Table 6.10.9(c) Summary of Land Acquisition Costs

Land Use Type	Land Area (Ha)	Land Acquisition Costs (Rs.)
Residential and commercial (including quarry land)	105.25	348,086,508
Home gardens and Market gardens	133.5	368,139,640
Other agricultural land – rubber, coconut and paddy	172.10	198,756,008
Scrub and marshland	71.05	0
Total	*481.9*	*914,982,156*

6.10.10 Loss of Paddy, Rubber, Coconut and other Agricultural Crops

The productivity approach was used to calculate the loss of agricultural crops. It is assumed that all rubber and coconut lands to be acquired are productive lands. Based on the land use survey, around 14 percent of paddy lands to be acquired are abandoned paddy lands. Since the loss in agricultural output would occur over the lifetime of the project, the approach adopted to assess the total economic loss of agricultural crops is the amortized value of foregone income from agricultural production at present value terms. Since market prices do not reflect the true price, shadow price factors for rubber, coconut, paddy and other agricultural crops were used to convert market prices into economic prices.

The annual net return of the agricultural produce was estimated by multiplying the average yield by the net market value of the crop. For coconut, rubber and paddy the national average yields were used to calculate the total production per annum. However, it should be noted that the actual cropping intensity and production output might vary for each agricultural plot.

The acquisition of coconut lands is expected to bring about a loss of around 162,065 nuts per annum. The economic loss of foregone earnings from coconut cultivation is estimated to be in the order of Rs. 1.25 Mn per annum. The annual loss of production was based on the average yield of 5,801nuts per ha. and the net income of Rs. 8.77 per nut. The market price for coconut was based on the selling price of fresh coconut, which is Rs. 11.17 per nut.

The annual loss of production of rubber is expected to be in the order of 30,451 kg as a result of the land acquisition for the proposed OCH project. Hence, the estimated annual economic loss of foregone rubber production is Rs. 210,811. This was based on the national average yield of 768 kg per ha and the cost of production at Rs. 44.41 per kg. Due to the decline in international rubber prices, the domestic market price of rubber has declined accordingly and is at Rs. 49.76 per kg for Ribbed Smoked Sheet (RSSI).

Most of the paddy lands under cultivation in the project study area are harvested only during one season. It is assumed that 80 percent of the paddy lands will be cultivated once a year whilst the balance 20 percent will be cultivated during both Maha and Yala seasons. The annual loss in production from paddy was calculated using the average

yield for both harvesting seasons. The average producer price of paddy is taken at Rs. 10.32 per kg and the market retail price of Rs. 12.40 was based on Co-operative Wholesale Establishment (CWE) and farmer organization prices. The estimated annual loss in production from paddy is 415,595 kg while the economic loss of income from paddy lands is anticipated to be around Rs. 602,513 per annum.

Table 6.10.10(a) below gives the net annual income foregone from rubber, coconut and paddy cultivation.

Table 6.10.10(a) Summary of Loss of Earnings from Rubber, Coconut and Paddy

	Rubber	**Coconut**	**Paddy**	**Total**
Total area (ha)	39.65	22.35	95.25	157.25
Yield	768 kg/ha	5,801 nuts/ha	3,636 kg/ha	
Annual Production	30,451 kg	162,065 nuts	415,595 kg	
Cost of Production	Rs. 44.41per kg	Rs. 2.40 per nut	Rs. 10.32 per kg	
Market Price	Rs. 49.76 per kg	Rs. 11.17 per nut	Rs. 12.40 per kg	
Total Annual Return (at Market Prices)	*Rs. 162,914*	**Rs. 1,137,051**	**Rs. 864,437**	*Rs. 2,164,402*
Conversion Factor	1.294	1.100	0.697	
Total Annual Economic Return	**Rs. 210,811**	*Rs. 1,250,756*	**Rs. 602,513**	*Rs. 2,064,080*

Home gardens and market gardens account for 44 percent of the agricultural lands to be acquired by the proposed project. It is difficult to estimate agricultural earnings from home gardens and market gardens due to the lack of data on the crop types, cropping intensity and cultivation practices adopted in these gardens. However, it is assumed that the cost of production for home gardens is minimal and the net return per quarter is around Rs. 1,500 per ha. In the case of market gardens, it is assumed that the cropping intensity is higher than at home gardens and therefore, the net return is estimated at Rs. 1,700 per quarter per ha. The total annual economic loss from home and market gardens is anticipated to be around Rs. 711,834.

Table 6.10.10(b) - Loss of Earnings from Home Gardens and Market Gardens

	Home Gardens	**Market Gardens**	**Total Gardens**
Total area (ha)	116.30	17.20	133.50
Net income per annum per ha	Rs. 6,000	Rs. 7,000	
Total Annual Returns (at Market Prices)	*Rs. 697,800*	*Rs. 120,400*	*Rs. 818,200*
Conversion Factor	0.87	0.87	
Total Annual Economic Returns	*Rs. 607,086*	*Rs. 104,748*	*Rs. 711,834*

6.10.11 Impact on Aesthetic Value

The OCH cutting across cultivated land will somewhat mar the aesthetic appearance of the surroundings. However, as a tree line is proposed on the verges of the OCH it will not become an eyesore as most of the land it traverses is already built up or disturbed and the vegetation is monoculture or secondary.

The total annual economic loss of income from agricultural production is Rs. 2.78 Mn. Although the extent of coconut land to be acquired for the proposed project is significantly lower than paddy, home gardens and rubber, the loss of income from the coconut sector is the highest accounting for 45 percent of the total loss of income from agriculture. Paddy accounts for around 22 percent of the total loss of income from agricultural production and home gardens and market gardens account for approximately 26 percent of the total loss. The loss from rubber cultivation is relatively low at 7.5 percent of the total loss of agricultural earnings.

6.11 Impacts of Construction Activities

6.11.1 Impacts during Construction Phase

During the construction phase of the proposed OCH, there will be some adverse effects on the residents of the project area. The main environmental impacts associated with the construction activities are:

- noise pollution
- air pollution

Noise Pollution

The construction phase will involve use of heavy mechanical equipment, drilling, cutting of road etc. that can be quite noisy. Most of the road trace will go through rural areas where the current noise levels are very low. Therefore, the community living close to the road construction area may be adversely affected by the increase in noise levels during the construction phase.

The noise levels could be minimized if appropriate construction equipment that reduces the level of noise generated is used. Any nighttime construction work, which is noisy, should also be avoided. The increase in background noise level will have a negative impact on the community living within 100 meters of the construction activity.

Air pollution

The construction activities will have an adverse effect on the air pollution levels of the project study area. There will be an increase of dust emission from earthworks and transportation of construction material. The vehicles traversing over unpaved road surfaces and increase in volume of construction related traffic will contribute significantly to the increased levels in particular matter.

The increased air pollution levels will have a negative impact on the health of the community living by the proposed construction activity. The short-term effects of air pollution include respiratory problems, eye irritation, headaches and increased exhaustion. People with asthma will be particularly sensitive to increase in the level of air pollution.

The human capital approach has been used to value the impact of air and noise pollution during the construction phase. It is assumed that the change in environmental quality causes illness that has negative short-term effects

6.11.2 Particulate Emissions

Heavy machinery as concrete mixers, asphalting plants etc will be employed along the road. Heavy haulage trucks will be used in transporting construction materials and machinery. These will emit exhaust gases, which would contaminate the air as described in section 6.6. Air pollution by the heavy machinery will be of significance as the polluting source is stationery and this could be a nuisance as well as a health hazard to the community in the immediate vicinity.

Dust particles generated by excavation exploitation of coarse aggregates and rubble will be released to the air polluting it Dust particles may also be released to the atmosphere during transportation and unloading. Stockpiles if not properly covered could add to the particulate matter emitted to the atmosphere. Cut and fill operations could add to the air pollution, too. Further the mixing of concrete and asphalt may also release air borne particulate matter as cement dust. While the deposition of these particulate matter could be a nuisance air borne particles might also contribute to health problems. Moreover when these particulate matter finds its way to the water bodies with the assistance of precipitation and settling it could result in water pollution affecting the aquatic ecosystems and especially fauna adversely.

Spraying of agro-chemicals in the process of turf stabilization by turfing will contribute to air pollution and deterioration of water bodies.

6.11.3 Impact of Haulage

Heavy haulage trucks will be employed for transporting large quantities of construction materials as earth, gravel, aggregate, metal etc. to the proposed sites through B,C,D and E class roads. Most of these roads, particularly the minor roads and unclassified roads are not designed and constructed to cater to transportation of these heavy loads. As the base and sub base strengths would not be able to withstand the transportation process and will deteriorate faster, especially during wet weather.

Further, the traffic increase on these narrow and mostly single lane roads, caused by the heavy haulage trucks could adversely affect the other road users.

6.11.4 Noise and Vibration

Noise and vibration of the haulage vehicles and construction machinery would increase the noise and vibration levels in the vicinity of the construction activities adversely affecting the nearby community and fauna particularly the avifauna.

The vibration of haulage trucks could damage residences on verges of the roads used for transporting construction material.

6.11.5 Sediment Generation

The cutting and filling process would inevitably generate sediments, which may reach nearby waterways. It has been estimated that 4,781,000 m^3 of fill material has to be brought in to fill the deficit between cut and fill material.

The exposed cuts could erode and cause sediment generation especially during the rainy season during transportation of construction materials as earth and sand aggregates spillages could occur. And during unloading and stock piling, too, sediments could escape to the environment. Stockpiled material if not properly covered could be washed away during rains.

The sediments thus generated could find its way to the water bodies causing sedimentation. The sediments could affect fish particularly gill fish, affect the breeding of aquatic fauna, affect primary producers and thereby the food webs by blocking sun light.

6.11.6 Waste Material

Construction activities of this magnitude would generate solid waste as used parts of machinery, used batteries, tyres and tubes, filter elements and packing material of equipment, spare parts and construction material as cement. If not properly disposed this solid waste would pollute the environment. Of particular concern would be the hazardous waste as used batteries.

Spillage of petroleum products and lubricants and hydraulic fluids and indiscriminate disposal of used lubricants and hydraulic fluids will add to environmental degradation. As these could enter waterways the aquatic ecology would be affected significantly and could curtail down stream water use.

Waste generated by the labour force will add to environmental degradation. Solid waste and sewerage disposal would cause problems if not properly addressed and the water bodies in the vicinity and would be affected. This could again affect downstream water use.

6.11.7 Extraction of Construction Material

In the construction activities of the Outer Circular Highway large volumes of construction material as sand, gravel, fill material, metal aggregate, bitumen, cement and steel would be required. Though the supply of these material would not cause problems in the small-scale construction works the large-scale supply will cause environmental impacts.

Impact of Metal Quarries

Metal quarries if located by the roadside will interfere with traffic movement at the time of blasting. Further, the excessive blasting noise can cause harm to human beings as well as animals. Birds etc.

With uncontrolled blasting, large masses of rock can fall on adjacent lands adversely affecting agriculture, fauna and flora. It may also cause harm to the rock mass itself or its stability.

The hauling of metal from quarry site to site by trucks will cause traffic congestion, dust and damage to existing roads. During rainy weather, the trucks will deposit mud on the road surface from tyres.

Impact of Burrow Pits

When excavating burrow pits for soil or sub-base, the following impacts can occur:

- Adverse affects on the stability of soil source
- Landslides
- Erosion of cut face
- Disruption of the drainage pattern prior to excavating
- Damage to trees, plants and flora

Impact of Sand Extraction

According to the preliminary estimates 1,148,500 m^3 of sand is required for construction activities of the road project. As extraction of this volume of river sand would certainly cause erosion and undermining of riverbanks this option cannot even be considered.

On the other hand the use of sea sand would cause high levels of salinity in the vicinity of the project area. This rise in salinity could affect the ecology and fauna and flora of the area significantly.

6.11.8 Influx of Labour

The construction activities of the road project would necessitate employing a large number of workers most whom will come in from outside. These employees would be of many different socio-cultural and religious backgrounds.

