AN ASSESSMENT OF SOIL QUALITY DECLINE IN NON - CONSERVED SLOPY CATCHMENT LANDS AT WELLAWAYA REGION AND IT'S CONSERVATION

BY

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DECLARATION

The work described in this thesis carried out by me at the Deputy agriculture office, Department of agriculture, Monaragala under the supervision of Dr. J.P Atapattu and Prof. Mahinda Rupasinghe. A report on this has not been submitted to another university for another degree.

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Affectionately dedicated
My
Parents and teachers

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ABSTRACT

The management of a catchment area is a vital aspect in conserving water, forest and soil resources in a particular area. The catchment area selected for this study is located at Icepeella, Wellawaya shows potential interruption by people in the surrounding area through encroachments leading to depreciation. A quantitative as well as a qualitative degradation of the selected water body has already been recorded. The present study focuses on finding remedies to the current situation by using soil conservation structures on the catchment agricultural lands.

According to the experimental data of the catchment, Soil erosion is the present acute problem in the area. Sixty percent of farmlands have a slop of more than 30 % and it represents the sloping nature of lands in area. Most lands have moderately deep or shallow soils. In most cases, surface soils was clay loamy in texture and some cases it was gravelly sandy clay loam as a result of severe soil erosion. Information was collected thought field activities and questionnaires.

Using the XRF analytical instrumental method, the soil samples are analyzed to identify the various levels of soil cations in conserved and non-conserved lands in the catchment. In the case of there were analyzed exactly 20 samples from each type of lands.

To identify the weight percentages differentiate of ion Na, K, Ca and Mg of the conserved and non-conserved lands, samples were collected at 0 – 15 cm soil depth to clearly identify the runoff effect on the non -conserved lands and conserved lands separately.

The Decline of most of the cations from non-conservated agricultural land is more than from 25 % - 50 % that of conserved lands in the catchment.

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ABBRIVIATIONS

OM	Organic Matter
XRF	X- Ray Florescent
FAO	Food and Agricultural Organization
TNT	Tri Nitro Toluene
RKP	Rock Knob Plan
VS	Vertiver Strips

CHAPTER – 1

1.1 Introduction

Land degradation includes all natural or anthropogenic process that diminishes or impairs productivity of lands. Among the anthropogenic factors are, overexploitation of land and water, deforestation, excessive use of agrochemicals. In Sri Lanka, man induced land degradation is more significant than that by natural process. This is evident in high rate of soil erosion and siltation, salinisation and decline in productivity of agricultural lands. Problems in land degradation in Sri Lanka have been evident through several period of our history. Chena cultivation practiced from prehistoric times, undoubtedly contributed to deforestation. (Natural resources of SriLanka , 2000).

The most concise and acceptable definition of sustainable land management is that by Greenland, which states " A sustainable land management system is one that does not degrade the soil or significantly contaminate the environment, while providing necessary support to human life ''. At the outset, it should be recognized that existing land use system and practices reflect that combined result of (a) several complex interaction between internal and external forces, (b) physical and biological process that are conditioned by human attitudes and values, and (c) the prevailing economic environment. At the same time, hardly any of the current land use or farming systems are in a stable state of equilibrium because they all require some external inputs in order to maintain their productivity. Economic factor such as providing subsidies can also have a major impact on land use practices. For a land use system or a farming system to be sustainable, it must provide the landowner with a reasonable quality and standard of living and rewards for his efforts (Panabokke,1996).

Soil, water and plant resources are nature's gift to mankind. Overgrazing, deforestation, faulty cultivation, shifting cultivation in the catchment areas, have led to devastating effects downstream. Drop in flow during the dry season and consequent loss of crops: and siltation of reservoirs and canals. The problem has been further aggravated due to high rate of population growth – both, human and livestock, resulting in discriminate exploitation of natural resources, for meeting the ever increasing demand for food, fodder, fuel, fiber and fertilizers. Thus continuous degradation of production base and imbalance in land – water – plant , human animal system is leading to ecological imbalance and economic insecurity, through severe soil erosion, both by water and wind threat to the quality of our life and cultivation. (Gurmelsingh et.al,1990).

Soil degradation due to the water erosion is a serious threat to the quality of the soil, land and water resources upon which man depends for his sustenance.(Pimentel et.al,1995). Estimated world wide cost of soil erosion to be about four hundred billon dollars per year, more than $70 per person per year. Swaify,(1994) Summarizing a recent study, indicated that water erosion had accounted for about 55%of the almost 2 billion ha of depredated soils in the world, there is no region of the glob. Where soil degradation due to water erosion is not a threat to the long term sustainability of mankind. Erosion is the removal of a mass of soil from one part of the earth and its relation to other parts of the earth. Water erosion is that portion of erosion caused by water. (Lal et al., 1998)

The water erosion process is frequently lumped in to sheet, rill, and gully erosion. Ellision, the erosion process was divided in interril erosion. (Ellision, 1947) and rill and gully erosion. Interrill erosion is best described as the process of detachment and transport of soil by raindrops and very shallow flow (Sharma,1996). Interrill erosion is constant over a slop as long as soil and surface properties remain constant.(Young,1973).

For short slops, most erosion may be interrll erosion. As slopes increase and as slope length increases, erosion due to channel processes begins to dominate.(Lal at al.,1998).

In all transects surveyed soil erosion was identified as a very wide spread and acute problem in the district. It is a combined effect of the other environmental problems of chena cultivation, encroachment of reserves, deforestation and monocroping which are caused by human activities. In the mountainous region of the North –Western part of the district, gully and rill erosion have occurred but most widespread type of soil erosion caused by clearing of land and burning the vegetation before the onset of the running off. The soil acts as reservoirs that conserve water; reducing both splash and runoff conserves soil.

Contouring, contour strip cropping, rough surface created by tillage and terracing all increases infiltration by holding water on the land longer. Some runoff occurs, but it is slower and carries less soil. Stream fed by slow runoff and seepage water have longer lasting flow and lower flood peaks than they would have if their water sheds were unprotected. Soil and water conservation becomes very important for plant growth in dry climate. Anything that helps get more water in to the soil or keep it there by reducing evaporation provides more water for plant growth.(Frederic,1980).

As matter now stands, control of erosion is the first and most essential step in the direction of correct land utilization about 75% of the present and potential cultivated area of the world. In the other words accelerated soil erosion presents the nation, not merely the individual farmer, with a physical land problem of enormous importance to the continuing welfare of agriculture in particular and the entire social structure in general more ever, beyond this whole land problem exists the intimate physical relationship of eroding land to mounting flood bights and to damaging silt deposits. (Bennet ,1991).

Erosion processes are set in motion by the energy transmitted from either rainfall, wind or a combination of these forces. Although the effects of erosion are not easily observed on a daily basis, water and wind are both capable of quickly damaging the soil. Raindrops hit exposed soil with an explosive effect, launching soil particles in to the air. For example, the energy in the raindrops falling on the state of Mississippi alone is the equivalent per year of nearly one billion tons of Trinitrotoluene (TNT). On sloping land more than half of the soil contained in the splashes is carried downhill. In most areas, raindrops splash and sheet erosion are the dominant forms of erosion. When rainfall is intense and rapid runoff occurs, gullies from ranging from 10 to 100m deep and large volumes of water and soil are swept away. (Asit, 1997).

