ENVIRONMENTAL IMPACT ASSESSMENT KIRINDI OYA IRRIGATION AND SETTLEMENT PROJECT (KOISP)

NALANI AMARASEKARA
ENVIRONMENTAL SCIENTIST
DRAFT FINAL REPORT

INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE
127, SUNIL MAWATHA
PALAWATTA
BATTARAMULLA
COLOMBO

DECEMBER 1991.

TABLE OF CONTENTS

FORWARD

In Sri Lanka, Environmental Impact Assessment Guide Lines have been prepared for most of the development projects since 1984. However, no such attempts have been made for water resources development and irrigation projects except in the case of Mahaweli Project.

Kirindi Oya Irrigation and Settlement Project(KOISP) is the most recent major project undertaken by the Irrigation Department. Although this provides a very good opportunity for Irrigation Department and Central Environmental Authority of Sri Lanka to initiate action on an impact assessment of the Environmental aspects on the project, no such steps have been taken so far.

I hope that this report of Environmental Impact Assessment on the Kirindi Oya Irrigation and Settlement Project will provide a good eye opener for these Institutions to initiate action on this very important area.

CONTEMPORARY ENVIRONMENTAL DEGRADATION IN KIRINDI OYA BASIN

INTRODUCTION

In river basin development planning, a common approach has been developed today; to treat the resource system of a river basin in its natural unity. One of the pioneer attempts based on this approach was the Tennessee Valley Development Project in the United States. The same trend was followed to some extent in Sri Lanka too, in the planning of the Gal Oya basin, and later in the development of the Walawe basin. Apart from the Mahaweli project, the Lunugamwehera project on the Kirindi Oya basin represents one of the concerted attempts at developing water resources of major river basins in Sri Lanka. These development efforts claimed to be based on comprehensive resource planning, often require studies involving river basins spreading over several hundred square kilometers. Inspite of these obvious needs for river valley development planning at meso and macro scales hydrological studies are hard to come by in Sri Lanka (Madduma Bandara, 1985).

The Kirindi Oya basin, like many other watersheds, extends from the central highland of the island through an intermediate level, an upland and across the lowlands to the sea. The basin has, therefore, been divided into three natural regions. Highland, Upland and Lowland, which are characterized by differences in elevation, structure, climate, soils and land use. It is not only convenient but essential to recognize these major regions before attempting to study the physical resources of the basin as a whole (Merritt and Ranatunga, 1957).

The first regional, the Lowland, consists of a flat to gently undulating rock-floored plain with scattered monadnocks or erosion remnants of more resistance rock breaking the monotonous relief. The plain grades from sea level at the coast to 600 feet above sea level at the foot of the first step above Wellawaya. The erosion remnants rise in places to 1000 feet or more and may be outliers of the Upland.

The Upland, second region, has a moderately dissected plateau with an elevation from 650 to 2000 feet. It forms a shelf-like feature approximately two to eight miles wide, abutting the face of the main hill mass in this area. Relief is of the order of 500 to 700 feet.

The third region, the Highland, is that part of the central hill mass contained within the Kirindi Oya valley. The land rises in an almost sheer wall to the level of the upper surface which consists of a moderately dissected plateau of rounded and angular hills with a mean elevation of roughly 4500 feet and a local relief of 500 to 1000 feet. The basin consists approximately 75 per cent Lowland, 15 percent of Upland and 10 percent Highland.

The Kirindi Oya river basin development/degradation however has been planned in two different ways, namely, downstream, where the Kirindi Oya Irrigation and Settlement Project (KOISP) is located and the upper catchment where contemporary environmental degradation occurred. This review is based on that belief, inspite of limitations in data macro hydrological studies covering larger river basins would, at least, for reconnaissance purposes, prove equally useful as the more common micro catchment studies.

Due to negligence and lack of knowledge of the importance of watershed management in the Kirindi Oya basin, there is considerable damage in downstream in the Kirindi Oya basin where the KOISP is operated. It is necessary, therefore, to consider contemporary environmental degradation in both downstream and watershed separately.

KIRINDI OYA IRRIGATION AND SETTLEMENT PROJECT

The Kirindi Oya Irrigation and Settlement Project (KOISP) is an important new project that has brought about a rapid transformation from an area of forest jungle to intensive agriculture in southern Sri Lanka (Fig. 1). KOISP is a fascinating example of a scheme which, in principle, should reflect the "state-of-the-art" in planning. It is one of the last new irrigated settlement schemes to be developed since most of the island's major river systems have been tapped already. The plans of KOISP are based on over half a century of accumulated knowledge and experiences gained in developing new major irrigation schemes in the Dry Zone.

Initial planning for the KOISP began in the 1950s as part of a more comprehensive scheme to develope the water resources of eight major river basins, including the Kirindi Oya. A political insurrection in 1971, which had its roots in the south also provided a strong impetus for the government to undertake a development project that would provide employment opportunities and benefits to the area. The Asian Development Bank (ADB) provided financial assistance together with the International Fund for Agricultural Development (IFAD) and the German *Kreditanstalt fur Wiederaufbau* (KFW).

A variety of factors, including high inflation and delays in contracts, resulted in large cost overruns. The dramatic overrun of about 105 percent of the original total estimated cost prompted the Sri Lanka government to request a project re-appraisal and supplementary financing for the project in 1981. This resulted in a reformulated plan in which the project was divided into two phases, each financed separately.

Under the re-formulated project, Phase I was completed in 1988 at an estimated cost of US$ 79.9 million. It included construction of the main reservoir, Lunugamwehera, which was completed in 1985. The reservoir has an active storage capacity of 210 million cubic metres. Phase I included 4000 new settlers along the left and right banks of the newly constructed irrigation system. Settlers received their first irrigation water for rice in 1986. In addition, rehabilitation of 4600 ha.s of the existing system was completed under Phase I. Phase II constitutes an extension of the irrigation and settlement facilities on approximately 4000 ha.s of additional land. Work is expected to be completed by 1992.

Although one cannot deny that the new settlement schemes have been a boon to many of Sri Lanka's poor, they have also been chracterized by irrigation inefficiency resulting in low agricultural yields and poor rates or return on national investments, inequitable distribution of water, lack of co-operation among settlers and inability of settlers to maintain their systems. Those have become standard features of the Dry Zone settlements. At the agency level, lack of co-operation among departments has also contributed its share to the irrigation inefficiency problems.

The project has brought land under permanent cultivation in the low lands of the Kirindi Oya basin. Historically, the area formed part of the Ruhuna Rata, an area rich in archealogical sites dating as far back as 200 B.C. In recent centuries, however, the area was abandoned in 1881. A Chronicler noted that it was a "desolate wilderness." Several of the ancient tanks were restored under the British in the later 19th century and a diversion scheme was developed to tap water from the Kirindi Oya. Under the KOISP, water for these tanks is augmented by the project and structures are being rehabilitated (Stanbury, 1989).

In 1980, a pre project survey was undertaken. Then, around 2897 families were found living in the catchment, command and tank bed are of the project. *Chena* and permanent highland cultivation is primarily done during *Maha*. Since the project began, however, the number of encroachers has continued to rise as speculative settlers have moved to the area hoping to gain legal access to land.

BASIC FEATURES OF THE PROJECT

KOISP has been designed to incoroporate six existing tanks and a new irrigated settlement area. The complete system includes four sub-systems:

1. The Ellegala System: tapping Kirindi Oya with five tanks which have been in existence for many years (the "old area"). Supplemented from the new left bank main canal.

2. The right bank main canal system with three new irrigation tracts in Phase I and four in Phase II.

3. The left bank main canal system with two new irrigation tracts in each phase.

4. The Badagiriya system on the Malala Oya, also a pre-existing system with supplementary water to be provided from the right bank.

THE PROBLEM OF THE PROJECT

The inflow of Kirindi Oya has been a point of controversy ever since the project was initated. During the past four years the project has been in operation with the water shortage. Kirindi Oya is a system with severe water shortage and the Lunugamwehera project has been justified econimically from the beginning on certain estimates of river inflows and assumption that the farmers will grow a lot of crops other than paddy. Apparently none of these two basic factors,seem to conform to the reality(CECB, 1991). Kirindi Oya project has been experiencing shortage of water ever since it was commissioned in 1986. Areas already under irrigation are not getting the supply to the desired extent and development of part of the projected area has been suspended due to shortage of water.

In accordace with the actual situation, the inflows in the Kirindi Oya have been less than estimated - may be due to somewhat over-estimation in the initial stage or subsequent change in the catchment regime for flow characteristics, which seeme to be further accentuated due to prevailing dry cycle.

The inflow of Kirindi Oya has been subject of debate ever since the initiation of the project and various investigators have given varying figures for inflow whic are invariably less than original estimation of 323 MCM. The latest estimate as a result of present studies is that the long range average annual inflow in Kirindi Oya after accounting from abstractions in a number of small upstream tanks in the basin may be 293 MCM. The need for augmentation of supplies to Lunugamwehera reservoir is therefore evident for amelioration of the present distress through which the project is passing.

ENVIRONMENTAL DEGRADATION OF THE PROJECT

With the land preparation activities, downstream degradation in the KOISP has initiated even before its operation. The Irrigation Department had the responsibilities of jungle clearing, basic levelling and ridging of upland soils. Major work was done by the agency official while minor work such as their own minor levelling, bunding and clearing have been done by the settlers themselves. There is some evidence that unsatisfactory land levelling and ridge construction by contractors have furthered degradation (Stanbury, 1989)

According to the plans of land development, rough grading of the land is done by bulldozers and the farmers did the final development of making individual flat basins. Rough grading is done with high powered bulldozers and destruction of land has been caused in many instances. With regard to the final land preparation done by farmers, it must be pointed out that farmers did not construct bench terraces. What the farmers did was lay out basins and level the individual basins. The land of upper slopes in the Right Bank Elevation area has uneven surfaces. Thus, numerous individual basins are constructed and each basin has its own average elevation. This is a detriment to the practice of efficient conventional surface irrigation methods. Only poor flood irrigation of basins can occur and surface drainage was difficult (Joshua, 1986).

It has been reported that machinery used in the land levelling have not had a pre palnning by professionals and proper guidance of markers. No operator is sufficiently skilled to level land by eye, whether the land is to be precision levelled or only rough levelled. Inevitably the result was waste of top soil. In KOISP the soil consists mainly of reddish brown earthers and low humic gley association. The reddish brown earth occupy the upper positions of the landscape and are recommended for irrigated upland cropping. The lower topographical positions are occupied mostly by low humic gley soils and to some extent by poorly drained alluvial soils. These soils are recommended for irrigated wetland cultivation.

Consequently, KOISP cross-levelled graded bench terracing was the method of land levelling that was recommended. The principal objection to this mnethod was that if terrace grades are not maintained properly, water logging may occur during heavy rains. Due to lack of proper machinery and inadequate knowledge however in land levelling proceudres have not been satisfactory.

Irrigation behaviour was the second reason for downstream degradation in KOISP. Because of the insufficiency of water and the relative abundance of arable land, the selection of the area to be irrigation should be governed by the rules of economy. Water should be used with preference on good irrigable land, i.e. to a land with adequate permeability and good soil structure and texture. The allocation of water to moderately irrigable land, i.e. slightly undulating with low permeability is acceptable. But lands with high irrigation requirements should be excluded. This also includes lands with salinity problems requiring leeching, which increases the irrigation water demand to some 125 percent and more. Saline soils should be considered as having undeterminal suitability for irrigation and, as such, excluded from irrigation. The same should be the case for margianlly irrigable lands (Water Management Strategy Paper, Volume 1). But in KOISP both marginal and saline lands are included in the project.

Due to irrigation baheaviour saline water and soil salinity have been caused for downstream degradation. The rate of salinity has increased due to lack of proper drainage system of the project area. There is no proper drainage system in KOISP to remove excess irrigation water. Two allotments in field channel 13 which had a very good harvest in Yala 1986 were completely devastated by salinity in Maha 1986/1987.

The unlined canal system in KOISP has increased downstream degaradation further. Even the full main canal is not lined; it is only lined half way. Main canal bund erosion has occurred once between tracts 1 and 2 when water level increased due to various reasons. Technical Assistants have to effect manual ooperation of the gate regulators on the main canal in order to prevent bund erosion (Merrery and Somaratne, 1989).

The third reason was irregular supply of water encountered by farmers during the land preparation period. The actual water requirement was not considered during the land preparation. Irrigation Officials' view was that shortage of water during land preparation could have been avoided by making constant issues to all the field channels and overloading them, given the lack of actual water requirement data. The ultimate result was bund erosion of canals and the delay of water supply to the field.

The system level problems in KOISP downstream were onvershadowed by the scarcity of water in the reservoir. It is true that if there had been sufficient water in the reservoir some problems could have been avoided or their effect could have been minimal.

The fourth environmental degradation in downstream was development of health hazards due to reservoir constructions. If water flow does not occur properly ground pools will be created and it is a suitable breeding place for mosquitoes. Most of these vectors were found to be breeding in rice fields and ground pools. The secondary data on larval breeding in KOISP show the paddy fields to be a major breeding place for mosquitores. The rotation for water release does not help to contral larval breeding in the irrigation canals (Herath et al, 1986)

Hydrologically, the sloping and irregular topography of KOISP has imposed two major constraints on the drainage of the area. First, drainage of the large area of land excluded from the irrigation scheme would have required a number of culverts and other devices because, in many cases, the newly constructed roads and canal bunds have cut off stretches of the land from the natural drains. Second, numerous small unirrigable patches are scattered within the irrigation system's boundaries. These contain natural and man-made surface dperessions that do not drain to the drainage network laid out as part of the irrigation system. These depressions collect water from block natural drainage, rainfall, surface runoff and seepage, to create large and small, often brightly sunlit, bodies of stagnant water that retain an overall breeding potential for the area throughout all phases of the irrigation cycle.

The quality of the design and construction, operation and maintenance, unfarmed water management and crop husbandry also created very good breeding places of vectors in KOISP. Despite the complexity of relationships between irrigation engineering and the creation of vector breeding places, efficient water management can impede the creation of the latter. An overall improvement in water management should be an important component in any irrigation project - serving, as it does, the dual purpose of better control over vector breeding and an increased agricultural productivity.

WATERSHED DEGRADATION

A watershed is a topographically delineated area that is drained by a stream system, i.e. the total land area that is drained to some point on a stream or river. A watershed is a hydrologic unit that has been described and used as a physical-biological unit and also as a socio-economic-political unit for planning and management of natural resources. Catchment is often used as a synonym for watershed (FAO, 1986).

Watershed degradation is the loss of value over time, including the productive potential of land and water, accompanied by marked changes in the hydrological behaviour of a river system resulting in inferior quality, quantity and timing of waterflow. Watershed degradation results from the interaction of physiographic features, climate and poor land use (indiscriminate deforestation, inappropriate cultivation, disturbance of soils and slopes by the movement of animals, road construction and badly controlled diversion, storage. transportation and use of water). Watershed degradation in turn, leads to accelerated ecological degradation, reduced economic opportunities and increased social problems. In Sri Lanka, estimated degraded land is around 656,000 ha.s and it represents 10% of the total area.

In the Sri Lankan context, watershed specially refers to the stream sources and head waters of river systems, the water divides and crests of ridges, vulnerable and critical locations on steep slopes, stream reservations and riparian land and vegetation, catchment areas of major and minor reservoirs, land above an elevation of 5000 feet and erodible areas declared and proposed under the Soil Conservation Act.

The first interim report of the Land Commission in 1986 has given the high priority for watershed management proposing to establish a powerful national level authority in order to implement the modern concepts of watershed management (Land Commission, 1985).

As a concomitant of deforestation and unwise land use in Sri Lanka in the past thirty soil erosion in the catchment areas has greatly accelerated. In the absence of systematic quantitative data for sub-watershed units, there seems to be a large measure of agreement that the most critical areas of soil erosion and mass movements are in the extensive catchment of the upper Mahaweli Ganga. Forest clearance and agricultural activities have already had a drastic detrimental impact on the hydrological functions of the Kirindi Oya catchment, supplying water to the Lunugamwehera reservoir with Kuda Oya and Maha Aru. The Land Commission commented that hardly any systematic studies of soil loss have apparently been undertaken in the Kirindi Oya basin.

Without one principal agency responsible for watershed management, without a watershed management policy or a national watershed plan, or even an effective soil conservation authority to administer existing legislation a great many reforestation and agricultural improvement schemes have been implemented in Sri Lanka with little beneficial effect (FAO, 1986 (a)). KOISP is one such scheme.

The Kirindi Oya basin is narrow and the total drainage area is 455 sq. miles. The catchment area at Kirindi Oya reservoir site is 355 sq. miles. Tea and rubber plantations are located about 2000 ft. M.S.L. and comprises 13% of the catchment area. 19% of the catchment comprises of thin forests and scrub jungle.

The trunk stream of Kirindi Oya originated from just south of Bandarawela in the Badulla District at an elevation of about 1829 meters above main sea level and flows past Wellawaya, Tanamalwila in the Moneragala District and Tissamaharama in the Hambantota District before reaching the seat at a point close to Kirindi on the southern coast of Sri Lanka.

The Kuda Oya and the Maha Aru, the two largest tributaries, join the Kirindi Oya nearly harlway down the watershed, and contribute water from 113 and 30 square miles of cathcment area respectively, to the Kirindi Oya total catchment area. The Kuda Oyua, of some 22 miles in length, drains the northwest portion of the watershed and rises in the Highland some 4 miles north-northeast of Koslanda and Diyaluma Falls. Nearly half of the Upland and Highland regions are drained by the Kuda Oya and the other half by the Kirindi Oya. The Maha Aru, 14-1/2 miles in length, flows from the northeast near Wellawaya into the Kirindi Oya and drains only a Lowland area, thus producing consderably smaller flows.

Other remaining larger tributaries, nearly all flow into the Kuda Oya and drain the Upland region. Several of these tributaries, although shorter in length and draining smaller catchment areas than the Maha Aru, often produce considerably larger flows. The Kuda Oya is, therefore, the only major tributary of the Kirindi System.

In general, the entire surface drainage network of the Kirindi Oya basin is well developed and well integrated. However, it should be pointed out that even though the entire systems is well developed, only those streams rising in the Highland, and a few in the Upland are perennial.