The interaction of this outside workers could have an adverse impact in two ways. The workers could cause to disruptions to the established socio-cultural ties on the one hand and give rise to conflicts with the local residents.

6.11.9 Public Health

Construction activities could result in formation of stagnant water pools by blocking of waterways. Further the discharge of used and fresh water on to low areas could also establish stagnant pools.

These stagnant pools may provide breeding places for vectors that transmit diseases as Filariasis, and depending on the location Japanese Encephalitis. During rainy season these pools filled with fresh water could provide breeding grounds for Aedes sp. which transmit Dengue Hemorrhage Fever.

7. MEASURES TO MITIGATE IMPACTS

7.1 Surface Run-off and Future Flood Water Levels

Estimation of flood peak values for different Return Periods and estimation of Detention Storage can provide the necessary basic data to design adequate waterways under the roadway at different strategic locations. Such locations would generally be already existing drainage lines. In identifying the 26 No. Sub-catchment, the main drainage lines for each such catchment was also identified. By allowing adequate waterway for discharge of floodwaters in each sub-catchment, it is possible, by applying hydraulic principles, to estimate the flood afflux at each drainage crossing. It is this afflux which will be the increased flood level caused by the construction of the OCH. Hence minimizing this afflux would be the goal of any designer to ensure least impact of the construction of the OCH on surface run-off and flood levels. The magnitude of this afflux will depend on the nature of the upstream land use in each sub-catchment and a reasonable value for the afflux can be decided on for each sub-catchment. While an afflux of 15cms may be allowable for some sub catchments in other cases due to existing development and nature of development, even an afflux of 05 cms may be excessive.

7.2 Irrigation and Flood Protection Works

If an irrigation canal or a drainage canal constructed to service a certain scheme or area is obstructed by the construction of the OCH and if a canal crossing under the OCR is absolutely necessary in order to ensure that the scheme continues to function properly, then such a canal crossing must be constructed under the OCH project, as a mitigatory measure.

7.3 Inundation Levels in Flood Plains

As explained in para 7.1, it is necessary to reduce the flood afflux caused by the construction of the OCH to an acceptable minimum, depending on the nature of the land use within each sub catchment.

7.4 Future Urbanization of the Sub-Catchments

In order to control the development within each sub catchment, based on engineering and environmental considerations, it is necessary to follow a procedure as enumerated below:

- Identify all low lying areas within each sub catchment
- Decide on a maximum High flood Level for a known Design Return Period
- Compute a minimum level for filling of low lying areas within each sub-catchment
- Estimate extents that can be developed in the low lying areas, under the above conditions, for each sub-catchment
- Establish land use controls

In this manner future urbanization along the OCH can be controlled in a sustainable manner.

7.5 Air Pollution

Adhering to the following best practises can minimize release of exhaust emissions during the operational phase of the OCH:

- Formulating vehicle emission standards and strict management of emission levels subsequent to a an awareness programme;
- Establishing a national policy on vehicle imports-Exhaust emission levels increase with age of vehicles;
- Taking precautions to avoid slowing down of traffic due to too many intersections, roadside developments and slow moving vehicles;
- Promoting mass transport and traffic management;
- Provision of a vegetative barrier to arrest the spread of air borne particles to residential areas.

7.6 Increase in Noise Levels

Noise level increases from the generated and diverted traffic in the OCH will also be controlled by the first four mitigatory measures recommended above. However, additional mitigatory measures may be needed depending on the land use pattern.

In areas with undeveloped land or with plantations as coconut rubber etc., noise abatement measures may not be required. However, in sensitive areas schools, places of worship, hospitals and libraries, sound barriers as tree linings will have to be employed. Further if these are situated in very close proximity to the OCH other measures as sound insulation will have to be considered if the option of shifting the building is not a possibility.

In areas with home gardens and commercial and industrial developments establishing a buffer zone with luxuriant vegetation would suffice.

7.7 Road Accidents

The proposed OCH will cater to vehicles travelling at comparatively high speeds and the volume traffic is also expected to be high. In order to minimize accidents the following measures should be adopted

In the absence of Safety standards and motor traffic regulations for limited access high-speed highways in Sri Lanka it is necessary to these standards and regulations are included in the Motor Traffic Act in use. This will assist in preventing unroadworthy

vehicles using the OCH and developing a behavioural pattern suitable for highway users.

Proper maintenance of crash barriers and road signs and immediate replacement if damaged.

An organized automobile services to attend to breakdowns and also telephones on both sides of the road at frequent intervals for emergency use.

24-hour emergency service unit with Police, Ambulance service, fire engines etc.; highway patrol service, rescue operation service and surveillance would be among the duties of this unit.

7.8 Habitats, Fauna and Flora

In order to minimize the depletion of ecologically important habitats such as marshes, it is recommended to avoid marshlands as much as possible. When deciding on the final trace this should be paid highest attention. In the northern region, to minimize the extent of marshy land that should be reclaimed in the east of present Colombo Katunayake road, the highway route could be slightly shifted north. Similarly in the southern part, by shifting the road trace slightly north, extent of marshy lands in the Bolgoda area that is needed to be reclaimed for the highway could be reduced. No new access roads to transport construction material should be constructed over the marshy areas. Existing access roads should be used for this purpose.

Proper maintenance and management should minimize spilling oil from construction machinery. All spent lubricants, worn tires, tubes and other discarded material including solid waste should be properly disposed. They should never be disposed into the neighbouring habitats, both terrestrial and aquatic. Proper disposal sites should be identified with consultation of Divisional Secretaries. An officer may be assigned at the construction sites to ensure proper disposal of debris. Precautions should also be taken to prevent falling of asphalt, oil and cement to the marshes, rivers and other aquatic habitats during the construction period.

The culverts should be constructed at regular intervals to mitigate the risk of inundation of low-lying areas. These will also serve as "through passages" for small mammals, reptiles and amphibians and will therefore minimize the risk of being run over by moving vehicles. These "through passages" will minimize the fragmentation of populations too.

Trees should be grown on either side of the highway. Fast growing species such as Gon Kaduru (*Cerbera manghas*), Wel aaththa (*Annona glabra*) and Wetakeiya

(*Pandanus odorotissima*) are recommended for this purpose in the wetland areas. Replanting along the roadway in other areas should be done using a mixture of species of local vegetation in the respective areas. These plants should not interfere with traffic. These trees will serve as noise and dust barriers and also provide roosting and nesting places for birds and sheltering sites for small mammals. Further, trees will serve as carbon dioxide sinks and help to minimize global warming. It is recommended that for every tree that is removed due to the construction of the road, one or more trees be planted.

Planting grass, shrubs and trees should prevent soil erosion of embankments. Fast growing local species are recommended for this purpose.

The marshy lands in the study area are widely used as dumping sites for solid waste. Further, these are largely reclaimed as container yards and warehouse sites. Some areas are continuously encroached by squatters. These activities should be stopped. The marshy lands on either side of the embankment should not be used as waste disposal sites and also should not allowed to be reclaimed or encroached. This will help to maintain sufficient amount of habitat area for marsh vegetation and maintain ecological values and functions of these wetlands. It is recommended that a reservation area of at least 100 m on either side of the highway in the marshy areas be declared.

The earth to fill the low lands should be obtained by leveling hilly landscapes in the nearby areas as much as possible. When transporting this earth, overloading of trucks should be strictly prohibited. The earth should never be allowed to fall on to the access roads while transporting. Sand should be obtained as much as possible from the river beds. The amount of sand that could be mined without causing the intrusion of seawater in the long run should be estimated and only that amount should be obtained. If additional sand is required, sea sand obtained from the sea bottom should be used. A survey should be carried out to determine where sufficient amount of sand is available in the seabed. A separate study should be carried out to determine the impacts of sand mining on marine ecology. The possibility of using the site where sand was mined for the Muthurajawela landfill should be explored. If sand is mined from the sea bottom this sand should be stockpiled on the shore and washed with fresh water to desalinate before being transported to the project sites. Since this would be a costly operation, possibility of substituting sand with metal particles of suitable size should be explored. During site clearing, weedicides should never be applied during the rainy season and only the organo-phosphorus compounds should be used.

Proper sanitary facilities should be provided for the work force. Proper sewerage facilities should also be designed for resettlement schemes.

Piling up of loose material shall not be done near rivers, waterways, lakes or places where they could get dislodged or eroded. Watering of stockpiles of sand and coarse aggregates should be done to minimize the emission of dust particles.

Debris should not be left in places where they may be carried by water to flood plains, rivers, lakes and lagoons. Solid waste should not be deposited on the sides of the road or close to residential areas. Solid waste and debris should be buried in a proper predetermined place or incinerated.

Leftovers from asphalt and concrete plants should be dumped only in predetermined places that do not disturb terrestrial and aquatic fauna and flora, and the people. Waste water, oil, grease and other material from these plants should not be directed to waterways. Oil and grease traps should be provided and wastewater should be treated to be in conformity with the CEA standards for effluents. These plants should also be provided with dust collectors and silos to minimize air pollution.

7.9 Community Severance

Except a negligible number the majority of households living within the identified road trace are not willing to leave the current place. This will be a greater challenge for the road planners and developers. The first step of mitigatory action would be to build effective rapport with the affected community. This will lead to build the trust and confidence among affected people on the project developers. If this situation is not created implementation of any mitigation plan will not be possible.

The step 2 of the mitigation plan should be preparation of a comprehensive relocation plan. The mitigation plan should include plans to minimize the likely community severance that could happen due to project implementation. Therefore, the relocation plan should include following aspects to minimize community severance:

- Identification of suitable land in close proximity of the affected community. In the case of OCH. There are 4 possible sources available to seek and select suitable lands for relocation. The four sources include:

- The Divisional secretaries of each division should be consulted to seek for suitable lands. When the final trace is decided the project planners and developers can reach the DSs to inquire about available lands;

- Grama Niladhris also know about the local environment and they are also a potential source. The consultants consulted the GNs and the lands available from their knowledge are given in the table 34 in this report. Once the final decision on the road right of way is decided the availability of these land should be verified;

- The other source is the 432 householders surveyed. Some of them (majority) indicated availability of some land. While some of the land is privately owned some belong to Government. Further verification is required to know the land ownership and the availability of such lands for the project to relocate displaced people;

- The final source is the land use planners' information on the availability of unutilized lands in the area. Further verification is needed of these information too;

- Once the land availability gets confirmed the planners should draw a map indicating the locations of the affected householders and the lands available in the vicinity of them. This will provide information to discuss with the affected people to select the places for reallocation in the close proximity of their present locations.

- The socio-economic environment of the inside and out side of the relocation lands must be well understood before deciding what community group will be relocated in which land etc.

- As far as possible the affected community groups should be given opportunity to select the community group to be relocated with them in the same site.

The compensation package should be worked out with consultation of the people. Different people will have different options with regard to compensation. As much as possible within the scope of the project t the community options should be accepted. For example in the household survey conducted in OCH the community gave different options for compensation.

- Finally it should be noted that as far as possible all the activities with regard to relocation of communities should be carried out with genuine involvement of the affected parties.

- Although the project involved involuntary relocation the project planners must be able to convert it to a participatory relocation program using various participatory methods and tools. This type of strategy will be quite helpful to address the likely community severance that would arise due to displacement of people.

7.10 Changes in Property Values and Values Decrease

Land values in the vicinity of the project will increase. Therefore, mitigation action is necessary only to address the properties in which values will get decreased. Due to fragmentation value of some lands will get decreased. The road planners should try to design the road right of way to avoid such problems. In unavoidable cases the project developers should think of paying moderate compensation for the landowners. But this should be done with careful verification because there will a tendency for non-affected landowners also to make claims.

7.11 Changes in Accessibility to and Demand for Schools, Religious Institutions, Business Etc.

Schools: As much as possible school buildings must be avoided when the final road design is prepared. There will be serious implications of taking the road through school premises. In such cases the design must provide some protection measures to safe guard children from accidents during the post-project period. In unavoidable cases some buildings of the schools may be demolished and the affected children may have to be handed over to another neighboring schools by improving the infrastructure of that school. Additional teachers should be provided to the host school. In the case where entire buildings of the school are affected the education department must be compensated to build another school in the vicinity. The road developer may build a school through a building contractor and hand it over to the education department.