Rotation, strip cropping, grass strips, mulches, living mulches, agro forestry, terracing, contour planting, covert crops and wind breaks.(Carter,1994).

The greatest single pollutant of surface water on a volume basis is soil sediment. The mudding of streams and lakes reduce their value for home, agricultural and industrial use, for recreation and as habitats for fish and wild life. The greater the sediment load, the less suitable the water is for any of these uses.

Another problem of more recent concern involves the contaminants that are carried in to the streams. Fertilizers and pesticides may be dissolved in running water or carried with the soil in to streams and rivers. In some instances these contaminants effect plants and aquatic animal life, and even land animals and man.

Although the rich bottomland soils adjacent to small streams and major river systems results from deposition of soil material eroded from the uplands, these same soils can be harmed when eroded subsoil and other less productive material is deposited on them. (Frederick et.al, 1980).

Soil conservation and wildlife conservation both depend fundamentally on the reestablishment and maintenance of vegetation. Each, therefore may not only make important contribution to the other but is actually essential to the other's highest expression. Without soil conservation, climax vegetation with its associated animal life must largely disappear; without wildlife conservation, the vegetation is deprived of important protection and ultimately the soil itself must lose the benefit of a powerful factor in its up building the direct influence of animal life. (Holt, 1937).

A catchment is simply an area of lands that drains in to a river or lake, the catchment which we live are dynamic and unique places. They are complex web of natural resources of soil, water, air, plants, and animals. Our everyday activities can impact on these resources, ultimately impact on our well being and economic livelihood. In order to prevent damage or a lessening of our standard of living we have to manage them correctly.

Widespread deforestation and intensive cultivation on strip lands have degradated the Kirindi oya upper water shed, resulting in accelerated soil erosion, reduction in crop yield, farm incomes, irrigation capacity and drinking water capacity. (An environmental profile, 1992).

In the recent past, tank water management primarily emphasized water distribution and improving the crop water use in the command area, but not much effort had been given for the management or improvements of water supplies to the village tank. In other words there had been no attempts to develop strategies to improve and stabilize the water supply to village tanks through the management of catchment areas. This applies to both major and minor tank catchments in the dry zone. There is now and urgent need to develop good management practices in the tank catchments because of the population pressure on catchment lands, unplanned development of tank catchments and extreme fluctuation of water supply to tanks. to develop agriculture in the dry zone outside the major irrigation areas, it is necessary to optimize the use of total incident rainfall both in uplands and in command areas of village tanks. Aberathne (1956) reported that the village tank is an essential factor to stabilize dry zone agriculture.

This study was carried out with the specific objective of evaluating the impact of catchment land use on the rainfall / runoff relationship and assess the cation degradation rate from the lands under such conditions.

1.2 Scope of the study

The management of a catchment area is a vital aspect in conserving water, forest and soil resources in a particular area. The catchment area selected for the present study is located at Icepeella; Wellawaya shows potential interruption by people in the surrounding area through encroachments leading to depreciation. A quantitative as well as a qualitative degradation of soil and water has already been recorded. The present study focuses on finding remedies to the current situation by using soil conservation strategies.

1.3 objectives

1) Comparative assessment of four major cation conditions in between conserved and non-conserved catchment agricultural lands.
2) Reduce runoff and soil loss from the catchment lands by applying proper soil conservation measures on such lands.
3) Reduce water pollution and siltation of low-lying water treatment plant and reservoirs, occurs by the sediment transport from the upper catchment sloppy agricultural lands.

CHAPTER - 2

2. Literature review

2.1 Prerequisites for soil and water conservation measures

Soil conservation is by itself the proper land husbandry, which would preserve the land and it's fertility on a sustained basis and at the same time promote better agriculture, increases yields and achieve maximum benefits from such land. Such land husbandry should be based upon proper classification of land utilization and allotment of lands for the different purposes, for which various local conditions are suitable. In planning reorganization of a farm for efficiently controlling soil erosion, conserving moisture and improving the productivity of soil, the characteristics of the following factors and the mechanics of erosion by water and wind are to be assessed

- Physiography (size, shape, relief, and drainage).
- Soil properties (soil series and soil phases physical, chemical, and biological properties).
- Vegetative cover.
- Land use practices.
- Nature and distribution of rainfall.
- Socio economic factors. (Germel singh, at al., 1990).

2.2 Soil erosion by water

Water causes soil erosion through rainfall, runoff, and waves of oceans and reservoirs similar to the control of soil erosion caused by wind, the basic approaches to control of soil erosion caused by water are aimed to reduction of impact of rainfall and corrosive power of flowing water, and increase in resistively of soil against getting eroded. Water causes soil erosion in the forms of splash, sheet, rill, gully, stream, bank slides, pipes (tunnels) and waves of oceans. Soil erosion increases with increases in the slop of land decreases in the case of plant cover over it. Mechanical and vegetative measures, commonly called soil conservation practices and structures;

and adopted for decreasing the effect of land slop. Vegetative cover also decreases the erosive power of raindrops by providing a canopy and leaf cover over the land surface. These approaches can be explained through a line diagram as follows. (Ghanshyma,2000)