The water resources potential of the Kirindi Oya basin has been a subject of discussion since the project was initiated in 1986. Over the years, there have been a number of estimates of water potential of the basin and the area that can be irrigated. These are, namely, the Asian Development Bank's first and second studies, Water Management Strategy Study done by an Indian firm, International Irrigation Management Institute and a number of individual research studies. The analysis of water resources in the Kirindi Oya basin however reveals a number of issues.

Some literature reviewed that the upstream development in the catchment area reduced the reservoir inflow (Dharmasena, 1986). A number of minor tanks in the upper catchment restored since 1945. The effect of restoration of minor irrigation schemes on the catchment water balances was broadly analyzed in this study and the concept was mainly depending on the changes in the evaporation and evapotranspiration rates in the catchment area of the Kirindi Oya reservoir.

Before restoration of tanks, the original tank beds would have been covered with grass, scrub jungle or forest. Water loss, therefore, to the atmosphere from the tank bed area was due to actual evapotranspiration from the original vegetation. After restoration, the condition was changed from actual evaporation to free evaporation of water from the tanks surface. In the command area, too, actual evapotranspiration rate was changed to potential evapotranspiration as it could be assumed that paddy fields are in a state of saturated moisture condition during the cultivation seasons.

In addition to the losses due to evaporation, deep percolation, application and conveyance losses are also assumed as losses and will not be significant in recharging the groundwater table as a contribution to the catchment water balance. This study indicates how the command area under the new reservoir would be affected by undertaking new developments in the catchment area and it has approximately a 4:3 ratio. In other words, the design command area according to the results of an operational study carried out in 1986 will hold good only if the catchment characteristics are not going to change. Therefore, the necessity of closely monitored watershed management plan need not be emphasized (Dharmasena, 1986).

A similar study has been done by a German firm (SCG, 1987) and a similar situation is encountered in catchments of the tanks. They consist of the intermediate and lowland geomorphological zone. Extensive and obsolete methods of cultivation excessively limit the water holding capacity of soil, which decreases low flows and increases the flood hazard. Construction of small reservoirs for local storage of water for rice irrigation contributes to further decrease of low flows. In the Kirindi Oya catchment, some twenty to thirty large irrigation tanks have been constructed in the last thirty to forty years.

Important land use changes have substantial effect on the hydrologic regime. The total annual runoff from the catchment has steadily increased whilst there were no corresponding changes in the rainfall. This change has increased the availability of water due to the regulating function of Lunugamwehera reservoir. Without this storage, the impact of deforestation would have reduced the area under potential irrigation.

This study, however, concludes proposed to co-ordinate hydrological studies in the catchment area.

In accordance with another research of water resources analysis in the Kirindi Oya basin reveals the existence of some interesting hydrological relationships (Madduma Bandara, 1985). The upper catchment of the basin, although small in size, contributed a disproportionately large share of the total water resources as exemplified by the Kuda Oya basin. This clearly indicates the necessity for conserving the upper catchments in order to optimize the utilization of water resources in the drier downstream areas. The rate of forest clearance had been extremely rapid and widespread in all parts of the Kirindi Oya basin during the last few decades and its adverse effects are now beginning to be felt in the hydro-ecosystem. Deforestation results in an increase of peak discharges of super-floods, which cannot be balanced by the regulation effect of the reservoir. It was pointed out, however, that watershed management established in the upper catchment jeopardizes the successful water management and utilization of water resources in the lower catchments. The impact of the deforestation and cultivation can be seen from the erosion hazard map prepared by the Land Use Division of the Irrigation Department for the year 1988. The survey and investigation to assess the present situation and consequences of the potential development should be intensified and co-ordinated. This study would suggest to have an adequate hydrological program to measure discharge in the Kirindi Oya catchment, including a rapid transformation.

There is a rapid transformation from an area of forest jungle to intensive agriculture in the Kirindi Oya basin (Water Management Strategy Paper, KOISP, Vol. 1). Forest clearance and agricultural activities have already had a drastic detrimental impact on the ecosystem of the catchment. The pace of these activities, which are undesirable from the environmental balance point of view and inexpedient from the development point of view has increased spectacularly in the last few decades. In the project proposal the major environmental effects of the project have been mentioned but there has been no significant consideration given.

Important land use changes have a substantial effect on the hydrological regime in the Kirindi Oya basin. The total annual runoff from the catchment has steadily increased whilst there were no corresponding changes in the rainfall. These changes has increased the availability of water due to the regulating function of the Lunugamwehera reservoir. Without this storage, the impact of deforestation would have reduced the area under potential irrigation.

The streamflow records at Lunugamwehera definitely indicates an increase in the annual water yield of the Kirindi Oya basin while rainfall remained more or less static. The only explanation for this phenomenon appears to be the clearance of forest cover which has led to an increase in runoff. All these inferences taken together leads to the general conclusion that there is a real necessity for a high degree of co-ordination in developing water resources in different segments of the Kirindi Oya basin. The administrative boundaries that haphazardly cut across natural watersheds should not in any way be permitted to hamper an integrated development of water resources (Madduma Bandara, 1985).

Realizing the problem of siltation of reservoirs under construction a program of watershed management has been initiated to protect the Kirindi Oya catchment area from erosion and degradation and thereby protecting the reservoir from premature sedimentation. Before preparation of the watershed management plan,the Hydrology Division in the Irrigation Department was instructed to carry out a study to estimate sediment yields in Kirindi Oya. Due to the urgency of the report the period of observation had to be limited to a period of five months to obtain a very approximate idea about sediment transport capacity of the Kirindi Oya (Dharmasena, 1987).

In this study, sediment load was estimated by direct measurements using water samples. According to the study, the estimated sedimentation rate will not form any major threat to the life span of the reservoir. When the suspended load is compared with the bed load, the suspended load is almost three times the bed load. By effective soil conservation methods, the suspended load can be controlled as it depends on the intensity of rainfall, land use, catchment slope etc. Therefore, any watershed management plan in a river basin will have a significant contribution to control the total sediment load. During this study, there was no surface runoff in that area. If the surface runoff occurred, suspended load would have been very much than the measured value.

Senarath and Joshua revealed that erosion from the catchment area does not cause any major siltation problems in the reservoir during its life span period of one hundred years (Senarath and Joshua, 1986). They have estimated the total soil erosion from the Kirindi Oya catchment area as 1,644,025 tons per year. This total volume eroded is not transported into the reservoir as sediment load. Comparative work done in the USA reveals that the sediment load transported is about 20% of the eroded soil volume. Therefore, 166,063 m3 of sediment load can be expected annually. This is about 134 cu. ft. and it is only 0.07% of the reservoir capacity. The dead storage capacity allowed at the Kirindi Oya reservoir is 13,320 cu. ft. The total sediment load is transported during the one hundred year period is 13,400 cu. ft. Field reports, however, mentioned the necessity for continuous measurements over at least six years in order to draw up firm conclusions (Table 1).

TABLE 1

FIELD MEASUREMENTS OF SEDIMENT TRANSPORT

Basin	Period Months	Area KM2	Annual Sediment Yield			Specific Weight t/m3
			acft sq.m.	t/km2	m3/km2	
Kirindi Oya (Lunugam-wehera)	1952-57 (60) 1951-52 (12) 1985-86 (12)	913	0.4 0.137 0.379	111 89 357	190 65 180	0.58 1.36 1.98

****

ENVIRONMENTAL DEGRADATION IN KIRINDI OYA BASIN

INTRODUCTION

The deterioration of the environment resulting from the interaction of human activities, delicate ecosystem and natural climatic conditions has reached alarming proportions in many parts of the world. This process includes the degradation of upland water basins; the destruction of forests and desertification caused by excessive deforestation and land degradation. The adverse effect of human activities is reinforced by the change from subsistences to cast economy which in combination with dramatic population growth has led to an expansion of cultivated areas, an increase in cultivation intensity, deforestation, use of marginal lands, fuel-wood harvesting and soil impoverishment.

In most developing countries, the lack of environmental consideration however in the planning process of water catchments can sometimes create a severe impact of an irreversible nature on the environment, resulting in ecological destruction. In Sri Lanka, too, the lack of environmental consideration in the water catchment and planning of several river basin development projects has created adverse environmental impacts. Although several river basin development projects are progressing at a rapid rate and many beneficial effects are being recorded, the environmental impacts of some projects have not been what planners had expected. Serious problems emerging from time to time have drawn the attention of all concerned to the fact that water projects may yield a mixture of desirable and undesirable effects. It has become clear that several of these projects have been planned and designed without taking into account the complex interrelationships between people, water, environment and development.

In the common perception of water supply and resource development, environmental issues have generally played a minor role. However, the continued availability of water for human consumption and production depends on its continuous circulation through fragile ecological systems in nature. Changes have been brought about the those systems by natural resources degradation and unsustainable water use, and in some areas the recharge of the sources of surface and ground water is diminishing.

Unorganized development has since resulted in water utilization for immediate and local needs in an uncoordinated manner, with water acting both as a catalyst and as a barrier to development. This is due to such factors as the complexity of the water environment, political conflicts and lack of planning and technical knowhow Traditional social and cultural systems have meant that the level of utilization of water resources is limited by availability and energy requirements. Despite these constraints, impressive development has occurred in some cases as a result of cultural and political influences. For example, water resource management system in Sri Lanka which dates back some 2000 years and includes extensive storage and distribution systems (Danida, 1988).

FUNCTIONING OF WATER CATCHMENTS

The deterioration of the environment resulting from the interaction of human activities, a delicate ecosystem and natural climatic conditions has reached alarming proportions in many parts of Sri Lanka. This process includes the degradation of upland water catchments, the destruction of forests, excess deforestation and land degradation.

An important aspect of water catchments in the agricultural sector is prevention of soil erosion which, most often, is caused by deforestation. Soil erosion leads to the loss of valuable top soil and causes silting, sedimentation and turbidity problems in downstream areas. Although it is unavoidable that storage reservoirs will receive some sediment, the upper watersheds should be managed in such a way that the design lives of reservoirs are not reduced. Erosion should be prevented primarily by eliminating its causes. However, in many cases this is a task of formidable proportions.

The adverse effect of human activities is reinforced by the change from subsistence to cash economy which in combination with dramatic population growth has lead to an expansion of cultivated areas and an increase in cultivation intensity. This has led to deforestation, use of marginal lands, fuel-wood harvesting, over grazing and soil impoverishment.

The hydrological regime of water catchments is affected by climatology (rainfall and evaporation), geology, topography, vegetation and soil types. The three latter factors play a significant role in determining the relative importance of the individual components of the water balance of a water catchment through evapotranspiration, rapid surface run off and groundwater recharge.

The removal of vegetation or reduction in leaf area of plants will often lead to reduction in evapotranspiration and interception losses, and hence increases in total run off. How this total run off is divided between surface run off, infiltration and groundwater recharge depends on the infiltration capacity of the soil and topography, with surface run off being relatively more dominant with decreasing infiltration capacity and increasing steepness of slopes.

It follows that soil and vegetation cover can influence the hydrological regime of water catchments by reducing flood flows and increasing dry season flows as a result of increased groundwater recharge. However, water also affects soil and vegetation, being an active agent in soil erosion and plant growth. Hence, soil and water conservation are highly interrelated and, as such, require an integrated approach to ensure sustainable conditions in watersheds.

The interaction between vegetation, soil and water is illustrated in Fig. 1A. The present conditions are characterized by human and animal destruction of vegetation cover and soil compaction leading to reduced infiltration and rapid surface runoff, and soil erosion, deterioration of soil productivity and sedimentation of rivers causing rising of river beds and subsequent flooding.

A model for sustainable development, illustrated in Fig. 1B, relies on soil protection to increase infiltration and groundwater recharge and hence that water is available for food and fodder production, especially in dry seasons. The reduced surface runoff leads to reduced soil erosion and improved soil productivity; at the same time, the risk and magnitude of floods are less and dry season flows increased.

The close relationship between soil and water conservation is of special importance in upland water catchments. Negligence and lack of knowledge of the importance of upland water catchments in soil and water conservation do not only affect people living in these areas, but also result in considerable damages and losses for lowland population due to flooding and sedimentation of reservoirs. As a result, an estimated 160 million hectares of upland water catchments in tropical developing countries have been seriously degraded, affecting approximately one fifth of the world's population (Danida, 1988).

EXPLOITATION OF WATER RESOURCES AND ENVIRONMENTAL ISSUES

The exploitation of water resources from both surface and groundwater sources constitutes, in effect, an intervention in the hydrological cycle. The water which is thus exploited will return to the environment in one form or another, in many cases more polluted.

One result of continuous exploitation of surface and groundwater sources can be the periodic or permanent lowering of the groundwater table or water level in surface water bodies, thus limiting both the quantity and quality of water available for other users. The natural recharge of groundwater aquifers decreases, sometimes seriously, when the utilization of surface water or surface runoff increases.

Heavy and sustained extraction of water and the resulting changes in its quantity, quality and accessibility can have irreversible effects on the flora and fauna in the affected area. For example, the Niger river dried out for the first time in history in 1986, due to the combined effects of drought and the extension of areas under irrigation with consequent water losses due to evaporation.

Dams and reservoirs are another form of water resources exploitation even though these projects are very important to the economy. In these large scale water projects the social and environmental impacts have to be addressed in upstream areas including resettlement of people living in the impounded area, loss of valuable fertile land, effects on wildlife and fish and loss of income for people on fishing, farming and related activities.

In the reservoir itself, decomposition of vegetation may seriously affect water quality and sedimentation will affect fisheries, dam equipment, reduce storage capacity of the reservoir and increase the risk of downstream flooding. In the downstream areas, flooding due to failure and sudden released of water may cause considerable damage to people living in flood plains, and loss of crops and fertile soils as the reservoir prevents the downstream transport of silt with its high nutrient content. Reduced downstream transport of silt may also lead to serious erosion problems in the river and delta area, and saline intrusion may increase because of reduced freshwater flow.

Irrigation is another major scale consumption area. Common sources of irrigation water are streams and rivers, downstream releases from reservoirs or pumping from groundwater aquifers. In addition, conjunctive use of surface and groundwater is particularly attractive in regions where dry season irrigation is impossible from surface water sources alone. Irrigation consumes eighty per cent of all fresh water used by humans today.

The major environmental problems related to irrigation schemes result from the excessive application of water to land with poor or non-existent drainage facilities. This may saturate soil, impede aeration, leach nutrients and increase evaporation and soil salination. The groundwater level rises and the land finally becomes waterlogged with increasingly saline water. Once thriving civilizations in ancient Sri Lanka were destroyed as a result of water-logging and salinization. Preventing water-logging and salinization is very costly and requires proper drainage systems, efficient water use, and continuous monitoring of soil salinity. Lining of irrigation canals and conjunctive use of surface and groundwater may alleviate the problems but is not as effective as a proper drainage system.

Reduction of downstream river flows due to diversion of water may affect human communities relying on water for drinking or dilution of waste water. Water quality downstream may deteriorate as a result of the increased leaching of biocides, fertilizers and salt which can make the river inadequate for irrigation and drinking as well as altering the biota in the water system.

The reduced river flows may also create breeding grounds for mosquitoes and other organisms that are vectors of human diseases. Soil erosion may result from the cultivation of annual row crops under intense irrigation. Changes in the ecological balance caused by increased population density as a result of new irrigation projects is another threat.

ENVIRONMENTAL EFFECTS OF WATER RESOURCES DEVELOPMENT

Broadly, four types of environmental effects of water development may be recognized.

The first one is disruption of human settlements and human activities. Occasionally such disruptions are very large. Insufficient attention to the assessment of bio-physical and socio-economic factors in relation to settlement activities can lead to a number of serious adverse impacts, many of which may not become evident until after a project is well under way. There are two basic categories of activities associated with settlement which influence the environment. The first relates to the formulation, design and implementation of the settlement and the second category includes productive activities which form the economic base for the settlement scheme.

The second type of environmental effects associated with water development in some parts of the world is the creation of favourable habitats for the parasitic and water-borne diseases, such as malaria and filariasis. This has been especially the case with certain irrigation projects, particularly in tropical and sub-tropical regions. Replacement of simple traditional irrigation practices with perennial schemes could lead to a considerable increase in the water-borne diseases.

A third type of environmental disruption is physical or chemical. It generally results from the alteration of land use, changes in the surface or groundwater regime, usually as a consequence of the construction of irrigation projects or flow control works, such as dams or levees. Soil salinization and waterlogging due to the lack of adequate drainage facilities is a classic example of such environmental problems.

One of the most serious environmental disruptions of this category is siltation. Reference is frequently made to reservoirs that were built for flow control or generation of hydro-electric power where the rate of accumulation of sediment was so rapid that a major reduction of reservoir capacity occurred within a few years of the construction of the associated dam.

Finally, the fourth category of environmental effects of water resources development deals with flora and fauna, including impacts on ecological systems taken in a broad sense of this term. For example, ecological problems that results from dam construction in certain regions of the world is that of the spread of aquatic weeds. The spread of weeds has a number of secondary impacts, notably water loses through evapotranspiration. Costs of weed clearing may be in the order of millions of dollars and some times the effects of the remedy may be even more destructive and hazardous than the weeds themselves. The use of herbicides is an example. Wildlife preservation also falls into this category of environmental effects.

It is clear from the foregoing that environment has a wide variety of meanings and that environmental disruption can take many forms. In some instances, water projects may even result in the destruction of the resource on which they depend. But it is also apparent that severe damage of water resources may be inflicted by activities other than those directly related to water resources development. Unfortunately, many essential "non-water" activities are decided on without due consideration being given to their potential impacts on the aquatic environment.

In fact, sometimes they are decided by nobody - they just happen as a result of the specific social and economic conditions. For example, the uncontrolled expansion of urban centres in many developing countries caused by migration of population from the poverty stricken rural regions. The excessive use of fertilizers and pesticides to increase crop yields is another example of a "non-water" activity having serious consequences for water quality. It is important, therefore, to consider linkages between environmental problems. Irrigation projects may not only result in soil salinization and waterlogging, but also may produce infestation by undesirable aquatic plans or create enlarged habitats for water-borne disease vectors. The experience underscores an important point, that remedial measures must be spread over a number of "non-water" sectors and activities, taking into account primary and secondary environmental effects as well as cumulative impacts (Biswas, 1989).