7.12 Effects on Other Modes of Transportation and Transportation Facilities

Road designers and planners can address these problems. The design of the new road should be prepared in such a way to solve the affects on existing road net work and the mode of Transportation.

7.13 Effects on Social Groups as Elderly, Handicapped and Economically Disadvantaged

There must be special care for these socially valuable groups from the project. If a person in this group heads the affected household the project developers can build a new house and settle them in a suitable environment for them. If another person manages the household the project can provide special allowance for them to shift these handicapped from the old place to new place. Again this action should be taken with caution.

7.14 Households to Be Relocated

The road right of way should be selected in such a way to minimize the number of households to be affected. To satisfy this condition considering only the civil engineering design would not be sufficient. The environmentally acceptable trace suggested by the EIA team should also be considered in finalizing the designs. The results of the household survey in volume II of this report provides the local people's suggestions to change the present right of way of the OCH to minimize the affects on the number of households. This implies that the participatory way of approach should be followed in finalizations of the right of way for OCH. If the effects on houses cannot be avoided by the final right of way, the affected houses should be compensated. The following suggestions should be carefully considered when compensation program for affected houses is implemented.

- The householders should be informed in advance.
- The households headed by socially vulnerable heads should be given priority and special attention.

- The choices of householders regarding compensation should be carefully considered.
- Prepare lists of onsite and off site relocation households and implement separate strategies for both groups
- Timely and adequate compensation will be most critical requirements

Further. The RDA guidelines on relocation of houses (especially prepared for southern development project) should be adopted this project too. (RDA July 1999).

7.15 Business and Industries to be Displaced

The road design should be prepared in such a way to minimize the number adverse impacts on these places. For this, steps mentioned under the item 7.1 should be followed. In the type of environment prevailing in the project areas negative effects cannot be eradicated but a mitigatory plan can be implemented for satisfaction of both parties, the affected and the developer. The following aspects should be considered in compensating these affected groups:

- Selection of places to reestablish business and industries should be done in a participatory manner; the businessmen and industry owners should be given opportunity to select the places.

- They should be given sufficient time for shifting their businesses and industries. This time period should not be detrimental for implementation schedule of the project.

- Timeliness and adequacy are two important criteria to be considered.

7.16 Retail/Whole Sale Business and Tax Revenues

The suggestions made above for business and industries are equally relevant to these groups too. In addition another major suggestion to be made for these groups is to compensate their foregoing income from business during the shifting time. The exact compensation for this can not be calculated in reality. But project the developer with the help of consultants can decide the nature of income they have to forego during shifting time. At least 25% of such income should be paid to them.

7.17 Employment Opportunities

The employment of the people who work in the business places and industries which would be evacuated due to the project will be lost. This will be a temporary problem in many cases. Once the displaced business and industries are started in the new locations many of the employees who lost employment will get their employment back. Due to some other problems associated with the new locations of business and industries some people may try to avoid working in the new places. The project developers together with business and industry owners can work out a strategy to compensate the foregone income of these employees.

7.18 Accessibility (Changes In Market Opportunities, Tourism, Availability of Labour)

There will be temporary difficulties for travelers, both internal and external, due to project implementation. Since this will be temporary problem compensation will not be required. Similar problems also may occur with regard to marketing facilities of the people. As far as possible project developers should not disturb the existing road net work and transport system. If so people can have access to other markets out side of the area.

7.19 Fragmentation of Agricultural Lands

Only some agricultural lands will be fragmented. Fragmentation will create problems if the owners will not have easy access to both plots of land. If the proposed road design will include facilities for the farmers to have such access this problem will not arise. In certain cases some potion fragmented will become so tiny and therefore, such tiny portions become uneconomical for owners to keep. The project developers should seriously consider compensating for such lands fragmented.

7.20 Loss of Paddy, Coconut, Rubber and Other Land and Associated Loss of Production

The extent of lands falls within the affected area should be compensated according to the prevailing market rate for such lands in the area. The income from such lands (production) also should be taken in to account when calculating the compensation packages for the landowners. At least three years of income from the crops prevailing in the affected land extent may be calculated for compensation.

7.21 Impacts Of Encroachment on Historical, Cultural Sites and Monuments

No significant historical and cultural places will have negative impacts due the proposed road. But several religious places will be negatively affected. The best solution recommended is to design the road right of way to avoid these places. But in reality all the places can not be avoided. The project planners and developers should discuss these issues with the religious leaders of each place and try to understand their demands.

There can be some leaders who are prepared to establish their places some where else with proper compensation. Whatever the action taken by the project authorities it should be with the full concurrence of the religious leaders in affected places.

8. EVALUATION OF ALTERNATIVES

The alternative alignments were considered in detail for their environmental impacts and a summary of the comparison summary with regard to the adverse impacts are given in Table 8-1 below:

The railway system alternative while being economically will not alleviate the traffic congestion as it cannot provide the connectivity among the trunk roads radiating out from the city of Colombo. Further the time saving by this option will also be much less. On the other hand, the environmental effects though lesser than the OCH, will be considerable as at least two tracks will have to be laid anew.

Though the No Action alternative will not have any adverse environmental effects it would not reduce the traffic congestion and urban sprawl which is an essential development requirement. Further the OCH is expected to reduce air borne pollutant levels by avoiding traffic congestion and slow moving traffic.

Table 8-1 Comparison of Alternative Segment

Factors/Effects	Sectors,Segments	Section 1							
		a1 - c1	a2 - b	b - c1	b - c2	c1 - e	c1- d - e	c2 - d -e	c2 - e
Engineering Index									
Route Length [km]	New Construction [Total km]	12.09	2.59	6.64	3.15	14.41	14.55	16.65	15.1
	Marshes [km]	1.28	1.39	2.71	2.47	0.69	0.75	2.05	1.56
	Alluvial Clays [km]	0.92	0	0.08	0	1.33	6.5	4.66	2.46
	Sandy Soil [km]	1.35	1.2	0.17	0.17	1.21	1.3	1.02	0.79
	Laterites and Gravelly Soils [km]	8.49	0	3.64	0.51	11.18	6.27	8.92	10.29
Design Speed [km/hr]	80 km/hr	O	O	O	O	O	O	O	O
Carriageway [lane]	4	O	O	O	O	O	O	O	O
Viaduct [Nos]		3	2	1	1	2	2	2	0
Inter Change [Nos]		3	2	1	0	1	1	1	2
Frontage Road		O	O	O	O	O	O	O	O
Urban Sustainability									
I Economic Sustainability									
Traffic Factors									
Forecasted Daily Traffic		31400	29800	53400	67600	59400			76300
[pcu/d in 2010 both directions] *									
Cost Factors [Construction] Unit = Million Rs.									
Earth Works		925.3	199.8	475.5	221.5	1077.5			1114.4
Road Works		516	94.3	294.8	128.3	647.1			711.7
Bridge Works		0	0	0	22.9	1032			1054.9
Viaduct Works		1200	800	400	400	800			0
Under Pass Works		173	54	146	93.3	254			438
Inter Change Works		1050	700	350	0	350			700
Other		166.6	36.2	106.1	49.4	213.8			250.1
Total Construction Cost		4030.9	1884.3	1772.4	915.4	4374.3			4269.1
Total Cost per/km		333.3	727.5	266.9	290.6	303.6			282.7

O = Yes

* aver. for 6 scenarios

Comparison of Alternative Segments for Selection of Preferred Possible Highway Alignments								
				Section 1				
Sections, Segments	a1 - c1	a2 - b	b - c1	b - c2	c1 - e	c1 - d - e	c2 - d - e	c2 - e
II Social Sustainability								
Socio Economic Factors								
Land Use	R High	High	High	High	Moderate	High	High	R High
Public Acceptability	Low	Low	Low	Low	R High	Low	Moderate	Low
Scale of Resettlement	R High	High	High	High	Moderate	High	High	R High
Development Effects								
Access to Development Sites	R High	R High	High	R High	Moderate	Moderate	R High	R High
Access to Inland Towns	R High	R High	R High	R High	Moderate	Low	R High	R High
III Environment Sustainability								
Environmental and Resettlement Effects								
Number of Project Affected Persons	R High	High	High	High	Moderate	Moderate	High	R High
Estimated Composition Resettlement Cost	R High	High	High	High	Moderate	Moderate	High	R High
Agricultural Land Take								
Homesteads	R High	High	High	High	Moderate	Moderate	High	R High
Paddy	Low	Low	Low	Low	R High	R High	Low	Moderate
Rubber	Low	Low	Low	Low	R High	R High	Low	Moderate
Coconut & others	Low	Low	Low	Low	Moderate	Moderate	Low	Low
Over all Environmental Impact	R High	High	High	High	Moderate	High	High	R High

High = Significant
Low = Low Level of Significance

RH = Reletively High
Moderate = Somewhat Significant

9. EXTENDED BENEFIT COST ANALYSIS

9.1 The Financial Plan

This section provides an overview of the investment costs and benefits of the OCH project for the preferred alignment option proposed by the design and engineering consultants. The financial cost estimates have been obtained from JICA Study Team. In this section, OCH covers the entire trace including the section that overlaps with Southern Highway.

9.1.1. Project Costs

The total investment cost is estimated to be in the order of Rs. 20 billion. The main cost items is:

- Engineering and construction costs;
- operation and maintenance costs;
- land acquisition costs; and
- compensation and resettlement costs.

Engineering and Construction Costs

The construction costs mainly comprise of costs related to:

- earth works;
- road works;
- structure works;
- interchange and junctions; and
- drainage works.

The construction costs will be incurred over an eight-year period. This is estimated to cost Rs. 12,394 million during the first eight years with an additional cost of Rs. 669 million to upgrade the road to 6 lanes. In addition to the above items there will be provision for engineering services and contingency costs. Total engineering services costs is estimated to cost Rs. 1,240 million without upgrading.

Table 9.1 [a] below gives a break down of the total foreign and local currency components of the engineering services and construction costs of the project.

Table 9.1 [a] Engineering and Construction Cost Estimates

(in constant prices)

Item	Cost (Rs. '000)		Tax (Rs. '000)		Total (Rs. '000)
	Foreign	Local	Foreign	Local	
Engineering Services	669,500	636,700	189,100	79,600	1,574,900
Construction Cost	6,695,000	6,366,900	2,379,800	1,203,300	16,645,000

Operation and Maintenance Costs

The OCH project will also incur annual and periodic maintenance and operation costs. The annual maintenance costs mainly involve:

- routine surface maintenance;
- sweeping;
- maintenance of shoulders; and
- electricity associated with lighting and signal.

The operating costs mainly comprise the cost of labour required to carryout the maintenance operations. The periodic maintenance cost involves the overlay of surface courses and will be carried out every 10 years. The initial periodic maintenance cost is estimated around Rs. 600 million in ten years increasing to Rs. 750 million in ten years when it will be upgraded. The annual operating and maintenance cost is estimated to be range between Rs. 15 million per annum to Rs. 55 million per annum in the latter years of the project.

Land Acquisition, Compensation and Resettlement Costs

The land acquisition, compensation for demolition of residential and commercial buildings and resettlement costs within a 60-meter ROW is Rs. 1,734 million and will be incurred over the first 3 years of the project.

Table 9.1[b] Summary of Land Acquisition, Compensation and Resettlement Costs

Year	Land Acquisition, Compensation and Resettlement Costs Rs. Million (in current prices)
2001	572.0
2002	580.8
2003	580.9
Total	*1,733.7*

The land acquisition, compensation and resettlement costs need to be financed domestically by the central government.

9.1.2 Financial Benefits

The OCH project is not a revenue-generating project and therefore, does not have any mechanism that will directly raise revenue to cover the capital or operating costs of the project. The project proponent does not intend to levy a user charge such as toll fee, which will provide a means of generating revenue in the future. Infrastructure development projects such as roads are public goods, which provides equal access to all without affecting the others enjoyment. Therefore, revenue generation from the project is not a key criterion in justifying the feasibility of the project. However, the OCH project has several direct and indirect benefits to the society, which are discussed in the next section.