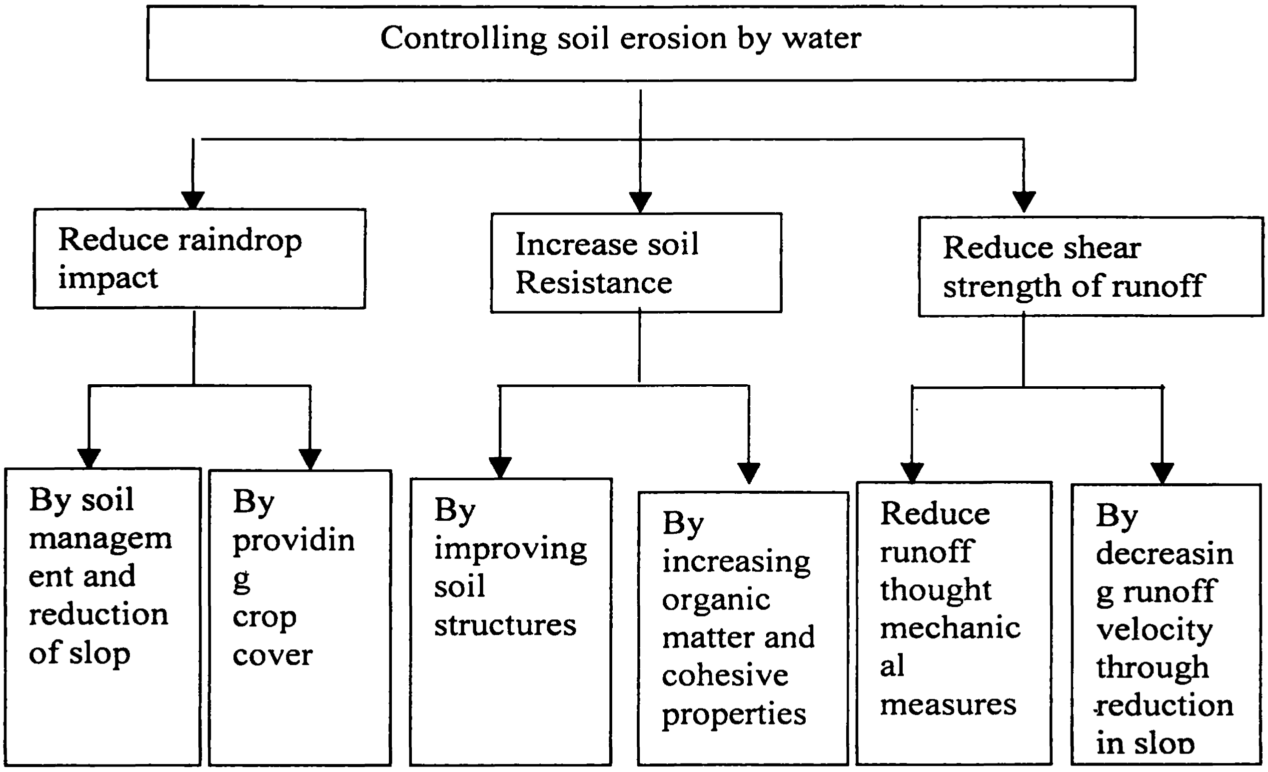


Figure 2.1: approaches to control of erosion of soil caused by water

(source – Ghanshyma, 2000)

2.3 Land use management

One of the first considerations of a soil conservationist is the use of land within its capabilities. Some land is suited for intensive cropping – especially where the soil is deep level, fertile, well drained and has favorable texture and structure. Other land is so steep, shallow stony or otherwise limited that it is suitable only for wildlife, recreation or other use that that causes no erosion. Many gradation exist between these two extremes. Most land is suitable for some use but sustainable for others.

Management can alter the effect of a single type of land use on a wide rang of erosive tendencies. Row crops, for example, can be grown in wide of narrow rows that may or may not follow contour lines. There may or may not be a lengthy exposure to elements between the harvesting of one crop and the protective growth of the next. The soil may or may not be protected by crop residues or by special cover crops during periods when the main crop is not on the land. Each of these variables has a considerable effect on the amount of erosion that is likely to occur. (Frederick at al., 1980).

2.4 Rainfall erosivity and potential erosion in dry zone

The magnitude of soil erosion can be estimated by using erosivity values. For example bellow table shows the amount of soil that would be lost annually from an open field of hundred meters and on 2,4, and 6% land slops. Here the soil is considered as well drained reddish brown earths and its erodibility value has been reported as 0.55. (Dharmasena,1993). Values were computed by using universal soil loss equation.

Table 2.1 - Potential annual soil loss in rhodustalfs

Location	Potential annual soil loss t/ha		
	Land slop %		
	2	4	6
Anuradhapura	27	52	84
Galgamuwa	26	51	83
Horowpatana	31	61	99
Kantale	34	66	108
Mahailluppallama	25	48	78
Maradankadawala	28	53	87
Polonnarawa	33	64	104

(Source – Wickramasinghe and Premalal,1998)

These values were obtained by considering a situation with no vegetative protection or supporting conservation practices. The soil erosion in reality is not always as such because other factors such as vegetation and topography can change the erosion predicted by using annual erosivity.

Soil erosion has been estimated from plot measurements at Maha Illuppallama, under various conditions. In cotton cultivated plots without any conservation measures, that annual soil loss was 22.2 t/ha. Dharmasena (1992 b) reported that soil erosion in a maha season could be as high as 54 t/ha from chena lands in the rhodustalf region. Wickramasinghae and Premalal (1998) observed that annual erosivity in the dry zone region is higher than that in the up country mainly due to high percentage erosive rainfall, which occurs in the low country dry zone.

In Sri Lanka, soil erosion and fertility decline are the two main land degradation processes and nearly 33% of the land extent in the island is subjected to soil erosion (Nayakakorale, 1998). Further Stocking (1992) reported a soil loss of 40, 70, 38 and 18 t/ha /year from old seedling tea, tobacco, capsicum and carrot, respectively and Krishnarajah (1984) showed soil loss due to erosion under different vegetative cover management.

With the establishment of plantation agriculture in Sri Lanka, mechanical measures have also been introduced for soil erosion control in plantation crops particularly in tea. Apart from the plantation sector, such mechanical measures have also been popular mainly among resources rich individual farmers, as field establishment of mechanical structures need significant investment. On the other hand, resources poor farmers continue their cultivation without taking adequate mechanical soil erosion control measures in most case. (Kandaragama at. al, 1998).

Table 2.2 - Changes in land characteristics due to establishment of biological soil erosion control structure.

Changes in land Characteristics as a % Of farmers	Major biological soil conservation Control measures		
	Wet zone		Intermediate zone
	Vetiver Strips	Gliraciada Headgerous	Gliracedia Head grows
Reduction of soil erosion	93.1	100	100
Increases of infiltration	34.5	54.5	95.2
Reduction of surface runoff	58.6	90.9	95.2
Improvement of soil fertilizer	34.5	36.4	61.9
Improvement of soil tilth	13.8	36.4	47.6
Changes in pest	3.4	0.0	4.8
Increases of shade on crops	3.4	7.3	19.0
Reduction of space for crops	0.0	0.0	28.6
Changes in crop yield	17.2	18.2	19.0
Reduction of weed growth	17.2	36.4	42.9
Increases of the wilting of the crop	0.0	0.0	14.3

(Source –Kandaragama at. al, 1998)

2.5 Influence of land use on catchment runoff and its impact on the village tank

Small scale reservoirs constructed across first, second or sometimes even third order valleys referred to as village tanks are a distinct feature in the dry zone of Sri Lanka. From early times, this tank system or (minor irrigation system), has been the most important single factor responsible for the establishment of human settlements in the dry zone and it occupies a central place in the life of the dry zone villager. The village tank is a community – owned water resources managed by the community for irrigation of rice fields and for variety of other uses such as bathing, washing, fishing, and as a source of water for animal. (Bandara and Somasiri, 1994).

2.6 Land use in micro catchment

The land use composition of the three tank catchments is given in below table. The demarcation of land uses in the micro catchment is based on the aerial photo interpretation and field verification. Estimation of areas under each land use was made using a planimeter. Nearly 80% of the land area of Kolongaswewa is under chena; 73% of the area of Siyambalagaswewa is under teak; and 89% of the area of Tammannagala is under forest. Home gardens and rock knob plain (RKP) assumed to have similar hydrologic proportions in Kolongaswewa and Tammannagala. Compared to the above two catchments, Siyambalagaswewa catchment has less of high runoff generating surface areas, such as RKP and home gardens and more of low runoff generating surfaces such as paddy lands. The runoff generating potential of forest, secondary forest and scrub jungle are shown to be very similar in this region.(Sumanarathne and Somasiri,1990).

