Pre-Project Technical Assistance Study for Proposed Area Development Project of North Central Province

Prepared for RH&H Consult/ADB

by

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EXECUTIVE SUMMARY[1]

1. The government of Sri Lanka (GOSL) sought the support from the Asian Development Bank (ADB) for a program aimed at augmenting the economic development in the North Central Province (NCP) of Sri Lanka. The GOSL specifically sought the assistance of the ADB for a broad-based, multi-faceted area development programme to complement the Participatory Rural Development Project which is being prepared for the NCP under CIDA and IFAD assistance. In response to the GOSL's request, the ADB has agreed to provide a Pre-Project Technical Assistance (PPTA) to assist the Government in preparing a comprehensive development programme.

The scope of the proposed PPTA includes:

(a) A regional economic development study;
(b) A natural resources management study; and
(c) Preparation of a detail proposal for an Area Development project for Bank financing.

The two studies mentioned under (a), and (b) will be the basis for the project proposal mentioned under (c) above.

The GOSL and the ADB invited IIMI to conduct the Natural Resources Management (NRM) Study which included three key activity areas, namely:

i. Assessment of Land and Water Resources Potential of the NCP.
ii. Overview of past and present tank rehabilitation strategies.
iii. Institutional and organizational arrangements.

2. Even though large investments have gone in the development of land and water resources in the NCP, these investments were project and sector specific and were made without considering the land and water resources and their integrated development potential in a holistic manner. In addition, water is the limited resource in many parts of the NCP and the land is becoming a limiting resource due to increasing population pressure and environmental degradation. Hence, all facets of an area development project designed for the NCP should be based on land and water resources development as well as related agro-based rural industry and support services. In other words, an innovative approach to development which will look at the resource potential and ways and means of optimizing the production level with protection of resource base has become a necessity. In the face of rapidly growing open market economy in the country, the new area development strategy needs to focus on the ways and means of strengthening the managerial and enterprenurial capacity of the small farmer as well as the

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1 The executive summary appears as Chapter of the Report.

capacity of farmer organizations to overcome the market competitive forces to enhance their agricultural incomes.

3. In this context, the Natural Resources Management study proposes a development strategy focussing on watersheds, sub-watersheds and tank cascade systems as basic units of development, for adoption in the proposed ADB funded Area Development Project in the NCP. For example, the strategy outlines a cascade based farming system approach with integrated surface and groundwater development coupled with a management process aimed at striking a balance between production and conservation. Agro-based rural industry and related agro-infrastructural development are integral parts of this strategy. This approach is suggested on the basis of the concepts and experiences achieved through the implementation of the Shared Control of Natural Resources (SCOR) project in the Huruluwewa watershed (Upper Yan Oya River Basin) in the NCP and other institutional development programmes undertaken by the GOSL. It is to be noted that the suggested cascade and farming system approach is not only applicable to minor tank cascades in Anuradhapura but also in those areas in the Polonnaruwa Distrct where the major systems are interspersed with medium and minor tanks.

4. The proposed strategy includes selection of sub-watersheds and cascades for project intervention during the project period based on hydrological endowment and assessment of the land and water resource base including its present extent/quantities, quality status, and potential future use. This study conducted a basin-wise assessment of natural resources of the NCP as the basis for delineating hydrologically endowed sub-basins and cascades. The study suggests the possibility of transferring surplus water within and among the cascades. This suggestion is based on the analysis of existing water balance and a rough estimation of the magnitude of such diversions of excess water which may not exceed 5 percent of the total surface water run-off of the cascades. However, with detailed data collection, the effects and impacts of such water transfers on the medium and major tanks downstream and outside the cascades have to be studied in detail with a hydrological simulation model.

5. The study also recommends the integrated use of surface and groundwater within the cascades. This suggestion is based on the recharge potential of the cascades computed on the basis of limited data evaluated under the study. The study also recommends setting up of a hydrologic and hydrogeologic data collection and monitoring network for systematic surface and groundwater data collection and continuous monitoring of cascade and river basin hydrological and hydrogeological parameters. Such a network will be essential for developing a data base required for planning and management of cascades and river basins for land and water resources development as well as for economic development in the NCP.

6. An extensive review of the past and on-going minor, medium and major tanks rehabilitation projects was done and the lessons and experiences of those projects were captured. The review indicates that these projects were conducted on a piece-meal basis without considering the overall hydrology of the cascades, farming systems approach, conservation of the land and water resource base and farmers perceptions and knowledge. These projects were heavily focussed on structural improvements to irrigation systems at the expense of the development of

other income generating avenues available in and around irrigation tank systems such as chena cultivation, home gardening, agro-processing and other agro-based industries. Those physical rehabilitation intervention strategies adopted in the past led to the realization of benefits and impacts which were far less than the expectations. The effects and impacts of the past and ongoing rehabilitation programmes as reported in this study justify the adoption of the new approach and the associated investment strategy proposed here for land and water resources management in the GOSL/ADB Area Development Project.

7. The proposed approach for land and water resources management in this report deviates from this traditional approach. Unlike in the traditional approach, farmer beneficiaries have been consulted through participatory appraisal and mapping for selected cascades to capture their experiences, needs and suggestions to develop indicative plans for water resources development and management at cascade level. The study suggests validating and improving such indicative development plans through appropriate hydrological, technical and economic feasibility studies for cascades before implementation.

8. It is proposed that in order to adopt this area development strategy, the necessary resources and support for implementing appropriate interventions be provided by the project. Such interventions will include: water transfers within and among cascades, rehabilitation of small tanks and agrowell development to improve cropping intensities of the irrigated commands areas; conservation and production interventions for stabilization of chena, development of home gardens, stream and canal reservations; livestock production; value added processing and industries; market development; and credit and marketing support. In addition, the project will provide for complementary agro-infrastructural facilities and institutional arrangements such as deployment of catalysts and forming and strengthening farmers' organizations and farmer companies to carry out the designed interventions on a sustainable basis.

9. The report begins with an introduction and background to the study in Chapter 1. Chapter 2 of this report provides an account of the present status of Land and Water Resources base and use of the NCP. This chapter addresses the major river basins and their characteristics; present land use and related issues; present surface water use and ground water use; present water quality; and potential for further water resources development in the NCP.

10. Chapter 3 provides a detailed review of the past and on-going irrigation rehabilitation projects conducted in the NCP. It addresses the strengths, weaknesses as well as lessons that can be learnt from the previous and on-going irrigation rehabilitation strategies and approaches. In view of the gaps realized between the expectations of those irrigation rehabilitation programmes and the actual achievements, this study discourages the conventional "single tank rehabilitation" approach. Instead it recommends a cascade-based water resources development and area development approach in which cascade is considered the basic unit of planning water resources development and complementary area development interventions using a production and conservation oriented farming system approach.

11. Chapter 4 describes the process followed in carrying out cascade selection and evaluation, beginning from identification of a potential cascade and sub-basins for area development to the identification of specific proposals for water resources development interventions in a cascade. Having identified the water resource development proposals based on farmer's perceptions, the chapter suggests a methodology and a tool for validating farmer proposals both technically and hydrologically. In addition, this chapter provides descriptions of the cascade simulation model and the small tank inventory developed under this study. It is proposed that the suggested process be adotped in the actual implementation of the GOSL/ADB project.

12. Chapter 5 starts with a detailed account of the strategies adopted by the Shared Control of Natural Resources (SCOR) project which is the basis for the land and water resources development in a watershed context proposed to be adopted for the area development project. The rational for adopting a holistic resources development approach taking river basin/sub basins or cascades as basic units for integrated planning is clear. The cascade/watershed/river basin is a physical entity geographically defined by an important natural resources, water. The ways in which water is used in the upper parts of the watershed affect the ways in which it can be used in the downstream. The various parts of the watershed - upper catchments, water bodies, command areas, re-use areas including associated highlands - are linked in important ways, and the potential benefits from integrated use can be large. This chapter formulates an integrated approach to capture such benefits. In addition, it describes the strategies, rationale, norms and the assumptions used for cost benefit computations, details of the cost benefit computations and the institutional arrangements proposed for the implementation of the strategies. This chapter proposes a M&E strategy and special data collection and research studies as well.

13. Chapter 6 provides separate cost estimates for rehabilitating medium and major irrigation schemes in the NCP based on the consultations held with the Irrigation Department and the Mahaweli Authority of Sri Lanka. The proposals and priorities for rehabilitation of major and medium projects presented in Chapter 6 have been framed on the basis of the suggestions of the relevant irrigation agencies. However, based on previous **IIMI analyses (such as Kikuchi and Aluwihare, 1991), SCOR experience and the present benefit cost analysis, it is clear that the strategy proposed in Chapter 5 is more cost-effective than major rehabilitation efforts. The watershed/sub watersheds approach presented in Chapter 5 yields a B/C ratio of over 2 and an IRR close to 20%. The net returns could be even higher if environmental benefits are included.** Therefore, the technical feasibility and the economic viability of those proposals needs to be worked out before budgetary allocations and investments under the project are finalized.

14. The rationale for considering Anuradhapura district of the NCP separate from the Polonnaruwa district is primarily based on the two contrasting types of 'land systems' and water resources potential that characterizes each of these districts, as well as the contrasting nature of present land use and settlement patterns in the two districts. Anuradhapura district is endowed with a large number of well demarcated small tank cascades and small tanks, while a larger proportion of the developed lands in the Polonnaruwa district are served under the command of four major irrigation settlement schemes. The Polonnaruwa district differs from the Anuradhapura district in respect of the number and distribution small tank cascade systems.

15. Polonnaruwa district located within the Mahaweli basin is a water rich district with ten times more runoff potential than the Anuradhapura district which is a very water short district. Stream flow analysis indicates that the Mahaweli Ganga (part) produces the highest runoff 0.780 (MCM/sq.km), while the Malwathu Oya produces the least run-off of 0.040 MCM/sq.km. There is a substantial diversion of Mahaweli water into the NCP. In terms of water available for further development, the Mahaweli Ganga (Polonnaruwa segment) stands first, followed by Yan Oya, Kala Oya, Malwathu Oya, Ma Oya and Moderagam Ara. Almost all the surface water potential of the four basins (except Yan Oya) in the Anuradhapura district is utilized. The strategy should therefore be to maximize productivity per unit of land in the Polonnaruwa district, and maximize productivity per unit of water in the Anuradhapura district as priority concerns. However, this priority does not preclude the necessity to maximize productivity per unit of land in the Anuradhapura and productivity per unit of water in the Polonnaruwa district.

16. The five major river basins of the Anuradhapura district in decreasing order of size namely, Malwathu Oya, Kala Oya, Yan Oya, Ma Oya and Moderagam Ara have been demarcated on a set of maps together with their component sub-watersheds and the second, third and fourth order streams. In the Polonnaruwa district only the medium size river basins, namely the Amban Ganga, Minneriya Oya Kaudulla Oya, Ambagaha Oya and Kalu Ganga have been demarcated together with their drainage systems.

17. The least endowed area in terms of rainfall occurrence is the north-west part of the NCP. The present studies indicate a downward trend for the annual rainfall for most of the basins studied and a downward trend for the runoff rainfall ratios in both Amban Ganga and Yan Oya basins. The reasons for these downward trends need further investigations.

18. Necessary data sets for proper evaluation of the groundwater potential of the NCP is not available yet. The limited data available with the Water Resources Board has yet to be professionally analyzed. A first approximation of the groundwater balance with the available data reveals a net recharge of 7 percent of the annual rainfall or 95 mm per year. It is emphasized that the exploitation of groundwater through the use of agrowells should proceed with extreme caution because it can have adverse impacts on the environment. The study shows that command areas of irrigation tank offer a higher potential for agrowell development than the highland areas. The nature and occurrence of groundwater and its potential has been discussed in Chapter 2 of the report. A methodology has been presented for evaluating the groundwater potential and the safe number of agro wells within a cascade area in Chapter 4.

19. Water sampling and analysis was carried out in September 1995, at the end of the dry season, on 30 tanks, 15 streams, 14 drainage streams and 34 agro-wells in the NCP during the study period. According to USBR standards, water of all major tanks fall within Class 2, and waters of medium and small tanks within Class 3. The corresponding Sodium Adsorption Ratio (SAR) values increase from 3.4 to 6.2. The EC values of the third order streams are nearly double those of the fourth order, but yet within safe limits of quality. The Electrical Conductivity (EC) value of agro well water under major, medium and small tanks are nearly the same, while the EC value of the drainage waters of major tanks show double the value of the main tank. The

surface waters of all categories of tanks fall within the potable quality standards of SLS (1993).

20. The method of delineation of the NCP into its component basins/watersheds, sub-watersheds and component cascades has been adequately outlined in Chapter 4. It is to be noted that for the Polonnaruwa district the demarcation was done only to the level of the sub-watersheds. A master map given in Volume II (Annexures) of the report shows the demarcation of both districts with their main river basins, sub-basins and cascades. The four main basins of the Anuradhapura district contain 36 subbasins ranging in size from 57 to 100 sq.miles with a mean size of 75 sq.miles. A separate map shows the Anuradhapura district with the boundaries of the cascades. A total of 309 cascades occur within the 36 subbasins with an average of between 8 to 9 cascades per subbasins. Details of their number and size distribution between the main and sub-basins are given in Chapter 4. The modal value for the area of a cascade is approximately 8.5 sq.miles or approx. 5,500 acres. A separate map showing the demarcation of the Polonnaruwa district into its main subbasins have been prepared and presented with.

21. The criteria adopted and the methodology employed in the selection of potential subbasins and cascades (15 in number of each) has been outlined in Chapter 4. The selection of the 15 subbasins out of a total 38 was made on the differentiation of rainfall probability, soils and land forms and present land use pattern. These 15 subbasins contain a total of 151 cascades, or almost half the total number of cascades for the districts. All these 151 cascades were then characterized on a scale of 1:50,000 in terms of their extent, number and area of tanks and present land use.

22. Based on IIMI's previous study of the "Guidance Package for Water Development component and Small Tank Systems" between 2 to 4 cascades per sub-basin, or a total of 43 cascades were selected out of the 151 on a ranking of their hydrological endowment. In the final stage of selecting one cascade from among the 2 to 4 cascades per sub-basin a novel field methodology was adopted by the field appraisal team which included a modified participatory rural appraisal technique coupled with participatory mapping of the water resources data and proposals as well as institutional arrangements proposed by the users. This is described in Chapter 4.

23. This component of the study introduces a mechanism for consulting beneficiary farmers in small tank cascades for identifying their specific needs and developing indicative land and water resources based development proposals. The mechanism involves carrying out a consultative participatory appraisal and mapping of the present status, use and potential future use of land and water for supporting and sustaining incomes of beneficiary farmers living in tank cascades. Indicative proposals and plans developed through this consultative mechanism provide a basis for stimulating followup technical, hydrological and economic feasibility studies by the implementing agencies to rationalize the plan for implementation with necessary technical modifications. The methodology was adopted in 15 sample cascades in Anuradhapura district mainly for identifying water resources development proposals and has been elaborated in Chapter 4. The details of the process followed and the outcome of the participatory appraisal and mapping exercise conducted in 15 cascades are presented as 15 case studies in Volume II (Annexure) of this study report. The adoption of the methodology through a beneficiary consultative process for planning

development interventions related with production and conservation activities in chena, homegardens, canal and stream reservations has been elaborated in Chapter 5.

24. A simulation model was developed to test and validate the farmers' proposals for water resources development within a cascade in terms of hydrological feasibility. The model, with necessary input data, can simulate the effect and impact of upstream interventions on water availability at each and every small tank within a cascade. The model can also be run to simulate the aggregated hydrological impact of interventions carried out in a number of cascades within a sub-basin. However, it needs further improvement. Features of this model, its utility and some sample outcomes are presented in the Volume II of the report. It is proposed that funds are allocated under the project to carry out further work to improve the capacity and utility of the model to enable wider application is cascade/watershed based area development planning in the future.

25. A key factor hindering the cascade/watershed based area development is the absence of a comprehensive understanding and database related to small tanks and tank cascades. For example, a conclusive inventory of small tanks for the NCP as well as the entire country is not available. Also, the present hydrometereölogical data collection network is not adequate to monitor water balance of river basins and hydrological parameters. In respect of ground water much data have yet to be collected to evaluate the hydrogeological parameters and ground water re-charge potential of the cascades and river basins. Research studies are needed to evaluate run-off/rainfall relationships of individual small, medium and major tank watersheds and the cascades to facilitate more rational and realistic planning and designing of land and water development interventions as well as for continuous monitoring in the future. Detailed surface water and ground water balance studies are required to substantiate the present data base of the NCP. The nature of the area development strategy proposed in this report demands various other research studies related to conservation and production as well as continuous monitoring and evaluation of the effects and impacts of such interventions to guide area development interventions and investment decisions in the future. Proposals for specific research studies and monitoring and evaluation have been outlined in Chapter 5 of the report.

26. The study initiated the preparation of a small tank inventory for the NCP during the short study period. It was possible to compile much physical, hydrological and social data for almost all the small tanks of the NCP. It was possible to identify the locations of the small tanks in relation to the Divisional Secretary's Divisions, cascades and river basins and whether the tanks were rehabilitated during the last fifteen years. The inventory of small tanks is presented in the Annexures. It is proposed that this exercise be continued as a special study under the GOSL/ADB project.

27. As stated earlier, on the basis of research studies conducted by IIMI (under the present assignment and under IIMI's SCOR project), Chapter 5 presents a holistic approach for land and water resources development in the NCP. The research results have been translated into project components, and, a benefits: cost analysis has been conducted. It is proposed to include 10 sub-watersheds in the GOSL/ADB Area Development Project for land and water resources

development and associated agro-industrial and institutional components. In each sub-watershed, two cascades comprising of about 20-30 tanks (assuming that an average cascade has about 10-15 tanks) will be selected. The 20 cascades (in 10 selected sub-watersheds) will represent five cascade types identified in the PRA. In each cascade, the total water and land resources will be considered in the development planning. This "contiguous area" approach or the consideration of sub-watershed land and water resources in its totality will yielded significant production-conservation benefits as experienced in the SCOR project.

Four different land and water use options are proposed. For these different options the benefit : cost ratio varies from about 2.0 to 2.8, at 22% discount rate. The corresponding range at 12% discount rate is 3.6 - 5.8. The Internal Rate of Return (IRR) varies from 18.4 to 19.9.

The project costs are also computed for the four different land and water use options. The estimated total cost for seven years is about US$20 million.

CHAPTER 1

INTRODUCTION

1.1 Background to the study

The government of Sri Lanka (GOSL) sought the support from the Asian Development Bank (ADB) for economic development in the North Central Province (NCP) of Sri Lanka. In developing its economic development programme in the NCP, the GOSL specifically sought the assistance of the ADB for a broad-based, multi-faceted area development programme to complement the Participatory Rural Development Project which is being prepared for the NCP under CIDA and IFAD assistance. In response to the GOSL's request, the ADB has agreed to provide a Pre-Project Technical Assistance (PPTA) to assist the Government in preparing a comprehensive development programme.

The scope of the proposed PPTA study includes:

a. A regional economic development study;
b. An institutional and human resources study;
c. A natural resources management study; and
d. Preparation of a detail project proposal for an Area Development project for Bank financing.

The three studies mentioned under (a), (b) and (c) will be the basis for the project proposal mentioned under (d) above.

The GOSL and the ADB has invited IIMI to conduct the Natural Resources Management Study included three key activity areas, namely:

- Assessment of Land and Water Resources Potential of the NCP.
- Overview of past and present tank rehabilitation strategies.
- Institutional and organizational arrangements.

The TOR for this Natural Resources Management Study for IIMI's services has been developed by IIMI in consultation with a working group composed of the Ministry of Irrigation, Power and Energy, Ministry of Agriculture, Lands and Forestry and IIMI. According to the TOR, IIMI will develop and define a strategy for the land and water based components of the GOSL/ADB Area Development Project. The study has been carried out independently by IIMI under a subcontract with the consulting firm (RH&H Consultants) appointed by the ADB to conduct the main PPTA study. It is expected that the consultants will make use of IIMI study recommendations for detail design of investment items related to land and water development components of the area development project. Such investment items may include: expenditure on land and water based development activities, staffing and manpower, equipment needs such as for GIS, infrastructure improvements required for recommended land and water development components (such as rehabilitation and modernization of irrigation systems, storage, marketing and other facilities for farmers' centers etc.)

1.2 Location, Access and Topography

The North Central Province is the largest province in the country, covering an area of 10,533 sq.km. It constitutes the two electoral districts of Anuradhapura and Polonnaruwa and comprises 27 Divisional Secretary's divisions divided into nearly 1,000 Grama Niladhari Divisions which embrace more than 2,700 villages. It is located in the north of the country where the central highlands turn into a gently to undulating terrain, slopes seldom exceed 4%. It is connected to Kandy (140 km), Kurunegala (120 km) and Colombo (210 km) by a good road network and is also part of the main rail system.

NCP is the largest province of the country, covering 16 percent of the land area, and has a population of about 1.2 million people, of whom more than 90 percent live in rural areas. NCP's contribution to gross domestic product is only 4.2 percent, largely attributable to the subsistence nature of its agriculture, which is the main source of income for about 70 percent of its population. Unemployment and underemployment in NCP are substantial, as opportunities for employment in commerce and industry are still limited. The population has increased faster than the national average because of substantial in-migration in recent years precipitated by civil disturbances in the North and East, and by population pressure in the South. NCP is among the poorest areas of the country, with nearly 60 percent of the population having a per capita income below the poverty line of SL.Rs.700/- (US$15) per month and depending on food subsides for their subsistence. About 44 percent of the people live in approximately 700 villages located in irrigation settlement schemes and in areas presently administered by the Mahaweli Authority. The population living in towns is about 11 percent, and the remaining 45 percent o the people live in approximately 2,000 older and more traditional villages.

NCP is located in the dry zone of the country, and the productive and sustainable use of its scarce water resources remains a development priority. Irrigation reservoirs (tanks), most of which are centuries old, number about 2,800 and cover seven percent of the land area. Seventy six reservoirs are medium-sized, seven are large, and the remainder small. The irrigated area amounts to nine percent of the land area, and the rainfed cultivated area, 30 percent. A significant expansion of irrigation has taken place in recent decades, combined with the settlement of migrants from other provinces. Increased population pressure and unsustainable practices of upland cultivation have combined to cause accelerated degradation of the six watersheds in the province. Forest cover, which was almost complete at the start of the century has decreased to 20 percent. Competition for the remaining scarce water resources is expected to increase sharply among different uses in the near future. The challenge of ensuring a reasonable income from agriculture for the young generation, while at the same time avoiding further land degradation and fragmentation in irrigation schemes and stopping encroachment in sensitive catchment areas, has become an urgent and complex problem. The Government has recognized the need for a holistic approach to natural resources management to optimize their use in boosting production in the short-term while ensuring protection for sustainable use in the longer term.

1.3 Scope of the study

The Natural Resources Management (NRM) study will conduct a basin wise assessment of water, land, and other relevant natural resources in the North Central Province. The assessment will involve both quantitative and qualitative aspects and the present status and management of natural resources. the study will make recommendations on approaches and strategies and administrative and institutional arrangements for improving, establishing and maintaining/sustaining of these resources under the GOSL/ADB Area Development Project. The study will interface with the work of consultants who will provide further needed inputs specially concerning: detailed investments items, administrative needs, staff requirements, etc.

The Natural Resources Management Study (NRM) is primarily meant for a basin-wise assessment of natural resources of all the basins contained in NCP, in addition to developing guidelines for quantitative and qualitative assessment of basin wise water, land and other related resources in the NCP; to analyze their present use and management practices, and to suggest scope for their improvement under the GOSL/ADB Area Development Project.

In this study, the following terminologies are used: basin watershed, sub-basin watershed, cascade watershed, and tank watershed. A watershed in general contains catchment area, storage area, command area and drainage area; watershed refers to the boundary line and therefore, it is to be qualified with an adjective to represent a particular area. A tank watershed refers to an area encompassing tank catchment, tank proper, its command and drainage areas; similarly a basin watershed refers to a large area encompassing a major river like Kalu Ganga or Mahaweli Ganga. A sub-basin watershed refers to an area encompassing a major tributary while cascade watershed refers to an area encompassing a series of interconnected tanks.

1.4 A General Overview of the Geography of the NCP

Geographically, the two districts of Anuradhapura and Polonnaruwa which made up the NCP fall totally within the dry zone of the country which is characterized by a bimodal rainfall pattern with a mean annual rainfall of around 1,500 mm and an annual evaporation of more than 1,750 mm. The main rainy season or maha is from October to February, and the stinter rainy season or yala is during late March to mid May.

The two districts are made up of a gently undulating to undulating, rock-floored, mantled plain which is referred to as the lowest peneplain of the three peneplains that mainly constitutes the island's physiography. The underlying precambrian rocks of the NCP are described as the Highland series which are made up of various gneisses, charnockites, quartzites, hornblende, gneisses some bands of dolomitic limestone.

The term "mantled plain" is used to designate a gently undulating to rolling plain which has a mantle of residual materials derived by weathering from the underlying bedrock. The

mantle consists of this residuum and the soil profile developed in its upper part. The term "rock-knob-plain" is used to designate those areas which are characterized by a rough and broken relief of extensive tracts of low bedrock exposure which are mainly rounded and take the form of low domes and ridges.

The soil mantle of the NCP is made up of a catenary sequence of well drained reddish brown earths in the upper aspects of the landscape, and the imperfectly to poorly drained low humic gley soils in the adjacent lower aspects and the inland valleys. Alluvial soils of variable texture and drainage are the dominant soils of the major Mahaweli flood plain and the minor flood plains of the other rivers.

The dominant type of natural vegetation or forest cover of the mantled plain is described as the "dry mixed evergreen" forest, which consists of both evergreen and deciduous species. The structure of the forest is relatively simple, with the deciduous species slightly taller than the evergreen species and with somewhat less than complete cover.

The geomorphology and the natural drainage pattern of the two districts are very different from each other. These will be described and discussed in the subsequent sections of this report.

On the basis of the comparative descriptions outlined in respect of the Anuradhapura and Polonnaruwa districts in the preceding paragraphs of this section, it is clearly evident that the Anuradhapura district is characterized by a "cascade landscape" over its total extent, whereas the Polonnaruwa district is dominated by an "alluvial plain" landscape within its settled and developed area made up of four major irrigation systems. In other words, the two districts are characterized by two different and contrasting types of land systems. Moreover, the western and southern segments of the Polonnaruwa district are made up of rolling landscape and land forms which are also located in the immediate catchment area of three major reservoirs, Parakrama Samudra, Minneriya and Kaudulla. These areas have been traditionally allocated to nature reserves of different categories, and to sanctuaries and forestry. These play an important role in environmental protection for the settled portions of the district and should not be tampered with. This is very clearly reflected in the 1:100,000 scale "Present Land Use" map of the Polonnaruwa district which demonstrates this contrasting character.

On the foregoing considerations demarcation of the Anuradhapura district into component sub-watersheds and cascades was feasible, whereas for the Polonnaruwa district only demarcation at the level of a sub-watershed was possible as could be discerned in maps 3 and 4. It logically follows that while the cascade approach was appropriate for the Anuradhapura district it was different for the Polonnaruwa district where those portions of the sub-watersheds located in the lowland and alluvial plains required an approach aimed at intensification of the agricultural production within the context of the land systems of the major irrigation schemes.

1.5 Socio-economic Situation

a. Population

The lack of a recent census, no regular collection of population statistics and considerable in and out migration have resulted in very inconsistent population statistics. Nevertheless, it is clear that the population of the Province has been expanding rapidly. In 1931, it had a population of about 10,000 only 8,000 of whom lived in Polonnaruwa district. By 1963, it has increased almost to 400,000 with a dramatic expansion in Polonnaruwa to 114,000 due mainly to new settlement on the colonization schemes. Today, the estimates range from about 1.2 million too about 1.4 million, with about two-thirds of the population in Anuradhapura district and one third in Polonnaruwa. With an average family size of about 5.2, the total number of families would range from 230,000 to 270,000. Since the early 1970s, the mean annual growth rates in the province have generally exceeded 4%. These high growth rates are attributable to immigration: (i) unorganized migration from densely populated area in the wet zone; (ii) resettlement inn the major colonization schemes in the 1950s and 1960s; (iii) resettlement in the areas developed by the Mahaweli Authority in the 1970s and 1980s; and (iv) refugees coming in recently from the Northern and Eastern provinces.

The population density in NCP is estimated to be currently about 102, persons/km^2, low compared to the national average of 273 persons/km^2. The smaller area of Polonnaruwa district and large proportion of the district covered by colonization schemes, which have relatively higher settlement levels, means that Polonnaruwa now has a slightly higher population density than Anuradhapura district.

b. Settlement

There are two very clear and distinct settlement patterns in the province: the purana areas and new settlement schemes. The purana areas (old areas) which make up about half the population of the province are the traditional settlements in which the village is located adjacent to the tank with chena/forest areas surrounding it. The settlement schemes, both earlier colonization schemes and Mahaweli areas, with about 40% of the rural population, are settlements which have been organized on the basis of the layout of the irrigation system, sometimes agglomerated such as in the Mahaweli areas, sometimes dispersed as in some of the colonization schemes.

A traditional village and now on average contain about 50 households. Growth in the village population both through natural growth and immigration has caused the villages to continue to expand cultivation into the surrounding forest and to continue splitting the fixed paddy. In some villages, the fragmentation of the paddy area as reached the point that the normal plot size in 0.25 ha and sometimes a family might only get access to the paddy land one year in four or five; in the intervening years other members of the extended family take their turn in cultivating the plot.

In the earlier scheme, settlers were given 2 ha of paddy and 1.2 ha of upland. In the irrigation settlement schemes of the NCP, these were reduced to 1 ha and 0.2 ha respectively. As the people generally constructed their houses on their upland plots in the earlier schemes they tended to be very spread out and at a distance from the paddy land. In the latter colonization schemes and in the Mahaweli areas, the families were settled in villages which were on average larger than purana villages. Whenever possible the previous settlement pattern of purana villages was used as the basis of the new settlements.

1.6 Climate, Soils and Water

a. Climate

NCP has a tropical monsoon climate with a bimodal but highly variable rainfall pattern. With a mean annual rainfall in the range of 1,000 to 1,500 mm, the Dry Zone of Sri Lanka is dry merely in comparison with the wetter and more humid areas and not by internationally recognized standards. The range of rainfall with 75% probability is 600 to 950 mm. The inter-monsoonal period in October, November and December provides for the maha season the most reliable rain for crop production and irrigation water collection. The north-east monsoon from the end of December to early March is generally dry, with considerable variation between years. The inter-monsoonal period from March to early May provides rainfall for the shorter yala cropping season, but its total and distribution are variable in both quantity and distribution throughout the province. The summer south-west monsoon from May to September brings little useful rain. More important for cropping than the total annual rainfall is the reliability and distribution throughout the year.

Temperatures are similar throughout the Province and mean monthly temperatures are uniform over the year in the range of 25-29°C with minimum temperatures occurring in November-March, but not at a level low enough to restrict plant growth.

b. Soil

Three major soil groups are represented in the NCP. The majority of the area consists of a complex of reddish brown earth on the upper and mid-slopes which merge into low humic gleys on the lower slopes an valley bottoms. The reddish brown earths are moderately to fine textured, well to imperfectly drained soils which are suitable for a wide range of rainfed or irrigated crops. The low humic gleys are poorly drained, moderately fine to fine textured soils well suited ponded rice growing with or without irrigation.

Alluvial soils of variable texture and drainage occur in the valley bottoms of major rivers, particularly those that drain to the north-west and to the Mahaweli Ganga floodplain complex in the extreme east of Polonnaruwa district. Wherever possible, these are developed for irrigated paddy rice and ar the main soils of the Mahaweli System B Scheme in Polonnaruwa District and System H in Anuradhapura.

c. Geology and Groundwater

The precambrian rocks which underlie the North Central Province produce the main water bearing aquifer which is made up of the weathered overburden. At the end of the Maha the water table is usually at or near to the surface but during the Yala it falls to a depth of 5m or more except where influenced by a nearby tank. This aquifer is tapped by dug wells for agriculture as well as domestic supplies. Tube wells which penetrate fractured crystalline rock provide a more reliable source of water for domestic purposes.

Out of the principle drainage basins in the Province with the exception of the Mahaweli, flow in the rivers would, in the natural state, be seasonal, but in fact the surface water flow over the whole province has been extensively modified. Water is retained in some 2,800 tanks which when at maximum water levels and taken in conjunction with the rivers, cover some 7% of the surface area. Further, water from the Mahaweli basin is introduced at the heads of the watersheds of the Yan Oya, the Kala Oya and the Aruvi Aru.

More details on soils, rainfall, river flows, surface water balance and groundwater balance are presented in Chapter 2.

1.7 Organization of the Report

Chapter 2 of this report provides an account of the present status of Land and Water Resources base and use of the NCP. This chapter addresses the major river basins and their characteristics; present land use and related issues; present surface water use and ground water use; and present quality in the NCP.

Chapter 3 provides a detailed review of the past and on-going irrigation rehabilitation projects conducted in the NCP. It addresses the strengths, weaknesses and terms that can be learnt from the previous irrigation rehabilitation strategies and approaches. In view of the gaps realized between the expectations of those irrigation rehabilitation programmes and the actual achievements, this study discourages the conventional "single tank rehabilitation" approach. Instead it recommends a cascade-based water resources development and area development approach in which cascade is considered the basic unit of planning water resources development and complementary area development interventions using a farming system approach.

Chapter 4 presents the detail process beginning from identification of a potential cascade and sub-basins for area development up to the identification of specific proposals for water resources development interventions in a cascade. Having identified the water resource development proposals based on farmer's perceptions, the proposal is evaluated both technically an hydrologically for validation. In addition, this chapter provides descriptions of the cascade simulation model and the small tank inventory developed under this study.

Chapter 5 presents a detail account of the strategies adopted by Shared Control of Natural Resources (SCOR) project, which is the basis for the area development for the proposed area development project of the NCP. It describes the strategies, rationale, norms and the assumptions used for cost benefit computations, details of the cost benefit computations and the institutional arrangements proposed for the implementation of the strategies. It also provides separate cost proposals for rehabilitating medium and major irrigation schemes in the NCP based on the consultants with the Irrigation Department and the Mahaweli Authority of Sri Lanka.

The SCOR project implemented in the Huruluwewa watershed in the NCP by IIMI in collaboration with the GOSL has adopted a novel but promising holistic approach for land and water resources management. The strategy is based on maintaining a sustainable balance between the production from the natural resources and protection to the natural protection to the natural resources base. It adopts a farming system based watershed approach by offering a package of interventions to improve production from the irrigated production-protection command, chena areas, homegardens, forests and even stream and canal reservations. The interventions are tested through novel institutional arrangements involving the active and productive participation of both the resource users and the field and provincial land officials of the Government. Even the linkages between the user's organizations and the commercial private sector are established as a part of the strategy. The area development strategy and intervention proposed in this study is based on the SCOR approach. Details of the SCOR approach, strategies and interventions are given in Chapter 5 of this report.

CHAPTER 2

RIVER BASINS, LAND, SURFACE WATER AND GROUND WATER RESOURCES

2.1 Major River Basins and their Characteristics

The following five major river basins occupy more than 95 percent of the extent of the Anuradhapura district -- 2770 sq. miles.

River Basin	Area (sq. miles)
Malwatu Oya	1210
Kala Oya	1084
Yan Oya	600
Ma Oya	403
Modurayan Oya	400

The area of each of the major river basins given above represents the area of the whole river basin up to its entry to the sea, and as a such it represents an area beyond the Anuradhapura district boundary. It should also be noted that the southern district boundary of the Anuradhapura district as shown in **Figure 2.1** is the central Kala Oya river and not its watershed boundary.

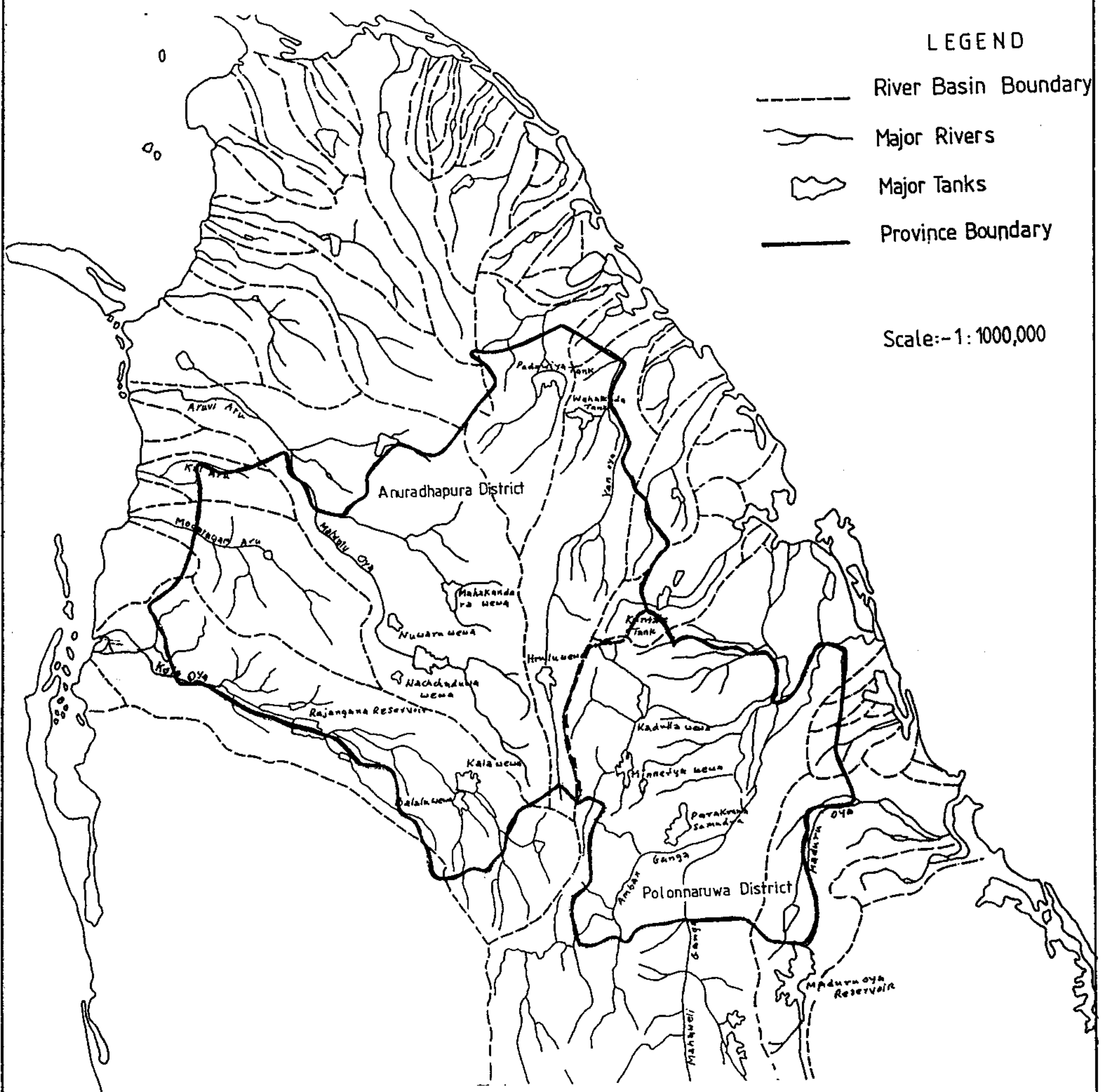
The head reaches of some of the smaller river basins such as the Kal ara, Pankulam ara and Mee Oya are also located within the Anuradhapura district and their total extent is approximately 125 sq. miles.

The catchments of all the foregoing river basins are situated completely within the dry zone environment. Recent Mahaweli trans basin diversion has augmented supply to the Kala Oya to a very high degree to the Malwatu and Yan Oya to a moderate degree, and to the Moderagam ara to a slight degree. The Ma Oya has not been influenced by any trans basin diversion.

All these river basins have the characteristic shape and form of catchment basins in this environment, namely narrow at the head reaches, broadest in the mid reaches and narrowing down again in the coastal plain where it enters the sea. The Malwatu, Kala and Yan Oyas originate at an elevation of between 500 to 1000 ft. and more than 90 percent of the total basin is situated at an elevation lower than 500 ft.

The incised nature of the main third or fourth order streams and rivers indicate that they are yet in the cutting down stage and have not reached the base erosion level. Because of the hard underlying crystalline basement complex of rocks the run-off ratio is a appreciably high, varying from 19-20 percent for the Yan Oya and Ma Oya, to 12-14 percent for Malwatu and Kala Oya. Base flow during the dry season is almost zero because of the impervious nature of the underlying rocks.

Figure 2.1 RIVER BASINS AND PROVINCE/DISTRICT BOUNDARIES OF THE N C P



A greater part of the Polonnaruwa district -- 1306 sq. miles is located within the Mahaweli ganga basin. On the western aspect of the main Mahaweli river, the following medium size rivers drain into the main Mahaweli water course. Amban ganga, Minneriya Oya, Kandulla Oya, Ambagaha Oya and Kalu ganga as shown in **Figure 2.1**. A very small portion of the eastern segment of the district is occupied by the eastern watershed of the Maduru Oya.

The upper reaches of these sub river traverse the undulating to rolling residual topography, while the lower reaches traverse the alluvial plain. The upper reaches of these sub rivers are yet in the cutting down stage, while in the lower reaches they have reached the base erosion level. There is no dry weather flow in the Minneriya, Kandulla and Ambagaha Oya, but there is appreciable dry weather flow in the Amban ganga which is tapped at Angamedilla and diverted to the Parakrama Samudra reservoir.

It should, however, be noted that all the major irrigation systems located within this Polonnaruwa district benefit from the additional Mahaweli diversion waters that derive from Bowatenna reservoir upstream of the Amban ganga.

2.2 Present Land Use and Related Issues

The present land use situation in the two districts of Anuradhapura and Polonnaruwa have been assessed from the 1:100,000 scale Present Land Use Maps (1984) published by the Survey Department. The most contrasting difference between the two districts is that while approximately 27 percent of the Anuradhapura district is under forest cover (both dense and open forest), approximately 52 percent of the Polonnaruwa district is under forest cover. This is not surprising considering the fact that a greater part of this forest cover in the Polonnaruwa district is distributed over a contiguous area in the western and south western segments of the district which are characterized by poor quality land in terms of relief, topography and soils. On the other hand, the forest cover in the Anuradhapura district is distributed in a scattered pattern across the district, except around the western boundary of the district adjacent to the Wilpathu National Park, and also along the lower reaches of the Ma Oya where a contiguous cover is present.

The extent of paddy land in the Anuradhapura district is approximately 120,000 ha or 17 percent of the district, and in the Polonnaruwa district it is approximately 45,000 ha or 13 percent of the district. The corresponding figure for homesteads is 55,000 ha for the Anuradhapura district and 24,000 ha for the Polonnaruwa district. Almost the total extent of this 24,000 ha of homestead land in the Polonnaruwa district is located within the hydrological influence of the irrigation delivery systems of the major schemes and thus constitutes a significant land resource that could be exploited for low-head, small-scale lift irrigated agriculture. It should also be noted that for every 2.0 ha of paddy land there is close to 1.0 ha of homestead land in both districts which is a satisfactory ratio for this environment. There is further scope for intensification of production on this homestead allotment especially in the major irrigation schemes in both districts. For the paddy lands, promotion of dry season crop diversification on the well drained areas would help to improve the efficiency of the present levels of water use.

Another significant present land use category is that of the "sparsely used crop land" or the chena land which amounts to approximately 200,000 ha or 28 percent of the Anurádhapura district as compared to approximately 45,000 ha or 14 percent of the Polonnaruwa district. In the Anuradhapura district, these chena lands are fairly uniformly distributed across the whole of the district with their major concentration around the small tank cascade systems. Stabilizing rainfed agriculture and minimizing land degradation are the main issues facing this category of land use.

The foregoing figures is shown below in **Table 2.1** in order to capture the significant features of these categories of present land use.

Table 2.1 Land use summary of Anuradhapura and Polonnaruwa districts

District	Forest Cover Percentage	Paddy Land ha	Homestead ha	Chena Land ha
Anuradhapura	27	120,000	55,000	200,000
Polonnaruwa	52	45,000	24,000	45,000

2.3 Surface Water Potential and Present Use

2.3.1 Introduction

Hydrological analysis of the NCP undertaken under this study cover an important and vital component of the overall assessment of land and water resources potential. The following specific tasks were undertaken under this component.

(a) Collection and compilation of time series hydrological data such as rainfall, streamflow, pan evaporation on a monthly basis and the preparation of a map showing the hydrometric network in the NCP area.

(b) Processing of time series data under (a), to arrive at long term average values, trends and extreme events such as flood peaks for each principal station under consideration.

(c) Estimating on an annual basis to understand the water usage in each river basin for irrigation, domestic, industrial and other uses.

(d) Estimating the annual transbasin diversion of water in these river basins from adjoining river basins or vice-versa.

(e) Estimating the annual water balance, based on (a), (b), (c) and (d).

(f) Developing a proposal for a long-term hydrological data collection program for the NCP.

2.3.2 Study Area

For the assessment of water resources in the NCP, the area bounded to the East by the left bank of Amban Ganga and Mahaweli Ganga and to the West, the right bank of Kala Oya were considered. The study area does not confine to the district boundaries of Anuradhapura and Polonnaruwa, but covers the central mountains of the Matale district to the South and extends towards Vavuniya, Trincomalee and Mannar districts.

The details of the study undertaken is presented in **Annex 2.1**. Only the salient results of this study are discussed in the main report.

2.3.3 Rainfall Analysis

The monthly rainfall data for 52 locations were assembled for the current study and average annual and seasonal rainfalls were estimated at these locations to draw iso-heights. For these stations, long term annual rainfalls for a continuous period of 30 years were taken from 1935 to 1990 depending on the consistency of data.

Three iso-heights maps depicted in **Plates 1 to 3** represent the annual rainfall, North East monsoon rainfall and the South West monsoon rainfall respectively. **Table 2.2** provides 50%, 75% and 90% dependable rainfall figures for the NCP.

By looking at the rainfall distribution in iso-heightal maps, it is evident that the highest annual rainfall in the region is experienced near Polonnaruwa and it decreases in two main directions. One is towards Trincomalee from Polonnaruwa and the other direction is towards Mannar. However, the Horowpatana and Gomarankadawala areas experience localized higher rainfall than Polonnaruwa and this is mainly due to the thunderstorms created near the coastal areas.

2.3.4 Estimation of Water Availability

The method of estimating the water availability is based on the conditions of the river basin with regard to the degree of human interventions, such as structural changes and land use. For some river basins, there are river gauging stations within, but for others, such stations do not exist. For these basins, information from gauged basins were extrapolated. Extrapolation of results of gauged catchments were made by considering the long term average rainfalls and the catchment areas of respective basins under consideration.

Log normal distribution was fitted to the observed data series in order to estimate the dependable annual flows at 50% and 75% probabilities. **Table 2.3** shows the summary of results of this analysis.

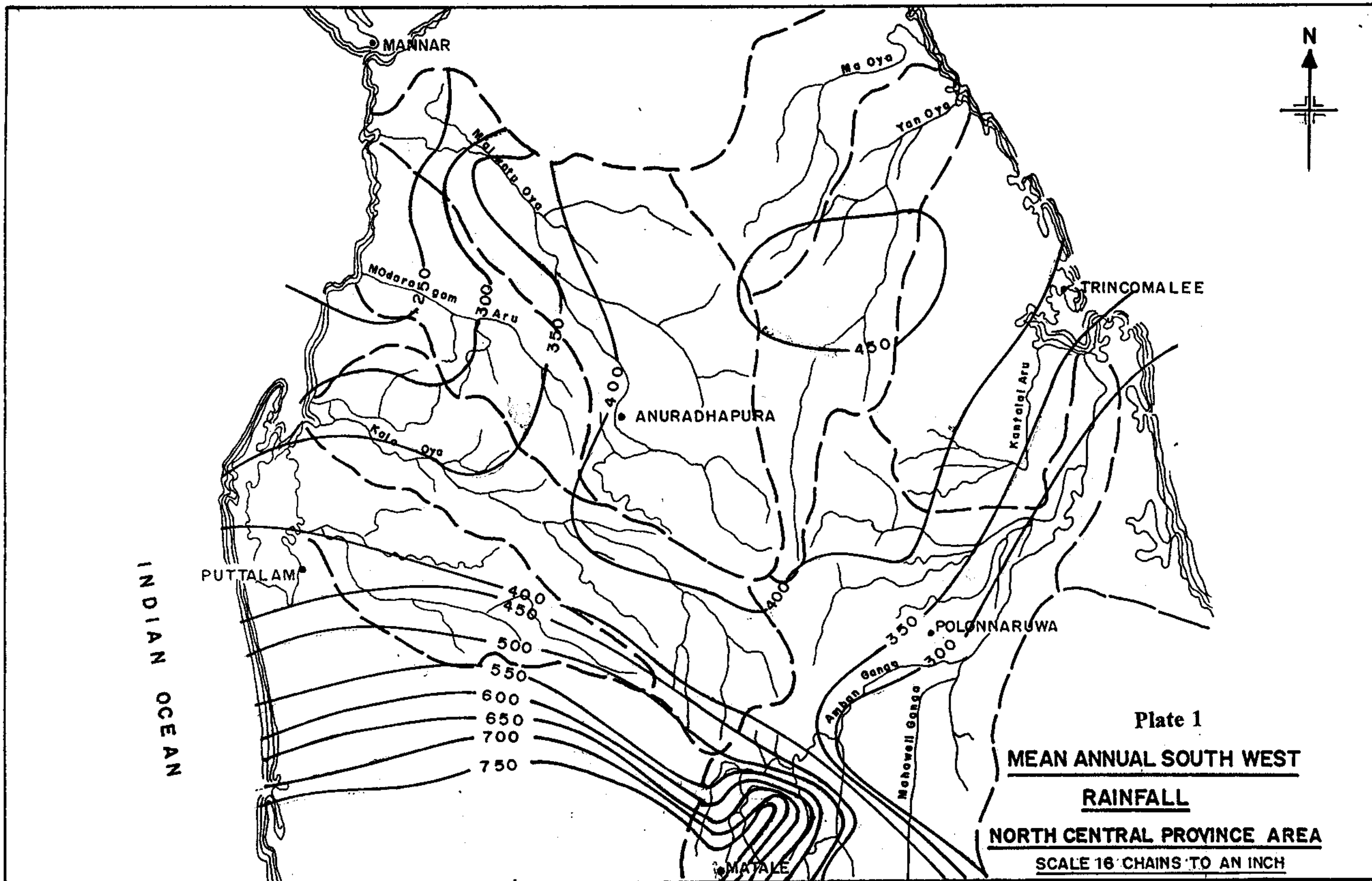


Plate 1

MEAN ANNUAL SOUTH WEST

RAINFALL

NORTH CENTRAL PROVINCE AREA

SCALE 16 CHAINS TO AN INCH

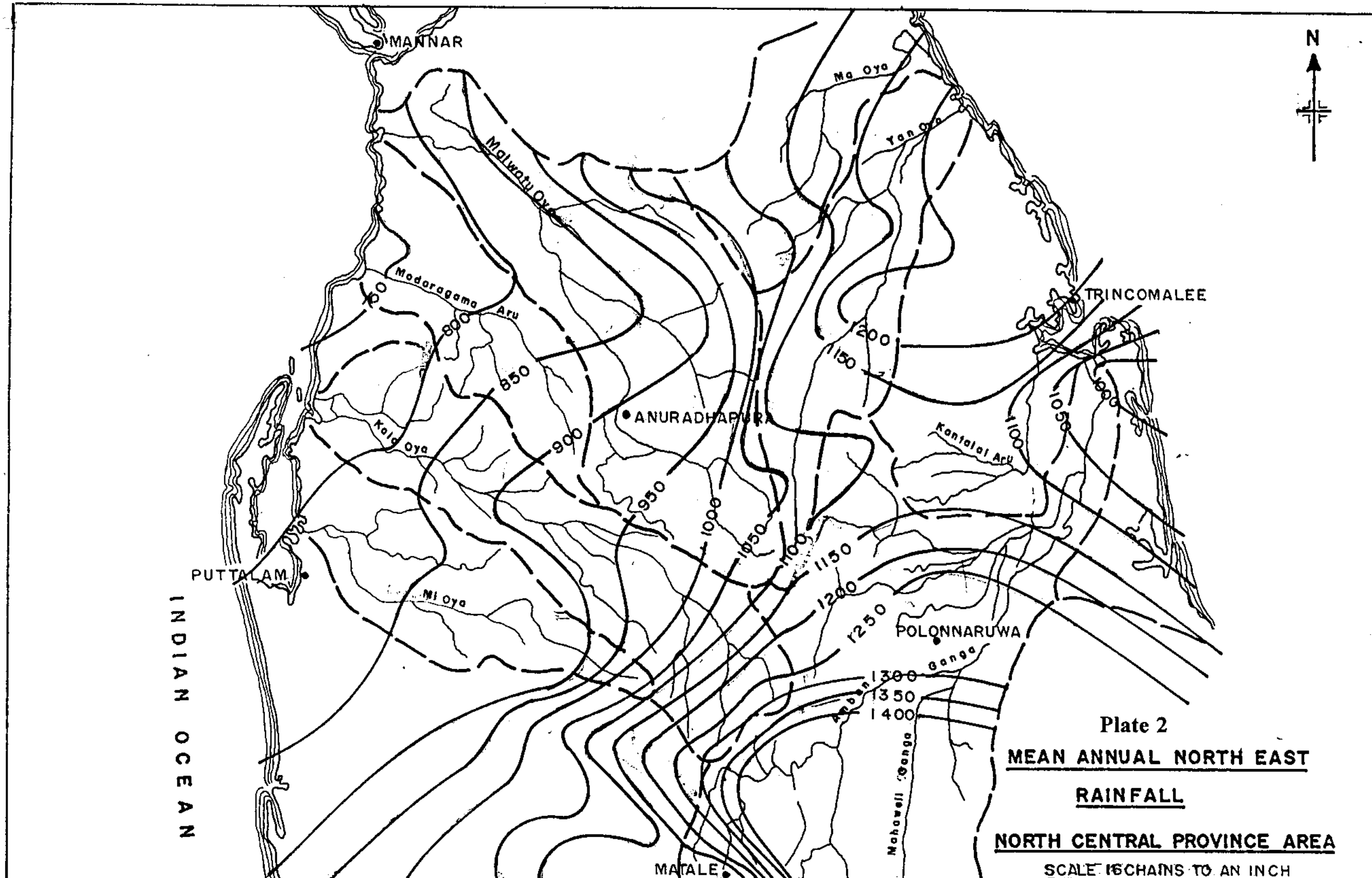


Plate 2

MEAN ANNUAL NORTH EAST RAINFALL

NORTH CENTRAL PROVINCE AREA

SCALE 16 CHAINS TO AN INCH

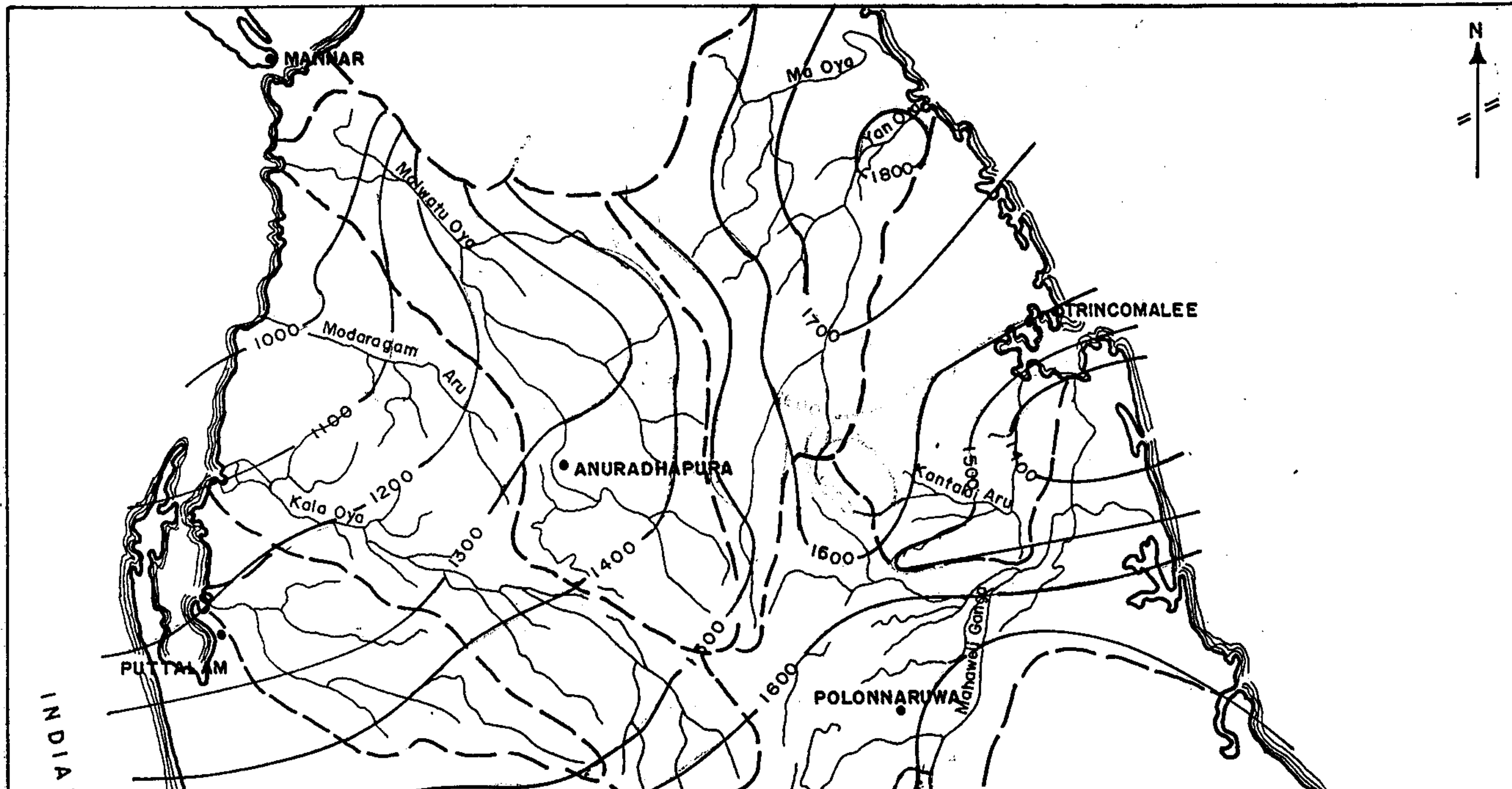


Plate 3

MEAN ANNUAL RAINFALL

NORTH CENTRAL PROVINCE AREA

SCALE 16 CHAINS TO AN INCH

Table 2.2 Annual stream flow analysis - N.C.P.

	NAME OF THE GAUGING STATION	CATCHMENT AREA IN SQ/KM	PERIOD	NO. OF YEARS	STATISTICAL PARAMETERS				ESTIMATED ANNUAL RUNOFF (MCM)	
					MEAN (MCM)	STD. DIV. (MCM)	COEF. OF VAR.	SKEW	50%	75%
1	AMBAN GANGA AT ELAHERA	774	1947-1980	31	776	220	0.284	0.372	741	603
2	YAN OYA AT HOROWPATANA	948	1961-1994	28	149	84	0.566	0.285	115	72
3	MALWATHU OYA AT KAPPACHCHI	2116	1949-1981	29	235	195	0.832	1.644	159	84
4	KALA OYA AT RAJANGANA	1564	1946-1962	15	268	175	0.653	0.624	209	112
5	KALA OYA AT NOCHCHIYAGAMA	1948	1965-1994	25	535	346	0.646	1.724	417	263

Table 2.3 50%, 75% and 90% Dependable rainfall for the NCP

	NAME OF THE STATION	PERIOD	NO. OF YEARS	STATISTICAL PARAMETERS				ESTIMATION OF ANNUAL RAINFALL (M.M)	
				MEAN (M.M)	STD. DIV. (M.M)	COEF. OF VAR.	SKEW	50%	75%
1	ANURADHAPURA	1961-1980	20	1265	315	0.248	0.74	1216	1023
2	PELWEHERA	1951-1980	30	1587	375	0.236	0.656	1531	1303
3	MINNERIYA TANK	1958-1988	31	1499	466	0.311	0.787	1445	1274
4	PADAVIYA	1957-1988	32	1690	464	0.274	1.089	1640	1380
5	MAHAILLUPPALAMA	1961-1990	30	1375	310	0.226	1.206	1334	1161
6	THABBOWA	1951-1980	30	1185	320	0.270	0.423	1140	944
7	NALANDA	1951-1980	30	1868	438	0.234	0.239	1875	1575
8	VAVUNIA	1954-1983	30	1413	379	0.268	1.221	1365	1148

This analysis was done on an annual basis and then sub-divided into North East monsoon and South West monsoon seasons separately by considering the rainfall distribution between two monsoons. The natural water availability in each of the river basins were extrapolated based on the average annual flow volumes at the gauging sites. This extrapolation was done on the basis of catchment area ratio and the ratio of average annual rainfalls in the respective drainage basins.

Estimation of water availability in river basins for which there are no stream gauge records were done by adopting the estimates of neighbouring river basins with similar climatic conditions and physical features.

2.3.5 Diversion from Mahaweli

Schematic representation of diversions of water from the Mahaweli river to the NCP area is depicted in the **Plate 4**. Water diverted on a seasonal basis from Mahaweli to the NCP was collected for the last 10 years and analyzed statistically to estimate the probable diversion requirements at 50% and 75% probability (**Table 2.4**).

2.3.6 Changes in Flow Regimes

Flow regimes in most of the river basins under the study have changed due to the Mahaweli diversion and construction of large reservoirs for irrigation. The impact of the Mahaweli diversion and construction of large reservoirs such as Rajangana and Huruluwewa on the flow regimes were examined under this study.

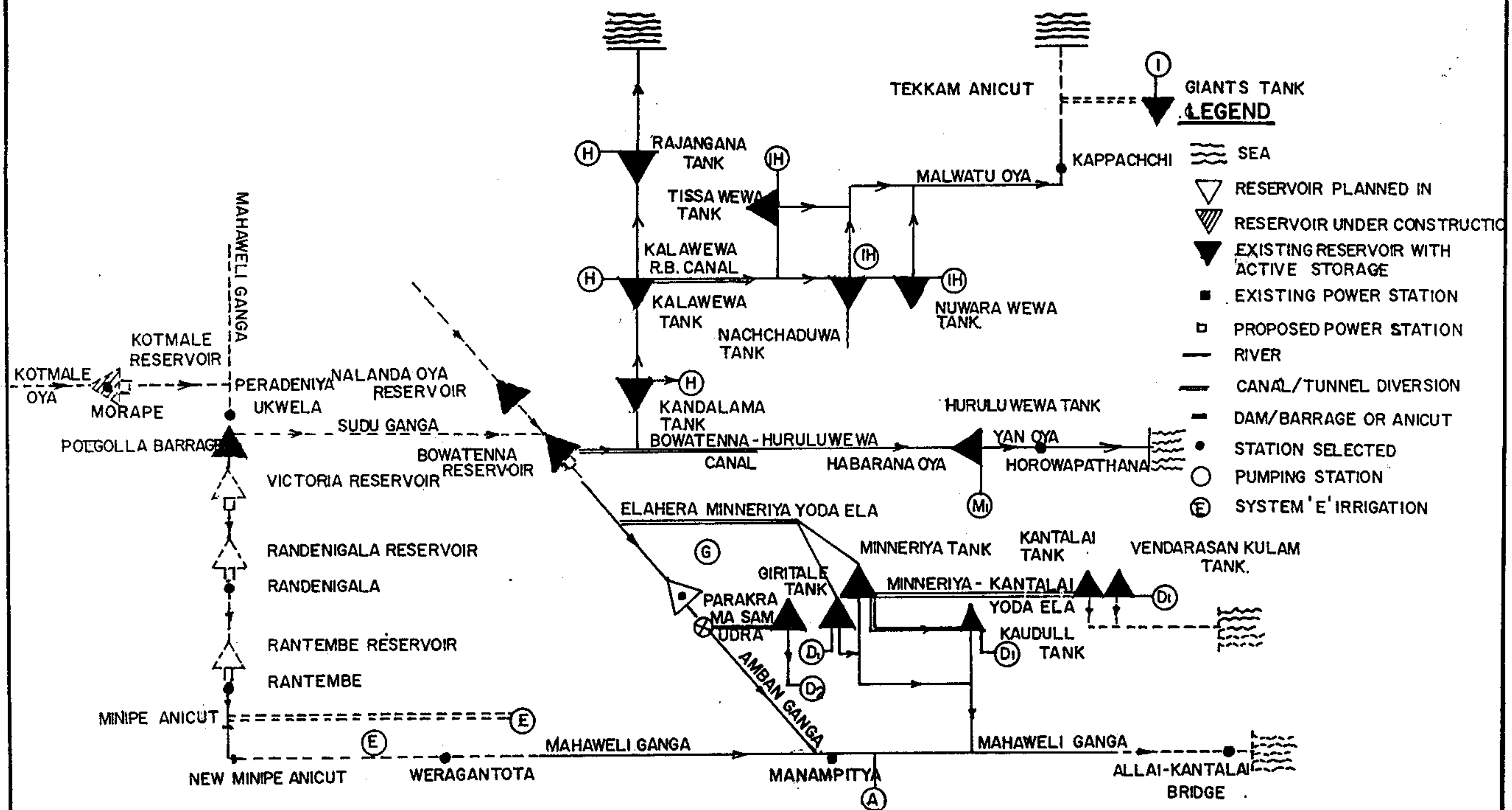
It was observed that after the construction of Huruluwewa reservoir, the average annual flow at Horowpathana was reduced from 197 mcm to 118 mcm which is a 60% reduction. Similarly, annual average flow at Kala Oya gauging station below Rajangana Reservoir was reduced from 724 mcm to 299 mcm after construction of the Rajangama reservoir in 1964 which is again a 60% reduction. In order to understand the change in flow regime due to Mahaweli diversion, the flow records available at Amban ganga gauging station at Elahera was analyzed. The analysis indicates that the average annual flow during the period of analysis (14 years before and 14 years after diversion) had increased from 312 mcm to 800 mcm which is a 256% increment.

2.3.7 Present Water Use

The present irrigation water use estimation is based on actual quantities of water used for irrigation (irrigation water duty multiplied by the actual area irrigated). Water usage for other purposes such as drinking water supplies was investigated and accounted separately. The principal water usage in the NCP area is for paddy cultivation and therefore, the extent of cultivation was estimated for different river basins. The seasonal tank duties of selected irrigation schemes to represent the different drainage basins of the study area for a period of the last 10 years were analyzed to work out an average duty which was then adjusted for long term average rainfall in that basin. The results of this analysis are presented in **Table 2.5**.