9.2 Economic Benefit-Cost Analysis

Economic analysis is a means for determining whether a proposed investment is justifiable and is concerned with the overall welfare of and benefit to the public and other stakeholders. It is concerned with measuring cost differences between the existing situation ('without' project scenario) and the situation after the new project has been implemented ('with' project scenario). Only incremental costs incurred as a result of the project are included in the analysis.

The 'with' project scenario depends on the preferred route option decided upon by the JICA Study Team, which has been presented in this EIA report. Accordingly, no assessment of alternative options has been carried out in this analysis.

9.2.1 Costs

The costs given below are in constant prices.

Land Acquisition Costs

The land acquisition costs involve costs incurred for the acquisition of residential, commercial and agricultural lands to be used by the OCH project. Based on preliminary engineering design estimates the land area to be acquired for the project is approximately 320 Ha.

It should be noted that the land acquisition costs are lower than the estimates given in Sections 6.15 as the estimates given here are based on the engineer's preliminary design with a right of way of 60 meters. The estimates given in Section 6.15 are for a 100-meter corridor based on the socio-economic survey study area carried out for the EIA. For the purpose of this analysis, the Study Team's preliminary design estimates of land acquisition costs, including cost for the removal of high tension towers, have been used and are estimated to be Rs 795 million for the acquisition of residential, commercial and agricultural lands along the road trace.

Table 9.2[a] - Land Acquisition Costs

	Land Acquisition Costs (Rs.)
Residential and Commercial	209,744,858
Home Gardens and Market Gardens	295,532,024
Other Agricultural Land – Rubber, Paddy and Coconut	180,023,745
Removal of High Tension Towers	110,000,000
Total	**795,300,627**

Compensation and Resettlement Costs

The compensation costs for the demolition of building structures within a 60-meter right of way, based on the engineer's preliminary design, are in the order of Rs. 768 million. In comparison to the estimates given in Section 6.15, the number of buildings to be demolished is 845 houses and 62 commercial and industrial buildings within a 60 meter right of way width. The alignment given in the preliminary design has been adjusted such that it does not disturb temples and schools.

The resettlement costs are estimated to be Rs. 170 million and includes ex-gratia payments for timely evacuation, shifting costs for relocation, cash assistance for income restoration, and loss of employment due to the project. A summary of the compensation and resettlement costs is given in Table 9.2 [b] below.

Table 9.2 [b] Summary of Compensation and Resettlement Costs

Item	Cost
Compensation for Demolition of Residential Building Structures	627,105,000
Compensation for Demolition of Non-residential Building Structures	141,297,000
Ex-gratia Payments for Timely Evacuation	151,384,886
Shifting Cost for Relocation	8,516,500
Cash Assistance for Income Restoration	6,180,000
Loss of Employment Due to the Project	3,915,000
Total	*938,398,386*

9.2.2 Benefits of the Project

There are direct and indirect benefits of a road project to the users who directly use the highway as well as indirectly to others that benefit from the spin off effects of the development. The benefits to be accrued from the project are:

- savings in vehicle operating cost (VOC);
- savings in passenger time cost (PTC);
- reduced accidents; and
- spin off effects from regional development and other activities.

The benefits generated by the project will be assessed by comparing the 'with' project scenario to the 'without' project scenario. The OCH will be operational from year 2006, thereby indicating that the benefits will begin to accrue from 2006.

Savings in Vehicle Operating Cost

With the implementation of the OCH project there will be a significant saving in the distance traveled per vehicle. In addition, vehicles will be able to travel at a relatively higher speed with a smooth flow thereby reducing engine operating and fuel consumption costs.

The total annual running distance by vehicle type under the 'with' project and 'without' project scenario is reflected in the table below.

Table 9.2[c] Total Annual Running Distance by Vehicle Type

Unit: Millions of vehicle km/year

Year	Car		Motor Cycle		Bus		Taxi		Lorry	
	Without	With	Without	With	Without	With	Without	With	Without	With
1999	1,465	-	373	-	648	-	209	-	465	-
2006	3,068	3,016	699	689	804	799	280	278	832	827
2010	3,755	3,739	951	941	876	874	344	340	997	990
2020	5,759	5,606	1,574	1,544	1,239	1,255	541	530	1,475	1,433

Source: JICA Study Team

The saving in vehicle operating costs have been calculated based on the holding period of the vehicle and the running distance of the vehicle. The costs related to the holding period of the vehicle include opportunity cost of fund used for purchasing the vehicle, insurance cost, depreciation cost and administration cost. The costs related to the running distance comprise of fuel cost, oil cost, tire cost, maintenance and depreciation costs. The average vehicle cost per annum for each vehicle type is given in Table 9.2 [d] below.

Table 9.2[d] Vehicle Operating Cost

Vehicle Type	VOC per annum (Rs.)	VOC per 100 km operation (Rs. /100 km)	Total VOC per km (Rs./km)
Car (Petrol)	184,250	3,630	12.8
Motorcycle (Petrol)	12,210	680	1.9
Bus	693,430	5,590	13.3
Taxi (Petrol)	80,980	750	3.2
Van	389,430	3,160	16.2
Lorry	325,480	4,470	15.3

Source: JICA Study Team

With the development of the OCH project, the estimated saving in vehicle operating costs is anticipated to be around Rs. 751.6 million in year 2006 (the year when the benefits begin to accrue) and is expected to increase to Rs. 2,521.7 million by year 2020.

Saving in Passenger and Cargo Travel Time

With the OCH project, the traffic on existing roads will not be as congested as with the 'without' project scenario. It is envisaged that the vehicles using the OCH will travel at a higher speed than if the existing roads were used. The distance traveled per vehicle will also reduce significantly. There will be a saving in travel time on both the new and existing roads. This saving in travel time can be used more productively at work, home or other activities.

The total annual running time by vehicle type under the 'with' project and 'without' project scenario is given in Table 9.2[e] below.

Table 9.2[e] Total Annual Running Time by Vehicle Type

Unit: Millions of vehicle hours/year

Year	Car		Motor Cycle		Bus		Taxi		Lorry	
	Without	With	Without	With	Without	With	Without	With	Without	With
1999	41.8	-	11.2	-	18.0	-	6.3	-	12.7	-
2006	105.5	96.4	25.0	23.1	28.5	26.0	10.1	9.4	28.5	26.5
2010	133.4	121.7	35.4	32.2	32.3	28.9	13.0	11.8	36.1	33.0
2020	225.5	193.9	67.1	59.0	49.1	43.2	23.2	20.4	57.9	50.7

Source: JICA Study Team

The average number of passengers by vehicle type is:

Car:	1.69 (excluding driver)
Motorcycle:	1.3 (including driver)
Bus:	40.0 (excluding driver)
3-wheeler:	1.16 (excluding driver)
Van:	12.0 (excluding driver)

By applying the above time savings in vehicle running time, together with the vehicle occupancy figures, the savings in passenger travel time was estimated at Rs. 1,850.0 million in the year 2006, using the values of time below, which were derived by adjusting the values of time countered in the Economic Feasibility Study of Southern Highway using the Colombo consumer price index:

Passenger car:	Rs. 68	Motorcycle:	Rs. 41
Taxi	: Rs. 68	Bus	: Rs. 26

There will also be significant benefits from savings in vehicle cargo travel time, which is estimated at Rs. 79.7 million in year 2006. Table 9.2 [f] gives a summary of the savings in passenger and cargo travel time.

Table 9.2[f] Savings in Passenger and Cargo Travel Time

Year	Passenger Benefit (Rs. Million)	Cargo Benefit (Rs. Million)	Total (Rs. Million)
2006	1,770.3	79.7	1,850.0
2010	2404.1	108.2	2,517.3
2020	5,061.2	227.7	5,288.9

Reduced Level of Accidents

The main causes for increased road accidents are the congested traffic flow and driving patterns. Around 2 percent of the total deaths in Sri Lanka are caused by transport accidents. The proposed OCH project should have a positive impact on the number of road accidents as it will be safer and will ease the traffic flow on existing roads. The loss of human life although difficult to quantify, should not be ignored. The benefit from savings through reduction in accidents are quantified by estimating the savings in expenditure on medical treatment and other compensation costs due to the OCH project. The traffic accident cost per passenger by accident level is given in Table 9.2[g] below.

Table 9.2[g] Traffic Accident Cost per Passenger by Accident Level

Accident Type	Traffic Accident Cost (Rs./passenger)
Fatal	1,100,760
Grevious	572,860
Non-grevious	32,840
Damage only	45,690

Source: JICA Study Team's estimate based on RDA survey results

The savings associated with the reduction in accidents due to the OCH project is estimated to be around Rs. 75.9 million in year 2006 rising to Rs. 240 million in year 2020.

9.2.3 Results of Economic Cost Benefit Analysis

The cost components considered for the economic analysis include engineering and construction costs, operation and maintenance costs, and land acquisition, compensation and resettlement costs. The benefit stream includes benefits to users from savings in vehicle operating costs, saving in passenger and cargo travel time and reduced levels of accidents. The social rate of discount used is 12% and the project life is assumed to be 30 years including the construction phase. As stated above the user benefits have been calculated based on the net effect of the 'with' project and 'without' project scenarios. Three scenarios have been given based on an increase or decrease in the costs and benefit streams:

- Scenario 1 - the base case;
- Scenario 2 assumes a 30 percent reduction of the benefit to users; and
- Scenario 3 assumes a 40 percent reduction of the benefit to users as well as an increase of 15% in the engineering, construction and operation and maintenance

costs and a 15% increase in corridor width of 100m for land acquisition, compensation and resettlement costs (as per Section 6.15).

Table 9.2[h] Summary of Results of Economic Analysis

	Scenario 1	Scenario 2	Scenario 3
Economic Internal Rate of Return (EIRR)	18.87%	14.21%	11.54%
NPV at 12% Discount Rate (millions)	Rs. 7,713	Rs. 2,274	- Rs. 9,195
B/C Ratio @ 12% Discount Rate	1.7	1.2	0.5

The results indicate that the marginal benefits of the project are greater than the marginal costs of the project for Scenario 1 and 2, meaning that the project would be feasible under these conditions. In addition, the economic internal rate of return (EIRR) of 18.87% and 14.21% for these two scenarios is higher than the opportunity cost of capital of 12 percent, indicating that even with a decrease in benefits by up to 30% the project would remain feasible. On the other hand, the NPV of Scenario 3 is negative and its EIRR lower than 12%, meaning that an increase in costs by 15% coupled with a 40% decrease in benefits would make the project not feasible. With the construction of the OCH, there will be regional and local spin off effects on economic activity in the project area that will contribute significantly to the benefit stream. However, the traditional economic analysis does not take account for the externalities and environmental costs and benefits, which could lead, to misallocation of resources. Therefore, the next section attempts to incorporate the environmental issues associated with the OCH project in the benefit-cost analysis.

9.3 Environmental Benefit-Cost Analysis

Benefit-cost analysis aims to express all the costs and benefits of a project in monetary terms. Although the environment provides a range of functions for the general economy to operate effectively, most environmental goods and services are not valued at all in the market place, and hence not included in the conventional benefit-cost analysis. The extended benefit-cost analysis attempts to evaluate all environmental impacts of a project and assesses the viability of the project from both an economic and environmental perspective. In an extended benefit-cost analysis, where possible, the environmental consequences are quantified using various valuation techniques. In cases of market failure, as for most environmental goods, shadow prices and surrogate markets are used as these reflect the social opportunity cost of the goods. However, in some cases these environmental costs and benefits cannot be quantified, even through direct or indirect market techniques.

The base case taken for the project is the 'without project' alternative, the present scenario. The 'with project' alternative assesses the incremental environmental damage and benefits incurred to the surrounding environment as a result of the proposed OCH project.

The environmental costs and benefits associated with the proposed OCH project are given below.