White (1970) pointed out that environmental effects of water resources development are real and it seems likely that man can cope with them effectively only through a very close integration of natural and social sciences, which should be adequately reflected in educational processes and institutional arrangements.

ENVIRONMENTALLY SOUND WATER RESOURCES DEVELOPMENT AND MANAGEMENT

Since the beginning of contemporary water management, respect was usually given to the conservation of nature, mostly in the form of supplementary comments in project reports. But gradually emerging problems have drawn attention of water resources planners to broader environmental implication of water projects. By the 1950s, for example, studies carried out for the Volta River Project identified questions of health, fisheries and resettlement. Because negotiations to finance the project took several years and the government became pre-occupied with the urgency of building power generation and aluminum smelting facilities (HMSO, 1956), construction started without adequate arrangements being made to deal with the health, fisheries and resettlement questions. It was rather late when actions were taken to deal with them.

Keener identified, in the late 1960s, "of the full network of ecological impacts incurred by construction of water projects" were stressed among major shifts in perspective of river basin planning (United Nations, 1970). With the passage of time, the worldwide recognition of the general decline in environmental quality has led to increasing pressure for its explicit inclusion as an objective , in addition to economic and social objectives, in water resources planning and management. Since water resources planners have always been concerned with evaluation of various intangibles and hard-to-quantify factors, the field was conceptually prepared for inclusion of the new environmental objectives.

Besides the largely unsuccessful path towards aggregation of indices of performance concerning individual objectives into a single monetary measure of composite achievement, inclusion of the environmental objective has been approached basically in two different ways:

1. by application of the multi objective framework of analysis; and

2. the Environmental Impact Assessment (EIA).

water resources planners have leaned towards a multi objective framework of analysis. Although the multi objective methods and techniques have not yet been applied on a wider scale, their interest in this approach continues.

The Environmental Impact Assessment (EIA) approach was pursued on a separate work track. In 1970, the USA became the first country to adopt legislation requiring an EIA on major projects. Other countries followed, and parallel with the growth of legislation there has been rapid development of various concepts, methods and techniques for EIA and it will be described in another section of this report.

Environmentally sound management of water resources must be considered then both at the zone and project levels. At both levels, account must be taken of the dynamic interrelationships between humans and their institutions, water, land, energy, climate and the entire biosphere. Land use patterns must be watched, taking into account their potential impact on surface and groundwater resources. Water quality must carefully be managed and monitored. A combined forest and watershed management must be contributing to water conservation in the catchment. All these factors must be simultaneously considered with the framework of a comprehensive basin-scale water resources analysis (Falkenmark et al, 1987).

There is no surprise, therefore, that the EIA methods that have been evolved so far "are not proving to be particularly effective in improving allocation decision." In fact, this would be incompatible with the purpose for which the EIA was originally developed. Instead of extending these purposes to encompass a more comprehensive evaluation perspective, an integration of EIA within the broader multi objective decision making framework is required.

All these considerations lead to a broader concept of the environmentally sound water resources development and management. This concept was given considerable impetus as a result of the proposal for a World Conservation Strategy by the International Union for the Conservation of Nature in 1980 which has called for a reorientation of all resources management practices in favour of sustainable development. It means such development that does not assume resources are cost-free and endless-development that does not force the poor to destroy tomorrow's resources just to stay alive today.

Based on the foregoing discussion, environmentally sound and sustainable development and management implies the following (Sewell and Biswas, 1986):

a. Development is controlled in such a way as to ensure that the resource itself is maintained and enhanced, and that adverse effects on other resources are considered, and where possible, ameliorated;

b. Options for future development are not foreclosed; and

c. Efficiency in water use and in the use of capital is a key criterion in strategy selection.

A review of processes currently used by developing countries to incorporate environmental issues in water management indicate that methodologies available at present do not appear to satisfy the special requirements of those countries. While the Environmental Impact Assessment process was made manadatory in several industrialized countries, its acceptance so far in developing countries has been somewhat slow. The reason for this slow acceptance is the lack of an operational methodology that can be successfully applied in developing countries with limited expertise, resources, data and time. The EIA methodologies that are being used in industrialized countries are not directly transferable to developing countries for various socio-economic and institutional reasons.

Even in those developing countries where multilateral and bilateral aid agencies have carried out fairly comprehensive environmental impact analyses of water development projects, primarily with foreign experts and consultants, their overall impacts in developing countries appear to have been generally minor. This is because such EIAs were carried out primarily to satisfy the internal requirements of the bilateral donor countries and the multilateral funding agencies, and generally not at the best of developing countries in which the projects were located. Not surprisingly, involvement and interest of developing countries in such external analyses have been minimal and somewhat superficial.

****

ENVIRONMENTAL IMPACT ASSESSMENT METHODOLOGY

INTRODUCTION

Water reservoirs are built essentially to store water which would otherwise flow to the sea during floods and be wasted. Any large scale storage of water is bound to have environmental impacts which, if properly identified in the planning stage, it would help in minimizing the adverse effects and in maximizing the advantages of the development projects. Recently there has been a move to examine and evaluate water projects for their design and for their impacts on the relevant environmental system (Mistry and Purohit 1989).

Environmental Impact Assessment (EIA) can play an important role for identification of these impacts as a planning tool for development, contributing to the discussion of more appropriate alternatives, based on a country's socio-ecological potentialities, and better adapted to the new situations to be faced during the actual crisis period.

An increasing interest is being shown in some of the early experiences in the practice of EIA on large-scale water projects in developing countries. These projects have been usually taken as a development factor, providing the infrastructure for introducing new forms and scales of production in Third World countries (Monosowski, 1986). However, they have been a source of significant environmental and social change. Their social and environmental costs have very often outweighed their expected benefits, which explains the interest shown in adopting EIA for evaluating this kind of projects.

Environmental Impact Assessment is normally incorporated at a very early stage in the development planning process to determine management alternatives for achieving desired economic and social objectives and to assist in the formulation, design and management of projects. Environmental Impact Assessment is normally used to evaluate the relative merits of a specific development proposal, or to examine existing development activities to determine means of reducing adverse impacts.

However, EIA is a study of the effects of a proposed action on the environment. In this context, "environment" is taken to include all aspects of the natural and human environment. Therefore, depending on the effects of the scale of the proposed action, an EIA may include studies of the weather, flora and fauna, soil erosion, human health, urban migration, or employment, that is to say, of all physical, biological, social, economic and other impacts.

EIA seeks to compare the various alternatives which are available for any project or program. Each alternative will have economic costs and benefits, as well as environmental impacts, both adverse and beneficial. Naturally, there must be a trade-off between the pluses and the minuses. Adverse environmental impacts may be reduced at higher project cost. EIA seeks to compare all feasible alternatives, and determine which represents an optimum mix of environmental and economic costs and benefits.

EIA is based on predictions. The technical work involved is estimating the changes in environmental quality which may be expected as a result of the proposed action. It attempts to weigh environmental effects on a common basis with economic costs and benefits in the overall project evaluation. If this is done, the decision-maker is less likely inadvertently to overlook an environmental consequence in arriving at his decision. Also he is less susceptible to charges of "undue influence," which tend to arise when environmental effects are considered separately from economic effects.

Finally, EIA is a decision making tool. Its ultimate objective is to aid judgmental decision making by giving the decision maker a clear picture of the alternatives which were considered, environmental changes which were predicted, and the trade-offs of advantages and disadvantages for each alternatives.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) AND ENVIRONMENTAL IMPACT STATEMENT (EIS)

Environment Impact Assessment is a brief examination conducted to determine whether or not a project requires an Environmental Impact Statement. When a new project is proposed, the EIA is the study which identifies the full environmental study that would be required. If the project is found to be exempted, a statement of negative findings is made. If not, work on the full environmental study proceeds and the findings are reported in an EIS. Clearly, EIS represents the fundamental activity, and EIA is simply an introduction to it.

Nevertheless, in most of the developing countries, generally, EIA is used to include the technical aspects of the environmental study, including data gathering, prediction of impacts, comparison of alternatives and the framing of the recommendations. EIS refers to the document which summarizes the results of the study, and forwards recommendations to the decision maker. According to the USA definition, the EIA in this context is the substantial technical activity, for which the EIS is a necessary reporting device.

PUBLIC INVOLVEMENT INTO EIA

One of the most significant aspects of EIA in many countries is the involvement of the affected public in the environmental impact study. This has taken two forms: the direct involvement of the public, and the inclusion of local values in environmental methodologies. The first inclusion of local values in the EIA process comes at the scoping stage. After the scoping exercise, there is a baseline study and quantification of impacts, followed by comparison of alternatives. Local perceptions of the environment must be included in the computations. If a cost-benefit analysis is performed, then the cash values placed on environmental impacts must reflect the society which will be affected.

If the cost-benefit analysis is deemed inappropriate there is another technique for doing this which involves the use of weighting-ranking or weighting-scaling checklists. A feature of these checklists is the assignment of relatively important weights to different aspects of the environment (Ahmad et al. 1987).

The second form of public involvement is direct comment by the public on the EIA. This is the process which is more generally referred to as "public involvement" or " public participation". The objective is to inform the public of what has been done and to seek their comments. Unlike in the inclusion of local values, which is integrated into the technical work of the EIA, public comment usually comes later on, after much of the technical work has been completed.

ENVIRONMENTAL ASSESSMENT PROCEDURES (EAP)

The environmental assessment procedure consists of six distinct phases:

1. PRELIMINARY ACTIVITIES

This includes the number of first steps that must be taken, including the identification of questions that must be answered, before an EIA can start. Among these are actions to - identify decision makers, select a coordinator, decide on work allocation, write a description of the proposed action and review existing legislation.

2. IMPACT IDENTIFICATION (SCOPING)

This is the process of identifying the important issues which must be addressed in detail in the Environmental Assessment. After developing the checklist, comes the task of determining which impacts should be studied in detail. Generally, four criteria should be applied: magnitude; extent; significance; and special sensitivity.

3. BASELINE STUDY

The baseline study is simply a record of what existed in an area prior to an action. It is not an end in itself and should not be mistaken for such. The baseline survey itself will require field work and review of existing documents.

However, this is the stage when the technical specialists make their first major inputs into the EIA.

4. IMPACT EVALUATION (QUANTIFICATION)

The quantification of impacts is the most difficult technical aspects of an EIA. It is also the most controversial. It is generally agreed that the quantitative change due to an impact should be computed wherever feasible. This document consists of a description of the proposed project, existing environment, impact analysis, mitigation, protection and enhancement measures, recommended actions, appendices, reviews and comments.

5. ENVIRONMENTAL ACTION PLAN

This is an implementation plan for specific mitigation, protection and/or enhancement measures which are recommended in the Environmental Assessment. The Environmental Action Plan presents in detail how these measures should be designed and operated, the resources required and the schedule for implementation. This document contains a work plan for design criteria, implementation schedule and staff and resources required (Figure 6).

6. SUPPLEMENTAL ENVIRONMENTAL REPORT

If a major change is made in a proposed project after the Environmental Assessment and/or Action Plan have been completed, then a Supplemental Environmental Report will be prepared to evaluate specific impacts which may occur due to the new changes (Figure 6.1).

METHODS USED IN THE ASSESSMENT

When carrying out the study, a number of techniques were used for handling information in the form of field surveys, monitoring, modelling, providing guidelines, literature surveys, workshops, interviews with specialists and public opinion polls . These techniques are used to at various stages of preparation of an EIA statement. When selecting an EIA method from among the available tools, the following questions should be considered as thoroughly as possible (Pande et al. 1989).

(a) comprehensiveness

(b) selectivity

(c) mutual exclusiveness and objectivity

(d) prediction of the interactions of various processes (Figure 6.2)

A large number of methodologies have been developed over the last years to assess EIA. According to the local conditions, different subjects have different impacts on environmental factors, so no single methodology can be universally acceptable. The methodologies which have been most extensively used are briefly discussed here.

AD HOC METHODS: Ad hoc methods give broad qualitative information which is of value in comparing alternative development sites or schemes. The information is stated in simple terms readily understandable by a decision maker or a member of the public, and no attempt is made to outline the actual impacts on specific parameters which will be affected. For example, there may be an indication of the number of people likely to be affected by a project adversely or favorably, the extent of the area likely to be developed or affected, etc..

CHECKLISTS: (Rapid Assessment Procedure) Checklists are one of the most basic methodologies used for impact assessment. Simple checklists identify environmental attributes that would be affected by a proposed project without any particular measurement or interpretation of impacts. They require that the project authorities should fill in a questionnaire giving detailed basic information related to the ecological aspects and other relevant aspects of the projects. The questionnaire elicits detailed information on various measurable changes as well as subjective scaling of other impacts which would result from implementation of the proposed project. Well-thought-out checklists of all the likely impacts based on critical case studies and past experience can form one of the most useful tools of an EIA.

OVERLAYS: This methodology uses a set of transparent maps of the project area to identify, project and illustrate the relative significance of various environmental characteristics (physical, social, ecological, etc.). The study area is subdivided into geographical units based on uniformly spaced grid points, topographical features or differing land uses. Within each unit the assessor collects information on environmental factors and human concerns. By means of the overlays so produced, the best combination of factors may be identified. Computers can be used to perform the task of aggregating the project impacts for each geographical subdivision and for searching for the areas least affected. The overall approach can accommodate both qualitative and quantitative data.

MATRIX METHODS: Matrix methods are checklists in which possible project activities are represented along an axis and potential environmental impacts along the other. In this manner, cause and effect relationships between project activities and impacts are identified. The entries in the cells of the matrix can be either qualitative or quantitative estimates of the cause and effect relationships. A number of different types of matrix methodologies have been developed and used for different water resources projects. In some, quantitative estimates have been combined into a weighing scheme leading to a total impact score.

NETWORKS: Network methods are an extension of matrices to incorporate long-term impacts of project activities. The project is generally defined as a set of possible impacts (from past experience of a particular project) and users can identify likely impacts and classify them as primary, secondary or tertiary. The major strength of the network approach is its ability to identify pathways for both direct and indirect environmental effects and it is useful when considering mitigating measures during the early stages of project planning.

METHODS OF ASSESSMENT FOR KOISP

Taking all these methods into account, the rapid appraisal method has been identified to be used at this stage of the analysis (Figure 6.3). The questionnaire makes use of impacts that might be expected from different activities and are based on past experiences. Various questionnaires currently exist. USAID (US Agency for International Development) has developed a questionnaire for assessing irrigation projects in the view of environmental consequences (Tillman 1981) and the Hydraulics Research Limited in Wallingford has developed another checklist of this nature (Boltan 1990). Asian Development Bank has developed environmental guidelines for irrigation projects (ADB 1987). Many types of checklists are available. Among them are simple, descriptive, scaling, scale-weighted and questionnaire checklists.

When questionnaires are useful and have certain advantages, they suffer from some limitations as well. They cannot assess the dynamics of change or the related uncertainties. Moreover, they deal only with the environment. Attention is focused only on the environmental impacts, and project performance in terms of other objectives is not considered. Nonetheless, checklists are useful as an initial guide, helping to ensure that important environmental factors are not left out of the analysis.

The checklist is designed in three sections to provide a procedure for assessing the potential for significant adverse environmental effects.

SECTION 1: includes general questions, which are in most cases, easy to answer from the information collected from the pre-feasibility study. The questions are grouped according to standard headings, i.e. hydrological changes, organic and inorganic pollution of surface and groundwater, salinity of soil and water and waterlogging, erosion and siltation, socioeconomic disruption and resettlement; health and ecological imbalance.

SECTION 2: includes questions which are specific to a particular type of environmental effect and which may involve in collecting more information. The questions are grouped according to the area of impact to which they relate. The collected information from section one of this section could be used to complete the checklist and to suggest action to take into account where a negative impact is indicated or where data or expertise are inadequate to form an opinion.

SECTION 3: includes a group of questions which should be answered by the farmers or settlers in the project area. The questions relate both to the irrigation project, including the problems which farmers face in cultivating their crops, and to the health of the people in the particular village.

INTERPRETATION OF THE CHECKLIST:

In order to assess the seriousness of each of the impact listed in section 2, evaluation has been made on the information in Section 1. A scoring system has been developed to assess the impacts of the project (Figure 6.4). The scores carry no quantitative meaning but act as codes for the following:

SCORE	MEANING
1	Positive impact is probable
2	Positive impact possible
4	No positive or adverse impact likely
5	No judgement possible at this stage
7	Adverse impact probable
8	Adverse impact possible

No positive or adverse impact likely:

(Impacts for which a score 4 has been assigned)

This is the simplest outcome. The identified issues in the project appraisal reported fall into this category together with any assumptions made or questionable pieces of data relating to each impact so that if the assumptions or data are revised later, the possible impact will be reassessed. Clarification should also be given for each impact is unlikely or a negative impact may occur but its scale is not judged to be serious.

No judgement possible at this stage:

(Impacts for which score 5 has been assigned)

This score is, in effect, a partial judgement indicating that a serious negative impact seems feasible but that the data or knowledge available are not adequate to give a more definite assessment. This result could be treated either in the same way as score 2, assessing what data would be needed to reach and possibly collecting some immediately, or in the same way as score 8 looking for possible adaptations to the project and incurring of the magnitude and seriousness of such an impact.

Adverse impact possible:

(Impact for which a score of 8 has been assigned)

The implications of assigning a score of 8 are that there is a certainty of serious adverse impact in project planning. Some doubt may still remain as to the likelihood or seriousness of the impact, but further data collection at this stage is unlikely to improve the certainty of the assessment. The first response to this result should be to review the project proposal to identify where the intended design or operation could be modified to reduce or remove the adverse impact or where counter-measures could be taken. In the real practice of EIA, at the early phase of project planning it is relatively easy to introduce quite major changes to project proposals. If similar changes were to be proposed at a later stage they might meet resistance and cause a considerable increase in the time and expense of the planning process.

OTHER METHODS USED IN THE ASSESSMENT

The other methods used in the assessment to obtain reliable results are briefly described below:

Field Investigation: The data and information collected from the questionnaire have been investigated in the field with the assistance of the project planners, engineers and the settlers. Another purpose of the field investigation was to assess the validity of information about the project.