Plate 4

SCHEMATIC LAYOUT SHOWING AUGMENTATION OF THE NCP BY MAHAWELI COMPLEX



SOURCE - HYDROLOGICAL CRASH PROGRAMME
MAHAWELI DEVELOPMENT PROJECT – 1982 NEDECO

NOTE:–
NCP BOUNDARY SHOWN THUS ———

TABLE 2.4 50%, 75% and 90% Dependable river flows of the N.C.P.

	Name of Gauging Station	Catchment Area in (Sq.km)	Period	No. of Years	Statistical Parameters				Estimation of Discharge (in M^3/sec			
									Return Period (Years)			
					Mean	Std. Dev.	Coe. of Var.	Skew	T=25	T=50	T=100	T=200
1	YAN OYA AT HOROWPATANA	948	1960-1993	34	257	260	1.012	1.835	630	734	838	942
2	KALA OYA AT KALA OYA BRIDGE	1948	1964-1994	26	654	558	0.853	0.983	1687	1968	2247	2525
3	KALA OYA AT RAJANGANA (KADIGALA)	1564	1945-1964	18	337	405	1.202	3.659	797	926	1054	1183
4	AMBAN GANGA AT ELAHARA	774	1946-1970	24	403	178	0.441	0.124	802	908	1014	1119
5	MALWATHU OYA AT KAPPACHCHI	2116	1948-1981	32	654	1199	1.833	4.119	1828	2167	2503	2838

Table 2.5 Diversion of Mahaweli water to NCP statistical analysis from 1984 to 1994

	Name of Tank	MAHA SEASON					YALA SEASON				
		Statistical Data			Probable Diversion		Statistical Data			Probable Diversion	
		Mean Flow (MCM)	Std.Dev. (MCM)	Coe. Var.	50% (MCM)	75% (MCM)	Mean flow (MCM)	Std. Dev. (MCM)	Coe. Var.	50% (MCM)	75% (MCM)
1	KANDALAMA	38.29	11.74	0.30	38.29	46.25	37.61	14.2	0.37	37.61	47.35
2	HURULUWEWA	47.26	9.94	0.21	47.26	54.15	27.75	15.82	0.57	27.75	38.1
3	KALAWEWA	245.54	94.77	0.38	245.54	310	227.2	58.31	0.25	227.2	267
4	NACHCHADUWA	27.47	8.44	0.30	27.47	33.2	28.86	11.22	0.38	28.86	36.5
5	NUWARAWEWA	23.34	14.07	0.60	23.34	32.8	6.78	3.93	0.57	6.78	9.5
6	TISSAWEWA	11.05	6.11	0.55	11.05	15.3	4.1	1.53	0.37	4.1	5
7	ELAHERA	388.37	92.03	0.23	388.37	450	281.01	89.86	0.31	281.01	340
8	GIRITALE	53.24	12.03	0.22	53.24	61.25	44.92	6.75	0.15	44.92	49.4
9	MINNERIYA	242.3	68.33	0.28	242.30	287	125.16	36.14	0.28	125.16	150
10	KAUDULLA	57.03	30.04	0.52	57.03	77	26.26	26.16	0.99	26.26	42.6
11	KANTALE	93.3	47.14	0.50	93.30	125	33.38	14.56	0.43	33.38	43.1
12	PARAKRAMA SAMUDRA	205.39	40.88	0.20	205.39	23	49.41	24.46	0.25	94.41	110

2.3.8 Evapotranspiration

The study estimated the actual evapotranspiration in river basins in order to provide an insight to the quantity of water utilization by non-crops such as scrub jungle, chena and grass lands where irrigation is not provided. Actual evapotranspiration in four river basins are estimated on an annual basis by the application of the water balance technique. It is assumed in this method that groundwater storage and soil moisture storage achieve the conditions at the beginning of every water year. **Table 2.6** shows the estimation of average annual evapotranspiration rates in the NCP and details regarding the data used.

2.3.9 Surplus Water

The surplus water below a gauging station was estimated by giving due consideration to the water usage downstream of a gauging station. When the river below a stream flow gauging station is not influenced by a major diversion or reservoir observed flow volumes were assumed to represent the surplus water. **Table 2.7** shows the results of this analysis.

2.3.10 Frequency Analysis of Floods

Annual maximum daily flood peaks from five selected hydrometric stations for a period where the streamflow is nearly natural were obtained for this analysis. Using extreme value distribution Type I (Gumbel), flood peaks for 25, 50, 100 and 200 year return periods were estimated and presented in **Table 2.8** along with the statistical parameters.

2.3.11 Trend Analysis of Rainfall and Streamflow

It is important to study the trends in the rainfall and streamflow time series of the region to understand future water availability. The trend analysis carried out in this study indicates (for details refer to **Annex 2.1**).

Among the three stations for which rainfall trend analysis was carried out, two of them show significant downward trend. The three stations are: Anuradhapura, Maha Illupallama and Minneriya. The highest downward trend was observed at Anuradhapura and it was estimated as 8 mm/year. Then trend analysis was done for the same stations by splitting into NE and SW monsoons. It was found from this analysis that except at Mahailluppalama grouped data also indicated downward trends. Only exception was the South West monsoonal rainfalls of Mahaillupalama where the trend was positive. This was the reason for the insignificant downward trend of the total rainfall at Mahaillupalama.

Table 2.6 Water utilization for irrigation in N.C.P.

	River Basin	Minor Schemes						Major Schemes			Annual Total (MCM)	Total Command Area (Ha)
		Area (Ha)	Cropping Intensity	Duty (m)		Water Utilization (MCM)		Area (Ha)	Water Utilization (MCM)			
				Maha	Yala	Maha	Yala		Maha	Yala		
1	Mahaweli Ganga (Part)	18211	1.0	1.0	-	182	-	31195	368	434	984	49406
2	Yan Oya	10898	1.0	1.0	-	109	-	3806	41	12	162	14704
3	Ma Oya	6977	1.0	1.0	-	70	-	4847	53	15	138	11824
4	Aravi	21439	1.0	1.0	-	214	-	15703	203	156	573	37142
5	Modaragam Aru	3169	1.0	1.0	-	32	-	1066	14	6	52	4235
6	Kala Oya	30739	1.0	1.0	-	307	-	10617	143	218	668	41356

NOTE: Water Utilization in Major Irrigation Schemes was taken from Table 13

Table 2.7 Estimation of average annual evapotranspiration

	NAME OF RIVER BASIN	NAME OF GAUGING STATION	CATCHMENT AREA AT GAUGING STATION (Sq.Km)	PERIOD	NO. OF YEARS	ANNUAL AVERAGE EVAPOTRANSPIRATION Ea (mm)
1	Mahaweli Ganga	Elahera	774	1946-1975	29	1222
2	Yan Oya	Horowpothana	746	1960-1993	28	1303
3	Aravi Aru	Kapachchi	2116	1948-1981	26	1290
4	Kala Oya	Rajangana	1564	1945-1964	16	1417

Table 2.8 Surface water availability of N.C.P.

	NAME OF RIVER BASIN	BASIN NO.	CATCH. AREA sq.km	AVG. RAIN FALL mm	OBSERVED STREAM FLOW AT STRATEGIC POINTS MCM					ESTIMATED FLOW VOLUME TO THE SEA - MCM				NO. OF GAU STA	BASIN ESTIMA
												ANNUAL TOTAL			
					LOCA-TION	CAT. ARE sa.km.	NE	SW	ANN. TOTAL	NE	SE	ESTI-MATED	NATIO-NAL ATLAS		
1	Kantalai Aru	61	451	1627	-	-	-	-	-	53.97	17.00	70.97	150	nil	Yan Oya
2	Pankulam Aru	64	381	1627	-	-	-	-	-	45.59	14.36	59.95	168	nil	Yan Oya
3	Yan Oya	67	* 1336	1661	Horowpo-thana	* 745.92	79.71	35.29	115.00	148.81	65.87	214.68	300	1	Yan Oya
4	Mee Oya	68	91	1615	-	-	-	-	-	10.81	3.40	14.21	28	nil	Yan Oya
5	Ma Oya	69	1036	1611	-	-	-	-	-	111.92	49.55	161.47	306	nil	Yan Oya
6	Parangi Aru	88	842	1488	-	-	-	-	-	66.95	16.80	83.75	273	nil	Aruvi Aru
7	Aruvi Aru	90	* 2958	1277	Kappach-chi	*1790.1 6	110.14	48.76	158.90	103.52	45.83	149.35	568	1	Aruvi Aru
8	Kal Aru	91	212	947	-	-	-	-	-	10.73	2.69	13.42	36	nil	Aruvi Aru
9	Moderagam Aru	92	643	1144	-	-	-	-	-	57.65	14.47	72.12	161	nil	Aruvi Aru
10	Kala Oya	93	2805	1362	Kala Oya Bridge	1948	289.04	127.95	416.99	390.01	172.65	562.66	587	1	Kala Oya

* Net catchment MCM = Million Cubic Meters NE = North East Monsoon SW = South West Monsoon

Regarding the trends in runoff series, the study shows a downward trend for runoff-rainfall ratios in both Ambanganga and Yan Oya basins. Further studies are needed to validate these results.

2.3.12 **Basin Water Balance**

The water balance results of the major basins in the NCP are shown in **Table 2.9.** In this exercise, return flow from irrigation is ignored as there are no quantitative data apart from assumed values of 15 to 20% adopted in design.

2.3.13 **Assessment of the Hydrometric Network**

A study of the hydrometrological network in the North Central Province indicates that rain gauges are more dense towards the South and thinner towards the North. The area under the study is about 17,000 sq.km and there are about 40 rain gauges within this study area. Therefore, the average network density is about 425 sq.km per rain gauge. However, there are only 6 stream flow gauging stations and 5 evaporation pans at present. The distribution of these networks is very poor. It was estimated for the entire study area that stream flow network density is 2800 sq.cm. and the evaporation network is 3400 sq.km.

While rainfall network density is satisfactory, the streamflow network density compared to other Asian countries is inadequate.

A set of improvements to upgrade the hydrology network in the NCP and a cost estimate to do that is suggested in **Annex 2.1**.

2.3.14 **Concluding Remarks**

i. **Rainfall Characteristics**

The predominant rainfall in the North Central Province (NCP) occurs during the north-east monsoon. The spatial variation in mean north-east monsoon seasonal rainfall is roughly one hundred percent from minimum to maximum with 1400 mm in the north-east to about 750 mm in the north-west. Thus, mean north-east monsoonal rainfall almost increases twice from north-east portion to north-west of the NCP. The mean south-west monsoon seasonal rainfall varies spatially between 750 mm in the south to about 250 mm in the north-west with a variation of two hundred percent between the maximum and minimum values. The coefficient of variation is more or less uniform throughout the NCP (0.234 to 0.311). The least endowed area in terms of rainfall occurrence is the north-west part of the NCP. Because of the large spatial variation in the mean seasonal rainfall, their use in planning and operation of the water resources systems must carefully consider local variation and distribution. In other words, location, specific rainfall data and their variation should be considered while planning and operating water development systems in view of their large spatial variations.

Table 2.9 Water balance in the N.C.P.

	BASIN NAME	CATCHMENT AREA sq.km	AVERAGE RAINFALL mm	RUNOFF FACTOR	ESTIMATED RUNOFF MCM	DIVERSION MCM	TOTAL RUNOFF MCM	WATER UTILIZATION MAJOR SCHEMES MCM	SURPLUS MCM	ESTIMATED RUNOFF FROM MEASUREMENT MCM
1	Mahaweli Ganga	* 3227	1600	0.45	2323	1512	3835	802	3033	N/A
2	Yan Oya	1538	1661	0.15	383	67	450	54	396	215
3	Ma Oya	1036	1611	0.15	250	-	250	68	182	161
4	Aruvi Aru	3284	1277	0.15	629	84	713	359	354	149
5	Modaragam aru	643	1144	0.15	110	-	110	20	90	72
6	Kala Oya	2805	1362	0.15	573	286	859	361	498	563

Note: * - Only a part of Mahaweli Catchment

ii. Streamflow Analysis

The analysis of seventy-five percent probability of annual streamflow for the five basins indicates that Mahaweli Ganga (Part) produces the highest runoff 0.780 MCM/sq.km while Malwathu Oya basin produces the least (0.040 MCM//sq.km) (**Figure 2.2**). This gives a ratio of roughly 20 between the highest and the least producing runoff/sq.km of basin area. Polonnaruwa District which lies in Mahaweli river basin, is a water rich district with roughly 10 times more runoff potential than Anuradhapura District. Anuradhapura is a less runoff producing district. As a major part of Polonnaruwa District is already developed and covered mainly under four large major irrigation tanks. Therefore, the strategy for water resources development in the NCP is to maximize productivity per unit of water in the Anuradhapura District while productivity per unit of land is to be maximized in the Polonnaruwa District.

iii. Diversion from Mahaweli Ganga

There is a substantial diversion of Mahaweli water into the NCP. The average 75% probable rainfall runoff in the NCP is 0.220 MCM/sq.km. The 75% probable diversion from Mahaweli to NCP is 0.390 MCM/sq.km. The above figures indicate that the NCP is augmented with 177 percent of its potential rainfall runoff from Mahaweli basin. This includes the water that was flowing into NCP before the construction of Mahaweli Ganga storage structures.

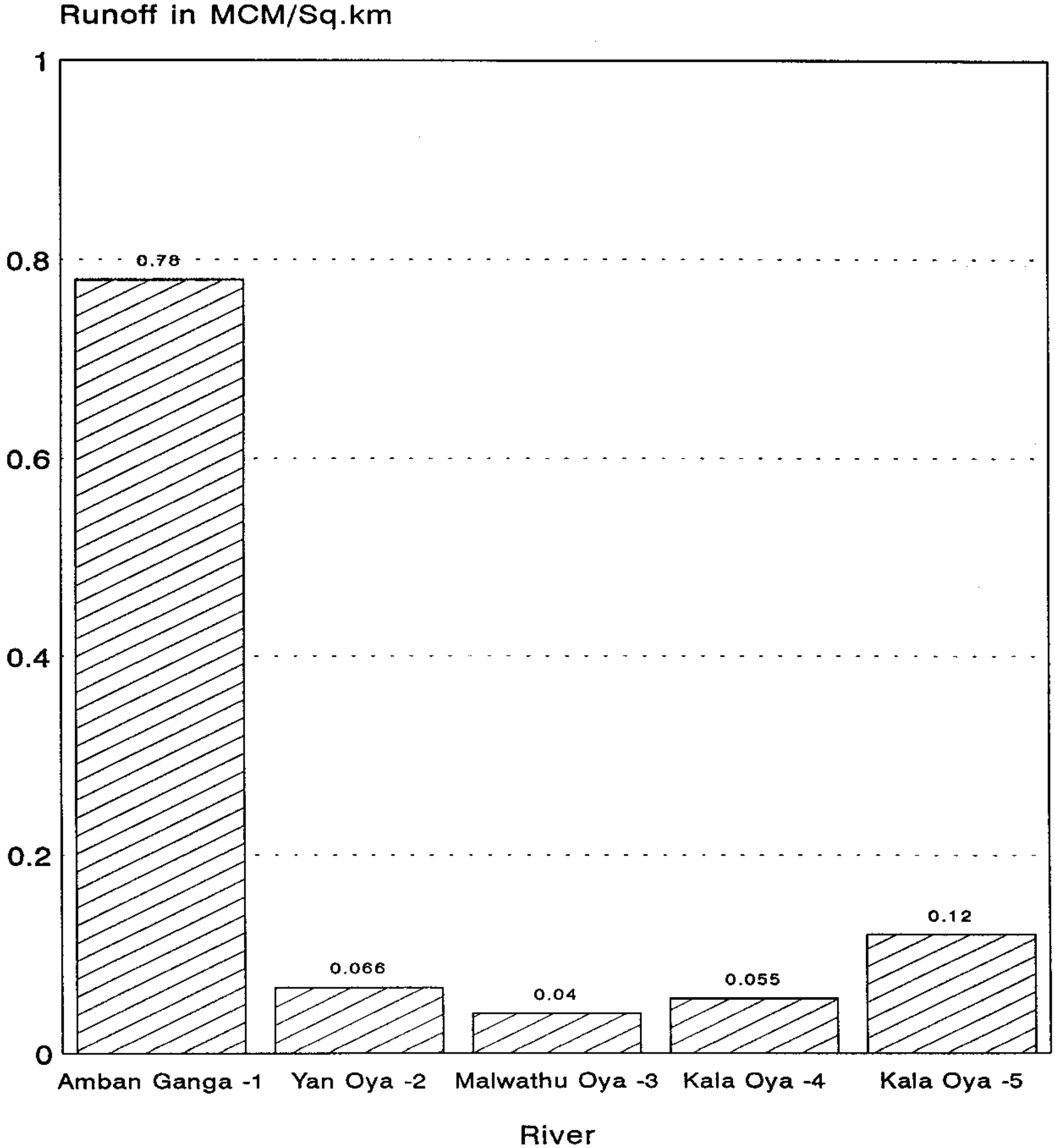
After the construction of Mahaweli storage structures, the average annual flow at Amban Ganga gauging station at Elahara had increased from 312 MCM to 800 MCM which is a 256% increment.

iv. Water Usage in River Basins

The average annual potential evapotranspiration (ETo) based on data for a four year period for Polonnaruwa District works out to 1558 mm. The average actual evapotranspiration based on water balance study for Mahawel river basin (based on Elahara gauge-catchment 774 sq.km) works out to 1222 mm. The ratio between actual and potential evapotranspiration is 0.79.

The actual average evapotranspiration in Polonnaruwa District is 1222 mm while in Anuradhapura District it is 1337 mm. The actual evapotranspiration in Anuradhapura District is roughly 10 percent higher than in Polonnaruwa District.

Figure 2.2 Annual River Runoff in the NCP



Guaging Stations
1. Elahara 2. Horowpatana 3. Kappachchi
4. Rajangana 5. Nochchiyagama

v. Present Water Use

The total surface water potential of NCP including diversion works out to 6217 Mm^3. Of this, 60% is in Mahaweli Ganga (mostly in Polonnaruwa District). The remaining 40% of the potential is distributed in 5 basins of Anuradhapura District. The present water utilization from major and medium tanks for irrigation is 2578 Mm^3. A major portion of the surplus is locked up in Mahaweli Ganga.

In terms of water available for further development Mahaweli Ganga stands first, followed by Yan Oya, Kala Oya, Aruvi Aru, Ma Oya and Modaragam Aru. Almost all the surface water potential in the four basins (except Yan Oya) in Anuradhapura District is utilized.

It is also to be noted that this study shows a downward trend for the runoff rainfall ratios in both Ambanganga and Yan Oya basins. The reasons for this downward trend needs further investigation.

2.4 Present Groundwater Use and Related Issues

2.4.1 Geological and Geomorphological Conditions of NCP

Anuradhapura and Polonnaruwa Districts form part of the crystalline basement complex of Sri Lanka. The hydrogeological conditions are similar to the hard rock areas of many other tropical regions. The description given below relates to Anuradhapura District only as Polonnaruwa District is copiously endowed with surface water and groundwater is not a major source of irrigation water.

Groundwater occurrence in the district is mainly associated with:

* weathered overburden of the basement rocks
* alluvial sediments
* bedrock when fractured, fissured and jointed or faulted.

a. Weathered Overburden

In most parts of the district, the bed rock is covered with an overburden of in situ weathered material of the parent rocks. The thickness and the composition of the overburden depends on the mineralogical composition of the parent rock, geomorphology of the location, and relative easiness for weathering of the parent rock.

The majority of dugwells in the district are constructed within the watershed overburden. The lower part of the overburden where the bedrock is moderately to slightly weathered, the formation is more sandy with less clay. Due to this the lower part of the overburden in many

places forms an aquifer with good permeability and porosity. The majority of the perennial dugwells in the district penetrate this part of the overburden.

A contour map showing the thickness of the overburden is shown in **Figure 2.3.**

b. **Alluvial Sediments**

Deposits of alluvial sediments are very limited in the District. Upto 5 meter thick recent alluvial deposits are found at some places along the banks of Kala Oya and Moderagam Aru. Due to limited scattered extent of such deposits and their location, the importance as economically usable water resources is limited.

c. **Bed Rock**

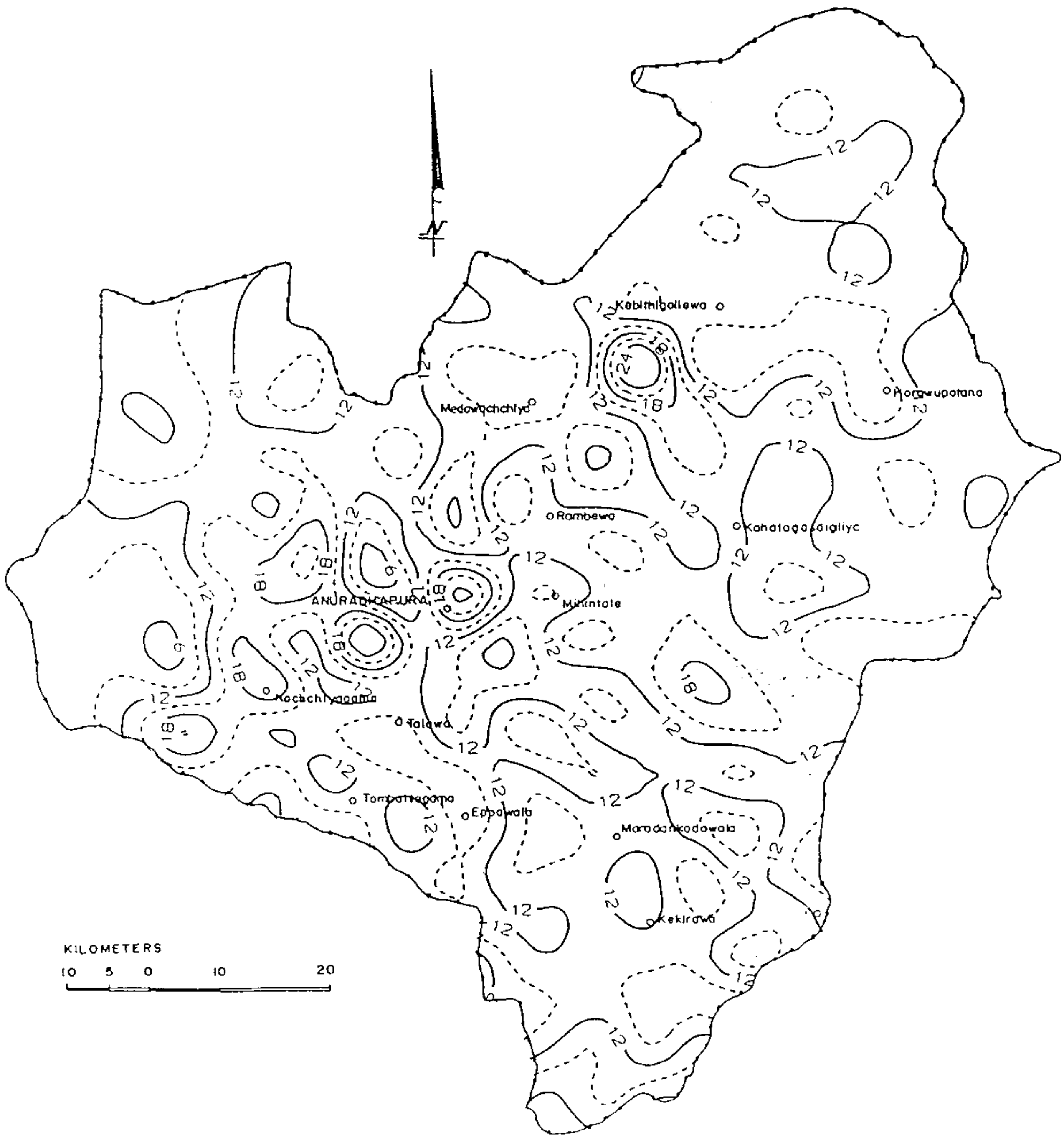
The district consists entirely of crystalline rocks such as charnockite and charnockitic gneiss, garnet-biotite - sillimanite gneiss, granitic gneiss, hornblende-biotite gneiss, quartzite and marble.

Basically there is no primary porosity in any of these rocks but a secondary porosity has been developed in all the rocks, however to varying degrees depending on the intensity of joining and/or fracturing of the rocks as a result of tectonic influence. Quartzite is the most intensively fractured and/or jointed rock and charnockite and charnockitic gneisses show only a limited number of joints. All other rock types show joint intensity between those of quartzites and charnockites.

2.4.2 Description of the Basins Taken up for Study

a. **Malwathu Oya Basin**

The basin is referred to as Malwathu Oya in the upper reaches and Aruvi Aru in the lower reaches. This is the second largest basin in the NCP (3668 sq.km) with about 1450 medium and mostly minor tanks. The basin depends entirely on the NE monsoonal rainfall and the average annual precipitation is 1400 mm. The upper segment of the basin is fairly well developed with the large reservoirs, rice lands, villages and several minor irrigation works all over the area.



NB: The calculation of contour lines is based on casing depth of 1252 wells.

Figure 2.3 - Contour map showing thickness of overburden (casing depth) in meters.

The basin area is underlain mainly by charnockites which are generally associated with granitic and gneissic bands, granite, quartzite and pegmatites are other types of rocks found in the area.

The following Malwathu Oya sub-basins were studied in detail: MAL-1, MAL-2, MAL-3, MAL-6, MAL-7, MAL-8 and MAL-10.

b. **Modaragam Aru Basin**

Modaragam Aru has its source near Anuradhapura and flows westward by the Wilpattu National Park, separating the Puttalam and Mannar districts reaching the sea at Marichchukaddi. The catchment areas of the Modaragam Aru basin is about 932 km^2. Besides a few village tank projects in the upper catchment close to Anuradhapura, the flow in the Aru is impounded at Maha Vilachchiya. The detailed study was undertaken in MO-1 basin having an area of about 412 km^2.

c. **Kala Oya Basin**

Kala Oya has its source near Nalanda and flows for 155 km in a north-westerly direction passing Dambulla, Kalawewa, Rajangana and reaches the sea near Ponparippu. The Kala Oya drains an area of over 1600 km^2 and its water is impounded at the Kalawewa tank and again at Rajangana reservoir. The K-6 sub-basin was taken up for detailed investigation.

d. **Ma Oya Basin**

Ma Oya, a 64 km long river commences at Kahatagasdigiliya area, passes through Kebithigollewa and Padaviya region and finally reaches the sea at Kokilai lagoon. It has an extent of 1024 km^2.

Two sub-basins, MA-1 and MA-2 were studied in detail.

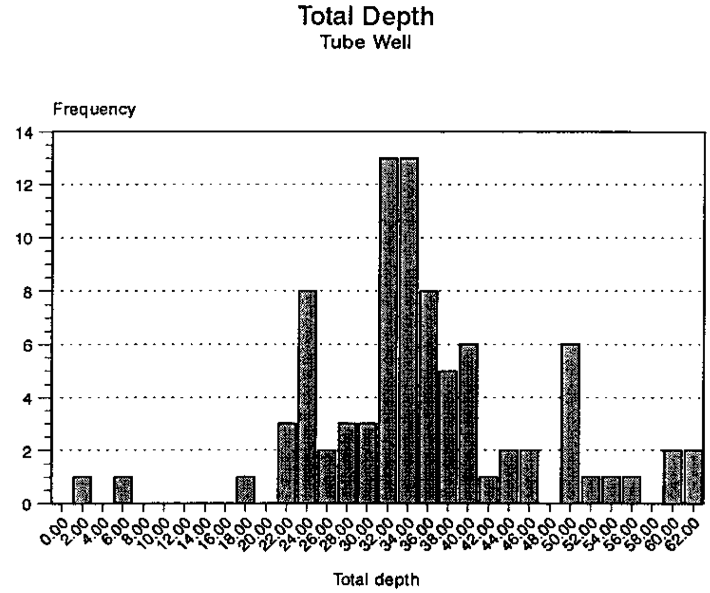
e. **Yan Oya Basin**

The entire Yan Oya basin is in the dry zone and is 1520 km^2 in extent. The mainstream Yan Oya rises in the hills near Dambulla and after being impounded at Huruluwewa flows a length of 150 km to reach the sea south of Pulmoddai. There are several minor tanks dependent on the flow of its tributaries, particularly in the upper reaches of the catchment. Y-1, Y-2, Y-3 and Y-4 are the sub-basins taken up for detailed study.

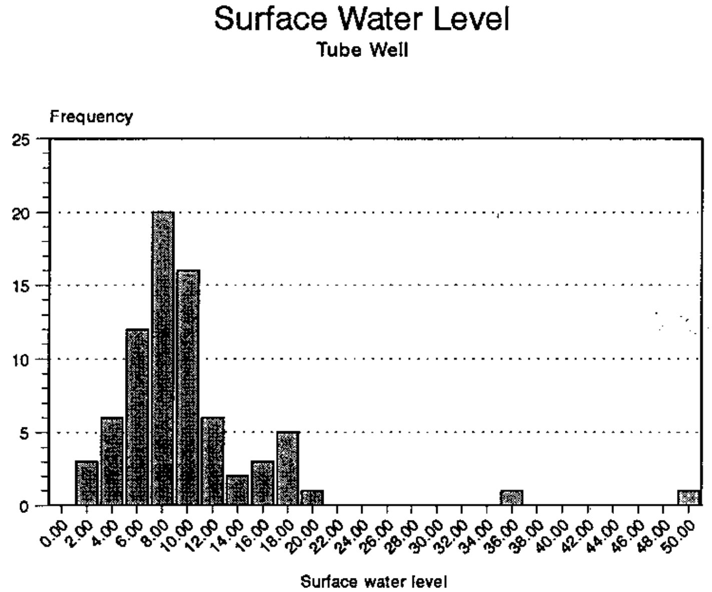
2.4.3 Analysis of Tubewells and Dug Wells in the Study Area

The tubewells in the sub-basins taken up for study were analyzed for total depth, surface water level below ground, tube well yield. They are shown in **Figure 2.4**. The dominant depth of tubewell varies from 32 to 36 m; the depth to surface water level from ground varies between 8 to 10 m; and the predominant will yield varies between 10 to 30 lpm.

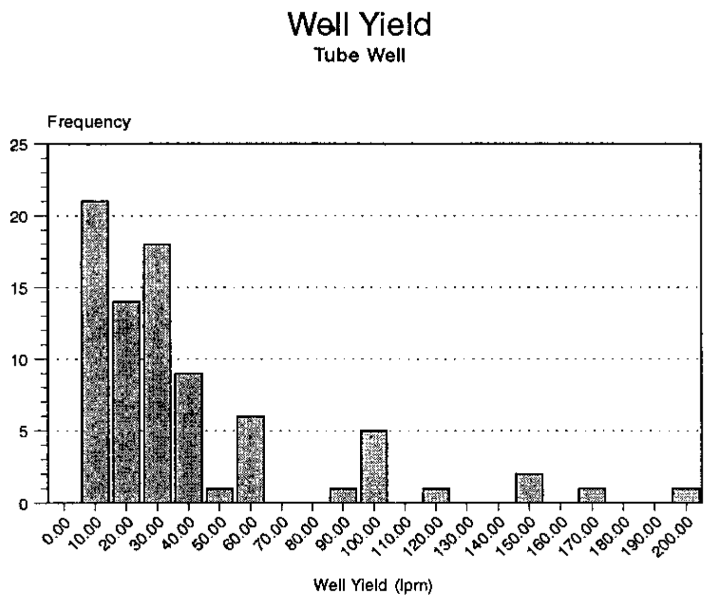
Figure 2.4 Analysis of tube wells of the NCP



Sample Size - 85



Sample Size - 76



Sample Size - 80

A similar plot (**Figure 2.5**) for agro wells in terms of its total depth, surface water level below ground and well diameter indicates: The total depth varies between 3.5 to 8 m with predominant depth occurring at 5 m; the depth of water surface below ground level varies between 2.5 to 6.0 m with predominant depth at 5 m; the well diameter varies between 5 to 7 m with predominant diameter occurring at 5.50 m.

2.4.4 Assessment of Groundwater Recharge

The water input to the groundwater aquifers is due to groundwater recharge. Therefore, the assessment of annual groundwater recharge is important for determining safe yield from groundwater aquifers. Any continued abstraction, over and above the average annual groundwater recharge, will lead to a permanent lowering of the groundwater table and a gradual depletion of the aquifer.

Groundwater recharge can be assessed using different approaches. An approach based on field observations of water level fluctuations is commonly used. The principle for calculating recharge by this method is that recharge causes a rise in the groundwater level which is directly proportional to the recharge and inversely proportional to the specific yield of the aquifer in question. The specific yield, in practice, may be considered to equal the effective porosity or drainable pore space of the aquifer.

A plot of groundwater level fluctuation as a function of time in tubewells is shown in **Figure 2.6** (Source COWI Consultant). The horizontal axis represents time, while the vertical axis shows the measured water levels expressed in meters below ground level. At the start of the monitoring period the water levels in the wells varied from only 1.2 meters below ground level to more than 10 mbgl. Such differences may be explained by local conditions such as topography, distance to water bodies like tanks or irrigation canals and hydrogeological properties of the water bearing rocks.

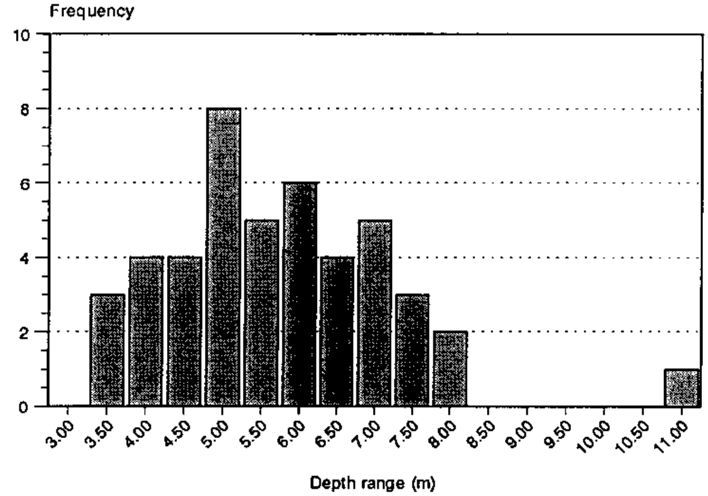
Only minor fluctuations in water level were observed from July upto October. However, at the end of October, when the rain intensity increased and significantly exceeded the evaporation, a very noticeable rise in water level was observed in all wells.

The recorded rise in water level varied from approx. 1 meter to 4.5 meter. Four of the wells showed an increase in water level from 3.0 to 4.5 meters within a period of two months. The small rise in water level in one well is due to the fact that the well is located close to a tank where recharge by seepage from the tank is likely to have a stabilizing effect on the water level.

The highest and lowest water level attained in dug wells can also be used to compute the average water level fluctuations. The frequency distribution of water level fluctuations from the perennial dug wells was found to follow a log-normal distribution with a calculated average fluctuation of 3.9 meters. This confirms the order of magnitude of groundwater level fluctuations in the Distract as recorded from the monitoring wells.

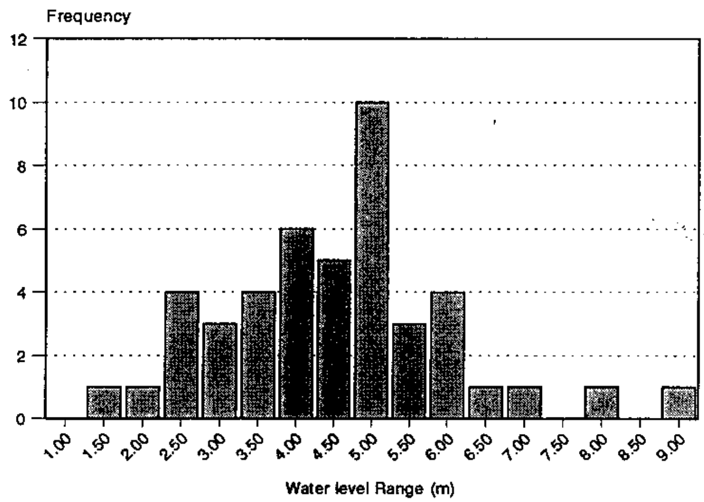
Figure 2.5 Analysis of dug wells of the NCP

Total Depth
Agro Well



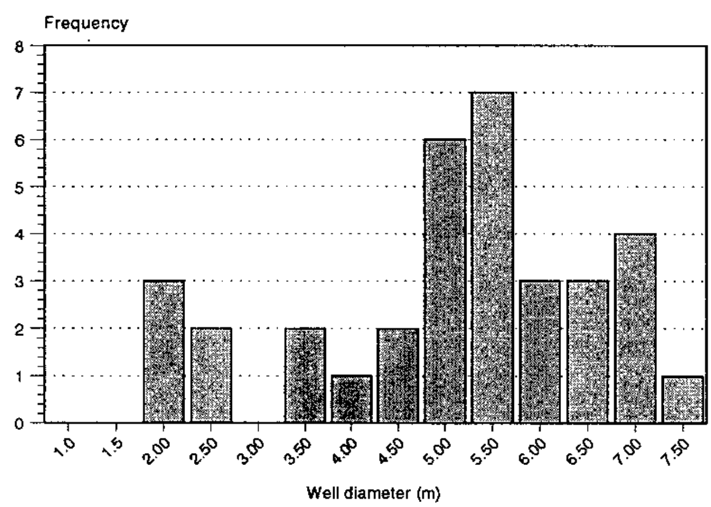
Sample Size - 45

Surface Water Level
Agro well



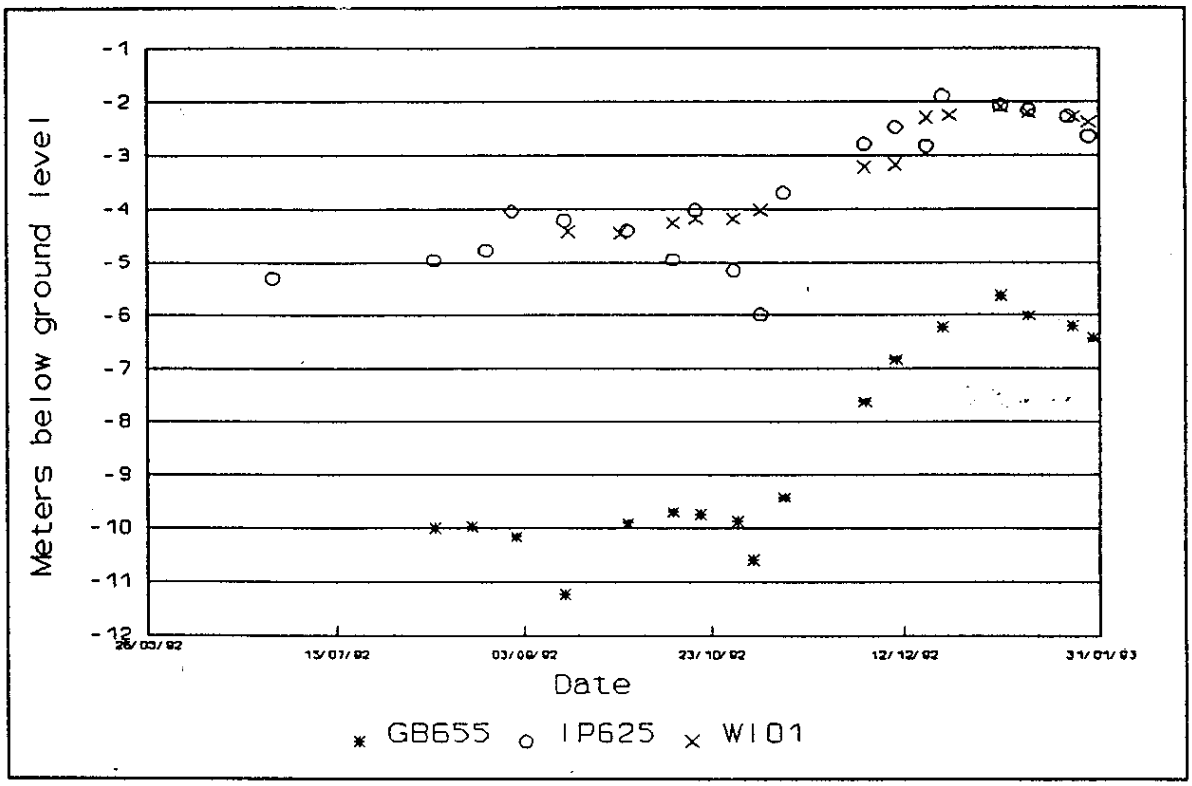
Sample Size - 45

Well Diameter
Agro Well



Sample Size - 34

Figure 2.6 Fluctuation of the ground water table in the NCP



For the purpose of recharge calculation, we can assume a water level fluctuation of 4.0 meter.

Available literature gives estimates for specific yields for different aquifer materials. For prevalent rock types in Anuradhapura District specific yields in the range from 2 to 4% are considered in the following computation.

By applying these values for specific yields and the water level rises mentioned above, the following calculations can be made:

Water level rise	Recharge if S=2%	Recharge if S=4%	Average
4.0 m	80 mm	160 mm	120 mm

A recharge of **120 mm/year corresponds to roughly 10 percent of the total annual average** precipitation. Because of the year to year variation in rainfall, the recharge can vary from **57 mm to 219 mm.** This variation interval corresponds to a potential variation in the level of groundwater table of 4.1 to 8.1 meters when considering areas with storage coefficients of 0.04 and 0.02 respectively. This has the implication that even during the time of the year (January) when the groundwater table is expected to be at its highest, there could be a variation of 4.1 meters to 8.1 meters between two extreme years. The likely variation are 2.0 meters to 4.0 meters when relating the values to the average groundwater level.

2.4.5 Groundwater Budget

To make a comprehensive groundwater budget, necessary data set is not available for the study area. However, an attempt is made to estimate on a crude basis the balance groundwater potential available in the sub-basins studied.

The average annual rainfall of the NCP area is reported as 1400 mm. This figure is used for calculating the total annual recharge of the sub-basins. Based on the topography, evaporation, evapotranspiration and soil type, a net recharge percentage of 7 (7% of annual average rainfall) was assumed. Therefore, net annual average recharge in the basin studied works out to 98 mm.

From the existing pumping data, the present extraction rate is worked out and subtracted from the potential to get at future potential for development. The computed values are presented in **Table 2.10**.

Table 2.10 Groundwater budget

SUB BASIN	CALCULATED TOTAL RECHARGE *10^5 (M^3/day)	NET RECHARGE *10^4 (M^3/day)	PRESENT EXTRACTION RATE *10^2 (M^3/day)	FUTURE POTENTIAL FOR DEVELOP-MENT *10^3 (M^3/day)
MO-1	16.0	11.2	70.0	105.0
K-6	2.6	1.8	5.4	17.0
MAL-1	11.0	7.5	15.0	7.4
MAL-2	6.3	4.4	4.5	44.0
MAL-3	7.3	5.1	4.8	51.0
MAL-6	5.4	3.8	D.N.A.	-
MAL-7	4.1	2.8	D.N.A.	-
MAL-8	94.0	6.5	D.N.A.	-
MAL-10	2.6	1.8	D.N.A.	-
MA-1	16.0	11.0	360.0	74.0
MA-2	6.6	4.6	380.0	80.0
Y-1	7.3	5.1	D.N.A.	-
Y-2	7.8	5.4	D.N.A.	-
Y-3	4.3	3.0	D.N.A.	-
Y-4	61.0	4.2	D.N.A.	-

D.N.A. - Data Not Available

2.4.6 Groundwater Related Issues

Groundwater related studies relating to the NCP are few and the data base is scanty. Even among the few studies carried out, there are differing opinions with regard to groundwater potential, its extraction and use. These differences are a manifestation of weak data base with which certain conclusions are arrived at. Groundwater occurrence in a hard rock aquifer is not distributed evenly due to hydrogeologic conditions of the aquifer such as weathered overburden, fractures, faults and fissures. Therefore, any conclusion based on averages and macro-estimation will lead to erroneous conclusions.

It is suggested that groundwater estimated should be based on either at sub-basin or cascade level to limit the variability of hydrologic and hydrogeologic parameters. A reliable groundwater budget for each cascade/sub-basin must be carried out before we can conclude

whether groundwater extraction through agrowells should be carried out or not. Also a systematic procedure for monitoring groundwater level fluctuations need to be put in place. Unless and until we develop a sufficient data base for each sub-basin/cascade, any attempt to predict the balance groundwater potential will lead to erroneous conclusions. Immediate steps must be taken to collect necessary groundwater related data through a well designed groundwater exploration and monitoring mechanism. A detailed study of the ground water in the NCP, conducted using the limited available data, is presented in the **Annexure 2.2**.

2.5 Present Status of Water Quality

In order to assess the present status of surface (tanks and stream) waters and shallow ground waters (dug wells), water sampling was carried out at the end of the dry season from the following sampling sites:

	Sites	No. of samples
Surface Water	Mahaweli Feeder Canal	2
	Major tanks	7
	Medium tanks	10
	Cascade (small) tanks	10
	Fourth order streams	8
	Third order streams	6
		43
Drainage water of	Major tanks	5
	Medium tanks	9
		14
Shallow Ground Water Open wells	Agro wells under major tanks	8
	Agro wells under medium tanks	8
	Agro wells under cascade tanks	18
		34

All the 91 water samples were analyzed for the following constituents ph, conductivity sodium, potassium, calcium and magnesium. From the preliminary results of these 91 samples, 66 samples were selected for analysis of the following additional constituents-nitrate, chloride, phosphate, and carbonate/bicarbonate. The method of analysis and results of analysis are reported in Tables of **Annexure 2.3**. The summary results are given below in **Table 2.11** including the calculated SAR values as well as the salinity class according to U.S.B.R. standards.

Table 2.11 Summary of results of the water quality study

	pH	EC	Na	K	Ca	Mg	No3	CC	P04	HC03	SAR	Salinity Class Mean
1. SURFACE WATER												
Feeder Canal	6.95	0.09	2.7	0.8	2.0	2.7	ND	ND	ND	ND	0.25	1
Major tanks	8.1	0.61	74	3.9	11.5	12.8	1.7	103	2.3	155	3.4	2.15
Medium tanks	8.1	0.85	102	5.6	13.2	14.5	1.4	134	2.5	200	4.7	2.6
Cascade tanks	7.8	1.28	142	21.1	18.6	15.2	3.3	205	3.8	117	6.2	2.9
Fourth order stream	8.2	1.25	157	4.7	30.0	20.1	2.9	243	2.7	309		
Third order stream	8.2	2.20	273	9.8	36.9	48.0	1.2	290	4.4	361	6.8	3.3
2. DRAINAGE WATER												
Major tanks	8.2	1.23	153	4.8	23.2	26.3	2.0	173	2.6	297	5.5	3.2
Medium tanks	8.1	1.20	143	4.2	25.6	22.4	1.8	190	4.5	350	5.0	3.2
3. SHALLOW GROUND WATER												
Agrowell: Major tanks	8.2	0.98	106	2.3	23.1	15.7	3.5	132	1.3	291	4.2	3.0
Agrowell: Medium tanks	6.2	1.0	85	0.6	23.4	20.7	2	139		356	3.5	3.0
Agrowell: Cascade tanks	8.0	1.56	121	0.2	37.2	32.2	3.8	300		349	3.4	3.1

The results as discussed against quality standards for (a) irrigation water and (b) potable water.

2.5.1 **Irrigation Water Quality**

The irrigation water quality standards adopted in Sri Lanka are the same as the USBR standards which are as follows:

Class	E.C. mmhos/cm	Salinity/hazard
1	0.01 - 0.25	Low salinity hazard
2	0.25 - 0.75	Medium salinity hazard
3	0.75 - 2.25	Medium high salinity hazard
4	2.25 - 4.00	High salinity hazard

In addition, the sodium absorption ratio (SAR) which is the ratio of sodium to calcium plus magnesium ions gives an indication of increasing sodium hazard with rising salinity levels. Irrigation waters with SAR values up to 8.00 are considered safe for irrigation.

As could be seen in **Table 2.11**, EC values of feeder canal water fall within Class 1, while major tank waters fall within Class 2, and medium and cascade tank waters fall within Class 3. Correspondingly, the SAR values increase from 0.25 to 6.2. Although there is a significant increase in sodium content as one proceeds from the major tanks to the cascade tanks, the irrigation water qualities are well within the boundaries of safe quality even though sampled at the end of the dry season.

As could also be seen in **Table 2.11**, there is a further increase in the EC values and sodium values in the waters of the third and fourth order streams. This too is not surprising considering the samples were taken at the end of the dry season when concentration of soluble ions reaches the highest values. However, these values are well within the safe limits of quality for irrigation water.

The drainage waters of the major tanks show double the EC and sodium values of the main tank water; and the drainage waters of the medium tank show a fifty percent higher value than the tank water. However, the SAR values are well within the acceptable limits.

As could also be seen in **Table 2.11**, there is only a small difference in the EC values and sodium values between the shallow ground water located under the command or influence of the major, medium and cascade tanks. Waters of agro wells under all three categories fall within Class 3 salinity hazards. These values again are for sampling done at the end of the dry season. Results of wet season sampling which will be carried out in early December would be available later.

2.5.2 **Potable Water Quality**

The chemical requirements for potable water as given in the Sri Lankan Standard Specification for Potable Water (SLS; 1983) is given below:

Parameter	**Unit**	**Minimum desirable level**	**Maximum desirable level**
pH	-	7.0 to 8.5	6.5 to 9.0
Conductivity	mmhos/cm	0.75	3.5
Nitrate	mg/l	-	45
Chloride	mg/l	200	1200
Phosphate	mg/l	-	2.0

As could be seen in **Table 2.11**, the quality of surface waters of all categories of tanks fall within the potable quality standards in respect of pH, conductivity nitrates and chlorides. The chloride content of the third and fourth order streams is slightly above minimum desirable level but well below the maximum level. Waters of the third order streams and drainage from medium tanks show a high phosphate value which is understandable in terms of their flush out position in the overall landscape.

CHAPTER 3

REVIEW OF PAST AND ONGOING IRRIGATION REHABILITATION ACTIVITIES

3.1 Introduction

The purpose of this chapter is to provide an overview of the selection, planning, design and implementation approaches adopted in tank rehabilitation in the NCP under a number of past and ongoing tank rehabilitation projects and address some key issues that emerge from lessons and experiences from those projects as a prelude to the planning of the proposed area development project. This section covers the lessons and issues that emerged from major tanks rehabilitation, specifically from Tank Irrigation Modernization Project (TIMP) and Major Irrigation Rehabilitation Project (MIRP) funded by the World Bank and the Irrigation System Management Project funded by the ISMP, which aimed at rehabilitating major projects. In addition, this section provides the main issues emerged from the lessons and experiences from minor and medium tank rehabilitation, particularly the Anuradhapura Dry Zone Agricultural Development Project (ADZAP) funded by IFAD, Village Irrigation Rehabilitation Project (VIRP) and the National Irrigation Rehabilitation Project (NIRP) funded by the World Bank and the rehabilitation work undertaken by the Sri Lanka Freedom from Hunger Campaign Board (FFHC), which aimed at the rehabilitation of small tanks.

3.2 Major, medium and minor(small) tanks

In Sri Lanka, reservoirs (tanks) are classified as "minor", "medium" and "major" on the basis of the designed command area served by tanks. According to the classification of the Irrigation Department of Sri Lanka, a minor tank is one having an irrigated command area lees than 80 ha (200 acres), a medium tank is one having a command area more than 80 ha but less than 810 ha (2000 acres) and a major tank is one having more than 810 ha. Minor tanks are also called as "indigenous systems", "village tanks" and "small tanks".

3.2.1 Major and medium irrigation schemes

The NCP includes about 15 major irrigation systems and 76 medium irrigation systems of which details are given in **Chapter 5.** The management of major systems are shared between the Mahaweli Authority of Sri Lanka and the Irrigation Department, whilst the management responsibility for the medium systems are the responsibility of the Irrigation Department.

3.3 Experiences and lessons learned from major irrigation rehabilitation projects

Under the three major rehabilitation projects the following major schemes were rehabilitated.

Name of Project	Systems Rehabilitated	Period
TIMP	Mahawilachchiya, Mahakandarawa Padaviya	1978 - 1983
MIRP	Nachchaduwa, Rajangana, Huruluwewa	1983 - 1992
ISMP	Giritale, Minneriya, Kaudulla, PSS	1987 - 1995

3.3.1 Tank Irrigation Modernization project (TIMP)

(a) Project features and assumption

A number of pre-project and post-project evaluation reports of the TIMP are available (Abeysekara, 1993, Abeysekara, 1986a and 1986b, Kariyawasam et al, 1984, Murray-rust and Rao, 1987a and 1987b). The TIMP covered an irrigated extent of 12753 ha under five major schemes, out of which 8543 ha were under three major tanks (Mahawilachchiya, Mahakandarawa, and Padaviya) in the NCP. The project conceived three major constraints hindering agricultural productivity, production, and net farmer income namely: (i) inefficient use of maha seasonal rainfall and wasteful use of irrigation water; (ii) poor agricultural extension facilities; and (iii) unsatisfactory farm roads causing difficulties in efficient marketing. It envisaged increases in: the annual cropping intensity from 83 percent to 170 percent within a period of five years; rice yields during maha season from 1.7 tons per ha to 3.4 tons per ha; the extent cultivated in yala season by four and a half times (ex in Mahawilachchiya scheme from 81 ha to 365 ha); area under non-rice crop in yala by seven times in five years; net farm income from Rs.2850 at pre-project level to Rs 7650 to a post-project level.

The rehabilitation planning and design assumptions much relied upon the efficient use of maha seasonal rainfall for rice cultivation coupled with dry sowing of land for short-season rice varieties under strict water management though rotational delivery of water as the primary means of achieving the project objectives. The canal system designs were modified to suit the design assumptions accordingly.

The planning approach of the TIMP was regarded as a rigid top-down approach with less involvement and consultation of beneficiaries before the specific rehabilitation proposals were framed. Even at the implementation stage, no effective mechanisms were in place to accommodate the logical needs of farmers in respect of location-specific as well as general modifications in rehabilitation designs and interventions.

(b) **Impact of the Project**

Post-project impact evaluation studies of the TIMP (Abeyasekara 1993) reported that despite large capital expenditure, the actual performance of the TIMP was not very satisfactory. The package of technology and solutions offered by the project was rejected by the farmers. Another study (Kariyawasam et al, 1984) concluded that as a result of the short-sighted attempt to rehabilitate a large number of small tanks in Mahakandarawa tank, the water availability for irrigated farming under that tank was seriously affected. This study signalled the importance and urgent need for a more rational approach of water resources management in the NCP. The cascade-based watershed approach suggested in this report for water resources management in the NCP now provide a technical base for operationalizing a rational water resources management approach under the ADB-funded Area Development project for the NCP.

Murray-rust et al 1987a and 1987b concluded that uncertainty of water and lack of proper marketing arrangements were major constraints for both crop diversification and the adoption of non-rice crops. Although, the specific lessons emerging from TIMP did not provide very positive results, the project clearly demonstrated that the technical feasibility of a development strategy alone is not sufficient to guarantee success without the need for economic feasibility of the operational plans as judged from the beneficiaries perspective.

3.3.2. Major Irrigation Rehabilitation project (MIRP)

(a) **Project features and assumption**

When compared with the TIMP, a few evaluation reports and literature are available in respect of MIRP (Abeysekara,1993, Agriswiss, 1990, and ARTI,1989). However, The MIRP covered a total project area of 46,240 ha of irrigated land and seven major systems, out of which 15400 ha of lands were under three major tanks in the NCP (Huruluwewa, Nachchaduwa and Rajangana). The project, similar to the conventional major rehabilitation projects conducted in the country, primarily aimed at increasing agricultural production under irrigated conditions mainly through water control and management. The project identified the need to: (i) rehabilitate the physical irrigation systems to facilitate optimum utilization of water; (ii) develop institutional arrangements in each irrigation scheme to promote farmer-focused, participatory management of irrigation to complement optimum utilization of water and operation and maintenance of rehabilitated irrigation systems; (iii) rehabilitate farm roads; (iv) regularize encroachments of reserved and state lands for cultivation; (v) strengthen agricultural support services and facilities; and (vi) undertake scientific studies on catchment management and socio-economic aspects of the schemes included in the project.

(b) **Impact of the Project**

Agriswiss 1990 highlighted a number of significant problems from the irrigation development point of view due to which the planning and design of rehabilitation were affected.

Those include: (i) non-availability of reliable irrigation system infrastructure data required for designing canal layouts, preparing water delivery schedules, assessing irrigable areas etc.; (ii) inadequate attention paid to the causes of earlier failures and deficiencies in irrigation schemes; (iii) rigid adherence to standardized designs leaving little room and flexibility for adaptations to suit specific local and site conditions; and (iv) inflexibility of the system design process that did not allow changes in relation to actual needs of the farmers as well as of the systems.

Abeysekera 1993 reports that in spite of the heavy expenditure incurred on the rehabilitation of the major irrigation systems and the establishment of institutional arrangements to complement O & M of the systems, the irrigation strategy adopted by the project was unlikely to deliver significant improvements in the long run. For example, the information available with the Irrigation Department shows a wide disparity of water consumption for rice cultivation in maha seasons, which did not show a tangible reduction in water use in the schemes rehabilitated under MIRP, except in Huruluwewa scheme in maha 1994/95 season. The problems of defective structures and water distribution too have been identified after the implementation of the project.

The reduction of water saving in Huruluwewa has resulted due to a more intimate and intensive seasonal planning and water management approach adopted in Huruluwewa scheme by the Shared Control of Natural Resources (SCOR) project under a participatory action-research mode. The intervention at Huruluwewa was a package of well integrated technical and institutional elements implemented through a team including irrigation agency staff and farmers. The intervention resulted in very effective utilization of rainfall and efficient management of water resulting in a seasonal tank duty of 0.67 m (2.2 acre.ft per acre) which was the lowest maha seasonal duty recorded for Huruluwewa scheme as well as for all major irrigation schemes in that particular season. The process and the results are documented (SCOR, 1995).

In respect of the agricultural benefits received from MIRP, the results were not encouraging in respect of cropped area, cultivation intensity, crop yields, and shift towards high-value crops (Abeysekara 1993). In fact, while non-rice crops are cultivated large scale in yala under the major schemes in the NCP managed by MASL, the trend of shift to non-rice crop is rather slow in the schemes managed by the Irrigation Department. The underlying cause for this slow trend appears to be an institutional issue rather than a technical issue. The evaluations conclude that it is most unlikely that the production targets contemplated under the MIRP are achieved.

In respect of the organizational and institutional benefits contemplated under the MIRP, the project management arrangement established with support from the MIRP facilitated the seasonal planning of cultivation, conflict resolution in O & M and water distribution to some degree (ARTI, 1989).

3.3.3 Irrigation System Management Project (ISMP)

(a) Project features and assumption

The ISMP covered a total project area of 76,537 ha of irrigated lands under six major systems, out of which 34,634 ha were under four major schemes (PSS, Giritale, Kaudulla and Minneriya) in the NCP. The project was designed on the basis of two implicit assumptions that: (i) the relatively low productivity of major irrigation schemes was due to institutional and management problems, particularly the lack of farmers' participation and other "software" problems affecting the irrigation settlement schemes (Abeysekara, 1993); and (ii) that if the irrigation systems are to be handed over to farmers organizations for joint and self management, then the irrigation systems should be upgraded with essential structural improvements as a necessary condition for effecting self and joint management as well as system turnover.

The ISMP included six major project components, namely: (i) establishment and strengthening of farmers' organizations; (ii) improvement of operation and maintenance of irrigation systems; (iii) enhancing financial management capabilities if farmers and others who are dealing with O & M fees and other sources of funds; (iv) Monitoring and evaluation of project activities and feedback; (v) enhancing training capacity; and (vi)applied research into the working of the project with a view to providing feedback information and improved guidelines.

The project costing was done for attending to pragmatic rehabilitation and undertaking the essential structural improvements. Thus, unlike in TIMP and MIRP, flexibility, and consequently funds, were not allocated for undertaking a full scale rehabilitation of the entire system. Under the concepts of pragmatic rehabilitation and essential structural improvements the estimated project costs, as at 1984 rates, were Rs 446/ha for essential structural improvements and Rs 175/ha for pragmatic rehabilitation. As a result, the project funds were not available for improving on-farm and internal road networks as well as drainage canals. The Irrigation Department now feels that there is a bulk of residual items of work, particularly in respect of on-farm and internal roads and drainage canals, remain to be done in order to ensure the higher productivity envisaged under the projects.

3.4 Key lessons learned

This section presents a brief overview of the lessons learned from the above three major irrigation rehabilitation projects as well as from the Uda Walawe Irrigation Improvement Project (WIIP) funded by the ADB and the Galoya Water Management Project (WMP) funded by the USAID. Based on the lessons a few recommendations are made for consideration for framing major tank rehabilitation proposals for the proposed Area Development Project of the NCP. Detail information on the lessons are available (Abeysekera 1993, Brewer et al 1993).

3.4.1 Evaluation of the sample projects

The analysis given below compares various aspects of the five projects to determine which features help ensure cost-effectiveness. For purpose of analysis, the five Rehabilitation and Modernization (R&M) projects are categorized on the basis of cost-effectiveness using traditional economic analysis.

Table 3.1 gives estimates of the benefit/cost ratios and internal rates of return (IRR) for the five projects. These figures are not definitive. The data needed to conclusively judge the economic soundness of these projects, three of which are not yet completed, are not available. However, these figures support the following categorization of projects:

a. TIMP was probably not cost-effective. The two systems listed include Mahawilachchiya whose performance is considered excellent by many specialists but whose construction costs were very high. Mahawilachchiya also has good water availability. In the other scheme, Mahakanadarawa, cultivation has failed in most seasons for lack of water. Analysis of the three other systems rehabilitated by TIMP might change the picture but that would probably not change the conclusion.

b. WMP focused on only one system -- Gal Oya left Bank -- then the largest system in the country. These figures show that WMP was cost effective, a conclusion that agrees with the end-of-project evaluation.

c. MIRP is an on going project rehabilitating four systems; hence the figures given here cannot be taken as final. However, these figures show that MIRP has had significantly different results under different conditions. In particular, the Huruluwewa Scheme has severe water availability problems while Rakangana, on the other hand, has no shortage of water.

d. As shown by the figures, ISMP is probably a cost-effective project. However, rehabilitation construction on the ISMP systems will continue for some time though the main portion of the project has been completed. The two systems listed here are reasonable representatives of the six systems where ISMP work has been carried out. Analysis of the others would probably not change the conclusion of the authors. The difference between the two schemes can be explained by the greater improvement in equity of distribution in Kaudulla than in Minneriya. Historically, Kaudulla has had greater head-tail problems than Minneriya.

Table 3.1 Actual B/C ratios and IRR for major irrigation rehabilitation projects

Project	Scheme	B/C ratio	IRR
TIMP	Mahawilachchiya	0.56	—[1]
	Mahakanadarawa	0.21	—[1]
MIRP	Rajangana	1.30	16.4%
	Huruluwewa	0.67	—[1]
WMP	Gal Oya Left Bank	1.57	33.0%
ISMP	Kaudulla	2.24	30.0%
	Minneriya	1.29	16.5%
WIIP	Uda Walawe	—[2]	8.0%

[1] The IRRs for these schemes were negative. [2] No B/C ratio calculated.

Notes: B/C ratio = Benefit/Cost ratio.
IRR - Internal rate of return

Sources: For TIMP, MIRP, WMP, ISMP: ECD/ADRC 1992
For WIIP: IIMI 1990

e. WIIP is still underway but it will probably not be cost-effective, in large part because the work done and planned will not bring any significant additional area under cultivation. Unlike the other figures, the IRR figure shown for WIIP is not a current estimate but one made by IIMI in 1990.

Based on this evidence, WMP and ISMP are categorized as cost-effective, TIMP and WIIP as not cost-effective, and MIRP as unsure. The following subsections explain some reasons for these results.

3.4.2 Project Components: Balance between hardware and software

A key finding is that the five R&M projects have placed very different emphases on different components. All five of the projects included the following major components:

a. Physical works including earthwork on canals, the rebuilding of concrete and masonry structures, and the building of new structures.

b. Design of a new operations system.

c. Design of a new management structure, sometimes incorporating some farmer involvement (institutional development)

In addition, some projects have included other components some of which are:

1. Agriculture improvements (TIMP, ISMP, MIRP)

2. Roads and other rural infrastructure (TIMP, MIRP, WIIP)

3. Research (ISMP, WMP,WIIP, MIRP).

All of the projects also included training and other support for the major components.

However, the resources allocated to the components have differed significantly among the various projects. **Table 3.2** shows an estimated breakdown among major components for the five projects.

Table 3.2 Major cost components of the projects (in percent)

Major component	TIMP	WIIP	MIRP	WMP	ISMP
1. Physical works	67	90	70	63	63
2. O&M systems	1	3	8	13	13
3. Institutional development	0	0	7	18	15
4. Others	32	8	15	6	9
Total	100	100	100	100	100

Note: The authors have found it very difficult to allocate project costs among these various components because accounting has not been done in these components. The figures given in the Table are based on information available on component breakdown and the authors' estimates of efforts put into each component.

Table 3.2 illustrates several important points.

a. Physical irrigation works dominate the budgets of all the projects.

b. The five projects fall into three categories with regard to expenditures on components:

c. TIMP and WIIP put very little resources into the software items, i.e. O&M systems and institutional development.

d. WMP and ISMP put significant funds into the software items.

e. MIRP is intermediate.

f. Only TIMP put a large amount of resources into other activities. TIMP invested a great deal in the purchase and distribution of tractors and other agricultural equipment and inputs to promote a new cropping system. The proposed cropping system turned out to be unacceptable to the farmers fr a variety of reasons. As a consequence, none of the later projects has dedicated significant resources to agricultural development. Without this large investment in agricultural development, TIMP's distribution of funds would be similar to that of WIIP.

ISMP and WMP, classified as cost-effective, are the two projects that put the most resources into the software components. TIMP and WIIP, classified as not cost-effective, put the least into the software components. MIRP is intermediate to both categorizations.

Clearly, this finding shows that investment in software components is an essential complement to investment in physical works. The implications are: a) that a balance between software and hardware components is necessary; and b) that WMP and ISMP were closer to the ideal balance than were the other projects.