9.3.1 Environmental Costs

The development of the OCH will give rise to several negative environmental impacts, which will affect the health and quality of life of the community in the project area. The environmental impacts will occur during both the construction and operation phases of the project. Implementing appropriate measures to mitigate the damage can help negate many of these environmental costs. The main environmental related costs of the project are:

- impacts during construction phase;
- noise pollution;
- loss of mineral resources; and
- loss of agricultural lands.

Impacts during Construction Phase

During the construction phase of the proposed OCH, there will be some adverse effects on the residents of the project area. The main environmental impacts associated with the construction activities are:

- noise pollution; and
- air pollution.

Noise pollution: The construction phase will involve use of heavy mechanical equipment, drilling, cutting of road etc. that can be quite noisy. Most of the road trace will go through rural areas where the current noise levels are very low. Therefore, the community living close to the road construction area may be adversely affected by the increase in noise levels during the construction phase.

The noise levels could be minimized if appropriate construction equipment that reduces the level of noise generated is used. Any nighttime construction work, which is noisy, should also be avoided. The increase in background noise level will have a negative impact on the community living within 100 meters of the construction activity.

Air pollution: The construction activities will have an adverse effect on the air pollution levels of the project study area. There will be an increase of dust emissions from earthworks and transportation of construction material. The vehicles traversing over unpaved road surfaces and increase in volume of construction related traffic will contribute significantly to the increased levels in particulate matter.

The increased air pollution levels will have a negative impact on the health of the community living by the proposed construction activity. The short-term effects of air pollution include respiratory problems, eye irritation, headaches and increased exhaustion. People with asthma will be particularly sensitive to increases in the level of air pollution.

The human capital approach has been used to value the impact of air and noise pollution during the construction phase. It is assumed that the change in environmental quality causes illness that has negative short term effects. In order to arrive at the overall costs of lost earnings the medical treatment costs are added on to the loss in earnings. The estimated value of loss of earnings and medical costs due to the deterioration of the environmental quality is a conservative estimate of the environmental damage to the community at risk. It was assumed that one in four persons living within the 100-meter corridor will be at risk to the increase in air and/or noise pollution. The table below gives the basis of calculating the loss of foregone earnings due to illness caused by environmental deterioration. The number of days lost from work is expected to be 4 days per annum at a daily wage rate of Rs. 125 (at market prices). The economic conversion factor 0.7535 has been used to determine the economic price of labour, which is Rs. 94 per day. This estimate has been used below to calculate the loss of foregone earnings of Rs. 725,244 per annum. The cost of medical treatment includes costs related to visit to doctor or health care centre and medication. The cost of medical treatment is estimated at Rs. 577,500 per annum, based on the average number of 3 visits per annum to a doctor or health care centre and the cost of Rs. 100 per visit for medication and doctor's fees.

The total economic loss is estimated at Rs. 1.30 Mn per annum. Since the impact from noise and air pollution is a short-term effect the capitalised value has been taken over the construction phase of the project. Therefore, the total economic loss over the life of the project is Rs. 7.65 Mn.

Table: 9.3[a] Estimation of Loss of Forgone Earnings

Population along 100 m wide corridor	7,700
Estimated percentage affected	25%
Estimated affected population	1,925
Cost of medical treatment per visit (Rs.)	100
No. of medical treatments per year	3
Total cost of medical treatment per year (Rs.) for affected population	577,500
No. of working days lost per year per person	4
Daily wage rate (Rs.) (at economic prices)*	94
Loss of earning (at economic prices) of affected population	725,244
Total annual economic cost of medical treatment and loss of earnings (Rs.)	*1,302,744*
Capitalised Value over the life of the project at 12% discount rate	7,650,392

* Daily wage rate at market prices is estimated at Rs. 125. The conversion factor of 0.7535 for price of labour was used to calculate the daily wage rate at economic prices.

Noise Pollution during Operations Phase

Noise levels are expected to increase during the operation phase of the proposed project, affecting residents living in close proximity to the project site. During the operation phase the main sources of transport related noise are engine exhaust systems, tyre-road interaction, use of horns and vibrations generated by the running of the vehicle. Noise from road transport activity can cause hearing loss, annoyance, disturbance of sleep, disruption of educational and other activities.

One way of valuing the increased levels of noise pollution is the property value approach. Evidence of studies carried out in other countries indicate that noise from road transport activities have a negative impact on property values. However, the socio-economic survey carried out for this study reveals that the respondents are of the view that the development of the road may have a positive impact on property values of the project area. That is the marginal benefits of the road development may be greater than the marginal cost of increased noise pollution from transport activities.

Various preventive measures can reduce the amount of noise that reaches a site. Noise will be significantly reduced if houses are constructed a reasonable distance from roads. For example, doubling the distance from roads can reduce the average noise levels by 3-4 dB(A). The type of road surface will also affect noise levels. Sound barriers, natural vegetation and mounds may also be used to mitigate any increase in noise levels.

The preferred route of the OCH will be designed to deviate from any noise sensitive areas thereby minimizing any impact from noise on the surrounding environment and reducing any costs associated with increased noise pollution during the operation phase. As a result the cost of noise mitigation is not included in this analysis.

Loss of Mineral Resources

The project will require a significant amount of sand, metal and general fill material for the construction of the road. The environmental cost of blasting quarry and dredging riverbeds is high, as the process is irreversible. However, this cost can be minimized considerably if the project uses the earthfill and metal that will either be excavated from the project site or from already operating quarries, rather than depleting an unutilized natural resource and creating a void space. This will also reduce the economic cost of obtaining metal, as it will minimize the transportation and administration costs.

The externality effects and irreversible effects of increased demand for mineral resources are difficult to quantify. However, the impact on current and future generations is expected to be high if new sites are exploited.

Loss of Agricultural Lands

The acquisition of land for the project will negatively impact on the agricultural production of crops harvested in the project area. The productivity approach was used to calculate the loss of agricultural crops due to the development of the OCH project. The main agricultural crops to be affected by the project are rubber, coconut and paddy. Home and market gardens also account for a significant proportion of the affected land

area. The land use survey estimates that approximately 291 Ha. of agricultural land including home and market gardens will be obtained for the project.

The annual net return of the agricultural produce was estimated by multiplying the average yield by the net market value of the crop. For coconut, rubber and paddy the national average yields were used to calculate the total production per annum. Section 6.15 gives a more detailed analysis of the loss of production. The estimated loss of production of rubber, coconut and paddy are summarized in Table 9.3[b].

Table 9.3[b] Summary of Loss of Production from Rubber, Coconut and Paddy

	Rubber	Coconut	Paddy	Total
Total area (Ha.)	39.65	22.35	95.25	157.25
Yield	768 kg/Ha.	5,801 nuts/Ha.	3,636 kg/Ha.	
Annual Production	30,451 kg	162,065 nuts	415,595 kg	
Cost of Production	Rs. 44.41per kg	Rs. 2.40 per nut	Rs. 10.32 per kg	
Market Price	Rs. 49.76 per kg	Rs. 11.17 per nut	Rs. 12.40 per kg	
Conversion Factor	1.294	1.100	0.697	
Total Annual Economic Return	**Rs. 210,811**	*Rs. 1,250,756*	**Rs. 602,513**	*Rs. 2,064,080*

Home gardens and market gardens account for 44 percent (133 Ha.) of the agricultural lands to be acquired by the project. Although, it is difficult to estimate agricultural earnings from home gardens and market gardens, it is assumed that the cost of production for home gardens is Rs. 1,500 per Ha. In the case of market gardens, it is assumed that the cropping intensity is higher than at home gardens and therefore, the net return are estimated at Rs. 1,700 per quarter per Ha. The total loss of production from home and market gardens is summarized in the table below.

Table 9.3[c] Loss of Production from Home Gardens and Market Gardens

	Home Gardens	Market Gardens	Total Gardens (Home and Market)
Total area (ha)	116.30	17.20	133.50
Net income per annum per Ha.	Rs. 6,000	Rs. 7,000	
Conversion Factor	0.87	0.87	
Total Annual Economic Return	*Rs. 607,086*	*Rs. 104,748*	*Rs. 711,834*

Therefore, the total loss of production from rubber, coconut, paddy, home gardens and market gardens is estimated at Rs. 2.7 Mn per annum.

9.3.2 Environmental Benefits

The project will have incremental benefits to the population, mainly in relation to air pollution reduction.

Reduced Air Pollution Levels

During the construction period the community living close to the proposed road construction site will be affected by increase dust levels from site clearance, movement of heavy vehicles and other construction activities. The air pollution costs associated with the construction phase have been estimated in Section 9.3.1.1 above. In the long run, however, the impact of air pollution may decrease due to the OCH project. The congestion in the existing roads are expected to reduce thereby reducing the concentration of the emission levels at a particular place. Overall, the project is expected to benefit from the reduction in air pollution levels.

The benefit of air pollution reduction was assessed using the cost of installation of exhaust reduction equipment based on vehicle type. It was assumed that the ratio of vehicles with exhaust reduction equipment to total number of vehicles to be imported will increase by 5 percent per annum, and the emission volume from vehicles which install the equipment satisfy the Sri Lankan air pollution standards by vehicle type. The installation cost of the exhaust reduction equipment during the life time of the vehicle is estimated at Rs. 13,760 for car, bus, taxi, van and lorry whilst the cost is Rs. 6,880 for a motorcycle. The emission volume by pollutant and vehicle typ per 1 km running distance is given in Table 9.3[d] below.

Table 9.3[d] Emission Factors

	Fuel type	Nox	CO	SPM
Motorcycle	Petrol	0.25	26	0.1
Three-wheelers	Petrol	0.65	30	0.3
Car	Petrol	1.4	32.5	0.05
Mini Bus	Diesel	4.6	1.5	0.8
Bus	Diesel	7.8	2.1	1.5
Truck	Diesel	4.2	1.5	0.8
Large Truck	Diesel	7.8	2.1	1.5

Source: National Building Research Organization, January 1999

The benefit of reduction in air pollution levels is estimated over a 14-year period and decreases over time. The total discounted economic benefit of air pollution reduction over the 14-year period is approximately Rs. 397.4 million.

9.3.3 Conclusion

As per Section 9.2, the following three scenarios were applied to the cost and benefit stream:

- Scenario 1 – base case;
- Scenario 2 assumes a 30 percent reduction in benefits to users, as well as and a 40 percent reduction in environmental benefits; and
- Scenario 3 assumes a 40 percent reduction in benefits to users, 50 percent increase in environmental costs as well as an increase of 15 percent of the engineering, construction and operation and maintenance costs and increase in corridor width of 100m for land acquisition, compensation and resettlement costs (as per Section 6.15).

Table 9.3[e] Summary of Results of Environmental Economic Analysis

	Scenario 1	Scenario 2	Scenario 3
Economic Internal Rate of Return (EIRR)	18.87 %	14.20 %	11.53 %
NPV (million) at 12% Discount Rate	Rs. 7,713	Rs. 2,274	Rs. –1,013

The results once again indicate that the project is feasible even after accounting for a greater reduction in environmental benefits as compared to other benefits, as long as the combination of very high reductions in benefits and very high increases in costs as in Scenario 3 does not occur. Environmental benefits are mainly due to benefits from reductions in air pollution levels. Except the worst case scenario, whose EIRR is 11.54 %, which is lower than the 12 % opportunity cost of capital, the other two scenarios have been found to be feasible. However, it should be noted that irreversible environmental costs relating to the loss of mineral resources are difficult to quantify and have not been included in this analysis. These costs could be very high and measures should be taken not to deplete these resources.

10. INSTITUTIONAL REQUIREMENTS AND ENVIRONMENTAL MONITORING PROGRAMME

10.1 Environmental Monitoring

The Environmental Monitoring Plan given below is to ensure that the mitigation measures for adverse impacts are implemented and assess residual and unforeseen impacts.

The mitigatory measures recommended in this report includes measures to mitigate adverse impacts of the following aspects:

- Social aspects-especially relocation of affected communities;
- Physical aspects- especially drainage and mineral extraction;
- Biological aspects-wetland ecology in particular.