Analogue: Some of the environmental parameters of the KOISP with similar completed projects were investigated using this method. Especially Mahaweli project explored in this nature.

Interviewing: This is one of the most efficient methods for assessing a single environmental parameter. Besides, as mentioned above, each parameter was studied by interviewing officers as well as settlers and farmers as relevant. This practically confirmed reliable conclusions for the assessment.

MAJOR IMPACTS OF THE PROJECT

Even though an environmental evaluation has not been carried out in the early stage of the project, some major, positive, long-term environmental impacts as well as negative impacts have been identified in the planning stage(ADB Report 1982).

The major, positive impacts identified by the project planners were:

* Land use changes - arrest *chena* (swidden) cultivation and its widespread destruction of forests and soil erosion.
* Crop production - convert the land into stable, sustainable high productive farms through proper land use and crop water management practices.
* Improvement of living conditions -

The ADB mission in 1986, has identified the major negative environmental effects of the project as:

* Converting secondary forest area to settled irrigated cultivation.
* Introduction of new settlers to the project area.

To identify the basic environment issues of the project, the designed questionnaire was field tested over a six month period. It has been reassessed three times for further clarification. Finally, it has been analyzed with a rule based interpretation as described in Chapter 6 and presented in Figure 6.4. KOISP is a very complex system with new development and old developed areas. Except that two other systems, Badagiriya and Ellegala have been in coöperated to the main system. Therefore environmental problems associated with the project is also very complex. In the socioeconomic terms, new area settlers have separate issues while old area farmers are having some other problems.

Taking into account of all these aspects the following major impacts were identified:

1. Impacts of Lunugamwehera Reservoir and dam construction
2. Changes of hydrological conditions
3. Watershed conditions and changes of land use
4. Losses of forestry, wildlife and fisheries
5. Potential of water-borne communicable diseases
6. Impacts associated with settlement
7. Issues associated with the operation and maintenance
8. Salinity of soil and water

Special consideration was given to evaluating impacts link between human and natural environments. This involved specific interviews with settlers to determine how the project has been affected for domestic water use health care services,living conditions, source of firewood and other primary facilities.

IMPACTS OF LUNUGANWEHERA RESERVOIR AND DAM CONSTRUCTION

The construction of the reservoir has made a lot of changes in the hydrological regime and created new conflicts between various branches of the water economy depending on the character and degree of runoff regulation, reservoir parameters, preparation of the submerged land operating regime, time of construction, initial filling etc. The construction of the reservoir, however, was accompanied by a number of undesirable impacts on natural conditions, on the economy of the territory where it is situated and on the areas downstream. Reservoir parameters (surface, volume, depth, length, width, configuration, composition of rocks forming bed and shores, character of regulation, operation regime, regional climate) all have a great influence on the changes in the natural processes and the direction of these changes, both upstream and downstream of hydraulic structures. The character and scale of diurnal, weekly, seasonal and annual flow variations have a considerable influence on changes of the natural conditions downstream of the dam (Avakian 1986).

There is much benefit for economic development from Lunuganwehara reservoir which was constructed across the Kirindi Oya. Among such benefits, the following are the most important:

(a) annual, seasonal, weekly and diurnal runoff redistribution and creation of water surface for irrigation purposes.

(b) transformation of the hydrological regime for rational land-use.

(c) recovery of non productive land for accumulation of water.

(d) attenuation or complete elimination of natural phenomena such as floods, mud-flows, siltation of canals, etc.

(e) improvements of natural conditions in the neighboring area; milder climate, construction of a special network of water bodies, etc.

At the same time the construction of Lunuganwehera Reservoir and its operation involve a number of undesirable and, as a rule, inevitable environmental changes. The most significant of these are:

(a) inundation of lands

(b) transformation of reservoir bed and shores

(c) raising of groundwater levels

(d) transformation and changes of soil and vegetation due to microclimate changes (intensification of winds, increased air humidity)

(e) changes of fauna habitat in the river valley

(f) changes of water quality, resulting from the reduction of flow velocity, and decrease of water self-purification capacity.

Downstream of the reservoir the river valley landscape also has changed, especially in the case of the seasonal or long-term runoff regulation. Significant environmental changes are observed downstream of the reservoir along the river regulated flow all though these are not visible. Changes of flood regime, spreading of vector-borne diseases due to stagnant water, changes of quality of water are some of these. Traditional flood plain cultivation has been abandoned automatically with the construction of the reservoir. Changes in stream flow and water releases from the dam have affected irrigation systems in the lower basin. The impacts however, are both positive and negative.

HYDROLOGICAL CHANGES

Every irrigation system with dams and reservoirs affect the natural, unregulated flow regime. The first and most immediate effect is hydrological which in turn have other physical and biological ramifications. The regime of Kirindi Oya is already very complex. It will increase with future development of the river water. Hydrological changes therefore made in the context of other uses of Kirindi Oya water such as water supply for drinking purposes.

Since 1945, in the catchment of Kirindi Oya several small tanks have been restored(Figure 7). Most of the tanks are located in the Monaragala District restored until 1985(Table 7). The hydrological effect of small tanks on the catchment for the project water balance has been estimated depending on the changes in the evaporation and evapotranspiration, by the irrigation department (Dharmasena 1986). The assumption of this study was before restoration of tanks original tank beds had been covered with vegetation. Therefore water loss to the atmosphere from the tank bed area was due to actual evapotranspiration from the original vegetation. After restoration, the condition was completely changed from actual evaporation to free evaporation of water from the tank surface. In the command area too, actual evaporation rate was changed to potential evapotranspiration as it could be assumed that paddy fields are in a state of saturated moisture condition during the cultivation seasons.

In this study, losses due to deep percolation application and conveyance losses are also assumed as losses. But it will not be significant in recharging the ground water table as a contribution to the catchment water balance (Dharmasena 1986). However, there is no other detail study has done except this. Therefore it needs further review in order to assess hydrological effects due to restoration of the small tanks.

A considerable hydrological effect of construction of the Lunuganwehera Reservoir is the disappearance of flood peaks. The complete suppression of floods had led to the disappearance of flood-lands which have dried up (Table 7.1).

The ratio of the reservoir capacity to the annual reservoir inflow is the main determinant of the degree of interference with the natural regime of hydrology. If the ratio is high, that is the capacity is large in relation to the reservoir inflow, a reservoir can considerably reduce the frequency and magnitude of floods (Smith 1989). Table 7.2 shows the ratio of reservoir capacity and the annual inflow to the reservoir.

Figure 7.2.3 accomplishes since 1987 (reservoir has constructed in 1985/86) the ratio is high only 1988. As reservoir capacity is 227 MCM expected annual inflow most of the years are very little than reservoir capacity including water releases for irrigation. It means reservoir is larger than actual inflow. Therefore, flood occurrence is limited.

However, there are considerable impacts on reduction of flood, both negative and positive. The positive impact is a storage for flood water preventing overflow to the sea. Two negative impacts have been identified. One is a lot of fertility soil from the upstream flowing towards the downstream with the flood water is deposited on the paddy fields. With out floods now no fertility soil deposits on the field in order to increase production. Second is reduction of floods is harmful to aquatic ecology in Bundala lagoon. Aquatic water ecosystem, aquatic life rare and valuable aquatic fauna and fisheries development have been reduced significantly in the lagoon. Though the exact data is not available in this nature, interviews conducted with the settlers and fishermen prove the statement.

The hydrological changes in downstream have been serious due to low flow regime and inundation of flood plains. The low flow hydrological regime of the Kirindi Oya has changed substantially by more than 20 per cent. Due to this change, adverse effects have occurred in the old area. The main problems faced by the people of old area are salinity, increase of malaria (more details in relevant sections), decrease of crop production, and loss of fertile soil. The rotational water distribution from the reservoir is not adequate to maintain pre-diversion ecological balances in the downstream.

The rise of groundwater table under irrigation is a well-known effect. There are several consequences of this rise which are important for agriculture. In Kirindi Oya, groundwater resource has examined by the Water Resource Board. According to the study:

water available for groundwater recharge is 134000 ac.ft.
evaporation and other losses is 53 acre.ft.
groundwater recharge is 81000 acre.ft.
average recharge is 178 acre.ft for sq.ml.

In general, about 55% of the area has poor groundwater(water Supply and Drainage Board, 1987).

The rise of water table however, in KOISP is a result of excessive conveyance losses in deep percolation and side seepage, higher operational losses in the irrigation system and substantial field application losses. High water table, apart from affecting agricultural crops, has many other adverse effects. Because of loss of moisture storage capacity in the soil profile even slight rains cause floods while the incidence of diseases and pests increases. If water table rise up, waterlogging occurs resulting in loss of soil structure. When the water table rises closer to the surface, it also moves up the slope. Thus, fields which once were suitable for upland cultivation now become suitable only for paddy. Since paddy itself contributes a greater amount of water to the water table, it is likely that a shift to paddy cultivation on these soils would push the water table still further up the slope. From the point of view of agricultural planners, control of the water table is of vital importance. The level of water table in the project area is still not known. Further research has to be done on this aspect to get exact data. However in the KOISP there is a strict control and management of water due to water scarcity.

Kirindi Oya is developed as a "one-off" river basin development concept, i.e., one big reservoir which collects all the runoff from the catchment area and from which reservoir water is supplied to the whole irrigation system. To achieve this "one-off" system, the already existing small reservoirs under this new reservoir (except the Ellagala system) were broken and developed as new irrigable areas. The one-off system has the advantage, from hydraulic engineering point of view, that one reservoir covers a comparatively smaller area for the volume stored. Thus, the evapotranspiration losses will be less. On the other hand, one big reservoir has the disadvantage that it requires more management inputs from the managing agency(Nijman 1991).

An important aspect of small tanks cascade system is their additional value for the community. The intermediate reservoirs were usually restored ancient reservoirs which had more meaning for the local community than just providing irrigation water. Especially, during the dry intermediate seasons water is available for drinking and bathing for the settlers. It has been reported that some of the small tanks have been demolished in the left and right banks(Table 7.3). This is one of the reasons for hydrological changes, occurred in the project area. Except that, these tanks have created an attractive set up for the area as well as a sanctuary for birds. One of these tanks named; Lassana Wewa located along the Kataragama main road. Many pilgrims used to break their journey at Lassana Wewa to have a rest.

WATERSHED CONDITIONS AND CHANGES OF LAND USE

Due to lack of data, the impact of the current and anticipated developments in the catchment, difficult to quantified. Because so many factors affect stream flow regimes, it is very difficult to determine the specific changes that may have occurred due to alterations in land use practices in the watershed.

The clearing of scrub and forest land, agricultural development and the extension of populated areas have been a result of the changes of land pattern. The natural vegetation of the area has already been seriously affected by long-term extensive loot land use, shifting cultivation as well as illicit felling. The population boom is expected to result in land over use and further pressure on forest and shrub clearance due to the need of inexpensive fuel wood and construction timber. The continuation of extensive loot land use would negatively affect the short-term retention and long-term accumulation capacity of soil and land, the quality of water and shallow groundwater occurrence.

Development of the irrigation service area depended on the clearing of nearby 6,000 hectares of secondary forest area of primarily low scrub, under uncontrolled slash and burn cultivation, which results in soil losses due to erosion. In this case, shaping and terracing for irrigation assurance has given with careful attention to preserving the top soil. The project authority has promised to incorporate soil conservation measures to assure the continued productivity of these lands.

Forest clearance and agricultural activities have already had a drastic detrimental impact on the hydrological function of the catchment of the main reservoir and other five tanks in the project. The pace of these activities, is undesirable from the environmental balance point of view and inexpedient from the development point of view.

Upstream of Kirindi Oya, chena cultivation is the most practiced form of traditional agriculture. Since the project was initiated, very little attention has paid to the current problems of chena cultivation.

LOSSES OF FORESTRY, WILDLIFE AND BIRDS

The KIOSP area is an existing bird sanctuary. The Bundala Lagoon and the existing five major tanks in the project service area are the prime importance focal points for water birds including many migrants pelican, flamingo, heron, duck,cormorant,stork,plover, teal, among others. It also contains three endangered turtle species. Bundala is probably the most threatened area, because of developments of the KOISP.

The terms of reference of the Feasibility Study requested an evaluation of the environmental impact of the project, and possible " methods and feasibility level designs of measures required, if any, to eliminate or minimize undesirable environmental effects". The feasibility study concluded that drainage into Bundala bird sanctuary had to be prevented because of its brackish nature, and its special value for bird life. How this should be prevented in terms of the Feasibility level designs had not been indicated. The Appraisal report did not accept this recommendation, nor did it refer to the environmental consequences of the Kirindi Oya project for the bird sanctuaries(Nijman 1990).

The present drainage into Bundala has led to serious problems within Hambantota district because it appears that about 300 shrimp fishermen were dependent on shrimp cultivation in the lagoons of the sanctuary. These shrimp cultures require brackish conditions, and are very vulnerable to pollution. Thus, they would be severely threatened by the mass inflow of polluted drainage water. The Government Agent had to intervene on behalf of the fishermen during 1988, and the Irrigation Department had to promise to solve this problem(Nijman 1990).

In the project proposal(ADB 1982), it has been mentioned that a half-mile buffer zone should be established to separate wildlife from inhabited or cultivated areas. The project authority has planned to develop additional wildlife corridors around the project area with the ultimate objective of providing a linked forest reserve system throughout the country. But the proposed wildlife corridors and the buffer zone could not be developed as planned. The ultimate result is that many elephants are roaming the project area. In the dry season many elephants are forced to migrate outside the Yala national park due to luck of water(Table 7.3.3). The increasing elephant man conflicts have come about in the last 10 years or so. Raids on chana farms used to be limited by careful watching and were not a necessity for elephants. The change has come because of the massive expansion of farming especially under the settlement scheme.

Elephants have been driven back from the former ranges of Lunuganwehera and Bundala sanctuary. They are squeezed into remaining jungle pockets and some forest plantations and chena plots at night. The hope that they might find sanctuary in the 3 parks including new Lunuganwehera Park, has not been fulfilled. In part, they are trapped and can not follow their former migration paths to reliable dry season feeding: but also the parks do not have sufficient fodder and water.

However, the wildlife habitat has been haphazardly destroyed in the entire southeast basin by various projects such as the Sevanagala Sugar plantation. In the case of KOISP too, vast tracts of land were cleared without consideration of the wildlife habitats in the area or the necessity to protect the catchment areas of the river.

Wholesale clearing of the forest around the reservoir has been carried out within the boundaries of several wildlife sanctuaries in the vicinity. Wirawila, an important bird sanctuary has been deforested up to the bunt and now remains a sanctuary only on paper. The impacts on the Yala National Park which is the home to large number of elephants and other animals have never been addressed. As a result, the elephants have been thrown out of their traditional habitats and have been pocketed in small areas thus inevitably giving rise to conflicts between these animal and the settlers.

Land clearing carried out by the project encroached into areas known to be inhabited by elephants. This has disrupted their migration patterns and has created isolated "pocketed" herds. When this happened, elephants destroyed crops and farm properties, and sometimes caused injuries or loss human life. Establishment of proposed wildlife corridors is an urgent need at present to protect wildlife in the area. There is another urgent need of drainage facility to conserve bird sanctuary.

SOCIOECONOMIC IMPACTS

It is hard to find examples in the world of successful settlement schemes under irrigation development. For various reasons more than 90 percent resettlement schemes under irrigation projects have failed to achieve their objectives.

Insufficient attention to the assessment of biophysical and socioeconomic factors in relation to resettlement activities can lead to a number of serious adverse impacts many of which may not become evident until after a project is well under way. The negative effects of poorly planned resettlement will be the need for extremely costly management interaction to correct unforeseen adverse impacts. The most significant example is the KOISP, where the selection of sites resulted in the incapability to sustain the planned activities. Most of the settlers lacked the skills and background to successfully colonize the resettlement site. The main reason for this is the failure to take into account the needs of concerned people which led to conflicts between new settlers and the local groups.

Stanbury 1989 reported that, after three years, the hamlet still looked like a frontier area. About 11 percent of the homesteads remained completely vacant and uncleared. Settlers built houses to lay legal claim to land but then did not reside there permanently. The most difficult problems the settlers faced were in obtaining domestic water and transport services. Settlers were told that domestic water would be supplied by the project and initially it was, but after a period of time, the service became unpredictable. The initial plan was to supply domestic water from local wells. The presence of brackish water, however, required a reformulation plan to bring piped water from the Lunuganwehera Reservoir. Settlers had not begun to reap any benefits from highland cultivation largely because of water shortage. According to the survey conducted in new area farmers responds indicate that the benefits obtained from the project is very little(Table 7.4).

Income from the project indicates what they earn from the irrigated lands including paddy and other field crops. Income from others descries what they earn from out of the project such as labors. The life in general of the project has described on the living conditions. Most of these settlers are from adjoin districts and they have started the life here from the beginning of the project. Since then, around five year period considered.

The following comparison between old area farmers and new settlers indicates, the old area farmers are in much better condition than new area settlers in the terms of earning, livening conditions, economic status, and organizational activities.

KOISP is one of the largest resettlement projects in Sri Lanka. For the environmentally sound resettlement projects, there should be sustainability, equity, conservation of natural resource and development options, matching people and potential settlement locations, integration of activities and monitoring of the same activities. But KOISP has not developed any of these options.

This settlement scheme has been a boon to many poor farmers in adjoining districts but it has also been characterized by irrigation inefficiency, resulting in low agricultural yield and poor rate of return on national investment, inequitable distribution of water, lack of cooperation among settlers and inability of settlers to maintain their system. However, in order to foster cooperation among settlers and to ensure water sharing and involvement in maintenance activities, settlers should be chosen from homogeneous backgrounds, with irrigated agricultural experience.