This finding agrees with other analyses which suggest that investments in operation and maintenance (O&M) and institutional development together with investment in physical works are likely to have a bigger payoff than investment in physical works alone (Aluwihare and Kikuchi 1991). The basic reasons for this conclusion are well known:

a. R&M are attractive when the performance of a system declines significantly. The decline may b due to (a) increased demands (enlargement of the command, increased cropping intensity, etc), or (b) deterioration in the physical system that makes effective operations impossible. The former implies a need for improved operations: the latter, a need for improved maintenance. Reconstruction of existing structures and construction of new structures alone without improvement of O&M will not solve the basic problems leading to the need for R&M.

b. Improvement of O&M systems requires significant investments. It is not enough for engineers to work out a new operational plan; the plan must be tried, negotiated with farmers, and modified as needed for the particular scheme. Moreover, the use of new technologies, as implied by modernization, generally means that system operators themselves need training and learning time to make the new O&M systems function well.

c. Inadequate maintenance and poor water distribution generally imply at least in Sri Lanka, that farmers are not taking sufficient responsibility for management. In some cases, they may interfere with agency plans; in others, agencies lack the funds and trained manpower to handle the maintenance and water distribution needs. In either case, there is a need for the development of institutions among the farmers so that they can effectively and responsibly contribute to overall system management. However, institutional development cannot be accomplished without resources.

Thus while physical works are a key element of an R&M project, the physical works must be supported by investments in O&M systems and institutional development to ensure that needed O&M changes take place.

For example, all of the projects except TIMP have incorporated greater control over water flows by adding measuring and other control structures and have proposed operating plans that require the use of these structures. This approach has been in line with expert opinion from outside Sri Lanka. However, the development of the management of the management systems to make use of increased control over water flows has lagged. WIIP simply assumed that the system managers and management systems could make effective use of this control (Nijman 1991). WMP and ISMP, on the other hand, expended a fair amount of resources on improving the management systems and mangers' capabilities so that the increased control would be effectively used. Again, MIRP has been intermediate.

The failure to provide funding for an item does not mean that the project planners omitted the item. Thus, although no funding as provided by TIMP for institutional development, its plans called for the establishment of Tank Committees with farmer representatives to manage the schemes after R&M. However, it was assumed by the planners that whatever costs there would be covered through regular government budgets. Similarly, most of the TIMP funding for agricultural development went for the purchase of tractors; it was assumed that the additional extension work required to get the farmers to adopt a new cropping schedule as proposed by the project would be met from regular funds. The experience in Sri Lanka is that extra government funding has rarely been made available unless explicitly provided for in the project budget. The lesson is that R&M project budgets must make explicit provision for the key items.

3.4.3 Need for seeking low cost rehabilitation options

The intensity and unit cost of major system rehabilitation (cost per ha and cost per lengths of main canals etc.) have varied from project to project depending on the strategies adopted. The available information reveals that: output effects of rehabilitation, in terms of increased crop yields, enhanced cropping intensity, improved water use efficiencies, and the shift towards crop diversification and adoption of new techniques and technology have been rather poor; in schemes where the capital intensity of rehabilitation is extremely high, the costs may even threaten the economic viability of the project; and there is no evidence, as yet, to test the hypothesis that major irrigation rehabilitation has led to significant increases in total crop production.

However, it may be surmised that the returns to investments in major irrigation rehabilitation were obtained through the prevention of potential reduction of crop yields, cultivated area and production as a result of rapid deterioration of physical system components which would have occurred had the rehabilitation not been carried out.

Therefore, more realistic assumptions should be made in respect of post rehabilitation benefits and unit costs of rehabilitation in planning for major tank rehabilitation component under the Area Development project.

3.4.4 Need for Management orientation to rehabilitation projects

Available information, in general, suggests that physical improvements of an irrigation system alone are unlike to generate high rates of return unless complemented with a strong management component, particularly covering institutional development aspects. More recently implemented major irrigation rehabilitation projects (ex: ISMP) allocated a higher proportion of budgetary allocations for farmers organizations (FOs) development and handing over of distributary canal systems to recognized FOs and relatively lower budgetary provisions for undertaking only the essential physical rehabilitation.

A recent Monitoring and Impact Evaluation study conducted by IIMI on Participatory Management Policy and its implementation has been very critical of the impact of participatory management policy and its implementation on the benefits expected from it. In fact, they question the sustainability of farmers organizations in major irrigation system management. One of the key recommendations of the study is that the scope of the farmers organizations should not be limited to system management and the FOs should be supported to become viable commercial entities through preoccupation in agriculture related business modes and activities (IIMIb 1995).

SCOR provides a novel management approach for ensuring sustainable production and incomes to farmers by promoting an existing farmer organization to become a farmer company. In Huruluwewa scheme in the NCP, the farmers, through the farmers organization and a collaborative mode of seasonal planning, cultivated soya been in one third of the extent on bethma basis. They cultivated soya for a target market in Colombo under a forward agreement on the supply of a pre-agreed quantity of produce at an agreed sale price. The intervention not only brought them an assured market and higher price for their produce, but also is paving way to a handsome share capital owned by the farmers to form a registered farmer company.

Thus, it is recommended that in allocating budgetary provisions for major system rehabilitation a proper balance in budgetary allocations for physical improvements and management improvements should be maintained. Also, sufficient budgetary provisions be made for providing financial grants to existing farmers organizations and for agro-infrastructural development to enhance their capacity to become viable commercial entities.

3.4.5 Need for rehabilitating medium irrigation schemes

Although, a number of funded projects have been implemented for the rehabilitation of major and small tanks, medium tanks have not been received the same emphasis. For example, in the NCP, all major schemes except Wahalkada scheme have been rehabilitated under the above three major irrigation rehabilitation projects during a period of about 15 -20 years. The on-going National Irrigation Rehabilitation Project (NIRP) has accommodated a few medium tanks in the programme for funding. In respect of the NCP, the Irrigation Department feels that the medium tank rehabilitation should receive priority attention in the Area Development Project.

3.5 Minor irrigation schemes

The term "minor irrigation system" is preferred over "small tank" or "village irrigation system" for three reasons (Widanapathirana, 1995). Firstly, each tank is linked to at least one other hydrologically, and each tank is essentially a part of a larger small tank cascade system. If one tank in the cascade is not in proper working order, it will affect the working of all other tanks in the entire cascade system. Secondly, each individual system as well as the entire small tank cascade system consist of an integrated farming system including chena cultivation, irrigated farming, livestock grazing, homestead gardening that is strongly linked to the hydrology, land use and socio-economy of the people. Thus, each individual tank system as well as each small cascade system can be seen as a system comprising four main landuse units: irrigated area (reservoir area, command area, and drainage area); chena lands; forest area; and homesteads. The different components of the integrated farming system is practised in the different land use units. These subsystems are closely inter-connected and the high level of integration is vital for the efficient operation of each tank system as well as the small tank cascade. Thirdly, there are linkages between these subsystems and ceratin social institutions. The proper functioning of the entire cascade, in fact, is due to the linkages that exist within subsystems as well as their close integration with the social institutions. Therefore, minor irrigation systems should be considered in a systems perspective in any area development interventions.

There is no conclusive estimate on the number of small tanks and diversion weir systems in the country, although reliable data about the major and medium tanks are available. A recent count done by the Department of Agrarian Services (in 1990) reported a total of 18,890 small tanks excluding the tanks in the Northern and the Eastern provinces. This is true for the NCP as well.

During the short time period of this study, attempt was made to prepare an inventory of small tanks in the NCP, compiling the scattered information and data available with different sources such as the DAS, the ID, Sri Lanka National Freedom from Hunger Campaign Board (FFHC), District Secretarys' offices in the NCP. In addition to the short time period available for the study, the inventorization exercise was hindered by a number of constraints, including the incompleteness of the available data. In spite of those facts, it was possible to prepare a list of tanks with some essential geographical, physical, hydrological and agricultural data, including the

past history of its rehabilitation for most of the tanks. However, there are data gaps in respect of many tanks. The most important achievement of the inventorization was the categorization of the small tanks under respective small tank cascades and river basins of the NCP, in addition to the provision of conventional topographic sheet coordinates conventionally used for the identification of tanks. The inventory reports a total number of 2500 (2493) small tanks in the entire NCP. However, follow up work is required to finalize the tank inventory for the NCP using the base inventory developed under this PPTA study. The small tank inventories are available in the Annexures.

3.6 Experiences and lessons learned from minor tank rehabilitation projects

This section presents an analysis of literature concerning the rehabilitation of minor irrigation systems undertaken by the (1) the Village Irrigation Rehabilitation Project (VIRP), (2) the Anuradhapura Dry Zone Agricultural Development Project (ADZAP), (3) the Integrated Rural Development Project (IRDP), (4) the Sri Lanka Freedom from Hunger Campaign (FFHC) and (5) the National Irrigation Rehabilitation Project (NIRP). All of the above projects (except the IRDPs) have funded the rehabilitation of minor irrigation schemes in the NCP. ADZAP project was exclusively implemented in the NCP. Each project is reviewed under the following 8 items:

a. Identification and selection of tanks: What have been the past approaches for identification and selection of tanks? What are the main weaknesses? How could such weaknesses be avoided?

b. Planning and design issues: What are the main lessons that can be learned from the past approaches to planning and design of rehabilitation programmes? What are the important issues that must be addressed? What strategies are planned in this respect?

c. Construction: What have been the main strategies and methods of construction in the past? How can their positive and negative aspects be identified? What can be done to overcome such problems?

d. Components: What have been the main disciplinary components such as research, training, extension, monitoring, evaluation and institutional strengthening in past projects? How well have they been accomplished? What are the lessons that can be learnt for the improvement of the process of rehabilitation?

e. Approach to rehabilitation: Did the past projects concentrate on the rehabilitation of physical irrigation system as well as on the agricultural and institutional systems? Did they focus on the rehabilitation of the tank, structures and the command area or did they adopt the farming systems approach? What proposals can be made in order to improve the performance and sustainability of rehabilitation strategy?

f. Institutional and organizational aspects: What are the main institutions and organizations which formed the focus of past rehabilitation projects? What aspects were weak and which were the strong points? What institutional and organizational issues should be considered and what is the strategy proposed?

g. Farmers' organizations: Comment on the adequacy of interventions on FOs. What are the main approaches and their results? What elements of FOs were least understood and implemented in the past? What are the main suggestions including any organizational models which should be considered in future rehabilitation approaches?

h. Management of rehabilitation projects: What have been the main strategies of management of rehabilitation projects at the time of implementation and during post-rehabilitation? What lessons of management can be drawn? What were the main post-management problems that surfaced and how did they affect the performance and sustainability of rehabilitation investments?

i. Political issues: What are the main political issues which affected the process of rehabilitation? To what extent did such issues affect the post performance of rehabilitation? What are the main proposals to minimize such interventions and which of them could be considered in the process of rehabilitation?

j. Socio-cultural issues: Based on the past programmes of rehabilitation, review socio-cultural issues which had been neglected. How could such aspects improve the performance of on-going and post-rehabilitation phases?

3.6.1 Village Irrigation Rehabilitation Project (VIRP):

The first minor systems rehabilitation and modernization project undertaken by the government was the VIRP implemented from 1981 to 1990. It was funded by the World Bank and implemented by the Irrigation Department (ID) and the Department of Agrarian Services (DAS). The main aim of the Project was the rehabilitation of 1700 minor systems which involved the repair of 1,200 minor irrigation systems by the ID as well as the modernization of 500 irrigation systems by the DAS. These systems were located in the Dry, Intermediate and Wet Zones of the country. They consisted of village tanks and anicut schemes. The main project components supported by the project in the process of rehabilitation and modernization were: (a) the strengthening of the two departments; (b) the provision of necessary training to relevant officials; (c) the initiation of a system of water management; and (d) the monitoring of project impact and the resultant agricultural progress through a process of project implementation. The focus of the project was on systems in which people were present and where cultivated lands were already available, but could not be fully utilized due to some malfunctioning in the systems. The project objectives did not preclude the expansion of the irrigable area, provided the selection criteria could be adhered to. The project expected to raise cropping intensity in the Dry Zone from 75 to 105 and in the Intermediate Zone from 115 to 145. The overall increase was expected

to raise from the present 82.5 to 116.2, resulting in an increase of 43 percent in per capita income.

a. Identification and selection of tanks

For the purpose of the VIRP, the tanks were identified by the officials using the lists of tanks found in the Paddy Lands Register and through interviews with people (Dayaratne, 1991). The same author indicates that the information disclosed at farmers' interviews had often been inaccurate and had led to wrong decisions. Although it is not clear as to how the interviews were conducted, the experiences indicate that participatory appraisals with the relevant people is a rich source of information for the identification of tanks. Discussions indicate that this approach had not been utilized. Literature on VIRP does not discuss participatory tank identification methods. Selection of tanks on the basis of Paddy Lands Registers had given rise to several problems as these registers are not regularly updated and hence are unsuitable as a basis for tank selection.

Discussions with officials and farmers in rehabilitated irrigation systems under VIRP indicate that the main strategy that had been adopted in identifying tanks had been the "priori" knowledge of officers. However, this aspect has not been documented. There had been little consultation with the farmers (Ibid). The tanks were identified as individual units and not as cascade systems (IIMI, 1994). Therefore, the important hydrological components of a minor tank cascade system such as Godawalas, smaller and bigger tanks and Olagamas have not been identified. It has to be borne in mind that the rehabilitation needs and approaches in respect of Godawalas, Olagamas, etc. are quite different from those of the minor tanks. In fact, there had not been any emphasis on the hydrological aspects of the STCs in the process of identification of tanks (Dayaratne, 1991; IIMI, 1994).

The selection of tanks was done using the seven criteria (World Bank, 1981) listed below:

a. The command area should not be less than eight hectares;
b. The tanks should be in an inhabited area and thus within easy access;
c. The useable storage capacity per acre of command area should not be less than 3 acre-feet in the Dry Zone, 2.5 acre-feet in the Intermediate Zone and 1.5 in the Wet Zone, and also should not exceed 70 percent of the yield potential;
d. After rehabilitation the tank should benefit a minimum of ten families;
e. The incremental area brought under direct Maha irrigation should be at least ten times the privately irrigated lands submerged, or three times the cultivated lands area submerged;
f. The soils of the catchment area, reservoir, and the command area should be suitable for their respective purposes;
g. The maximum cost of a project including all civil works and physical contingencies, engineering and administration should be calculated at a rate of Rs.24,700 per hectare of incremental area.

Due to the particular strategy of tank selection adopted as mentioned above, there had been no emphasis on the identification of tanks which were used by the local people in terms of the socio-economic and cultural backgrounds. Accordingly, Olagama tanks which are also a part and parcel of the cascade system had not been selected for rehabilitation. A perusal of the above criteria indicates that the socio-cultural issues and matters concerning the cropping intensity had not been considered at all. There is also no reference to poor people or the willingness of the farmers to contribute, or their participation, etc.

b. Planning and design of rehabilitation

Under the VIRP, planning and the design were done by the technical officials such as engineers, agronomists and technicians. The planning with regard to the rehabilitation needs had been assessed mainly from a technical and engineering point of view. As a result, rehabilitation was often confined to the introduction of certain technical packages and physical repairs. No attempt had been made to ascertain from the farmers the reasons responsible for the state of disrepair of the system. Nor had any discussions taken place to identify steps that were necessary in addition to technical improvements. In short only the engineering and agronomical aspects had been considered. The local residents had not been consulted with regard to the planning and designing of rehabilitation. The results of such a planning and design process, as could be expected cannot be very beneficial to the farmers. As indicated by TEAMS (1991), the designs were far from satisfactory as about 30 % of the new structures installed by the officials had never been used by the farmers. The cropping intensity did not increase as expected and a large number of tanks were managed with a poor level of sustainability after rehabilitation.

c. Construction

The planning and design strategy of the VIRP had a heavy construction component. Dams were raised, new structures were added, roads and bridges were constructed or repaired and the channel system was modified. The expenditure on construction work had been much higher than the amount spent on the institutions. At the beginning, most of these construction works were undertaken by private contractors appointed by the ID and/or DAS. Later, some of the construction work was assigned to some farmers' organizations, but the actual work was carried out by the same private contractors. In the beginning, skilled labour and unskilled labour were brought from outside. Later on, the unskilled labour was recruited from the villages themselves. The "construction bias" of VIRP is to be expected considering the particular planning and design approach used in the project as discussed above.

d. Components

The main aspects which received attention under VIRP were irrigation engineering, hydrology, water management and agricultural technology. The VIRP concentrated almost entirely on the irrigated sub-sector within the overall farming system. The project did not focus any attention on customs, rituals, indigenous technologies, conflict resolution, land tenure, marketing, income generation activities, agro-processing, conservation of the catchment areas, de-

siltation of tanks or the development of livestock.

e. Approach to rehabilitation

The main approach to rehabilitation under the VIRP has been physical construction and introduction of technical packages. The technical package consisted of introduction of water management and improved agricultural practices. It concentrated entirely on the irrigation system only. The water management package centered on the Walagambahuwa model according to which rain water was utilized to the maximum for land preparation while water in the tank was used principally for crops (Upasena, 1984). The other aspects of irrigation management such as utilization of draught power to supply farm power, consolidation of fragmented land parcels, strengthening FOs, improving linkages with other sub-systems, revival of cultural ceremonies, strengthening of customs and their incorporation into the functioning of the system, income generation, strengthening social harmony and unity and other socio-institutional aspects were not included in the project. Moreover, components closely associated with irrigation such as development of highlands, livestock, chenas, homesteads, etc. too were not a part of the VIRP.

As discussed earlier, minor irrigation systems have several linkages with the functioning of society and the systems function as an integrated whole. Therefore, a project such as VIRP should have taken a holistic approach to the rehabilitation of minor irrigation systems.

The main approach of the technical package was the formation of a team called the "Agricultural Planning Team-APT" which consisted of the TA, the AI and the DO. The APT was entrusted with the responsibility of introducing the agricultural package. However, due to problems such as the presence of only a few officials, their lack of training and orientation, and lack of proper supervision, this approach has not been successful (Perera and Abeyratne, 1985; Abeyratne, 1990).

f. Institutional and organizational aspects

Although there were several important institutions, the VIRP focused only on the organizational set up of the project and the APT. Other institutions such as village level catalysts and local leadership development, cultural institutions and the bureaucracy were not considered by the VIRP.

The ID and the DAS benefited through better training, expansion of staff, provision of staff facilities and infrastructure development. As a result these two departments were better able to handle rehabilitation work. The project also gave an opportunity for the two departments to learn about minor irrigation systems and their future needs.

g. Farmers' organizations

The VIRP did not pay any special attention to farmers' organizations. It did not obtain the services of a specially trained cadre of catalysts to facilitate the process of formation of FOs.

IOs were not appointed or placed. The project also did not do anything with regard to the strengthening of local Even the existing organizations within the minor tanks system.

h. Management of rehabilitated projects

The project was implemented by the ID and the DAS. A committee was formed in each department to monitor and spearhead in the implementation work. At the national level, overall guidance in project implementation and steering were done by a central steering committee. Within the 2 departments, there were planning committees. At the field level, the work was undertaken by the Irrigation Engineer in-charge who had a small staff to work on VIRP.

Special management programmes were not planned for the post-rehabilitation period. The completed projects were handed over to the DAS, and thereafter their management became a part of the normal functions of the DA. No specific authority or mechanism had been set up to monitor whether the new structures and technologies introduced were functioning satisfactorily.

i. Impact of VIRP

A post project impact evaluation of the VIRP was undertaken in 1991 (Teams 1991) using a sample of 180 tanks. Out of the 180 tanks 51 tanks were from the NCP (Anuradhapura district).

The study reported that the stated criteria were violated in the selection of a large number of tanks. According to the study findings, no maha cultivation was practised after rehabilitation in 29, 28 and 26 tanks out of the 51 tanks in the NCP in maha seasons 1987/88, 1988/89 and 1989/90 respectively. Although, it was expected, according to the project reports of the sample tanks, that the total area benefitted under the rehabilitated tanks in the entire dry zone would increase by 550 ha (1400 acres) from 2958 ha (7515 acres) to 3503 ha (8900 acres), the extent cultivated in maha has not increased after rehabilitation. In fact, by 1990, there was a 28 percent decline in the area cultivated in yala after rehabilitation of the 180 sample tanks. In the NCP, it was found that out of the 64 randomly selected tank schemes rehabilitated under the VIRP, no cultivation was done under 23 tanks (35 percent) even in maha season after rehabilitation. In spite of those shortcomings, the farmers of the rehabilitated tanks were of the opinion that rehabilitation improved the convenience of water distribution after rehabilitation. The increase of the area cultivated with OFCs did not increase after rehabilitation.

3.6.2 Anuradhapura Dry Zone Agricultural Development Project (ADZAP)

The Anuradhapura Dry Zone Agricultural Development Project (ADZAP) was essentially a rural development project. The main objectives of ADZAP were to increase food production and raise the income of about 4,000 farm families (Dayaratne, 1991). Therefore, it was basically a rural development project and focused mainly on agriculture. It was confined only to Anuradhapura district and was implemented from 1981 to 1987. Its objectives were (1) the rehabilitation of about 600 minor tanks, (2) the development of the agricultural infrastructure for rainfed lands, (3) livestock development, (4) the improvement of minor roads and (5) the

provision of agri-support services for the people in the areas where tanks were rehabilitated (MADR, 1991).

a. Identification and selection of tanks

The tank selection criteria under the ADZAP were have been based almost exclusively on technical parameters. These parameters were as follows:

i. The command area of each tank should be greater than 8 ha with a storage capacity of 0.91 hectare-meters of command;

ii Tanks should be surrounded by settlements, which would enable the provision of services and labour during the construction stage;

iii. The maximum investment cost was to be Rs.37,000 (1982 prices) per hectare for upstream works and Rs.15,000 per hectare for downstream development;

iv. The internal rate of return for each tank was to be at least 15 percent per year.

It is clear from the above that techno-hydrological aspects such as cascade principles, the actual level of storage, the status of the catchment area, the availability of water supply to the reservoirs, etc. have not been taken into consideration in the selection of tanks. Moreover, the selection criteria are heavily biased towards technical aspects. Socio-institutional aspects such as the cultural background, organizational issues, existence of farmers' organizations, the relations between Olagamas and main tanks, etc. had not been considered at all.

Dayaratne (1991) reports that although selection criteria were determined they had not been strictly adhered to during the process of implementation. This is another serious defect since it led to malpractice in the allocation of rehabilitation funds.

b. Planning and design

Planning and designing under the ADZAP had undertaken by the agencies without adequate consultation with the beneficiaries (Ekanayake, et al., 1990). The same source indicates that in many cases the beneficiaries had not been physically present when the construction work began. In two-thirds of the systems, a rural development society or a political party had approached the project regarding the selection of allottees and construction work (Ibid). As Ekanayake (Ibid), Dayaratne (1991) and Navaratne (1989) reported, the main reasons for the failure of the irrigated component were the low level of involvement of beneficiaries, low quality design work and various technical problems as well as political intervention in project management.

c. Construction

As discussed elsewhere, there had been a construction-bias in the ADZAP. The approach to construction work under ADZAP had been the DI's staff to prepare engineering designs and the work was executed by private contractors. The contractors in turn were supervised by the DI and the DAS. For construction in the upstream area, hired labour had been used while the downstream work was executed by the intended beneficiaries (IIMI, 1994). It had not been possible to request contractors to make use of the beneficiaries for construction since the contract agreement did not have a clause to that effect.

d. Components and approach to rehabilitation

The focus of the ADZAP was to provide a viable farming system through careful development of local resources (Dayaratne, 1991). Accordingly, there were several components other than irrigation. The chena system was to give way to permanent cultivation of both irrigated command areas and the uplands and the rearing of livestock. With regard to service categories, there were four components, namely, minor roads, agricultural extension, credit and training. However, rehabilitation of minor irrigation systems constituted the main emphasis of the ADZAP. The rehabilitation component involved three aspects, namely, upstream development including surveying, engineering design, repair and construction of tank bunds, spills and sluices while downstream development work included land clearing, construction of channel network and introduction of 20 pilot schemes of water management.

As reported by Ekanayake, et al. (1990), the project is unique with its multi-components and focus on the entire farming system as a whole. The above authors report that the highland component of the project had performed well compared to the irrigated component. Another important component of the project has been its plan to re-settle chena farmers in the newly developed allotments under the tanks rehabilitated by the project.

e. Institutional and organizational aspects

As in the case of VIRP, this project too did not plan any interventions in the area of institutions. It was expected that the existing institutions would continue to implement the project. The project also did not consider forming an organization involving the re-settled farmers to meet their variety of needs including bargaining power. The farmers had nothing in common to bind themselves together other than poverty.

The project was under the overall charge of the Ministry of Agricultural Development and Research. In order to steer the project and to provide basic institutional framework, a national coordinating committee had been established with some 19 agencies as its members. At Anuradhapura, a project implementation committee under the District minister was set up (Dayaratne, 1991). This was the first time where a minister headed the implementation of a project. The project office was responsible for the preparation of detailed implementation arrangements, coordination, preparation of budgets, day-to-day work, etc. The project office was

headed by the project director who was assisted by three specialists - an agronomist, an engineer and a livestock specialist. The work connected to upstream development was carried out by the ID, while the DAS was responsible for the development of downstream work.

The interference of politicians in project management work is certainly not a good practice. As stated by Dayaratne (1991) and Ekanayake, et al., (1990), there had been a high degree of political interference in the management of the project. The same authors have reported that political decisions dominated in the spheres of financial allocations, selection of tanks, selection of settlers, and other project activities. Such political interference led to a lot of malpractice and deviations from the project objectives. The failure of this project can be attributed to political interference.

f. Farmers' organizations

As mentioned earlier, the ADZAP did not create new FOs nor make use of existing FOs for project management. Neither did it envisage any management functions to FOs in the past project period.

g. Management of rehabilitated projects.

As mentioned above, the management of the project was by a project implementation committee. Budgetary constraints and poor coordination among the agencies responsible for its implementation gave rise to a lot of problems (Dayaratne, 1991). Accordingly, a re-formulation of the project was done in November 1984 with limited scope and financing. After rehabilitation, it was expected that the completed projects would be taken over by the respective departments. As such no specific arrangements were made either for monitoring and supervision or for the provision of technical advice regarding the continued implementation of the project.

h. Impact of ADZAP

A post-project evaluation was conducted by IIMI using a sample of 21 tanks in the Anuradhapura district. The post-project average upland cropping intensity of the sample tanks after rehabilitation was found to be 51 and 74 percent in yala and maha seasons respectively. But, in contrast, the post-project cropping intensity of the irrigated command areas under the sample tanks was found to be only 13 percent in yala and 15 percent in maha seasons. The study reported that the interventions of the ADZAP increased the upland cropping intensity significantly, due to the assistance provided by the project for constructing open dug wells for upland cultivation. In some of the sample tanks, the upland areas cultivated in yala and maha seasons, in fact, were higher than cultivated areas in the irrigated commands.

The poor performance of the irrigated agriculture under the rehabilitated tanks were attributed to a number of reasons. Firstly, the improper evaluation of the catchment area and the catchment runoff to tanks were identified as two main factors. The study highlighted the difficulty and inaccuracy involved in identifying and demarcating catchment boundaries, and

hence catchment areas, of minor tanks on mildly sloping land terrain of the NCP using the topographic survey sheets of the survey department of Sri Lanka, which are available in 1:50,000 and/or 1:63,360 scales. In respect of the estimation of the seasonal inflows to tanks, there is general consensus among the Irrigation Engineers of the Irrigation Department that hydrological design parameters of small tanks need to be further refined and updated. The impact evaluation study concluded that over-estimation of the catchment areas or over-estimation of the seasonal runoff to small tanks or both may have resulted in the over estimation of the potential cropping intensity and cultivable extent under the rehabilitated tanks. The porus tank beds, inadequate technical design and construction defects and resulting o & M problem were quoted as other factors contributed to low post-rehabilitation performance.

3.6.3 Integrated Rural Development Project (IRDP):

The Integrated Rural Development Programme (IRDP) which began in the late 1970s focused on the development of all the sectors in the rural economy. Since irrigation is an important component in the rural economy of Sri Lanka, rehabilitation of minor irrigation systems was also taken up as a component of the IRDP. The first IRDP commenced in 3 districts namely, Kurunegala, Hambantota and Matara (Dayaratne, 1991). Later they were extended to other districts. At present, almost each district other than the north has an IRDP. Since each IRDP had its own funding sources, there had been a multiplicity of approaches to rural development under IRDPs funded by different donors.

The irrigation sector usually involved the rehabilitation of 12-15 minor irrigation systems. The largest allocation of funds was in respect of this item. Since there were several different funding sources, there were different approaches to planning and implementation in different districts (Dayaratne, 1991). Therefore, IRDPs did not have a uniform approach towards the planning or implementation of irrigation projects. Dayaratne (Ibid) reports that there were three main approaches namely, (a) Typical blue-print approach associated with the World Bank projects; (b) Fixed sectoral sub-project (rolling plan) and (c) Annual programme model.

a. Tank identification and selection

No uniform method was adopted for the selection of tanks. Different procedures were followed in different places. In some places, a special cell of the IRDP identified the tanks through interaction with the local communities. The officers were irrigation engineers or persons who had experience in irrigation. It was natural for their expertise to be used to identify tanks for rehabilitation. In other districts, the rehabilitation was actually undertaken by the department concerned. IRDP gave financial support. Here, the approach was not different from what was practised under the VIRP. Dayaratne (1991) too noted that the approach to selection of tanks under the IRDP was not vastly different from that of the VIRP. As Dayaratne (1991) reported, there were only a few sources of information about smaller tanks suitable for rehabilitation such as the lists compiled by the relevant technical agencies, lists provided by the respective Parliamentarians and a few instances of farmers' organizations (FOs) making requests to the

agency. The lists submitted by technical agencies were biased in favour of schemes which were technically sound while the lists provided by the Parliamentarians had some political bias. The requests submitted by FOs were more rational, but only a few fell into this category. Dayaratne further reports that the selection criteria developed were such that there was a tendency to exclude very small and non-feasible schemes.

There is no evidence for the establishment of specific criteria for the selection of tanks under IRDP. This made proper identification and selection of tanks a very difficult task.

The identification and selection of tanks adopted by the IRDP did not have the cascade as a focal point. Individual tanks were selected for rehabilitation without considering the entire hydrological system. As in the case of VIRP, special types of tanks which form the cascade system were not identified.

b. Planning and design

There was no definite records in this respect. According to the strategy adopted, the nature of the officials involved and their irrigation-related background, it was not surprising that the planning and design process adopted for tank rehabilitation under IRDP was not different from what was adopted under VIRP.

c. Construction

Construction work in connection with the IRDPs was undertaken by contractors and they were supervised by the departments concerned. There was no clause to compel contractors to employ local labour or to consult local people in execution of work.

d. Other issues

The approach to rehabilitation adopted by the IRDP was determined by agencies such as ID and the DAS. Therefore, the approach adopted by these officials were the same as that adopted in other projects such as VIRP. There was no mechanism to identify any specific demands of the farmer community through the process of rehabilitation. As a result, the components identified for rehabilitation were only those associated with irrigation infrastructure such as raising tank bunds, construction of spills, structures, etc. There is a dearth of literature with regard to the specific aspects of tank rehabilitation such as the approach to rehabilitation, institutional and organizational aspects, farmers' organizations and the management of rehabilitated projects under the IRDP. Discussions indicated that there had been no emphasis by the IRDP on the formation and strengthening of Fos for the purpose of rehabilitation. Since rehabilitation itself was undertaken by the agencies involved, this review safely assumes that their post-management was not different from what the agencies would have adopted under normal circumstances.

3.6.4 Rehabilitation by the Sri Lanka Freedom from Hunger Campaign (FFHC):

The Sri Lanka Freedom from Hunger Campaign (FFHC) is a public corporation established by Parliamentary Act No.15 of 1973 under the then Ministry of Agriculture and Lands. The primary objective of its programme was the successful implementation of rural development projects to improve the quality of life of people living in the wewa country (Wijetunga, 1986). Dayaratna (1991) reports that its activities in the area of rural development took the form of an NGO in carrying out its village development activities. The primary purpose of its tank restoration and rehabilitation programme was the improvement of the quality of life of the people living in the tank country (Ibid). The FFHC started rehabilitation and restoration of tanks in 1979. According to FFHC sources, it has completed the rehabilitation of 135 tanks as of June 1989. During its period of operation of 10 years, it developed an area of approximately 2,510 ha and nearly 3,100 farm families have benefited directly.

a. Tank Identification and selection

Dayaratna (1991) states that tank identification and selection for rehabilitation under the FFHC programme preceded requests from village communities. Specifically, attention had been given to tanks which had been abandoned or those which had been in operation but in a state of disrepair. There is no reference to the use of cascade systems approach in the identification of tanks. There was no clear policy with regard to the identification of tanks (Ibid). The FFHC however, gave preference to small reservoirs (capacity to irrigate 20 ha) and those in the Dry Zone where the populations were less privileged. Therefore, tank selection criteria under the FFHC programme were somewhat vague.

a. Planning and design

The strategy for planning and design adopted by the FFHC was for the village communities to take the initiative(Wijetunga, 1986). This preceded the establishment of Wewa Sabha. The manner of planning the process of rehabilitation/restoration has not been documented.

b. Construction

Unlike many other organizations which used machinery for rehabilitation/ restoration, the FFHC's approach to construction had been to use labour of the participating beneficiaries (Wijetunga, 1986). Therefore, contractors had not been employed.

c. Components

Components of Irrigation interventions included refurbishment of the irrigation system, formation of wew Sabhas, identification of settlers, their training and settlement, upland development and settlement development. The rehabilitation and/or restoration of the Irrigation systems included constriction of the dam, reconstruction of sluice to replace village-type sluice and construction of the water distribution system. The formation of wew sabha was the starting

point in this process. The poorest of the poor who received land under a given tank were organized to form a similar saba. Each such unit was to represent one tank only. The membership per wewa saba ranged from 20 to 40 farm families (Dayaratne, 1991). The process of their formation is not documented.

Training had been an important aspect of the restoration programme which was organized by the FFHC. In the case of functioning irrigation systems, training concentrated on water management, formation of wew sabha and community development, while in the case of tank restoration, training covered wide sphere of activities ranging from settler orientation to settlement and water/Agricultural management. In both cases, training was also provided on agriculture and water management. In addition, there were separate training programmes for women also. The list of areas where training had been provided by the Board is vast. However, there is no documentary evidence with regard to the efficiency of the training imparted.

As mentioned earlier, the approach to rehabilitation under the FFHC programme was to form a wewa sabha and to entrust all planning and implementation work to its members. As it is documented, it is the beneficiaries which had planned and implemented the programme. However, it is not reported the approach to get the agency officials involved in this process. The FFCH had given loans to the people in order to implement various activities such as maintenance, marketing, repair work, etc.

d. Institutions and organizations:

It is stated that the programme of irrigation intervention included formation of wewa sabas, provision of assistance to revive customs and religious functions, training and land distribution under Baga system (Wijetunga, 1986; Dayaratne, 1991). The task of organizing the wew sabhas to undertake rehabilitation work and the overall project organization was the duty of the Project Officers appointed by the Board. These Project Officers resided in the village societies. The nature of officials and the membership which spearheaded the rehabilitation and other activities is not clear. Although reference is made to the involvement of the Lands Commissioners Department with regard to land matters, there is no evidence of the involvement of other agencies such as the Irrigation Department or the Agrarian Services Department. Whether there was an organization to plan and implement work in each of the areas where the FFHC's activities concentrated is also not shown in the documents.

Apart from the formation of wewa sabhas, the impact of other institutions and their linkages with them have not been assessed and documented. The manner of revitalizing the indigenous customs and their impact on rehabilitation and project management has not been evaluated. Moreover, the manner of revitalizing customs and religious activities is not stated. Whether there were interventions in the areas mentioned above other than training is also not known.

Although the FFHC programme had focused on a comprehensive approach to restoration, it had not paid attention to the establishment of a system of federation of these organizations at

a higher level in order to facilitate exchange of ideas and experiences among wewa sabhas. It had also over-looked strategies to deal with social and irrigation related conflicts and the necessity to link these organizations with other institutions. A long term programme to sustain these organizations had also not been worked out.

e. Farmers organizations

As mentioned earlier, the nature of Farmers' organization established under the programme of FFHC took the form of wewa sabhas. They were established though the guidance provided by the Board. Their activities and the extent to which they had involved themselves in the performance of irrigation management, agricultural development and social welfare have not been documented. Their performance during the post-rehabilitation period is another area about which there is no documentation. As a matter of fact, it would be interesting to find out the present status of the wew sabas established and their involvement in the subsequent management of tanks. In this connection it has to be stated that there is no evidence of any effective use of the Maintenance Fund introduced by the Board at the time of restoration of tanks (Dayaratne 1991). The same author also indicates that the farmers expected the Board to continue helping them repair the damage caused to the tanks by cattle and wild elephants. These are indications of the low level of sustainability of the tanks rehabilitated under FFHC.

Linking wew sabhas with a higher level of organizations and federating them to district and eventually to the national level would help them to gain better bargaining power and economic strength. This is one main draw-back of the programme of FOs established by the FFHC.

f. Impact of FFHC programme

The post-FFHC impact evaluation study conducted by IIMI (Dayaratne 1991)concluded that:

(a) Wew sabha system of grouping the beneficiaries was not successful and not sustainable.

(b) Performance of irrigated agriculture under the rehabilitated tanks were very poor. In most of the tanks studied for the impact evaluation: no cultivation was practised at all after rehabilitation; not more than two seasons were cultivated during 10 years of post rehabilitation period; even in the years of abundant water availability, the full extent were not cultivated in maha, and; the rice yield was lower than the average for the NCP. In total, the increase in the cultivated area and the cropping intensity after rehabilitation was not very significant.

(c) In the upland plots consisting o.6 ha of homestead and 0.6 ha of market gardens, cash crops such as cowpea, greengram, blackgram, maize, chillies, sesame,and vegetables were grown and the perennial crops such as coconut, mangoes, jak, lime and banana were planted. Irrespective of the tank being renovated, upland farming continued to play a

dominant role in the rehabilitated tanks.

(d) Upland farming in the foreshore areas of minor tanks under lift irrigation from open dug wells was significant. The farmers cultivated lands extending from 0.4 ha to about 0.6 ha under dug wells and obtained high cash incomes.

(e) The shortcomings in the adoption of proper technical designs were partly responsible for the poor performance.

3.6.5 National Irrigation Rehabilitation Project (NIRP):

The National Irrigation Rehabilitation Project (NIRP) which is being executed at present is a follow up to the VIRP. Its aim is to rehabilitate and improvement of 1,000 minor systems and 60 medium/major system in the country. This will benefit 37,500 ha of command area. The work in this project began in 1993 and will continue until 1997.

a. Tank Identification and selection

The main criteria developed for the selection of tanks as stated in the Staff Appraisal Report (World Bank, 1991) are as follows:

a. FOs should be established and registered before any scheme is selected for rehabilitation/ improvement;
b. FOs should agree to contribute 10 percent of the total cost by contributing labour or by other means and also agree to operate the scheme after rehabilitation;
c. In the case of minor schemes below 80 ha, the FOs should bear the full cost of operations and maintenance after completion of rehabilitation, while in major/medium schemes, the FOs should bear the total cost of operation and maintenance in respect of the distributary channel and below. They should also absorb the total cost of main canal operation and maintenance for two years after rehabilitation;
d. The command of schemes selected for rehabilitation should be not less than 4 ha and the number of families should not be less than 10;
e. The investment cost should not exceed Rs.40 million (1991 prices) and the economic rate of return should be 15 percent in the case of major/medium schemes. The investment cost per ha should not exceed Rs.30,000 per ha (1991 prices) in selected minor schemes.

As seen above, more emphasis is placed on economic criteria such as cost recovery, operations and maintenance work and returns to investment. However, criteria such as cropping intensity have not been considered. For the first time, the existence of FOs has been considered as a criterion in selecting tanks for rehabilitation. However, this criterion takes the form of a blue-print with little room for flexibility.

The hydrological parameters and cascade principles are not given any emphasis in this project also. As in past programmes, there is no emphasis on de-siltation, land tenure reforms

through consolidation or the protection of the catchment area, etc.

Since rehabilitation is the responsibility of the ID, or the DAS, or PC officials as the case may be, identification of tanks is also done by them. In the case of smaller systems, tanks are identified by the officials of the PCs. The officials are requested by the ID to identify tanks which require rehabilitation and improvement. The officials use their own knowledge to identify and select individual tanks. Since the technical agencies are doing the work, it is natural that tanks where more civil work are involved are also selected. There is very little farmer consultation with regard to identification and selection of tanks. Therefore, it is not, in this respect, very different from the VIRP. Smaller tanks are identified by the DOS of the DAS. Although there has been some suggestion of making use of the cascade system in the process of rehabilitation, the project has so far not adopted this method for selecting tanks (Widanapathirana, 1990).

b. Construction

The method of construction adopted by the NIRP is to employ private contractors for the execution of pre-identified tasks under the supervision of the ID, DAS or the PC. There are no clauses compelling the contractors to hire local labour or to obtain their views at the time of construction.

c. Components

In the case of other agency-executed projects, NIRP also concentrates on the irrigation sub-sector only. The important components of the NIRP are rehabilitation and improvement of tanks, establishment of FOs, training of farmers and staff of implementing agencies, environmental protection and related studies, establishment of units at the ID, and provision of consultancies in project planning, implementation and impact assessment. It appears that even the irrigation sector has not been considered in a comprehensive manner. For instance, there is hardly any emphasis on land consolidation, de-siltation, revitalizing indigenous customs and technologies, catchment reforestation, etc. which are considered important in the rehabilitation of minor irrigation systems.

Other sub-sectors such as highlands, homesteads, livestock and chenas, and the provision of support services such as inputs, credit, marketing services and income generating activities based on value-adding enterprises have not been considered in the process of rehabilitation.

d. Approach to rehabilitation

The main approach to rehabilitation under NIRP is to establish FOs and to execute the work through them. It is also assumed that the FOs will develop the capability to operate and manage the systems after rehabilitation. As in other projects, the approach almost entirely relies on the rehabilitation of the irrigation component only.

e. Institutional and organizational aspects

With regard to institutions, the main item considered in the process of rehabilitation is the formation of FOs. The approach adopted towards the formation of FOs and entrusting them with the responsibility of managing the system is more or less mechanical. It is questionable whether such a system could be sustained. This aspect is further discussed in "f" below.

The organizational model responsible for implementing the project consists of the Project Coordination Committee headed by the Secretary to the Ministry of Lands, Irrigation and Mahaweli Development, a Central Management Cell (CMC) located within the ID, the Provincial Project Coordinating Committee, and the Regional Support Teams (RST) located in the Provinces. The CMC is headed by the Project Director supported by technical experts while the RTS team is headed by a Construction Engineer. The other members are an Institutional Development Officer and a Technical Officer. The rehabilitation of medium scale systems falls directly on the ID while the smaller systems are rehabilitated by the PCs.

f. Farmers' organizations

The NIRP is the only government executed minor system rehabilitation project in which a specific component is suggested to form and strengthen FOs. For this purpose, institutional organizers (IOs) have been recruited and placed in systems being rehabilitated. The IOs are expected to facilitate the formation of FOs in irrigation systems.

Although the formation and strengthening of FOs is an essential part of the project, the emphasis placed on this vital issue appears to be very weak. Firstly, the IOs do not receive any guidance. Secondly, supervision and monitoring of their work by the higher level of officials is inadequate (Brewer et al. 1994). Moreover, the IO's do not seem to receive leadership or guidance they require for the formation of FOs because the higher officials themselves have no proper guidance, training or proper orientation towards the FOs. Further, the responsibility of training, placing and monitoring of IOs has been vested with the technical officials of the Irrigation Department. There does not exist a suitable mechanism within this department to provide training and overall guidance required for this programme. As a result, Brewer et al., point out that the FOs continue to need direct assistance from the IOs and the agencies.

There is reason to suspect that due to these weaknesses and also due to certain other factors the formation of Fos in minor/medium projects has been done following the concepts established for the formation of FOs in major irrigation systems. This assumption that the model developed in respect of major systems would be equally applicable in the case of minor/medium tanks has led to many weaknesses in the FO's in the latter systems. The observations by the author indicate that the IOs are expected to carry out routine administrative matters are therefore demoralizing Whether the IOs have undertaken any useful work has been questioned by farmers in some systems. Under these circumstances, whether the IOs are able to empower farmers and facilitate sustainable FOs remains a major question.

g. Management of rehabilitated projects.

The NIRP is being managed by the Project Cell headed by the Project Director located within the ID. The Project Director gets guidance and directions through a National Steering Committee. The work is implemented by the IE in-charge in the case of medium systems, and by the Assistant Commissioner of the Provincial Agrarian Services Department (PASD). The PASD gets technical advice from the technical cell established in each province while there is no similar set up for channelling advice on socio-institutional matters.

The objective of NIRP is to rehabilitate the systems and then to turn them over to the respective FOs for management. In the case of medium systems, they are expected to be managed by the ID itself after rehabilitation. The project is in the process of implementation and it is premature to make an assessment of the performance of rehabilitated systems with special reference to their management by FOs.

3.7 Key Lessons Learned

The main lessons that will be useful for the future can be highlighted as follows.

3.7.1 Blue-print Approach

The review indicates the blue-print approach to planning and implementation of rehabilitation projects by government agencies. In the case of government executed projects dealing with rural development, there appears to be very little possibility of incorporating new lessons learnt in the process of rehabilitation.

On the other hand, the project experiences by the NGOs offer some flexibility in planning and implementation and thereby it is possible to incorporate later lessons and experiences into the design and implementation process. The NGOs had officials living with the people and the organization had a mechanism to obtain views of the people. Many rehabilitation projects undertaken by the NGOs have taken the approach of mobilization of local people. Such an approach has its own advantages with greater benefits to the people.

3.7.2 Variety of experiences

There has been a wide range of different experiences concerning tank selection, formation of Fos and different approaches to rehabilitation as a result of a variety of agencies and NGOs executing projects in the 1980s. These experiences are a rich source of learning from which several useful lessons can be learnt to improve the process of rehabilitation and the management of these schemes.

3.7.3 Overwhelming attention on technical interventions

A study of all past rehabilitation projects indicates that the main thrust had been placed on technical and engineering aspects such as raising bunds, re-designing the channel system, the construction or replacement of existing sluices, the construction of a good network of roads, the construction of buildings, etc. Another main draw-back had been that some of the rehabilitated projects had incorporated design features of larger systems, as the designers had considered smaller systems as miniature versions of larger systems. Because of this, the construction costs further escalated and gave rise to new problems.

In the meantime, technical aspects such as the adoption of a watershed approach based on small tank cascades, tank de-siltation, reforestation of catchment, etc. have not been considered by any of the past projects. The over-concentration on limited technical/engineering aspects at the expense of other necessary technical/engineering issues that are involved in the management of minor systems is a major draw-back of past approaches.

3.7.4. Neglect of institutional aspects

A review of five main rehabilitation projects indicates that the importance of institutional issues in the management of smaller irrigation systems has been least understood. Accordingly, a majority of past projects have over-looked many of the important institutions such as FOs and linking them with other organizations, federating FOs to higher levels, customs and rituals, development of irrigation leadership at the local level, conflict resolution, land tenure including Baga system of land management, Bethma, Kanna meeting, etc.

3.7.5 Rehabilitation of irrigation tank vis-a-vis systems

All past projects concentrated only on individual units (tanks and anicuts). None of the projects identified STCs as a strategy for rehabilitation of minor systems. Therefore, what has been rehabilitated constituted only a smaller part of an irrigation system. Irrigation as a system involving the wider farming system had not received any consideration. In this connection, attention should have been given to other components of the farming system such as highlands, chenas, homesteads, catchment areas, etc.

The linkages that exist between different components of the farming system have not been appreciated in the conventional tank rehabilitation approaches. Development of one component at the neglect of another component could be harmful. For instance, full benefits of de-siltation of the reservoir cannot be realized if the catchment area is not protected and re-forested at the same time. Similarly, if there are no income generating opportunities linked with irrigation development, the people will not be interested in maintaining the rehabilitated system in a proper state of maintenance and repair. One major drawback of the past projects is the failure to include any income generation activity.

3.7.6 Emphasis on research studies

The review indicates that areas for interventions had been determined by the officers on the basis of their knowledge of the systems, based on quick preliminary investigation surveys. It should have been better if interventions had been based after a participatory assessment of the baseline status of the system as well as needs and proposals of the farmers.

The relationship between the components of the farming system including irrigation and their relationship to the institutions is an area where present knowledge is very inadequate. The past projects indicate a lack of research studies particularly in the areas of sociology and institutions. There has virtually been no research investigating the sustainability of institutional innovations introduced by various past projects. Hence, there is only a limited scope to learn from previous experience or to correct such mistakes in future projects. This is a major draw-back.

There have been some studies on aspects such as tank water balances, catchment runoff-rainfall relationships, water management, etc. Even these studies are not altogether helpful in understanding the complex socio-technical behaviour of small tanks. For instance, although cropping intensity is one parameter which reflects the combined effect of hydrological, technical, managerial, organizational and socio-economic aspects of minor irrigation tanks, it has not been considered as an indicator for selecting tanks for rehabilitation (Sakthivadivel et al, 1994).

3.7.7 Farmer consultation

A review of all past projects indicates a gross inadequacy of consultation of farmers for recognizing and comprehending specific needs of the people, their wisdom and specific proposals for water resources development and management in the entire cascades. For example, farmers have many constructive proposals on acquisition, diversion, augmentation and sharing of the total quantity of water available within a cascade unit for improving the overall cropping intensity of the cascade unit. But the conventional procedures adopted for technical investigations of tanks for rehabilitation do not provide adequate room to capture and appraise such proposals in determining rehabilitation components. Low intensity of farmer consultation is partly due to the rigidness of the single-tank based rehabilitation model adopted.

3.7.8 Low Income of Farmers

One common problem faced by the farmers who depend on minor irrigation systems is the low margin of profits from irrigated agriculture. This is a result of a series of related issues such as higher level of application of externally purchased inputs and increases in the prices of inputs relative to the prices of output (Wijayaratna et al, 1993), and low yields of minor systems (Gunadasa et al, 1979). On the other hand, sustainability in context of the new economic scenario characterized by liberalization of exports, the open economy, low level of government control and privatization is determined by the volume of profits generated from irrigated farming.

Unlike in the past, farmers' need have increased greatly at present and their most important need is adequate purchasing power. Therefore, it is vital that farmer incomes are increased substantially by increasing yields, reducing production costs, obtaining higher sale prices for commodities and the initiation of value adding enterprises.

In planning strategies aimed at increasing farmer income, it is most important to lay emphasis on processing of agricultural products and the introduction of value-adding enterprises to irrigation. The amount of profits that could be generated by strategies such as delayed sale, converting raw products into simple value-added forms such as making flour from kurakkan, packeting, etc. are substantial (SCOR, 1994). None of the irrigation projects rehabilitated since 1970s have had a budget, project components or a package of assistance in the area of value-adding enterprises.

3.7.9 Over dependence on external supplies

A high level of dependency on external inputs (such as chemical fertilizers, pesticides, weedicides, tractor power, etc.) and on outside funds for O&M of irrigation systems are observed at present. The high level of dependence on external resources can lead to several undesirable consequences. First, production can come to a standstill if the supply of external inputs is curtailed for some reason. Second, dependence on external inputs such as chemical fertilizer and pesticides can lead to ecological problems as well as reduction in agricultural productivity (Fernando, et al., 1993; WHO, 1990; Conway, et al., 1990). Third, the O&M activities of many minor irrigation systems are undertaken with financial allocations made available by the government. If such allocations are not forthcoming, it will virtually result in the cessation of O&M activities which are vital for the physical sustainability of the system. Fourth, the lack of timely supply of inputs of appropriate quality has been a serious problem. Under the above circumstances, sustainability of irrigation management is very vulnerable and the entire system could collapse due to outside forces. Therefore, finding alternative means to sustain production and appropriate strategies to undertake O&M work are vital for the sustainability of irrigation systems.

3.7.10 Problems Relating to Water Management, Agricultural Pests and Diseases

Efficient and proper management of water is affected by a variety of factors such as the inefficient functioning of the government technical support and extension system. Inefficient practices with regard to the use of water, land and agricultural resources adopted by the farmers are another issue, contributing to inefficient irrigation management. The complicated nature of land tenure transactions makes water management and complex agricultural operations such as staggering difficult to enforce. If the inefficient land tenure practices continue as at present, there will be a negative impact on the functioning of the irrigation systems.

3.7.11 Discipline among Farmers and Officers

Discipline among farmers is an important factor which determines the efficiency of water management, proper maintenance of the system and success of agricultural undertakings. Discipline among officers is also important for the proper conduct of rehabilitation activities.

There is evidence pointing to the increased number of part-time farmers in irrigation systems (Herath et al., 1981; Jogaratnem, 1994; Wickremasekera, 1981). A major problem with regard to the presence of part-time farmers is the difficulty of contacting them when necessary to obtain their participation in decision making and implementation with regard to agriculture. It is also difficult to motivate part-time farmers to join in the maintenance and upkeep of the irrigation systems because they have other sources of income which reduce their commitment to the system.

3.7.12 Differential Policies, Programmes and Projects

At present, there is no policy as regards irrigation (rehabilitation, O&M, formation of FOs, research, extension, etc.) and agriculture. In the absence of an overall policy, different agencies adopt their own guidelines with regard to various aspects such as rehabilitation, groundwater utilization, etc. These guidelines are basically developed in the context of various projects funded through external assistance.

3.7.13 Land Tenure

The system of land tenure in minor irrigation systems is very complicated. There are various types of land transactions. Plots are sub-divided into small parcels, and are scattered in several places within a given system. Several plots are operated by non -resident farmers and a large number is operated under various tenancy arrangements. These land tenure-related problems have prevented the cultivation of some plots and have also been the main cause of conflicts among farmers. Land consolidation has been attempted only in a handful of schemes and none of the projects have included this as a main component.

3.7.14 Absence of programmes to restore ecological stability of tanks.

The ecological stability of minor systems is in danger due to several factors. First, the catchment areas of almost all systems have badly deteriorated due to burning of forests, chena cultivation, extraction of timber, etc. Second, the tank eco-system consisting of **Gasgommana** (patch of trees), **Perahana** (filter), **kattakaduwa** (salt absorbing area), etc. have been degraded, and are not in existence in several places (SCOR, 1994-b). Third, a large majority of tanks have silted up to a great extent and there is no mechanism to effect de-siltation. Fourth, lack of adequate soil conservation measures on the adjoining farmlands has accelerated the process of soil erosion. The eroded soil finds its way into the tanks and the command area of minor systems. Finally, the hydrological connection of each minor tank within a cascade which existed in the past has been disturbed due to haphazard development work. Roads have been constructed across

tanks, water diverted from one cascade to another and the breaches of tanks not repaired. It is reported that many of the tanks have silted up and the storage level has been affected badly. Farmers too have made numerous requests from the authorities and politicians to protect the catchment area and to de-silt their tanks. However, there is no strategy or a programme to revitalize the ecological stability of minor irrigation systems. None of the past rehabilitation projects has ventured into this area of vital importance.

3.7.15 Problems related to private sector

The involvement of private sector in the provision of services, inputs and value-adding enterprises is an accepted fact by the government. There are a few private sector agencies which have already signed contract agreements with FOs to purchase their produce. These lessons indicate that there is a vast potential to improve linkages between the farmers and the private sector agencies for the mutual benefit of both. In the meantime, there are problems such as under-payment, neglect of agreements by the agencies and inadequate mechanism to resolve conflicts arising from such transactions. It is certain that these problems could be overcome and the linkage should be strengthened.

3.7.16 Systems Approach to rehabilitation

There are several issues that should be highlighted. First, none of the past projects have considered a watershed approach to rehabilitation of minor irrigation systems. A majority of the projects considered only the irrigation sector and confined themselves to channels, structures, roads and other physical aspects. One clear similarity of all the past rehabilitation projects is the absence of a systems approach to the process that included all different components of the farming system and incorporated all tanks in a cascade. All of them concentrated on the irrigation sub-sector, especially the channel system and the reservoir only. The ADZAP included the additional components of highland development and livestock development, which however, is considered a failure on several other grounds. All past projects did the same mistake by concentrating only on 1 or 2 tanks within a given cascade.

Second, within the irrigation sector, solutions to some of the pressing problems of the farmers such as de-siltation, land consolidation, reforestation of the catchment area, strengthening of the draught power situation, etc. have not been considered in the process of rehabilitation. Rehabilitation was considered as just rehabilitating isolated tanks and the important aspect of tank cascade systems had been ignored. As discussed elsewhere in this report, it is the linkages within a minor system such as the connection with other tanks as well as the sub-systems such as chenas, highlands, livestock, etc. that contribute to the efficiency of the system. This important link has not been considered in most of the past projects.

Third, the approach to rehabilitation had been a blue print where each step was identified on paper. Due to inadequate understanding of the functioning of the minor

irrigation system, this approach is unsuitable. All projects follow the blue print approach with very little room for any adjustment in the programme. The approach of the FFHC was a little more flexible in that certain modifications could be accommodated. In all other projects, the planning team developed the approach, the rehabilitation consisting of raising the dam and other civil work. None of the projects had any room for the inclusion of farmers' suggestions.

Finally, the composition of the rehabilitation package should include not only issues relating to irrigation, but also those which help income generation. There is increased necessity to plan interventions in income generating activities. These need not be confined to irrigation only. An analysis of the composition of past projects indicates that the issues such as value-adding, land consolidation, ecological restoration, etc. have not been built into the process of rehabilitation. The importance of making a comprehensive rehabilitation package is all the more important in the light of prevailing problems of the minor irrigation systems.

The approach proposed in this study therefore, differs from the conventional tank rehabilitation strategies adopted so far by the irrigation agencies. In the first instance the proposed approach discourages the conventional single tank based rehabilitation. Instead it proposes a cascade based integrated area development approach in which small tank rehabilitation may or may not be an integral component. Secondly it proposes a mechanism for consulting farmers for identifying their needs and requirements for water resources development on the individual tanks as well as in the entire cascade units. The methodology proposed here is an improved participatory rural appraisal and mapping technique. Once the specific water resource development (water transfers, augmentation, etc.) and small tank rehabilitation needs of the farmers are captured, documented and mapped, it is required to consider that tentative development plan as the starting point for carrying out technical and hydrological feasibility. In other words, this approach begins with a farmer perceived water resources development plan which has to be further investigated, studied and validated (or rejected) by the irrigation engineers and technical officers subsequently. If the proposals can be implemented with or without necessary technical modifications they can be undertaken after a detailed cost and benefit evaluations supported by detailed technical studies. Thirdly, the proposed strategy is to adopt an integrated development approach within the cascade. Thus, unlike in conventional small tank rehabilitation projects, development interventions in chena, homegardens, reservations of canals and streams and forests too will be undertaken together with tank rehabilitation and other water resources development interventions. Once a cascade is selected for interventions based on its hydrological endowment, the package of development interventions will be implemented in the entire cascade. In addition, agro-infrastructural such as processing centres, marketing support, agricultural equipment, extension support are also a part of the development intervention package for the selected cascades. The chapters that follow in the study report describes the key processes, procedures, methodologies and strategies that have to be followed in adopting this novel area development concept. It has to be noted the proposed concept is based on the concepts, and experiences of the Shared Control of Natural Resources Project (SCOR), which is currently implemented in the NCP.

CHAPTER 4

SELECTION OF SMALL TANKS CASCADES AND PLANNING AREA DEVELOPMENT INTERVENTIONS

4.1 Selection and planning process; an overview

The purpose of this chapter is to describe the process adopted by the study team for developing the cascade concept for formulating an area development proposals for this study on sample basis. The process followed by the study team needs documentation as it describes the procedure that have to be followed during the implementation of the project if the proposed cascade based area development concept is adopted for actual implementation. The process involved a number of sequential steps namely:

4.1.1 Delineation of the NCP to sub-basins/cascades and their characteristics.

An adoption of cascade based area development strategy needs the identification and demarcation of cascades of the above NCP. Although, the topographical survey maps prepared by the Survey Department shows the topographic features, ground contours, the basic land and water use details including land use, locations of minor, medium and major tanks, natural streams and man-made canals etc, those do not show the demarcation of cascade boundaries, sub-basin boundaries and river basin boundaries of the country including the NCP. Thus, the process of developing the "cascade based area development methodology" began with the tedious task of demarcating the cascades, sub-basins (watershed) and river basin boundaries, drainage lines and streams of different order, including the main river, and preparation of the maps showing those features for future use by the agencies during the implementation stage of the project. The maps indicating the locations and demarcations of cascades, sub-basins and river basins and drainage lines and streams together with landform, morphology soil and rainfall characteristics were used to interpret and identify the characteristics of the cascades. This is described in section 4.2 of this chapter.

4.1.2 Selection of hydrologically endowed cascades for sampling and field studies

The next step of the process was the initial selection of hydrologically endowed cascades for sampling and detail field studies. Out of the 309 cascades identified within 36 sub-basins (sub-watersheds) of the 5 river basins of the NCP, a total of 90 cascades were selected out of selected 15 sub-basins based on rainfall probability regime, soil and land forms pattern and present land use pattern. All 90 cascades were analyzed using a criteria and about 3-4 cascades from each sub-basin were ranked in the order of hydrological endowment. These cascades were further studied in the field by a field team using 41 cascade maps prepared in the office, and a sample of 15 cascades were selected on the basis of field verification. The detail process including the methodology and criteria used are described in section 4.3 of this chapter.

4.1.3 Criteria and methodology for identifying water resources development and rehabilitation intervention: Participatory rural appraisal and mapping.

Having selected the sample 15 cascades, the third key step of the process was the identification of the necessary water resources and rehabilitation interventions within the cascades. At this stage, the procedure adopted was different from the single-tank based conventional procedure that is adopted by the irrigation agencies to formulate rehabilitation proposals. The procedure adopted by the team developed a mechanism and methodology for capturing the farmers experience on rainfall patterns, cultivation data and history of the cascade, tank hydrological behaviour including spilling history, frequency of occurrence of floods and droughts and typical cropping intensity, as base line information to plan water resources development interventions. The interventions proposed by the farmers included water transfers from tank to tank within the cascade as well as inter-cascade water transfers and diversions. The proposals for each sample cascade were captured and mapped on scale maps of cascades prepared by the study team for the field study team. This novel approach and methodology adopted by the team included a modified participatory rural appraisal technique coupled with participatory mapping of the water resource data and proposals as well as the institutional arrangements proposed by the users for managing the cascades after the proposed water resources development and rehabilitation interventions. This is described in section 4.4.

4.1.4 Tool for validating the farmer's water resources development proposals: A simulation model

Having captured and mapped the farmer's proposals for water resources development within a cascade, it is required to test and validate the proposals in terms of hydrological and technical feasibility. The tool used to test the hydrological feasibility is a computer operated simulation model which can simulate the hydrological effects and impacts o the water resources development proposed by the farmers (e.g. pattern of filling of the tanks in the cascade). A brief description of the features of the model its utility and sample outcomes are presented in section 4.5 of the chapter. It has to be noted here that an accurate and detail cascade hydrological model studies require accurate details such as cascade based rainfall data, tank spilling history, catchment runoff-rainfall coefficients, depth area capacity relationships for the tanks in the cascade etc., for which are not readily available. As such, the model was used with a number of approximations (e.g. approximate depth-area capacity relationships). However, the model works well and need to be improved further. It was used as a basic tool for validating the farmer's proposals before detail technical investigations are commenced based on such proposals.

4.1.5 Pre-feasibility and financial viability of the proposed development interventions

Having tested the pre-hydrological feasibility of the five sample cascades (section 4.4), a subsequent field visit was made by the team for collecting data for costing the proposals. The costs of the proposed water resources development of five sample cascades were used as an input for detailed cost-benefit evaluations prescribed in this report in chapter 5. The estimated costs and benefits of water resources development area mainly associated with the improvement of the

command area, which is only one component of the entire farming system and land use of the cascades. These costs and benefits were considered together with the anticipated costs and benefits accrued for the complementary interventions on the chena, homegarden and reservations, which are the other integrated units of the farming system and land use of the cascade. The strategy proposed for area development, proposed interventions, cost-benefit computation of the package of interventions contemplated within a cascade unit and the institutional arrangements proposed for the implementation of the project area described in chapter 5 of this report.

4.1.6 Criteria for agro well development

One of the strategies proposed in this report is to provide agro wells in both irrigated command areas and highland areas to supplement the present available surface water to increase highland and lowland cropping intensity. However, use of groundwater through agro wells has to be promoted with caution as it can potentially cause adverse impacts on the environment. However, it does not mean that groundwater utilization for supplementary and conjunctive use in the command areas and highland area is not prohibitive. The nature and occurrence of groundwater and its potential was discussed in chapter 2 of this report. It appears that, in certain cascades, where the level of groundwater utilization has not exceeded the critical levels, a few more agro wells can be provided without exceeding the safe limits. Section 4.6 of this chapter presents a methodology and guideline criteria for evaluating the groundwater potential and the safe number of agro wells any given cascade area, tank catchment or command areas can support without causing adverse impacts.

4.1.7 Inventory of small tanks

One of the main hindrances to natural resources management is the absence of a reliable data base on natural resources base. In respect of the NCP, absence of an inventory of small tanks and primary tank data including the history of rehabilitation is a serious draw back. For example, some tanks may have been undertaken for some improvements by a number of successive small tank rehabilitation programs repetitively while some tanks may have not get selected for any improvements at all. In order to fill this gap, attempt was made to initiate the preparation of a small tank inventory of the NCP. The procedure and methodology followed for the preparation of the inventory is highlighted in section 4.6 of this report. The tank inventory prepared is found in the Volume II annexed. However, it is to be noted that this exercise have to be continued with in the future to finalize the inventory of small tanks.

Detail descriptions on each of the above sub items are described below:

4.2 Delineation of the NCP to basins, sub-basins and component cascades and their characteristics

A four step process as described below was adopted in the delineation of the boundaries of the major and minor river basins, the sub-basins and the component cascades within each sub-basin.

Step 1

Making use of the 1 inch to 1 mile topo sheets of the Survey Department, the watershed boundaries of 5 major river basins and 3 minor river basins for the Anuradhapura district, and the 2 major river basins for the Polonnaruwa district were demarcated. (See **Annexure 4.1** for the master map.) These boundaries have been shown in thick green lines on a set of master topo sheets. A total of 21 topo sheets cover both districts, as shown in **Map 4.1** and a set of replicates were made on photo copies of the 1 inch to 1 mile topo sheets which could be used for future work requirements.

Step 2

By overlaying clean tracing paper over the 1 inch to 1 mile topo sheets, the drainage network of each river basin including second, third and fourth order streams; minor, medium and large tanks and diversion canals were demarcated in blue lines. The main river basin boundaries were then traced on to this set of 21 transparencies covering both districts. The drainage network of each main basin watershed is thus clearly outlined in this set of overlays.