Table 2.3 - Land use patterns in selected micro catchment

Land use	kolongaswewa		Siyambalagaswewa		Thammanagala	
	Extent (ha)	% total	Extent (ha)	% total	Extent (ha)	% total
Forest	-	-	-	-	32.8	48.8
Secondary forest	-	-	-	-	27.4	40.8
Chena	31.5	79.2	2.9	2.9	-	-
Scrub jungle (abundant)	4.0	10.1	17.9	17.9	-	-
Garden (homestead)	0.7	1.7	3.5	3.5	-	-
Paddy	1.0	2.4	3.5	3.0	-	-
Rock knob plain	2.6	6.6	-	-	7.0	10.4
Teak	-	-	73.7	79.2	-	-
Total	39.80	100.00	101.20	100.00	67.10	100.00

(Source - Bandara and somasiri,1994).

2.7 Runoff and soil loss

The chena land runoff generation was greater than that of the scrub and forest; but the difference in runoff between scrub and forest was negligible (below table). Chena with unprotected soil surface during Maha planting time is directly exposed to the early intermonsoon high intensity rains. With the result the bare land surface is converted to a high runoff-generating surface. Furthermore, the destruction of soil aggregates by the impact of raindrops and slaking causes surface sealing while repeated calculation of Alfosols compacts soil layers by practicle translocation. (Pathak et.al 1983).

These enhance runoff generation, in these chena lands; as water infiltration is low, initial crop growth is retarded; hence surface remains bare for a longer duration, thereby generating greater runoff. (El- swaify,1983).

Table 2.4 – rainfall and runoff in thee different land systems

Parameter	Chena		Scrub		Forest	
	Maha	Yala	Maha	Yala	Yala	Maha
1987/88						
Rainfall (mm)	802	382	555	275	727	413
Runoff (mm)	292	73	7	4	8	0
Soil loss (Kg/ha)	10334	215	88	20	66	0
Runoff %	36.4	19.1	1.3	1.5	1.1..	0
1988/89						
Rainfall (mm)	342	165	587	338	323	243
Runoff (mm)	188	27	2	1	3	0.3
Soil loss (Kg/ha)	3273	484	78	4	21	1
Runoff %	54.9	16.4	0.5	0.3	0.7	0.1

(Source – Sumanarathne and Somasiri,1990)

2.8 Soil erosion, preview and important fact

Soil erosion is the removal of soil by water and or wind. Erosion is slightly from soil well covered by dense grasses or forest but is enormous from steep, poorly covered soils that are exposed to heavy rainfall or strong winds. Well-aggregated soils resist erosion but pulverized silts and very fine sands are the most easily eroded.

Natural or geologic soil erosion does not occur at a constant or consistent rate. Semiarid and arid soils, which lack protective plant covers, may erode naturally at rates averaging 10 – 15 times greater than those for humid climate soils. In Indian, where rainfall is adequate to support extensive plant ground covers, soil erosion loss averages about one metric tons per hectare (0.5 t/a) annually, a rate that does not seriously deplete soil productivity and that is about same erosion rate as that for undisturbed or well- managed forest lands. This rate of erosion is a loss of 2.5 cm (1 inch) of surface soil every 300 years. These losses are compensated by new soil formation, which for Indian glacial till is about equal to that lost from natural erosion. New soil forming from bedrock will take more than 10 times longer, so natural erosion of soils forming on bedrock is a more serious loss than from deep sediment. This is also true for soils in cold an arid climates, as in Alaska, because both conditions retard soil formation. The natural progress of soil erosion can be increased horrendously by human activities, such as over cultivating depleted soils until the protective ground covers are gone and accelerated erosion takes place. Severe erosion exceed 200 Mg / ha /yr (about 90 t / a /yr). (Raymond and Donahue,1997).

2.9 Sri Lankan situation

The reasons for soil degradation are reflected from the pressure on land resources of Sri Lanka. From the total land area of about 6.5 million ha, only about 3 million are arable due to unsuitable terrain, forest reserves and inland water bodies. The gross land / man ratio, which was 2.7 ha in 1871 with a population of 2.4 million, has been reduce to 0.35 ha with about 19 million people in 2000. The directly available land for human use is estimated at 0.15 ha per person. The pressure on land is also reflected from the forestry perspective where the forest cover decline throughout the years. The forest cover which was 90 % of the country during 1900 when the population was 3.5 million, declined to 50% in 1953 with the increase the population to 8 million and further reduce to 23% in 1982 with the population rising to 15 million. At present, the forest cover is estimated at less than 20%. Out of this, only 9% are in the sensitive watershed areas showing the importance of relocating them with proper planning.

Main reason for soil degradation in Sri Lanka is listed as soil erosion due to water, fertility decline resulting from reduction of organic matter and plant nutrients, salinization resulting from improper water management and soil compaction.(Maddumabandara, 2000)

Nayakekorale(1998) listed soil erosion as the major soil degradation processes in Sri Lanka where more than 33% of the land are exposed to erosion soil erosion. The Central Environmental Authority of Sri Lanka, which is the major body dealing with environmental issues, listed soil erosion as the major cause of soil degradation in Sri Lanka. They documented that soil erosion resulted from encroachment of forests, disturbing of hydrologically critical areas, shifting cultivation, inadequate attention to lands higher than 1500 meters from mean sea level. They also highlighted that the fragmentation of responsibilities of soil conservation among different agencies is a drawback in controlling this problem. (Mapa, 2003).

As pointed out by many environmental economists the estimation of losses due to environmental degradation is a very complicated process (Gunathiklake, 2003). The most recent estimate about losses due to soil erosion in Sri Lanka is documented by Where on site and off site losses add up to about Rs. 3000 to 4000 million annually. The adverse impacts on irrigated agriculture mainly due to sedimentation are estimated to be equivalent to Rs. 320 million annually. These are only conservative estimates, at the intangible off site events, as flooding, detrimental impacts on human health and recreation are not taken in to account.

Even though the major causes of soil degradation is soil erosion, not much published data are found on erosion rates and related soil conservation. The tolerable soil erosion rate, which is the allowable soil erosion rate without declining the soil productivity was estimated by (Krishnarajah 1984), is given in table 2.5

Table 2.5 - Estimated rates of tolerable soil loss for different soils of Sri Lanka

Agro ecological region	Soil order	Potential Rooting (cm)	Tolerable Soil loss (t/ ha /y)
Up country Wet zone	Ultisol	180-240	13.2
Mid country Ewt zone	Ultisol	120-150	9.0
Low country Dry zone	Alfisol	90-150	6.7

(Source: Krishnarajah, 1984).