10.2 Institutional Requirements

Since the mitigation measures encompass many fields of expertise it would be necessary to establish a Project Monitoring Committee. RDA Resettlement Plan for Southern Expressway Project –July 1999 on resettlement plan suggests that RDA with an experienced independent agency will monitor the process of resettlement process. The services of an experienced an independent consultant to assist the RDA is also suggested in this report.

While agreeing completely with the RDA suggestion on monitoring, the EIA team strongly recommend that local agencies as the Divisional Secretariat, GN, Pradeshiya Sabha, and local community based organization or non governmental organization should be included in the monitoring process.

For close collaboration between the RDA, independent consultant and the personnel of local agencies a monitoring committee system is proposed. Further, these committees can be established in each Divisional Secretary's division within the project area.

The Project Monitoring Committee (PMC), therefore, will consist of representatives of the RDA and the local agencies and organizations suggested above and an independent consultant with expertise not only on resettlement but also on each of the other environmental aspects where potentially significant adverse impacts have been identified.

These DS division committees should meet at least once in three months in each DS division should meet and review the progress of implementing monitoring plan and assess the success of mitigatory measures. The committee should have necessary authority to instruct the contractor to abide by the environmental safeguards included in the contract documents and advice the planning engineers of the project.

10.3 Flood Levels

The flood levels should be monitored at strategic locations in Kalu Ela, Kelani Ganga and Bolgoda Basins after establishing baseline data.

Irrigation Schemes

A detailed inventory should be prepared of all irrigation schemes affected by the OCH to serve as baseline data. Data should include:

- Name of Scheme
- Location of Headworks
- Extent Cultivated
-
    - Maha
    - Yala
- Extent lost due to OCH
- Nature of Modification
- Necessary to Restore Scheme
- G N Division
- D S Division
- Relevant No. and Names of Shareholders
    - Before OCH
    - After OCH
- Sub Catchment No.

Development of Low Lying Areas

Baseline data should be established by surveying Low Lying Areas within each sub catchment.

Based on environmental and technical considerations a land allocation programme for each sub catchment should be prepared and land allocation after construction of OCH should be monitored.

The monitoring results would be evaluated by the PMC and necessary recommendations made

10.4 Air and Water Quality and Noise Levels

Air quality and noise levels should be monitored every month during construction and once in three months during the first year of the operational phase. Water quality of surface water bodies should be monitored every other month during the construction phase and once in four months during the first year of operation. The parameters to be

monitored are as given in the monitoring results in this report. Frequency of monitoring air quality, noise levels and water quality after the first year can be determined after evaluation of the monitoring results.

The RDA can engage NBRO to carry out the monitoring and the results could be evaluated in comparison with the background levels given in this report.

The evaluation results will be interpreted by the PMC and necessary recommendations will be made

10.5 Biological Aspects

The PMC should monitor whether the project is implemented in accordance with the recommendations made in the section on mitigatory measures for biological aspects, during pre-construction, construction and operational phases.

The PMC should assign the relevant provincial Environmental Officer to ensure that proper disposal of solid waste is carried out. He should submit a biweekly report to the monitoring committee.

PMC members should frequently visit the project sites to ensure that machinery are properly maintained and construction material are properly managed in order to prevent pollution of the surrounding terrestrial and aquatic environments by oil, asphalt, cement etc.

The PMC should also ensure that grass and trees are planted on either side of the embankment in marshy areas in time in order to control erosion. Monitoring committee should also ensure that plantation of trees on the road side in other areas is carried out without delay.

The PMC, with the help of relevant authorities should ensure that the industrial, residential and agricultural activities are not spread into the Buffer zone and conservation zones of the Muthurajawela marsh. Further, the PMC should also ensure that the marshy areas on either side of the highway are not reclaimed, encroached or used as dumping sites of solid waste.

If there is no alternative to use sea sand, monitoring committee should ensure that this sand is obtained from the deposits in the seabed and used after proper desalination.

The PMC committee should ensure that no organochlorine weedicides are used and that the weedicides are not applied during the rain.

The committee should also ensure that proper sanitary facilities for the labour force and proper sewerage disposal facilities for resettlement schemes are provided.

11. CONCLUSIONS AND RECOMMENDATIONS

The most critically affected environment in the OCH project is socio-economic environment, which has been established over a long period of time. Nearly 1680 households will be negatively affected. In addition long term operating business and industrial places, too, will be affected. If the current trace for the OCH is selected most of these households and business/industrial establishments will have to be evacuated. In addition several schools, religious places also will be negatively affected. Evacuation of all these properties will lead to social unrest in the area. In additions some lands will also be affected in different ways.

The state of affairs mentioned above indicate the nature of challenge that will be faced by the project planners and the developers of OCH in future.

A carefully planned strategy is needed to deal with the problems and solve them in the hostile environment. The RDA should conduct a comprehensive and professionally sound social marketing program to win the confidence of losers due to proposed OCH project. Participatory approach is suggested to deal with all these problems. Forceful attempts to evacuate people will create social, political and other problems and also it will not be acceptable to the donor agencies and in general it would work against the concept of development. Therefore, a comprehensive participatory approach, which will integrate all the stakeholders in harmonious manner in project activities, should be applied. The project planners and developers should work collaboratively with local government agencies such as the divisional secretariat, Grama Niladhari and the Pradeshiya Sabha.

The OCH is a development necessity of the country and its benefits, environmental and economic, are significant. If the present trace is adopted adverse environmental and social impacts have been predicted. If the Project Planners take into consideration the environmentally acceptable trace it would minimize the potential environmental as well as social impacts. Thus, it is recommended that the OCH be implemented taking into consideration the environmentally acceptable trace and implementing all the recommended mitigation measures and monitoring plan.

An appropriate trace, in terms of environmental viewpoint, is shown in a map in the Volume II.

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VOLUME II

FIGURES, TABLES, MAPS

CONTENTS

DATA ON HYDROLOGY

CLIMATOLOGICAL TABLE OF OBSERVATORIES IN SRI LANKA

STATION: KATUNAYAKE Lat: 07 10'N Long:79 53' E Anemometer: 20ft I = 08.30 SLST. II = 1730 SLST.

Month		Mean Sea Level Pressure mb.	Dry bulb temp C	Relative humidity %	Mean daily max. temp. C	Mean daily min. tem. C	Highest max. temp. recorded C	Lowest min. temp. recorded. C	Mean wind speed at hour kmph	Mean daily wind speed kmph	Prevailing Wind Direction	Monthly rain fall mm	Number of rainy days	rainfall driest month mm	Rainfall wettest month mm	Heaviest rainfall in 24 hrs mm	No. of hrs. of sun shine per day	Cloudiness (Oct-as)
January	II	1012.8	26.3	78	31.4	21.6	34.9	15.6	12		NE	55.4	6	0	175.8	93.5		3.8
	II	1009.2	28	63			1973,29	1975,13	15.2		N			1974	1963	1961,16		4.8
February	I	1012.3	26.8	79	32.2	21.8	37.2	16.8	8.2		NE	76.7	6	0	286.5	88.9		3.4
	II	1008.6	28.7	64			1974,20	1972,25	15		N			1972	1963	1963,6		4.5
March	I	1011.9	26.2	80	32.3	23	37.1	17.9	4.5		Var.	126.7	10	15.2	220.7	108.2		3.2
	II	1008.5	28.9	69			1973,60	1961,1	14.1		W			1965	1961	1963,23		4.8
April	I	1010.6	27.3	80	32.1	23.9	35.6	20.6	4.6		Var.	283.5	16	86.6	628.9	1443,00		4.5
	II	1007.5	28.8	72			1967,20	1963,23	13.2		WSW			1967	1970	1961,22		5.9
May	I	1009.5	27.6	81	31.1	25	33.7	19.7	11.4		SW	327.2	20	109.2	715.8	259.8		6.2
	II	1007	28.4	76			1973,20	1963,25	15.7		SW			1960	1963	1963,24		6.5
June	I	1010	27.4	80	30.3	25.1	32.7	22.0	15		SW	176.8	18	61.5	265.7	119.1		6.1
	II	1007.9	27.8	76			1972,16	1967,23	16.6		SW			1965	1971	1962,25		6.4
July	I	1010	27.8	80	30.1	24.8	32.2	20.8	12.9		SW	127.8	14	22.4	409.7	62.7		6.4
	II	1007.9	27.4	76			1973,11	1962,8	15.6		SW			1965	1960	1968,4		6.6
August	I	1010.4	27	79	30.2	24.8	32.8	21.7	15.6		SW	115.6	13	6.1	398.5	143		6.2
	II	1008	27.4	75			1972,10	1969,27	16.1		SW			1970	1962	1965,10		6.5
September	I	1011.1	26.8	80	30.3	24.2	33.2	21.3	12.9		SW	254.1	18	23.6	475.2	78.8		6.1
	II	1008.3	27.3	75			1971,11	1961,17	16.3		SW			1960	1966	1966,21		6.6
October	I	1011.5	25.4	81	30.1	23.6	33	19.5	8.2		Var.	424.2	21	69.8	767.3	179.3		5.6
	II	1008.7	27.0	76			1973,15	1967,27	12.7		SW			1974	1969	1967,19		6.5
November	I	1012.1	24.8	80	30.8	22.7	34	17.4	6.6		NE	280.9	15	9.9	561.3	210.3		4.3
	II	1009.1	27.2	73			1968,24	1972,21	10.6		Var.			1971	1963	1963,27		6
December	I	1012.3	25.0	79	30.6	22.3	33.7	16.6	11.1		NE	155.4	12	26.4	349.5	160.3		4.7
	II	1009.1	[illegible]	70			1972,25	1975,3	11.6		N			1960	1969	1969,30		5.9
Annual	I	1011.2	26.9	79	31.0	23.6	37.2	15.6	10.2		-	2400.60	17	1880.6	4099.1	259.8		5.1
	II	1008.3	27.8	72					14.4					1971	1963			5.9
Period of data (yrs.)		15	15	15	15	15	15	15	15		10	15	15	15	15	15		15

Source: Department of Meterology - Climate Branch

Table 5.1.1 (A)

CLIMATOLOGICAL TABLE OF OBSERVATORIES IN SRI LANKA

STATION: COLOMBO Lat:6 54'N Long:79 52' E Anemometer: 20ft. I = 08.30 SLST. II = 1730 SLST.