COMPARISON OF NEW SETTLERS AND OLD AREA FARMERS

Right bank Hamlet	No of farmers	Benefits from Project	Living Condition	Motivation
8	10	45%	medium	little
9	9	50%	satisfactory	moderate
10	12	33%	unsatisfactory	nil
12	11	22%	"	"
15	10	40%	"	"
18	4	38%	"	"
OLD AREA				
Gamunupura	15	78%	excellent	highest
Vigithapura	13	85%	"	"
Badagiriya	8	88%	"	"
Ellegala	12	80%	very good	"

They should be settled in concentrated communities and should not be settled as early as possible into the project to avoid encroachment and ensure rapid development of homesteads and irrigated allotments.

In the case of selection, priority was given to families who lost land owing to construction work in the reservoir catchment and downstream areas. The remaining settlers came from the neighboring electorate. Most of these settlers are landless, young, married and had agricultural education and experience. The concept of a "clustered hamlet" was proposed to settle them to foster social cohesion and facilitate more economical provision of services. Both of these groups of settlers were to be settled in separate hamlets where possible, since planners envisaged that there might be friction between these groups of different types of beneficiaries. However, problems associated between these two groups are vary. The design of clustered settlements of settlers from homesteads strung out along a new irrigation canal system also caused some problems among them.

It is reveled that, near future settlers will face for the fuel wood problems. Even though this is not a serious problem at present. After couple of years it will be a main problem among the settlers. In the project proposal it has been considered to establish some forest lots fuel wood purposes. But it didn't work out.

The women's participation in farming is very little. It was suppose that women should play a major role in the livestock and dairy component which aim to distribute dairy cattle to settlers in providing income generating activity. But this was not successful due to various reasons. No other significant event which women participate in the project.

Changes in the infrastructure due to project is considerably high in terms of roads,electricity supply,schooling and medical facilities. A number of new jobs have been created in the project area such as management and administration, skilled for operation and maintenance and irrigation farming. Most of the settlers used to work in the canal and building construction and earning money within the project area.

SALINITY OF WATER AND SOIL

In many areas of the world where continuous irrigation systems have been introduced, the buildup of salts in the soil has become a problem. Saline lands existed in many river basins long before they were irrigated and severely affected lands were usually excluded in laying out new irrigation systems. In KOISP also saline lands existed before it came into operation because this project is located in the arid zone. Nevertheless, saline affected lands were excluded in the planning stage. Various reasons have been caused for salinity built up.

* project location

* neglected drainage facilities

* complex between highland and lowland

Since KOISP was initiated, in newly developed areas, drainage facilities have been neglected mainly because of capital investment. In old area also there is no proper drainage canals due to encroachment of drainage canals. Existing un proper drainage system caused secondary salinity. The extent of the problem however in Kirindi Oya is not known. The water management study done by Agrar- und Hydrotechnik in 1987 refers to about 110 ha as salt land that can not be reclaimed. It also cites 500 ha in the coastal part of the project and 200 ha in the Badagiriya system that could be reclaimed. The exact figures would not be easy to provide. Some salinity lands, automatically will be reclaimed with the continues irrigation. If the water is available salinity could be washed out. Nevertheless, the study dose not refer to saline lands having depressed yields or those reclaimable with gravity drainage.

Due to lack of information the number of people affected is not known, but judging by complaints, it is not negligible. Farmers are aware of the relationship between salinity and drainage. Where farmers have complained of salinity the Agricultural Research Center(ARC) at Wirawila has always confirmed it. A soil salinity monitoring programme in old tanks has been carried out by ARC to study the salinity build up with time due to drainage water coming from the new area. Water of existing five tanks were tested, sampling was done on 10th and 25th of every month 15cm below the surface. The results indicated that there is marked variation in quality between the tanks with regard to EC and Ph of the tanks remained around neutral with a few exceptions. Yodawewa, Weerawila and Tissawewa exhibited high EC values(class ii) compared to other tanks and water quality of these tanks falls into upper boundary of class 2 with respect to salinity hazard. But during November and December the quality of water has improved due to the dilution effect caused by high rainfall received (approximately 250 mm in each month). The Lunuganwehera reservoir water has low salinity level and it is negligible contribution(Table 7.5).

Use of irrigation water having high EC values (around 0.75 ds/m) may lead to salinization of soil where drainage facilities are inadequate. Therefore drainage lines have to be cleaned and maintained at a sufficient depth to ensure the leaching of salts that are present in the irrigation water. New drainage lines between and within the allotments should be opened up if the salinity problem have already appeared in the paddy fields irrigated by this water.

Consequently, there has been a rise of water table due secondary salinization in the project. The correct figures of water table rise is not known. Even though the need for proper drainage facilities has been recognized, due to financial constraints it couldn't be constructed. However, it is unfortunate that drainage has not yet been seriously taken into account. Soil salinity in irrigation command areas continue to aggravate with time.

It has been reported that the salinity affected area is mainly located in the old area, i.e., downstream of the project. But in new area also salinity has developed from time to time. The main reason for this was the drainage water following through the high plains. Merrey and Somaratne 1989, identified some of the salinity affected areas after the project activities. The Agricultural Research Center has been identified salinity effected area as shown in the Table 7.5. Many samples from different salinity intensities were taken to cheek the EC using both saturation and 1:5 extracts. Regression analysis was performed using 1:5 value as the X variable and EC value as the Y variable.

A highly significant correlation was observed between two variables.

$$Y = 11.97\,x + 0.14$$

where Y = value of EC using saturation extract
X = value of EC using 1.5 extract
Regression coefficient = 0. 9926 xx

This identification has done in accordance with the farmers complains. If salinity level is very high and according to the percentage of effected area, farmers may be able to change their fields with high productivity lands. However, it was observed that most of the allotments are lacking drainage facilities.

Essentially the problem seems to be are water scarcity and inadequate drainage. With good rainfall or sufficient irrigation and unimpeded drainage the problem would disappear in a few seasons. In the Walawe scheme, which is nearest to KOISP, salinity declined steadily during the first years of irrigation.. However, it appears that KOISP has bigger constraints regarding irrigation water availability and the problems may remain many years. It is estimated that 25 to 40 per cent more irrigation water than is used at present is required to leach out salinity from the root zone. During implementation of phase 1 some farmers commenced cultivation their lands before the drainage canals were completed which often resulted in sub-standard work. Sometimes drainage canals could not be constructed because land had already been blocked out and allocated. Phase ii avoids these pitfalls, and the Irrigation Department is improving some drainage lines(IRDP, 1990).

Saline water is found in deep wells as well as in shallow wells. The lower region which lies below 150 ft. contour represents an area of high salinity. It can be reasonably assumed that shallow groundwater will contain high chloride(CI) concentrations. But potable water may be found in wells close to rivers,streams and tanks. The degree of salinity varies with the depth of the wells. In shallow wells the water is less saline than in deep wells. Table 7.8 shows chemical analysis carried out on water samples obtained from the shallow bore holes constructed in the project area.

The main source of groundwater recharge in the area is rainfall, except the aquifers close to the Kirindi Oya, the irrigation canals and the existing tanks.

Along the coastal belt reasonably good quality water, floating on saline water is found in wind-blown sand deposits. However, this water is available only within limited areas such as Bundala. All lagoons along the coastal areas consist of saline water. Evaporation causes accumulation of salts in these lagoons.

SURFACE WATER QUALITY

The most important physical quality of surface water is turbidity. The turbidity of kirindi Oya is expected to vary over a wide range, due to possible variations of flow. The chemical quality of the selected sources could be expected to have high variations during the year. The irrigation canals flow through highly agricultural areas and the surface runoff will carry large quantities of insecticides and weedicides which include compounds of Arsenic, Copper, Phosphorus and synthetic organic materials. The existing irrigation tanks are bound to contain them in harmful quantities. The lands upstream of the Lunuganwehera reservoir however, is not highly irrigated and it can be reasonably expected that high concentrations of harmful chemicals will not be present in the reservoir. The erosion of river banks during the periods of high flow, introduces compounds of Iron, Manganese, Ammonia, Nitrates etc.

The lower reaches of Kirindi Oya flows through the dry zone and is a major source for bathing and washing for the inhabitants of its surrounding area. Thus faecal pollution is inevitable due to the human and animal waste discharges. Further more, the surface runoff will contain excreta from human, cattle etc. and also many harmful bacteria from top soils. This faecal pollution is more aggravated by the minimum flow during drought periods, due to less dilution and salt discharges from impounding(Table 7.7).

Water quality of five existing tanks has been examined. The results of Weerawila and Tissa tanks indicate the slightly higher amount of hardness and iron. The presence of highly irrigable lands upstream of the tank will cause an inflow of all types of chemicals into the tanks(Table 7.5). However, electrical conductivity and ph value in the five existing tanks in the project area are very high. The graph shows the fluctuation of the salinity level during the four year period(Figure 7.5.4).

CHANNEL MAINTENANCE PROBLEMS:

The questionnaire revealed where serious loss of conveyance capacity was occurring but a problem of quantification arises. The effects of sediment and weeds on channel performance cannot adequately be judged although it appears that the sediment loads in channels are not high. The main problem of canal maintenance is inadequate funds as well as farmers participation.

SEDIMENTATION

Despite the extensive volume of stream flow information, both in terms of number of stations and record lengths, the measurement of erosion and sediment transport has received considerably less, and in fact insufficient, attention. It is believed that the measurements have been done on request by project planners at various times. Apparently no systematic measurement program for a continuous period has ever been undertaken.

As other reservoirs, Lunuganwehera storage reservoir also retains virtually all of the sediment inflow until the reservoir capacity is so depleted its efficiency is reduced. This reservoir has a large capacity in relation to the annual flow of the Kirindi Oya and it has a long useful life. Several studies have indicated that even 100 years sedimentation may not be a problem. Inadequate data however, in this nature reduced the analytical capacity in KOISP. It is apparent that most studies have tended to assess the sediment problem in a similar and rather simple manner by comparison of different sediment yield estimates ranging from:

- field measurements,
- regional recommended values,
- universal values,

Design aspects considering actual deposition (sediment profile) which depends on sediment constituency, reservoir size, site topography, stream flow regime and reservoir operation has been given little attention in KOISP project. Following a summary of sediment studies done in Kirindi Oya for various purposes.

Period (months)	Area km2	Annual Sediment Yield acft/sqm	t/km2	Specific t/m3	Source of information
1952/57 (60)	913	0.4	111	0.58	Three basin study 1968
1951/52 (2)		0.137	89	1.36	Bowetenna study 1972
1985/86 (12)		0.379	357	1.98	ID Field Report 1986

The major sources of sediment can be categorized as follows in KOISP:

Existing sediment: Sediment resulting from previous natural erosion remains in the bed of watercourses and elsewhere in the watershed area and will continue to flow into the reservoir, particularly in periods of heavy rainfall.

Unusual natural sedimentation: Natural events such as landslides and "20 years

	precipitation events" caused heavy sedimentation regardless of watershed management measures.
Road building and construction work:	Not necessarily associated with the dam. For example, Buttala sugar plantation and other associated construction work caused soil erosion and associated sedimentation.
Erosion:	From usually unplanned clearing of vegetation, logging and chena cultivation by people who have moved in to the watershed area as a direct or indirect result of the construction of the dam project. This is largely a planning and regulation problem.

The Hydrology section of the Irrigation Department (1985) has made extensive calculations on sediment yield on the basis of limited field data. The calculated sediment yields are as follows:

	Catchment Area sq.mile	Average Yield af/year/ sq.mile	Maximum Yield af/year/ sq.mile	Number of Years
1. Kirindi Oya at Lunuganwehera	353	0.137	0.31	1952/53 to 1956/57
2. Walawe Ganga Embilipitiya	610	0.28	0.38	Two years
3. Mahaweli Ganga Kandakadathural	2,907	0.193	-	Six years 1952/53 to 1957/58
4. Kalani Ganaga	234	0.31	-	Three years 1962/63 to 1964/65

The sediment load at Lunuganwehera has been estimated on the basis of daily mean discharge and sediment relationships:

$$Qs = 6.907 \times 10^{-4} \quad Q^{2.268}$$

Qs = daily average silt in tons per day.

Q = daily average discharge in cusec.

Averaging the daily discharge for sediment calculations would contribute to underestimation of sediment load, particularly in the context of high flow pertained only for a few hours. It was noticed that, at Lunuganwehera gauge site, the river had filled the gullies joining the river with one to two feet of coarse sand during the flood of 12th November 1978 (about 30,000 cusecs). Some coarse sand had also been visible on the flooded low lying areas.

As the sill of irrigation sluices has been kept at EL (elevation level)_15 ft, the sedimentation problem of this reservoir is of not much significance. However, WAPCOS (1986) has evaluated the long term effect of siltation on the live storage of the reservoir and the results are as follows:

Rate of siltation	Total sediment in 100 yrs	Elevation of siltation after in 100 yrs	Elevation of siltation after in 50 yrs
1.0 ac.ft/yr/sq.mile	35,300 ac.ft	142.0 ft	133.6 ft
0.5 ac.ft/yr/sq.mile	17,650 ac.ft	133.6 ft	129.4 ft

As the sill elevation of irrigation sluices are designed to be at 150.0 msl, the reservoir sedimentation has no effect on this aspect. There are no details of sedimentation of the nearby Badagiriya tank or Tissawewa tank, which are large tanks in the project area. It may be prudent to consider a sedimentation rate of 0.50 ac.ft per sq.mile per year.

The existing literature revealed that, very low sedimentation rate in KOISP. Universal Soil Loss Equation was the main source for this calculation done by the Land Use Planing Division in 1986. Joshua 1977 also has computed sediment yield of 9 locations in Sri Lanka. Kirindi Oya is one location, based on the Universal Soil Loss Equation (USLE). But it has not included relief/slope factor and erosion hazard in upland areas probably higher than indexed. With a comparison of present land use and previous land use, it can be predicted that in the watershed if the present land use changes continues the rate of sediment will be higher than estimated
However, since rains in this region of the island occur after long period of droughts, very high sediment loads are transported to the river from surface runoff.

From the figures given in, or derived from, the various reports it is difficult to draw up definitive results and conclusions regarding actual transported sediment in KOISP. Compared to an estimated 70% of forested area of the country existing in 1900, recently documented statistics indicated a rapid decrease to 45% in 1956 and 27% in 1981. If left uncontrolled, further deforestation and haphazard land development can only mean that erosion, sediment transport and reservoir deposition will increase in the future leading also to the threat of irreversible climatic changes such as lower rainfall and more frequent occurrence of droughts.

Nevertheless, field reports of the most recent measurements on the Kirindi Oya at Lunuganwehera correctly mention the necessity for continuous measurements over at least 6 years in order to draw up firm conclusions.

HEALTH

Environmental changes associated with the development of irrigated agriculture and human settlement are known to have a great impact on vector and waterborne diseases. Malaria is endemic in the project area. A study conducted by the Anti-malaria Campaign revealed 11 species of anopheline and 27 of culicine found from the KOISP. Among these are a number of species known to be vector or potential vectors of malaria, filaria and arboviral diseases. The most vector-borne diseases in KOISP are malaria, filariasis, dengue and Japanese encephalitis.

A vast network of irrigation canals, not maintained properly and even not lined properly have created a good breeding ground in KOISP. Health impacts in KOISP can be categorized under two main headings:

1) Those arising as a direct consequences of irrigation schemes

2) Those due to associated population movement

From the beginning of the project in 1985, only a few number of malaria and japanese encephalitis incidence have been reported (Vitharana et al. 1986). Vector habitats however do not occur through the entire irrigation systems. The most common potential breeding places in KOISP are:

1. Large bodies of fresh water in full or partial sunlight such as marshes, small irrigation tanks, level crossings, large borrow pits and waterlogged pools behind filled channel bunts.

2. Small water collections, stagnant and often muddy but may not be polluted, in full to partial sunlight such as marginal pockets along irrigation canals, new road ditches, wheel ruts, foot or hoop-prints, rain water and ground pools.

3. Paddy fields such as swampy, poorly drained fallow lowland fields before land preparation, fields during seedling, and fields during transplanting.

4. Running water courses, clear fresh water, direct sunlight.

5. Man-made containers.

Health impacts of irrigation projects can be both positive and negative. Unfortunately, many recent irrigation projects have spread or amplified many water-related human diseases.

The health impacts of the KOISP, would be discussed under two categories;

1. Vector-borne diseases

2. Waterborne diseases

VECTOR-BORNE DISEASES

It is reveled that lack of data with regard to the vector-borne diseases, interpled the survey. But a fairly close correlation between questionnaire survey and scientific data was found.

Name of the diseases	Questionnaire survey evaluation	further study	field data far's respond	%infected
Malaria	serious	yes	serious	65
Amoebiasis	quite serious	yes	quite serious	50
Encephalitis	quite serious	yes	not much serious	35
Filaria	not serious	no	not serious	10
Leprosy	quite serious	no	not much	9
Viral fever	serious	yes	serious	55

It has been reported that three diseases have erupted in KOISP. The most severe vector-borne disease is malaria, while dengue and Japanese encephalitis have also occurred slightly. A very few filariasis incidence have been reported. It is clear that malaria is a major problem generally in Sri Lanka, but the questionnaire approach was not very successful in clarifying the situation because the population could not distinguish malaria from other feverous diseases, and the disease being seasonal, people's memory of recent attacks was limited to the previous few months rather than providing the full annual picture.

As other irrigation schemes, KOISP too has significant effects on the habitats suitable for breeding of mosquitoes. These effects have been derived from the following project-related changes: an increased volume of open water in the project area, the creating of new areas of standing water, changes in the annual water level in tanks, a rapid increase of dysentery of population within the project area with a concomitant increase of breeding places for household mosquitoes, an increased use of broadcast pesticides on agricultural lands, the migration into the area of people who are less resistent to malaria because their previous residence was in malaria-free areas in the zone,a change in the ratio of domestic animals to the human population and lastly, on the positive side, an increase in the availability and accessibility of health care.

WATERBORNE DISEASES

There is a high level of water-borne diseases in the project area. The most common waterborne disease is dysentery. After some time many of the settlers have built up resistance to, or at least tolerance of, the parasite and rarely seek medical treatment. It is, however, very difficult to assess highly accurate figures because mild cases are not presented to health authorities or are not positively diagnosed. It is clear, that there is a high level of such disease probably stemming from two human behavioral characteristics. One is that very few proper latrines are in use. The other is that very few people in the project area boil water before drinking it. Farmers frequently drink irrigation water when they work in the field.