Step 3

The sub-watersheds that make up each of the main river basin watersheds were then delineated by studying the main features of the drainage patterns and by aggregating the lower order streams in to a higher order assemblage that would represent a sub-watershed in terms of the hydrology and main physiographic features as revealed in the coloured 1 inch to 1 mile topo sheets showing the elevation and contours. This demarcation of the sub-watershed boundaries have been shown in purple coloured line. This set of 21 overlays (See **Maps 4.2 & 4.3**) constitute the master set that shows the demarcation of the sub-watershed boundaries. The number of sub-watersheds within each river basin is shown in **Table 4.1**. The respective areas in (sq. miles) of each sub-watershed is shown in **Table 4.2.**

Step 4

The final step of demarcating the component small tank cascade or meso-catchment boundaries within each sub-watershed was done as follows. By placing a clean recently revised 1 inch to 1 mile topo sheet over the master overlay showing the sub-watershed boundaries on a light table, the main drainage and land form features that constitute an individual cascade were identified and the cascade boundary then demarcated. A cascade should have at least two successive tanks along a second order stream, and those not conforming to this requirement were demarcated and designated as non-cascades. The cascade boundaries were finally transferred to the master topo sheets that were made in step 1 and which show the main watershed boundaries. This demarcation of the cascade boundaries have been shown in red coloured line. The number of cascades within each

river basin is shown in **Table 4.1** and the number of cascades within each sub-watershed is shown in **Table 4.2.**

Table 4.1 Number of sub-watersheds and cascades within each main watershed basin

Main Watershed Basin	Area sq. miles	No. of sub-watersheds	No. of Cascades
Yan Oya	600	08	69
Malwathu Oya	1,210	17	152
Ma Oya	403	07	36
Moderagama Ara	400	04	52
Kala Oya	1,084	15	114

Table 4.2 River basins, areas of sub-watersheds and number of cascades within each sub-watershed of the NCP

Main basin and symbol for each watershed		Area of each sub-watershed (sq.miles)	Number of cascades within each sub-watershed
Yan Oya	Y1	75	12
	Y2	94	16
	Y3	37	07
	Y4	59	08
	Y5	48	05
	Y6	77	13
	Y7	116	06
	Y8	100	02

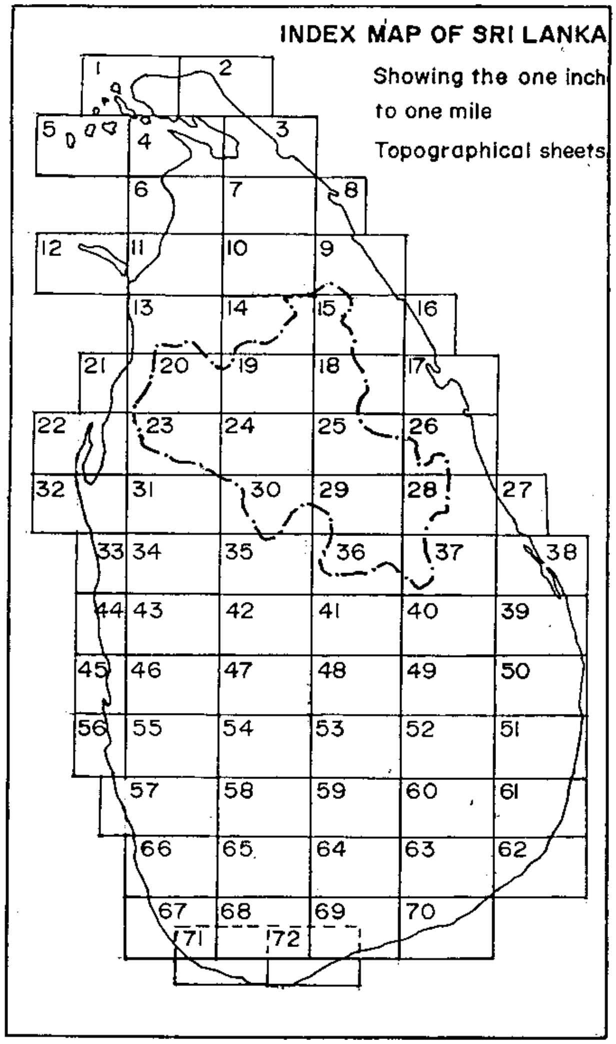
Table 4.2 Continued..

Continuation of Table 4.2

Main basin and symbol for each watershed		Area of each sub-watershed (sq.miles)	Number of cascades within each sub-watershed
Malwathu Oya	MAl1	99	14
	MAl2	60	11
	MAL3	73	08
	MAL4	15	02
	MAL5	71	15
	MAL6	51	09
	MAL7	38	08
	MAL8	92	09
	MAL9	86	15
	MAL10	28	05
	MAL11	74	15
	MAL12	39	06
	MAL13	72	10
	MAL14	41	06
	MAL15	30	04
	MAL16	54	02
	MAL17	290	13
Ma Oya	MA1	122	19
	MA2	71	06
	MA3	34	05
	MA4	22	00
	MA5	57	00
	MA6	16	00
	MA7	49	06
Modaragam Aru	MO1	154	31
	MO2	74	13
	MO3	76	08
	MO4	80	00
Kala Oya	K6	26	06

It should be noted that for the Polonnaruwa district the demarcation was done only to the level of the sub-watershed and no demarcation of cascades boundaries were made because of the near absence of small tank cascades in this district.

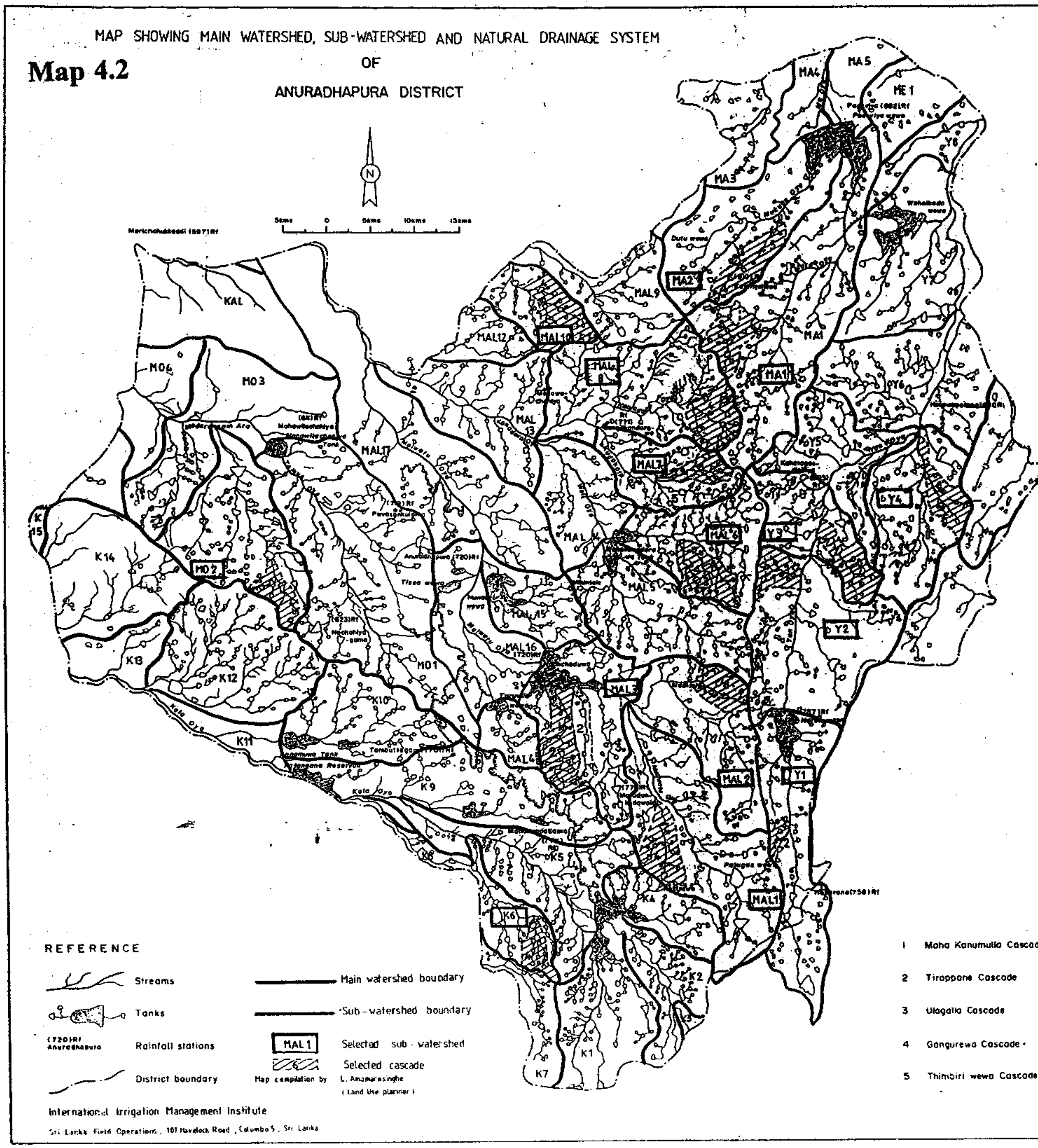
Map 4.1



Topographical Sheets Covering the Study Area

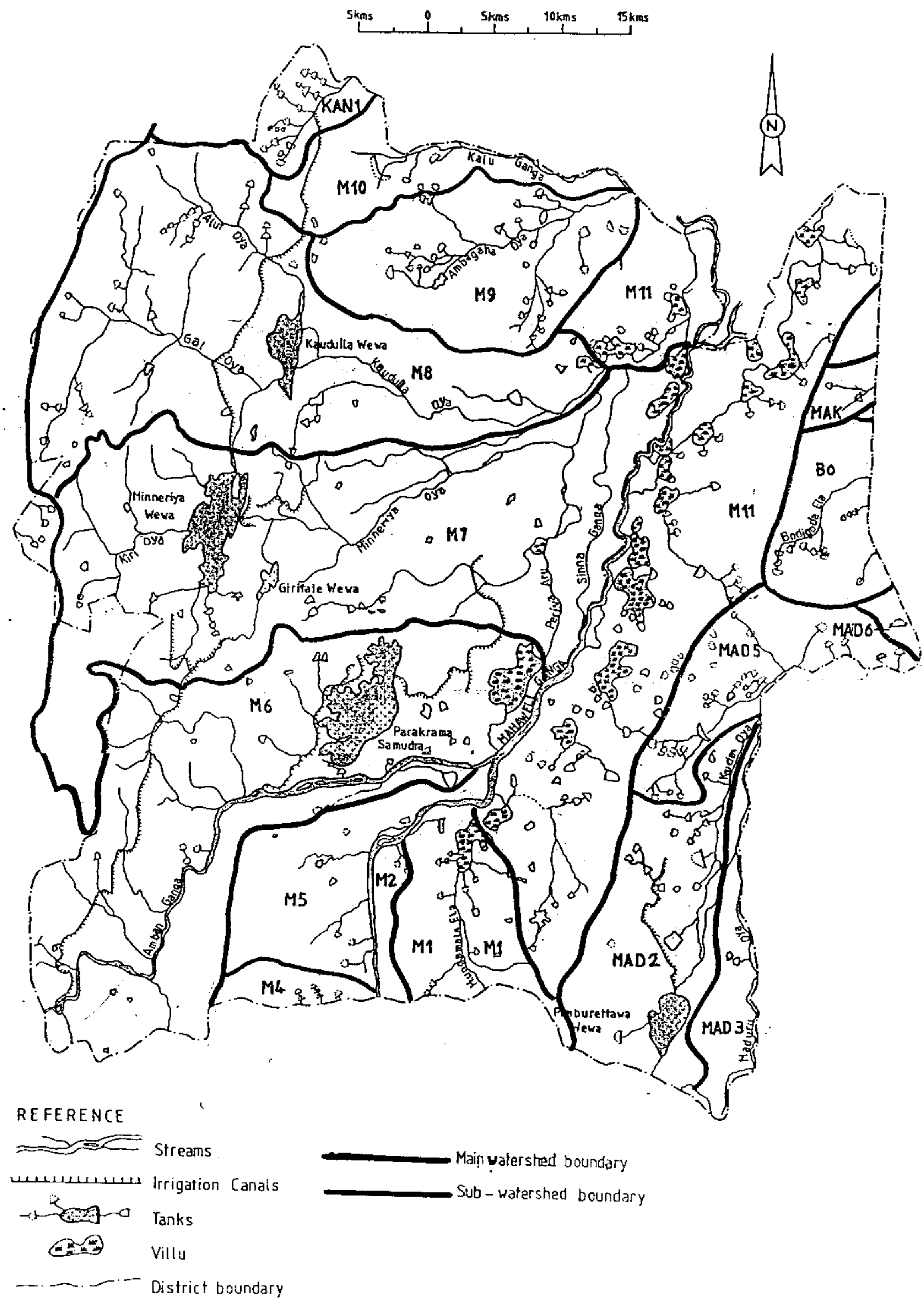
MURUNKAN	(13)	KOKKILAI	(9)
MARICHCHUKADDI	(20)	PADAWIYA	(15)
KALA OYA	(23)	HOROWUPOTANA	(18)
GALGAMUWA	(31)	KAUDULLA	(25)
		POLONNARUWA	(29)
		ELAHERA	(36)
PULLIYANKULAM	(10)		
VAVUNIYA	(14)		
MEDAWACHCHIYA	(19)	NILAVELI	(16)
ANURADHAPURA	(24)	TRINCOMALEE	(17)
DAMBULLA	(30)	KATHRAVELI	(26)
NALANDA	(35)	VAKANERI	(28)
		RUKAM	(37)

Map 4.2


MAP SHOWING MAIN WATERSHED, SUB-WATERSHED AND NATURAL DRAINAGE SYSTEM
OF
ANURADHAPURA DISTRICT
REFERENCE
Streams
Tanks
Rainfall stations
District boundary
Main watershed boundary
Sub-watershed boundary
MAL 1
Selected sub-watershed
Selected cascade
1 Maha Kanumulla Cascad
2 Tirappane Cascade
3 Ulagalla Cascade
4 Gangurewa Cascade
5 Thimbiri wewa Cascade
International Irrigation Management Institute
KAL
MO3
MO4
MO2
MO1
K14
K12
K13
K11
K10
K9
K6
K5
K4
K2
K1
K7
MAL17
MAL16
MAL15
MAL9
MAL12
MAL10
MAL3
MAL2
MAL1
MA1
MA2
MA3
MA4
MA5
ME1
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Y8
Kala Oya

MAP SHOWING MAIN WATERSHED, SUB-WATERSHED AND NATURAL DRAINAGE SYSTEM OF POLONNARUWA DISTRICT

Map 4.3



4.2.1 Main Characteristics

The mean size of a sub-watershed ranges from 57 sq. miles in the Ma Oya watershed to 100 sq. miles in the Moderagama aru watershed as could be seen in **Table 4.2**. The average size of a sub-watershed in the Yan Oya, Malwathu Oya and Kala Oya basins is around 73 sq. miles. Thus, for the Anuradhapura district the average size of a sub-watershed is around 75 sq. miles.

In the Polonnaruwa district, the four sub-watersheds that flow into the Mahaweli ganga range in size from 60 to 250 sq. miles. Because of the specific circumstances relating to the Polonnaruwa district, it is not possible to define an average size of a sub-watershed.

The main features of the sub-watersheds within each basin could be seen in the master map for the NCP, which shows the main watershed boundaries, the sub-watershed boundaries, the 2nd, 3rd and 4th order streams and major, medium and minor tanks and reservoirs. A separate set of maps on the same scale 1:250,000 has been made for the Anuradhapura district as well as the Polonnaruwa district and are shown as **Maps 4.2 and 4.3**. The one inch sheet topo boundaries are also shown in these two maps for ease of reference and discussion.

As could be seen in **Map 4.2** for the Anuradhapura district, there are both independent and dependent sub-watersheds. In the case of the Malwathu Oya basin, it could be observed that the sub-watersheds of MAL 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 15 are independent sub-watersheds, while the sub-watersheds of MAL 13, 14 16 and 17 are dependent sub-watersheds in that they receive flow from the adjacent sub-watershed or sheds. Similarly, for the Yan Oya, of the eight sub-watersheds only two namely Y1 and Y4 are independent; while for the Ma Oya it is two out of seven, and Moderagama area it is two out of four. For the Kala Oya of the 15 sub-watersheds twelve are independent and three are dependent.

In the case of the Polonnaruwa district as shown in **Map 4.3**, the five sub-watersheds of M6, M7, M8, M9 and M10 which are located on the left bank of the main Mahaweli ganga could be considered as independent sub-watersheds. However, the Elahara canal transports irrigation supplies across all these sub-watersheds.

The total number of cascades occurring within each main watershed basin is shown in **Table 4.1**. For the four main watershed basins in the Anuradhapura district there are a total of 309 cascades occurring within 36 sub-watersheds, or an average o between 8 to 9 cascades per sub-watershed. For the Kala Oya basin of which only a part is in the Anuradhapura district, there are a total of 114 cascades occurring within 15 sub-watersheds, or again an average of around 8 cascades per sub-watershed.

From 15 out of the 36 sub-watersheds, a total of 90 cascades were selected and their individual areas were measured by overlay a dotted grid transparency. The mean average area of a cascade for each watershed basin is shown in **Table 4.3**.

Table 4.3 Mean average areas of cascades in river basins of the NCP

Main Watershed Basin	Mean Average Area of cascade (sq.miles)
Yan Oya	8.7
Malwathu Oya	8.0
Ma Oya	11.2
Moderagama Ara	7.7
Kala Oya	9.5

By arranging the values for the 90 cascades, the modal value for the area of a cascade is found to be approximately 8.5 sq. miles or close to 5,450 acres. This corresponds to the size class of medium which is between 2,500 to 5,000 acres according to the size class categorization that was earlier (1994) adopted for characterization of small tank cascades in the Anuradhapura district, where the size class small was defined as below 2,500 acres, and size class large as between 5,000 to 7,000 acres.

4.3 Selection of Potential Sub-watersheds and Cascades: Criteria and Methodology

As described earlier, the four main watershed basins of the Anuradhapura district, namely Yan Oya, Malwathu Oya, Ma Oya and Moderagama ara contain a total of 36 sub-watersheds. Of the 15 sub-watersheds that make up the main Kala Oya basin, only 10 sub-watersheds fall within the Anuradhapura district, and out of these ten sub-watersheds as many as eight have been absorbed and developed under system H of the Mahaweli. As such, the selection of 15 sub-watersheds have to be made from a total of 38 sub-watersheds which include 36 sub-watersheds from four main basins plus two sub-watersheds from the Kala Oya basin.

The selection of the 15 sub-watersheds from the above 38 was made on the following criteria: (1) Rainfall probability regime, (2) Soils and land forms pattern (3) Present land use pattern. The detail procedure adopted was as follows:

The rainfall probability map of the NCP developed by the Land and Water Use Division of DOA on a scale of 1:250,000 shows the following four regimes in an increasing order of dryness DL1, DL1 (c), DL (d), DL1 (e). Superposing an overlay of this map on the Map (3) referred to earlier, all the 38 sub-watersheds were grouped within the above four rainfall probability regimes. This represents the highest level of screening. At the next level, an overlay of the soils and land forms map at a scale of 1:250,000 was superposed on the map showing the grouping of sub-watersheds according to the rainfall probability regimes. The sub-watersheds that show a similar soil and land form pattern within each rainfall region were then identified and selected. A total of 21 out of the 38 individual sub-watersheds were selected at this level.

These 21 sub-watersheds were then matched with the 1:100,000 scale present land use maps of the Survey Department published in 1984 and on which all the 36 sub-watershed boundaries were also demarcated. The colour scheme that has been used to demarcate the different types of land use on these Survey Department maps provides an integrated picture of the present land use patterns, which in turn could be visually interpreted to bring out the dominant form of land use within the area of a sub-watershed. At this final level of screening, 15 sub-watersheds were selected from among the 21, in a manner that these 15 reflect the dominant form of land use within the sub-watershed. The final outcome is shown below in **Table 4.4**.

Table 4.4 Selected sub-watersheds for detailed studies

Main watershed	Total number of sub-watersheds present	Number of sub-watersheds selected
Yan Oya	8	4
Ma Oya	7	2
Malwatu Oya	17	7
Moderagama aru	4	1
Kala Oya	12	1
Total	**38**	**15**

For each of the selected sub-watersheds, the following data was computed making use of the 1:50,000 Agricultural Base Maps (ABMP) of the Survey Department 1982 on to which both the sub-watershed boundaries and cascade boundaries were transferred.

> Total area of cascade
> Number of tanks within the cascade
> Total area of tanks within the cascade
> Total area of paddy within the cascade
> Total area of scrub and chena within the cascade
> Total area of homestead within the cascade
> Total area of forest within the cascade

Also, by making use of the soils and landform maps of the Land Use Division the extent of rock knob plain (RKP) within the cascade was computed.

Based on IIMI's previous study on the "Guidance Package for Selection of Tanks for Rehabilitation" the following screening criteria were employed in the selection of three or more cascades within each sub-watershed.

> Ratio of cascade area/tank area should exceed a value of 7.5
> Ratio of paddy area/tank area should be less than 2.0
> The (chena and scrub) area to cascade area should exceed 40 percent

> The area of homesteads to paddy area should be less than 40 percent

The area of the cascade should also be at least 10 percent of the total sub-watershed area. The extent of forest and rock knob plain is also taken into account at the lower level of ranking in the selection process.

The final result of the number of cascades selected within each sub-watershed is shown below in **Table 4.5.**

Table 4.5 Cascades selected for preliminary study

Name of sub-watershed			Total no. of STC present	Total no. of STC selected
Malwathu Oya	MAL1	Horiwila Oya	14	04
	MAL2	Maminiya Oya	11	03
	MAL3	Nachchaduwa	08	03
	MAL6	Ranpathwila Oya	09	03
	MAL7	Kadahathu Oya	08	03
	MAL8	Upper Kanadara Oya	09	03
	MAL10	Ulukkulama	05	02
Yan Oya	Y1	Upper Yan Oya	12	04
	Y2	Huruluwewa command	16	03
	Y3	Parahe Oya	07	03
	Y4	Sellige Oya	08	03
Ma Oya	MA1	Mora Oya	19	03
	MA2	Mukunu Oya	06	01
Moderagam Aru	MO2	Ittikulama	13	02
Kala Oya	K6	Negama	06	03
Total			**151**	**43**

In the final step of selecting one cascade from among the three or more cascades identified from each sub-watershed, the following methodology was adopted.

Both a 1:50,000 scale and a 1:63,360 scale map of each individual cascade showing as accurately as possible the following details was then prepared:

(i) Streams and tanks (ii) Paddy land (iii) Forest (iv) Scrub land (v) Chena (iv) Homestead (vii) Rock outcrops (viii) Roads.

These were then taken to the field by the field team and any improvements or modifications needed in respect of the tank waterspread area, paddy area, homestead area and chena area were made based on the field rapid appraisal studies.

Adopting a scoring technique in the field rural appraisal approach, the most appropriate single cascade was selected from among the three investigated and studied in the field. A detailed description of the methodology adopted by the field study team is given in the next section.

Finally, a 1:25,000 scale map was prepared for each of the selected 15 small tank cascades showing the following details: (i) small tank boundary (ii) tank/streams (iii) paddy (iv) forest (v) scrubland (vi) chena (vii) homesteads (viii) rocky areas. In addition, a set of 1:25,000 scale overlays were also prepared for each of the 15 small tank cascades which show (a) the small tank cascade boundary (b) the micro catchment of each individual tank (c) updated paddy area and (d) correct location of drainage system.

4.3 Criteria and Methodology for identifying water resources and rehabilitation: Participatory rural appraisal and mapping interventions

This section includes the analysis of work carried out by the Field Study Team. Participatory methodologies were adopted for selecting a potential cascade for land and water resource development proposals from among the cascades suggested based on desk studies.

The analysis focusses on the methodology adopted and the validity of the methodology in the planning of land and water resource development at micro-level within a cascade and specific outputs achieved in developing comprehensive proposals for cascade level land and water resource development.

4.3.1 Objectives of the Field Study

Field studies were carried out in 15 sub-basins with the objectives of:

* Selecting 15 cascades which have the most potentials for improving water resource development.

* Identifying potential improvements to land and water resources and to develop proposals for land and water resources development in each of the selected 15 cascades.

* Categorizing 15 cascades into different models of development depending on the nature of development needs.

* Preparing a comprehensive development package for each category of cascade for both hardware and software interventions for improving the economy and the quality of life of the people in the cascade.

* Providing a field tested area development strategic planning tool (methodology) to the NCP-Area Development Project implementing team to replicate it to other cascades

4.3.2 Cascade based Methodology

There is no evidence in the existing literature that cascade based methodology for land and water resource development planning has been applied in a wider range of area although various professionals argued on the feasibility of the cascade based land and water resource development (M.U.A. Tennekoon, C.M. Madduma Bandara). In the present NRM study the methodology was extensively applied to 49 different cascades in 15 sub-basins to validate the methodology. Therefore, the NCP-PPTA Area Development Project would be the first to apply the methodology for selecting resource potential cascades, formulate land and water resource development strategies for improving the cascade as a whole and also to implement the strategies through its land and water resource development component of the project.

A logical stepwise approach was followed to achieve the following broader outputs. It is important to mention that participatory rural development planning tools were applied at each step of the field study. Further, beneficiary involvement was sought not only to obtain data but also to get them actively involved in interpreting data, diagnosing their own problems, and developing proposals for strategic development interventions.

4.3.3 Process of Developing the Methodology

At the beginning of the NRM study, no specific indicators were developed to select the most potential cascades. Therefore, the Field Study Team visited all the cascades in the first two sub-basins (see Case Studies 14 and 15). Although the Field Study Team selected two cascades (i.e., Nagama and Maha Kanamulla cascades) as the most potential cascades, the selection was not based on any specific indicators. In Nagama and Maha Kanamulla cascades, three individual tanks representing the head, middle and tail were selected for developing rehabilitation proposals. The proposals developed in the first two cascades did not take into account the inter-linkages existing among tanks within the cascade and therefore, they are not different from the conventional approach of tank rehabilitation efforts hitherto adopted in the North Central Province (individual tank centered rehabilitation strategy).

However, from the lessons learnt from Case Studies 14 and 15, the IIMI Research team was able to work out an alternative planning approach for selecting better water resource endowed cascades and developing proposals for improving land and water resources.

4.3.4 Alternative Methodology Followed

a. Selection of the best hydrologicaly endowed cascade

The Land Use Planners based on their desk study selected two to four better resource endowed cascades from each of 13 sub-basins using the specific criteria (see section...) The criteria for selecting better resource endowed cascades were based on the data and information extracted from 1:50,000 maps. The Land Use Planners ranked the selected cascades in each sub-basin depending on the potential of water resource development.

The Field Study Team was given 1:63,360 maps together with the selected cascades in each sub-basin.

b. Data Collected from Individual Tanks of Selected Cascades in Sub-basins

Since the criteria developed by Land Use Planners were based only on the data and information extracted from the maps, the Field Study Team collected some additional field data to select the most potential cascades out of the 2-4 cascades suggested.

The following aspects were covered in field data collection program:

1. Number of families in each village/hamlet.
2. Number of land holding families in a each tank.
3. Command area.
4. Cropping intensity.
5. Cropping pattern.
6. Yield data.
7. Tank spilling data.
8. Physical condition of the tank.
9. Farmer organization.
10. Operation and maintenance practices.
11. Agro-wells.
12. Potential new land area for development.

Data relating to the above mentioned aspects were collected from all tanks in the suggested cascades in 15 sub-basins.

c. Summarizing of Data and Information in Each Cascade

The data collected on the various aspects mentioned above from individual tanks in the cascade were summarized to assess the condition of the cascade as a whole.

d. **Assessing the Levels of Land Water Resource Development Potentials in Different Cascade**

A set of criteria was developed to assess the land and water resource development potentials in each cascade. The criteria included the following:

* Potential beneficiary families.
* Average landholding size (family unit).
* Cropping intensity.
* Yield.
* Magnitude (quantity wise) of excess water that can be captured.
* Conditions of the physical features of the tanks.
* Level of institutional performance (farmer organizations).
* Possibility of conjunctive water resource use (agro-wells).
* Potential new area for development.

The above mentioned criteria and some special factors observed by the field Team were converted into measurable indicators through the following scoring index in **Table 4.6.**

Table 4.6 Scoring index selected for assessing land and water resources potential of cascades

Criteria	Indicator	Score
(1) Potential beneficiary families	* Less than 500 families * More than 500 families	0 1
(2) Average land holding size of a family	* Less than .5 acres * Between 1-2 acres * More than 2.5 acres	0 1 2
(3) Cropping intensity	(Only maha season considered) * 100% * 100% - 75% * 75% - 50% * Less than 50%	 0 1 2 3
(4) Yield	* Low due to unsuitable soil, weather, and other conditions. * Low due to low level of input application. * Yield low due to insufficient water.	0 1 2
(5) Magnitude of excess water	* More than 50% of tanks do not spill. * More than 50% of tanks spills occasionally. * More than 50% of tanks spills annually.	0 1 2

Criteria	Indicator	Score
	* More than 50% of tanks spills for less than 7 days continuously per season.	0
	* More than 50% tanks spills between 7-15 days per season.	1
	* More than 50% of tanks spills for more than 15 days per season.	2
	* Last two tanks does not spill.	0
	* Last two tanks spills.	1
	* More than two tanks in the tail-end of the cascade spill.	2
Physical condition	* In more than 50% of tanks all components of the headwork are in good condition.	0
	* In more than 50% of tanks, some components are dilapidated.	1
conjunctive water resource use	* More than 50% of existing agro-wells has insufficient water.	0
	* More than 50% of existing agro-wells has unsuitable water (quality).	0
	* More than 50% of existing agro-wells has sufficient and good quality water.	1
Potential new land for development	* No significant area available for new development. Less than 50 acres).	0
	* Moderately significant area available for new development (between 50-250 acres).	1
	* Significant area available for new development (more than 250 acres).	2
Special factors	* No special factors observed.	0
	* Observed moderately significant factors.	1
	* Observed significant factors.	2

Note: To have a comprehensive idea of tank potential, the different scoring indicators should be considered collectively. Consideration of individual scoring index does not give the correct meaning, besides, it might also project a wrong picture.

The objective of this scoring index was to assess the degree of land and water resource potentials in each cascade. The following assumptions were considered in selecting the best water resource endowed cascade.

> Higher the number of beneficiaries, more the justification for development.
> Higher the average size of family land holdings, better the potential for development.
> Lower the cropping intensity during maha, higher the potential for development.
> Lower the yield due to water factors, higher the potential for justification of water resource development.
> Higher the number of tanks spilling annually in the cascade, more the potential for water resources development.
> Higher the length of spilling period, more the potential for water resources development.
> More the number of tail-end tanks of cascade spilling annually, higher the potential for water resource development.
> Higher the number of tanks with dilapidated features, more the potential for justification for improvement.
> Higher the number of agro-wells with adequate and good quality of water, more the potential for water resource development.
> Larger the area existing for development, more the justification of investment in water resource development.
> Higher the number of significant additional water sources observed, more the potential for water resource development.

e. Application of Scoring System

The scoring system discussed under Item C was applied to assess the level of land and water resource performance in the suggested cascades by the land use planners.

The scoring system was applied to 34 cascades in 12 sub-basins.

Table 4.7 below provides the actual scores obtained in 34 cascades in 12 sub-basins and the cascades which obtained highest score in each sub-basin were selected as the most potential cascades for land and water resource development.

Table 4.7 Results of scoring for the selected cascades

Sub-basin	Cascades	1	2	3	4	5	6	7	8	9	10	11	12
K-6	No*												
MAL-1	MAL-1 3	0	-	1	1	2	1	0	1	0	0	0	6
	4	1	-	2	0	2	1	2	1	0	1	2	12
	10	0	-	2	0	2	1	2	1	0	1	1	10
	14	0	-	2	1	0	0	0	1	1	1	0	6

MAL-2	MAL-2	1	0	1	2	0	2	2	1	1	0	2	1	12
		8	1	1	1	1	2	2	1	1	1	2	0	13
		3	0	1	2	1	2	0	0	1	0	2	0	9
MAL-3	MAL-3	2												
MAL-6	MAL-6	2	0	-	1	1	2	1	0	1	1	0	0	7
		3	1	-	1	2	2	1	1	1	1	2	1	13
		4	1	-	1	1	0	0	0	1	0	2	0	6
MAL-7	MAL-7	3	1	-	1	1	0	0	1	1	1	1	1	8
		4	1	-	1	2	2	1	1	1	1	1	0	12
		6	1	-	1	1	0	0	0	1	0	0	0	4
MAL-8	MAL-8	1	1	2	1	0	1	1	0	1	1	2	-	10
		2	1	1	1	0	1	1	0	1	1	1	-	8
		4	1	2	1	1	2	1	2	1	1	2	-	14
MAL-10	MAL-10	1	0	2	1	1	0	0	1	1	1	0	-	7
		4	1	1	1	0	1	1	1	1	1	2	-	10
Y-1	Y-1	1	0	-	1	1	1	0	0	1	1	2	1	8
		2	0	-	1	1	2	1	2	1	1	2	1	12
		7	0	-	1	0	2	0	2	1	1	0	0	7
Y-2	Y-2	1	1	1	1	2	1	1	1	1	1	2	1	13
		2	0	1	1	0	2	1	1	1	1	1	1	10
		3	0	1	0	0	1	1	1	1	1	1	1	8
Y-3	Y-3	6	0	2	1	1	2	2	2	1	1	1	1	14
		1	1	2	1	0	2	2	2	1	1	1	0	13
		2	0	1	1	0	1	0	0	1	0	1	0	5
Y-4	Y-4	6	0	2	2	0	2	2	2	1	0	2	1	14
		3	0	2	1	0	1	1	2	1	0	2	-	11
MA-1	MA-1	6	0	2	1	2	1	1	2	1	1	2	1	14
		8	0	1	1	2	1	1	1	1	0	2	-	10
		10	1	1	1	2	1	1	1	1	1	0	-	10
MO-2	MO 2	1	0	1	3	0	1	1	1	1	1	1	1	11
		2	0	2	1	0	0	2	1	1	1	1	0	9

1. Beneficiaries
2. Land carrying capacity
3. Cropping intensity
4. Yield performance
5. Spilling I
6. Spilling II
7. Spilling III
8. Physical features
9. Agro Wells
10. New Area Development
11. Special factors
12. Total

4.3.5 Land and Water Resources Development Proposals

The Field Study Team met 4-10 farmers in each tank of the selected cascades. The farmers included 1-2 farmer leaders (velvidane, FO leader) and the rest general farmers. Most

of the farmers suggested to improve the physical features of their tanks, i.e. raising bund and spillways, improving sluices and canal system. At the same time, in many cases, farmers indicated that water resources would not be adequate even with the improvement of the physical features of the tanks. But they perceived physical improvement is the best alternative available. Again in the first two cascades (Negama and Maha Kanamulla) where our first field studies were conducted, we attempted to conduct PRAs in three selected tanks representing head, middle and tail areas of the cascade. Although we met about 15-20 farmers representing various physical and community characteristics of the area, the results of the PRA sessions were not much different from the results of meetings with farmers from individual tanks. The only difference was that we were able to learn the nature of problems farmers faced within the tanks. Farmers of individual tanks could not analyze the problems in relation to other tanks in the cascade.

The major drawback observed in the individual tank based PRA was limiting the farmers belonging to the individual tanks. Therefore, their knowledge was limited to their tank and no opportunities were created for farmers to interact with farmers in other tanks in the cascade. In other words, it was felt that our approach was not appropriate to create a dialogue among farmers to seek solutions for the cascade as a whole.

The state of affairs described above prompted us to seek alternative methodology to develop comprehensive proposals for the cascade as whole. (As described under Item 4.3.3).

a. Basic Features of the Alternative Approach

* The main objective of this approach was to tap indigenous knowledge of farmers to develop proposals for water resources development in their cascades.

* The farmers involved in PRA discussions acted not merely as data and information providers but also analyzed their problems collectively and attempted to come up with solutions from their perspectives.

b. Nature of Participants at PRA Sessions

Depending on the size of the cascade (geographical area), two to three PRA sessions were organized. These sessions were designed to cover the entire cascade. At each PRA session, farmers involved represented number of tanks to be covered by the particular session. In many cases some tanks were represented at more than one session because the farmers of particular tanks also attended other sessions organized in the cascade.

The participants for the PRA sessions were selected so as to capture the physical and community variations in the cascade. About seven to eight farmers from each tank participated at the PRA sessions. Two farmer leaders from FOs were also included. In tanks where there were no FOs, a velvidane and one common farmer was included.

c. Method Followed When Conducting PRAs

Primarily, the Field Team acted as facilitators to farmers to draw a series of community maps. We found that this method was much more effective than conducting group discussions. The farmers were able to illustrate the condition of tank system and also identify various problems faced by them due to unfavorable conditions.

Depending on the series of maps drawn, the following maps were developed as tools for the preparation of water resources development plans.

1. Map depicting existing community aspects including road network, settlement details, and some basic details on farmer organizations.

2. Map depicting catchment area information including size of the catchment area, natural streams and inflow inlets to each tank in the catchment and water availability status of each tank.

3. Map depicting command area information including cropping intensity.

The farmers participated at the PRA session were actively involved in analyzing their problems. The common problem faced by farmers was the severe water shortage problem. Implications due to water shortage was also discussed by the farmers in detail. The other common problem discussed was the problem of agriculture.

* Inability to do cultivation during yala season. Water is not effectively utilized to do cultivation of other field crops even in tanks which have adequate water.

* Most farmers are compelled to take the risk of cultivating akkarawelas. Akkarawelas would be given irrigation water only if sufficient water is available in the tank, otherwise even at the critical stages of the crop, akkarawela farmers would not receive water from the tank.

Farmers in most of the tanks stressed the acute problems they faced with the service delivery programs of various government departments, especially the Department of Agrarian Services and the Department of Agriculture.

Although Village or Grama Niladhari Division based farmer organizations have been established in most of the tanks, no significant collective actions have been carried out to improve operations and maintenance activities. In most cases, one or two farmers take the responsibility of operating the main sluice. It is not done in a systematic way to improve the water management practices. Water sharing among farm lots is the responsibility of farmers. Farmers accepted that although water is a scarce resource in their tanks water wastage is a common problem during maha season. Prolonged land preparation was a common problem reported.

On the other hand, no mechanism exists for farmers in the entire cascade to organize activities that are beneficial to all farmers. Non availability of cascade level farmer organization was seen as a problem.

Farmer groups attempted to analyze problems faced in existing agro-wells in the area. Many agro-wells constructed under the assistance of external financial assistance are under utilized.

The farmers' observations are substantial. **Table 4.8** below shows a tabulation of information obtain form farmers in respect of number of agrowells in each cascades and average areas cultivated at present under those agrowells.

Table 4.8 Average number of agrowells and average area cultivated under agrowells in selected cascades

Sub-basin	Cascade	No. of Agro-wells	Area Cultivated (in acres)
Y 3	Y 3-1	7	5.25
	Y 3-2	11	1.25
	Y 3-6	32	11.0
Y 4	Y 4-3	14	1.0
	Y 4-6	34	7.0
MA 1	MA 1-6	22	6.0
	MA 1-8	2	-
	MA 1-10	08	2.25
MO 2	MO 2-1	3	2.0
		2	1.25
Y 2	Y 2-1	16	12.5
	Y 2-2	07	4.0
	Y 2-3	02	1.0
Y 1	Y 1-1	04	1.0
	Y 1-2	15	6.0
	Y 1-7	15	6.0
MAL 2	MAL 2-1	22	9.5
	MAL 2-8	47	28.5
	MAL 2-3	06	0.5
MAL 6	MAL 6-2	01	0.5
	MAL 6-4	10	3.0
	MAL 6-3	23	9.0

Sub-basin	Cascade	No. of Agro-wells	Area Cultivated (in acres)
MAL 8	MAL 8-3 MAL 8-1 MAL 8-2	23 48 74	4.5.0 27.5 16.0
MAL 10	MAL 10-2 MAL 10-1	86 29	39.0 11.0
MAL 1	MAL 1-3 MAL 1-4 MAL 1-10 MAL 1-14	6 3 6 13	27.5 0.75 2.0 0.7
Total	**30**	**591**	**229.5**

d. Results of Participatory Mapping

Initially, when farmers from individual tanks were met separately, they proposed improvements to main physical components of the individual tanks in the cascade. This situation changed in the second step of our methodology. When groups of farmers from different tanks were consulted they attempted to bring forward various proposals for land and water resources development of the cascade.

At this stage the proposals put forward by farmers were beneficial to most of the tanks in the cascade. The main concern of farmers was to improve the water resource condition in water shortage tanks in the cascade.

The information shown in **Table 4.9** below indicate the number of tanks that would be benefitted if the specific proposals made by the farmers during the PRA sessions conducted by the field study team are implemented. It has to be noted that the number of tanks that would receive benefits from the proposed interventions are as perceived by the farmers and are not on the basis of a detailed technical investigations.

Table 4.9 Farmers perceptions on the potential benefits

Cascade	No. of tanks	No. of Tanks Benefitted
MAL 1-4	22	10
MAL 10-4	27	10

Cascade	No. of tanks	No. of Tanks Benefitted
MAL 8-4	24	14
MAL 7-4	22	3 tanks (within the cascade) 2 tanks (outside the cascade)
MO 2-9	12	3
MA 2-5	18	6
MA 1-6	18	2 (within the cascade) 4 (outside the cascade)
Y 4-6	16	11 (within the cascade) 1 (outside the cascade)
Y 3-6	23	15

Note: Farmers suggested various improvements to tanks which are not coming under the proposed project for improving water acquisition and distribution.

Farmers who participated at PRA sessions attempted to justify their proposal based on the following perceived benefits:

1. Possibility of developing new lands.

2. Encouraging farmers to take risk by providing minimum quantity of water to a tank to start cultivation.

3. Increasing cropping intensity in the existing command area.

4. Social equity through acquisition and distribution of water among disadvantageous communities.

5. Promoting interrelationship among various communities under different tanks in the cascade.

Table 4.10 below indicates the new areas that can be undertaken for irrigated agriculture and the existing areas where the cropping intensity can be substantially increased if the proposed interventions are implemented. It has to be noted that the figures indicated in the table are quoted purely on the basis of wisdom and suggestions made by the farmers during the PRA sessions and not on the basis of any technical investigations. However, it is the responsibility of the subsequent

study teams to ascertain the extent benefitted during the detailed feasibility studies during the implementing stage.

Table 4.10 Farmers' perception on the areas benefitted

Cascade	Size of Potential New Area (in acres)	Size of existing area in which cropping intensity be increased (acres)
Y 4-6	1450	915
Y 3-6		591
MA 1-6		812
MA 2-5	635	255
MO 2-9	165	106
Y 2-1	505 (within cascade) 140 (outside cascade)	735
Y 1-2	525	119.5
MAL 2-8	625	861
MAL 7-4	40	558
MAL 6-3	305	1222
MAL 8-4	140 (within cascade) 165 (outside cascade)	1332
MAL 10-4	435	1067
MAL 1-4	207	727

Farmer groups participated at the PRA sessions proposed mechanisms for institutional development in the following areas

i. Improving collective farmer activities through farmer organizations.

ii. Improving service delivery programs of government agencies, i.e., the Department of Agrarian Services and the Department of Agriculture.

e. **Institutional arrangements proposed by the farmers**

The proposed nature of institutional framework for managing cascades is the following:

First level: Tank Level Organizations

Farmers proposed to form farmer organizations at individual tank level of the cascade. These organizations would undertake the role of organizing collective activities of O&M of the tank and its command area.

Second level: Farmer Committees

Farmers proposed to establish farmer committees based on the proposed water resources development strategy.

As a result of the proposed water acquisition and water distribution canal system, individual tanks which would benefit from the proposed canals will have to depend on each other for water. Farmers proposed to establish farmer committees with the participation of farmer representatives from beneficiary tanks. The committees would be responsible for O&M of the proposed water acquisition and distribution canal system. (Water distribution among tanks).

3. Third Level: Cascade Level Farmer Federation

Farmers that participated at PRA sessions highlighted the need for establishing farmer federations to organize combined activities with the participation of the entire cascade community. They further pointed out that establishing federations at cascade level would help to improve agricultural input delivery and marketing activities.

4.3.6 Categorization of Cascades for Rehabilitation

Depending on the nature of physical rehabilitation proposals to tanks suggested by farmers in 13 cascades, they can be divided into five categories. It was difficult to categorize Nagama and Maha Kanamulla cascades because we did not follow the improved methodology in these two cascades and therefore, they were not included for categorization.

Category I

Potential to rehabilitate individual tanks by improving main components of the tanks, i.e. bund, sluices, spills and distributary canal network, etc.).

Category II

Potential to divert spill water of some tanks to water short tanks in the cascade.

Category III

Potential to tap natural drainage streams to divert water into the cascade and distribute water among water short tanks in the cascade.

Cascade IV

Potential to tap water in tanks of adjoining cascades and supply of water to tanks that are water short in the cascade.

Category V

Potential to divert spill water of tanks located in the tail-end of the cascade to adjoining cascades.

Depending on the nature of rehabilitation needs proposed by farmer beneficiaries, we observed that all the cascades in the NCP can be grouped to the above five categories. For example, the 13 cascades studied by the field team can be grouped to the above five categories as shown in **Table 4.11**.

Table 4.11 Categorization of sample cascades

Category I	Category II	Category III	Category IV	Category V
Kappirikkgama MAL 7-4	Maminiyawa MAL 1-4	Maha Kirimatiyawa Y 2-1	Sivalakulama MAL 2-8	Kolibandawa MA 1-6
Diyatitawewa Y 4-6	Gangurawa MAL 6-3	Pandarallawa Y 3-6	Kidawarankulama MAL 10-4	
Vihara Hallmillawa MA 2-5	Pihimbiyagollawa MAL 8-4			
Ambagahawewa MO 2-9	Weragala Y 1-2			

4.3.7 Nature of Other Rehabilitation Components

The foremost nature of physical improvements suggested was to develop the water resources in the cascade which would address the most critical needs of the farmers, i.e., water availability in the tanks.

Availability of water in the cascade itself would not increase the productivity and also its long-term sustainability. Therefore, it is necessary to develop other essential components of land and water resources in the cascade.

Although detailed proposals are not made at this stage, focus is on areas in which developments are needed. Emphasis has been made on the following components:

i. Catchment area development (mainly land and water conservation).
ii. Command area development (mainly improving cropping intensity).
iii. Institutional development (farmer organizations and improving agency service delivery programs).
iv. Program for homestead development.

a. Catchment Area Development

The following activities will have to be carried out:

i. Chena modernization program to minimize rapid shifting cultivation in the catchment.
ii. To motivate farmers to undertake stabilized chena cultivation. Certain areas of the catchment can be legally allocated to the farmers to grow trees, i.e.fruit trees as well as trees for timber.

b. Command Area Development

To increase cropping intensity a program has to be launched to improve water management practices of farmers during maha season. This will help to increase cropping intensity by expanding the cultivation area during maha, and also some portion of command areas during yala. Farmers can be motivated to undertake OFC cultivation during yala by providing other necessary supports.

c. Institutional Development

It is vital to developing cascade level farmer organizations to function as an institution to improve the productivity in the cascade as a whole. The cascade level Farmer Federation can work actively in collaboration with the respective agrarian service centers. This would be a supplementary input for the ongoing government efforts to set up production based Agrarian Service Centers.

The farmer level federation set up with the membership of farmer representatives from different individual tanks can get involved in cascade level seasonal planning. (In future, a cascade may function as an unit of irrigation settlement project which has 10-22 small tanks).

d. Program for Homestead Development

A uniform set of strategies cannot be proposed to develop homesteads in the cascade areas. Some of the basic principles in developing homesteads in the different cascades can be as follows:

Some homesteads are close to the tanks and also close to the distributary canals of the command area. Farmers with these types of homesteads can be motivated to grow fruit crops and vegetables in their home gardens.

They can be encouraged to develop their agro-wells depending on the ground water table and the quality of water. Since excessive pumping is not required for growing fruit crops there would not be adverse environmental effects.

4.3.8 An Illustration of the Outcome of Sample Case Studies

To illustrate the details on the specific outcomes achieved through participatory rural mapping, we illustrate one case; Maminiyawa cascade in Malwathu Oya river basin in the NCP. The following specific outputs were achieved in the case of participatory mapping exercises conducted in Maminiyawa cascade. Base maps of Maminiyawa cascade prepared by the land use planners as a desk study was used as the guide to capture the details which are shown on maps described below.

Based on the community maps drawn with the active participation of the farmers, following set of descriptive and problem diagnosing maps were developed.

i. Map showing the catchment area. This includes the size of the catchment area of each tank, nature of catchment area, i.e. chena, scrubs, forest, etc., and the inflow patterns of each tank in the cascade.

ii. Map showing present status in the command area. This includes size of the command area, cropping intensity and the condition of the tank, i.e., spillage condition, condition of sluices, bund, spillways and distributary canal network.

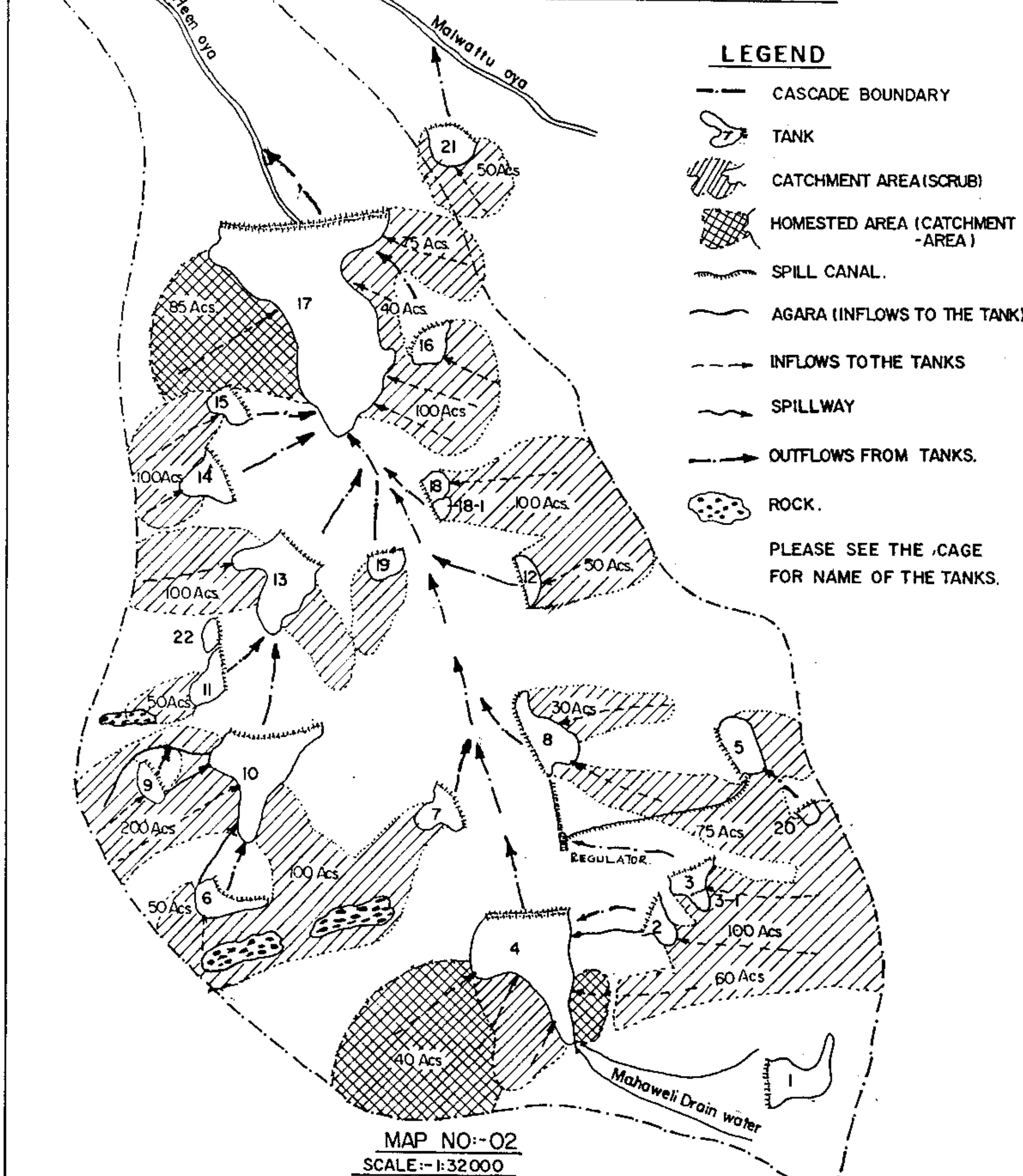
iii. Map showing community details. This includes, settlement area particulars and road network, etc.

The above three maps are shown in **Maps 4.4 to 4.6.**

The second set of maps were developed based on the present problems regarding land and water resources development. This set includes following maps.

MAMINIYAWA CASCADE - (MAL-I-4) Map 4.4

HYDROLOGICAL INFORMATION

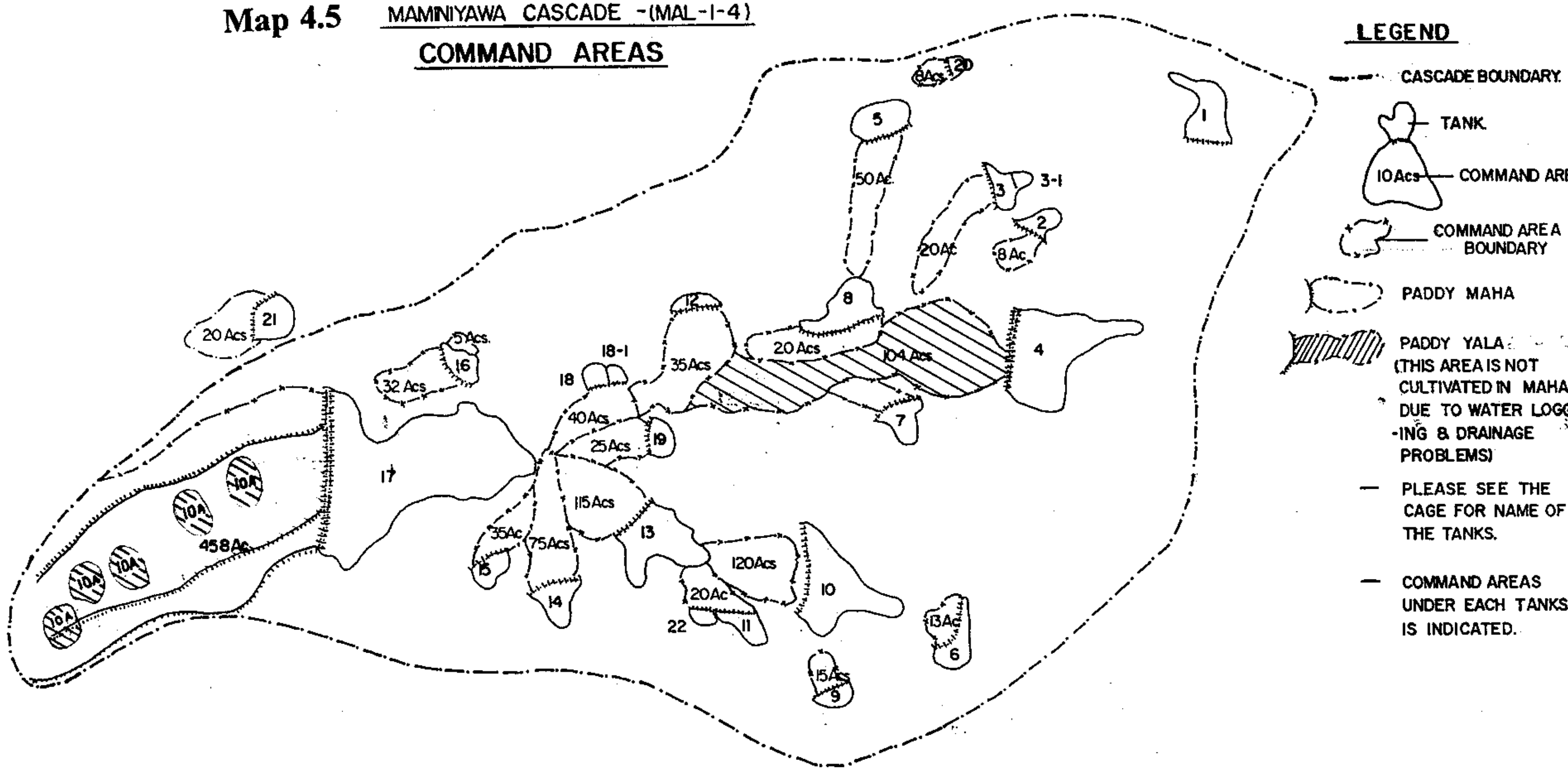


NO	NAME OF TANKS
01	VERUNKULAMA
02.	IHALAGAMA WEWA
03	PAHALA VITARANGAMA WEWA.
03-1	IHALA VITARANGAMA WEWA
04.	MANKADAWELA WEWA
05	EMBULGAS WEWA
06	IHALAWATTA WEWA
07	KATHANKULAMA WEWA
08	KANKANIYAGAMA WEWA
09	PALUGAS WEWA
10	OLUKARANDA WEWA
11.	ALANKULAMA WEWA
12	HITTARAGAMA WEWA
13	MUDURUPPUWA WEWA
14	IHALA KOLLANKUTTIYA WEWA.
15	PAHALA KOLLANKUTIYA WEWA
16	KADDAWA WEWA
17	MAMINIYAWA TANK
18	PAHALA HETTIYAWA WEWA
18-1	IHALA HETTIYAWA WEWA
19	RAMBEWA WEWA
20	ULPATHGAMA WEWA
21	POTUWEWA
22	DAMBULU WEWA.

PHYSICAL FEATURES	SPILL WAY	EARTH.	| — — — | — — — — | — — | | | — | | | | — — |
		DAMAGE	| | | | — — — — | | | | — — — | | | | — | | —
		CONCRET	| | | | | | | | | | — | | — | | | — — — | | |
	BUND	STRONG	| | | | | | | | | | | | | | | | | — — | | | |
		ERODED	| — — — — — — — — — — — — — — — — | | — — — —
		DAMAGE	| — | — — | | | | — — — | | | | | | | | | | —
	SLUICE	MODERN SLUICE.	| | | | | | | | | | | | | — | | | — — | | | |
		LEAKING	| | | — — — | — — | — | | | — — | | | — | | —
		STEP SLUICE	| — — — — — — — — — — — — | — — — | | — — — —
SPILLING DATA	SPILLING PERIODS	30 DAYS	(Mahaweli area) | | | — | | | | | | | | — | | — — — — — | |
		15-30 DAYS	| | | | | | | — | | | | | | | | | | | | | |
		7-15 DAYS	| | | | | — — | | | | | | | | | | | | | | |
		< 7 DAYS	— — — | — | | | | — — — | — — | | | | | — —
	NO SPILLING.		| | | | | | | | — | | | | | | | | | | | | |
	OCCATIONAL SPILLING.		— — — | — | | | | — — — | — — | | | | | — —
	ANNUAL SPILL		| | | — | — — — | | | | — | | — — — — — | |

Map 4.5 MAMNIYAWA CASCADE -(MAL-1-4)

COMMAND AREAS

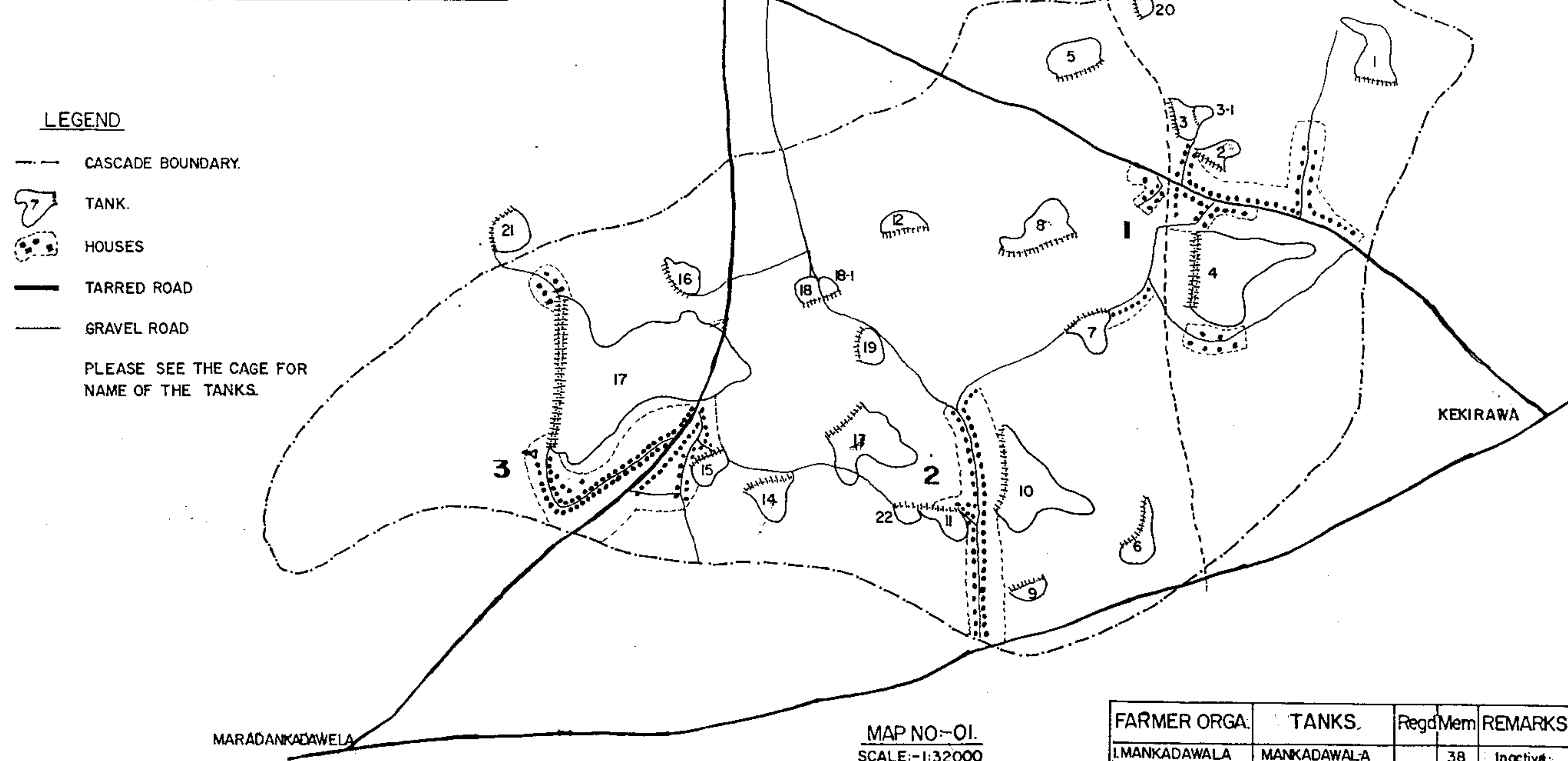


MAP NO:- 03

SCALE:- 1:32000

NO	NAME OF TANKS	NO	NAME OF TANKS
01	VERUNKULAMA	12	HITTARAGAMA WEWA
02	IHALAGAMA WEWA	13.	MUDURUPPUWA WEWA
03	PAHALA VITARANGAMA WEWA	14	IHALA KOLLANKUTIYA WEWA
03-1	IHALA VITARANGAMA WEWA	15	PAHALA KOLLANKUTIYA WEWA
04	MANKADAWELA WEWA	16	KAUDAWA WEWA
05	EMBULGAS WEWA	17	MAMINIYAWA TANK
06	IHALAWATTA WEWA	18	PAHALA HETTIYAWA WEWA
07	KATHANKULAMA WEWA	18-1	IHALA HETTIYAWA WEWA
08	KANKANIYAGAMA WEWA	19	RAMBEWA WEWA
09	PALUGAS WEWA	20	ULPATHGAMA WEWA
10	OLUKARANDA WEWA	21	POTU WEWA
11.	ALANKULAMA WEWA	22.	DAMBULU WEWA

Map 4.6 MAMINIYAWA CASCADE-(MAL-I-4)
COMMUNITY DEVELOPMENT



MAP NO:-01.
SCALE:-1:32000

NO	NAME OF TANKS	NO	NAME OF TANKS
01.	VERUNKULAMA WEWA	12	HITTARAGAMA WEWA
02.	IHALAGAMA WEWA	13	MUDURUPPUWA WEWA
03.	PAHALA VITARANGAMA WEWA	14.	IHALA KOLLANKUTIYA WEWA
03-1	IHALA VITARANGAMA WEWA	15	PAHALA KOLLANKUTIYA WEWA
04	MANKADAWELA WEWA	16	KAUDAWA WEWA
05	EMBULGAS WEWA	17	MAMINIYAWA TANK.
06	IHALAWATTA WEWA	18	PAHALA HETTIYAWA WEWA
07	KATHANKULAMA WEWA	18-1	IHALA HETTIYAWA WEWA
08	KANKANIYAGAMA	19	RAMBEWA WEWA
09	PALUGAS WEWA	20	ULPATHGAMA WEWA
10	OLUKARANDA WEWA	21	POTU WEWA
11.	ALANKULAMA WEWA	22	DAMBULU WEWA

FARMER ORGA.	TANKS.	Regd	Mem	REMARKS
1.MANKADAWALA	MANKADAWALA		38	Inactive
	KATHANKULAMA			
	VITARANGAMA			
	IHALAGAMA			
	KANKANIYAGAMA			
	HITTARAGAMA			
	EBULGASWEWA			
2.OLUKARANDA	PALUGASWEWA		37	Active
	IHALAWATTA		50	"
	ALANKULAMA			
3.RAMBEWA	RAMBEWA		70	
4.HETTIYAWA	HETTIYAWA			
5.KOLLANKUTTIYA	KOLLANKUTTIYA		120	
6.MAMINIYAWA	MAMINIYAWA		45	
	KAUDAMA			
	POTUWEWA			

i. Map indicating proposals for water resources improvements of the cascade.

ii. Map indicating new land that can be undertaken for development as a result of improving water resources in the cascades.

iii. Map indicating the nature of community organizations that can be developed. (Farmer organizations).