2.10 Soil fertility decline

Soil fertility decline in Sri Lanka is mainly due to the depletion of soil organic matter. Being a tropical country, soils of Sri Lanka contain low activity clays with mostly kaolonitic and oxidic mineralogy (Mapa 1992). The cation exchange capacity in soils other than Entisols and Inceptisols show value, sometimes even lower than 10 cmol / Kg even in the top soil. The water retention values of such soils are also low with less than 120 mm of available water in one-meter depth of soil. In such instances the organic matter plays a major role in retaining soil nutrients and water. If organic matter is not added periodically, the fertilizer use efficiency will decrease. The removal of most fertile topsoil, which causes lowering of soil depth also, contributes to the fertility decline. The removal of first five centimeter of the topsoil reduced crop yields by almost 50 %. The depletion of soil nutrients due to leaching and runoff is also a major cause of fertility decline. The loss of nutrients in a five month observation period from a tea land in the up country Wet zone of 30 % slop was documented. The loss during the five months period amounted to 0.37 Kg of N, 0.87 Kg of P and 0.045 Kg of K per hectare of land. As many farmers do not apply adequate fertilizers according to recommended rates, the depleted plant nutrients are not replenished, thus accelerating the fertility decline.

2.11 Salinization

Development of salinity is another soil degradation process, which is mostly related to improper irrigation without adequate drainage facilities. This is very common in many irrigation systems and about 45,000 ha in Sri Lanka are affected by salinity at present. Punyawardena (1990) reported electrical conductivity values of about 32ds/m in Kirindioya irrigation system. According to the FAO classification if the electrical conductivity exceeds 8 ds/m these are classified as high salinity water effecting crop production.

2.12.some terms relation with soil

2.12.1 Parent material

The consolidated and more or less chemically weathered mineral or organic matter from which pedogenic processes develop the soul of soil. The upper part of the regolith may be designated as parent material of soil

2.12.2Regolith

Above bedrock usually consolidated debris (close earth material) is present. This material is known as regolith. The upper portion of the regolith which has been subjected to more weathering actions of wind, water and organisms, forms parent material and the topsoil.

2.12.3 Topsoil or surface soil

When a soil is plowed and cultivated, the natural state of the upper 12-18 cm (5–7 inches) is modified. This manipulated part of the soil is referred to as the surface soil or the topsoil.

Topsoil or surface soil is the major zone of root development for crop plants. It contains many of the nutrients available to plants and supplies much of the water necessary for their growth.

2.12.4 Bedrock

The solid rocks underline soils and the regolith or exposed at the surface without a cover. (Guptha 2000).

2.13 Soil and its profile

2.13.1 Soil

An introduction soil, in its traditional meaning. is the natural medium for the growth of land plants. Soils are all unconsolidated material of the earth's crust in which land plant can grow, if water and temperature are adequate, at least the minimum nutrients are available and toxic substances are in low concentration.

The soil is a natural body of mineral and organic materials differentiated in to horizons, which differ among themselves as well as from the underlying material in morphology, physical make- up, Chemical composition and Biological characteristics. All soils developed from weathered rock, volcanic ash deposits, or accumulated plant residue. (Guptha, 1994)

2.13.2 Soil profile

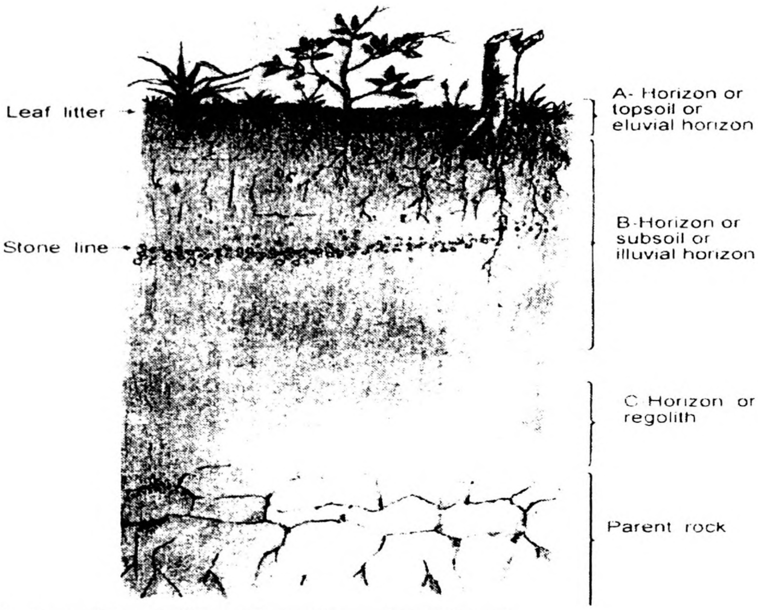


Figure 2.2: soil profile of undisturbed land
(Source -Soil and agro. 1996)

It represents the number of horizons of the vertical soil series from top to the bottom. The upper most horizon, which is the topsoil, is referred to as the A horizon. The organic matter is concentrated in this horizon and it is therefore darker in color than the rest of the profile. Ti is also called the eluvial horizon because material has been removed from this horizon by leaching or eluviation. Below the A horizon is the sub soil or B horizon it is also called the illuvial horizon because most of the materials removed from the A horizon by leaching has been deposited in this B horizon. The A horizon is the horizon of impoverishment, while the B horizon is the horizon of enrichment. Where the B horizon is enriched with clay that move down from the A horizon. In modern terminology it is called argillic or argic horizon. Below the B horizon is the C horizon. These horizons A,B and C, together constitute the soil profile. (Soils and agro,1996)

2.14 Importance of some cations in to plant crops

2.14.1 Potassium (K) (a major plant nutrient)

Potassium (K) is an essential plant nutrient. It is one of the three major nutrients along with Nitrogen (N) and Phosphorus (P). Agronomic crops contain about the same amount of K as N, but more K than P and many high – yielding crops, K content exceeds K content. Below table shows that amount of some crops take up from the soil.

Table 2.6 - Potash taken up by some common crops at a given yield level

Crop	Yield level	K2O taken up by crop Kg
Alfalfa (hay)	18.0	538
Banana	40.0	1000
Citrus	30.0	350
Coconuts	_	200
Coffee (clean beans)	1.5	130
Corn	6.0	120
Cotton (lint)	1.0	95
Oil palm	25.0	300
Peanut	2.0	92
Potato	40.0	310
Rice (paddy)	6.0	130
Soybean	3.0	150
Tomatoes	50.0	286
Wheat	6.0	180

(Source: Guptha, 2003).

2.14.1.1 Role of Potassium in plants

Potassium is absorbed by plants in the ionic form (K^+). Unlike N and P, K does not form organic compound in the plant. In primary function seems to be tied to plant metabolism. It is involved in several plant processes.

Potassium is vital to photosynthesis. When K is deficient, photosynthesis declines, and the plant's respiration increases. The functions of K in plant are as follows.

- Reduce photosynthesis and increased respiration.
- Lower the plant's carbohydrate supply.
- It is essential for protein synthesis.
- It is important in the break down of carbohydrates, a process that provides energy for plants growth.
- Ti helps to control ionic balance.
- It is importance in the translocation of heavy metals such as iron (Fe).
- Ti helps the plant to overcome the effect of diseases.
- It is important in fruit formation.

2.14.2 Calcium (Ca) as a secondary nutrient

2.14.2.1 Role of calcium in plants

Plants take up calcium as the Ca2+ cation. It is readily transported to root surfaces by mass flow. Root interception can also provide this nutrient in some soils. The main functions of Ca inside the plant are as follows

- Calcium stimulates root and leaf development, microbial activities and uptake of other nutrients.
- It forms compounds, which are part of cell walls.
- This strengthens plant structure.