Month		Mean Sea Level Pressure mb.	Dry bulb temp C	Relative humidity %	Mean daily max. temp. C	Mean daily min. tem. C	Highest max. temp. recorded C	Lowest min. temp. recorded C	Mean wind speed at hour kmph	Mean daily wind speed kmph	Prevailing Wind Direction	Monthly rain fall mm	Number of rainy days	rainfall driest month mm	Rainfall wettest month mm	Heaviest rainfall in 24 hrs. mm	No. of hrs. sun shine per day	Cloudiness (Oct-as)	Number of days of thunder	Number of days of fog.
January	I	1,013.0	24.5	81.0	30.3	22.2	34.4	15.2	8.7	9.0	NE	87.9	8.0	0	310.4	124.7	7.5	4.3	3.0	0.1
	II	1,009.2	27.6	70.0			1932,25	1950,40	11.9		N			1932 & 1974	1934	1969,13		5.4		
February	I	1,012.7	24.9	82.0	30.6	22.3	36.2	16	6.6	7.6	NE	96.0	7.0	0	269.2	132.6	8.2	3.9	3.0	0.0
	II	1,009.0	28.1	72.0			1915,23	1949,15	11.1		NW			1972	1950	1913,28		5		
March	I	1,012.1	26.4	83.0	31.0	23.2	36.1	17.7	15.3	7	E	117.6	11	4.3	286.8	126.5	8.8	3.4	11.0	0.0
	II	1,008.4	28.8	72.0			1973.6	1961,10	9.7		W			1957	1924	1966,25		5.2		
April	I	1,011.2	27.3	84.0	31.1	24.3	35.3	21	5.3	7	E	259.8	18	18.5	657.1	210.1	7.9	5.0	19.0	0.1
	II	1,007.8	29.1	74			1922,5	1916,16 1943,21	8.5		SW			1911	1953	1949,17		6.5		
May	I	1,009.9	27.8	83.0	30.6	25.3	33.8	20.6	8.4	10.0	SW	352.6	23.0	20.1	858.8	289.6	6.2	6.4	9.0	
	II	1,007.1	28.7	78.0			1911,14&15	1923,10	10.1		SW			1953	1936	1936,18		6.7		0.0
June	I	1,010.3	27.5	82.0	29.6	25.2	33	21.4	9.8	10.8	SW	211.6	22.0	38.1	482.8	134.7	6.6	6.6	2.0	
	II	1,007.9	28.0	78.0			1915,4	1912,50	10.9		SW			1921	1912	1902,19		6.8		0.0
July	I	1,010.5	26.9	82.0	29.0	24.9	31.7	21.2	8.9	10.0	WSW	139.7	15.0	7.1	528.8	191.3	6.1	6.5	1.0	
	II	1,006.2	27.6	78			1911,22 1916,14	1916,18	10.0		SW SW			1952	1953	1960,17		6.8		0.1
August	I	1,010.7	27.1	81.0	29.4	25.0	32.3	21	9.7	10.5	SW	123.7	15.0	3.3	435.1	126	6.5	6.4	2.0	
	II	1,008.1	27.6	77.0			1911,17	1923,10	10.8		SW			1951	1962	1932,20		6.7		0.1
September	I	1,011.5	26.9	81.0	29.6	24.7	32.6	21.8	8.7	10.0	SW	153.4	17.0	17.8	551.2	155.4	6.4	6.2	2.0	
	II	1,008.5	27.5	77.0			1911,2	1961,28	10.3		SW			1957	1966	1937,28		6.7		0.0
October	I	1,012.0	26.5	83.0	29.4	23.8	32.7	20.2	6.8	8.0	Calm	354.1	21.0	82.6	847.9	215.9	6.2	6.1	8.0	
	II	1,008.8	27.2	78.0			1911,29	1923,21	8.7		SW			1916	1930	1932,27		6.8		0.1
November	I	1,012.1	25.1	83.0	29.6	22.9	33.5	17.8	6.1	6.9	NE	324.4	19.0	56	640.3	210.3	6.8	5.0	10.0	
	II	1,008.8	27.1	77.0			1913,9	1912,13	8.0		NW			1908	1925	1934,7		6.5		0.1
December	I	1,012.6	25.1	81.0	29.8	22.4	33.5	17.3	5.2	8.5	NE	174.8	12.0	6.9	547.1	117.9	6.9	4.3	8.0	
	II	1,009.1	27.1	74.0			1921,13	1939,7	10.3		N			1930	1957	1969,27		6.0		0.1
Annual	I	1,011.6	26.4	82.0	30.0	23.9	36.2	15.2	7.7	8.9	-	2,395.6	188.0	1360.4	3933.7	289.6	7.0	5.4	80.0	
	II	1,008.4	27.9	75.0					10.0		-			1921	1963			6.3		0.7
Period of data (yrs.)		30.0	23.0	23.0	30.0	30.0	63	63	25.0	30.0	10.0	50.0	30.0	68.0	68.0	83.0	25.0	23.0	10.0	10.0

Source: Department of Meteorology - Climate Branch

Table 5.1.1 (B)

CLIMATOLOGICAL TABLE OF OBSERVATORIES IN SRI LANKA

STATION: RATMALANA Lat:6 49'N Long:79 58' E Anemometer: 20ft. I = 08.30 SLST. II = 1730 SLST.

Month		Mean Sea Level Pressure mb.	Dry bulb temp C	Relative humidity %	Mean daily max. temp. C	Mean daily min. temp. C	Highest max. temp. recorded C	Lowest min. temp. recorded C	Mean wind speed at hour kmph	Mean daily wind speed kmph	Prevailing Wind Direction	Monthly rain fall mm	Number of rainy days	rainfall driest month mm	Rainfall wettest month mm	Heaviest rainfall in 24 hrs. mm	No. of hrs. of sun shine per day	Cloudiness (Oct-as)	Number of days of thunder	Number of days of fog.
January	I	1012.9	24.2	80	30.7	21.8	33.8	14.4	9.2	8.7	NE	78.7	8	0	333.5	173.5		4.1	6	2
	II	1009.4	27.7	66			1965,29	1950,40	13.8		NW			4 yrs.	1948	1966,11		5.6		
February	I	1012.4	24.7	81	30.8	22.2	35.7	16.1	6.1	7.2	NE	94.7	8	1.3	269	133.6		3.9	8	4
	II	1,009.0	28.2	68			1950,13	1949,13	13.2		NW			1972	1950	1938,80		5.1		
March	I	1,012.0	26.2	81	31.4	23.2	35.7	18.1	4	6.4	Var.	142.2	12	16.5	460.8	130		3.4	16	4
	II	1,009.8	28.9	68			1938,70	1961,10	10.8		W			1957	1954	1954,13		5.2		
April	I	1,010.9	27.2	80	31.6	24.1	33.4	20.1	4.3	6	Var.	281	18	69.3	680	242.1		4.9	24	0
	II	1,007.9	29.0	71			1967,90	1974,18	8.7		W			1967	1974	1949,14		6.4		
May	I	1,009.2	27.8	80	30.9	25.9	33.3	20.9	8.7	7.8	W	388.4	22	129.4	959.4	412.5		6.2	15	0
	II	1,008.1	28.7	74			1973,20	1971,20	10.8		SW			1953	1936	1936?13		6.3		
June	I	1,010.3	27.6	79	30.2	25.6	32.3	21.6	11.6	8.7	WSW	207.9	21	43.7	420.6	167.6		6.4	6	0
	II	1,008.2	28.1	75			1972,50	1975,16	12.1		WSW			1938	1945	1962,25		6.6		
July	I	1,010.3	26.9	80	29.8	24.8	31.3	21.4	10.3	8.4	W	187.5	16	8.1	567.4	161		6.4	4	0
	II	1,008.2	27.7	75			1963,28	1975,26	12.2		W			1952	1953	1951,11		6.7		
August	I	1,010.3	26.8	78	29.8	25.1	31.8	21.4	11.8	8.7	SW	107.5	14	2.8	3986.6	104.1		6.3	3	0
	II	1,008.2	27.7	74			1964,25	1963,11	12.6		SW			1951	1962	1965,90		6.6		
								1974,16												
September	I	1,011.3	26.9	79	29.9	24.6	31.8	21.1	10.5	8.0	SW	224.8	19	8.9	635.3	149.9		6	6	0
	II	1,008.5	27.6	75			1951,23	1952,30	11.9		SW			1957	1963	1937,28		6.5		
October	I	1,011.8	26.5	81	29.8	23.9	32.3	20.6	7.9	7.2	Var.	375.2	22	97.8	677.4	279.1		6	12	4
	II	1,009.0	27.3	75			1947,31	1974,20	10		SW			1938	1945	1969,12		6.7		
November	I	1,011.4	25.8	81	30.2	22.9	33.2	18.3	6.1	7.0	NE	336.0	18.0	61.2	674.4	161		4.8	14.0	3.0
	II	1,009.4	27.2	74			1972,30	1972,21	9.8		NW			1971	1957	1951,11		6.5		
December	I	1,012.1	24.9	80	30.4	22.3	33.6	17.3	9.3	8.3	NE	196.1	13.0	18.8	563.1	162.1		4.4	10.0	1.0
	II	1,009.5	27.1	72			1972,14	1973,30	10.6		NW			1960	1957	1946,24		6.2		
Annual	I	1,011.3	26.3	80	30.5	23.9	33.7	14.4	8.3	7.7				1,891.3	3792	279.1		5.2	123.0	15.0
	II	1,008.6	27.9	72					11.4					1938	1963			6.2		
Period of data (yrs.)		25	25	25	25	25	25	25	25	15	25	25	25	43	40	40		25	10	10

Source: Department of Meteorology-Climate Branch

Table 5.1. 1 (C)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTEL
COLOMBO (mm)	99.0	101.0	124.0	102.0	120.0	99.0	120.0	108.0	99.0	102.0	93.0	93.0	1242.0
BOMBUWALA (mm)	82.0	97.0	110.0	97.0	93.0	84.0	90.0	88.0	84.0	82.0	82.0	78.0	1067.0

Source: Dep. Meteorology, Irrigation Dep.

MEAN MONTHLY PAN EVAPORATION OBSERVED AT COLOMBO METEOROLOGY STATION AND BOMBUWELA AGRICULTURAL STATION

Table 5.1.1 (D)

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
GLENCOURSE (m^3/Sec.)	54.5	41.5	49.3	96.5	169.8	243.9	182.6	141.1	165.2	232.5	220.4	100.5

MEAN MONTHLY DISCHARGE AT GLENCOURSE (m^3/Sec.)

ource: Irrigation Department

Table 5.1.1 (E)

MEAN MONTHLY DISCHARGE ESTIMATED FOR BOLGODA GANGA BASIN

STATION	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	TOTAL
RATMALANA (mm)	335	294	118	65	67	107	224	346	206	118	131	266	2277
MILLEWA	443	369	252	111	115	249	367	511	347	231	256	358	3609
MEAN RAINFALL (mm)	389	331	185	88	91	178	296	428	277	175	194	311	2943
MEAN RAINFALL - MCM	147	125	70	33	34	67	112	162	105	66	73	118	1112
ESTIMATED RUNOFF - MCM	41	34	23	10	11	23	34	47	32	21	24	33	333

Table 5.1.1 (F)

PEAK FLOODS RECORDED IN KELANI GANGA AT HANWELLA

WATER YEAR	GAUGE HEIGHT IN METRES	FLOOD PEAK IN m^3/Sec.	MONTH & DATE
1973/74	7.45	2378.60	29-07-1974
1974/75	7.71	2619.28	24-05-1975
1975/76	6.61	1704.37	18-11-1975
1976/77	6.72	1776.92	03-08-1977
1977/78	6.89	1911.37	24-10-1977
1978/79	7.26	2217.19	25-11-1978
1979/80	4.25	679.92	11-11-1979
1980/81	6.67	1670.68	19-09-1981
1981/82	6.67	1737.22	10-06-1982
1982/83	5.14	928.78	29-11-1982
1983/84	7.12	2009.15	14-07-1984
1984/85	6.08	1401.39	28-06-1985
1985/86	5.81	1254.42	13-11-1985
1986/87	3.52	522.78	02-10-1986
1987/88	5.33	979.68	27-10-1987
1988/89	8.08	2745.58	05-08-1989
1989/90	4.03	668.00	02-11-1989
1990/91	4.69	1007.00	03-11-1990
1991/92	4.79	1076.00	06-06-1992
1992/93	5.36	1292.00	14-10-1992
1993/94	5.40	1172.40	09-10-1993
1994/95	3.47	764.00	08-05-1995
1995/96	5.25	1135.00	23-09-1996

METRIC GAUGE ZERO = 3.475m M.S.L.

Source: Irrigation Department

MAXIMUM 24 HOUR RAINFALL RECORDED AT COLOMBO IN EXCESS OF 150 m.m.