The above three maps are shown in **Maps 4.7** to **4.9.**

To prepare the cost estimates for the farmer proposals on water resources improvements, a team including a technical officer, social scientist and field assistants visited the five cascades which would represent the nature of improvements suggested by farmers for water resources development. The team did not attempt to verify the technical and economic feasibility of the proposals in detail. However the farmer proposals need serious verifications of the technical experts.

The outcome of the 15 case studies are presented in **Annexure 4.2**.

4.3.9 Conclusions

The method suggested and tested herein for selection of cascades and to develop proposals for land and water resources development is unique. This is mainly because of the following reasons.

i. In the past, there was no attempt made to understand the nature of hydrology in the cascade as a whole and whatever rehabilitation projects carried out were based on improving main physical features of individual tanks. The methodology adopted in this study was quite different and cascades as a whole was considered for land and water resources development.

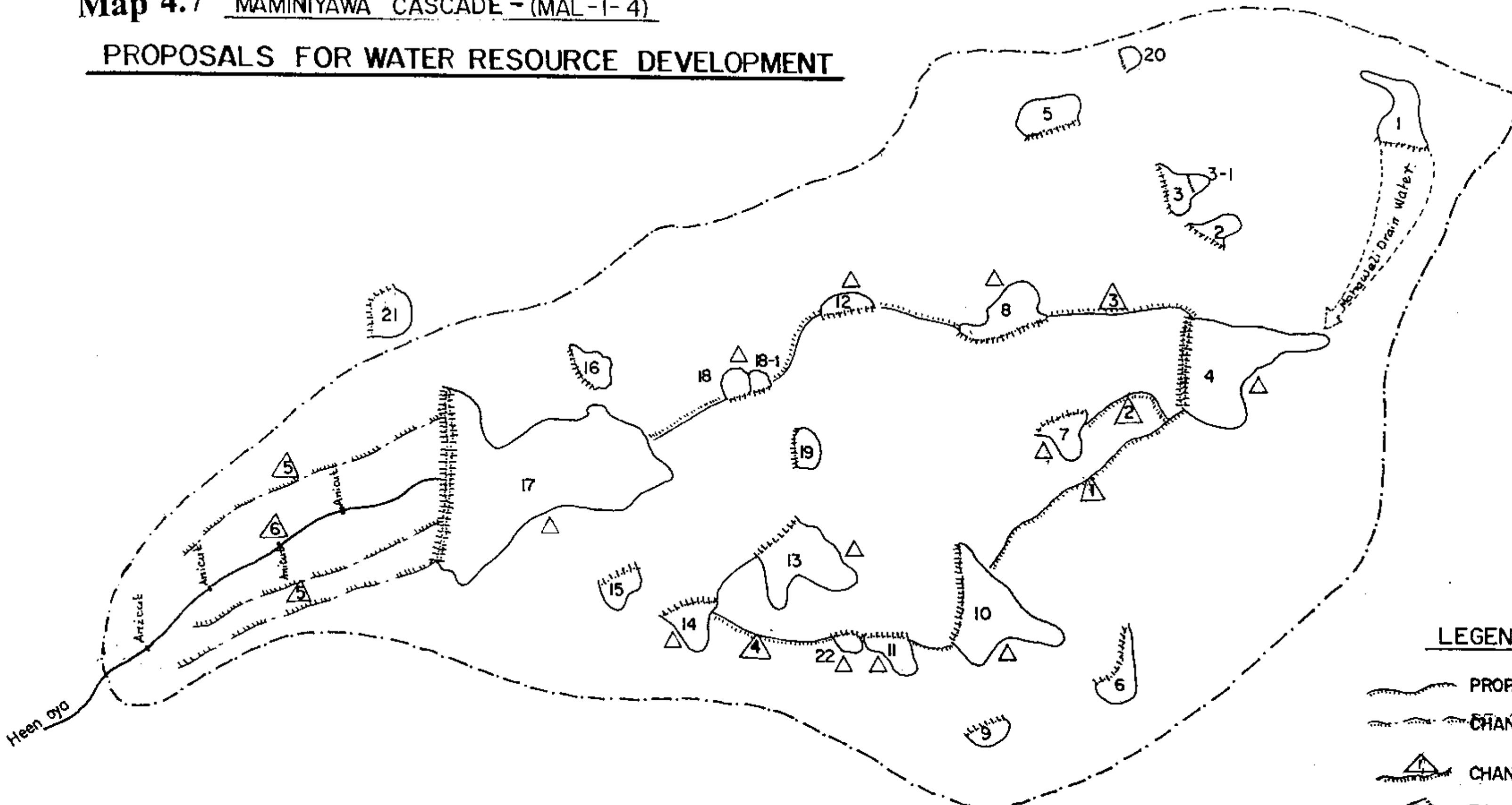
ii. Cascade selection for land and water resources development was based on carefully developed criteria/indicators. In the past even individual tanks for rehabilitations were selected on an ad hoc manner, i.e., requests from local politicians, influential leaders of the community, etc.

iii. The indigenous knowledge of the farm community was very useful for the development planning. This type of consultation process did not take place in the previous rehabilitation projects neither in planning stages nor during implementation.

iv. The most acute problem common to most of the farmers in the cascades were identified with the active involvement of farmers. The proposals developed for water resources development would be beneficial to majority of the farmers in the cascade.

Map 4.7 MAMINIYAWA CASCADE - (MAL-1-4)

PROPOSALS FOR WATER RESOURCE DEVELOPMENT



LEGEND

- PROPOSED NEW CHANNEL
- CHANNELS TO BE REHABILITA-TED.
- CHANNEL NUMBER.
- TANK.
- CASCADE BOUNDARY
- PLEASE SEE THE CAGE FOR NAME OF TANKS.
- REHABILITATE THE TANKS ATTENDING TO SPECIFIC ITEMS OF WORK ONLY.

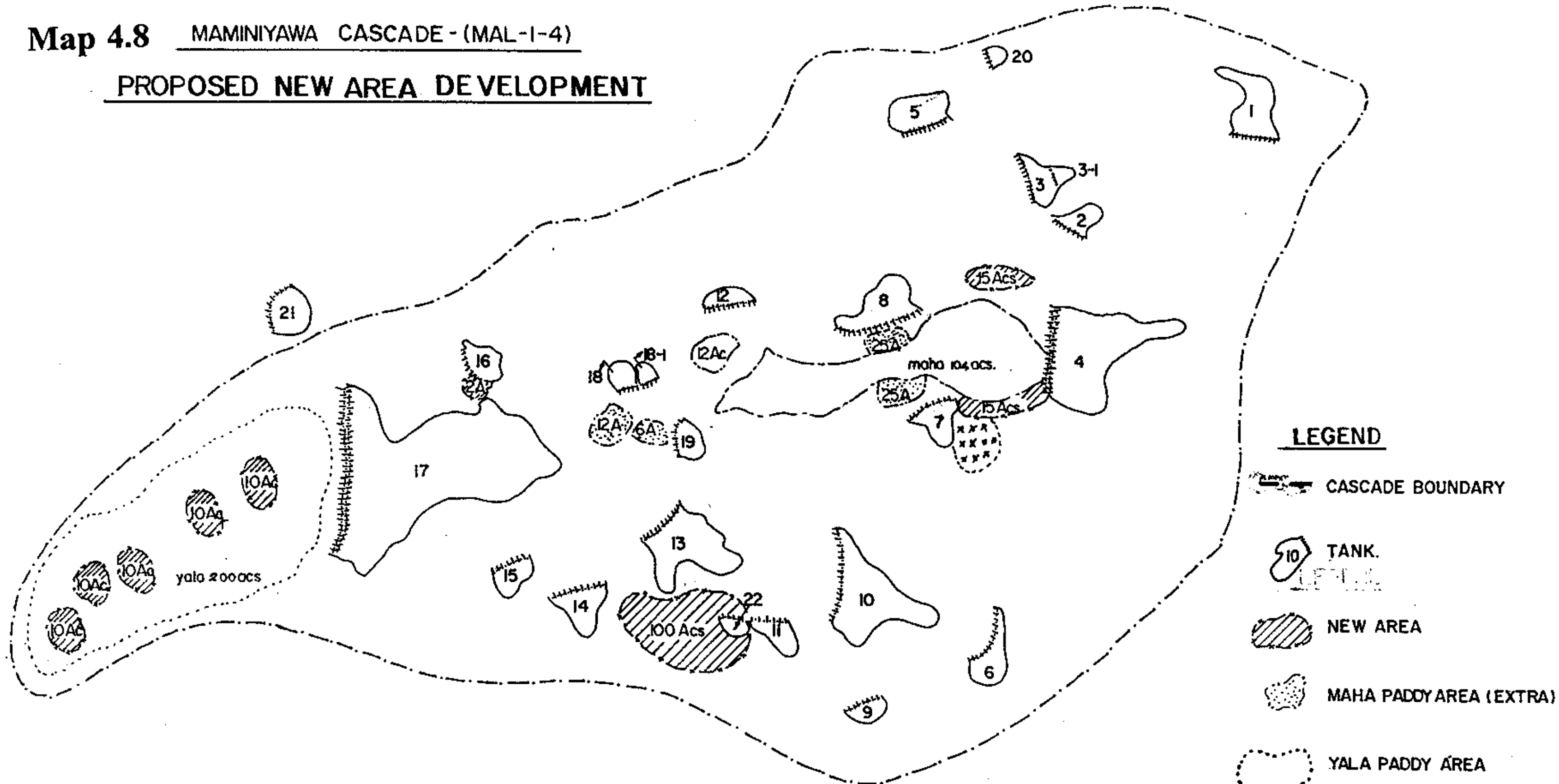
MAP NO:-04

SCALE:- 1:32 000

NO	NAME OF TANKS	NO	NAME OF TANKS
01	VERUNKULAMA WEWA	12	HITTARAGAMA WEWA
02.	IHALAGAMA WEWA	13.	MUDURUPPUWA WEWA
03	PAHALA VITARANGAMA WEWA	14.	IHALA KOLLANKUTIYA WEWA
03-1	IHALA VITARANGAMA WEWA	15.	PAHALA KOLLANKUTIYA WEWA
04	MANKADAWELA WEWA	16.	KAUDAWA WEWA
05	EMBULGA WEWA	17	MAMINIYAWA TANK
06	IHALAWATTA WEWA	18	PAHALA HETTIYAWA WEWA
07.	KATHANKULAMA WEWA	18-1	IHALA HETTIYAWA WEWA
08	KANKANIYAGAMA WEWA	19	RAMBEWA WEWA
09	PALUGAS WEWA	20	ULPATHGAMA WEWA
10	OLUKARANDA WEWA	21	POTU WEWA
11.	ALANKULAMA WEWA	22	DAMBULU WEWA

Map 4.8 MAMINIYAWA CASCADE - (MAL-1-4)

PROPOSED NEW AREA DEVELOPMENT



MAP NO:-05

SCALE:-1:32000

NO	NAME OF TANKS	NO	NAME OF TANKS
01.	VERUNKULAMA	12.	HITTARAGAMA WEWA
02	IHALAGAMA WEWA	13	MUDURUPPUWA WEWA
03	PAHALA VITARANGAMA WEWA	14	IHALA KOLLANKUTIYA WEWA
03-1	IHALA VITARANGAMA WEWA	15	PAHALA KOLLANKUTIYA WEWA
04	MANKADAWELA WEWA	16	KAUDAWA WEWA
05	EMBULGAS WEWA	17	MAMINIYAWA TANK
06	IHALAWATTA WEWA	18	PAHALA HETTIYAWA WEWA
07	KATHANKULAMA WEWA	18-1	IHALA HETTIYAWA WEWA
08	KANKANIYAGAMA WEWA	19	RAMBEWA WEWA
09	PALUGAS WEWA	20	ULPATHGAMA WEWA
10	OLUKARANDA WEWA	21.	POTU WEWA
11	ALANKULAMA WEWA	22	DAMBULU WEWA

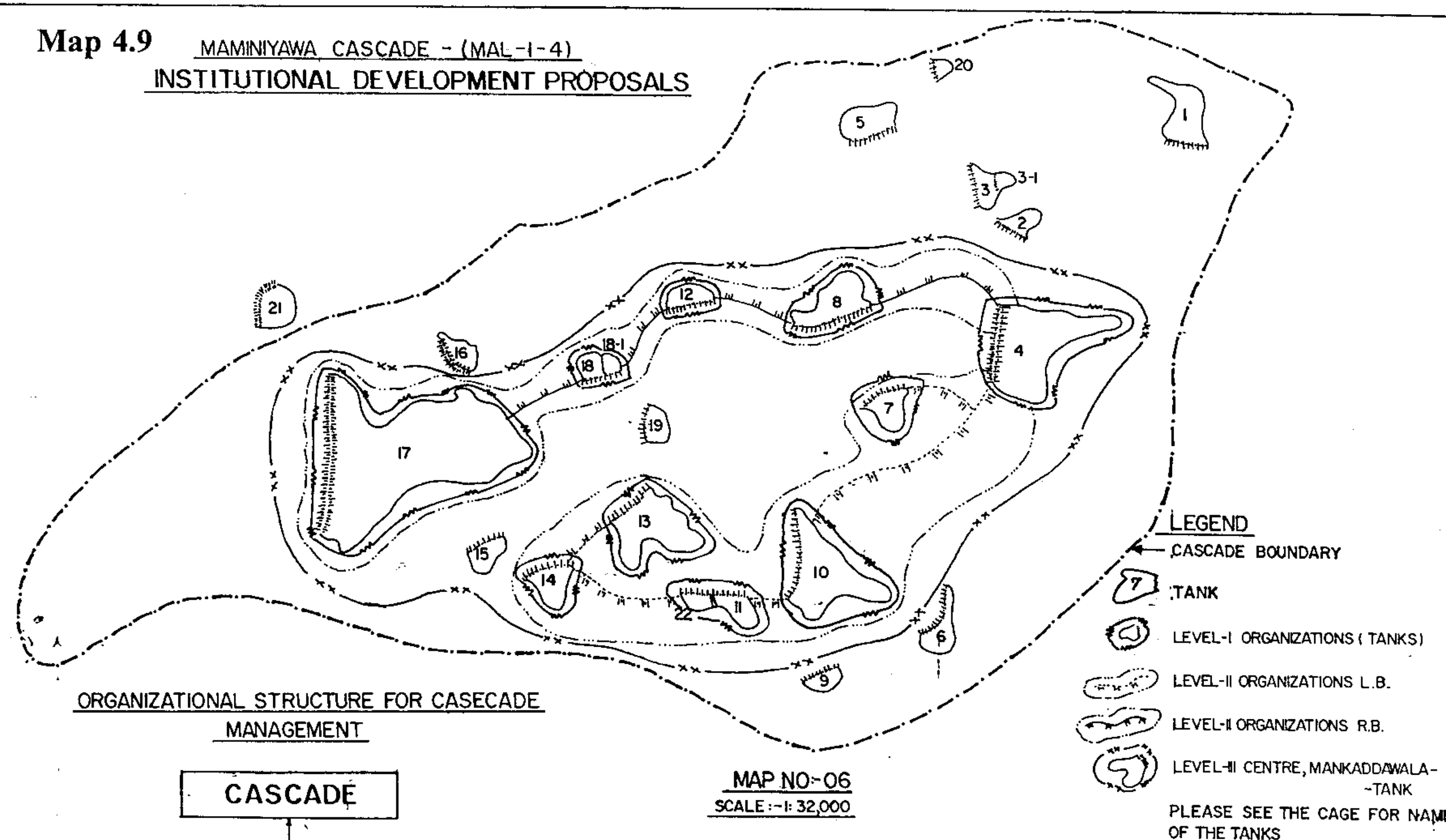
NOTE:-

NEW AREA THAT CAN BE CULTIVATED IN MAHA WITH INCREASED WATER AVAILABILITY AFTER THE PROPOSED WATER RESOURCES DEVELOPMENT.

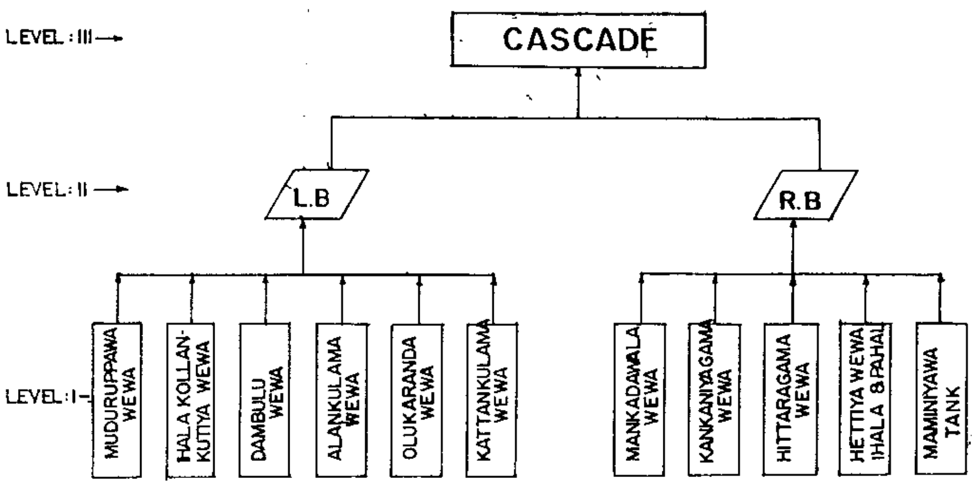
AREAS PROVIDING NOT CULTIVATED IN MAHA DUE TO DRAINAGE PROBLEMS, BUT CAN BE CULTIVATED AFTER THE PROPOSED WATER RESOURCES DEVELOPMENT DUE TO REDUCTION OF WATER.

PLEASE SEE THE CAGE FOR NAME OF THE TANKS.

Map 4.9 MAMINIYAWA CASCADE - (MAL-I-4)
INSTITUTIONAL DEVELOPMENT PROPOSALS



ORGANIZATIONAL STRUCTURE FOR CASECADE MANAGEMENT



NO	NAME OF TANKS	NO	NAME OF TANKS
01	VERUNKULAMA	12.	HITTARAGAMA WEWA
02.	IHALAGAMA WEWA	13.	MUDURUPPUWA WEWA
03	PAHALA VITARANGAMA WEWA	14	IHALA KOLLANKUTIYA WEWA
03-I	IHALA VITARANGAMA	15	PAHALA KOLLANKUTIYA WEWA
04	MANKADAWELA WEWA	16	KAUDAWA WEWA
05	EMBULGAS WEWA	17	MAMINIYAWA TANK
06	IHALAWATTA WEWA	18	PAHALA HETTIYAWA WEWA
07	KATHANKULAMA WEWA	18-I	IHALA HETTIYAWA WEWA
08	KANKANIYAGAMA WEWA	19	RAMBEWA WEWA
09	PALUGAS WEWA	20	ULPATHGAMA WEWA
10	OLUKARANDA WEWA	21	POTU WEWA
11.	ALANKULAMA	22	DAMBULU WEWA

v. Increasing of cropping intensity would be the major output of the proposed land and water resources development strategies.

4.4 A tool for validating the water resources development proposal: A simulation model

Once the farmers' participation and wisdom on how the water resources within a cascade unit can be best utilized, it is required to validate those proposals by studying the effect and impact of those interventions on the overall hydrology of the cascade. In order to do this validation, a computer operated simulation model was developed. Apart from its strength for using as a validation tool, the model can be used to study the effects and impacts on the patterns of reservoir filling, tank storage, water availability and cropping intensity of the downstream tank of a cascade resulting from the increased utilization and diversion of available water in the upstream part of a cascade. In the same manner, the model can be used to simulate the beneficial impact on the cropping intensity of the downstream tanks of a cascade resulting due to increased water availability to these tanks brought about by improved augmentation.

The system has been designed to handle the following three major functions of a water resource system analysis in the context of our watershed approach. A detailed description of the simulation model is given in **Annexure 4.3.**

i. Isolated single tank analysis
ii. Cascade analysis (which integrates a cluster of isolated single tanks into a cascade unit)
iii. Basin analysis (which integrates a cluster of cascade units to a complete basin unit)

The following sections provide a brief description of each of the three key features:

4.4.1 Isolated Tank Analysis

The operation of a single reservoir is analyzed under given operational situations. Various inflows to the reservoir, outflows from reservoir as well as all forms of water losses from reservoir are calculated using basic input data given to the system. The water balance of the particular reservoir is calculated at each time step. The analysis could be carried out for over long periods with a given time step.

4.4.2 Cascade Analysis

The model has the capability to analyze the system of reservoirs operating a given cascade. The model could be used to analyze cascade systems with no limitations to the number of reservoirs and their physical characteristics. The integrated operation of the system is analyzed at each time step and for any time period. By calculating various inflows, outflows and losses to each reservoir, the water balance of each reservoir is calculated in order to obtain the resultant status of reservoirs at each time step. In cascade operation the surplus water spilled through the spillways and the feeder canal releases from a particular reservoir is considered an input to the down stream reservoir.

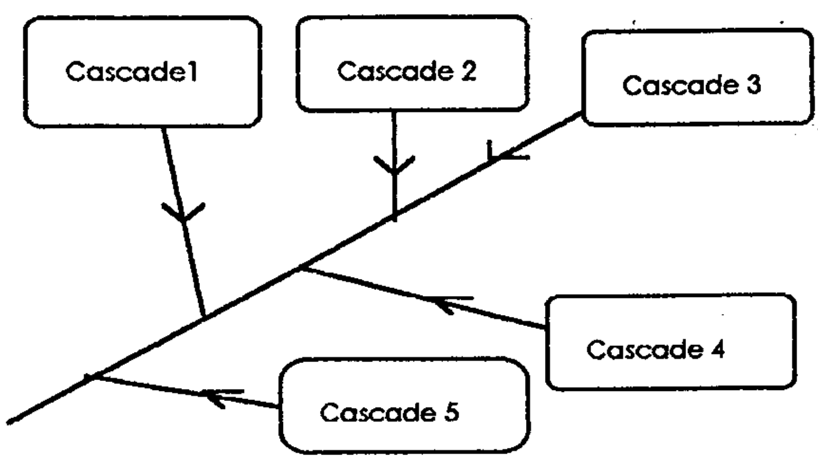
In analyzing such a cascade system, the whole system of tanks is treated one by one in a determined order to obtain the water balance of each reservoir considering their interactive operations.

In this process, as an obvious rule built into the software system is that any reservoir is analyzed only after analyzing all the upstream reservoirs which contribute water through waterways to the particular reservoir.

4.4.3 **Basin watershed analysis**

Several cascades can be combined to form a complete basin. In other words, the basins could be sub-divided into several cascade systems. These cascade systems could be analyzed separately to obtain the reservoir operation status as well as water outflows from such cascades. Then these cascades can be combined to simulate the behaviour of a hydrological complete basin watershed. Therefore, in this analysis, the resultant status of component sub-systems (cascades) which forms the basins obtained and us used in analyzing the combined cascade (basin) watershed.

The analysis procedure is similar to the procedure used in isolated cascade analysis, except that several such cascades are treated separately in a determined order with defined interactions between them. A conceptual diagram showing the integration of cascades to a basin is shown below.



The status of each reservoir in the basin system is obtained. The sub-division is only a method used to simplify the process. As an alternative method to this, the whole basin could be considered as a single cascade. But this method will complicate the process, since all the reservoirs in the basin should be defined to a single model resulting increased number of nodes and links in the model. A description about the node-link model is given in the following chapters.

4.4.4 Modelling method

The widely accepted model-link modelling method of water resource simulation is used. Each hydrologically important structure is a node in the model. The water conveyance system such as canals, streams are considered as links. A link connects two nodes. The model could consist of following node types:

1. Start node (hypothetical)
2. Reservoirs
3. Diversions (bi-furcations)
4. Confluences
5. Cross regulators
6. Lateral feeders
7. Terminating nodes (hypothetical)

The start node is a hypothetical structure used in the node link model to account for the virgin flows or lumped inflows into a particular cascade.

Also, the hypothetical node named (terminating) node is used to associate the final outflows from extreme ends of the cascades. The nodes and links are numbered for reference purposes.

Therefore, the initial step of modelling a cascade system is the translation of the physical system to the node-link model used in the software system. In this translating process, it is important to identify all the nodes and links of the physical system. After identifying the nodes and links, the data related to each node and link in the model should be input to the software system. Data required to define a node in the model differs depending on the type of the node.

In addition to the sequential numbering the nodes and links, more descriptive identities and descriptions of each node should be given as inputs in addition to the other characteristic and parametric data.

Out of the node types 1-7 listed above, the reservoir node is the most important node type in the model and they require a higher number of input data items.

Refer the sample node-link model given in **Figure 4.1.** Representation of one cascade (Maminiyawa cascade) for modeling is shown in **Figure 4.2**

4.4.5 **Important features of the software system**

Since the system is intended to use as an assistance tool in analyzing water resource systems by the water resource personnel who may not be experts in computer systems, every effort has been made to provide all its operations through a user-friendly, comprehensive menu system. Much flexibility is built to avoid limitations in respect of physical and characteristic details of the water resource system. Therefore, the user can use the system to analyze any water resource system. The user should understand the process of converting the physical system to node-link model. Also, some practice may be required to handle the menu system to perform its functions effectively.

The input data could be input to the system easily using data entry menu and through comprehensive data entry screens. All necessary functions (e.g. saving the defined data, loading the previously saved data, defining the system from scratch, modifying entered data etc) are provided under data entry menu.

The outputs can be viewed on screen or could be printed to attached printer. The graphical representation of results eg. reservoir storages, levels, spilled volumes are available for each reservoir.

4.4.6 **Usage of the model and model inputs and outputs**

Since all the variables and parameters of the model could be changed, the model could be used for following purposes.

1. To simulate the operation of reservoir systems under various operational situations.

2. To carry out sensitivity analysis to various parameters and data items e.g. cropping pattern (crop, area cultivated, start date of cultivation)

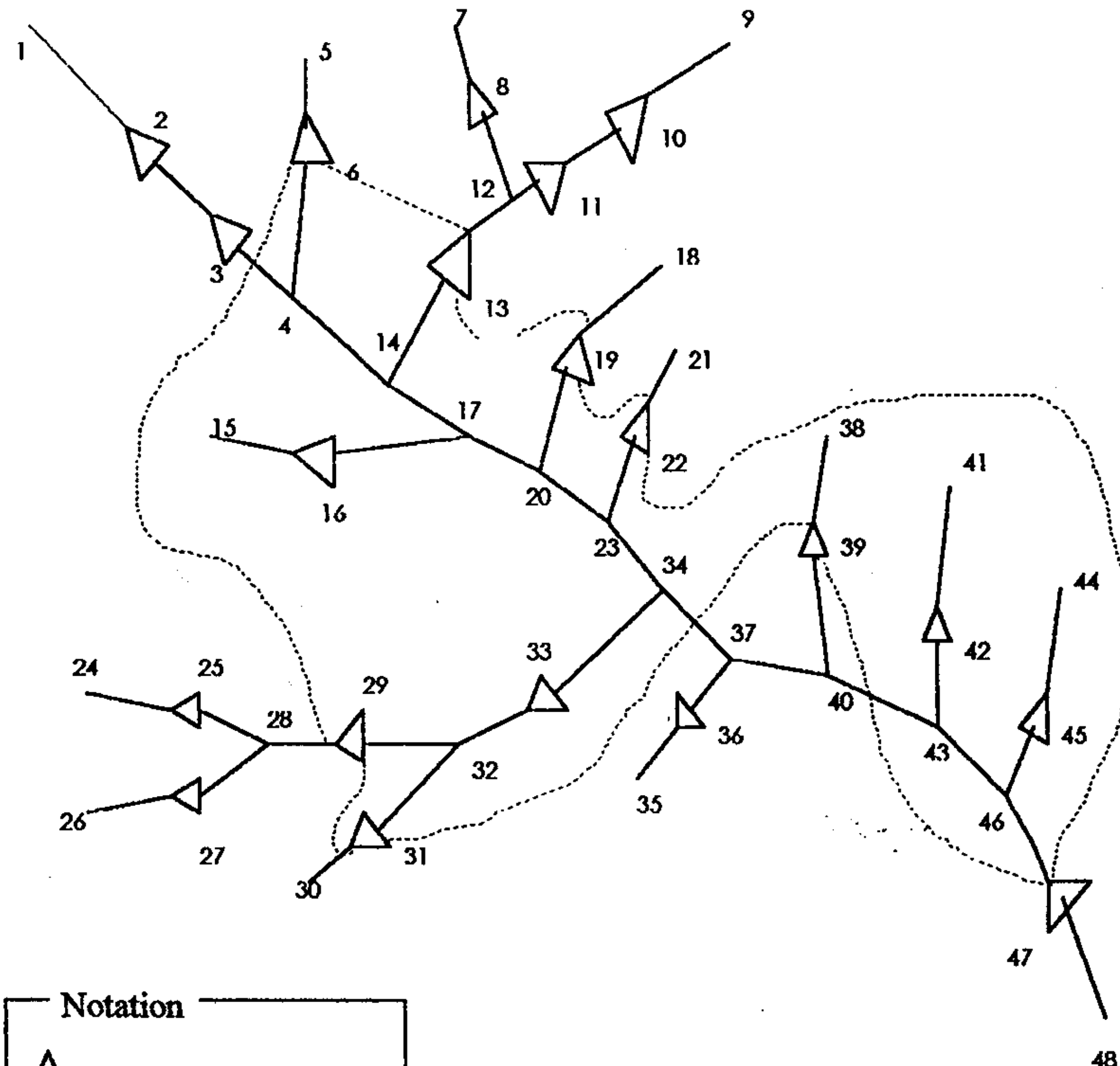
3. To investigate the hydrological impact of any water resources development interventions (e.g. various proposals for rehabilitation, tank restoration) within a cascade and a basin.

The primary model inputs are converting the cascade into a farm consisting of nodes and links.

- depth-area-capacity relationship of the tank;

- catchment area of the tanks of the cascade;

- monthly 75% probability rainfall values and catchment run-off coefficients;



Notation

Δ - Reservoir

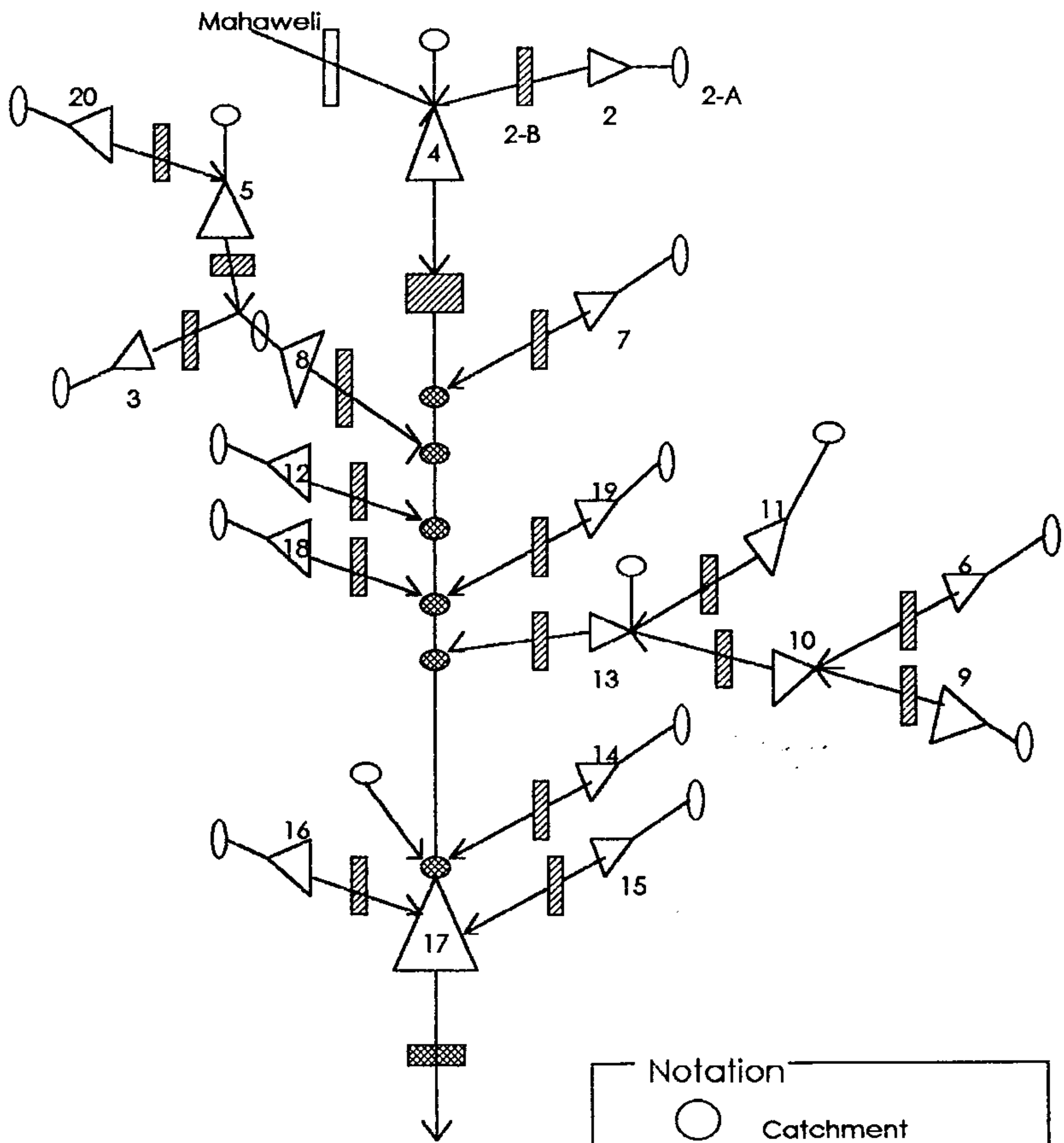
— - Link

25 - Node number

..... - Proposed Rehabilitation canals

Figure 4.1

Node-Link Model of Maminiyawa Cascade in Malwathu Oya River Basin of the NCP



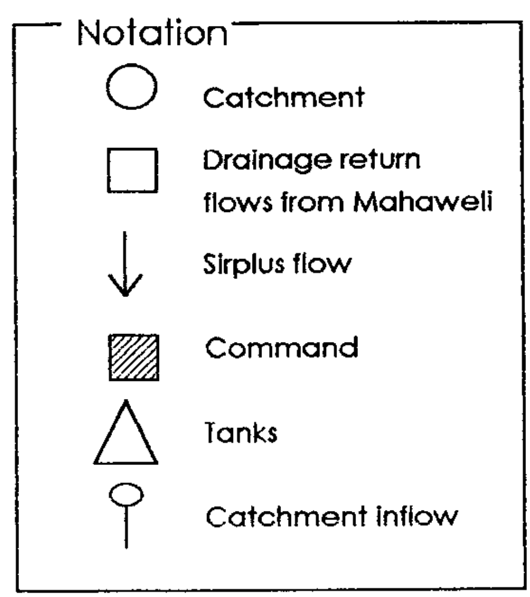


Figure 4.2

Schematic Representation of Maminiyawa Cascade

- monthly open water evaporation rates and tank loss rates (specific data are available);

The variable input parameters are:

- assumed cropping pattern;
- respective areas of well-drained and poorly drained soils of the tank command area;
- assumed date of commencement of the season;
- date on augmented inflows to cascade and augmentation form tanks in the cascade;
- assumed/actual conveyance efficiency of the canals; and
- assumed/actual farm application efficiencies

4.5 Criteria for agro well development

The following are the steps involved in groundwater estimation in a cascade system.

Step 1: Prepare a detailed land use map of the micro-watershed (cascade system) indicating the catchment area contributing to the tank, tank water-spread, lowlands paddy area, upland chena, scrub and homestead (settlement, recent chena, old chena) area, and upland area contributing to drainage through paddy land. It is essential to use 1:10,000 maps with 5 ft contours to delineate these areas more carefully and then field check the map prepared.

Step 2: Find out the area of each of the above category of land including tank storage.[1]

Step 3: Identify the hydrogeological condition of the micro-catchment such as weathered overburden, number of agrowells, number of drinking water supply wells, groundwater level fluctuation, etc. This can be obtained from participatory resource mapping techniques.

Step 4: Estimate the recharge rate from catchment area, tank water spread area and paddy irrigated area[2].

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[1] Use the thumb rule $V = 0.4 \times A \times D$, where V is the tank storage, A is the waterspread area assessed from topo or 1:10,000 maps and D is the average full supply depth at sluice head.

[2] The average recharge in the catchment area of the dry zone has been worked out by a number of investigators as 110 mm/year. Of this, 50 percent would be allowed for maintaining flora and fauna of the catchment and for base flow, and the remaining 50 percent is available for extraction through wells.

Step 5: Estimate the recharge contributed by the catchment area, tank waterspread area and paddy irrigated area. The sum of all these three components gives the total estimates of groundwater available for extraction.

Step 6: Find out the present groundwater used by:

(a) Tube and domestic wells for drinking water supply,
(b) Agrowells.

The drinking water supply as per COWI Consultants (see reference) works out to 1 mm/ha of micro-watershed.

Estimate the groundwater extraction from an agrowell in the upland area which uses groundwater both during maha and yala seasons and an agrowell situated in the low-lying paddy area which abstracts groundwater only during the yala season.[3]

The present use of groundwater can be evaluated by knowing the number of agrowells in the upland area and multiplying by 7000 and the number of agrowells in the low-lying paddy land multiplied by 3000.

Step 7: The difference between quantity of groundwater estimated under **Step (5)** and **Step (6)** gives the groundwater available for further extraction.

Step 8: Determine the number of additional agrowells that can be constructed within the micro-watershed taking into consideration the irrigable area available both in the upland and in the low-lying paddy land.

Step 9: **Sitting of Agrowells**

Hard rock aquifers encountered in NCP are low transmissivity aquifers, capable of holding groundwater only in secondary porosities created by weathering, valley fills, faulting and jointing. Only wells constructed in these locations are capable of

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The average recharge under the tank waterspread is equal to 160 mm which is governed by the weathered formation and not the water availability.

For paddy irrigated land, the recharge rate is equal to groundwater level fluctuations multiplied by the specific yield, (i.e if 7.5 m is the groundwater level fluctuation then the recharge in irrigated paddy area = 7.5 x 20 = 150 mm, where 20 mm is specific yield/meter.

[3] A method is indicated in the Final Report to compute groundwater extraction from an agrowell based on the crop and the areal extent irrigated. By this method, it is estimated that an agro-well in the upland area would use 7000 m^3 of water per well while that in the low-lying paddy land would use only 3000 m^3 of water per agro-well. This is because upland agro-well uses water both during maha and yala seasons while agro-well in the lowlying paddy land uses well water only during the yala season.

yielding sufficient quantity of water for agricultural purposes. Therefore, in hard rock aquifers, wells cannot be constructed in any place without looking into the hydrogeology of that area. **In other words, delineating the probable area for well construction in a micro-watershed is a pre-requisite for successful construction and use of agrowells**

A number of methods such as geophysical, geological, air-photo analysis and drilling are available to identify potential zones for agrowell construction. One or more of these methods need to be used to identify these potential zones.

In addition, the following general criteria can be followed while selecting sites for agrowells:

(a) The terrain selected for agrowell construction should be flat or gently sloping and will not exceed in slope more than 5°,

(b) Some of the most suitable locations are:

- downstream of existing or abandoned tanks,
- valley fills or valley axis,
- downstream of rock outcrops having considerable recharge potential,
- areas where plant life indicates a high water table,
- along drainage valleys.

Having selected a site within this delineated zone, one can further confirm its suitability by constructing a pilot well of 1.2 m diameter to a depth of about 5 to 7 m and testing it for recuperative capacity by completely pumping out the well water. A recuperation of 100 mm in the first hour after pumping stopped is considered sufficient for providing adequate water during dry weather period. Such a site is considered a suitable for agrowell development.

Step 10: Selection of Agrowell Owners

(i) From the technical point of view, the owners of the agrowells should be situated in and near the zones delineated for agrowell development. Too much distance from the center of agrowell development will increase the cost of distribution system.

(ii) From among the farmers who are located nearer the zone of groundwater availability, preference be given to:
- those who do not own paddy land,
- those whose annual income is less than a prescribed minimum,
- those who have sufficient family labor, willing to take up OFC cultivation and credit worthy, etc.

(iii) The selection of farmers for owning agrowells as well as monitoring and regulation of agrowells within a micro-catchment should be left to the villagers or a committee constituted at the village level to take care of agrowell development; this committee at the village level should be aware of the locations where agrowells can be constructed, the probable number of agrowells that can be constructed in the upland and low-lying paddy land so that they can monitor and regulate the development of agrowells within their micro-catchment.

The Technical Expert Team should work with this committee and provide necessary training and support to carry out their task effectively.

Step 11: Management of Agrowells Within a Micro-Catchment

For sustainable agrowell development and use, the total extraction of groundwater from the micro-watershed should not exceed the potential extractable recharge (safe yield of the aquifer). This then requires the complete cooperation of the beneficiaries using the agrowells. To get their full cooperation and to use the agrowells more efficiently, it is suggested that the farmers owning agrowells at a village level be brought as a group for providing training, information dissemination and other support services including repair of pumps, etc; and they be also federated at the cascade level. Such a group will act as a stakeholder for sustaining the agrowell development program within the cascade and at the same time arrange for training, repair and other support services that can be provided through this federated organization. Again, the Expert Technical Team through the Institutional Organizers will provide the necessary technical input to institutionally strengthen this organization.

A numerical example for computing number of agrowells in a sub-watershed encompassing a tank is given in below.

4.5.1 A Numerical Example for Computing a Number of Agrowells Under a Tank

The following are the assumptions and hypothetical data used in the illustrative example.

a. Assumptions

1. The number of agrowells computed under a tank includes both agrowells in the lowland paddy area and agrowells in the highland area (chena, homestead and catchment).

2. The upland agrowells will irrigate on an average 2 acres in maha and 1.1 acres during yala while agrowells in the lowland paddy area will irrigated on an average 1.0 acre of OFC during yala and no well cultivation during maha.

3. Agrowells in the upland area will start groundwater use from January upto mid-'April for a maha crop and thereafter upto August for a yala crop. Agrowells in lowland paddy area will use groundwater from mid-April to August for OFC crop.

4. The groundwater recharge is contributed by the following sources: i) rainfall, ii) tank water, and iii) irrigation seepage and percolation water.

5. The area contributing to recharge is: i) catchment area including those draining into the lowland paddy area, ii) tank waterspread area, and iii) lowland paddy area.

6. The recharge in the catchment area is restricted by rainfall amount while the recharge in tank waterspread and the low-lying paddy area is restricted by underground weathered formation.

7. Groundwater extraction per dug well is estimated based on the area irrigated, crops grown, and their water requirement. Because of the differing cropping calendar, agrowells in lowland areas and upland areas will abstract different quantities of water.

8. Fifty percent of the recharge will be assumed to be necessary for maintaining base flow and the flora and fauna of the area. (i.e., only 50 percent of the recharge is available for groundwater extraction).

b. Data Used

1.	Catchment area (ha):	=	860
2.	Tank water spread area (ha):	=	100
3.	Lowland paddy area (ha	=	40
4.	Recharge in the catchment area (mm):	=	110
5.	Recharge in the tank waterspread areas (mm):	=	160
6.	Recharge in the paddy area (mm):	=	150
7.	Recharge available for groundwater extraction:		
	i. in catchment	=	55mm
	ii. in waterspread	=	80mm
	iii. in paddy area	=	75mm
8.	Number of upland agrowells:	=	10

9. Number of paddy area agrowells: = 2

10. Yearly abstraction by an upland agrowell in the upland area: = $7000 m^3$/well

11. Yearly abstraction by lowland agrowell: = $3000 m^3$/well

c. Groundwater Estimation

1. Estimated groundwater availability:

$$= 860 \times 10^4 \times \frac{55}{1000} + 100 \times 10^4 \times \frac{80}{1000} + 40 \times 10^4 \times \frac{75}{1000}$$

$$= 10^3 (473 + 80 + 30) = 583 \times 10^3 \text{ m}^3$$

2. Estimated present groundwater use:
$= 10 \times 7000 + 2 \times 3000 = 76 \times 10^3 \text{ m}^3$

3. Balance groundwater available for extraction:
$= 507 \times 10^3 \text{ m}^3$

4. Groundwater available in the upland area:
$= 403 \times 10^3 \text{ m}^3$

5. Groundwater available in the tank and paddy area:
$= 104 \times 10^3 \text{ m}^3$

6. Number of additional agrowells in the upland area:
$$= \frac{403 \times 10^3}{7 \times 10^3} = 58$$

7. Number of additional agrowells in the lowland area:
$$= \frac{104 \times 10^3}{3 \times 10^3} = 35$$

8. Total number of wells in the upland area:
$= 68$

9. Extent of upland area required to support 1 agrowell:
$= \frac{860}{68} = 12.5$ ha

10. Total number of wells in the lowland area:
$= 37$

11. Extent of lowland area required to support 1 agrowell:
$= \frac{40}{37} = 1$ ha

4.5.2 Concluding Remarks

For the chosen set of parameters, approximately 12.5 ha is required to support one agro-well in the highland area (chenas, homestead, catchment), while 1 ha is required to support one agrowell in the lowland paddy areas. However, this may vary depending on the areal extent of tank and command area, catchment area and renewable annual recharge rate. For representative values of these parameters as obtained in the field, the surface areas required to support agrowells both in the highland and the lowland need to be worked out. Field measurements indicate that there exists good hydraulic continuity between tank water spread and command area. Observation of water levels carried out in Kurunegala District (North-Western Province, Sri Lanka) and Padianallur in Madras (India) indicate a very good correlation between tank water level and groundwater levels in the command area. Therefore, the assumption that agrowells in command would be able to draw upon the groundwater under tank waterspread area appears to a valid assumption. Also, these are the areas for further studies during implementation of this area development project.

4.6 Preparation of an inventory of small tanks

We wished to make an inventory of small tanks in the NCP for use in the preparation of the proposed Area Development Project for the province. It was expected that this inventory, apart from the more common details, should reflect the tanks location, both spatially as well as in the tank cascade systems identified in the area. It was also expected that the inventory should reflect the past interventions in the tank by way of rehabilitation or restoration.

4.6.1 Sources of information

Information for making the inventory was collected mainly from the following sources:

Department of Agrarian Services (DAS)
Irrigation Department (ID)
Sri Lanka National Freedom From Hunger Campaign (FFHC)
Provincial Agrarian Services Commission (PCAS)
District Secretary's Office, Anuradhapura (DSA)

In addition, use was made of the notes kept by engineering and technical grade officers of ID and DAS who had served in the NCP for verifying the data obtained from the above sources.

One of the most striking difficulties was the apparent absence of a central set of reliable data as mentioned earlier. The small tanks are very abundant in the province, in various stages of repair and use. While a large fraction of these have been restored and are in use for agricultural pursuits, a significant number is still abandoned and covered by the jungle.

4.6.2 Previous attempts of small tank inventorization

An attempt at preparing a data base of small tanks had been made during the 1970-1977 era too. Island wide tank lists were prepared by each Executive Engineer's office of the now disbanded Territorial Civil Engineering Organizations (TCEO). These were collected in a card index. This attempt was not a success owing to a number of reasons. Even where these indices were made, data was often of poor quality, not verified by a properly trained person. Most of these data cannot be traced now, as the TCEO was re-absorbed into ID, Department of Highways, Buildings etc., and those subsequently were affected by the setting up of Provincial Administrations.

Freedom from Hunger Campaign also prepared a list of minor tanks. This list in many instances was found to be at variance with the earlier list. It left a large number of tanks unlisted in the NCP.

More recently, DAS attempted a more practical approach in cataloguing the tanks, It collected details of only working tanks, without bothering about the abandoned tanks. Even though this does not give the full picture as regards the hydrology or the water resources, from the point of view of the DAS, they have what they need most, viz, details about cultivations. Details were collected in pre-printed forms, one for each tank. This as not completed as certain areas were considered too dangerous to work in because of the insurgency.

The project to collect tank data was not brought to a completion. Something, still little understood has put a stop to this data gathering process. Sets of forms completed were not handed over to a central office, but were retained by the officers themselves. With their

subsequent transfers and retirements, these forms have become very difficult to track down. With difficult, as many forms as possible were traced, some as far afield as Kataragama.

DAS collected certain physical details too. Yet certain details, such as tank capacity and the water spread area, were based on the subjective assessment of the collectors of data. Particularly the water spread area appears to be quite unreliable.

4.6.3 Method adopted for this study

Records found in the ID, Kachcheri, ADZAP etc., served to cross check the tank lists compiled from the above sources for this study. They were used to fill the gaps in the combined lists. Data extracted from the preliminary information reports (PIR), which is routinely filled by the ID whenever a tank rehabilitation proposal is framed, was particularly rich source of information. Sifting through a large number of files for the PIRR as a tedious task, as there is no central filing system for this type of information. However, it is noted with regret that PIRR are not being routinely submitted of late. Even when it is submitted, the completeness and the accuracy leaves much to be desired.

Some difficulty was encountered with the use of different names for the same tank. This is specially true of tanks newly restored or in more remote areas with only a few families under them. Whatever the reason for a tank having more than one name, this report uses the name adopted by the DAS to avoid ambiguity.

Several minor tanks in the NCP happen to be maintained by the ID. These are the tanks that are fed by the major reservoirs, feeder canals, or fall within the command area of the major schemes and are used as balancing reservoirs for a part of the command area. These have no separate existence independent of the major scheme. Such tanks have been omitted from the present list as they cannot be rightly treated as minor tanks. There is one anomaly. it was found that many of these tanks were rehabilitated under the VIRP programme, which was strictly meant for village tanks not connected to major schemes.

Details of the rehabilitation carried out was collected by analyzing the approved estimates for each tank. The estimated cost is used for the cost. There is one problem in this approach. During the rehabilitation, there can be a re-adjustment of the estimated items. Change of the cost component is also possible, even though the practice of estimate revision appears to have been absent from these projects.

Ideally, a complexion report listing the physical work done and a financial statement should have been filed for each tank rehabilitated. This was never done for these tanks. It is theoretically possible to arrive at this information by going through all the measurement books, contract payment registers and check roll registers etc., of the institutions concerned. This was not carried out owing to two reasons. First, the time and labour spent to tack down records of one tank would be quite out of proportions to the amount of information that can be gleaned. The project could not have been completed within any realistic time period. Second, the type

of search may give rise to unease and resentment among the local officers, as such activities are often carried out by auditing officers - an unwelcome species.

Therefore, it was decided to use the sanctioned cost estimates prepared for the rehabilitation of small tanks to find out what type of rehabilitation has been carried out on a tank and at what cost. The resulting information, it is hoped, would deviate from the actual by a negligible amount only. When taken for the province, any deviations for individual tanks may cancel out each other except for the cost. If the cost is deviated, it will mostly be upward with no hope of deviations balancing in the aggregate.

The tentative inventory of small tanks are found in **Annexure 4.2.** The inventory shown in the **Annexure 4.2** gives a list of tanks classified on the basis of an index no assigned to each tank. The inventory provides two separate lists, one showing the list in alphabetical order of the name of the tank and the other showing the list of tanks sorted on the ascending order of the index numbers. The details such as tank name, district, divisional secretaries divisions, river basins, cascades, survey department topographic survey sheet co-ordinates, physical dimensions (as and when data are available) and whether rehabilitated in the past are given in the inventory in respect of the tanks.

CHAPTER 5

LAND & WATER RESOURCES MANAGEMENT IN A WATERSHED CONTEXT
- Strategy, Process, Costs, Benefits & Institutional Arrangements -

Introduction

This chapter is organized in four parts. Part one describes the proposed strategy and process for land and water resources development in a watershed context. As these are being translated into practice in IIMI's SCOR project, and, as the initial progress is encouraging, SCOR example is used to explain the proposed process. Rehabilitation component, however, is not considered in Part I. In part two, combining the information on cost effective rehabilitation generated by the management specialist in the PRA exercise **with** SCOR data on land and water resources management in sample sub watersheds, an analysis of benefits and costs is presented. This part starts with a description of project activities and project's benefit and cost items. The detailed benefit-cost analysis is followed by a summary of project's proposed cash flow. Closely following SCOR experiences, part three of the chapter submits the proposed institutional and project management arrangements. Part four of the chapter is focussed on Monitoring and Evaluation and special research studies. Much of the research studies will be based on the M&E data base. Hence, M&E and special studies are integrated. This is an integral component of land and water resources development, which will also be used as a feed-back and correcting mechanism.

Assessment of watershed and sub watershed water resources (Chapters 2 and 3) as well as the PRA exercise (Chapter 4) were focussed on the design of a cost-effective strategy for rehabilitation. The PRA exercise, in particular, was instrumental in analyzing the linkages between tanks in cascade systems and in the identification of specific components in the rehabilitation process. The expected increase in low land and cropped area as well as cropping intensities have been identified in the PRA. Subsequently, rehabilitation costs have been estimated for five sample cascades. However, the PRA (chapter 4) were not aimed at developing methodologies or generating data/information on land and water resources management in watersheds by integrating high lands and low-land rice-based farming systems. This was due to the fact that such a holistic strategy/process as well as data required for a detailed benefit-cost analysis were readily available from IIMI's SCOR project, which is covering 14 sub watersheds in the Yan Oya basin of the NCP. On the otherhand, irrigation rehabilitation (which was the focus of chapters 2,3 & 4) was not included as a major component in SCOR. Hence, the SCOR data base and PRA data base were used jointly to compute benefits and costs.

5.1 STRATEGY & PROCESS

A minor tank cascade system is a sub-system within a (river) basin watershed - (frequently used in this report as **watershed**). The term watershed is defined as the area of land surface that

drains water into a common point along a stream or river. The rationale for using the river basin watershed as the basic unit for integrated planning of (land and water) resources utilization is clear. The watershed is a physical entity geographically defined by an important natural resource, water; the ways in which the water in the upper parts of the watershed are used affect the ways in which it can be used downstream, and they affect the associated land resource. Thus, the various parts of the watershed are physically and operationally linked in important ways, and the potential benefits from integrated use can be large.

For example, the SCOR Huruluwewa watershed contains about 220 small tanks (in addition to the major reservoir). Most of these small tanks are in series of clusters or in cascades. In addition, ground water extraction from the weathered rock up to a depth of about 10 m in the dry and intermediate zones of Sri Lanka is taking place at an increasing rate. No regulations or accepted norms have been adopted with regard to well density, spacing between wells, pumping durations, etc. In certain locations, it is reported that pumping operations of one or more wells interfere with adjoining wells. This is evident from the sudden drawdown of water in the well while pumping from adjoining wells in progress. This situation has limited the "on-demand" nature of some wells. Moreover, in certain locations, farmers, after excavating to depths exceeding 6-7m and spending about Rs. 40,000 - 50,000 (US$800-1,000) per well, have found out that the water yields are not satisfactory - (N. Fernando, 1994). Some of them continued their efforts by driving tubewells from that point up to the underlying deep rock. In addition, the negative consequences of the proliferation of agro-wells include the lowering of the water table and associated problems such as moisture deficits in rainfed farming areas, threats to domestic wells, and income disparities. According to SCOR Project's participatory resource mapping, there are about 1000 agro-wells within the command area of the reservoir and associated highlands. Most of these have been constructed over the past 2-4 years. Moreover, recent monitoring of rainfall at several points within the watershed shows a significant "microscale variation". *Following SCOR, the present project will consider the spatial and temporal variations of: rainfall, and other sources of water available to the agricultural production system and assist users in distributing and using those supplies rationally (among various users) and between different uses.* The present major problem in both major and minor tank commands (within the watershed) is the inadequacy of water for agricultural production, especially in the dry season. However, it is clear from the above discussion that different combinations of various sources of water can be used.

In addition, the people in the different components of the watershed having access to different aspects of the natural resources base may be engaged in different economic activities, and may be of different social and/or cultural backgrounds. For example, people in the upper catchment areas may have very different environmental, economic and social conditions from those in associated irrigated commands and those in downstream areas of the irrigated areas. Thus, the personal and economic interests in the different areas do not necessarily coincide, introducing problems for planning and implementation.

This implies that socioeconomic and institutional factors too influence the linkages between "upstream and downstream." For example, the interrelationships between ***chena***

(shifting, slash and burn cultivation) in the catchment areas of reservoirs in the watershed (mainly in the upstream of watersheds) and rice farming in the irrigated commands and drainage areas (downstream) are influenced by socioeconomic factors. Similarly, there exist significant socioeconomic relations among tank systems within a "minor tank cascade." Such factors as land tenure, power structure, village institutions, community traditions, etc. can influence land and water use patterns within tank systems as well as within river basins/watersheds. As people are the final decision makers regarding the use of land and water resources, they not only influence these linkages and relationships but also can change the production potential of land and water resources either favorably or adversely.

Thus, any conservation or environment management approach should consider those physical, socioeconomic, and institutional linkages that exist between upstream and downstream of a river basin/watershed, and between systems within watersheds (such as the variations within and between micro watersheds/basins like the tank cascade systems). It should also consider the role of users both in "production and conservation." *In other words, sustainable agricultural development in the broad context of rural development in these areas requires a watershed-based integrated approach which not only optimizes the production, but also ensures the protection of the natural resources or production base with active participation of the users concerned. Potential benefits from such an integrated participatory watershed management effort can be large.*

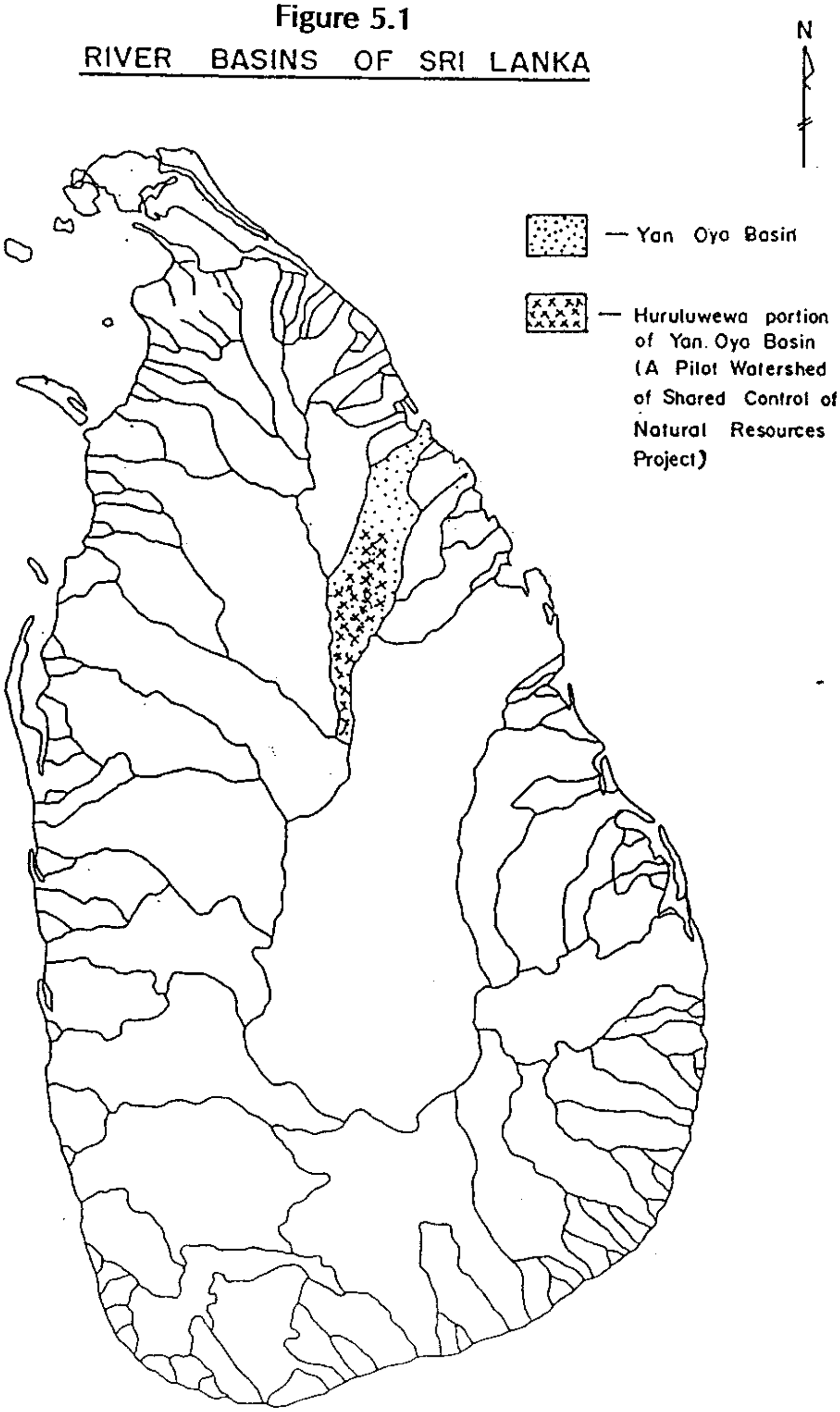
Moreover, the physical boundaries of the watershed are rarely congruent with the boundaries of the administrative or constituent political entities. This situation complicates the processes of planning and implementation.

An integrated participatory approach is useful to overcome these problems, the Project emphasizes an integrated participatory approach, and makes a substantial effort in linkage and coordination. Experience in the major irrigated commands in many countries has shown that the combination of the use of catalysts, sharing of information, and reasonable administrative and political support can bring divergent groups into successful cooperative activity. While the process will be more difficult in the context of the full watershed, *there is a reasonable probability of success, and the potential for major benefits.* (SCOR Project Paper, 1993)

To develop and maintain a balance between production and protection (or conservation) an on-going action-research project - namely Shared Control of Natural Resources (SCOR) has focused on watersheds as the basic planning, co-ordinating and implementation units. The project is being implemented by the International Irrigation Management Institute (IIMI), and the Government of Sri Lanka and is funded by the United States Agency for International Development (USAID). SCOR has selected two watersheds representing different agro-climatological and hydrological characteristics, each from the wet and dry zones of Sri Lanka. The dry zone pilot watershed, namely Huruluwewa (**Figure 5.1**) is located in the Anuradhapura district. There are about 220 minor tanks and one major tank in the Huruluwewa watershed. In addition, ground water extraction from the weathered rock upto a depth of about 10m is taking place in an increasing rate. (**Figure 5.2**)

Figure 5.1

RIVER BASINS OF SRI LANKA



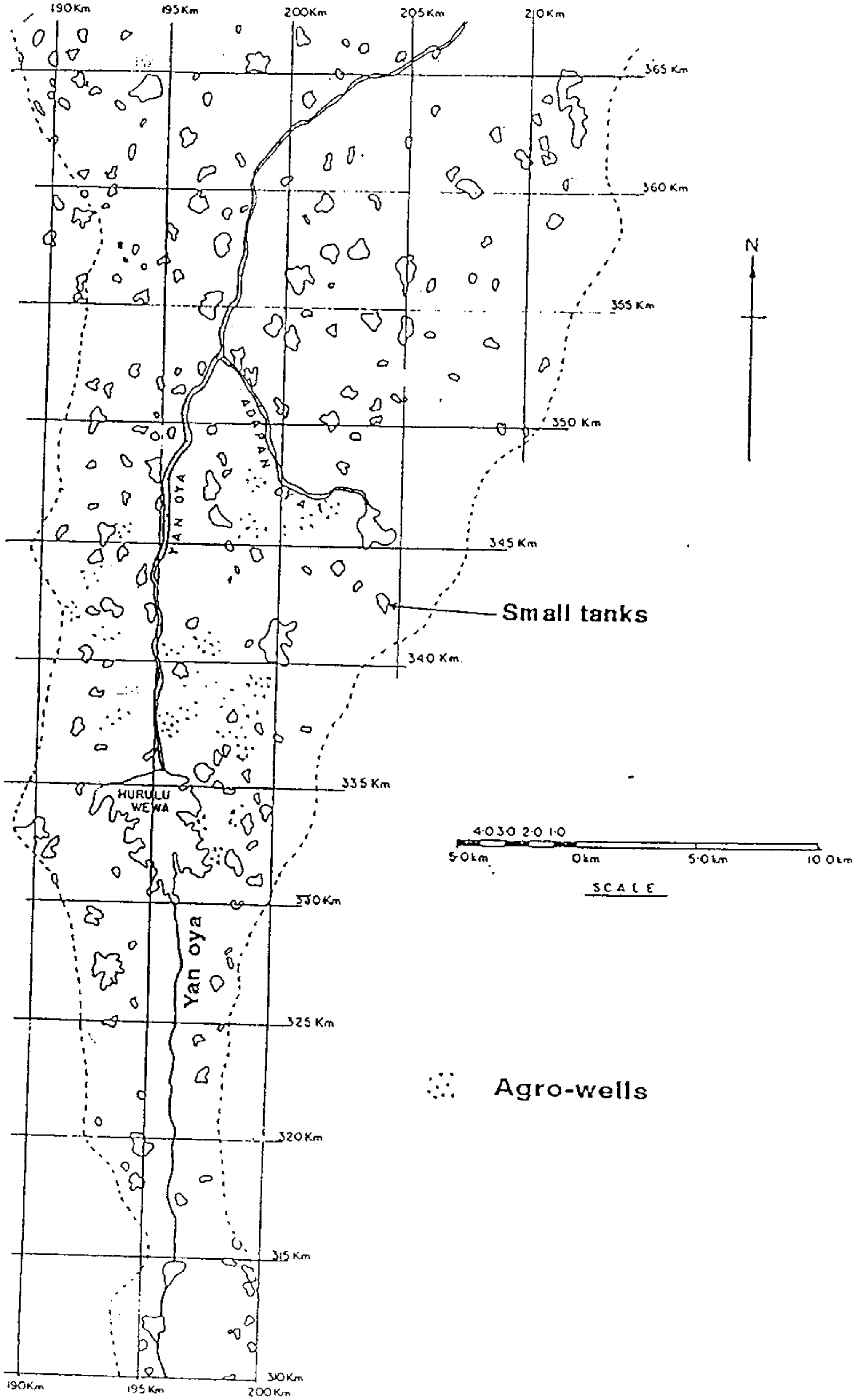


Figure 5.2

DISTRIBUTION OF WATER RESERVOIRS AND AGRO-WELLS IN HURULUWEWA WATERSHED

In the initial phase of SCOR implementation, several tank cascade systems or sub-watersheds within the Huruluwewa watershed have been selected for pilot research interventions. Prior to participatory planning aimed at revitalization of deteriorated tank ecosystems, SCOR examined the past and present land use patterns of various segments in a typical watershed.

In ancient times the entire agricultural systems had been governed according to a set of established norms aimed at optimum utilization of land and water resources. A tank itself has several features in order to reduce siltation, lengthen the storage life of water and a system of natural purification of water. In addition to agricultural production benefits, the small tank cascade systems offer several other benefits such as fish, flood control, maintenance of water table, lengthening the period of water availability, soil conservation and reduction of siltation. The small tank cascade technology and the institutional landscape surrounding them have been **time-tested for its adaptation to the local environment**.