- It helps to reduce nitrate nitrogen, to activate plant enzyme systems and to neutralize organic acids in the plan.

- It is essential for nut development in peanut.

- Calcium also influences yield indirectly by reducing soil acidity (calcium carbonate). This lowers solubility and toxicity of manganese (Mn), copper (Cu) and aluminum (Al).

- It is required in large quantities by nitrogen fixing bacteria.

2.14.2.2 Calcium in the soil

Total amount of the calcium in the soil range from les than 0.1 percent to as much as 25 percent. Arid, calcareous soils contain the highest level of calcium. Recently drained organic soils often contain very little Ca and have extremely low PH values. Clay soils usually more Ca than sandy soil. It is held as exchangeable Ca2+ on the negatively charged surfaces of soil colloids. It is usually the most dominant action in the soil, even at low PH; and normally occupies 70 percent or more of the sites on the soil's cation exchange complex. Like other cations, Ca is also present in the siol solution. It is part of the structure of several soil minerals. In fact, such soil minerals as dolomite, calcite, apatite and calcium feldspar are a major soil surface of Ca.

2.14.3 Magnesium

2.14.3.1 Role of Magnesium in plants

Plants as the Mg2+ cations take up magnesium. Mg is the central atom in the chlorophyll molecule, so it is actively involved in photosynthesis. Magnesium and Nitrogen are the only soil nutrients that are constituents of chlorophyll. Magnesium also aids in phosphate metabolism, plant respiration and the activation of many enzyme system.

2.14.3.2 Magnesium in the soil

Soil magnesium, other than that added in fertilizer or liming materials, comes from the weathering of rocks containing such minerals as biotite, hornblende, dolomite and chlorite. Being a action, Mg2+ is subjected to cation exchange. It is found in the soil solution and is adsorbed to clay and organic matter surfaces. Soils usually contain less Mg than Ca because; Mg not adsorbed as tightly by clay and organic matter and is more subject to leaching. Also, most parent materials contain less Mg than Ca. Although, many soils contain enough Mg to support plant growth, Mg deficiencies frequently occur, most often on causer textured, acid soils developed under high rainfall conditions. (Guptha, 2003)

2.15 Cation bonding energies of root colloids

Mean free bonding energies of cations calculated from activity measurements of soil colloids have been calculated by marshall. MC Lean and Breaker made similar calculations from activity measurements of Na, K and Ca on roots of several plant species. They reported root caton exchange values of 42.4 meq / 100g for alfalfa, 41.1 for soybeans, 14.1 for red top and 11.8 for reed canary grass. The alfalfa and soybeans roots, with relatively high cation exchange have bonding energies for Ca which are more than double the bonding energies for K. for Ca on red top roots with low cation exchange, the bonding energy was about 50 percent of the value with the legumes, whereas K was held with about 80 percent of the value for legumes. Reed canary grass bonded K with about 90 percent of the value for Ca. Bonding energy value of clay usually increases as percentage saturation decreases. These bonding energies were determined on roots saturated with K, Ca or Na. Thus, at lower saturation values it would be responsible to expect that the bonding energies of the grasses for K would exceed those for Ca. unusually high Ca bonding values would result if the root contained material such as oxalate which combined with Ca to form relatively insoluble compounds. Plant root containing oxalate and citrate would be highly effective in releasing Ca from minerals such as limestone and rock phosphate.

Table 2.7- Activities, fractions active and mean free bonding energies of cations in homoionic plant root system.

CEC Meq /100g	Saturated Cations	Activity *1000	Fraction active	Δ Ft (Cal)
Alfalfa				
42.4	Na	4.85	36.4	599
42.4	K	4.26	32.0	672
42.4	Ca	0.49	7.3	1594
Soybean				
41.1	Na	3.25	24.1	843
41.1	K	3.81	30.1	711
41.1	Ca	0.38	6.1	1654
Red top				
14.1	Na	2.86	59.6	305
14.1	K	1.79	37.3	588
14.1	Ca	0.54	22.4	885
Read canary				
11.8	Na	8.40	91.0	55
11.8	K	2.36	63.2	272
11.8	Ca	1.10	58.9	314

ΔFt – mean free bonding energy in (cal /mol).

(Source; Firman, 1964):

2.16 Manmade activities and sediment yield

Sediment load aggregation occurs due to the river flow through easily eroded loess soils, which have been cleared of their forest cover for farming.

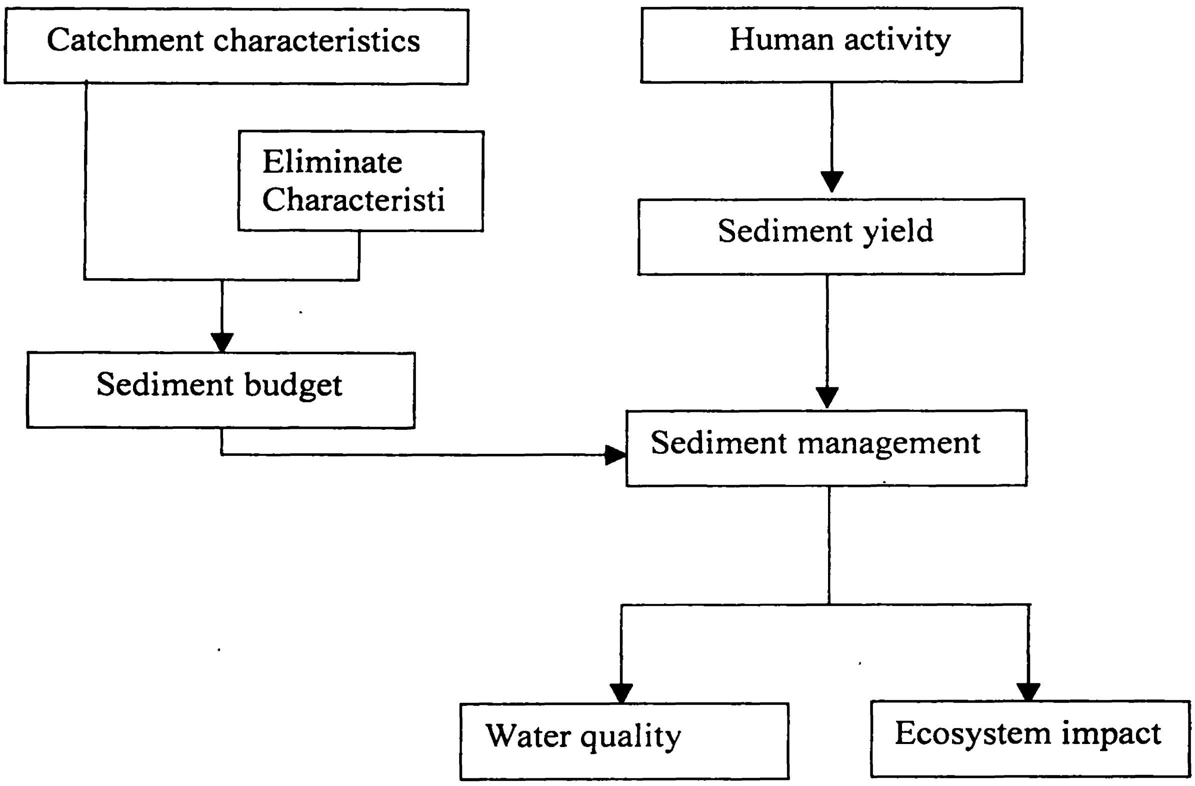


Figure 2.3 manmade activity and sediment yield
(Source – Robert and Victoria, 1987)

