiela*	karamba	0.203
		Leguminosae	*Microglossa*		
			zeylanica		
		Apocynaceae	*Tamarindus indica*		
			Carissa spinarum		
The bank is wet	2	Combretaceae	*Terminalia arjuna*	kumbuk	1.106
		Euphorbiaceae	*Croton laccifer*	keppetiya	0.668
		Sapotaceae	*Madhuca*	mee	0.571
		Rubiaceae	*longifolia*	rathmal	0.566
		Verbenaceae	*Ixora grandis*	milla	0.497
		Verbenaceae	*Vitex altissima*	nambada	0.435
		Ebenaceae	*Vitex leucoxylon*	kunumella	0.271
		Ebenaceae	*Diospyros*	thimbiri	0.267
		Sterculiaceae	*ovalifolia*	welang	0.178
			Diospyros		
			malabarica		
			Pterospermum		
			canencens		
The bank is both wet and dry	3	Fabaceae	*Dichrostachys*	andara	0.878
		Rutaceae	*cineria*	burutha	0.723
		Euphorbiaceae	*Chloroxylon*	unknown	0.678
		Euphorbiaceae	*swietenia*	welkeppetiya	0.578
		Melastomatace ae	*Drypetes gardneri**	kuratiya	0.571
			Croton aromaticus	pethan	0.469
		Fabaceae	*Memecylon*	weera	0.286
		Euphorbiaceae	*rostrum**		
			Bauhinia		

	tomentosa
	Drypetes sepiaria

* endemic species

Socio-economic study

There were farmers of local origin as well as the settlers who had come from other districts, such as Kegalle, Kandy, Nuwara-Eliya etc. Some, especially in Zones 1 and 5, had already been mobilized by the forestry organizations that were formed under the MARD Project, to undertake riparian forestry work. Some had already been motivated to establish nurseries of bamboos along the Menik Ela. Bamboo plants will be distributed free of charge. Once they are ready to be planted out the MARD Project will purchase them for Rs. 7.50 per plant, which will include the cost of nursery work and planting. As a further incentive, utility trees such as coconuts, mangoes, etc. have been issued to anyone actively participating in the tree planting. However, despite all these efforts, there were some farmers who were not properly convinced that the objectives of the project were worthwhile, and who were not very supportive towards it. More awareness programmes must be organized to motivate these people in community forestry work.

Recommendations

The following recommendations are suggestions for immediate remedial measures:

- Strict legislation against the encroachment of stream reservations.
- Taking over the encroached land and planting it with suitable plant species, with the participation of neighbouring farmers, motivated by suitable incentives.
- Strengthening extension to make people aware of the environmental benefits of nature conservation.

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