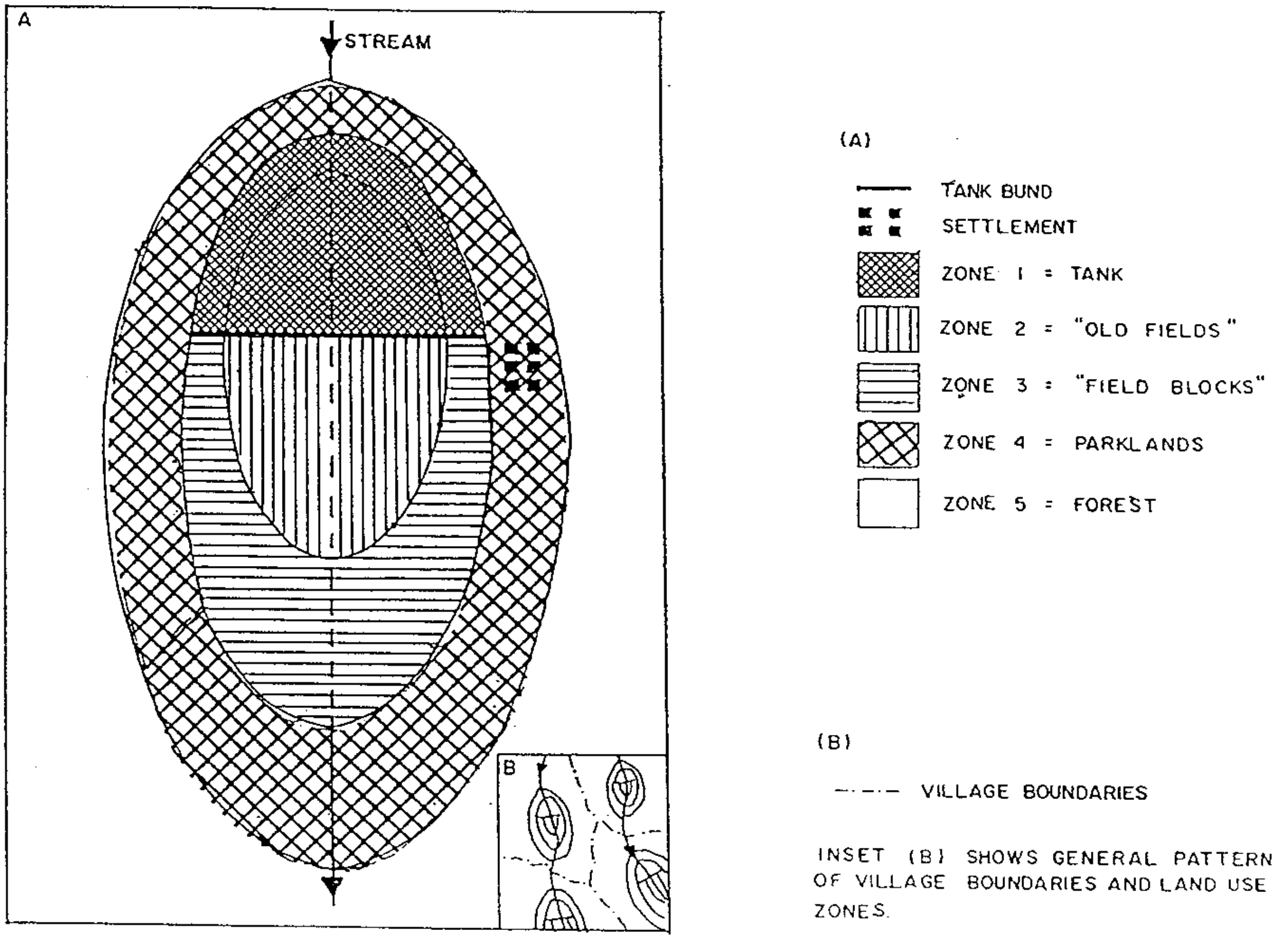
Evidence indicated that the small tank cascade system had functioned satisfactorily until the 12th century A.D. Thereafter, the system started to decline due to several reasons, and a large number of them were completely abandoned. During this long period of abandoning, some tanks were breached, siltation became serious and the people even left some of the tank eco-system. Several of such breached tanks have been restored subsequently. The present status characterizes low and variable cropping intensity, low harvest ratios and crop yields, and deforestation in the catchments. Social problems are considered to be serious and resource degradation and depletion have appeared to be intense. The institutional system has subjected to a series of changes and the orderly manner within which tank resources were managed in the past are no longer a reality.

Tennakoon (1974) has identified five "broad zones" in a typical traditional tank - village system (**Figure 5.3**). Zone I is the tank which could be considered as the "nerve centre" of the village economy. The geometry and hydrology of the tank is important as it determines the size of the area that can be irrigated and the cropping intensify. Zone 2 is the **Purana wela** (old field), which is located much closer to both the settlement and the tank.

In traditional systems, the land in this zone, which can be irrigated even if the water level is fairly low, has been divided between all the villagers. On the contrary, the land in zone 3, which are owned by few individuals, is usually irrigated by a higher level sluice. Even in instances where the tank is operated by a single sluice, the irrigation supply can be less satisfactory due to its distance from the tank (Tennakoon, 1986). Traditionally zones 1 and 2 have been cultivated to paddy (rice). "Paddy cultivation is the whole basis of village life with institutions, customs, beliefs and values roofed in it. Secondly, under normal weather conditions the farmer always gives first priority to paddy cultivation which has its implications on highland and **chena** (slash and burn) cultivation. Thirdly, the social value attached to the ownership of paddy land, especially the 'old field', is still strong. Ones place in the village rituals and festivals, role in community work, chances of becoming a leader and at one time even the right to fish in the tank were restricted to persons with some claim to 'old field'. However, in recent years this trend is fast disappearing particularly with the presentation of the market economy" (Gooneratna at. al., 1980, p. 68).

Figure 5.3

SCHEMATIC DIAGRAM OF A TYPICAL DRY ZONE VILLAGE



Irrigation is nearly impossible in zone 4; mainly because of the distance and, in general, is covered short grasses, isolated trees and bushes. Zone 5 covers the largest extent of "village land" (Tennakoon, 1986). This zone is usually called the village/community forest. However, mainly due to shifting or slash and burn cultivation and illegal logging activities scrub lands have increased at the cost of forest. In the wet season **Chena**[1], coinciding with the main rainy season, a variety of non-rice crops - such as grain, millets, pulses - is cultivated. Dry season chena is not common and involves cultivation of crops such as gingerly.

The home gardens are generally planted with perennial crops. In general in the study area the cropping intensity (70%-80%) and land productivity (2000-3000 kg/ha) are low in the paddy fields and large extents of under-utilized highlands, both state and privately owned (including home gardens), formed a common feature in the pre-project land use pattern.

The SCOR approach emphasizes the need for an integrated ecosystems approach to dry zone development, considering the hydrological, socio-economic and other interventions between the various segments such as catchment, tank, command and drainage areas and associated highlands.

SCOR - Participatory Action-Research in Sub-Watersheds - Integration of Conservation Concerns with Production Goals

The selected sub-watersheds for SCOR action-research are contiguous areas of manageable size, having characteristic profiles of ecological, socio-economic and environmental features similar to that of the respective main watersheds. Size of these selected pilot sub-watersheds ranges from about 200-1000 ha. One such sub-watershed is used here to illustrate the SCOR participatory action research process aimed at testing hypotheses and developing models for integrated land and water development. Hydrological characteristics of this sub-watershed, namely Maha Meegaswewa (MM), is shown in **Figure 5.4.** Action is being taken through a participatory process to learn, test and demonstrate on "ideal" land use pattern with due emphasis on production and conservation. This participatory approach of developing methodologies for combining technology, organizations and resources would illustrate the various production-conservation elements with their intimate relationships, that will have to be incorporated in the management of watersheds or tank ecosystems in a sustainable manner. Micro concentration on **contiguous areas** or tank ecosystems within which "every inch of surface" is carefully planned and monitored for the impacts of participatory research interventions is a unique characteristic of SCOR.

---

[1] Slash and burn cultivation

Participatory Appraisal of Sub Watersheds/tank Ecosystems

In the selected sub-watersheds, participatory appraisal of the characteristics of resource uses and users as well as mapping of **current** resource use were done by groups comprising of resource users/farmers, local officials of government agencies such as Irrigation, Agriculture, Forestry and Agrarian Services departments, IIMI-SCOR professional and catalysts. The catalysts took the lead role in preparing the resource use maps and recording information. General objectives of this Participatory Rapid Appraisal were to:

a) Prepare a **detailed** map of the sub watershed or tank ecosystem indicating: the land use pattern of **individual holdings** in the entire tank ecosystem/sub-watershed (catchment, command areas, homesteads, drainage areas etc.), cropping/vegetation patterns, type and quality of cropping/vegetation cover, tank and the natural drainage system, road network, residential pattern.

b) Develop a database, including basic data such as: type and membership of user organizations, land fragmentation, ownership and tenurial patterns, cropping patterns and intensities (current and in the recent past), slop category, apparent degree of soil erosion, conservation practices, cultivation practices, input use of agriculture, production and productivity, and constraints to production and conservation, yield performance, profits derives from different holdings in different zones. Social organizations including farmers organizations, conflicts, assistance from government support services and NGOs.

c) Help establish a baseline for the resource use pattern using (a) and (b).

d) Sensitize the officials of relevant government agencies/NGOs, and resource users on the importance and need for this exercise and obtain their active participation in future work.

For this purpose, each group was provided with a line diagram/sketch map of 1:3000 scale with land marks indicating roads and streams for guidance. The groups collected data and mapped each land plot of a village. Refining of the map to maintain accuracy to scale was done subsequently by the draftsman supporting the group and the *map was used for participatory planning of resources management of the village.* Land and water use as well as other information collected through the participatory mapping exercise have been incorporated into the SCOR spatial database using a Geographic Information System (GIS). This was repeated for each village in selected sub-watershed system and for all selected sub-watersheds. For example, **Figure 5.5** shows the pre-project land use (as of January 1994) by individual plot of one such sub-watershed, in this case a tank system namely Maha Meegaswewa, MM. For this village, a participatory resource management "mini project" was formulated with an investment of Rs. 1.2 million (US$ 24,000). The project aims to change the present *land and water use pattern to a more profitable and diversified resource use combining production and conservation using appropriate technologies/ techniques, novel shared control arrangements and resource augmentation.* New commercial enterprises and conservation practices in a typical sub-watershed in the Huruluwewa Watershed include: integrated wet and dry season water management in

Figure 5.4 Maha Meegaswewa Micro Watersheds

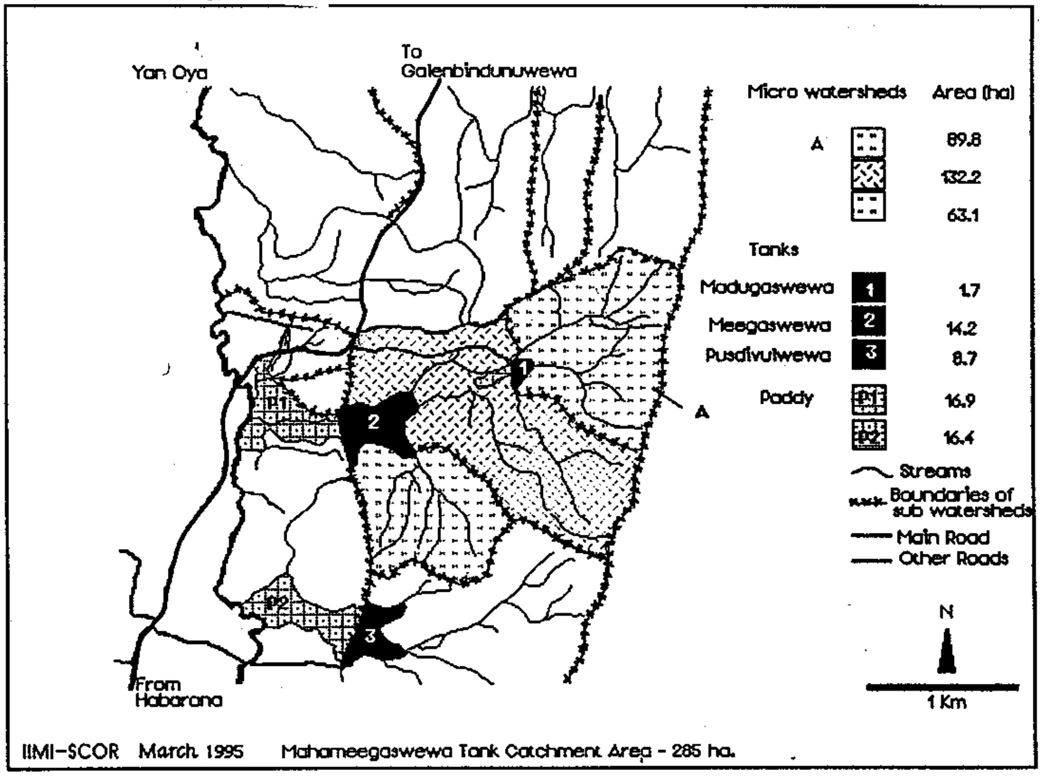
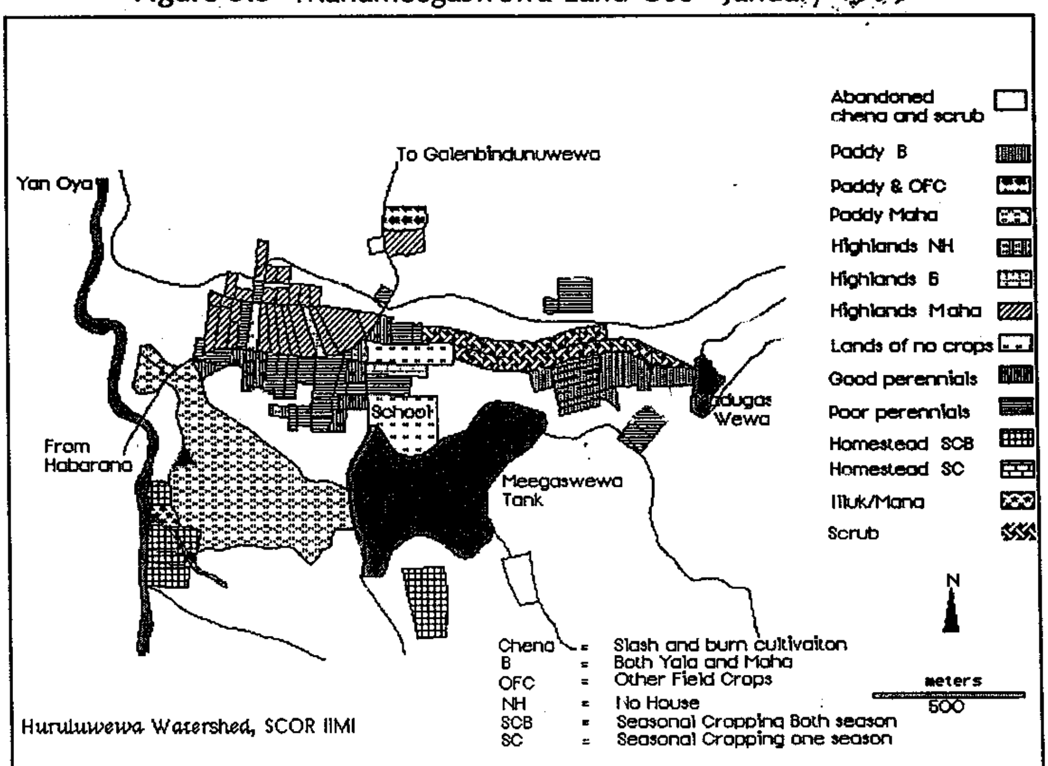


Figure 5.5 Mahameegaswewa Land Use - January 1994



command areas (eg: water saving techniques to improve cropping intensity and introducing short duration commercial crops in the dry season, cultivation of medicinal plants, fruits and vegetables in chena (shifting cultivation areas), processing industry for medicinal plants, stabilized cropping patterns for chena and highlands, contour bunds to cover the entire area, water harvesting techniques, etc.

This means that the villages in such pilot sub-watersheds have "action plans" that guide them along a path to the planned future from the current status of resource use. The planned future land use pattern is illustrated in **Figure 5.6** while the March 1995 & current (Sept. 1995) status are illustrated in **Figures 5.7 & 5.8**. Contour bunds and drains are being established to cover the entire extent shown in this map as well as in several other pilot areas.

Components of Conservation Farming and organic matter management (adopted by users) in selected tank ecosystems include:

a) mulching (crop or weed residues) to increase soil moisture retention and to effectively use the limited rainfall and irrigation water. Promising results have been achieved in all sites: farmer managed to increase irrigation interval from 3 to 6 in chillies and from 8 to 16 in beans; time take to reach wilting point was significantly higher when compared to areas without mulch; branches, leaves, flowers and pods per plant were significantly higher and consequently high crop yields have been achiever;

b) adoption of contour bunds and drains and stabilization by biological means - as water harvesting/saving technique and for soil conservation.

c) combination of agriculture and forestry eg: through alley cropping, home gardening (forest gardens), growing seasonal and perennial between contour bunds in the uplands,

d) green manuring,

e) mixed cropping and integration of livestock,

f) integrated pest management

Novel modes of state-user partnerships in land and water resources use have been arranged. The banks have agreed to provide loans for the user organization. A Colombo-based company offered a forward contract to the user organization to purchase most of the expected produce under the "mini-project".

Figure 5.6 Planned Future Landuse for Mahameegaswewa

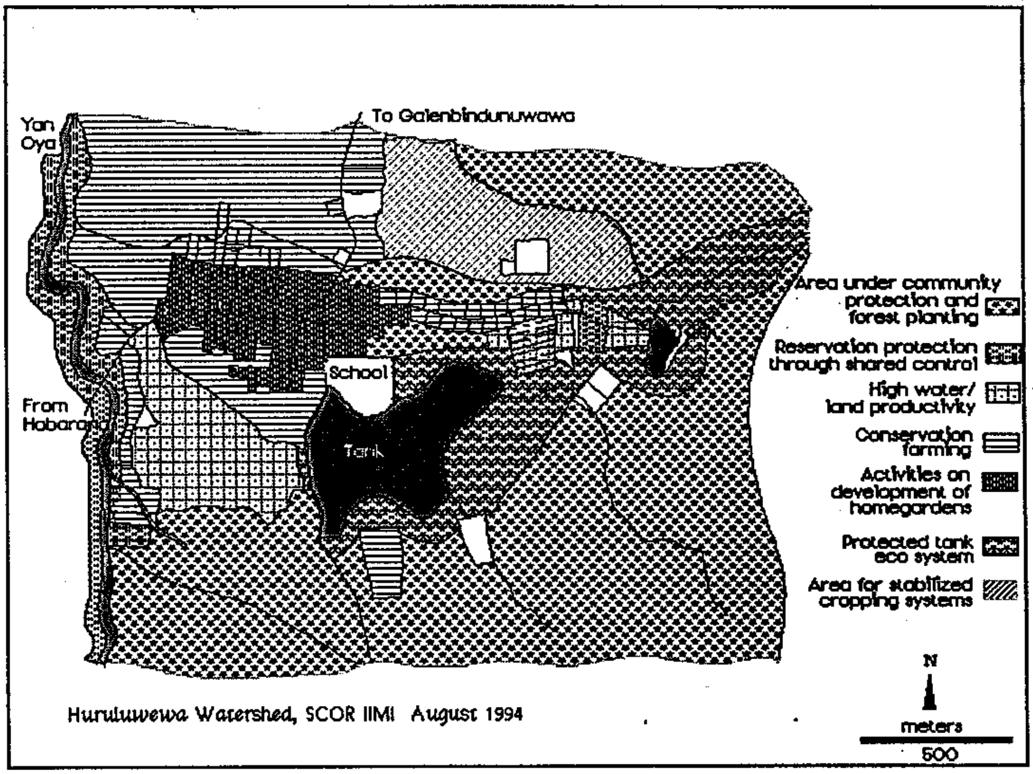


Figure 5.7 Mahameegaswewa Land Use - March 1995

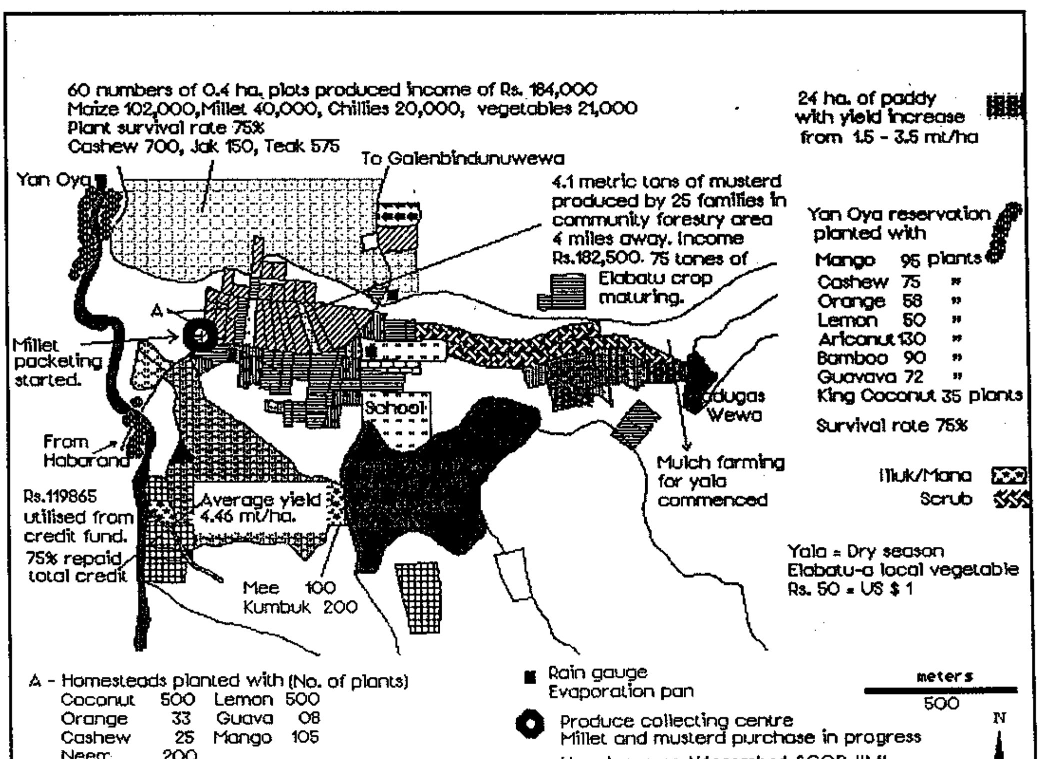
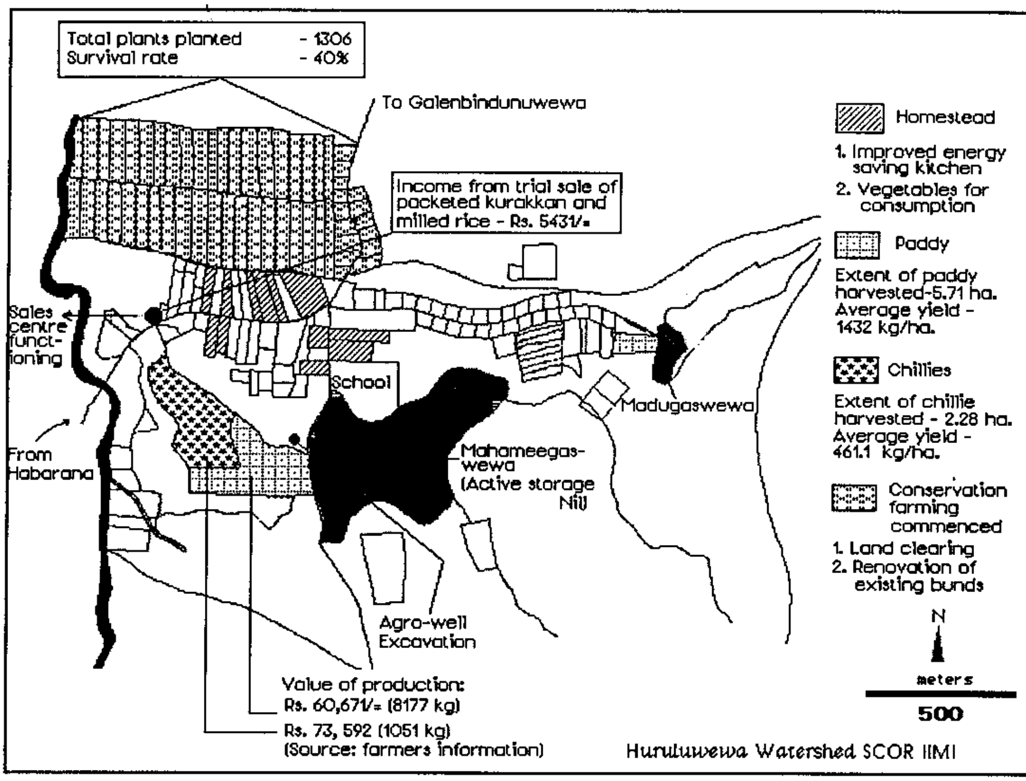


Figure 5.8 Mahameegaswewa Resource Use - September 1995



A leadership emerged from the community with leaders of groups, organizations and companies aimed at production and conservation (**Figure 5.9**) and volunteer catalysts representing each production zone in the village, which is the correct basis for selecting mobilizers without considerations of party politics. They have access to information from outside and knowledge gained from their own experiments in their own farms with the support of the government officers and others who extend such support to them. They can mobilize resources to carry out their plans and finally become shareholders of their own company will control over the production process, which is a productive way of small farmers to gain and share prosperity in an open economy.

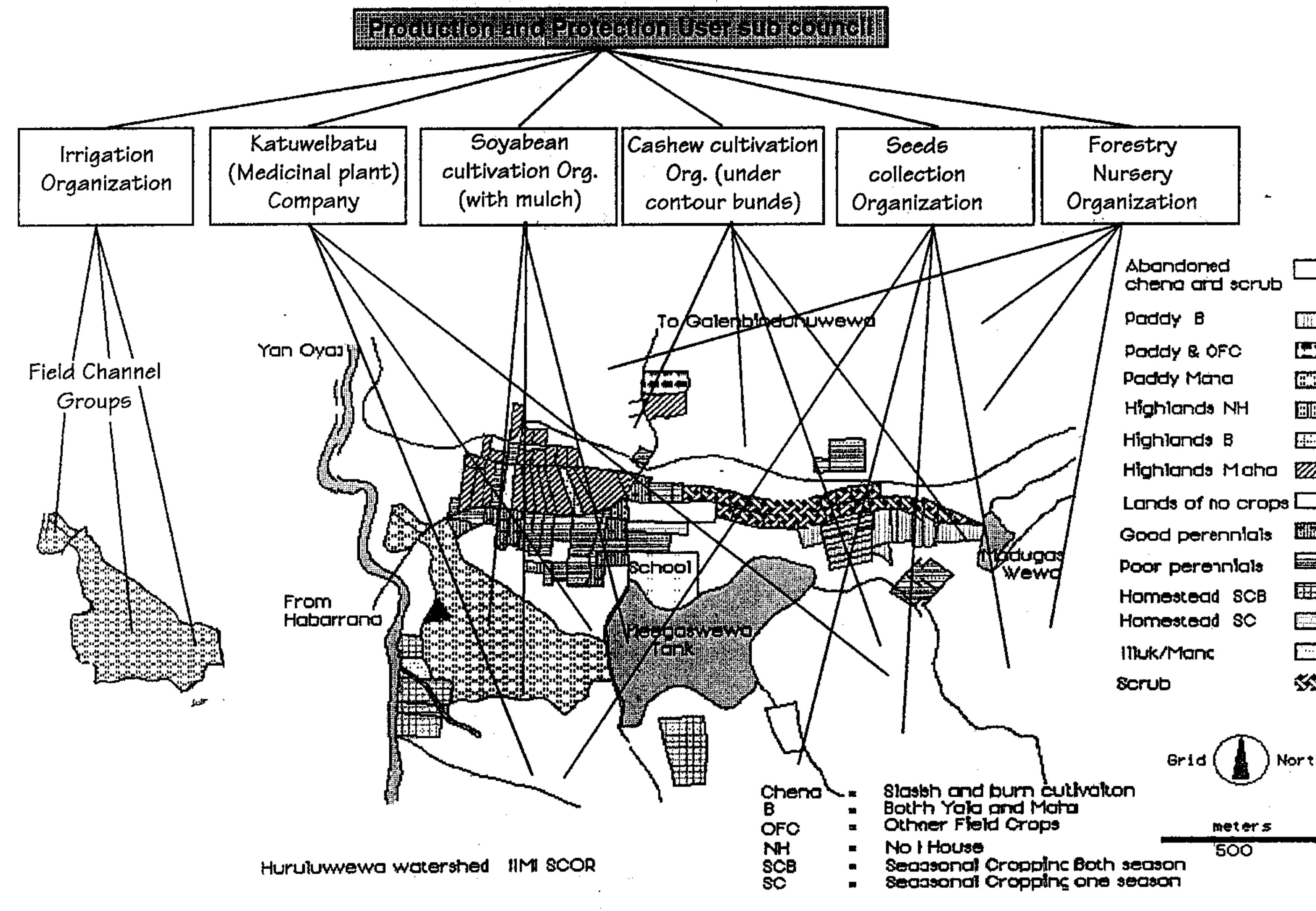
5.2 ASSESSMENT AND EVALUATION OF COSTS AND SELECTED BENEFITS IN LAND AND WATER RESOURCES DEVELOPMENT

In the strict sense, this is not an economic analysis. For example, shadow pricing/ opportunity costs are not considered and transfer of benefits and costs are not quantified. Additionally, a large number of benefits accrued to the **project** are intangible and are difficult to evaluate correctly. Examples are the downstream benefits such as impact of natural resources management resulting from the group action of users in the upstream areas. **It should be noted, however, that almost all the project specific costs are direct ones and are included in the cost estimates. In short, benefits are underestimated while the costs are being evaluated adequately.**

Figure 5.9

A SCHEMATIC PRESENTATION TO ILLUSTRATE GROUP, ORGANIZATIONS AND (SUB) COUNCIL FORMATION IN A SUB WATERSHED

From Groups to Organization/Company to Sub Council/Council



It should be re-emphasized that the proposed land and water resources development approach is based on IIMI's SCOR experience on integrating conservation concerns with production goals. Hence, the project will have far-reaching benefits compared to the projects focussing either on production or on conservation. The several manifold benefits attributable to the project could be due to:

i. Novel technologies -- such as more profitable cropping patterns, cultivation practices coupled with natural resources conservation measures;

ii. Water saving technologies, "land saving technologies" improvements in cropping intensity;

iii. Market oriented production eg. production for a fixed price or forward contracts, profits through group action/enhanced collective bargaining power;

iv. Value added production;

v. Establishment of institutional mechanisms for land and water resources management which would continue the management process beyond the life span of the project;

vi. Strengthening user groups and improvement of their capacity to undertake sustainable land and water management practices that will continue to provide benefits beyond the life span of the project;

vii. Spread effects which are augmented by specific mechanisms

All these would help institutionalize the project approaches which, in turn, will lead to sustainable development. A project aimed at the introduction and institutionalization of participatory processes to achieve a proper balance between production and natural resources conservation should yield much higher socio-economic and financial benefits.

5.2.1 PROJECT ACTIVITIES

A series of project benefits are identified in respect of some of the selected project activities. Other activities will lead to the production of some immediate outputs which are a prerequisite for the attainment of what may be called "intermediate benefits" which would finally lead to the achievement of the project goals. This latter category includes those benefits which cannot be measured directly and the intermediate benefits referred to above.

The major activities (which are similar to those of IIMI's SCOR project) are classified under four themes below:

I Irrigation Rehabilitation in a watershed (and sub watershed/cascade system context)

II. Strengthening the Capabilities of Resources User Groups

a) Survey of Existing Local Organizations (in pilot areas)
b) Participatory constraints Analysis (in pilot areas)
c) User Group Creation (in pilot areas)
d) Legal Status and Powers for User Groups including formal agreements between user groups and state
e) Skill Development and Training for User Groups and Trainers
f) Environmentally sound Economic Opportunities for User Groups
g) **Appropriate technologies and techniques aimed at balancing production and protection: eg: selection of crops, cropping patterns and practices, inter and intra segment management of water, conservation farming, water saving techniques, conjunctive use of water aquaculture agro-forestry.**
h) Supporting Services and Facilities for User Groups
i) Establish Production Companies (for advanced user groups)

III. Improving Land and Other Resources Tenure Arrangements

a) **Regulatory and Legal Mechanisms including land & water rights**
b) Resources Access and Tenurial Arrangements
c) Policy and Process Reform (long term)
d) Land Titling
e) Consolidation of fragmented land holdings

IV. Strengthening Government, NGO and Private Sector Capacities to Support User Groups through Participatory Land and Water Management, Training and Skill Development

a) Information Systems
b) National Departments and Agencies
c) Provincial Councils and Staffs
d) Divisional Offices and Line Agency Staffs
e) Strengthening of NGOs
f) Strengthening of the Private Sector and Banks

V. Improving Coordination and Linkage for Land and Water Resource Management

a) Coordination among Projects, Programs and Activities within selected watersheds;
b) Coordinate and Improve Provincial and Divisional Planning and Implementation
c) Coordinate the activities of different Government Agencies and Donors
d) Administrative and Coordination Mechanisms for Watersheds
e) Multi-Level Planning
f) User Group Federations in Watersheds
g) Establishment of Information System

5.2.2 OTHER FEATURES

Applications at multiple levels

While the Project focuses the majority of its activities at the local level, with the watershed as the basic unit, other activities will take place at the divisional, district, provincial and national levels. The specific activities at the intermediate levels will be determined in the process of dealing with the problems and constraints identified in the selected watershed. It is anticipated that these activities will be those that strengthen the ability of the government and others to more adequately provide supporting services to the user groups, and to assist in the reorientation of the government agencies to a client-centered mode. At the **National level**, the primary emphasis is on strengthening the capacity to deliver appropriate information on natural resources to the broad community that can benefit from that information.

Inter-Project/Activity Co-ordination

In the watersheds, the project will take the leadership in bringing the activities (projects, programs, etc.) based on land and water resources into closer co-ordination. The project will strengthen the capacity of the provincial and Divisional Secretariats in integrated planning for the utilization of land and water resources in the watersheds. As conceptualized by SCOR, the institutionalization of such an approach will shift the strategy of development of land and water resources (in the watersheds) from an uncoordinated "project mode" to a well co-ordinated "program mode".

Integrating Agro-forestry and Inland Fisheries into Watershed Management Strategies

Following SCOR model, linkages will be established with Forest Department to implement the participatory agro-forestry program and with the Ministry of Aquaculture to implement and inland fisheries program using participatory modes. The initial emphasis in the latter will be on minor tanks or village tanks.

5.2.3 SELECTED BENEFITS

i. Increased User Incomes Through Expanded Agricultural Production:

- increased area under irrigation due to:

  a. rehabilitation; and
  b. improved water use efficiency.
- increased cropping intensities (CI)
- planting high value crops in irrigated commands in the dry season and in highlands;
- increased service employment opportunities - eg. due to diversified production, management and other positions in matured farmer organizations,
- livestock production

ii. Increased Incomes Due to Improvements in Marketing, Storage, etc. Especially Through Organized Group Action.

- bulk sale of produce;
- bulk purchase of inputs;
- better prices for quality products.

iii. Improved Protection of Environment and Enhanced Sustainability of Natural Resources Base.

- changes in rainfall: run-off relations;
- reduced erosion;
- reduced siltation of tank beds;
- improved vegetation cover and canopy.

iv. Non-agricultural Products and Employment.

- agro-processing;
- non-traditional products to identified markets.

v. Increased Farmer Savings and Investments

vi. Reduced Government Expenditure on Natural Resources Systems.

- enhanced user role in natural resources management;
- shared control of natural resources;
- enhanced private sector involvement;
- better co-ordination;
- reduced conflicts; improvements in local resolution of conflicts;
- reduced Government's direct involvement in planting trees etc.

vi. Other social benefits including reduced conflicts, local resolution of conflicts, improved bargaining power of small farmers.

Analysis

The analysis was done mainly on the following selected Benefits and Costs:

Benefits	Costs
1. Benefits from present practices of land and water use (which are not charged by the project). 2. Benefits from improvements to present practices. 3. Income from additional area benefitted (irrigated and non-irrigated), increased cropping intensities etc. 4. Income from new products.	1. Costs of existing land and water use (production). 2. Estimated O&M costs of irrigation. 3. Project expenditure. 4. Enhanced user expenditure on added production-conservation activities introduced by the project. 5. Depreciation/inflation

A given cascade would need at least 4 years of project inputs to enhance production and profits and to develop an acceptable trend in natural resources conservation. Therefore, it is proposed to select 3 sub watersheds including 6 cascade systems in the first year. Three more sub watersheds (6 cascades) will be added in year 2. This process will be continued until project year 3. In year 4 only one sub watershed will be added.

Project Year	1	2	3	4	5	6
Total sub watersheds	3	6	9	10	10	10

In each cascade system GOSL/ADB Project inputs, including the catalysts and technical assistance will be limited to four years. This is explained in Section 5.3. It is assumed that 10 sub watersheds consisting of 20 cascade systems will be included in the project.

5.2.4 BENEFIT : COST ANALYSIS

As described in chapter 4, the PRA exercise selected 5 sample cascades for detailed investigations aimed at cost-effective rehabilitation methodologies. All cascades in the NCP can be categorized into these 5 groups. The cost of rehabilitation differs from one group to another. The land extents classified by the use category - such as homesteads, slash & burn/shifting (or **chena**) cultivation, forest and command areas - for 15 cascades are summarized in **Table 5.1**. The area increase as well as the improvements expected in the cropping intensity of low land due to rehabilitation is also given in this table.

Projects staff plan is given in **Table 5.2**. (please refer next section for explanation).

Tables 5.3.1 through **5.3.5** presents the summary of the outcome of benefit:cost analysis. For the four different land and water resources utilization options and for five cascade or sub watershed types, the **B:C ratio varies from about 2.0 to about 2.8**, at 22% discount rate (**Table 5.4**). The corresponding range at 12% discount rate is 3.6 - 5.5. The Internal Rate of Return, IRR varies from 19.3 to 19.9. The cash-flows of the financial Benefit:Cost analysis for selected 5 model cascades are given in **Annexures 5.10.1(a) to 5.10.5(c)**. In order to obtain respective values for model sub watersheds, these cash-flows should be doubled.

Table 5.5 gives the total investment levels by sub watershed. **Tables 5.6 and 5.7** summarizes project's investment plan and cash flow. The project's expenditure or investment is divided into two categories:

1. ADB/GOSL Project Funds
    - 1.1 Rehabilitation costs
    - 1.2 Capital and operational (especially management costs)
    - 1.3 User grants

2. Farmers's contribution
    - 2.1 Direct
    - 2.2 From loans obtained by farmers or farmer organizations from local banks

Table 5.1 Land Extents Calssified by Use Category and Cascades

No.	Name of the Cascade	No of Tanks/ cascade	Extent (ha)									Total Area of cascade	No fo House Holds	Rehabilitation Cost Rs.	Operational and maintanance cost
			Command area					Catchment area							
			Present Cultivation Area			Proposed Expansion	Total area after project								
			Maha	Yala	Total			Chena and scrub	Forest	Homestead	Tank area				
1	K6-4 Negama	11			333		333	628	200	241	179	1621			
2	Mal-1-4 Mamaniyawa	19	369	62	543	238	781	1498	58	577	312	3251	788	31074000	195344
3	Mal-2-8 Siwalakilama	16	438	40	455	269	724	1199		185	227	2204	956	12675000	180972
4	Mal-3-2 Maha Kandarawa	26			724		724	2289	241	362	355	4070			
5	Mal-6-3 Gangurewa	29	666	72	803	234	1037	1415	383	27	387	3209	1182		
6	Mal-7-4 Kappirigama	21	315	40	389	90	479	939	224	206	270	2322	762	11799000	119838
7	Mal 8-4 Pihimbiyagollawa	23	699	55	734	92	827	1204	271	255	397	3425			
8	Mal-10-4 Kidawarankulama	26	730	8	750	19	769	1556	355	392	369	3874	1044		
9	Y-1-2 Weragala	5	87	7	109	234	343	664		6	36	789	242		
10	Y-2-SB Maha Kirimatiyawa	13	410	8	416	211	626	691	824	139	138	2394	676		
11	Y-3-6 Pandarellawa	24	430	24	430	216	646	1172	440	235	277	2654	405	33914000	161437
12	Y-4-6 Diyatithawwa	16	249	13	452	203	655	472	1670	41	180	2764			
13	MA-1-6 Kolibenduwewa	14	434		479	114	593	841	486	192	170	2566	472	20042000	148279
14	MA-2-SB-5 Vihara Halmillawa	14			267		267	599	628	105	90	1781			
15	MO-2-9 Ambagahawewa	18	63	24	132	160	292	1492	62	65	224	2091			
	Total				27611			57807	20276	10515	12533	135381			

Notes: Watershe K = Kala Oya Mal = Malwatu Oya Y = Yan Oya MA = Ma Oya MO = Moderagam Aru

Table 5.2 Staff plan for Project Period

	Project reqirement (person years)							Total person	Salary & benefits	Total salary requi	Time allocation	Salary & benefits
Professional Staff:	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	years(for 7 years)	/year/person	per year/project	per cascade/ year	Per year per cascade
Team Leader (Land and water)	1	1	1	1	1	1	1	7	1140000	1140000	0.05	114000
Conservation Farming Specialist	2	2	2	2	2	2	2	14	840000	1680000	0.10	168000
Institutional Development Specialist	1	1	1	1	1	1	1	7	840000	840000	0.05	84000
Water Resource management Specialist	1	1	1	1	1	1	1	7	840000	840000	0.05	84000
Monitoring and Evaluation Specialist	1	1	1	1	1	1	1	7	840000	840000	0.05	84000
Senior Agricultural Economist/Enterpric	1	1	1	1	1	1	1	7	840000	840000	0.05	84000
–development specialist												
Communication/training specialist	1	1	1	1	1	1	1	7	840000	840000	0.05	84000
Agricultural economist	1	1	1	1	1	1	1	7	720000	720000	0.05	72000
Marketing specialist	2	2	2	2	2	2	2	14	720000	1440000	0.10	144000
Senior catalyst	2	2	4	4	4	4	4	24	600000	2057143	0.17	205714
Catalysts	24	48	72	100	56	32	8	340	300000	14571429	2.43	1457143
Voluntier catalysts	25	50	75	100	100	100	100	550	108000	8485714	3.93	848571
Support staff:												
Administrative Officer	1	1	1	1	1	1	1	7	480000	480000	0.05	48000
Finance Officer	1	1	1	1	1	1	1	7	480000	480000	0.05	48000
M & E assistant	2	2	2	2	2	2	2	14	300000	600000	0.10	60000
Administrative/account assistant	1	1	1	1	1	1	1	7	300000	300000	0.05	30000
Data entry operator	2	3	3	3	3	3	3	21	300000	900000	0.15	90000
Secretary	2	2	2	2	2	2	2	14	300000	600000	0.10	60000
Field assistant	10	15	15	15	15	15	15	100	240000	3428571	0.71	342857
Drivers	8	8	8	8	8	8	8	56	180000	1440000	0.40	144000
Office aids	2	2	2	2	2	2	2	14	180000	360000	0.10	36000
House keeper	3	3	3	3	3	3	3	21	108000	324000	0.15	32400
Total										43206857		4320686

* Total number of cascades included = 20
* No of cascades selected per sub–watershed included in the project = 2
* No of sub–watershed selected = 10

Table 5.3.1 Benefit Cost Ratio and Internal Rate of Return and Land Use Pattern in Cascade/Sub-watershed Type 1 (Mamaniyawa)

A. Project Financial Returns for Cascade/Sub-watershed

Option	B/C ratio At 12% DR	B/C ratio At 22% DR	IRR
1	4.8	2.5	19.6
2	4.6	2.5	19.8
3	5.1	2.6	19.7
4	5.6	2.8	19.7

B. Project Investments Plan for Cascade Type 1

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	31,074,000	25,062,980	9,311,470	293,968,406	42,817,100	402,233,956
2	31,074,000	25,062,980	11,042,176	321,153,423	42,419,805	430,752,384
3	31,074,000	25,062,980	8,305,601	252,423,764	67,735,675	384,602,020
4	31,074,000	25,062,980	7,337,763	227,419,528	53,317,267	344,211,538

C. Project Investments Plan for Sub-watershed Type 1

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	62,148,000	50,125,959	18,622,939	587,936,813	85,634,200	804,467,911
2	62,148,000	50,125,959	22,084,353	642,306,846	84,839,610	861,504,768
3	62,148,000	50,125,959	16,611,203	504,847,528	135,471,349	769,204,039
4	62,148,000	50,125,959	14,675,526	454,839,056	106,634,535	688,423,076

D. Land Use in Cascade/Sub-watershed (with project and without project)

Sub-System	With project			Without Project
	Extents (ha) Cascade	Factor	Extents (ha) Sub-watershed	Extents (ha) Cascade
Paddy -maha	781	2	1563	369
OFC yala	391	2	781	62
Homegarden	577	2	1153	577
Chenalands	674	2	1348	337
Community forest	508	2	1017	203
Chena seasonal crop	315	2	630	236
Reservation	10	2	20	2

DR -- Discount Rate
B/C - Benefit Cost Ratio
IRR - Internal Rate of Return

Table 5.3.2 Benefit Cost Ratio and Internal Rate of Return and Land Use Pattern in Cascade/Sub-watershed Type 2 (Siwalakulama)

A. Project Financial Returns for Cascade/Sub-watershed

Option	B/C ratio		IRR
	At 12% DR	At 22% DR	
1	3.9	2.2	19.8
2	3.8	2.2	19.9
3	4.1	2.3	19.8
4	4.6	2.4	19.8

B. Project Investments Plan for Cascade Type 2

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	12,675,000	24,695,000	8,675,127	267,880,980	16,286,187	330,212,294
2	12,675,000	24,695,000	10,278,496	293,065,856	15,366,182	356,080,534
3	12,675,000	24,695,000	7,743,265	229,392,990	39,712,620	314,218,876
4	12,675,000	24,695,000	6,846,636	206,228,444	27,136,760	277,581,840

C. Project Investments Plan for Sub-watershed Type 2

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	25,350,000	49,389,999	17,350,254	535,761,961	32,572,375	660,424,588
2	25,350,000	49,389,999	20,556,993	586,131,712	30,732,365	712,161,069
3	25,350,000	49,389,999	15,486,531	458,785,981	79,425,240	628,437,751
4	25,350,000	49,389,999	13,693,272	412,456,889	54,273,520	555,163,679

D. Land Use in Cascade/Sub-watershed (with project and without project)

Sub-System	With project			Without Project
	Extents (ha) Cascade	Factor	Extents (ha) Sub-watershed	Extents (ha) Cascade
Paddy -maha	724	2	1448	438
OFC yala	362	2	724	40
Homegarden	185	2	370	185
Chenalands	540	2	1079	270
Community forest	277	2	554	111
Chena seasonal crop	382	2	765	287
Reservation	10	2	20	2

DR - Discount Rate
B/C - Benefit Cost Ratio
IRR - Internal Rate of Return

Table 5.3.3 Benefit Cost Ratio and Internal Rate of Return and Land Use Pattern in Cascade/Sub-watershed Type 3 (Kappirigama)

A. Project Financial Returns for Cascade/Sub-watershed

Option	B/C ratio At 12% DR	B/C ratio At 22% DR	IRR
1	4.1	2.2	19.5
2	4.0	2.2	19.6
3	4.3	2.3	19.5
4	4.8	2.5	19.5

B. Project Investments Plan for Cascade Type 3

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	11,799,000	24,677,480	6,124,053	191,778,817	22,207,262	256,586,611
2	11,799,000	24,677,480	7,185,792	208,456,050	22,603,346	274,721,668
3	11,799,000	24,677,480	5,506,981	166,292,363	37,098,523	245,374,347
4	11,799,000	24,677,480	4,913,240	150,952,977	27,347,078	219,689,774

C. Project Investments Plan for Sub-watershed Type 3

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	23,598,000	49,354,959	12,248,105	383,557,634	44,414,524	513,173,223
2	23,598,000	49,354,959	14,371,584	416,912,100	45,206,692	549,443,336
3	23,598,000	49,354,959	11,013,963	332,584,726	74,197,047	490,748,695
4	23,598,000	49,354,959	9,826,480	301,905,953	54,694,155	439,379,548

D. Land Use in Cascade/Sub-watershed (with project and without project)

Sub-System	With project			Without Project
	Extents (ha) Cascade	Factor	Extents (ha) Sub-watershed	Extents (ha) Cascade
Paddy -maha	479	2	959	315
OFC yala	240	2	479	40
Homegarden	206	2	413	206
Chenalands	422	2	845	211
Community forest	212	2	423	85
Chena seasonal crop	305	2	610	229
Reservation	10	2	20	2

DR - Discount Rate
B/C - Benefit Cost Ratio
IRR - Internal Rate of Return

Table 5.3.4 Benefit Cost Ratio and Internal Rate of Return and Land Use Pattern in Cascade/Sub-watershed Type 3 (Koliabedumwewa)

A. Project Financial Returns for Cascade/Sub-watershed

Option	B/C ratio		IRR
	At 12% DR	At 22% DR	
1	4.7	2.3	19.5
2	4.5	2.3	19.7
3	4.9	2.4	19.6
4	5.5	2.6	19.5

B. Project Investments Plan for Cascade Type 4

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	33,914,000	25,119,780	7,288,020	227,987,609	19,018,674	313,328,082
2	33,914,000	25,119,780	8,718,319	250,453,983	18,471,869	336,677,950
3	33,914,000	25,119,780	6,456,745	193,654,083	39,747,076	298,891,685
4	33,914,000	25,119,780	5,656,900	172,989,961	28,140,765	265,821,405

C. Project Investments Plan for Sub-watershed Type 4

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Bank loan	
1	67,828,000	50,239,559	14,576,040	455,975,218	38,037,348	626,656,165
2	67,828,000	50,239,559	17,436,638	500,907,965	36,943,738	673,355,901
3	67,828,000	50,239,559	12,913,491	387,308,166	79,494,153	597,783,369
4	67,828,000	50,239,559	11,313,799	345,979,921	56,281,529	531,642,809

D. Land Use in Cascade/Sub-watershed (with project and without project)

Sub-System	With project			Without Project
	Extents (ha) Cascade	Factor	Extents (ha) Sub-watershed	Extents (ha) Cascade
Paddy -maha	646	2	1291	430
OFC yala	323	2	646	24
Homegarden	235	2	470	235
Chenalands	527	2	1055	264
Community forest	483	2	965	193
Chena seasonal crop	162	2	324	122
Reservation	10	2	20	2

DR - Discount Rate
B/C - Benefit Cost Ratio
IRR - Internal Rate of Return

Table 5.3.5 Benefit Cost Ratio and Internal Rate of Return and Land Use Pattern in Cascade/Sub−watershed Type 5 (Koliabenduwewa)

A. Project Financial Returns for Cascade/Sub−watershed

Option	B/C ratio		IRR
	At 12% DR	At 22% DR	
1	3.8	2.0	19.4
2	3.6	2.0	19.5
3	4.0	2.1	19.4
4	4.4	2.2	19.4

B. Project Investments Plan for Cascade Type 5

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub−grant	Direct	Bank loan	
1	20,042,000	24,842,340	6,910,460	211,929,356	18,561,659	282,285,815
2	20,042,000	24,842,340	8,224,183	232,564,614	19,023,648	304,696,785
3	20,042,000	24,842,340	6,146,938	180,394,174	37,004,452	268,429,904
4	20,042,000	24,842,340	5,412,284	161,414,274	24,978,481	236,689,379

C. Project Investments Plan for Sub−watershed Type 5

Option	Project contribution			Farmer Contribution		Total
	Rehabilitation Cost	Capital and Operational cost	Sub−grant	Direct	Bank loan	
1	40,084,000	49,684,679	13,820,920	423,858,711	37,123,319	564,571,629
2	40,084,000	49,684,679	16,448,366	465,129,229	38,047,296	609,393,570
3	40,084,000	49,684,679	12,293,877	360,788,347	74,008,904	536,859,808
4	40,084,000	49,684,679	10,824,568	322,828,549	49,956,961	473,378,757

D. Land Use in Cascade/Sub−watershed (with project and without project)

Sub−System	With project			Without Project
	Extents (ha) Cascade	Factor	Extents (ha) Sub−watershed	Extents (ha) Cascade
Paddy −maha	593	2	1186	434
OFC yala	297	2	593	0
Homegarden	192	2	385	192
Chenalands	378	2	757	189
Community forest	274	2	547	109
Chena seasonal crop	189	2	378	142
Reservation	10	2	20	2

DR − Discount Rate
B/C − Benefit Cost Ratio
IRR − Internal Rate of Return

Table 5.4 Summary of B/C ratios and IRRs by types of Cascades/Sub–watersheds

Sub–watershed Types	Crop Option	NPV% (Mil. Rs.)		B/C Ratio		IRR
		At 12%	At 22%	At 12%	At 22%	
SW –1 to 2	Option –1	1638	1638	4.84	2.52	19.64
	Option –2	1668	1668	4.63	2.48	19.75
	Option –3	1653	1653	5.06	2.62	19.68
	Option –4	1654	1654	5.59	2.81	19.66
SW –3 to 4	Option –1	1047	248	3.94	2.18	19.81
	Option –2	1075	264	3.78	2.17	19.90
	Option –3	1060	255	4.14	2.27	19.83
	Option –4	1061	254	4.59	2.43	19.78
SW –5 to 6	Option –1	850	200	4.14	2.22	19.52
	Option –2	868	211	3.98	2.20	19.60
	Option –3	859	206	4.33	2.31	19.55
	Option –4	861	206	4.76	2.46	19.53
SW –7 to 8	Option –1	1209	262	4.68	2.30	19.53
	Option –2	1234	277	4.47	2.28	19.66
	Option –3	1221	268	4.91	2.40	19.57
	Option –4	1222	268	5.46	2.57	19.54
SW – 9 to 10	Option –1	822	182	3.76	2.00	19.35
	Option –2	844	195	3.61	2.00	19.50
	Option –3	833	188	3.95	2.09	19.41
	Option –4	835	189	4.39	2.24	19.40
Averages	Option –1	1113	506	4.27	2.24	19.57
	Option –2	1138	523	4.09	2.22	19.68
	Option –3	1125	514	4.48	2.34	19.61
	Option –4	1127	514	4.96	2.50	19.58

* NPV – Net Present value

Table 5.5 Project Investment Plan for Total sub-watersheds (Rs.)

Sub-waters No	Crop Option	GOSL/ADB Project contribution			Farmer Contribution		Total
		Rehabilitation Cost	Capital and Operational cost	Sub-grant	Direct	Through Bank loan	
SWS -1	1	62,148,000	50,125,959	18,622,939	587,936,813	85,634,200	804,467,911
	2	62,148,000	50,125,959	22,084,353	642,306,846	84,839,610	861,504,768
	3	62,148,000	50,125,959	16,611,203	504,847,528	135,471,349	769,204,039
	4	62,148,000	50,125,959	14,675,526	454,839,056	106,634,535	688,423,076
SWS -2	1	62,148,000	50,125,959	18,622,939	587,936,813	85,634,200	804,467,911
	2	62,148,000	50,125,959	22,084,353	642,306,846	84,839,610	861,504,768
	3	62,148,000	50,125,959	16,611,203	504,847,528	135,471,349	769,204,039
	4	62,148,000	50,125,959	14,675,526	454,839,056	106,634,535	688,423,076
SWS -3	1	25,350,000	49,389,999	17,350,254	535,761,961	32,572,375	660,424,588
	2	25,350,000	49,389,999	20,556,993	586,131,712	30,732,365	712,161,069
	3	25,350,000	49,389,999	15,486,531	458,785,981	79,425,240	628,437,751
	4	25,350,000	49,389,999	13,693,272	412,456,889	54,273,520	555,163,679
SWS -4	1	25,350,000	49,389,999	17,350,254	535,761,961	32,572,375	660,424,588
	2	25,350,000	49,389,999	20,556,993	586,131,712	30,732,365	712,161,069
	3	25,350,000	49,389,999	15,486,531	458,785,981	79,425,240	628,437,751
	4	25,350,000	49,389,999	13,693,272	412,456,889	54,273,520	555,163,679
SWS -5	1	23,598,000	49,354,959	12,248,105	383,557,634	44,414,524	513,173,223
	2	23,598,000	49,354,959	14,371,584	416,912,100	45,206,692	549,443,336
	3	23,598,000	49,354,959	11,013,963	332,584,726	74,197,047	490,748,695
	4	23,598,000	49,354,959	9,826,480	301,905,953	54,694,155	439,379,548
SWS -6	1	23,598,000	49,354,959	12,248,105	383,557,634	44,414,524	513,173,223
	2	23,598,000	49,354,959	14,371,584	416,912,100	45,206,692	549,443,336
	3	23,598,000	49,354,959	11,013,963	332,584,726	74,197,047	490,748,695
	4	23,598,000	49,354,959	9,826,480	301,905,953	54,694,155	439,379,548
SWS -7	1	67,828,000	50,239,559	14,576,040	455,975,218	38,037,348	626,656,165
	2	67,828,000	50,239,559	17,436,638	500,907,965	36,943,738	673,355,901
	3	67,828,000	50,239,559	12,913,491	387,308,166	79,494,153	597,783,369
	4	67,828,000	50,239,559	11,313,799	345,979,921	56,281,529	531,642,809
SWS -8	1	67,828,000	50,239,559	14,576,040	455,975,218	38,037,348	626,656,165
	2	67,828,000	50,239,559	17,436,638	500,907,965	36,943,738	673,355,901
	3	67,828,000	50,239,559	12,913,491	387,308,166	79,494,153	597,783,369
	4	67,828,000	50,239,559	11,313,799	345,979,921	56,281,529	531,642,809
SWS -9	1	40,084,000	49,684,679	13,820,920	423,858,711	37,123,319	564,571,629
	2	40,084,000	49,684,679	16,448,366	465,129,229	38,047,296	609,393,570
	3	40,084,000	49,684,679	12,293,877	360,788,347	74,008,904	536,859,808
	4	40,084,000	49,684,679	10,824,568	322,828,549	49,956,961	473,378,757
SWS -10	1	40,084,000	49,684,679	13,820,920	423,858,711	37,123,319	564,571,629
	2	40,084,000	49,684,679	16,448,366	465,129,229	38,047,296	609,393,570
	3	40,084,000	49,684,679	12,293,877	360,788,347	74,008,904	536,859,808
	4	40,084,000	49,684,679	10,824,568	322,828,549	49,956,961	473,378,757
Total	1	438,016,000	497,590,313	153,236,516	4,774,180,673	475,563,531	6,338,587,033
	2	438,016,000	497,590,313	181,795,866	5,222,775,703	471,539,404	6,811,717,286
	3	438,016,000	497,590,313	136,638,127	4,088,629,497	885,193,388	6,046,067,325
	4	438,016,000	497,590,313	120,667,291	3,676,020,736	643,681,401	5,375,975,740
Average	1	43,801,600	49,759,031	15,323,652	477,418,067	47,556,353	633,858,703
	2	43,801,600	49,759,031	18,179,587	522,277,570	47,153,940	681,171,729
	3	43,801,600	49,759,031	13,663,813	408,862,950	88,519,339	604,606,733
	4	43,801,600	49,759,031	12,066,729	367,602,074	64,368,140	537,597,574

Summary of Project Contributions (mili. US$)

	Option 1	Option 2	Option 3	Option 4
Total GOSL/ADB Contribution for 10 sub-watersheds	21	21	20	20
Total Farmers Contribution for 10 sub-watersheds	99	107	94	82

The project costs are given for the four different land and water use options. The average total cost for seven years, as indicated in **Table 5.7** is about US $ 20 million.

5.2.4.1 Major assumptions and norms employed in Benefit/Cost analysis

The GOSL/ADB Area Development Project will include 10 sub watersheds for its land and water resources development and associated agro-industries and institutional components. In each sub watershed, two cascades comprising of about 20-30 tanks (assuming that an average cascade has about 10-15 tanks) will be selected. The, 20 cascades will represent all 5 types. In each cascade the total water and land resources will be considered in the development planning. This "contiguous area" approach or the consideration of sub watershed water and land resources in its totality has yielded significant production - conservation benefits in SCOR.

In each of the first three years of project implementation three sub watersheds will be included. The 10th sub watershed will be taken in the fourth year (**Figure 10**). In cost computations and in the cash flow, the five cascade types are being assigned to sub watersheds in the following manner:

Cascade type I	--->	Sub watershed 1 & 2
Cascade type II	--->	Sub watershed 3 & 4
Cascade type III	--->	Sub watershed 5 & 6
Cascade type IV	--->	Sub watershed 7 & 8
Cascade type V	--->	Sub watershed 9 & 11

GOSL/ADB inputs will be directed to a selected sub watershed or a cascade only for four years. However, farmer inputs are distributed throughout the project period. In short, for GOSL/ADB inputs, it is assumed that the land & water resources development in a sub watershed or a cascade will take a four year cycle.

It is assumed, based on practical experience in watershed management in the NCP, that an effective leadership will be emerged and the production - conservation activities as well as other business ventures of the farming community will reach a sustainable level in about four years, if the project efforts are directed in the manner proposed in this report.

The volunteer catalysts, for example, will be paid by the project only for four years in each sub watershed/cascade. Once the farmer organizations/companies reach a sufficient level of maturity and if they feel that these volunteers or change agents are profitable to the organizations, they will be absorbed and paid by the organizations. Therefore, the final level of volunteer catalysts will be continued as 100.

Similar to SCOR project, the proposed land and water resources development in the GOSL/ADB project hypothesizes that a balance between production and protection or a sustainable system of resource use can be achieved by planning agricultural production with watersheds as basic planning and implementing units through a participatory approach by resource users, government agencies and non-governmental organizations including the private sector.

As the proposed land and water resources development approach is primarily based on IIMI SCOR experience on participatory resource management, Mahameegaswewa production and

Figure 5.10 Project Activity Plan and Catalysts Allocation Plan During the Project Period

Sub–Watershed	Cascade (Serial Number)	Project Years 1	2	3	4	5	6	7
1	1							
	2							
2	3							
	4							
3	5							
	6							
4	7							
	8							
5	9							
	10							
6	11							
	12							
7	13							
	14							
8	15							
	16							
9	17							
	18							
10	19							
	20							
Total no. of catalyst		24	48	72	100	56	32	8
Volunteer catalyst		25	50	75	100	100	100	100

Catalysts and Volunteer catalysts working together (Paied by Project)

Only volunteer catalysts working (Paied by Farmer Organizations)

conservation sub-watershed model was adopted to compute the benefit and cost for the proposed sub-watershed models. This sub-watershed consists of 4 sub-systems, viz. the catchment area (dense forest and open forest), homegardens, command area and the drainage area. The catchment area comprises 3 parts which are chena land (slash and burn cultivation), abandoned chena land and scrub and forest lands.

As most of cascades of the NCP typify Mahameegaswewa cascade in respect of topography and land use, the adoption of costs and benefits of this sample for benefit-cost analysis of five sample cascades is justifiable. It should be noted, however, that the cost of rehabilitation differs from one cascade type to another. As indicated in **Tables 5.2.1** through **5.2.5**, different costs of rehabilitation have been considered for different types of cascades.

Without Project Situation

Present status of resource management in project area is very poor for sustainable agricultural production. The resource degradation due to soil erosion and poor resource management have resulted in progressive reduction of productivity. However, due to the lack of accurate information, this reduction in productivity is not considered in the "without project" computations. At present there is less or complete absence of any soil and water conservation practices adopted by farmers and agencies in this area to conserve the resources for better production. Slash and burn cultivation is practiced in each year on a large scale in open forest area resulting in soil erosion during the rainy season. Each house hold cultivated on an average 0.3 ha chena land with seasonal crops such as finger millet, greengram, maize, gingerly and chili. Supplementary irrigation facilities to complete the crop life during the dry seasons are poor. Therefore, some extents cultivated are affected due to water stress. Inputs and their unit cost for seasonal chena cultivation (based on the SCOR resource survey and mini-projects) are given in **Annex 5.1**.

Major part of the catchment area is covered by abandoned chena lands and scrub lands that have been cultivated for several years with seasonal crops. Very few fruit plants and forest plants exist in those lands, and their present production levels are lesser when compared to the average potential or achievable production levels under "with project" situation. Second largest extent of the catchment area is covered by denuded forest with minimum density of forest trees. The input cost and maintenance costs per unit of land of abandoned chena and forest land are shown in **Annex 5.2**. Production figures and out put prices for tree products and their wood values are given in **Annex 5.3**.

Existing home gardens are not well organized and there is not much conservation practices and diversification in crops and livestock production. Some fruit trees and forest trees exist without proper management. Input costs and maintenance costs for existing model home garden are given in **Annex 5.2** and their production values and output prices are given in **Annex 5.3.** It should be noted here that, the average crop yields in these areas are much less than the Sri Lanka average. For example, SCOR baseline/pre-project analyses show that the average paddy yield in minor tank systems is much less than the country's average for irrigated paddy[2].

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2 This is partly due to the fact that crop yields in well irrigated major irrigation systems push the country's average upwards.

However, due to the lack of accurate yield data for sample cascades outside SCOR sites, it is assumed that the existing yield levels (as well as input levels) are approaching the country's average. Due to this an other assumptions on densities of perennial crops, marketable produce etc, average income per ha. or per family in the "without project" situation is much higher than the actual.

It is also assumed that there is no big difference in the rate of input use between "without project" and "with project" situations. In other words, it is assumed that the level of technology related to input use for a particular crop would not change due to project. However, as mentioned earlier, cropping patterns, other cultivation practices including soil and water conservation, area cultivation etc. are assumed to be enhanced with the project. It is assumed, based on SCOR and similar experiences in major irrigation projects, that the cost of inputs to the farmer will be lowered due to group purchasing and other interventions by the farmer organizations. Additionally, environmentally friendly measures such as organic matter management will help reduce the expenditure on chemical inputs. Furthermore, farmers will get a better price for their outputs, due to interventions by farmer organizations.

With project situation

The project aims to change the present resource use pattern into a more profitable and resource conserving land use pattern to improve the livelihood of the people in this area. It is assumed that the rehabilitation of tanks can only improve the productivity in a limited area of the command. But cascades is considered as the primary planing and implementing unit. As indicated earlier, four major production sub-systems have been identified viz. paddy area (command area), the homestead, the highlands for stabilized farming system in place of shifting cultivation, and other highland areas with open and denuded forest. The land extents under each sub system for selected 15 cascades are given in **Table 5.1**.