The drinking water problem has created much influence on health. There is no centralized sources of domestic water. The supply of domestic water is limited. Several settlers have complained about the water supply by buzzers and the quality of water. A scheme of drinking water supply has been already initiated as a solution but it has taken several months to implement. There is no proper health care delivery system in the project to educate settlers.

DISCUSSION AND CONCLUSION

Popular thinking holds large reservoirs to be of great economic and social benefits because they produce water for irrigation, stop damaging floods and help combat world hunger. Edwards Goldsmith and Nicholas Hildyard(1985) have pulled together an unparalleled assemblage of data demonstrating that large irrigation projects have not only achieved their basic objectives but have also left a legacy of unsurpassed cultural destruction, disease, and environmental damage.

Most of the large irrigation projects are evidence of the extensive range of problems ranging from engineering mistakes and operational errors to severe social disruption and the spread of diseases, to the elimination of forests and significant wildlife habitats to the destruction of estuaries and endangered species.

Kirindi Oya Irrigation and Settlement Project (KOISP) is the one of the largest projects in Sri Lanka. But, since 1986 what economic benefits have been derived from the project is in question. One could argue that it is not easy to derive economic benefits as planned from the beginning of the project. Some of the other well planned major irrigation schemes have derived most of the expected benefits though they also have some issues. The Mahaweli project is a case in point.

A proper understanding of the environmental changes occurring downstream of the reservoir can only be achieved through careful studies commencing before construction begins and continuing for a considerable period thereafter. In the case of KOISP, this study actually undertaken was of short duration. However, KOISP has faced some serious environmental problems which can be mitigated using remedial measures.

The impact evaluation based on the "rule base system" (Table 8) and both negative and positive impacts can be categorized into different sections.

1. No significant impacts on environment
2. Adverse environmental impacts
3. Further studies necessary.

These three categories, however, are not isolated. All are well integrated but with different aspects. For example, there was no significant impact in reservoir sediment. On the other hand, soil erosion rate of upstream is very high even though it has not really affected sedimentation.

Any river valley project requires meticulous planning and careful implementation, involving complete and accurate information on all the important variables to be dealt with: economic, socio-cultural and environmental. This is especially true of a significant scheme like KOISP. Although the project authorities claim to have undertaken a study which takes into account these variables, the validity of the information is doubtful. One might expect that the long-term environmental changes brought by the project would carry important environmental implications. Unfortunately, it is unlikely that this can ever be verified, due to lack of statistics and relevant information for the region.

The project entailed the large-scale exploitation of natural resources, thus engendering a host of environmental problems. Vast tracts of forest have been submerged, in addition to agricultural lands. The extension of canal irrigation and rational water distribution have caused salinity, waterborne diseases and socioeconomic disruption. Ecological disruption seems to be the most serious drawback of the project both upstream and downstream of Kirindi Oya; yet it is also one of the most neglected aspects. There is, for instance, no comprehensive information on the extent and diversity of flora and fauna in the valley. There is no compiled inventory of natural resources in the project area prior to the project proposal. However, a serious drawback was the lack of sufficient background data on specific aspects such as wildlife distribution and carrying capacities, groundwater resources, and water quality.

There is no overall study on the existing state of catchment forests in upstream of Kirindi Oya, the present and future demand supply position for firewood and other forest products. In short, no attempt has been made to find out whether the forest resources can withstand the impact of the project and its ancillary activities.

Transmigration projects however, such as KOISP, are very few in number in the world. Though some are found in Asia, most of them have not been successful as initially planned. The key factor behind this failure is that most of the planners forget that they are dealing with human beings whose behavior is most unpredictable. The human behavior connected with a project is more important than or equally important as technical aspects of the project. The settlement in KOISP was based on the concept of advance alienation. The allotters of land in the project were to be brought from outside and resettled in the project area within one year from the first issue of water for cultivation. However, due to unavoidable technical difficulties faced, some settlers in the project could not get water for their cultivation for about 3 1/2 years, after their settlement. Some of these settlers are from the area now covered by the reservoir. Almost all of these settlers lived on chena cultivation and are now deprived of their main livelihood. Inevitably, irrigation requires the splitting up of traditional farmers and the redistribution of land. Such redistribution has caused considerable social upheaval. Whereas,traditionally, the distribution of land was based on the government decision. The long term result is not only the disaffection of numerous passant farmers but also a lack of concern for the management of allotments. No doubt, it is the peasants who blame for the failure of the scheme. The traditional farmers employed in irrigated areas lost their independence. Once taken away from their traditional lands, they have to cultivate the lands according to "norms" dictated to them by the new authorities.

The KOISP is a complex system having old systems and new systems covering upland and low land areas. The location of the system has been created most of the questions of the project. Indeed, KOISP looks a reliable project for farmers in the area, but it is an unsuccessful project for the environmentalists. The most serious issues influencing environmentally sound irrigation development in Kirindi Oya Project can be summarized as follows:

1. Hydrological impacts of down stream
2. Salinity of soil and water
3. Soil erosion and siltation of canals
4. Rapid forest clearance of the catchment area
5. Disruption of wildlife habitat and fisheries development
6. Socioeconomic issues and management issues
7. Health hazards

Unfortunately, in the KOISP, the economic aspects of its work have taken priority over social aspects and no environmental questions were examined. Even no attempt has made to assess the overall impact of the project. Most of the issues have been discussed in the previous chapter. The management factors including administration, operation and maintenance is another area effected for the seriousness of these matters.

Irrigation Department(ID) is the responsible body for the project. In reality, planning has been highly compartmentalized and fragmented, and the implementation is likely to be the same. There is no single body which is responsible for overall planning and execution. Except ID, Irrigation Management Division(IMD), Land Settlement Department, Water Supply and Drainage Board and Agricultural Department have been involved for the implementation work. There seems to be little co-operation between them. The absence of a single overall supervision body has meant the absence of a comprehensive implementation for the project. Although the project plan gives detail of the dam and canal systems, it hardly deals with other crucial aspects of the project, such as the preservation of catchment forests, the education of farmers, the provision of medical facilities, the existing and future demand-supply positions for firewood and other forest products, the treatment of pollution or the rehabilitation of those who will be resettled. The same is true for implementation, which has been entrusted to various departments among whom there is hardly any coordination or cooperation. As of today, the Forest department, the Soil Conservation department, the Land Settlement department, the Irrigation department, the Agricultural department, and various others, work in isolation and conflict with each other. The lack of environmental planning in the planning stage and as well as implementation stage is the most serious problem and no representation of the Environmental Authority for the planning stage.

Moreover, the various planning and implementation bodies are as open to political interference as any other body, and responsibilities are so divided that ultimate control usually rests in the hands of politicians. Worst impact is local people have not been involved in either the planning or the implementation of the project-yet they are expected to make drastic changes in their lifestyles, working patterns, attitudes and social relationship within a single generation. It is expected that with the completion of the project, a significant change of agriculture development. But the scenario is very frightening, for there is little forethought about the environmental and social consequences of all the development.

The main purpose of water-resource development projects is to increase agricultural production for socioeconomic development and the well-being of the growing population. However, it was observed that if a well planned research policy is not drawn up at an early stage of the planning, this purpose will be defeated. The investigation made on KOISP clearly indicate that negative impacts are of serious concern.

MITIGATIVE RECOMMENDATIONS

A significant emphasis in the EIA is placed on providing practical recommendations to minimize possible detrimental impacts or to enhance beneficial aspects of the program. The functional approach is evolved to integrate the proposed implementation of civil work with an optimal use of environmental resources in KOISP. Even after six years, it is not yet difficult to integrate some action plan to depreciate present obstacles. The proposed principal environmental action plan and mitigative recommendations can be summarized as follows:

A. CONSIDERATION OF KIRINDI OYA RIVER BASIN AS AN ENVIRONMENTAL UNIT

All interactions between water and the other environmental factors lead to the concept of the river basin, the catchment area or the watershed as an environmental unit. As water has proved to be the factor that is most easily defined from physical aspects, its selection for the purpose of delimiting an environmental unit appears appropriate. Significant in this context is also the fact that,. owing to the particularities of the hydrological cycle - which is determined above all by gravitation - the energetic processes all lead in the same direction. This aspect, too facilitates the identification of interrelations in that environmental unit of the river basin.

PROPOSED PLANS

1. Any river valley development plan should pay more attention to upstream and downstream facets of projects.
2. Cost -benefit analysis should be included the environmental values of natural resources.
3. Development of river basin and conservation of upstream should go simultaneously.
4. Effects of the environment on river basin development as well as effects of river basin development on the environment has to be considered.

B. PROTECTION OF KOISP CATCHMENT

In the upper catchment of Kirindi Oya, above Wallawaya, extensive soil erosion is occurred due to traditional chena cultivation practice. Future erosion of the catchment also is expected to increase. Therefore, it is necessary to establish various conservation measures to develop ground cover to stabilize exposed slopes and poorly managed lands.

PROPOSED PLANS

1. Proper watershed management plan for Kirindi Oya Basin.
2. Afforestation of catchment by mixed vegetation of native species with good shrub cover to reduced erosion.
3. Inventory of present forest species.
4. Community forest project for settlement area.

C. HOLISTIC APPROACH FOR KIRINDI OYA BASIN

A major drawback in the planning stage is a lack of holistic approach for the whole Kirindi Oya Basin. One reason for this is that the Irrigation Department which implemented the project has no responsibility for upstream of Kirindi Oya. Consequently, the whole basin belongs to the three different administrative districts, Moneragala, Badulla and Hambantota. Nobody is responsible for conservation of the basin. It is interesting to note how the Kirindi Oya Basin spreads over many of the climatic zones of the island, namely, the "arid" zone, "dry" zone and the highland "dry and wet" zones. However, the upper part of the catchment which covers less than 1/3 of the total basin area accounts for nearly half the water received from rainfall. This makes the upper catchment all the more important in an integrated planning of water resources of the whole basin.

Prof. Madduma Bandara has mentioned in his review of Kirindi Oya Basin the importance of conserving the headwater areas of the Kirindi Oya if the utilization of water resources are to be planned on a long term basis. The upper catchment in Kirindi Oya, although small in size, contributes a dispropotionately large share of the total water resources as exemplified by the Kirindi Oya Basin. This clearly indicated the necessity for conserving the upper catchments in order to optimize the utilization of water resources in the drier downstream areas.

This study however revealed the necessity for a high degree of coordination in developing water resources, in different portion of the Kirindi Oya Basin. If there is a need to integrate water resource development in the Kirindi Oya Basin there should not be administrative boundaries indiscriminately cut across natural watersheds. Most of the environmental impacts have been reported, however, due to negligence and lack of knowledge of the importance of upland water catchment. Therefore, there should be a very comprehensive plan of action has to be seriously considered.

PROPOSED PLAN

1. Integrated water resources research and monitoring.

2. Development of water resource database for three administrative districts: Hambantota, Moneragala and Badulla.

3. Further improvements of hydrological studies of the basin.

4. A well planned coordination program for relevant institutes and departments that work in the projects.

5. Encourage studies on climatic fluctuations and cycles in order to ensure more realiable water availability for agricultural production.

D. CONSERVATION OF WILDLIFE HABITAT

The most feasible approach which will benefit the largest number of a wildlife species is to provide natural habitat as contiguous as possible. This, then can be integrated with other land use planning.

PROPOSED PLAN

1. To establish a buffer zone to prevent encroachment and crop losses to settlers.

2. Prevent encroachments of the National Park.

3. To create a favorable site for migrant birds in the project area using five other tanks.

4. Improvement of possibilities for fish production.

5. Establishment of proper drainage facilities.

E. UPGRADING OF SOCIOECONOMIC ASPECTS

To improve the capacity of settlers to take part in irrigation management, there should be a process of implementing a set of settlement activities. This is particularly important because settlement schemes are so often characterized by highly inefficient irrigation systems with inequitable water distribution and water wastage. New irrigated settlement schemes face unique management problems but they are also potentially highly innovative because they involve new land development, new settlers selected according to certain criteria and a high degree of horizontal coordination among project implementation staff.

PROPOSED PLAN

1. Improvement of settlement conditions providing basic facilities such as water supply for domestic purpose, sanitation, good health care, schooling, etc.

2. Provision of alternative ways for additional income generation.

3. Provision for proper communication between settlers and agency staff.

4. Improvement of farmer participation for project activities.

5. Establishment of tree belt on the canal embankment to fulfil the fuel wood and fodder requirements of the village.

6. Project infrastructural facilities should be developed to meet the requirements of increased crop production which result from intensive irrigation farming.

F IMPROVEMENT OF HEALTH CARE

Health care facilities in the form of hospitals, dispensaries and peripheral referral units have to be provided as a part of improvement of health care. Of the vector diseases, malaria is considered to be the primary concern in the project area. Malaria has a long history of high incidence in the region and project implementation could further spread this disease. Consequently, control of Malaria and other vector diseases should be high priority objectives in the provision of health care. An adequate attention has to be focused on a safe water supply scheme and installing suitable sanitary facilities for the disposal of human waste.

PROPOSED PLAN

1. Improvement of anti Malaria campaign activities.

2. Extension of health care facilities.

3. Advancement of health education.

4. Introduction of water supply scheme.

5. Establishment of solid waste disposal system.

G. WATER AND SOIL MANAGEMENT

A few specific environmental aspects involving water and soil management practices in the downstream irrigation system have to be considered here. The objectives of this plan are directed toward alleviating problems of excessive soil erosion, improper on-farm water application, soil salinization and pest control. Yet, KOISP has not taken into account any water and soil management methods. Therefore, it is time to consider soil and water management even at this late stage to prevent adverse impacts.

PROPOSED PLAN

1. Adoption of proper soil conservation methods.

2. A monitoring program for soil and water management.

3. Standardization of land use classification system.

4. Ongoing research program for crop diversification with reference to the soil classification system.

5. Establishment of proper drainage net work within the project area.

6. Use realistic distribution and on-farm irrigation efficiencies when estimating drainge volume and drainge system requirements.

7. Implement groundwater monitoring to record water table level and water quality changes.

8. Initiate water balance studies in order to predict water table build-up and drainage requirements, taking into consideration contirbution to ground water from canal seepage, farmer's fields and other sources.

9. Initiate appropriate soil salinity surveys, analyse data, and adopt techniques to measure changes in soil salinity.

10. Educate and train extension staff in water management principle and practices.

H STRENGTHEN OF MANAGEMENT CAPACITY OF THE PROJECT

Ecologically sustainable development has been considered here as a concept incorporating wise management of the environment. It implies that development should not exceed the frame which is ecologically sustainable both now and in the future. The following guidelines have been proposed to eliminate the negative impacts of irrigation project to ensure ecologically sustainable development and wise management capacity.

PROPOSED PLAN

1. Strict regulations should be introduced to villagers for the cutting trees.

2. The indiscriminate use of insecticides and fertilizers should be minimized and Integrated pest management strategies should be popularized among farmers.

3. Complementary education and training program should be introduced for all professional levels involved in water management.

4. High priority should be given to improving the understanding of decision-makers, including mid-level and senior officials in regard to the water management.

5. A suitable infrastructure, involving the participating of farmers should be developed, such as irrigation cooperatives at village level for the distribution of water, at the micro level, and for water management in general.

6. Complementary education and training program should be introduced for all professional levels involved in water management. High priority should be given to improving the understanding of decision-makers, including mid-level and senior officials, in regard to the special problems of water management.

7. Consider alternative capital investments in irrigation facilities for increasing the efficiencies of distribution and on-farm irrigation systems, which can greatly delay the need for drainage and reduce the eventual capacuty and costs of drainage.