The sediment in the drainage basin causes problems for the water quality of drinking water and also an ecosystem such as turbidities. Therefore, information about the erosion, transfer and deposition of sediments is important for managing the low land treatment plant and irrigation water bodies. (Robert and Victoria, 1987)

CHAPTRE – 3

3. Materials and Methodology

3.1 Relative study area and background

The relative study area The Icepeella catchment is located in GPS (Geographical Position System) locations between the northern latitudes $6^{0}43$'and $6^{0}58$' between eastern longitudes $81^{0}12$'and $81^{0}25$' the soils are mainly well drained red brown earth (RBE) on the higher ground, with low humic clays (LHC) and alluvial soils along the river course. The total area of the catchment, with human settled and non-settled is about 500 – 600 acres. Mean rainfall is about1900 mm /yr and mean temperature is about 27 $C^{0.}$

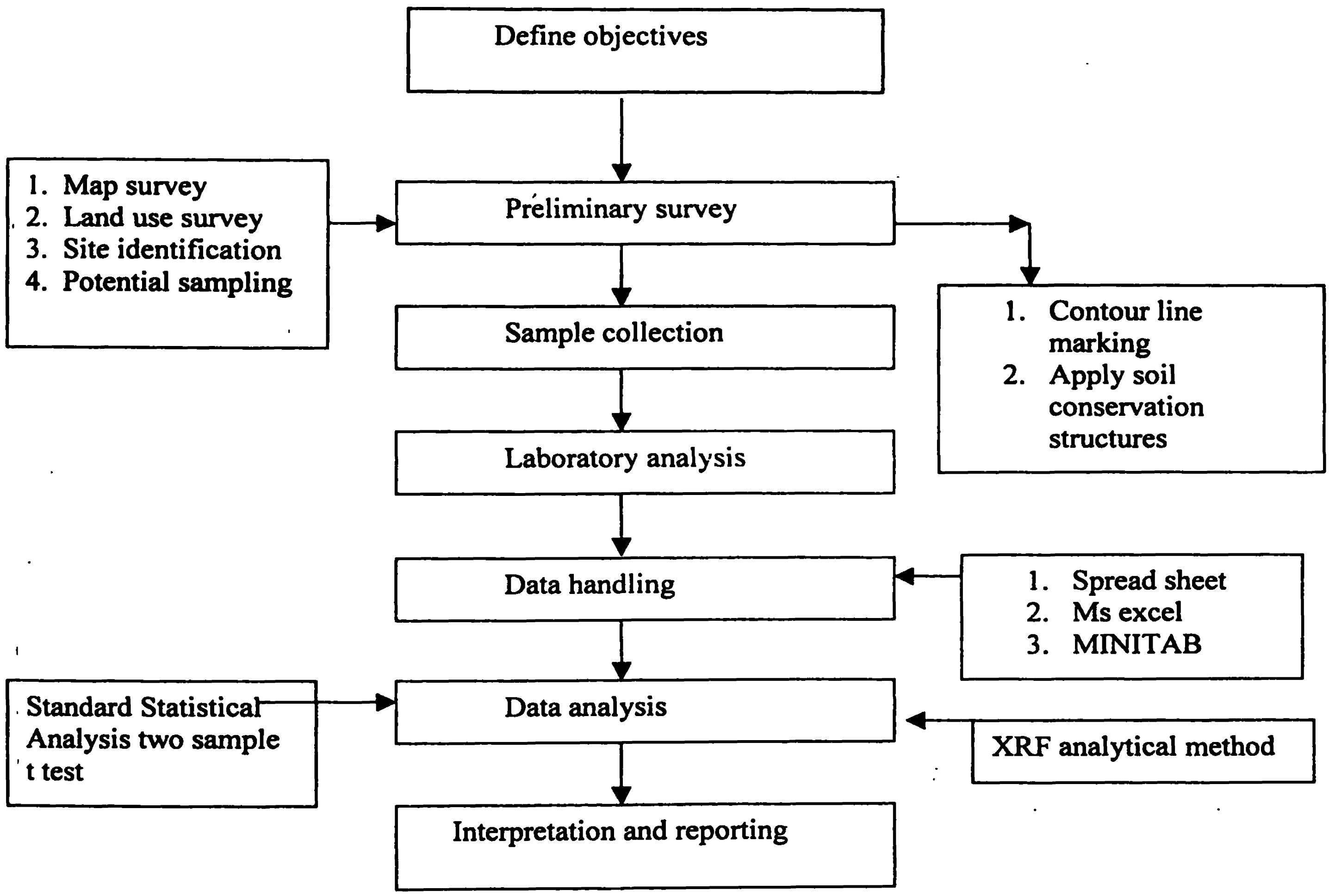
The parts of the project area is involved in to two administrative districts, Monaragala and Baddla. Lower part of Haldummulla AGA division from Badulla district and upper part of the Wellawaya AGA division from Monaragala district.

At least 300 families are live in the catchment base area. Most of the families in the area are depending under agriculture base activities and annual income of large portion of this population is under poverty line.

This catchment area has a significant value as a drinking and irrigation water sources. But recently it has been shown reduction of the water yield from the catchment. That means the deforestation and other destructive anthropogenic activities are caused to decrease the water yield of the catchment. Then, the sudden improvement of water yield of the cathment using environmental management strategies that are suitable is a more important incident to protect the benefits of water consumption population in the area.

As a major concept to conserve this area, the soil management by using soil conservation structures and replantation are major issues have come to the first. The ultimate objects of the above plan, to develop soil condition by conserving, reduce runoff and increase infiltration, reduce sediment yield and finally develop water table and increase water yield of the catchment.