Sub-system 1. Command area:

Proposed rehabilitation of cascades will make additional extents available for cultivation and increase cropping intensity in already available command areas. This includes the area asweddumized, and the proposed area newly asweddumized. It is assumed that the rehabilitation of a typical cascade will require 3 years. It is also assumed that 25% of the rehabilitation work is completed in the first year, 50% in the 2nd year and the rest in the 3rd year. Incremental area benefitted due to rehabilitation is assumed as 25% in the 2nd year, 50% in the 3rd year and the rest (25%) in the 4th year. It is further assumed that the full extent of command area can be cultivated in maha with paddy using tank water after rehabilitation of the cascade and 50% of the total area can be cultivated with Other Field Crops (OFC) in the dry season utilizing ground water through agro-well for supplementary irrigation. There is a considerable extent of land where crop production can be intensified by introducing supplementary irrigation during the dry season which extends for about 2-3 months. As a supplementary irrigation facilities, 30 agrowells will be installed in the command as well as in the highland areas in a typical cascade. For yala, OFC, cultivation, 4 crop options can be adopted. The proposed crop options for yala season are listed below.

1. 25% of chilli+25% of Soya
2. 20% of chilli+15% of soya+15% of B-onion
3. 25% of chilli+15% of soya+ 10% of maize

4. 25% of soya+10% of maize+15% of greengram

Diversified cropping with less water consuming crops will save irrigation water, from which additional area can be cultivated during the yala season. This can be improved by adopting better on farm water management practices and following other water use efficiency methods. It is considered that the operational and maintenance cost for minor irrigation system is about Rs. 250 per ha per year. This cost will be borne by farmers organizations. Under "With project" situation, most of the activities will be done in a collective way to reduce the cost of production. Improved technology will be adopted and practiced by farmers to obtain higher income. This can be done by forming/strengthening the farmers organizations and through their engagement in economic activities such as securing forward contacts, bulk sale of agricultural inputs, delayed marketing of production until the prices increase and value adding processes based on their production. Farmer Organization may enter into forward agreements with private companies and government agencies to get higher output prices. To facilitate this process peoples' centers (Agrarian Service Centers) have to be strengthened to meet services required by farmers. This will be in accordance with the Government policy and the project will follow the guidelines and procedures already established by the Ministry of Agriculture. **To fulfill this task, it is assumed that the project would provide one large scale processing center, one large scale marketing center, 30 water pumps, 30 sprayers, one four wheel tractor, 30 two wheel tractors, 30 threshing machines and one store per each selected cascade. As a model for the proposed project, it is assumed that the project would undertake two cascades per each sub-basin and one Peoples' Center to serve two cascades.**

Operation and maintenance cost of the equipment provided by the project will be shared by the farmer organization in charge of a particular Peoples' Center. This will improve the production disposal and marketing structure. Input amount and their costs for paddy cultivation and OFC cultivation are given in **Annex 5.4**. The production figures and out put prices for above crops are also given in the same annex (based on cost of cultivation reports, Department of Agriculture and SCOR data base). The proposed share allocation of equipment for a Peoples' Center and cascades, cost for storage, marketing center and processing centers and installation cost and maintenance cost of agrowells are shown in **Annex 5.7**.

Sub-system - 2: Homegarden

Under the homegarden development, on the average, about 257 plants per hectare (improved plant varieties) will be established in each and every home garden. Present homegardens have space to introduce new plants. This process will improve the home garden in a organized manner for production through-out the year. This will be diversified by introducing a livestock component to the home garden. Proposed plan will include 150 goats per cascade, and 75 cross breed cattle per cascade. About 5-10% of the home garden area will be utilized for seasonal cultivation with gingelly, green gram, chilli and maize. The full extent of the home garden in each cascade model will be conserved by constructing contour bunds. These bunds will be properly maintained each year by farmers. Homegarden development plan will commence in the first year. Fifty percent of the area will be completed and the balance in the 2nd year. Labour cost for establishing new plants, and construction and maintenance cost for contour bunds and 92% of the material requirement will be borne by farmers and 8% of the material cost will be contributed by the project through sub-grants. Number of trees by species per hectare and cost for establishment and maintenance are given in **Annex 5.5**. Expected production figures and their

out put prices are given in **Annex 5.6**. (based on Cost of Cultivation Reports prepared by Department of Agriculture and norms used by Perennial Crop Development Project.)

Sub-system 3: Stabilization of chena land and introduction of agroforestry systems.

The 55% of the catchment is covered by this sub-system and part of this area is used for seasonal chena cultivation. Full extent of the upland area will be conserved by constructing contour bunds. This will be phased out for 5 years. In the first year 15% will be completed, 2nd year 20%, 3rd year 25% and the balance covered at the rate of 20% in each year in the next two years.

It is assumed that each household utilizes 0.4 ha extent for seasonal cultivation in each year with supplementary irrigation systems (agro-well). For the proposed cascade model, the gingelly, maize, greengram, fingermillet and chilli are considered as common crops to be cultivated by farmers in chena land as a seasonal crops (according to the SCOR experience in Maha Meegaswewa). Input cost, production values and out put prices are also given in **Annexures 5.5 and 5.6.**

The proposed agro-forestry systems for the scrub and abandoned chena land include more fruit trees with forest trees. The Department of Forest adopts community forestry programmes for this type of lands. With the collaboration of the Forest Department, the agro-forestry intervention in the project area can be included for this programme. After the establishment of perennial plants, semi perennial can be cultivated in vacant area upto the year 5. The proposed plant composition, the number of plants, cost of materials and maintenance per hectare are given in **Annex 5.5**. The area under agro-forestry will yield fruits and other products such as fodder, beekeeping, pasture, medicinal plants, non-timber forest products and timber. Therefore, the benefits are likely to be evenly spreaded though fruits and timber values only have been considered for the benefit analysis. This analysis does not consider the value of tress planted in the catchment and command areas for timber use, except teak, jack and mahogani.The jack, teak and mahaogani trees planted in the catchment and home garden areas can be harvested for timber in 15 years, 20 years and 25 years respectively. In addition, several other benefits such as improved land use, erosion control, moisture conservation, etc. may also take place from which other crops might be benefitted. However, these positive aspects are not included for financial cost Benefit:Analysis. The expected production, output prices and input cost values are given in **Annexures 5.5 and 5.6**.

Sub-system 4: Forest enrichment

Forty five percent of the catchment area is covered with denuded forest together with small extent of dense forest. This area can be improved by introducing an enrichment planting programme. This area also will be conserved by constructing contour bunds. Most of the area will be covered by introducing forest plants to enrich the existing forest area. Forest enrichment programme will be phased out for five years as agro forestry development programme. The planting composition and cost for materials and maintenance are given in **Annex 5.5** and production figures and their output prices are given in **Annex 5.6.**

5.2.5 SUB GRANTS

The proposed lánd and water resources development can be initiated and adopted by providing sub-grants to farmers organization at the initial "take-off" phase to meet part of the expenses for materials, and that money can be used as a collateral fund to obtain loans from the state banks worth of 4-5 times higher than collateral. This has been successfully practiced in SCOR project. Therefore, the total project cost of each cascade type, can be divided in to four major parts such as capital and operating investment by project, sub-grants providing by project, investment by farmers and bank loan obtaining by farmers.

Providing small grants to the existing and new user groups is considered to be crucial. Such grants, among other things, will enable the group to:

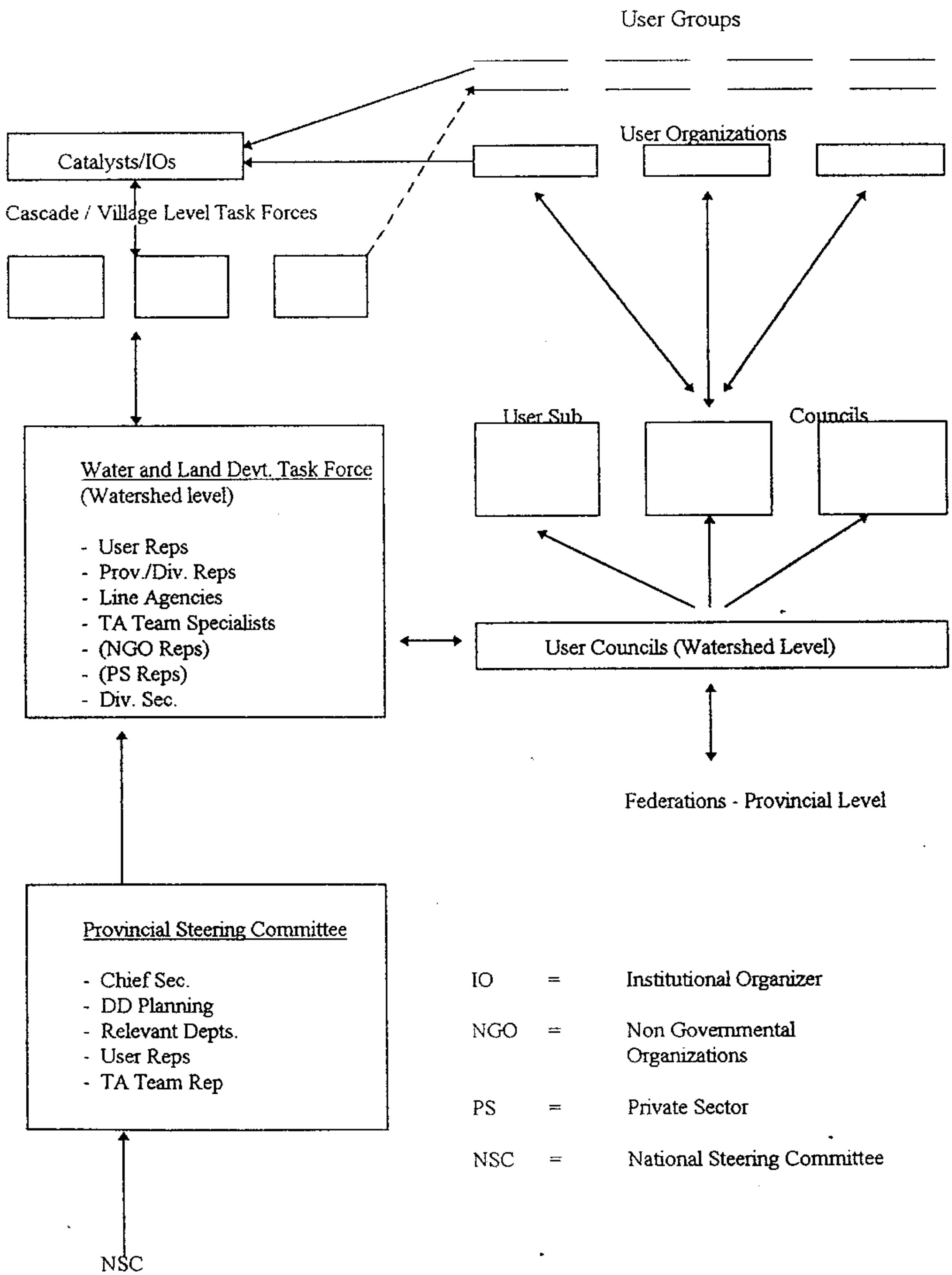
- Show collateral when seeking additional loans through private financial institutions.
- Develop and promote insurance schemes for new crops, conservation schemes and investments.
- Construct storage facilities, markets, terraces, nurseries or other small physical infrastructure.
- Purchase equipment needed to initiate or upgrade joint enterprises to gain economies of scale and value added to their production.
- Join with other user groups to establish revolving funds for investments and/or the purchase of agricultural inputs.
- Obtain legal, financial and other services associated with establishing user rights, small enterprises and productive ventures.

Most of such "grants" will be transferred to new organizations after the completion of mini-projects. Hence, grants are used as revolving funds. In the cost distribution it is assumed that 8% of cost of material inputs required for production and conservation would come from such grants/revolving funds provided by the project. The balance 92% will be contributed by farmers through their own savings and through loans obtained from local banks. In addition, all the labour inputs as well as the cost of agro-wells etc. will be provided by the farmer.

5.3 ORGANIZATIONAL STRUCTURE & INSTITUTIONAL ARRANGEMENTS

The proposed Organizational Structure is illustrated in **Figure 5.11**. The project will be implemented primarily by the user groups with the help of Catalysts/Institutional Organizers (IO), a multi-disciplinary team of professionals and line agencies. The project activities at field level will be coordinated by the catalyst. A small task force composed of the catalyst (co-ordinator), farmer representatives and concerned government officials (eg: Agric. Instructor, Grama Niladhari, Technical Assistants, etc.) is responsible for planning and day-to-day implementation

Figure 5.11
Proposed Organizational Structure



IO = Institutional Organizer

NGO = Non Governmental Organizations

PS = Private Sector

NSC = National Steering Committee

and M&E at the cascade level. A highly qualified locally recruited multi-disciplinary team of professionals stationed at the provincial level provides technical assistance, and facilitate implementation (**Table 5.2**).

The Professional team at provincial level includes:

(1) Institutional Development Specialists with **experience in organizing farmers**, training and skill development, co-ordination and with strong interpersonal and training skills.

(2) A Resource Management Specialist - preferably a hydrologist with experience in irrigation design, agro-well design and operation, irrigation and drainage (O&M), farmer organizations, rainfed agriculture OR an agriculturist with adequate knowledge on hydrology experience in agricultural extension, farm management, irrigation and land-use.

(3) Senior Agric. Economist/Enterprise Development Specialist and an Assistant (Junior Economist); especially to prepare land and water development, mini projects and for enterprise development.

(4) An Agronomist/Conservation Farming Specialist with a good knowledge in conservation farming, water saving techniques, crop husbandry, rainfed agriculture.

(5) Marketing Specialist with diverse experience, linking farmer groups with appropriate markets/private sector, co-operative business ventures, etc.

(6) Communication/Training Specialist.

(7) A Team Leader will be appointed to oversee overall project implementation activities on a day-to-day basis.

At the Watershed level, there will be a Task Force/Co-ordinating Committee namely the Watershed Resources Management Team, WRMT, **chaired by the Divisional Secretary**. The Committee is composed of user representatives, concerned line agency representatives, relevant NGOs, and Technical Assistance (TA) team representatives.

At the provincial level, there will be a Steering Committee chaired by the Provincial Chief Secretary. The Provincial Land Commissioner or Provincial Secretary for Agriculture act as the Secretary/Convener and the committee is represented by TA team, farmer organization federation/council, concerned line agencies such as Department of Irrigation, Agrarian Services and Agriculture Department, etc.

There is a National Steering Committee at the National level, chaired by (to be decided by Team). Other relevant Ministries, Provincial Chief Secretary, Provincial Co-ordinator are included in this committee. Its specific responsibilities will include:

- review project progress. Examine any discrepancies between planned and actual achievements and make recommendations for accelerating progress in the upcoming quarter;

- reviewing and approving the quarterly and annual workplans, recommend changes, if necessary;

- facilitate progress by adding to the efforts of PSC, watershed resources management team and other implementors;

- discuss and resolve specific policy/and or procedural impediments.

The Provincial Steering Committee will perform a similar role at the Provincial level.

Authorities related to project implementation decisions are decentralized to a greater extent. And, a senior official of the host ministry as the National Level Facilitator/Co-ordinator. His responsibilities include:

- Planning and convening meetings of the NSC in consultation with Project Leader;

- Recording and communicating the decisions of the NSC to the parties concerned;

- Make independent visits to project sites as necessary;

- Help resolve policy/procedural impediments, if any, through discussions with the staff of relevant agencies, provincial and divisional authorities and provincial professional team of project;

- Facilitating and ensuring the harmonious functioning of management by promoting the effective participation of all concerned agencies, and

- Representing the host Ministry in the Provincial Steering Committee.

At the provincial level, Secretary to the Provincial Steering Committee, i.e. Provincial Land Commissioner or Secretary - Provincial Ministry of Agriculture assumes similar responsibilities to facilitate the smooth functioning of the project.

While the Steering Committees review and facilitate the project implementation, the responsibilities of the Provincial Professional Team (i.e. TA team) include:

- **Catalyzing all aspects of project implementation;**

- Providing professional expertise for project implementation;

- Prepare workplans and budgets, in consultation with user groups & line agencies at sub-watershed and Provincial levels;

- Conduct regular reviews and analyses;

- Arrange for specialized assistance when necessary; including preparation of terms of reference, work supervision and evaluation;

- Providing guidance and technical advice to the NSC, Co-ordinating Committees or task forces at lower level and catalysts;

- Developing close links and working relationships with relevant GOSL or other donor funded projects operating in the area; and

- **Co-ordinate and Monitor all project activities.**

- Sub-contracting project activities, if necessary.

- Aggregating project reporting at sub watershed and provincial levels;

- Attending to other functions that may be decided upon by the NSC or PSC.

5.3.1 Organized Group Action for Production and Protection

SCOR group formation and the anticipated organizational structure are illustrated in **Figure 5.9**. It is assumed that GOSL-ADB project would adopt a similar model. To maximize the environmental impact, efforts/activities aimed at balancing production and protection must cover the entire area of the selected contiguous block, *and should not be limited to sample plots or selected farms/home gardens.* As most of the holdings are small (ranging from about 0.2 ha to about 1 ha), most productive conservation practices such as integrated water management, building contour bunds and water harvesting/saving techniques, biological measures (e.g., planting along contour)s, integrated pest management, reducing water pollution, etc., demand group action. For instance, contour bunds will cut across individual holdings.

Moreover, group action will enhance individual profits through various means: benefits accrued to pooled resources and scale economies, increased bargaining, exchange of expertise in a complementary way, etc. Users are being grouped and united for various purposes, ranging from groups for multiplication of seeds through groups for small hydropower plants (coupled with conservation of the corresponding "catchment") to production companies or NGOs.

5.3.2 Principles for Group Formation

Group formation in a given contiguous area may be guided by certain principles:

I. ***Groups (10-20 users)***

Groups may be formed for the realization of various service functions, production purposes, protection purposes or for combined action of production and protection. The

most common mode is the latter, that is, most groups are aimed at balancing production and conservation. Single purpose group formation (either production *or* protection or even for specific services such as marketing, input supply, etc.) *will not be* discouraged because the composition of different activities in the contiguous area will ensure that the objective of balancing production and protection will be achieved when they are put together. And, the total area will be covered by the interventions.

II. ***Organization (5-20 groups)***

Usually, various groups in a particular contiguous area may get together and form an organization.[3] When all the activities in a contiguous area are assembled, it will take the form of an integrated production and protection plan for that sub-watershed/contiguous area.

III. ***Councils/Sub-Councils***

It is expected that the users will like to federate up small groups into area councils or sub-councils. (through organizations). For example, all the organizations in the Huruluwewa watershed may decide to federate into one body for production and protection purposes. Such a trend can be seen in Polonnaruwa and Anuradhapura.

IV **Producers Councils**

At a higher level, preferably combining FO s of two cascades or one sub watershed, a production or People's Center may be established. This may be based on Agrarian Service Center. It is proposed that these production service centers be owned, managed and operated by the Producers' Council of the Area. **However, at the initial stages the farmers (or until producers organizations and councils reach the required degree of maturity) will manage PSCs in a partnership mode with relevant government officials.** (DAS, IMD, Forest Dept., Dept. of Agriculture, etc). With the forming and strengthening of Producers' Organizations, and with the expanded activities under the new strategy, the Producers organization and PSC system will assume greater responsibility for the production and related service activity in the area, and it is best that they be invited to assume control over the PSCs with an expanded role, to cover all agriculture and agriculture related industrial production and service activities.

A cadre of change agents or catalysts will help farmers, first to organize themselves into groups facilitate forming the groups into Producer Organizations and constituting these organizations, eventually into a Divisional or Watershed Producers' Council. **The**

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[3] Even though a typical process of formation of organizations may follow this pattern, there may be exceptions as desired by the users.

Council will take charge of the PSC. The Technical services personnel will be housed in the center. The Center will be progressively developed into to a fully-fledged Producers'/Farmers' information center - A center for marketing,technical, legal information, conflict resolution, and also for facilitating other agriculture and agriculture related services. Eg: establishing cold storage facilities, demonstration plots, etc. The PSC serving as a training and extension center and a demonstration center adds credibility and convincibility to the new technologies, cultivation practices etc.

5.3.3 Tasks and responsibilities of production services centers

The catalysts will develop, jointly with relevant government officials, the **agrarian service centers** as "peoples centers", to be managed by the Producers. Those will become the main centers for providing institutional and technical services, market and research information, legal assistance, quality control and training, and linking user organizations and groups with state and private sector, and markets for all production, conservation and agro-industry related activities.

The village level FOs and their immediate federations within the areas of operation and viability would actively participate in such areas as: scheduling production and marketing, marketing contracts, land improvement services, environmental conservation, managing organic matter and soil fertility, integrated pest management, input supplies, credit, storage, processing, value addition, transport, market information services, marketing etc. They are also expected to develop as contributors and share holders of the proposed rural financial services institutions (Farmers Banks). They could develop to serve as centers for agricultural and agro-industrial demonstration, education and training in production, soil conservation, cropping systems, new technology, plant nurseries, etc. and carry (on a pilot scale) field laboratories with to service farmers and their organizations.

More specifically, the roles and functions of PSCs will be:

- recognize the need for resources use change for improving the livelihood of people: production and conservation planning, focus on **special crops for special markets,** and on meeting local demand in the large scale expansion of diversified cropping: focus on agro-based rural industries incl. processing.

- involve all the families through farmer organizations and groups in sharing the effort to change the present land use to a high-income and resource - conserving land use.

- production planning and scheduling to enable the councils/organizations to predict production, enter into forward contracts, organize marketing, processing, etc.

- diffusion and adoption of appropriate technologies: for example, establish plant nurseries, seed production demonstrations for technology etc. The PSC will work closely with technical agencies in these activities.

- capture **economies of scale** in cropping practices, input and output marketing,

value-added production and agro-industries through the producer organizations and producer councils and agrarian services centers.

- bridge the **gap between progressive and non-progressive farmers** by promoting the use of quality seeds, better management of land and water, capturing economies of scale through organized group action; etc.

- adopt a **holistic approach in land use** based on watershed concept integrating the lowlands and highlands, including chena and homesteads into a single development workplan and package intensive but ecologically sound land use in watersheds including irrigated commands, catchments and drainage areas: promote and adopt **land and water conservation** measures such as mulching, contour bunding, agro-forestry and SALT, as integral components of the crop and livestock production processes: replace progressively, and without sacrificing crop output/profit; the use of chemical fertilizers and agro-chemicals through **soil-fertility improvements** by measures such as organic manuring, integrated pest management and crop rotations: promote and adopt **water harvesting in highlands** to grow crops while ensuring adequate catchment runoff to grow crops in irrigated commands;

- encourage and adopt **participatory planning and decision making** in land use and in the management of resources for agricultural activities at rural level;

- develop **data bases** at village level to facilitate and help participatory planning and managing resources;

5.3.4 Deployment of catalysts to form, activise and strengthen, producer/farmer groups and organizations and production service centers

An important feature in the proposed arrangement is the introduction of (preferably a non-governmental/voluntary) cadre of catalysts at farm level and PSC/Divisional Secretary level. When the farmer organizations/councils and PSCs reach higher levels of maturity and business modes, the catalysts may be absorbed by these organizations.

The catalysts' tasks will be to -

a) Motivate and encourage producers in their respective areas to form production groups/organizations/sub councils/councils and strengthen them through training and organizational development programmes;

b) Link producer groups/organizations with government technical services and private sector/NGO know-how and services available in the area, and outside, eg: Link Producers' organizations with Technical services in programming for agricultural production and production scheduling;

c) Link producer groups/organizations with potential markets/private sector firms and provide market information;

d) Assist producer groups/organizations in organizing the supplies and marketing of produce, and assist Producer organizations to enter into forward agreement with various parties for marketing of their produce;

e) Assist the Divisional Secretary/Divisional Producer Council/PSC/farmers to co-ordinate the overall production/marketing programme in the area.

f) be accountable to the Producers Organization/Sub Council for the satisfactory performance of their tasks;

g) Assist in participatory self monitoring and evaluation of performance by organizations and PSCs.

It should be emphasized that the catalytical function will be a critical input to get things moving, and generate the required dynamism of the strategy. It is extremely important to avoid the mixing up of technical functions with administrative functions. The cadres of government, should be deployed in a manner that would gain the acceptance of the widest possible sections of the community through the effectiveness and benefits of their active involvement in the programme. In performing their role these cadres should primarily aim at assisting the rural people to shed their dependency syndrome, developing their self-respect, self-confidence, in discovering what they could do for themselves to develop and achieve the objectives of their enterprises, developing themselves into responsible and active receiving groups which would demand, as of right, the various technical and other services the state owes to them, assuming increasing control over the resources they judiciously utilize for production and becoming true partners in the development process.

5.3.5 Strengthening of technical services/support system

An important change proposed in the strategy is to reform and strengthen technical services/support system, particularly the marketing and credit arrangements. The proposed diversified rural economy will demand a variety of services in a way different to the traditional input and output systems. Only few examples are cited below:

5.3.6 Credit for Economic Ventures

The current practice for farm credit is not sustainable since it breeds defaulters with the end result of writing off loans by political process. second, it does not lead to recognizing the importance of improving farmer credit-worthiness that could lead to action improving credit rating of the individual farmer. Third, it dose not recognize the importance of transactions with farmer organizations dealing with viable economic ventures in which the individual farmers are a part.

These deficiencies do not facilitate the emergence of a production environment that would motivate farmers to engage in profitable economic ventures in an <u>open market setting</u>. Instead, the current practice takes the form of an act of providing relief or a rescue operation to farming community that would be a burden on government budget.

The remedial actions through the proposed Farmers' Bank or any other means should recognize the fact that credit to farmers should finance/supplement an economic venture of the farm. This recognition can create a demand for,

a) organization where farmers could collectively plan their individual economic ventures, and use community action on discipline for credit repayment,

b) Information on crops, processing, markets, transport, legal contracts, banking etc.,

c) mechanisms among the lending institutions to lower transaction costs, and offer better packages of support with relaxed procedures in supply of credit.

Such a demand could activate processes of supplying such support which itself will generate a lot of complementary activity that would enrich production planning, production scheduling, forward contracts, exploration of new markets and other diversified economic activity. Hence, farmer organizations and councils are expected to develop as contributors, through PSC, and share holders of the proposed Farmers Bank. This is well within the capacity of matured and dynamic FOs which can be found in places like Gal Oya, Kaudulla or SCOR sites.

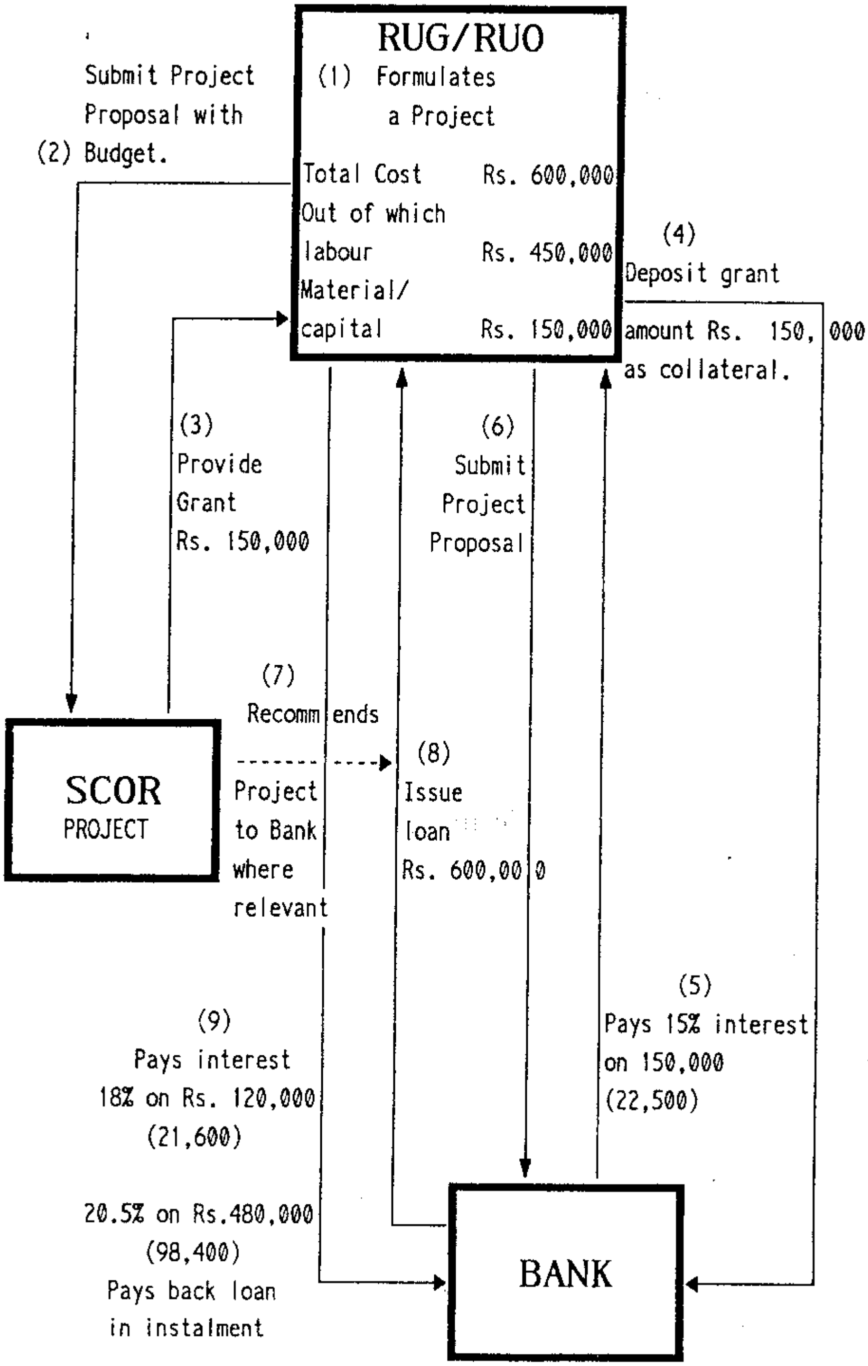
Based on such productive activity the state could provide support where necessary to farmer organizations to receive grants that would be used as collateral to raise bigger packages of credit from lending sources. The SCOR models of grants/credit is illustrated in **Figure 5.12.**

5.3.7 Legal Arrangements

Though the smaller groups may remain at "informal status," the organizations, more often than not, would like legal recognition. Certain farmer organizations may not like to register under the existing legislature. In the future, certain organizations may wish to have more independence. They may not like that a government department is vested with the powers of dissolving user organizations. In addition to such legal recognition, the groups, organizations and councils may need to enter into contracts with their partners. These may include: state-user contracts for usufructuary rights, producer-buyer contracts such as forward contracting, user group-bank contracts, service contracts, etc.

As stated earlier, in most cases, the integrated plans (of respective contiguous areas) will be developed into PROJECTS. A typical budget of such a project will comprise of a collection of mini-budgets for individual activities. There will be three sources of inputs/funding: (a) User inputs including labor, materials, and money, (b) Seed money/grant from project (often, this will be used as a revolving fund and will not exceed 20 percent of the total budget) and (c) A bank loan (according to present arrangements, this will be 4-5 times more than the project contribution).

Figure 5.12 GRANT/LOAN DISBURSEMENT - A HYPOTHETICAL CASE SCOR PROJECT

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RUG pays 18% on    120,000   =    21,600
        20.5% on 480,000     =    98,400
                                  ------
              Total          =   120,000
RUG receives interest 15%    =    22,500
Net interest payment = (120,000-22,500) = 97,500
Interest              = 16.25%
                        ======
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Based on SCOR experience, the main features of the sub-watershed production-protection plan or the "mini-project" that illustrate the elements of the proposed strategy are:

(a) The action plan covers the entire geographic area of the sub-watershed

(b) It recognizes the function of each major segment of land use in the landscape, in the watershed context.

(c) It recognizes the need for resource use change in each of these land segments for improving the livelihoods of all the people. Example: It involves all the families in the villages in sharing the effort to change the present land use to a high-income and resource-conserving land use.

(d) It has identified major zones for production, facilitating production planning and scheduling so that production activity can be organized enabling the organization to predict production, enter forward agreements, mobilize resources and exercise joint control over production, processing and marketing process with the membership.

(e) It has a path for new technology to flow into the community to improve and balance protection and production. Example: For the first time the MM (Maha Meegaswewa) in SCOR villagers were exposed to new knowledge from the SCOR teams on conservation farming. They shifted *chena* (shifting cultivation) farming from the catchment of their tank to a highland area and established organic bunds followed by earth bunds on contours with protective and productive plants and crops for a stabilized farming system that ensures a family food supply with maize, pulses and vegetables. In addition, valuable timber trees planted on boundaries provide security for the future. They tried mulch farming using straw in the rice fields raising a crop in *yala* season for the first time in their village.

(f) It facilitates balanced disposal of economic activity in the village providing work opportunities to everyone. Example: The families have the opportunity to choose the economic activity based on the comparative advantages they have, stemming from the economic assets, including labor, skills that each family possesses, and family confidence in a particular activity such as rice farming, vegetable farming, livestock farming, trading, etc., or confidence (risk taking) in new ventures.

(g) It facilitates organization and leadership, provides mechanisms of self-assessment and conflict resolution, increases the ability to analyze and predict, strengthens the bargaining capacity, and encourages risk taking in viable economic ventures.

A leadership will emerge from the community with volunteer catalysts representing each production zone in the village, which is the correct basis for selecting mobilizers without considerations of party politics. For example, these volunteers and farmer leaders in the Maha Meegaswewa Settlement can catalyze development, harmony and contentment. They have access to information from outside and knowledge gained from their own experiments in their own farms with the support of the government officers and others who extend such support to them. They can mobilize resources to carry out their plans

and finally become shareholders of their own company with control over the production process, which is the only way for small farmers to gain and share prosperity equally among themselves.

(h) It produces credit worthiness for the resources users so that they can mobilize capital for their economic ventures from sources of credit. The accessibility they have to sources of expert knowledge and information, extension, local administration, sources of funds, and markets through forward contracts and shares of business ventures increase the credit rating of each individual resources user family. Each of these factors can be considered in assessing the credit worthiness of the farm family, the recognition of which would further help resources users to increase their rating in each factor.

(I) It guides the identification of complementary economic and social infrastructure (health, education, transport, energy), the provision of which has legitimacy based on the increased productive capacity generated by the community with the production and conservation effects.

The above illustration shows how the project concepts can be translated into practice with local communities, the government functionaries at sub-divisional, divisional, provincial and national level, NGOs and the private sector. There are many such locations where this model is being used, in the two SCOR pilot watersheds in the dry zone and the wet zone.

5.4 MANAGEMENT INFORMATION SYSTEM, MONITORING AND EVALUATION, AND SPECIAL STUDIES

A continuous flow of information is required to enrich the participatory process facilitating interaction, debate and resolution. The prudent use of information technology (IT) in the generation, process and analysis of information needed is crucial to support the planning, implementation and evaluation processes. For this, the project will use a Management Information System (MIS) and a rigorous monitoring and evaluation (M&E) activity through a participatory procedure involving user groups, government and other project participants. It reviews the progress and employs a feedback/correcting mechanism to ensure that project inputs, work schedules, targeted outputs and other related actions are proceeding according to plan. This mechanism also provides data for continuous and periodic evaluations to determine systematically and objectively the relevance, efficiencies, effectiveness (and impact) of project activities.

MIS and M&E of the project will monitor and evaluate *project activities* or inputs as well as the *achievement of specific objectives of the project*. These two are related to each other and will eventually lead to *project's impacts*. The proposed system is similar to the SCOR MIS and M&E system.

Figure 5.13 lists the basic data requirements to gain knowledge on the watershed and **Figure 5.14** illustrates the Management Information Systems and the Operation of the Monitoring and Evaluation System of SCOR.

Figure 5.13 **INDICATORS FOR MONITORING AND EVALUATION SCOR PROJECT**

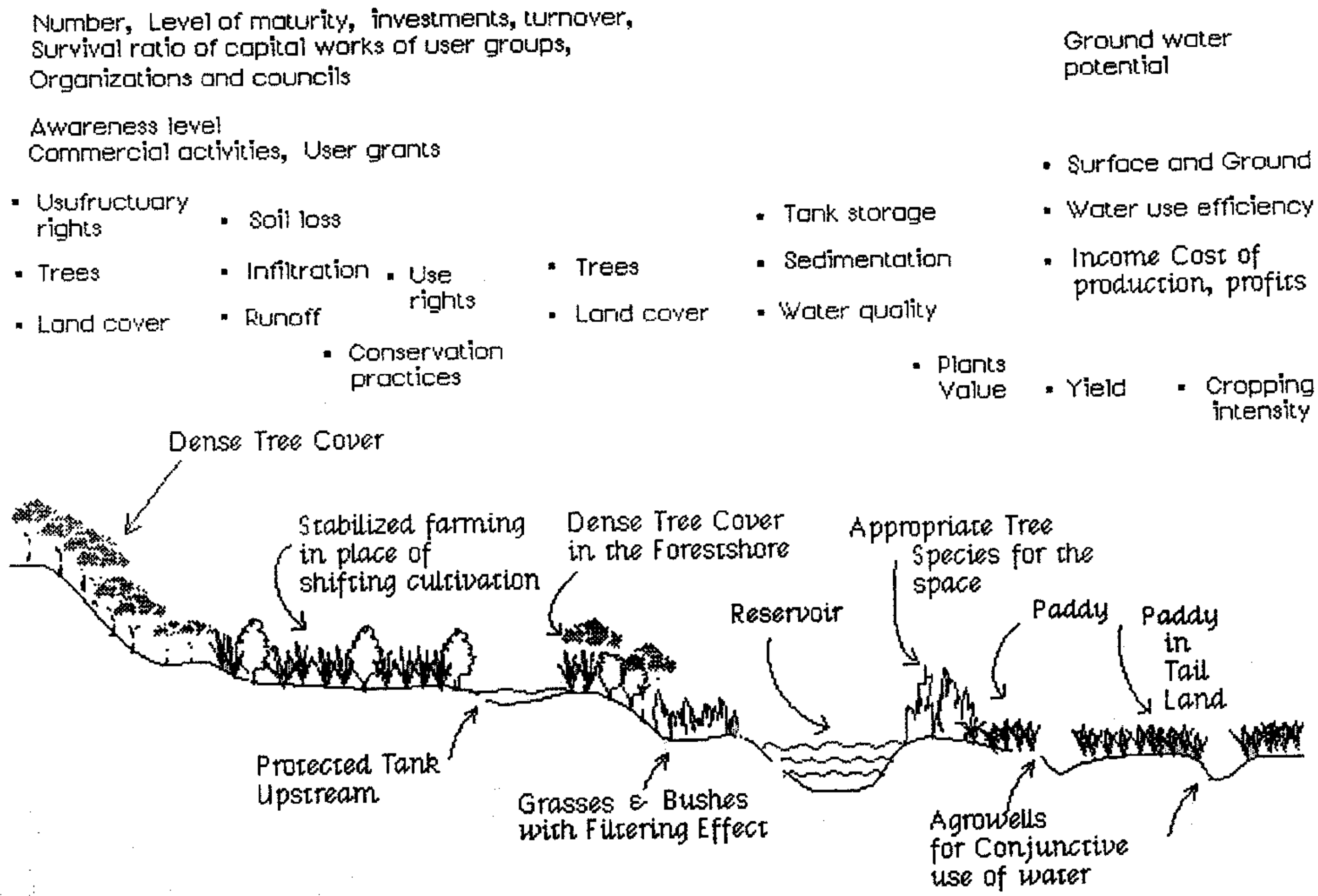
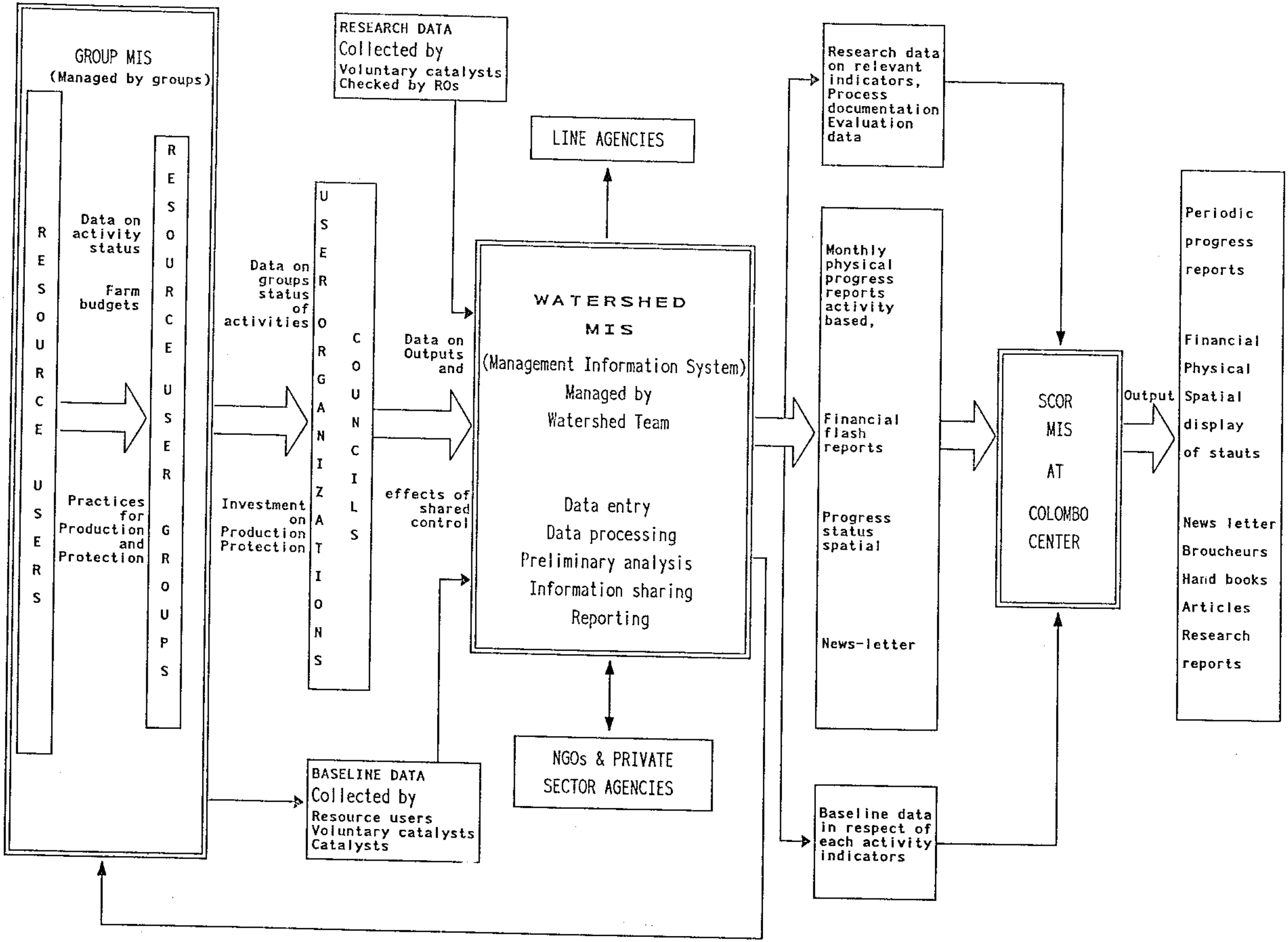


Figure 5.14 OPERATION OF M&E SYSTEM OF SCOR PROJECT



It is proposed to integrate M&E and special studies. As much as possible, a common data collection program and a database will be used to compute M&E indicators as well as the indicators used for special research studies and indepth analyses.

Data for establishing "benchmark" and follow-up M&E will come from three sources:

a) Data base maintained by farmer/user groups using simple indicators - **Self M&E:-** This can be expected only after organizing user groups and at the intervention phase. For example, a minimum set of indicators would include:
- no. of current members of the group;
- quantity/extent of new production/conservation activities undertaken during the month/quarter such as:
- contour bunds covered as a % of recommended coverage.
- group tree planting, group nursery established; etc.
- no. of interactions had with government officers on project activities;
- no. of members received training; officers/farmers
- no. of meetings held;
- no. of conflicts recorded and mode of resolution;
- group investments (cumulative) by activity;
- change of (legal) status of the group.

b) Data collected by educated volunteers employed by IIMI/universities or other research institutes e.g.: students in the community, teachers, others:- Such data/indicators may include:

- farm inputs: labor, agro-chemicals, seed, power (as & when necessary);
- crop yields, profitability and productivity;
- water flow measurements, water use efficiency, water productivity;
- salient features of meetings;

c) Data collected by agency officials or specially employed Research Assistants:- Data/indicators covered by this group would include:

  a) in the catchments: - rainfall, run-off, soil moisture, soil fertility, soil loss/sediment transportation, moisture retaining capacity and infiltration, trees/plants by type, investments, water quality;

  b) in the irrigated command: - extents irrigated, adequacy of supply, reliability of supply, equity in supply, agency/user participation in O&M, adequacy of maintenance activities, user-agency conflicts;

  c) in both areas: - crop yields through crop cuts, incomes, tree/crop density, re-use patterns of water, user interactions between watershed and command areas.

Outputs:

Major outputs of M&E and Research studies will be the assessment of SCOR Project based on specific indicators. Major indicators are listed below :

- Targeted hectares under improved production and conservation techniques

- Value of targeted investment by the resource users in environmentally sound production practices

- Government policy decisions initiated

- Targeted land area covered by new agreements between GSL and user groups (Extent now under conservation and production practices expecting user rights)

- Farm households using improved environmental techniques

- Number of Natural Resource Groups Operating

  - total production and value added
  - farmer/user acceptance and participation
  - Technology adoption
  - User-agency relations
  - extents irrigated, extents cultivated in high lands
  - Erosion coefficients
  - vegetative cover by type of vegetation
  - soil and water conservation improvements
  - rainfall: run-off ratio
  - cropping intensity improvements
  - water use efficiency (macro/watershed and micro)
  - water productivity
  - land productivity
  - income/investment levels by users
  - equity
  - profitability

Research and Special Studies

The project is designed to innovate novel approaches to watershed management through participatory methods. Hence, proper documentation, dissemination of information and sharing of international experiences should be planned for. The International Irrigation Management Institute, IIMI may undertake the M&E and Research Component of the project. Allocation for special study/research contracts in the proposed budget will be utilized to study specific aspects related to watershed management. Universities/other research institutions will also be contracted for this purpose. The topics research include: watershed-wide land & water use efficiency, Watershed water balance, integrated water management, competing users and uses, shared control and organizational development in watersheds, impact on environment, social conflicts, and agri-

business, etc. **It is proposed to allocate about US$500,000 per year, for seven years, for this purpose. This is included in B:C analysis as Monitoring and Evaluation (contract research/training/technical expertise).**

Progress & other special reports will include the following:

1) Periodic progress reports/seasonal reports (including for phase I)

2) Integrated workplans for a 5-year implementation programme.

   * Annual reports assessing the progress and problems encountered with the formation and operation of resource user groups;

   * Special reports on impacts and problems encountered with implementation and operation of various interventions designed to promote shared control of resources or increased of tenure to the resource user;

3) Research papers/Analytical Reports to strengthen project activities

4) Special studies

   A key factor hindering the cascade/watershed based area development is the absence of a comprehensive understanding and database related to small tanks and tank cascades. For example, a conclusive inventory of small tanks for the NCP as well as the entire country is not available. Also, the present hydrometereological data collection network is not adequate to monitor the water balance of river basins and cascades and hydrological parameters. In respect of ground water, much data have yet to be collected to evaluate the hydrogeological parameters and ground water re-charge and potential of the cascades and river basins. Research studies are needed to evaluate run-off/rainfall relationships of individual small, medium and major tank watersheds and cascades to facilitate more rational and realistic planning and designing of land and water development interventions as well as for continuous monitoring in the future. Detailed surface water and ground water balance studies are required to substantiate the present data base of the NCP.

   The study initiated the preparation of a small tank inventory for the NCP during the short study period. It was possible to compile much physical, hydrological and social data for almost all the small tanks of the NCP. It was possible to identify the locations of the small tanks in relation to the Divisional Secretary's Divisions, cascades and river basins and whether the tanks were rehabilitated during the last fifteen years. The inventory of small tanks is presented in the Annexures. It is proposed that this exercise be continued as a special study under the GOSL/ADB project.

   A simulation model was developed to test and validate the farmers' proposals for water resources development within a cascade in terms of hydrological feasibility. The model, with necessary input data, can simulate the effect and impact of upstream interventions on water availability at each and every small tank within a cascade. The model can be run to simulate the aggregated hydrological impact of interventions carried out in a

number of cascades within a sub-basin. However, it needs further improvement. Features of this model and its utility and sample outcomes is presented in the report.

The detailed cost estimates for the establishment of the hydrometric data collection network and ground water studies are given in the Annexures 2.1 and 2.2 respectively. Funds could be granted to the Irrigation Department and the Water Resources Board for the hydrometric data collection and ground water studies respectively.

CHAPTER 6

PROPOSALS FOR REHABILITATION AND IMPROVEMENTS TO MAJOR AND MEDIUM IRRIGATION PROJECTS OF THE NCP

6.1 Prelude

The purpose of this chapter is to present proposals for the rehabilitation of medium and major irrigation schemes in Anuradhapura and Polonnaruwa districts of the NCP. **Chapters 4** and **5** of this report presented the strategy, methodology and guidelines for the proposed area developed approach, supported by sample economic evaluations to justify the proposed strategy.

The strategy proposed in **Chapters 4 and 5** for area development in the NCP is based on a farming system approach in which a package of interventions for increasing sustainable production in the command area, chena cultivated areas, abandoned chena areas, home gardens, and stream and canal reservations of the NCP is included. The strategy also proposed to select hydrologically endowed cascades for the implementation of the area development activities of the project following the guidelines in **Chapter 4**, with the package of interventions proposed in **Chapter 5**.

However, it appears that the proposed area development project needs special focus on the requirements of people living in and around some of the medium and major irrigation settlement schemes of Anuradhapura and Polonnaruwa districts of the NCP.

Although, some medium tanks which need early attention may fall within the cascades that would be undertaken by the project for area development, there may be some medium tanks which may not fall within the selected cascades, but will require priority attention of the project. Similarly, some priority item of rehabilitation and improvements work in respect of the major irrigation schemes of the NCP need to be undertaken by the project. These items of work have to be undertaken separately in addition to the project investments for the selected 20 cascades. This chapter provides budget proposals for these special item of work that have to be included in the project proposals.

However, it is to be noted that the suggested cascades and farming system approach is applicable to major and medium tanks as well. It is not only applicable to minor cascades in the Anuradhapura District but also in those areas in both district where the major systems are interspersed with medium and minor tanks.

6.2 General Setting of medium and major irrigation schemes

The Irrigation Department classifies the irrigation projects as "minor", "medium" and "major" on the basis of the designed command areas served by the projects as follows:

Category	Designed Command Area (A)
Minor	A < 80 ha
Medium	80 ha < A < 810 ha
Major	A > 810 ha

The rehabilitation aspects of minor (small) tanks have been intensively addressed by this report. This section addresses the rehabilitation of medium and major irrigation projects of the NCP including Anuradhapura and Polonnaruwa districts.

Some medium and major irrigation projects of the NCP are supplemented with both water supplies from the Mahaweli power and irrigation complex. **Figure 6.1** shows a line diagram indicating the hydrological linkages between the Mahaweli complex and the major and medium irrigation projects of the NCP (and outside the NCP) receiving Mahaweli water.

The management of medium and major irrigation projects in the NCP are shared by two agencies. The Mahaweli Authority of Sri Lanka (MASL), through Mahaweli Economic Agency (MEA) manages about 51,000 ha of irrigated farm lands. MASL manages System H, Bakamuna Block of system B (previously called system G) and about 20,000 ha out of the 28,000 ha of the left bank of System B under the command of Maduru Oya. A map showing the location of System H and B is in shown in **Figure 6.2**. Layout diagrams of Mahaweli System H and B are shown in **Figures 6.3** and **6.4** respectively. The command area of Mahaweli System falling within the NCP are as follows:

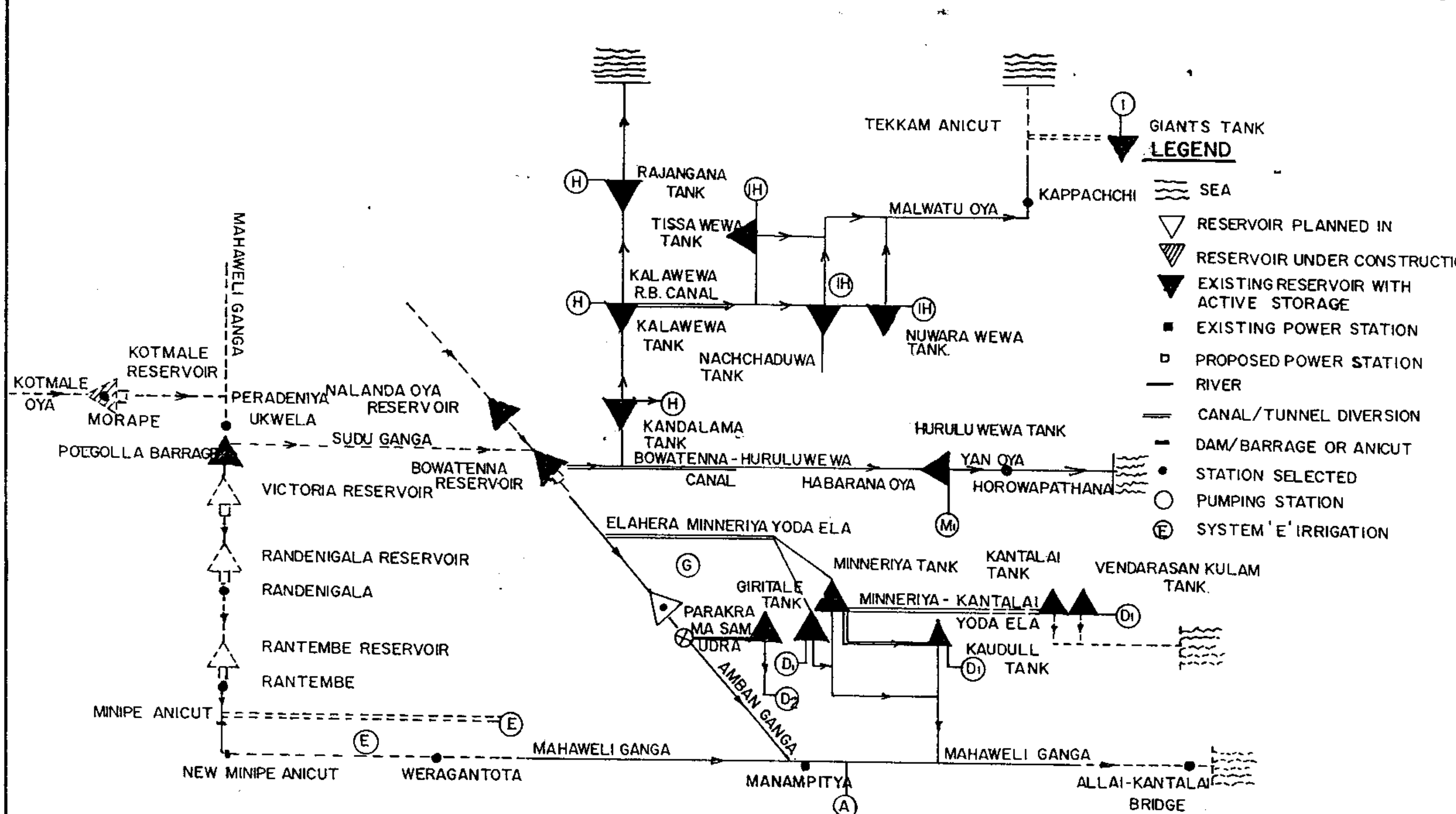
Bakamuna Block in system B (earlier System G)	-	5,000 ha
System B (part)	-	20,000 ha
System H	-	26,000 ha

In addition, a total command area of 25,030 ha of lands under major irrigation schemes including feeder canals and a total area of 9360 ha are irrigated under medium tanks, which come under the administration of the Irrigation Department.

It is estimated that there are about 2600 minor irrigation schemes in the NCP. There are 82 medium irrigation schemes in the NCP, out of which 77 schemes lie within Anuradhapura district and 5 in Polonnaruwa district. A list of medium tanks in the NCP is given in **Table 6.1** and the location map of the medium tanks are shown in **Figure 6.5**. It is observed that in the recent past, almost all major irrigation schemes except Wahalkada scheme and a fair number of small irrigation schemes have been undertaken for rehabilitation and improvements under a

Figure 6.1

SCHEMATIC LAYOUT SHOWING AUGMENTATION OF THE NCP BY MAHAWELI COMPLEX



SOURCE - HYDROLOGICAL CRASH PROGRAMME
MAHAWELI DEVELOPMENT PROJECT – 1982 NEDECO

NOTE :-
NCP BOUNDARY SHOWN THUS ——

Figure 6.2

LOCATION MAP OF MAHAWELI IRRIGATION SETTLEMENT SCHEMES

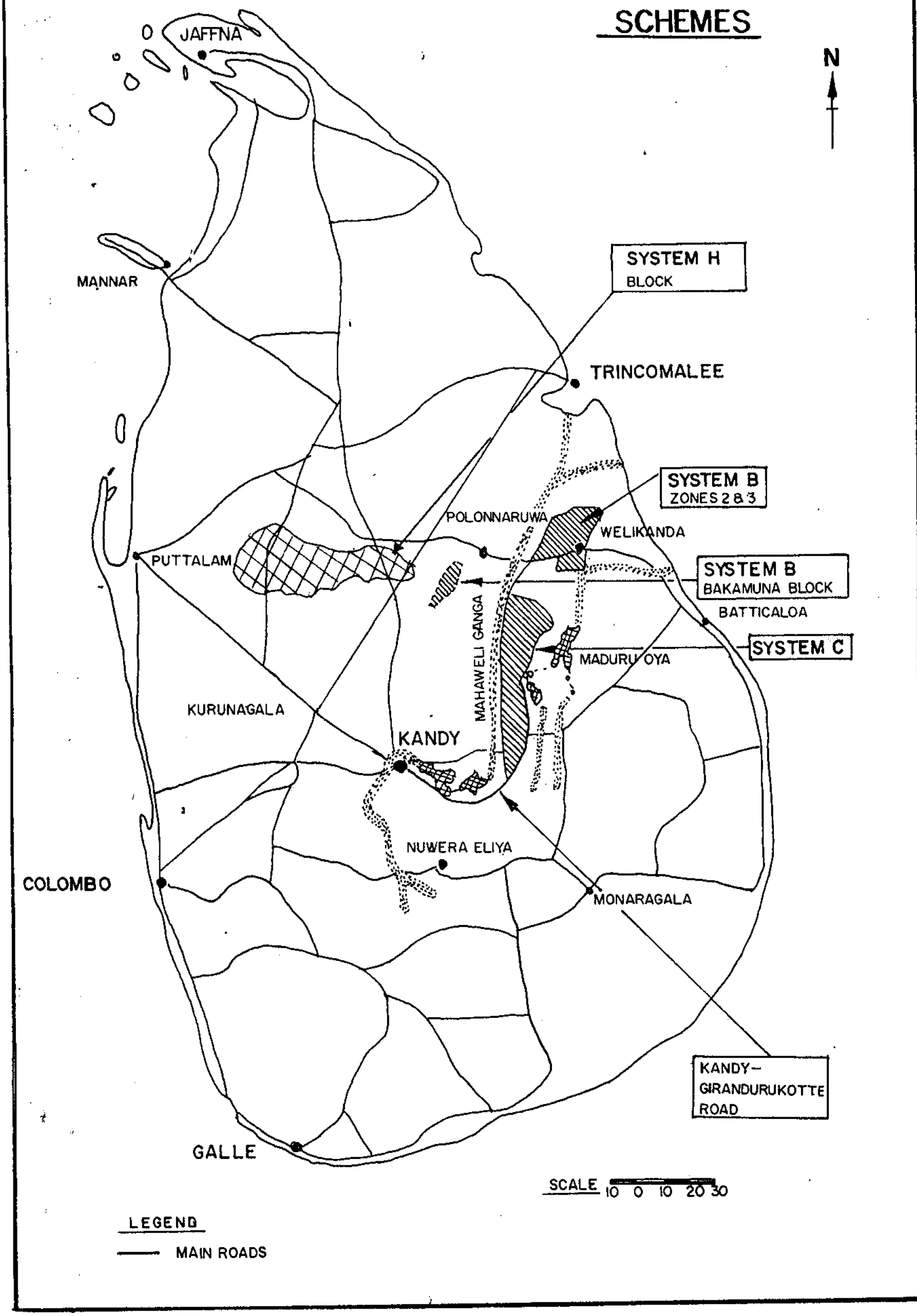
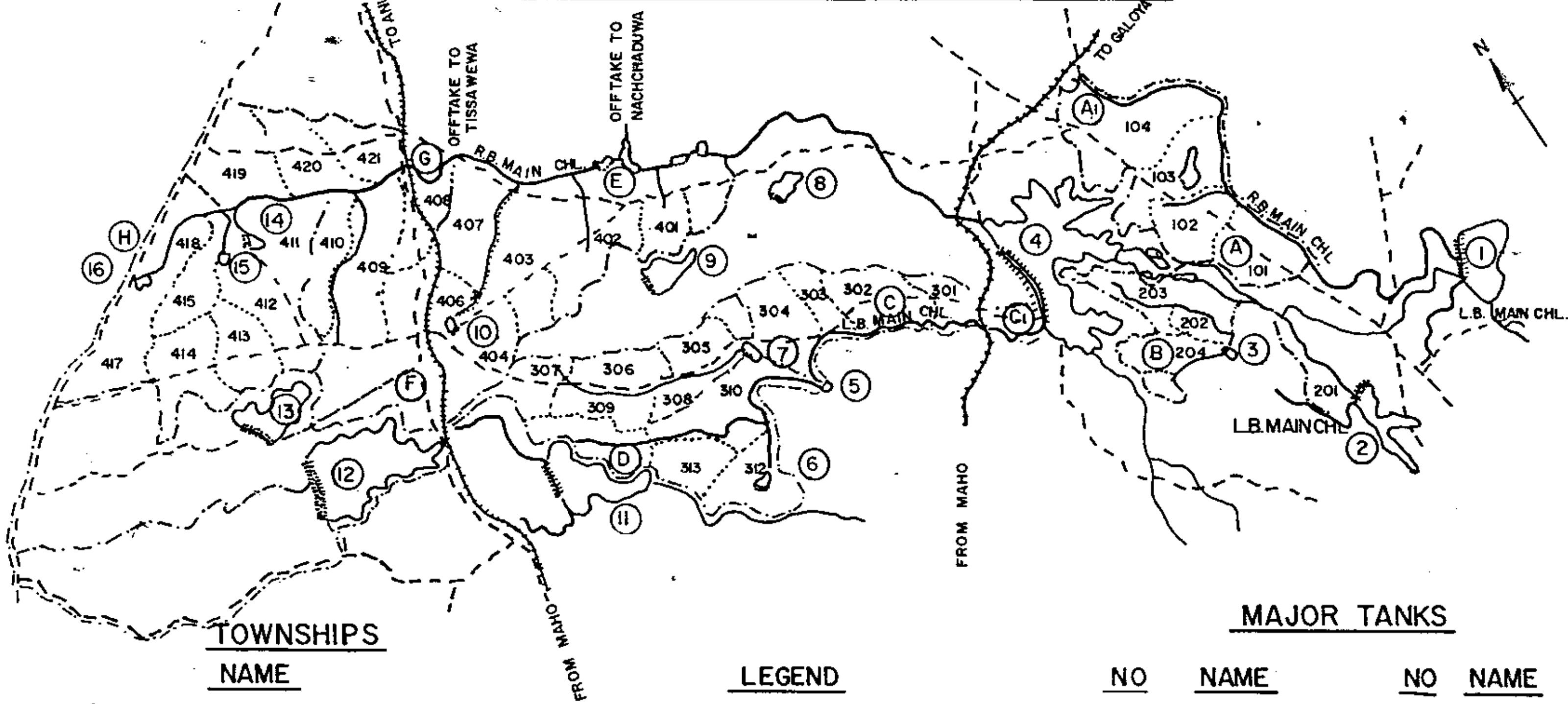


Figure 6.3

LAYOUT OF MAHAWELI SYSTEM 'H'



TOWNSHIPS

	NAME		
A	MADATUGAMA	A1	KEKIRAWA
B	GALAKIRIYAGAMA		
C	GALNEWA	C1	AVUKANA
D	MEEGALEWA		
E	EPPAWALA		
F	TAMBUTTEGAMA		
G	TALAWA		
H	NOCHCHIYAGAMA		

LEGEND

- MAIN CANAL
- BRANCH CANAL
- MAIN ROADS
- BLOCK BOUNDARY
- SUB SYSTEM BOUNDARY
- TANKS
- RAILWAY LINE

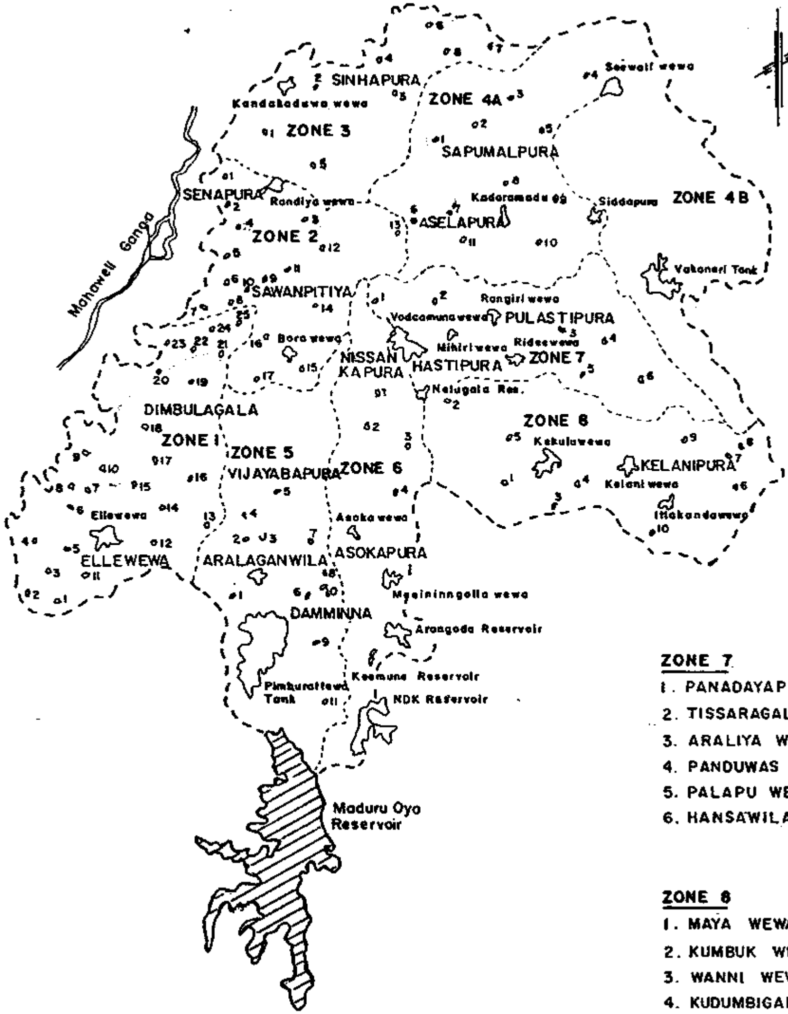
SCALE 5 0 5 10Km

MAJOR TANKS

NO	NAME	NO	NAME
✓ 1.	KANDALAGAMA	9	KATTIYAWA
2.	DAMBULU OYA	10	NALLACHIYA
3	RANAWA	11	USGALA SIYAMBALANGAMU-wa
✓ 4	KALA WEWA	✓ 12	RAJANGANA
5	MULANNATUWA	13	ANGAMUWA
6	MAHAKATNORUWA	14	PAHAMUNEGAMA
7	IHALA KOLLANKUTTIYA	15	DOMBAWALAGAMA
8	MAHA ILUPPALLAMA	16	HALMILLA KULAMA