8. Link project performance with operation and maintenance costs and agricultural production.

9. Estabilish or strenghthen irrigation technical support infrastructure.

****

TABLE 7.2

RESERVOIR CAPACITY RATIO

Year	Annual Flow(mcm)	Ratio
1987	227	1
1988	257	1.32
1989	105	.46
1990	203	.89
1991 upto October31		.57

Table 7.3

DEMOLISHED TANKS IN THE PROJECT AREA

NAME TANK	CAPACITY ac.ft	IRRIGABLE AREA Acs.	Area
Punchi Appu Wewa	537.0	400	Left bank
Beralihela		80	Right bank
Tikiri	248.0	82	Right bank
Asarappuli	265.0	89	Right bank
Ratmal Wewa			Right bank
Etha Bandi Wewa			Left bank
Pan Wewa	90.0	34	Right bank
Punchi Wewa			Reservior
Gal Wewa	186.0	62	Right bank
Sittarama Wewa			Reservior
Sinukku Wewa			Right bank
Seramunigama			Reservior
Beeragama			Reservior
Mohahalambogo			Reservior
Halambagas			Reservior
Mahagal			Reservior
Rota			Reservior
Bogas			Reservior
Katakubuke			Left bank
Degaldehera			Left bank
Ilukpelessa			Left bank
Unatuwewa			Left bank
Padavkeme			Left bank
Kadawara			Left bank
Mahadebara			Right bank
Kukulkatuwa			Right bank
Galwewa			Right bank
Mahapepessa			Right bank
Karambagas			Right bank
Weharagoda			Right bank
Kaliyalanda			Right bank
Kapuwatte			Right bank
Palugas			Right bank

Table 7.3.3

Estimation of elephant population in the parks towards the project

Location	Approximate number of elephants Minimum	Maxium
Ruhuna National Park, Blocks 1,11,111 1V, V and Yala South National Park including Palawatte	350	400
Hambntota District outside Ruhuna National Park(between Walawe Ganga and Kirindi Oya)	150	160
Uda Walwe National Park and environs	150	200

(Source Jayantha Jayawardhana)

TABLE 7.4

SOCIOECONOMIC CONDITIONS OF SELECTED SETTLERS

Hamlet Right Bank	Farmer interviewed	Income from project	Income from others	Living conditions
1	5	28%	50%	poor
2	3	32%	45%	satisfactory
3	8	20%	68%	medium
4	5	45%	30%	satisfactory
5	6	58%	30%	medium
6	4	60%	20%	satisfactory
7	5	50%	35%	medium
Left Bank				
1	10	33%	68%	medium
2	12	40%	30%	medium
3	10	25%	55%	poor
4	8	35%	30%	poor
10	8	30%	35%	poor

Table 7.5

SOIL SALINITY INVESTIGATIONS
IN FARMER'S FIELDS

Hamlet No.	Allotment No.	Salinity Level
01	187	high
	145	very high
	98	high
	188	very high
02	593	high level
	142 (138)	high level
	606	very high
05	54	very high
	51	very high
	325	high
	169	high
	318	high
	424	very high
	82	high
06	469	high
	386	high
	387	high
	45	high
	398	high
	560	very high
	456	high
	470	very high
	461	very high
	424	very high
	548	very high
	278	medium
	440	high
	457	very high
	458	very high
	471	very high
	555	very high
	556	very high
07	699	very high
	826	very high
	691	very high
	702	very high
	846	very high
08	727	very high
	663	very high
	606	very high
	755	very high
	597	very high
09	828	very high
	937	very high

950	very high
821	very high
903	very high
845	very high
403	very high
411	high
448	high
443	very high
401	very high
400	very high
247	very high
450	very high
459	very high
275	very high
312	high
234	high
299	high
227	very high
951	very high
468	very high
434	very high
958 A	very high
358	very high
355	very high
469	very high
339	very high
293	very high
281	very high
249	very high
453	very high
452	high
451	very high
423	very high
354	very high
461	very high
460	high
459	very high
458	high
969	very high
967	very high
959	very high
400	very high
395	very high
377	high
355	very high
320	very high
239	high
238	very high
421	very high
414	very high
402	very high
401	very high
441	very high
440	very high

TABLE 7

Year of construction	Name of scheme	Command area Ac	Capacity Ac/ft	Catchment area Sq.mile
1945	Randeniya Anicut	206		
1952	Handapangala wewa	1400	19.7	588.92
1953	Balahuruwa wewa	31		
1960	Dambe wewa	230	1171.0	4.30
1967	Tanamalwila lift	40		
1972	Debara Ara wewa	240	973.46	8.60
1974	Salgahadigana	60		
1974	Maharanawarana	165		
1975	Batala ara wewa	60		
1980	Walaskema Ara wewa	50		
1982	Theullawewa	40		
1982	Kiul wewa	160		
1983	Galamuna wewa	30		
1983	Sanasuma wewa	186		
1983	Baduruwagala wewa	180	664.26	9.50
1983	Thora Ara wewa	40		
1984	Colombawatte wewa	85		
1985	Alikete Anicut	200		
1985	Ihala Digiri Ara wewa	80		

(source Irrigation Department)

Table 7.1

ANNUAL FLOODS LUNUGANWEHERA DAM SIDE

year	dates	peak cfs	max.daily cfs	volume ac.ft
1944/45	Nov.22/27	9800	8600	34650
45/46	Dec.4/29	9300	8900	47900
46/47	Apr.2/7	10000	8750	26400
47/48	Nov.16/19	7200	5450	10500
48/49	Nov.21/25	11000	7500	43700
49/50	Dec.5/9	9000	7500	18150
50/51	Dec	8000	7400	
51/52	Apr.18/26	16500	8300	71700
52/53	Apr.6/13	6000	2750	21800
53/54	Nov.14/20	13500	7100	30800
54/55	Apr.21/26	18500	5700	29700
55/56	Nov. 19/26	10000	2600	14050
56/57	Nov.2/24	12100	3350	20790
57/58	Dce. 17/Jan4	15300	12900	120000
58/59	Nov.28/30	8000	2150	8080
59/60	Oct.22/25	15400	2250	16650
6/61	Jan.15/17	14600	6600	25450
61/62	Nov.24/28	15400	5000	35300
63/64	Nov.27/Dec4	12850	4650	21050
64/65	Apr.23/25	32800	11600	30500
65/66	Nov.22/27	9500	5450	17800
66/67	Dec.1/6	25700	7600	52500
67/68		17800		
8/69	May.4/10	44500		
69/70	Dec.27/Jan2	47800	29200	146450
70/71	Nov.19/23	30000	8350	40000
71/72	May.3/4	4700	2550	5780
72/73	Apr.2-5	19700	8800	21780
73/74	Nov.27/29	18800	6150	17490
74/75	Mar.4/8	4580	2650	7750
75/76	Nov.22-25	20000	3225	22110
76/77	Dec.5/9	24500	5900	28380
77/78	Dec.7/12	30000	5200	15404
78/79	Nov.11/13	30600	17739	30525

(source Irrigation Department)

	431	very high
	429	very high
	449	high
	444	very high
11	28	medium
	55	very high
	548	high
	509	very high
	484	very high
	273	high
	83	very high
	1010	very high
	23(523)	very high
	523	high
	541	very high
	208	very high
	22 A (19)	very high
	88	very high
	89	very high
	104	very high
	20	very high
	174	very high
	106	very high
	105	very high

TABLE 7.7

RESULTS OF THE CHEMICAL ANALYSIS OF FIVE EXISTING TANKS

Tank	Weerawila	Tissa	Debera	Pannegamu	KO
date	17/6/85	20/12/85	5/6/85	15/7/85	
appearance	Turbid	slightly turbid		Turbid	
turbidity(JTU)	59	16	63	14	11
ph	7.6	7.3	7.4	7.8	7.90
Ec(mg/1)	0.287	0.506	0.493	0.38	0.517
Chlorides(mg/1)	38	76	38	16	33.00
Alkalinity(mg/1)	192	234	180	121	200
Hardness(mg/1)	224	194	198	37	169
Solids(mg/1)	-	-	-	-	-
Nitrates(mg/1)	-	1.76	-	6.0	5.96
Nitrites(mg/1)	0.016	0.026	-	0.004	.014
Ammonia(mg/1)	minute trace	-	-	0.06	M.T
Iron(mg/1)	0.05	1.0	0.08	0.06	.23
Colour (APH-cobolt Scale)	200	165	150	30	30

KO = Kirindi Oya

Acceptable Limits of the Chemical

Turbidity = 2 to 10
Chlorides = 200 to 600
Solids = 500 to 1500
Ammonia = .06

ph = 7.0 to 8.5
Hardness = 100 to 500
Nitrates = 50 to 100
Iron = 0.3 to 1..0

KIRINDI OYA BASIN

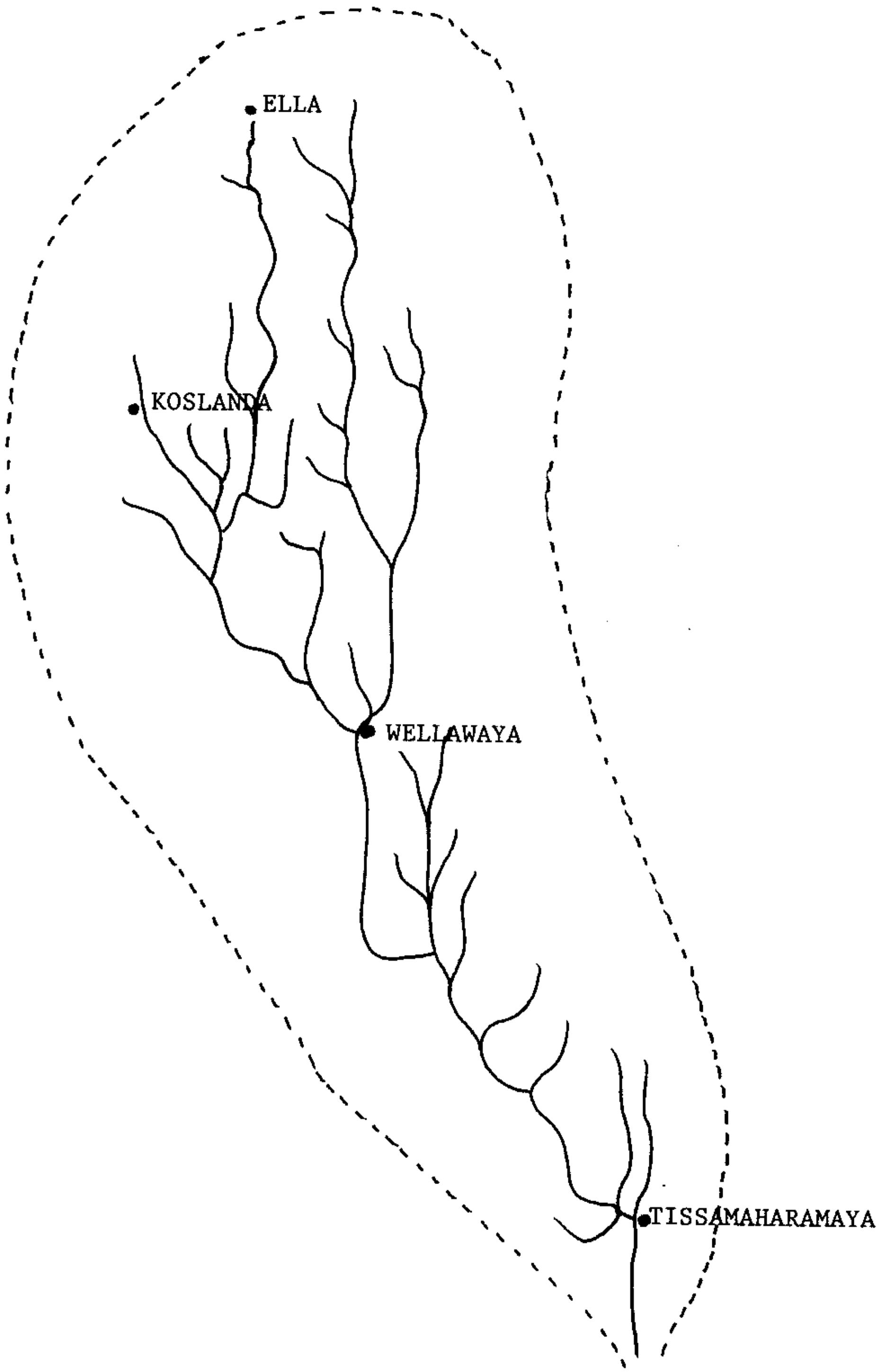
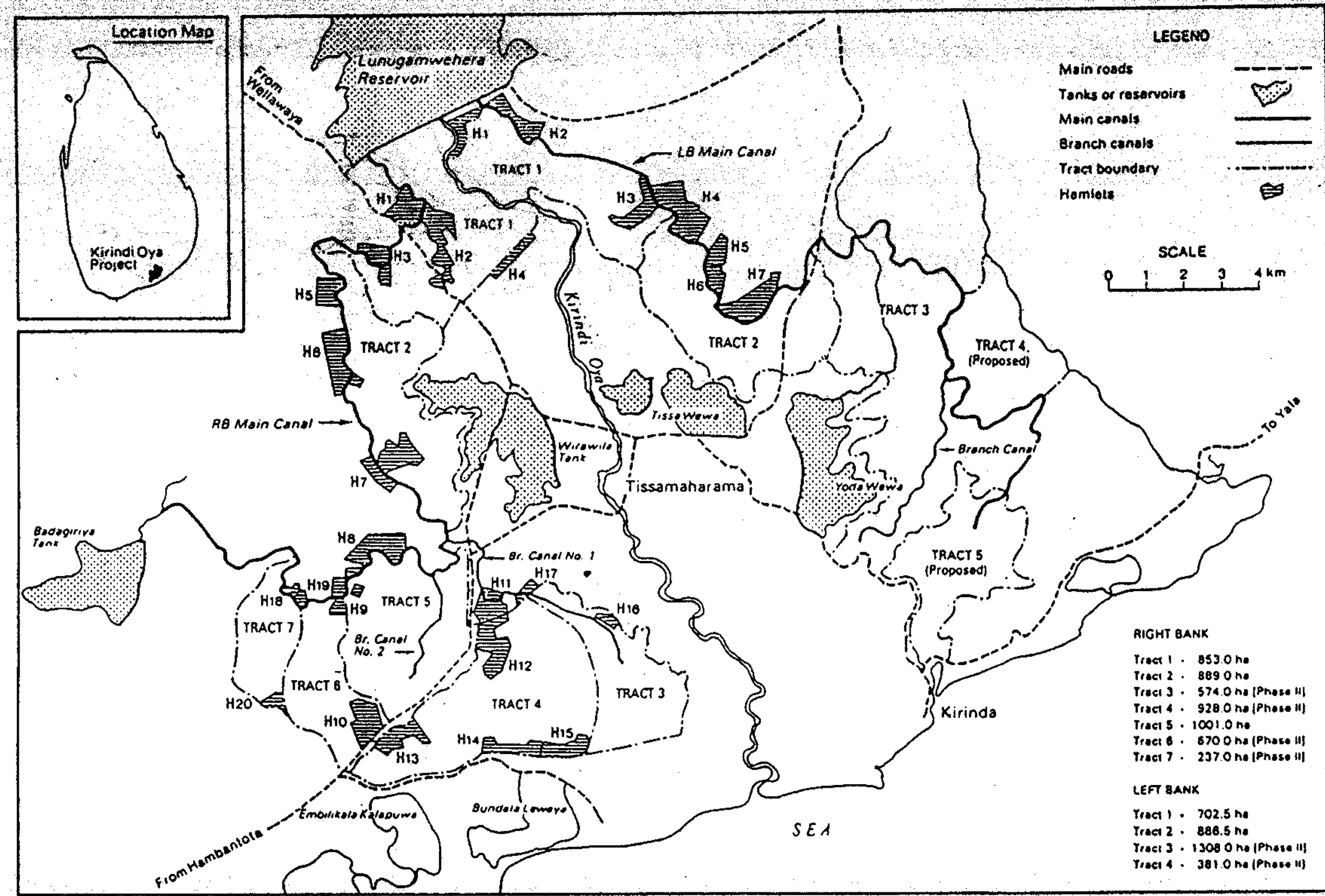
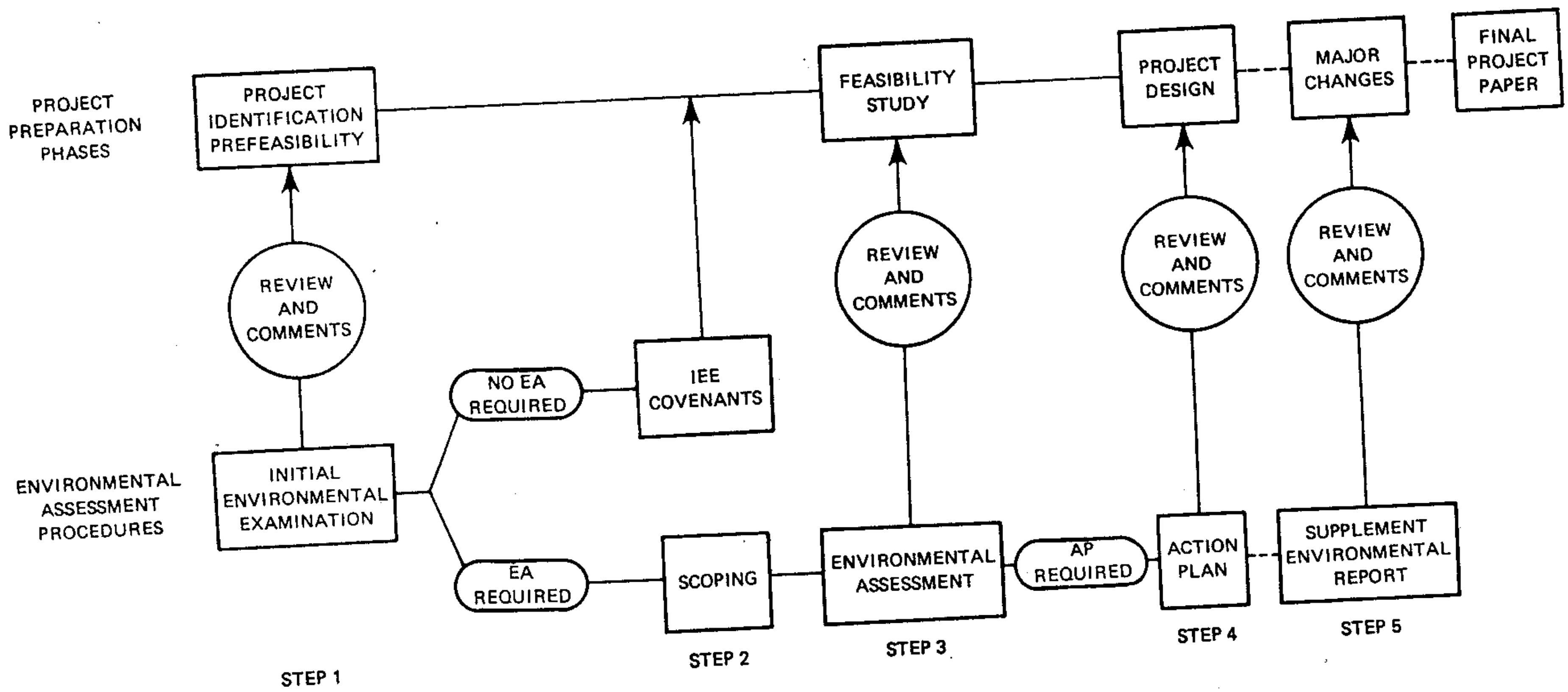