R/F mm

WATER YEAR	FLOOD LEVELS IN METRES
1907	160.7
1916	166.6
1916	164.1
1925	160.5
1926	231.6
1930	256.2
1932	264.9
1934	210.3
1937	153.4
1939	163.0
1947	179.3
1949	210.0
1951	161.3
1954	166.7
1960	191.2

YEAR	R/F m.m.
1962	238.5
1963	193.3
1964	190.5
1965	190.5
1967	182.6
1969	198.9
1974	179.80
1976	238.6
1977	227.0
1981	153.3
1982	154.7
1983	194.1
1987	161.2
1988	151.2
1992	493.0

Source: Irrigation Department

STATION KELANI BASIN	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
KENILWORTH	109.00	108.00	173.00	338.00	622.00	834.00	700.00	587.00	625.00	646.00	453.00	161.00
AVISSAWELLA	95.08	120.90	228.89	379.19	425.01	341.46	230.42	214.63	341.97	458.46	404.15	212.03

LONG TERM AVERAGE MONTHLY RAINFALL IN mm

Source: Irrigation Department

Table 5.1.1 (I)

HYDROLOGICAL PARAMETERS OF SUB CATCHMENTS INTERCEPTED BY PROPOSED OUTER CIRCULAR ROAD TO CITY OF COLOMBO

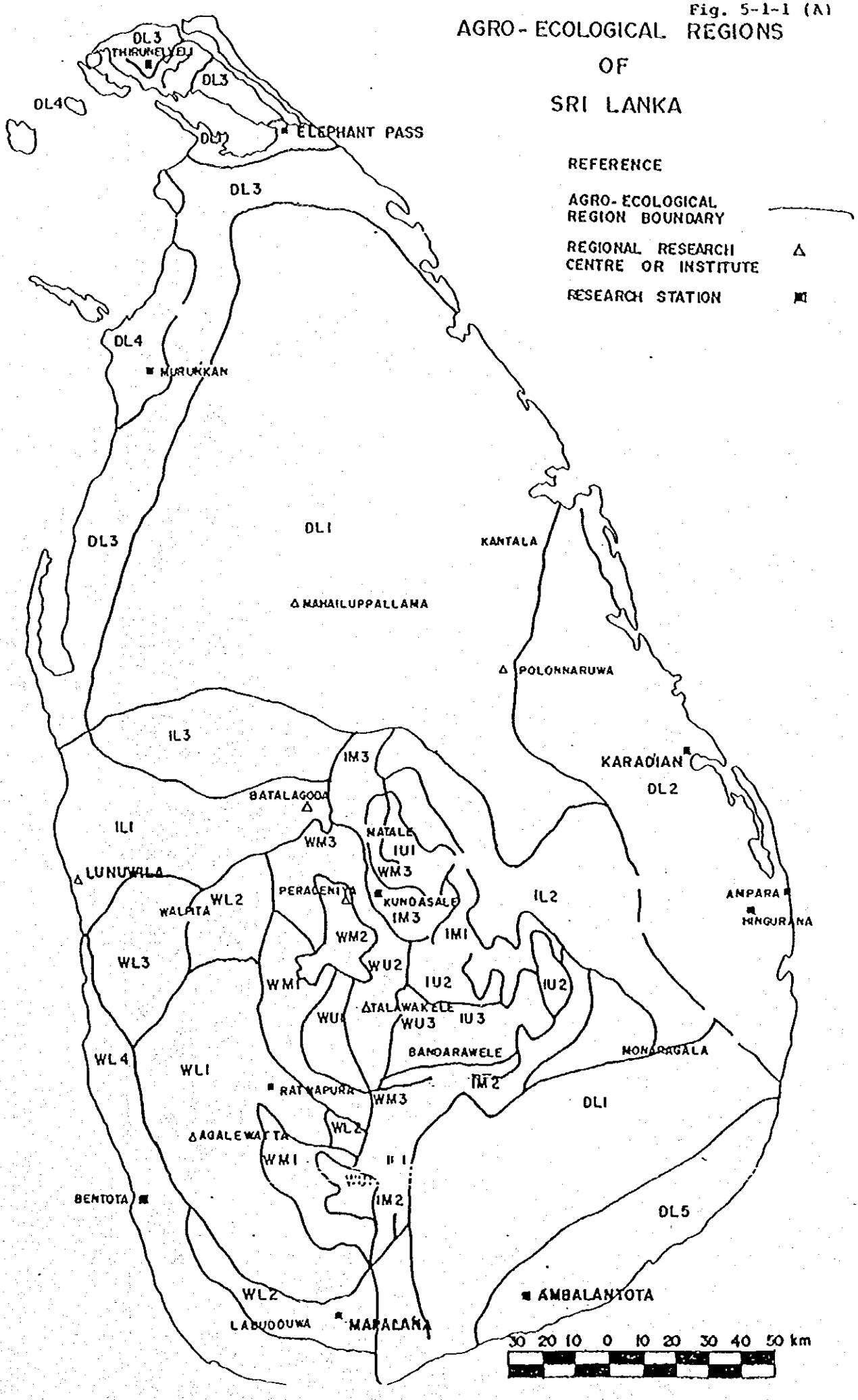
SUB CATCH NO.	DESCRIPTION OF SUB-CATCHMENT	CATCHMENT AREA		ESTIMATED PEAK FLOW - CUMECS			RETENTION AREAS		ESTIMATED FLOOD DETENTION CAPACITY MCM
		SQ. ML	SQ. KM	RETURN PERIOD 50 YRS	RETURN PERIOD 100 YRS	RETURN PERIOD 200 YRS	UPSTREAM %	DOWNSTREAM	
1	Kalu Ela Crossing - Northern Arm	4.391	11.372	21.70	23.90	25.60	30	Significant	3.40
2	Kalu Ela Sub Basin - Tributory	0.213	0.552	1.10	1.20	1.30	10	Significant	0.05
3	Kalu Ela Sub Basin - Tributory	1.252	3.243	6.20	6.80	7.30	15	Significant	0.49
4	Kalu Ela Sub Basin - Tributory	2.467	6.390	12.20	13.40	14.40	20	Significant	1.28
5	Kalu Ela Sub Basin - Minor Tributory	0.480	1.229	0.70	2.60	2.90	25	Significant	0.27
6	Kelani Ganga - Minor Tributory	0.141	0.365	3.00	114.50	0.80	25	Only Waterway	0.09
7	Kelani Ganga - Minor Tributory	0.600	1.553	1.60	3.40	3.50	25	Only Waterway	0.39
8	Kelani Ganga - Minor Tributory	0.320	0.828	2.40	1.80	1.90	25	Only Waterway	0.21
9	Kelani Ganga - Tributory	21.081	54.58	104.00	104.40	122.80	25	Only Waterway	12.45
10	Main Kelani Ganga Crossing	776.300	2009.800	3759.40	4060.60	4596.40	10	Kelani Ganga	187.00
11	Kelani Ganga Basin - Minor Tributory	0.504	1.305	2.52	2.94	3.36	15	Significant	0.05
12	Kelani Ganga Basin - Minor Tributory	0.190	0.492	0.90	1.00	1.10	35	Significant	0.14
13	Bolgoda Ganga Basin - Minor Tributory	0.960	2.485	4.30	4.30	5.30	25	Significant	0.06
14	Bolgoda Ganga Basin - Tributory	2.120	5.490	10.50	11.50	12.40	30	Significant	1.65
15	Bolgoda Ganga Basin - Tributory	2.500	6.475	12.30	13.50	14.50	35	Significant	2.27
16	Bolgoda Ganga Basin - Tributory	13.429	34.781	66.30	72.90	78.20	35	Significant	12.17
17	Bolgoda Catchment - Minor Tributory	7.24	18.75	35.70	39.30	42.20	30	Significant	5.63
18	Bolgoda Basin - Tributory	14.286	37.000	70.50	77.50	83.20	30	Significant	11.10
19	Bolgoda Ganga - Minor Tributory	0.519	1.344	2.60	2.90	3.10	20	Significant	0.27
20	Bolgoda Ganga - Minor Tributory	0.955	2.473	4.70	5.20	5.50	30	Significant	0.74
21	Bolgoda Ganga - Minor Tributory	1.802	4.667	8.90	9.80	10.50	30	Significant	1.40
22	Main Bolgoda Ganga - from South	48.962	126.812	190.60	209.60	224.90	35	Significant	44.38
23	Bolgoda Basin - Minor Tributory	0.961	2.489	4.70	5.20	5.50	20	Significant	0.50
24	Bolgoda Basin - Tributory	3.247	8.410	16.00	17.60	18.90	20	Significant	1.68
25	Bolgoda Ganga Basin - Minor Tributory	0.307	0.795	1.50	1.60	1.80	20	Significant	0.16
26	Bolgoda Ganga Basin - Minor Tributory	1.320	3.419	6.50	7.20	7.70	20	Significant	0.68

TOTAL AREA OF SUB-CATCHMENTS INTERCEPTED	906.547	2347.099

Table 5.1.1 (J)

Fig. 5-1-1 (A)

AGRO-ECOLOGICAL REGIONS OF SRI LANKA



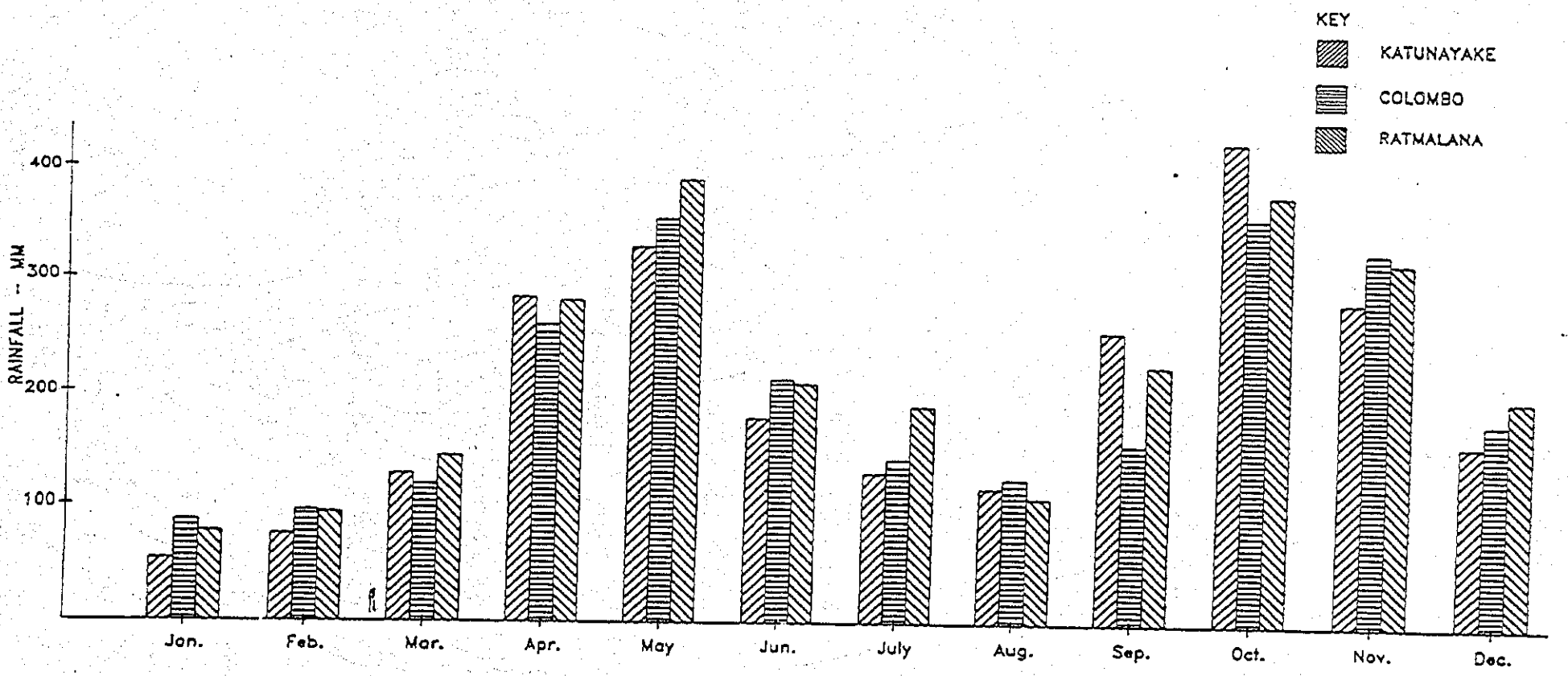

MEAN MONTHLY RAINFALL – KATUNAYAKE, COLOMBO & RATMALANA
KEY
KATUNAYAKE
COLOMBO
RATMALANA
RAINFALL - MM
400
300
200
100
Jan.
Feb.
Mar.
Apr.
May
Jun.
July
Aug.
Sep.
Oct.
Nov.
Dec.

Fig. 5-1-1(B)