Figure 6.4 MAJOR & MINOR TANKS

SYSTEM - B



ZONE 7
1. PANADAYAPE KUDA WEWA
2. TISSARAGALA WEWA
3. ARALIYA WEWA
4. PANDUWAS WEWA
5. PALAPU WEWA
6. HANSAWILA WEWA

ZONE 8
1. MAYA WEWA
2. KUMBUK WEWA
3. WANNI WEWA
4. KUDUMBIGALA WEWA
5. AMBAWINNA WEWA
6. NAMAL WEWA
7. KAPURU WEWA
8. MALIGA WEWA
9. NUGA WEWA
10. DAMBA WEWA

ZONE 1
1. BANDANA WEWA
2. TISSAWEWA
3. DAHAM WEWA
4. KALUKELE WEWA
5 ELAPOLLAKADA WEWA
6 MAGULDAMANA WEWA
7. BANDARA WEWA
8. LANKA WEWA
9. PELATIYA WEWA
10. PUNCHI WEWA
11. IHALAELLE WEWA
12. JAYANTHI WEWA
13. MAHADIL WEWA
14. EKSATH WEWA
15. MENIK WEWA
16. BOGAHA WEWA
17. VAJIRA WEWA
18 IDDEPICHCHA WEWA
19. DALUKANA WEWA
20. KASYAPA WEWA
21. MAHA WEWA
22. KUDA WEWA
23. MANAMPITIYA WEWA
24. AMBULANA WEWA
25. KALUDIYA WEWA

ZONE 2
1. KATUWANWILA WEWA
2. SENAPURA WEWA
3. ATHUGALA WEWA
4. MUTHUGALA WEWA
5. KARAPOLA WEWA
6. RUKGAHA WEWA
7. SAWANPITIYA WEWA
8. MALLINDA WEWA
9. MADURANGALA WEWA
10. SUSIRAGAMA TANK
11. RUHUNUKETHAWEWA
12. SINGANA WEWA
14. SADAMBU WEWA

ZONE 3
1. KUDAPOKUNU WEWA
2. SINHAPURA- WEWA
3. MUTHUWELLA WEWA
4. SURIYA WEWA
5. MAHAWELITENNA WEWA
6. RUWANKETHA WEWA
7. MALWENNA WEWA
8. RANDENIWELA WEWA

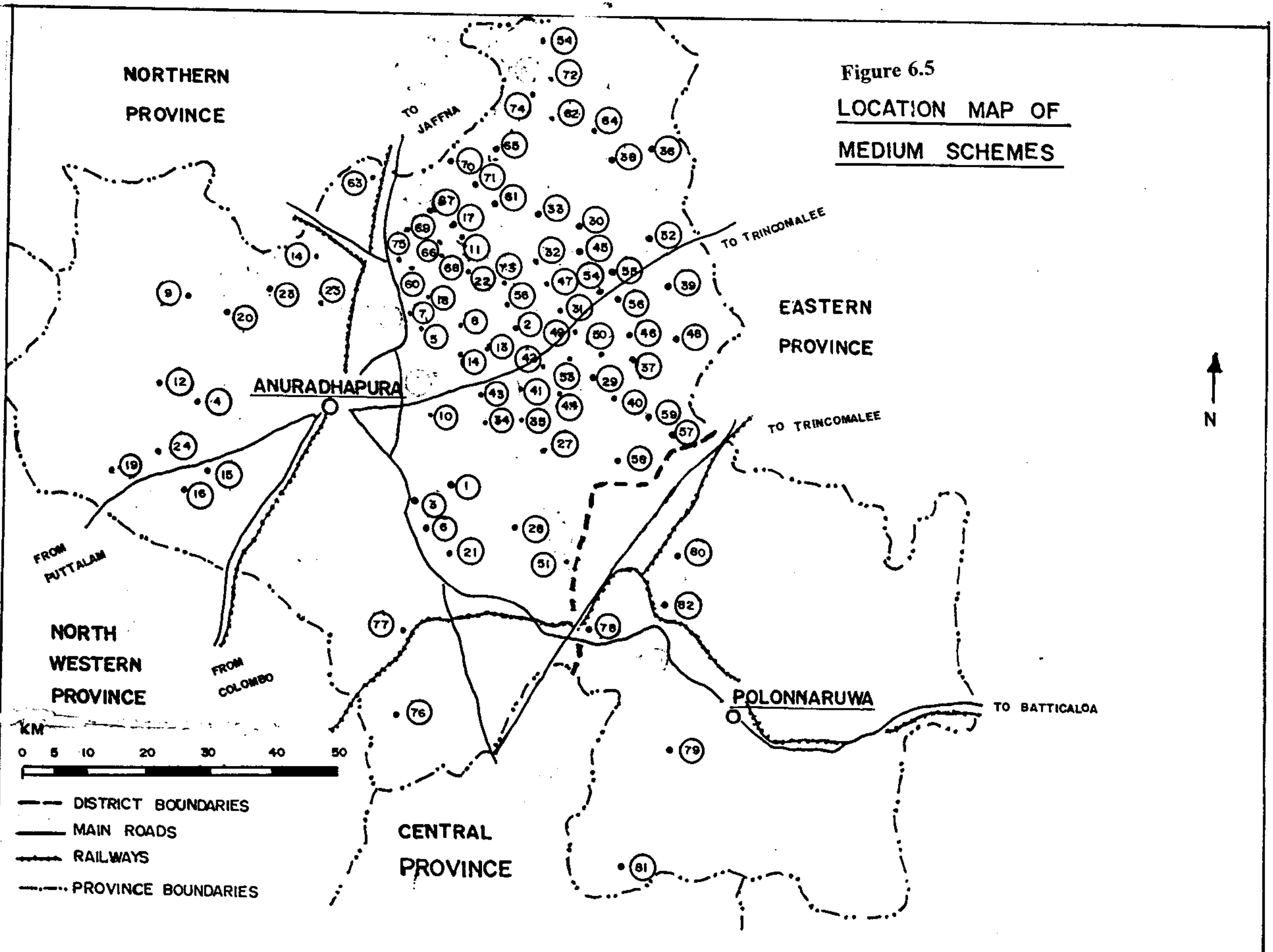
ZONE-4A
1. MAITHREE WEWA
2. MAHASEN WEWA
3. BADDE WEWA
4. SAPUMAL WEWA
5. MIGAHA WEWA
6. SIYABALAGAS WEWA
7. ASEL WEWA
8. NAGAS WEWA
9. RANAPOKUNA WEWA
10. RIDEE WEWA
11. RUWAN WEWA

ZONE 5
1. ALUT WEWA
2. MANGALA WEWA
3. IKHAN WEWA
4. BAMUNUKOTUWA WEWA
5. IGURU WEWA
6. NARAN WEWA
7. DIVULDAMANA WEWA
8. NIDANWELA
9. DAMMANA WEWA
10. IHALA WEWA
11. KANDULA WEWA

ZONE 6
1. MEERANDA WEWA
2. NISSANKA WEWA
3. WEERA WEWA
4. MADURUDENIYA

Figure 6.5

LOCATION MAP OF MEDIUM SCHEMES



Medium Tanks

Anuradhapura District

Table 6.1

	Scheme	Co-ordinate	IE Division	DS Division	Irrigable Extent Ha	Estimated Cost Rs. '000
1	Labunoruwa	F/15(6.32 * 4.77)	Anuradhapura	Thirappane	258	25,800.00
2	Kallanchiya Wewa	F/5(4.8 * 6.75)	Anuradhapura	Rambewa	243	24,300.00
3	Maminiyawa Tank	F/15(6.25 * 0.85)	Anuradhapura	Thirappane	202	20,200.00
4	Mahalindawewa	F/3(9.60 *1.55)	Anuradhapura	Nochchiyagama	172	17,200.00
5	Kadahathawewa	C/25(1.25 * 0.55)	Anuradhapura	Rambewa	170	17,000.00
6	Mahamankadawela Wewa	F/20(7.57 * 7.65)	Anuradhapura	Thirappane	170	17,000.00
7	Thalagahawewa	C/25(2.8 * 0.15)	Anuradhapura	Rambewa	142	14,200.00
8	Mankadawela wewa	F/4(8.75 * 3.16)	Anuradhapura	Mahawillachchiya	140	14,000.00
9	Mahamankadawala wewa	F/3(11.76 * 1.38)	Anuradhapura	Mihintale	140	14,000.00
10	Weruppankulama	F/10(4.70 * 8.40)	Anuradhapura	Mihintale	130	13,000.00
11	Pihimbiyagollewa wewa	C/25(6.90 *3.45)	Anuradhapura	Medawachchiya	129	12,900.00
12	Ambagaha wewa	F/8(5.50 * 7.20)	Anuradhapura	Nochchiyagama	121	12,100.00
13	Kappirikgama wewa	F/5(6.60 * 7.00)	Anuradhapura	Rambewa	113	11,300.00
14	Kadurugasdamana wewa	F/4(8.55 * 7.85)	Anuradhapura	Nochchiyagama	107	10,700.00
15	Mahabulankulama Anicut	F/8(12.7 * 5.0)	Anuradhapura	Rambewa	103	10,300.00
16	Ralapanawa wewa	F/8(8.90 * 4.95)	Anuradhapura	Nochchiyagama	101	10,100.00
17	Kokatiyawagollewa wewa	C/25(7.25 * 4.45)	Anuradhapura	Medawachchiya	95	9,500.00
18	Kandewa wewa	C/25(6.00 * 0.01)	Anuradhapura	Medawachchiya	106	10,600.00
19	Mahabulankulama	F/9(2.25 * 6.50)	Anuradhapura	Nochchiyagama	89	8,900.00
20	Maningamuwa wewa	F/3(11.5 * 5.50)	Anuradhapura	Mahawilachchiya	85	8,500.00
21	Uttimaduwa wewa	F/10(2.75 * 1.85)	Anuradhapura	Tiramppane	85	8,500.00
22	Thambalagollewa tannk	C/25(8.90 * 2.35)	Anuradhapura	Medawachchiya	85	8,500.00
23	Kawarakkulama	F/9(11.00 * 4.85)	Anuradhapura	Nuwaragampalatha	85	8,500.00
24	Mahahoruwila wewa	F/8(2.15 * 3.75)	Anuradhapura	Nochchiyagama	81	8,100.00
25	Tannayankulama	F/4(8.35 * 1.20)	Anuradhapura	Nuwaragampalatha	81	8,100.00

Medium Tanks
Anuradhapura District

Table 6.1 contd..

	Scheme	Co-ordinnate	IE division	DS Division	Irrigable Extent Ha.	Estimated Cost Rs. '000
26	Periyakulama	F/15(1.60 * 4.45)	Anuradhapura	Thirappane	81	8,100.00
27	Ilukwewa Anicut	G/6(1.30 * 7.80)	Hurulu wewa	Galenbinduna wewa	347	34,700.00
28	Holwila wewa	F/20(10.05 * 5.40)	Hurulu wewa	Palugas wewa	209	20,900.00
29	Kanhinda wewa	G/1(6.05 * 7.10)	Hurulu wewa	Horowpothana	194	19,400.00
30	Welimuwapothana wewa	D/21(4.42 * 7.60)	Hurulu wewa	Horowpothana	191	19,100.00
31	Kuda Pattiya Diul wewa	D/21(0.70 * 1.50)	Hurulu wewa	Kahatagasdigiliya	187	18,700.00
32	Rasnakawewa	D/21(0.80 * 5.50)	Hurulu wewa	Horowpothana	182	18,200.00
33	Sinhala Walahavidda wewa	D/25(13.4 * 4.0)	Hurulu wewa	Horowpothana	168	16,800.00
34	Maha Halmillewa wewa	G/1(2.10 * 7.40)	Hurulu wewa	Kahatagasdigiliya	154	15,400.00
35	Kanadara Ratmale wawa	F/5(8.90 * 0.20)	Hurulu wewa	Kahatagasdigiliya	153	15,300.00
36	Wagollekada wewa	D/16(11.2 * 4.8)	Hurulu wewa	Horowpothana	146	14,600.00
37	Parangiyawadiya wewa	D/21(10.7 * 0.60)	Hurulu wewa	Horowpothana	142	14,200.00
38	Kapugollewa wewa	D/16(8.0 * 3.65)	Hurulu wewa	Horowpothana	142	14,200.00
39	Wadiga wewa	D/21(4.20 * 1.1)	Hurulu wewa	Horowpothana	101	10,100.00
40	Dekethipothna wawa	G/1(5.30 * 3.50)	Hurulu wewa	Horowpothana	130	13,000.00
41	Ella wewa	C/5(9.1 * 2.15)	Hurulu wewa	Kahatagasdigiliya	109	10,900.00
42	Pandarallawa wewa	G/1(3.25 * 2.30)	Hurulu wewa	Kahatagasdigiliya	109	10,900.00
43	Ranpathwila wewa	F/58.35 * 5.30)	Hurulu wewa	Kahatagasdigiliya	105	10,500.00
44	Maha wewalkada wewa		Hurulu wewa	Kahatagasdigiliya	101	10,100.00
45	Tavalan Halmillewa wewa	D/16(4.96 * 2.00)	Hurulu wewa	Horowpothana	101	10,100.00
46	Muslim Walahavidda wewa	G/1(9.80 * 5.80)	Hurulu wewa	Horowpothana	92	9,200.00
47	Kalpewewa	D/21(3.20 * 1.75)	Hurulu wewa	Horowpothana	92	9,200.00
48	Maradanmuduwe wewa	D/16(9.35 * 4.90)	Hurulu wewa	Horowpothana	89	8,900.00
49	Moragahadigiliya wewa	C/25(11.15 * 3.26)	Hurulu wewa	Kahatagasdigiliya	85	8,500.00
50	Bellannkadawala wawa	G/1(2.1 * 8.7)	Hurulu wewa	Horowpothana	85	8,500.00
51	Mahakiulekada wawa	F/20(10.7 * 2.97)	Hurulu wewa	Palugas wewa	81	8,100.00
52	Mahakiulekada wewa	D/21(5.97 * 5.85)	Hurulu wewa	Horowpothana	81	8,100.00
53	Wahagahapu wewa	G/1(4.75 * 6.9)	Hurulu wewa	Kahatagasdigiliya	81	8,100.00
54	Serune wewa Mahawewa	G/2(0.90 * 5.90)	Hurulu wewa	Horowpothana	81	8,100.00

Table 6.1 Contd..

	Scheme	C0-ordinate	IE Division	DS Division	Irrigable Extent Ha	Estimated Cos Rs. '000
55	Horowpothana wewa	D/21(7.50 * 5.10)	Hurulu wewa	Horowpothana	81	8,100.00
56	Tirappankadawala wewa	D/21(8.20 * 3.80)	Hurulu wewa	Horowpothana	81	8,100.00
57	Iratiyawa wewa	G/1(13.1 * 3.95)	Hurulu wewa	Horowpothana	81	8,100.00
58	Panvella wewa	G/1(3.3.60 * 2.80)	Hurulu wewa	Kahatagasdigiliya	81	8,100.00
59	Demata wwa	G/1(9.40 * 3.15)	Hurulu wewa	Horowpothana	81	8,100.00
60	Sangilikandarawa wewa	C/25(0.35 * 2.50)	Padaviya	Medawachchiya	206	20,600.00
61	Ellawewa Anicut	C/25(13.15 * 8.40)	Padaviya	Kebithigollewa	162	16,200.00
62	Marakkala Etaweera we	D/16(3.48 * 5.16)	Padaviya	Kebithigollewa	162	16,200.00
63	Kidawarankulama	C/19(9.10 * 2.25)	Padaviya	Medawachchiya	151	15,100.00
64	Bandara Ulpotha wewa	D/16(2.15 * 2.51)	Padaviya	Kebithigollewa	133	13,300.00
65	Hendagamawewa	C/20(9.80 * 0.30)	Padaviya	Kebithigollewa	108	10,800.00
66	Kirigollewa wewa	C/25(3.75 * 3.80)	Padaviya	Medawachchiya	108	10,800.00
67	Ethakada Maha wewa	C/20(3.40 * 8.35)	Padaviya	Medawachchiya	105	10,500.00
68	Muwaetagama wewa	C/25(4.10 * 2.85)	Padaviya	Medawachchiya	104	10,400.00
69	Mahadiul wewa	C/24(13.40 * 6.90)	Padaviya	Medawachchiya	101	10,100.00
70	Kebithigollewa wewa	C/20(9.9 * 2.0)	Padaviya	Kebithigollewa	100	10,000.00
71	Gonuhathdena wewa	C/25(13.4 * 6.91)	Padaviya	Kebithigollewa	94	9,400.00
72	Alyatige wewa	C/20(10.10 * 1.90)	Padaviya	Kebithigollewa	92	9,200.00
73	Wattawewa	C/24(11.9 * 5.35)	Padaviya	Kebithigollewa	84	8,400.00
74	Tittagonewa wewa	D/16(2.20 * 6.25)	Padaviya	Kebithigollewa	81	8,100.00
75	Medawachchiya wewa	C/24(12.0 * 3.0)	Padaviya	Medawachchiya	81	8,100.00
76	Kirindiwatta wewa	F/20(10.7 * 2.5)	Rajangana	Palagala	188	18,800.00
77	Manewa wewa	F/14(13.4 * 1.4)	Rajangana	Ipalogama	81	8,100.00

number of donor funded irrigation rehabilitation projects (ex. VIRP, ADZAP, FFHC, NIRP, TIMP, MIRP and ISMP - see chapter 3 for details). Even at present, a number of small irrigation schemes as well as four medium tanks are being rehabilitated under the NIRP. Also, some completion work are being undertaken under the ISMP in respect of PSS, Kaudulla, Minneriya and Giritale schemes. Twelve minor irrigation schemes in Polonnaruwa district are being improved and rehabilitated under a special programme.

A strategy for rehabilitating and developing water resources within cascades in the NCP has been suggested earlier in this report. Discussions were held with the senior officials of the Irrigation Department, Mahaweli Authority of Sri Lanka and the Provincial Irrigation Department to obtain their proposals and suggestions in respect of the water resources development and rehabilitation of the NCP. The general consensus among the field and headquarters based key staff is that, although minor irrigation schemes may be undertaken for specific rehabilitation and improvements considering cascades and sub-basins as operational unit, special attention is required for the rehabilitation to major and medium irrigation schemes. Accordingly, this section provides specific proposals on priority basis for improving and rehabilitating medium and major irrigation scheme of the NCP. The items of work and the budgetary proposals proposed for the Area Development Project have been framed after having discussions with the senior officials of the Irrigation Department and Mahaweli Authority of Sri Lanka. The priorities have been decided on the basis of the recommendation of the senior officials of the two national irrigation agencies. Actual cost-benefit computations of these proposals have to be worked out before the implementation of these proposals.

6.3 Rehabilitation and Improvement Proposals for Irrigation Schemes Managed by the Irrigation Department in Anuradhapura District

Priority 1: Rehabilitation of Medium Irrigation Schemes

The priority list of medium tanks proposed for improvements and rehabilitation and the required budgetary provisions are shown in **Table 6.2**. The list includes 26 medium tanks proposed to be included in the Area Development project. It is observed that out of those 26 irrigation schemes, about 16 schemes are in disrepair needing urgent rehabilitation. The O&M responsibility for these 16 schemes were neither with the Irrigation Department nor with the Provincial Irrigation Department for some time since 1990 and as result the schemes are badly deteriorated. Although it is the policy of the government to hand over the O&M of medium schemes to established FOs, handing over to FOs, is not possible due to dilapidated canal systems. The total extent benefitted would be 3785 ha and the anticipated cost would be Rs 379 million.

Table 6.2 PRIORITY LIST - MEDIUM TANKS
Anuradhapura District

	Scheme	Co-Ordinate	Irrgable Extent Ha.	Estimated Cost Rs. '000
1	Mahamankadawalawewa	F/3(11.76x1.38)	140.00	14,000.00
2	Kuda Pattiya Diul wewa	D/21(0.70x1.50)	187.00	18,700.00
3	Horiwila wewa	F/20(10.05x5.40)	209.00	20,900.00
4	Kallanchiya wewa	F/5(4.80x6.75)	243.00	24,300.00
5	Ranpathwila wewa	F/5(8.35x5.30)	105.00	10,500.00
6	Bandara Ulpotha wewa	D/16(2.15x2.51)	133.00	13,300.00
7	Muwettegama wewa	C/25(4.10x2.85)	103.00	10,300.00
8	Maminiyawa wewa	F/15(5.25x0.85)	202.00	20,200.00
9	Horowpothana wewa	D/21(7.50x5.10)	81.00	8,100.00
10	Kirindiwatta wewa	F/20(10.7x2.50)	188.00	18,800.00
11	Kadawarankulama	C/19(9.10x2.25)	150.00	15,000.00
12	Ilukwewa Anicut	G/6(1.30x7.80)	347.00	34,700.00
13	Ralapanawa wewa	F/8(8.90x4.95)	100.00	10,000.00
14	Maningamuwa wewa	F/3(11.50x5.50)	85.00	8,500.00
15	Hendagama wewa	C/20(9.80x0.30)	108.00	10,800.00
16	Mahamankadawala wewa	F/20(7.57x7.65)	170.00	17,000.00
17	Wagollekada wewa	D/16(11.2x4.80)	146.00	14,600.00
18	Tittagona wewa	D/16(2.20x6.25)	81.00	8,100.00
19	Medawachchiya wewa	C/24(12.0x3.00)	81.00	8,100.00
20	Sangilikanadarawa	C/25(0.35x2.50)	207.00	20,700.00
21	Thambalagollewa wewa	C/25(8.90x2.35)	85.00	8,500.00
22	Thalagaha wewa	C/25(2.80x 0.15)	142.00	14,200.00
23	Welimuwapothana wewa	D/21(4.42x7.60)	192.00	19,200.00
24	Pihimbiyagollewa wewa	C/25(6.90x3.45)	129.00	12,900.00
25	Manewawa wewa	F/14(13.4x1.40)	81.00	8,100.00
26	Kandewa wewa	C/25(6.00x0.01)	94.00	9,400.00
	Total		3,789.00	378,900.00

Polonnaruwa District

	Scheme	Co-Ordinate	Irrgable Extent Ha.	Estimated Cost Rs. '000
1	Erige Oya	G/16(5.40x4.95)	85.00	8,500.00
2	Heerati Oya	J/1(4.60x6.00)	92.00	9,200.00
3	Bebiya wewa	G/12((.60x6.50)	94.00	9,400.00
4	Atharagallewa	J/1(6.80x0.70)	324.00	32,400.00
5	Pinnamankada	G/12(6.00x0.50)	243.00	24,300.00
	Total		838.00	83,800.00

Priority 2: Rehabilitation of Wahalkada scheme

As mentioned earlier in this report, Wahalkada is the only major tank irrigation scheme which did not receive any financial provisions for rehabilitation since its construction in late 1970s. Wahalkada scheme commands an area of 787 ha and was originally designed for growing rice in a 320 ha and the rest of area for growing non-rice crops even in maha season. The system was originally designed with lined field and distributery canals with partially lined main canals. At present, the irrigation scheme is badly deteriorated with low cropping intensity, poor production levels and water use efficiencies. In the lower reaches of the scheme salinity has developed due to poor drainage facilities. Most of the lined FCs do not exist on ground. Also, from the inception of the project, no basic infrastructure facilities such as hospitals, schools, etc. were not available to the settlers. As a result, the settlers undergo severe hardships in their day to day life. An Intensive rehabilitation is required to upgrade the production potential of this scheme. A proper rehabilitation of this scheme is essential to achieve the objectives of irrigation management and to ensure the safety of canal system in peak demand periods. The canal system consists of a main canal of 8.7 km in length and 8 distributary canals of 11 km in total length and 51 field canals. There are 97 drainage canals adding to a total length of 49 km. The canal system needs extensive repairs and rehabilitation in order to ensure proper water distribution and drainage. A 300 m long toe filter is necessary to ensure the safety of the earth dam of Wahalkada Reservoir. The major items of work include: improvements to spilling capacity and spill tail channel; improvements to the access road to Wahalkada tank; improvements to head works, including the toe-filter and irrigation system. The total area benefitted is 820 ha and the anticipated cost of rehabilitation is Rs 85 million.

Priority 3: Rehabilitation of Rajangana Right bank Lift irrigation scheme

Rajangana lift irrigation scheme is one of the few lift irrigation schemes operated and maintained by the Irrigation Department. Rajangana scheme was constructed in 1960-65 to irrigate 5,523 ha under gravity and 1,602 ha under lift irrigation. The irrigable area is commanded by 2 main canals both right bank and left bank. In the right bank 2971 has are irrigated by gravity and 745 ha under lift irrigation with 10 pump stations installed with 31 diesel pumps. In the left bank the gravity command area 2,552 ha and 858 ha are under lift irrigation using 14 pump stations with 40 installed diesel pumps. This part of the project has not undergone a considerable rehabilitation since its construction except for maintenance repairs and the essential structural improvements. The pumps have been handed over to the farmer organizations under O&M agreements. Some of the pumps need expensive major repairs.

The Left Bank scheme lies in the North Western Province (NWP) and is now being rehabilitated under the ADB-funded water resources development project for the North Western Province (NWP). The Right Bank scheme, which commands 724 ha, lies within the NCP and needs rehabilitation of its distributary system and replacement of four lift pumps. The project will benefit 745 ha and the anticipated cost is Rs 45 million.

Priority 4: Rehabilitation of Karambela Yoda Ela

Karambe Ela-Yoda Ela is 7.75 km long canal feeding and supplementing an irrigated command of 230 ha. The canal originates from Tisa wewa and feeds a chain of eight minor irrigation schemes en-route as follows.

Name of Scheme	Irrigated Command Area
Bulankulama	24 ha
Lologaswewa	12 ha
Katukeliyawa	4.5 ha
Perumiyankulama	30 ha
Karambewewa	30 ha
Pahala Kudawewa	8 ha
Parasangahawewa	7 ha
Galkadawala wewa	122 ha
Total	**238 ha**

The present capacity of the canal is not sufficient to feed these eight tanks and it is proposed to increase the capacity of the canal to 150 cusecs. There is no proper O&M road along the canal for the maintenance of it. It is proposed to construct an O&M road along the canal. This road will also be used as an access road by the village community. Since the construction of this canal, new villages have been established and it is proposed to construct 4 bridges across the canal for the use of these villages. The tentative cost of these works have been estimated to be Rs 10 million according to the Irrigation Department.

The proposal includes: the rehabilitation of the canal with provision of double banking and canal spills; improvement to above minor irrigation schemes; major improvement to Galkadawala tank which is the tail most irrigation scheme augmented by the canal. The area benefitted is 238 ha and the anticipated cost would be Rs 10 million.

6.4 Rehabilitation and Improvement Proposals for Irrigation Schemes Managed by the Irrigation Department in Polonnaruwa District

Priority 1: Rehabilitation of Medium Irrigation Projects

Irrigation schemes which command an area between 80 to 787 ha fall into this category. There are 5 medium irrigation schemes within Polonnaruwa range as given below. All these schemes are maintained by the Irrigation Department.

	Name of Scheme	Irrigated Command Area
1.	Attaragallewa Scheme	324 ha
2.	Heeratiya Oya Scheme	92 ha
3.	Bebiyawewa Scheme	94 ha
4.	Pinamankada Scheme	234 ha
5.	Erige Oya Scheme	85 ha
	Total:	838 ha

Attaragallewa Scheme

Attaragallewa scheme has already been rehabilitated under ISMP funded by the USAID. However, under this project only the ESI works were undertaken for rehabilitation. Although there is a possibility of extending this system in order to accommodate an additional extent of about 40 ha 39.3 ha it has not been undertaken under this project due to inadequacy of funds. Accordingly, additional rehabilitation works need to be done. The tentative cost requirement for the rehabilitation of this scheme is Rs 32.4 million benefitting 40 ha.

Pinamankada Anicut Scheme

This anicut has not been rehabilitated since its original construction. Existing channel system has been badly deteriorated. Anicut also needs to be rehabilitated in order to provide easy operation of gates, as these are essential specially during floods. The tentative cost of rehabilitation is Rs 24.3 million. This will benefit for about 243 ha.

Heeratiya Oya Scheme

This scheme is being rehabilitated under the National Irrigation Rehabilitation Project (NIRP). However, only the essential items have been considered for rehabilitation under NIRP. Distributary and field canals and farm roads of the schemes and drains need to be rehabilitated as it contribute for better operation of the project as well as to enhance the living condition of farmers. Accordingly, the rehabilitation would benefit 92 ha and Rs 9.2 million would be the anticipated cost.

Bebiyawewa Scheme

This scheme is being rehabilitated under the National Irrigation Rehabilitation Project (NIRP). However, only the essential items have been considered for rehabilitation under NIRP. Distributary and field canals and farm roads of the schemes and drains need to be rehabilitated as it contribute for better operation of the project as well as to enhance the living condition of farmers. The project would benefit 94 ha of irrigated command. The cost estimate is Rs 9.4 million.

Erige Oya Scheme

This scheme is being rehabilitated under the National Irrigation Rehabilitation Project (NIRP). However, only the essential items have been considered for rehabilitation under NIRP. Distributary and field canals and farm roads of the schemes and drains need to be rehabilitated as it contribute for better operation of the project as well as to enhance the living condition of farmers depending on 85 ha of irrigated command. The tentative cost estimate is Rs 9.5 million.

Priority 2: Residual Improvements in Major Irrigation Schemes

Polonnaruwa district consists of the following major schemes:

	Name of Scheme	Irrigated Command Area
1.	Parakrama Samudra Scheme	10,120 ha
2.	Minneriya Scheme	9,565 ha
3.	Giritale Scheme	3,000 ha
4.	Kaudulla Scheme	5,060 ha
5.	Galamana Scheme	3,000 ha
6.	System G (Head works and Elahera Minneriya Yoda Ela)	-
	Total	**30,745 ha**

The major projects mentioned above 1 to 5 were rehabilitated during the period 1987 to 1994 under USAID. These systems have been restored about 40 years before and this was the only rehabilitation effected after the restoration. Rehabilitation works under this project were mainly concentrated for essential structural improvements (ESI). Accordingly, no earth work was allowed in rehabilitation of F.CC as well as important roads. Due to this many items have been left out without paying due attention and it has caused following major problems.

i. Water issue difficulties in tail end areas and accordingly low yield in these areas.

ii. FCC canal bunds and roads have not been rehabilitated, and therefore many communication as well as transport problems are noticed. (at present tail end farmers incur an extra cost for head carrying of paddy bags due to non-availability of proper road system in F.CC).

iii. Canal bund roads and important Link Roads also have not been rehabilitated since restoration of projects, and therefore it has affected living condition of farmers mainly due to lack of transport facilities aggravated by deteriorated farm and link roads.

In addition, the financial allocations granted for the above mentioned rehabilitation works under the USAID, were not sufficient to complete even ESI works proposed under the project due to price escalation over the years of rehabilitation. Therefore, sections of the schemes which have not been rehabilitated also need to be rehabilitated in order to achieve better operation of these schemes.

Many drainage pick-up anicuts have been constructed across drainage canals within these schemes in order to provide better irrigation facilities to tail-end areas through recycling of drainage water. These anicuts have not been considered for rehabilitation either under ISMP or NIRP. Therefore, rehabilitation of these anicuts also to be given priority in a future rehabilitation project.

The main items of the proposed rehabilitation are:

a. Earthwork in rehabilitation of field canals and field canal roads.

b. Earth work in rehabilitation of distributary canals and roads.

c. Earth work in main and branch canals.

d. Improvements to important link roads.

e. Improvements to drainage canals.

f. Rehabilitation of pick-up anicuts.

g. Other residual works.

Tentative cost estimate based on the length of canals and roads have been prepared by the Irrigation Department. These estimates were used in this report and total cost for each scheme appears in the summary shown below. The total cost for rehabilitation of major schemes is Rs 60 million.

Priority 3: Rehabilitation of Minor Irrigation Schemes

Operation and maintenance of minor schemes are generally done by Provincial Irrigation Department. However, there is no Provincial Irrigation Engineering suboffice in Polonnaruwa district and, therefore, many important irrigation related matters of almost all minor irrigation schemes in Polonnaruwa district are presently handled by the Irrigation Department. Similarly, rehabilitation and restoration of minor tanks in Polonnaruwa district under NIRP as well as 12 tanks project are handled by the Irrigation Department at present.

Few minor tanks are being rehabilitated under NIRP and twelve tanks irrigation rehabilitation project. However, there are a few more working tanks and anicut schemes which need rehabilitation as they are in a deteriorated condition. In addition, there are proposals to restore a few abandoned tanks within the district too.

A lump sum provision may be made for rehabilitation of 10 working small tanks linked to major conveyance canals such as the Minneriya Kantale Yoda Ela. The estimated cost is Rs 30 million.

Priority 4: Provision of Marketing Centres

At present, farmers face many difficulties in collecting, storing and selling their produce. Therefore, it is proposed to provide storage and milling facilities in sub-project area basis in order to overcome present marketing difficulties to some extent. Accordingly, a sum of Rs 60 million is required to effect this proposal as shown below.

Name of scheme	Number	Tentative Cost
P.S.S.	3	Rs.15,000,000.00
Minneriya	3	Rs.15,000,000.00
Gal Amuna	1	Rs. 5,000,000.00
Giritale	2	Rs.10,000,000.00
Kaudulla	2	Rs.10,000,000.00
Meegaswewa Tank Centre	1	Rs. 5,000,000.00

Priority 5: Improvements to Kaudulla Spill Tail Canal

Capacity of existing spill tail canal of Kaudulla tank is not adequate even to discharge nominal flood discharge mainly due to following reasons:

i. Insufficiency of canal capacity.
ii. Bends in existing spill tail canal.
iii. Encroachment of canal reservations.
iv. Weak flood bunds, etc.

Investigations are being carried out in order to frame proposals to improve this spill tail canal to a capacity of 10,000 cusecs. This also may be given priority in a future rehabilitation project, as at present it causes many damages to paddy lands under Kaudulla, Minneriya an Gal Amuna schemes during floods. The tentative cost of rehabilitation is about Rs 30 million.

Priority 6: Bakamuna Lift Irrigation Scheme

The existing Bakamuna Lift Irrigation Scheme has not rehabilitated since its original construction. This may be taken up under the area development project, as pumps in this scheme need to be replaced early. In addition, there are requests for new Lift Irrigation Projects around major schemes. As there are possibilities of obtaining water for such projects, it is better if a few such schemes could be promoted in a future rehabilitation project. Rehabilitation of existing Bakamuna Lift Irrigation Project and provision of another three new Lift Irrigation Schemes are proposed under this project. Tentative cost requirement is around Rs 20 million.

6.5 Rehabilitation and Improvement Proposals for Irrigation Schemes Managed by Mahaweli Authority of Sri Lanka

6.5.1. The Mahaweli Consolidation project for Bakamuna Block of System B (Previously System G)

a. Introduction

It is not proposed to include the rehabilitation of Bakamuna Block of System B (previously System C) under the Area Development Project as the system will be rehabilitated under the funds provided from the European Economic Commission (ECC). However, this section provides a summary description of the project objectives, activities, strategies and budgets that may be useful for the formulation of rehabilitation proposals for the other major schemes.

The Mahaweli Consolidation Project (MCP) for System B (Bakamuna Block) envisages an integrated intervention, where the focal point is farmer organization (FO). The wider objectives of the project are to support and consolidate the investment and development initiated in the Mahaweli area to support and consolidate the investment and development initiated in the Mahaweli area to create and support viable self-sustaining farmer communities based on commercial agriculture, where irrigation structures and irrigation water are seen as assets which have to be maintained; to create a commercial environment with improved access to credit, business facilities and skills training which can provide alternative job opportunities for the second and third generation; and to safeguard the environmental equilibrium of the area.

The specific objectives are to:

* increase agricultural production and income in the communities by rehabilitating and improving the irrigation infrastructure;

* ensure sustainability of the investment by training farmers and technical staff in operation and maintenance;

* intensify and diversify agricultural activities in order to increase productivity and income by establishing demonstration units.

* further support the transformation to commercial agriculture by providing improved access to credit, storage facilities, and improved market roads and facilities;

* support development of commercial activities by establishing enterprise employment opportunities for the second generation;

* improve the awareness and technical capability of farmers and technical staff to contribute to a self-sustainable process;

* protect farm- land and houses from being destroyed by elephants;

* promote cultivation of local species of fruit trees and medicinal herbs;

* increase knowledge and interest in home-garden cultivation;

* introduce and develop agro-forestry.

b. Major Components Envisaged

The following are the major components and activities envisaged:

i. Strengthening of Farmer Organizations

This component comprises two main activities: (a) to support the establishment and strengthening of the FO to facilitate turnover of the responsibility for maintenance of D-canals, and F-canals to FO; and (b) support to women to facilitate their active participation in community development.

ii. Rehabilitation and Improvement of Infrastructure

This component comprises four main activities: (a) rehabilitation and improvement of irrigation structures; (b) rehabilitation and improvements of access roads and market roads; (c) establishment of Farm Demonstration Units (FDU) to facilitate training of farmers and technical staff in periodic and preventive maintenance and training in water management and crop diversification, and (d) participatory consultation with FO and MECA to decide upon O&M improvement and rehabilitation to be undertaken and FO input.

iii. Credit Support Component

This component comprises three main activities: (a) institutional strengthening of the Regional Rural Development Bank to facilitate farmers' access to the formal credit system; (b) establishment of a Loan Guarantee Funds to facilitate restoring the credit worthiness of groups containing a high number of previous defaulters; and (c) support to primary milk societies in the project area comprising provision for establishment of a livestock development centre, a milk processing centre, and three milk collecting centers and a model poultry farm.

iv. Enterprise Development and Marketing Component

This component has two main activities (a) Support Business Development Centre (BDC), and (b) support to marketing activities

v. Environment and Forestry Component

This component comprises four main activities: (a) protection of farm- land and houses and natural reserves, (b) upgrading of nurseries to produce seedlings for agro-forestry, (c) applied research for cultivation of native species of medicinal herbs and fruit trees, and (d) development of an agro-forestry project.

vi. Project Implementation Support

This component covers provision for support to a Project Management and Coordination Unit (PMU) which includes Technical Assistance (TA) and an allocation for monitoring and evaluation.

c. Economic Internal Rate of Return

The economic internal rate of return (EIRR) has been calculated taking into consideration the following situations:

Scenario I - where benefits are derived from increased cropping intensity and costs include rehabilitation and improvement of irrigation structures and O&M costs of D-canals and F-canals. In Scenario II based on net incremental income the EIRR is 14.1 percent.

Scenario II - where benefits are derived from increased cropping intensity and farm crop diversification. Costs include support to farmer organizations, rehabilitation and improvement of irrigation structures and access to market roads, O&M costs, improved O&M and water management, improved marketing and storage facilities, and improved access to credit. The overall internal rate of return (EIRR) is 16.8 percent based on the net incremental income,

measured as the difference between the present area income and the future area income, less total project costs and total O&M costs.

d. Expected Project Outputs

The main outputs of the project over a period of six years will include (i) trained farmers, organizers, staff, youth and trainers; (ii) rehabilitated and improved irrigation systems; (iii) established system for loan guarantees for previous defaulters/farmers; (iv) establishing a Business Development Centre; to improve marketing facilities, storage facilities; FO training in marketing, storage and crop selection; farmers trained in planting, nursing and harvesting on FDU; (i) building power fence, control/guard houses, inspection of road constructed; inspection of guards trained; research on cultivation of indigenous medicinal herbs and fruit tree species carried out and agro-forestry program initiated.

e. Funding

The European Community (EC) has been funding the development of System B, Zone 2 and Zone 3. There is a balance of about ECO 6.6 million left, approximately Rs 400 million. The government of Sri Lanka, through the MASL has proposed the remaining funds including residual Food Aid counterparts funds (about Rs 225 million) be spent on consolidation of the investment already undertaken in System C/Zone 2 and in System G (now System B/Bakamuna Block).

The EC has agreed to consider utilizing the residual funds, in total about Rs 625 million for a single well defined project covering System C/Zone 2 and System, G, the Mahaweli Consolidation Project (MCP). Thus, no proposals are made in respect of Bakamuna Block of system B.

6.5.2 Mahaweli System H

Rehabilitation and improvement of water for Mahaweli System H has been proposed under the proposed, World Bank funded, Mahaweli Consolidation Project. Therefore, it is not proposed to include Mahaweli System H area under the Area Development Project of the NCP.

A layout map of System H is shown in **Figure 6.3**. System H area consists of around 31,000 ha of farm land lying under the command of three major reservoirs namely, Kandalama, Dambulu Oya and Kalawewa. System H area is divided into nine subsystems viz. H1 to H9. System H area includes an area of 6200 ha which had been developed before the implementation of the Accelerated Mahaweli Programme. The balance 25,000 ha was developed under the Accelerated Mahaweli Programme during 1974 to 1980.

Key characteristics of Mahaweli System H is shown in **Table 6.3.**

Table 6.3. Characteristics of Zones of Mahaweli System H

SYS-TEM	ZONE	SUB SYSTEM	FEEDER TANKS AND CANALS	MANAGEMENT BLOCK	FARM AREA (ha)	CANAL LENGTH (Km)				TANK (No)	ANICUT (No)
						Main	Br.	Dist.	Field		
H	1 Kandalama & Dambula Oya	H6 & H8	Kandalama Tank/ LB & RB Main Canal	Kandalama	1218			23.2	21.5		
		H7	Kandalama Tank/ RB Main & BC1	Madatugama	3354	43.2	2.7	61.9	181.4	8	
		H9	Dambula Oya Res./ LB Main BC 1 & 2	Galkiriyagama	2160	5.9	8.7	47.3	133.0	2	
		SUB-TOTAL			6732	49.1	11.4	132.4	335.9	10	
	2 Kalawewa Yoda Ela	H3	Kalawewa Tank/RB Yoda Ela, D13 & D15	Maha Illupulama	4700	25.7	24.3	100.9	79.0	17	14
	3 Kalawewa RB	H4	Kalawewa Tank/RB Main Canal BC 1, 3, 4, 6, 7 & 8	Eppawela	3740			78.8	276.8	23	
		H4		Thambuttegama	3050	49.9	32.2	86.8	170.8	18	
		H4 & H5		Talawa	3230			85.3	194.6	21	
		H5		Nochchiyagama	3280			78.2 .	193.4	25	
		SUB-TOTAL			13300	49.9	32.2	329.1	834.6	87	
	4 Kalawewa LB	H1	Kalawewa Tank/LB Main Canal BC 1 & 2	Galnewa	3930	29.1	22.8	74.1	192.2		
		H2		Meegalewa	2170			37.8	153.5	6	
		SUB-TOTAL			6100	29.1	22.8	111.9	345.7	6	
	TOTAL				30832	153.8	90.7	674.3	1595.2	120	14

A proposal has been prepared for physical rehabilitation of System H based on a detail costing exercise carried out for sample units selected from each subsystem from H1 to H9. Based on the costing of rehabilitation and improvement work required for each sample unit, the total budget required for rehabilitation of the entire System H has been computed as shown in **Table 6.4** below.

Table 6.4. Cost of Physical Rehabilitation of Mahaweli System H

Zone	System	Cost in Rs.	Area Benefitted (ha)	Cost (Rs/ha)
1	-do-	112,125,541	6,732	16,656
2	-do-	114,139,283	4,700	24,285
3	-do-	194,983,344	13,300	14,660
4	-do-	71,889,935	6,100	11,785

Thus, the total anticipated cost of rehabilitation of System H is Rs 423 million. However, it is not proposed to include this activity under the Area Development Project.

6.5.3 Mahaweli System B

Maduru Oya System B Irrigation Project is part of the Accelerated Mahaweli Programme and is the largest of the development areas, encompassing a gross land area of 136,000 ha. System B lies in the east-central section of Sri Lanka along the left and right banks of the Maduru Oya. The total irrigable land is about 42,000 ha, of which about 28,000 ha will be served by the left bank main canal. Interventions for development of the right bank are underway.

Maduru Oya Left Bank Irrigation Project consists of five zones (Zone 1, 2, 3, 4A and 5) and the area is divided into nine blocks for convenience. They are namely Dammina, Wijebapura, Ellewewa, Dimbulagala, Sevanapitiya, Senapura, Asselapura and Sapumapura. As at date the construction work is almost completed except 20% at Sinhapura, 10% at Asselapura and 50% at Sapumalpura as these areas are situated in the Eastern Province. Details of the blocks are shown in **Table 6.5**.

Table 6.5 Management blocks of Mahaweli system B

Zone	Management Block	Period of Construction	Funding Agency
1	Ellawewa Dimbulagala	1984-1987	GOSL
2	Sevanapitiya Senapura	1985-1988	EEC/SFD
3	Sinhapura	1988 to date	EEC/SFD
4A	Asselapura Sapumalpura	1987 to date	USAID/SFD/ GOSL
5	Dammina Wijebapura	1979-1982	GOSL

GOSL = Government of Sri Lanka
EEC = European Economic Commission
SFD = Saudi Fund for Development
USAID = United State Agency for International Development

A layout diagram of Mahaweli System B (Maduru Oya) area is shown in **Figure 6.4**. About 10,000 ha of Zones 1 and 5 of the left bank of System B was rehabilitated at a cost of Rs 50 million under USAID funds between 1993-1995. Only the Essential Structural Improvements were done under the USAID funds. The average investments per ha of command area range from Rs 4000/ha (Rs 6000/ha for Zones 1 to 5.

It is proposed to include a total of 3500 ha including a part of Block 5 of Zone 5 (500 ha) and blocks 201 and 204 of Zone 2 (3000 ha) (see **Figure 6.4**). This area falls within the NCP. Total anticipated cost of rehabilitation, based on the pro-rated cost of the previous rehabilitation is Rs 22 million.

A summary schedule of the proposals for improvements and rehabilitation to major and medium irrigation schemes, including estimated cost of the interventions, is shown in **Table 6.6** below. It is presumed that each of the proposal is appraised for their financial viability before the implementation.

Table 6.6. Summary Schedule of Proposed Irrigation Rehabilitation Activities for Major and Medium Schemes

District	Priority	Description	Benefitted Area (ha)	Cost (Rs/Million)
Anuradhapura	1	Rehabilitation of 16 medium tanks.	3785	379
	2	Rehabilitation of Wahalkada major tank.	820	85
	3	Rehabilitation of distributary canal system in Rajangana Right Bank lift irrigation system.	745	45
	4	Rehabilitation of Karambe Ela-Yoda Ela including minor improvements to eight minor schemes fed by this canal.	238	10
		Subtotal		519
Polonnaruwa	1	Rehabilitation of 5 medium irrigation schemes.	554	84.8
	2	Residual improvements in major irrigation schemes.	30,745	60
	3	Rehabilitation of minor tanks.	-	30 (A lump sum)
	4	Establishment of 12 marketing centres in major irrigation schemes.	-	60
	5	Improvements in Kaudulla spill tail canal.	-	30
	6	Rehabilitation of Bakamuna lift irrigation project.	-	20
		Subtotal		284
		Total		803

CHAPTER 7

PROPOSED STRATEGY*

1. The government of Sri Lanka (GOSL) sought the support from the Asian Development Bank (ADB) for a program aimed at augmenting the economic development in the North Central Province (NCP) of Sri Lanka. The GOSL specifically sought the assistance of the ADB for a broad-based, multi-faceted area development programme to complement the Participatory Rural Development Project which is being prepared for the NCP under CIDA and IFAD assistance. In response to the GOSL's request, the ADB has agreed to provide a Pre-Project Technical Assistance (PPTA) to assist the Government in preparing a comprehensive development programme.

The scope of the proposed PPTA includes:

(a) A regional economic development study;
(b) A natural resources management study; and
(c) Preparation of a detail proposal for an Area Development project for Bank financing.

The two studies mentioned under (a), and (b) will be the basis for the project proposal mentioned under (c) above.

The GOSL and the ADB invited IIMI to conduct the Natural Resources Management (NRM) Study which included three key activity areas, namely:

i. Assessment of Land and Water Resources Potential of the NCP.
ii. Overview of past and present tank rehabilitation strategies.
iii. Institutional and organizational arrangements.

2. Even though large investments have gone in the development of land and water resources in the NCP, these investments were project and sector specific and were made without considering the land and water resources and their integrated development potential in a holistic manner. In addition, water is the limited resource in many parts of the NCP and the land is becoming a limiting resource due to increasing population pressure and environmental degradation. Hence, all facets of an area development project designed for the NCP should be based on land and water resources development as well as related agro-based rural industry and support services. In other words, an innovative approach to development which will look at the resource potential and ways and means of optimizing the production level with protection of resource base has become a necessity. In the face of rapidly growing open market economy in

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* Chapter 7 appears as the Executive Summary of the report as well.

the country, the new area development strategy needs to focus on the ways and means of strengthening the managerial and enterprenurial capacity of the small farmer as well as the capacity of farmer organizations to overcome the market competitive forces to enhance their agricultural incomes.

3. In this context, the Natural Resources Management study proposes a development strategy focussing on watersheds, sub-watersheds and tank cascade systems as basic units of development, for adoption in the proposed ADB funded Area Development Project in the NCP. For example, the strategy outlines a cascade based farming system approach with integrated surface and groundwater development coupled with a management process aimed at striking a balance between production and conservation. Agro-based rural industry and related agro-infrastructural development are integral parts of this strategy. This approach is suggested on the basis of the concepts and experiences achieved through the implementation of the Shared Control of Natural Resources (SCOR) project in the Huruluwewa watershed (Upper Yan Oya River Basin) in the NCP and other institutional development programmes undertaken by the GOSL. It is to be noted that the suggested cascade and farming system approach is not only applicable to minor tank cascades in Anuradhapura but also in those areas in the Polonnaruwa Distrct where the major systems are interspersed with medium and minor tanks.

4. The proposed strategy includes selection of sub-watersheds and cascades for project intervention during the project period based on hydrological endowment and assessment of the land and water resource base including its present extent/quantities, quality status, and potential future use. This study conducted a basin-wise assessment of natural resources of the NCP as the basis for delineating hydrologically endowed sub-basins and cascades. The study suggests the possibility of transferring surplus water within and among the cascades. This suggestion is based on the analysis of existing water balance and a rough estimation of the magnitude of such diversions of excess water which may not exceed 5 percent of the total surface water run-off of the cascades. However, with detailed data collection, the effects and impacts of such water transfers on the medium and major tanks downstream and outside the cascades have to be studied in detail with a hydrological simulation model.

5. The study also recommends the integrated use of surface and groundwater within the cascades. This suggestion is based on the recharge potential of the cascades computed on the basis of limited data evaluated under the study. The study also recommends setting up of a hydrologic and hydrogeologic data collection and monitoring network for systematic surface and groundwater data collection and continuous monitoring of cascade and river basin hydrological and hydrogeological parameters. Such a network will be essential for developing a data base required for planning and management of cascades and river basins for land and water resources development as well as for economic development in the NCP.

6. An extensive review of the past and on-going minor, medium and major tanks rehabilitation projects was done and the lessons and experiences of those projects were captured. The review indicates that these projects were conducted on a piece-meal basis without considering the overall hydrology of the cascades, farming systems approach, conservation of the land and

water resource base and farmers perceptions and knowledge. These projects were heavily focussed on structural improvements to irrigation systems at the expense of the development of other income generating avenues available in and around irrigation tank systems such as chena cultivation, home gardening, agro-processing and other agro-based industries. Those physical rehabilitation intervention strategies adopted in the past led to the realization of benefits and impacts which were far less than the expectations. The effects and impacts of the past and ongoing rehabilitation programmes as reported in this study justify the adoption of the new approach and the associated investment strategy proposed here for land and water resources management in the GOSL/ADB Area Development Project.

7. The proposed approach for land and water resources management in this report deviates from this traditional approach. Unlike in the traditional approach, farmer beneficiaries have been consulted through participatory appraisal and mapping for selected cascades to capture their experiences, needs and suggestions to develop indicative plans for water resources development and management at cascade level. The study suggests validating and improving such indicative development plans through appropriate hydrological, technical and economic feasibility studies for cascades before implementation.

8. It is proposed that in order to adopt this area development strategy, the necessary resources and support for implementing appropriate interventions be provided by the project. Such interventions will include: water transfers within and among cascades, rehabilitation of small tanks and agrowell development to improve cropping intensities of the irrigated commands areas; conservation and production interventions for stabilization of chena, development of home gardens, stream and canal reservations; livestock production; value added processing and industries; market development; and credit and marketing support. In addition, the project will provide for complementary agro-infrastructural facilities and institutional arrangements such as deployment of catalysts and forming and strengthening farmers' organizations and farmer companies to carry out the designed interventions on a sustainable basis.

9. The report begins with an introduction and background to the study in Chapter 1. Chapter 2 of this report provides an account of the present status of Land and Water Resources base and use of the NCP. This chapter addresses the major river basins and their characteristics; present land use and related issues; present surface water use and ground water use; present water quality; and potential for further water resources development in the NCP.

10. Chapter 3 provides a detailed review of the past and on-going irrigation rehabilitation projects conducted in the NCP. It addresses the strengths, weaknesses as well as lessons that can be learnt from the previous and on-going irrigation rehabilitation strategies and approaches. In view of the gaps realized between the expectations of those irrigation rehabilitation programmes and the actual achievements, this study discourages the conventional "single tank rehabilitation" approach. Instead it recommends a cascade-based water resources development and area development approach in which cascade is considered the basic unit of planning water resources development and complementary area development interventions using a production and conservation oriented farming system approach.

11. Chapter 4 describes the process followed in carrying out cascade selection and evaluation, beginning from identification of a potential cascade and sub-basins for area development to the identification of specific proposals for water resources development interventions in a cascade. Having identified the water resource development proposals based on farmer's perceptions, the chapter suggests a methodology and a tool for validating farmer proposals both technically and hydrologically. In addition, this chapter provides descriptions of the cascade simulation model and the small tank inventory developed under this study. It is proposed that the suggested process be adotped in the actual implementation of the GOSL/ADB project.

12. Chapter 5 starts with a detailed account of the strategies adopted by the Shared Control of Natural Resources (SCOR) project which is the basis for the land and water resources development in a watershed context proposed to be adopted for the area development project. The rational for adopting a holistic resources development approach taking river basin/sub basins or cascades as basic units for integrated planning is clear. The cascade/watershed/river basin is a physical entity geographically defined by an important natural resources, water. The ways in which water is used in the upper parts of the watershed affect the ways in which it can be used in the downstream. The various parts of the watershed - upper catchments, water bodies, command areas, re-use areas <u>including associated highlands</u> - are linked in important ways, and the potential benefits from integrated use can be large. This chapter formulates an integrated approach to capture such benefits. In addition, it describes the strategies, rationale, norms and the assumptions used for cost benefit computations, details of the cost benefit computations and the institutional arrangements proposed for the implementation of the strategies. This chapter proposes a M&E strategy and special data collection and research studies as well.

13. Chapter 6 provides separate cost estimates for rehabilitating medium and major irrigation schemes in the NCP based on the consultations held with the Irrigation Department and the Mahaweli Authority of Sri Lanka. The proposals and priorities for rehabilitation of major and medium projects presented in Chapter 6 have been framed on the basis of the suggestions of the relevant irrigation agencies. However, based on previous **IIMI analyses (such as Kikuchi and Aluwihare, 1991), SCOR experience and the present benefit cost analysis, it is clear that the strategy proposed in Chapter 5 is more cost-effective than major rehabilitation efforts. The watershed/sub watersheds approach presented in Chapter 5 yields a B/C ratio of over 2 and an IRR close to 20%. The net returns could be even higher if environmental benefits are included.** Therefore, the technical feasibility and the economic viability of those proposals needs to be worked out before budgetary allocations and investments under the project are finalized.

14. The rationale for considering Anuradhapura district of the NCP separate from the Polonnaruwa district is primarily based on the two contrasting types of 'land systems' and water resources potential that characterizes each of these districts, as well as the contrasting nature of present land use and settlement patterns in the two districts. Anuradhapura district is endowed with a large number of well demarcated small tank cascades and small tanks, while a larger proportion of the developed lands in the Polonnaruwa district are served under the command of four major irrigation settlement schemes. The Polonnaruwa district differs from the Anuradhapura district in respect of the number and distribution small tank cascade systems.

15. Polonnaruwa district located within the Mahaweli basin is a water rich district with ten times more runoff potential than the Anuradhapura district which is a very water short district. Stream flow analysis indicates that the Mahaweli Ganga (part) produces the highest runoff 0.780 (MCM/sq.km), while the Malwathu Oya produces the least run-off of 0.040 MCM/sq.km. There is a substantial diversion of Mahaweli water into the NCP. In terms of water available for further development, the Mahaweli Ganga (Polonnaruwa segment) stands first, followed by Yan Oya, Kala Oya, Malwathu Oya, Ma Oya and Moderagam Ara. Almost all the surface water potential of the four basins (except Yan Oya) in the Anuradhapura district is utilized. The strategy should therefore be to maximize productivity per unit of land in the Polonnaruwa district, and maximize productivity per unit of water in the Anuradhapura district as priority concerns. However, this priority does not preclude the necessity to maximize productivity per unit of land in the Anuradhapura and productivity per unit of water in the Polonnaruwa district.

16. The five major river basins of the Anuradhapura district in decreasing order of size namely, Malwathu Oya, Kala Oya, Yan Oya, Ma Oya and Moderagam Ara have been demarcated on a set of maps together with their component sub-watersheds and the second, third and fourth order streams. In the Polonnaruwa district only the medium size river basins, namely the Amban Ganga, Minneriya Oya Kaudulla Oya, Ambagaha Oya and Kalu Ganga have been demarcated together with their drainage systems.

17. The least endowed area in terms of rainfall occurrence is the north-west part of the NCP. The present studies indicate a downward trend for the annual rainfall for most of the basins studied and a downward trend for the runoff rainfall ratios in both Amban Ganga and Yan Oya basins. The reasons for these downward trends need further investigations.

18. Necessary data sets for proper evaluation of the groundwater potential of the NCP is not available yet. The limited data available with the Water Resources Board has yet to be professionally analyzed. A first approximation of the groundwater balance with the available data reveals a net recharge of 7 percent of the annual rainfall or 95 mm per year. It is emphasized that the exploitation of groundwater through the use of agrowells should proceed with extreme caution because it can have adverse impacts on the environment. The study shows that command areas of irrigation tank offer a higher potential for agrowell development than the highland areas. The nature and occurrence of groundwater and its potential has been discussed in Chapter 2 of the report. A methodology has been presented for evaluating the groundwater potential and the safe number of agro wells within a cascade area in Chapter 4.

19. Water sampling and analysis was carried out in September 1995, at the end of the dry season, on 30 tanks, 15 streams, 14 drainage streams and 34 agro-wells in the NCP during the study period. According to USBR standards, water of all major tanks fall within Class 2, and waters of medium and small tanks within Class 3. The corresponding Sodium Adsorption Ratio (SAR) values increase from 3.4 to 6.2. The EC values of the third order streams are nearly double those of the fourth order, but yet within safe limits of quality. The Electrical Conductivity (EC) value of agro well water under major, medium and small tanks are nearly the same, while the EC value of the drainage waters of major tanks show double the value of the main tank. The

surface waters of all categories of tanks fall within the potable quality standards of SLS (1993).

20. The method of delineation of the NCP into its component basins/watersheds, sub-watersheds and component cascades has been adequately outlined in Chapter 4. It is to be noted that for the Polonnaruwa district the demarcation was done only to the level of the sub-watersheds. A master map given in Volume II (Annexures) of the report shows the demarcation of both districts with their main river basins, sub-basins and cascades. The four main basins of the Anuradhapura district contain 36 subbasins ranging in size from 57 to 100 sq.miles with a mean size of 75 sq.miles. A separate map shows the Anuradhapura district with the boundaries of the cascades. A total of 309 cascades occur within the 36 subbasins with an average of between 8 to 9 cascades per subbasins. Details of their number and size distribution between the main and sub-basins are given in Chapter 4. The modal value for the area of a cascade is approximately 8.5 sq.miles or approx. 5,500 acres. A separate map showing the demarcation of the Polonnaruwa district into its main subbasins have been prepared and presented with.

21. The criteria adopted and the methodology employed in the selection of potential subbasins and cascades (15 in number of each) has been outlined in Chapter 4. The selection of the 15 subbasins out of a total 38 was made on the differentiation of rainfall probability, soils and land forms and present land use pattern. These 15 subbasins contain a total of 151 cascades, or almost half the total number of cascades for the districts. All these 151 cascades were then characterized on a scale of 1:50,000 in terms of their extent, number and area of tanks and present land use.

22. Based on IIMI's previous study of the "Guidance Package for Water Development component and Small Tank Systems" between 2 to 4 cascades per sub-basin, or a total of 43 cascades were selected out of the 151 on a ranking of their hydrological endowment. In the final stage of selecting one cascade from among the 2 to 4 cascades per sub-basin a novel field methodology was adopted by the field appraisal team which included a modified participatory rural appraisal technique coupled with participatory mapping of the water resources data and proposals as well as institutional arrangements proposed by the users. This is described in Chapter 4.

23. This component of the study introduces a mechanism for consulting beneficiary farmers in small tank cascades for identifying their specific needs and developing indicative land and water resources based development proposals. The mechanism involves carrying out a consultative participatory appraisal and mapping of the present status, use and potential future use of land and water for supporting and sustaining incomes of beneficiary farmers living in tank cascades. Indicative proposals and plans developed through this consultative mechanism provide a basis for stimulating followup technical, hydrological and economic feasibility studies by the implementing agencies to rationalize the plan for implementation with necessary technical modifications. The methodology was adopted in 15 sample cascades in Anuradhapura district mainly for identifying water resources development proposals and has been elaborated in Chapter 4. The details of the process followed and the outcome of the participatory appraisal and mapping exercise conducted in 15 cascades are presented as 15 case studies in Volume II (Annexure) of this study report. The adoption of the methodology through a beneficiary consultative process for planning

development interventions related with production and conservation activities in chena, homegardens, canal and stream reservations has been elaborated in Chapter 5.

24. A simulation model was developed to test and validate the farmers' proposals for water resources development within a cascade in terms of hydrological feasibility. The model, with necessary input data, can simulate the effect and impact of upstream interventions on water availability at each and every small tank within a cascade. The model can also be run to simulate the aggregated hydrological impact of interventions carried out in a number of cascades within a sub-basin. However, it needs further improvement. Features of this model, its utility and some sample outcomes are presented in the Volume II of the report. It is proposed that funds are allocated under the project to carry out further work to improve the capacity and utility of the model to enable wider application is cascade/watershed based area development planning in the future.

25. A key factor hindering the cascade/watershed based area development is the absence of a comprehensive understanding and database related to small tanks and tank cascades. For example, a conclusive inventory of small tanks for the NCP as well as the entire country is not available. Also, the present hydrometereological data collection network is not adequate to monitor water balance of river basins and hydrological parameters. In respect of ground water much data have yet to be collected to evaluate the hydrogeological parameters and ground water re-charge potential of the cascades and river basins. Research studies are needed to evaluate run-off/rainfall relationships of individual small, medium and major tank watersheds and the cascades to facilitate more rational and realistic planning and designing of land and water development interventions as well as for continuous monitoring in the future. Detailed surface water and ground water balance studies are required to substantiate the present data base of the NCP. The nature of the area development strategy proposed in this report demands various other research studies related to conservation and production as well as continuous monitoring and evaluation of the effects and impacts of such interventions to guide area development interventions and investment decisions in the future. Proposals for specific research studies and monitoring and evaluation have been outlined in Chapter 5 of the report.

26. The study initiated the preparation of a small tank inventory for the NCP during the short study period. It was possible to compile much physical, hydrological and social data for almost all the small tanks of the NCP. It was possible to identify the locations of the small tanks in relation to the Divisional Secretary's Divisions, cascades and river basins and whether the tanks were rehabilitated during the last fifteen years. The inventory of small tanks is presented in the Annexures. It is proposed that this exercise be continued as a special study under the GOSL/ADB project.

27. As stated earlier, on the basis of research studies conducted by IIMI (under the present assignment and under IIMI's SCOR project), Chapter 5 presents a holistic approach for land and water resources development in the NCP. The research results have been translated into project components, and, a benefits: cost analysis has been conducted. It is proposed to include 10 sub-watersheds in the GOSL/ADB Area Development Project for land and water resources

development and associated agro-industrial and institutional components. In each sub-watershed, two cascades comprising of about 20-30 tanks (assuming that an average cascade has about 10-15 tanks) will be selected. The 20 cascades (in 10 selected sub-watersheds) will represent five cascade types identified in the PRA. In each cascade, the total water and land resources will be considered in the development planning. This "contiguous area" approach or the consideration of sub-watershed land and water resources in its totality will yielded significant production-conservation benefits as experienced in the SCOR project.

Four different land and water use options are proposed. For these different options the benefit : cost ratio varies from about 2.0 to 2.8, at 22% discount rate. The corresponding range at 12% discount rate is 3.6 - 5.8. The Internal Rate of Return (IRR) varies from 18.4 to 19.9.

The project costs are also computed for the four different land and water use options. The estimated total cost for seven years is about US$20 million.

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