Figure 1

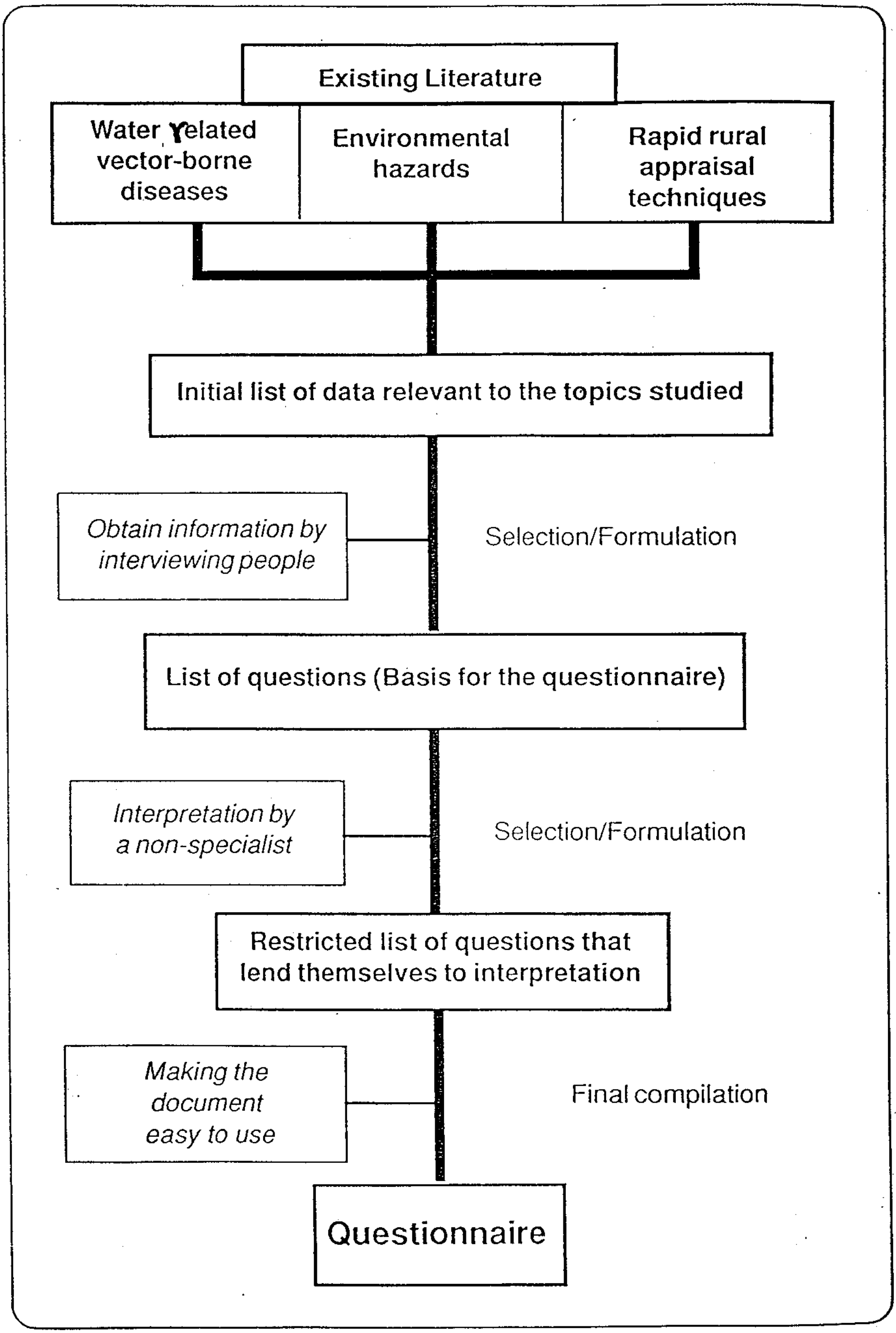
KIRINDI OYA IRRIGATION AND SETTLEMENT PROJECT



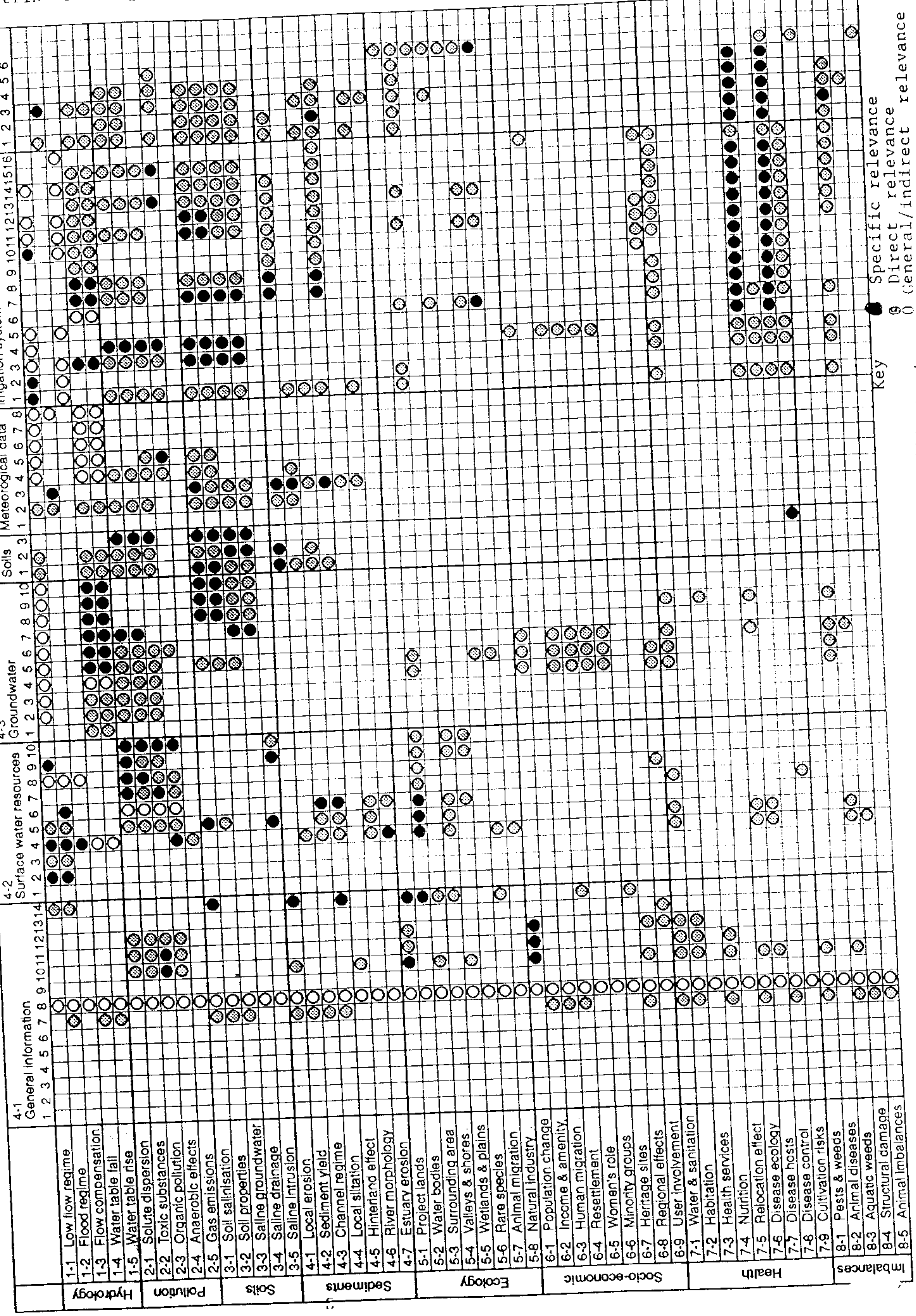


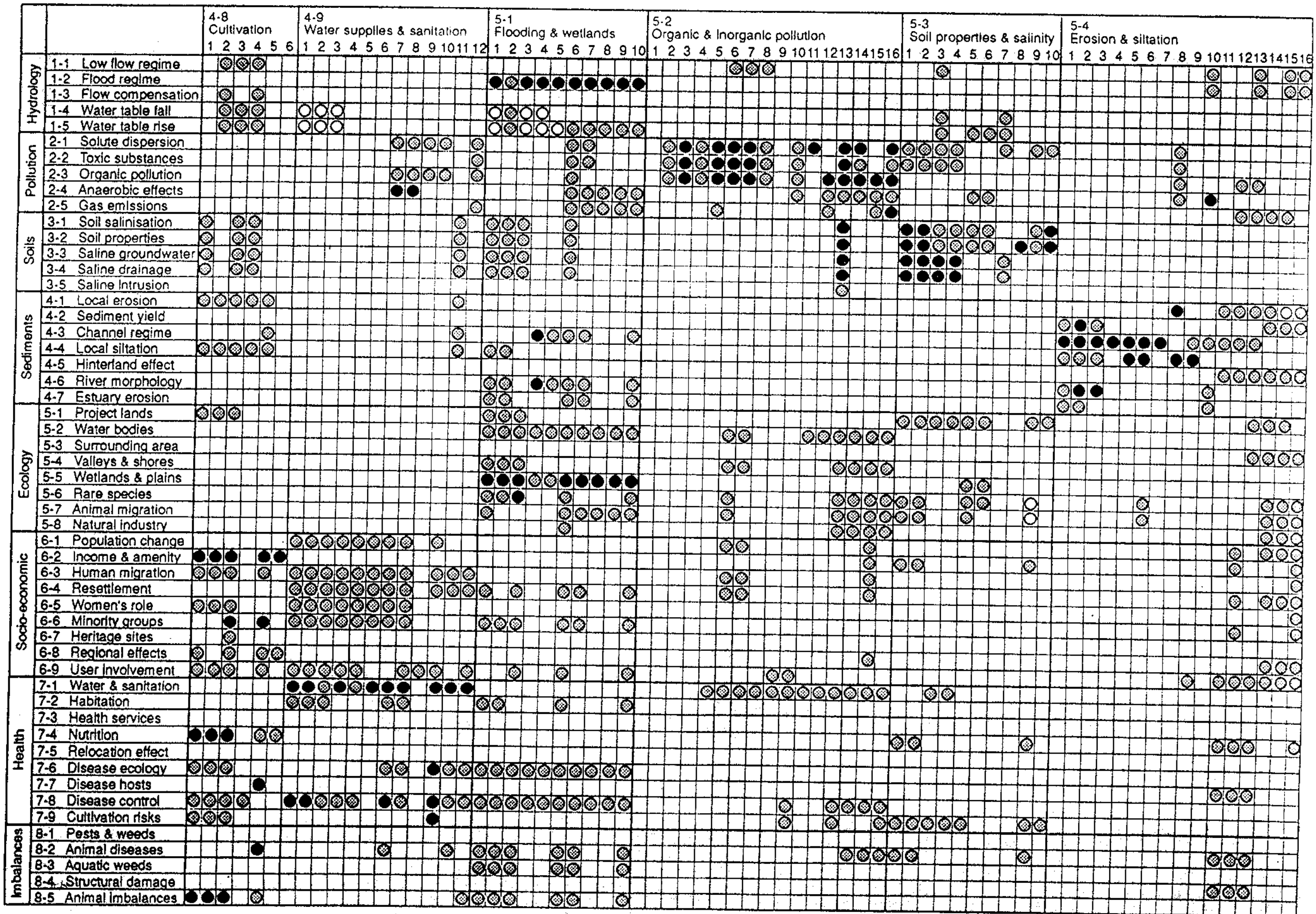
FLOW DIAGRAM: ENVIRONMENTAL ASSESSMENT PROCEDURES

Figure 6.1

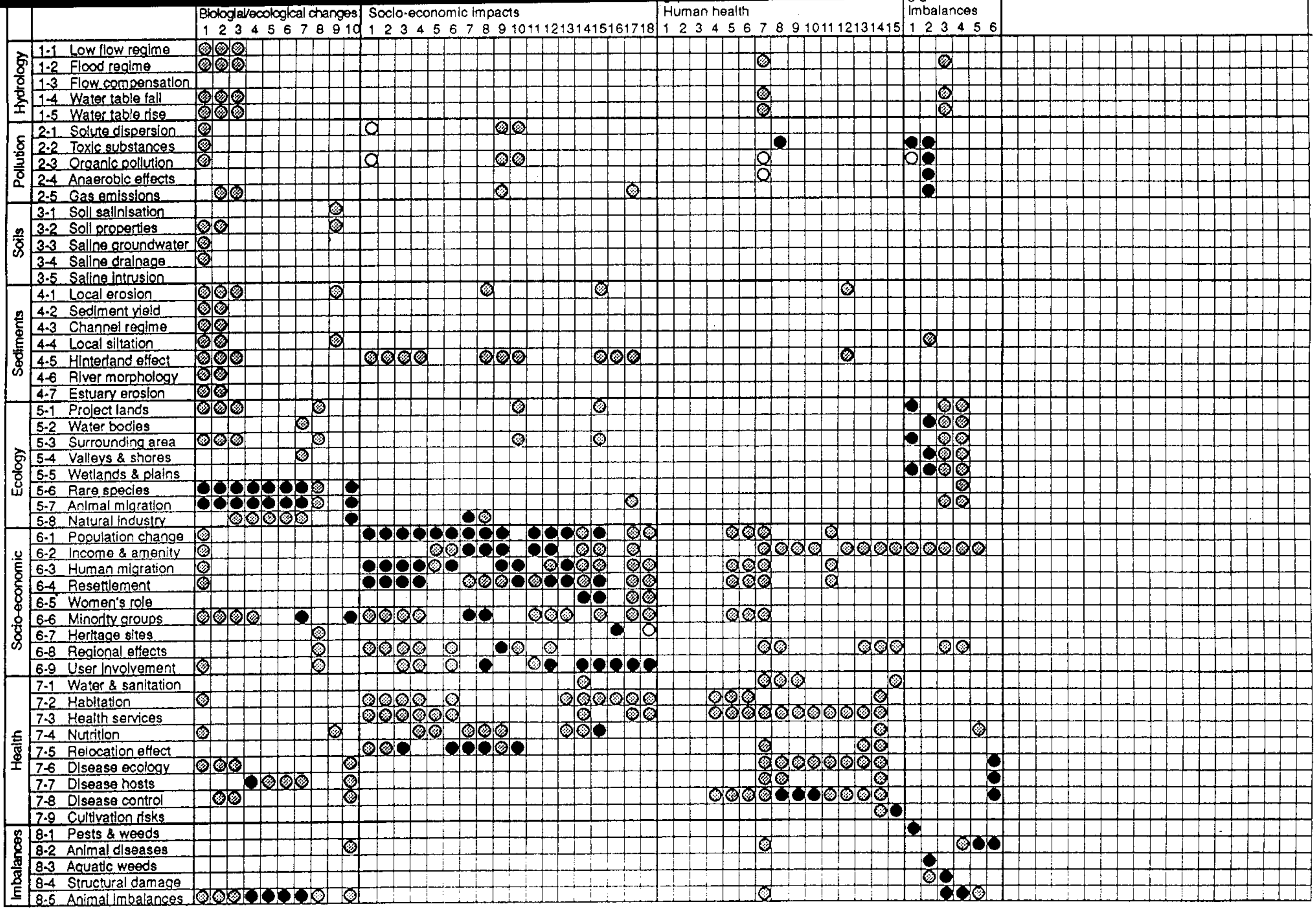

Existing Literature
Water related vector-borne diseases
Environmental hazards
Rapid rural appraisal techniques
Initial list of data relevant to the topics studied
Obtain information by interviewing people
Selection/Formulation
List of questions (Basis for the questionnaire)
Interpretation by a non-specialist
Selection/Formulation
Restricted list of questions that lend themselves to interpretation
Making the document easy to use
Final compilation
Questionnaire

Matrix showing which information in the data sheets relates to items in the checklist





4-8 Cultivation
1 2 3 4 5 6
4-9 Water supplies & sanitation
1 2 3 4 5 6 7 8 9 10 11 12
5-1 Flooding & wetlands
1 2 3 4 5 6 7 8 9 10
5-2 Organic & Inorganic pollution
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
5-3 Soil properties & salinity
1 2 3 4 5 6 7 8 9 10
5-4 Erosion & siltation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Hydrology
1-1 Low flow regime
1-2 Flood regime
1-3 Flow compensation
1-4 Water table fall
1-5 Water table rise
Pollution
2-1 Solute dispersion
2-2 Toxic substances
2-3 Organic pollution
2-4 Anaerobic effects
2-5 Gas emissions
Soils
3-1 Soil salinisation
3-2 Soil properties
3-3 Saline groundwater
3-4 Saline drainage
3-5 Saline intrusion
Sediments
4-1 Local erosion
4-2 Sediment yield
4-3 Channel regime
4-4 Local siltation
4-5 Hinterland effect
4-6 River morphology
4-7 Estuary erosion
Ecology
5-1 Project lands
5-2 Water bodies
5-3 Surrounding area
5-4 Valleys & shores
5-5 Wetlands & plains
5-6 Rare species
5-7 Animal migration
5-8 Natural industry
Socio-economic
6-1 Population change
6-2 Income & amenity
6-3 Human migration
6-4 Resettlement
6-5 Women's role
6-6 Minority groups
6-7 Heritage sites
6-8 Regional effects
6-9 User involvement
Health
7-1 Water & sanitation
7-2 Habitation
7-3 Health services
7-4 Nutrition
7-5 Relocation effect
7-6 Disease ecology
7-7 Disease hosts
7-8 Disease control
7-9 Cultivation risks
Imbalances
8-1 Pests & weeds
8-2 Animal diseases
8-3 Aquatic weeds
8-4 Structural damage
8-5 Animal imbalances



Biologial/ecological changes
Socio-economic impacts
Human health
Imbalances
Hydrology
1-1 Low flow regime
1-2 Flood regime
1-3 Flow compensation
1-4 Water table fall
1-5 Water table rise
Pollution
2-1 Solute dispersion
2-2 Toxic substances
2-3 Organic pollution
2-4 Anaerobic effects
2-5 Gas emissions
Soils
3-1 Soil salinisation
3-2 Soil properties
3-3 Saline groundwater
3-4 Saline drainage
3-5 Saline intrusion
Sediments
4-1 Local erosion
4-2 Sediment yield
4-3 Channel regime
4-4 Local siltation
4-5 Hinterland effect
4-6 River morphology
4-7 Estuary erosion
Ecology
5-1 Project lands
5-2 Water bodies
5-3 Surrounding area
5-4 Valleys & shores
5-5 Wetlands & plains
5-6 Rare species
5-7 Animal migration
5-8 Natural industry
Socio-economic
6-1 Population change
6-2 Income & amenity
6-3 Human migration
6-4 Resettlement
6-5 Women's role
6-6 Minority groups
6-7 Heritage sites
6-8 Regional effects
6-9 User involvement
Health
7-1 Water & sanitation
7-2 Habitation
7-3 Health services
7-4 Nutrition
7-5 Relocation effect
7-6 Disease ecology
7-7 Disease hosts
7-8 Disease control
7-9 Cultivation risks
Imbalances
8-1 Pests & weeds
8-2 Animal diseases
8-3 Aquatic weeds
8-4 Structural damage
8-5 Animal imbalances

Yearly Discharge
Kirindi Oya and Menik Ganga