3.2 Methodology



3.3 Map of the area

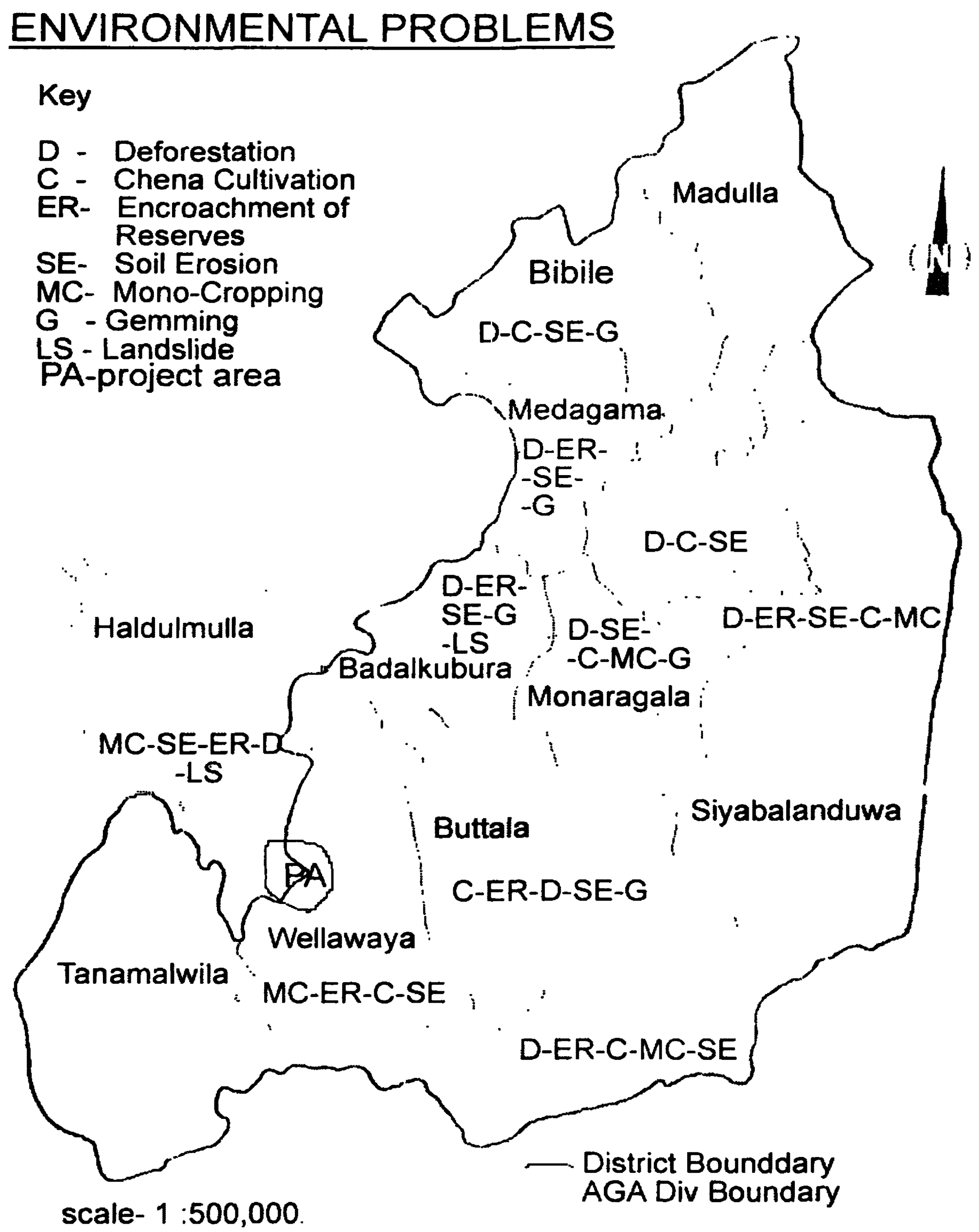


Figure 3.1: map and main environmental problems in the area

(Source -: An environmental,1992)

3.4 Field activity

Preliminary survey was conducted during one February to March 2005 in the Ice peella catchment area in six villages namely Ice peella, Malwattawala, Ihala-Malwattawala, Medagoda Nitolla, and Watawana wattha. Farmlands either in which soil erosion controls measures have been adopted or not. Collected information is listed in appendix (iii).

Sixty percent of farmlands have a slop of more than 30 % indicating the sloping nature of lands in area. Most lands have moderately deep or shallow soils. In most cases, surface soils was clay loamy in texture and some cases it was gravelly sandy clay loam as a result of severe soil erosion. Following Information was collected thought questionnaires.

- General information of the farmer;
- Extent of the lands and the extent adopted with the soil erosion;
- Land characteristics such as land lop, soil type, soil depth and soil texture;
- Present land use;
- Soil erosion control measures adopted previously;
- Overall performances of individual soil erosion control measures;

After the identification of various sloppy irregular chena and other farmlands to design the soil conservation structures (according to the slop and drainage type of the land it would have to used soil conservation structures with various distance and different sloppy angle). Thus, using proper instrument such as Road Razor or Abnilevel were measured and marked the contours to build up the soil conservation structures. Finally, about 150 different types and various size lands were marked for build up soil conservation structures.

On these marked contours the farmers were applied several type of conservation structures on their lands is described below.

3.5Soil conservation methods used on the site

1) Mechanical

2) Biological

3) Cultivation

3.5.1 Mechanical methods

Construction costs of these methods were very high and also efficiency and durability was more than that of other methods. By adding technical knowledge, in to our traditional soil conservation systems farmers were achieved best results from the mechanical soil conservation purposes.

- Lock and spill drains
- Stonewalls
- Contour stages
- Individual stages

3.5.1.1 Lock and spill drains

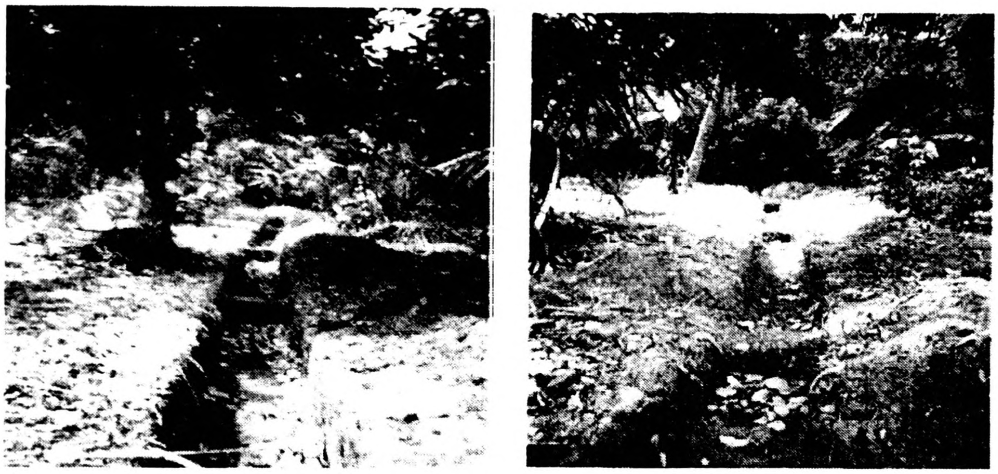


Figure 3.2: lock and spill drains on contours in the field

The width and depth of the drain were to be 60 cm and 45 cm separately. In between 4.5 m of the drain a gap were remained with 45 cm width, and depth was not less than 15 cm depth from the ditch depth. Loose soil yielded when ditch was dug, were laid in to down side in the slop. Drains were made in same contour lines or with slop 120: 1 feet.

Target of the soil conservation by ditches were, reduce the distance and speed of the surface flowing water and increases the infiltration rate and reduce quantity of water loss by the runoff process.

3.5.1.2 Stonewall

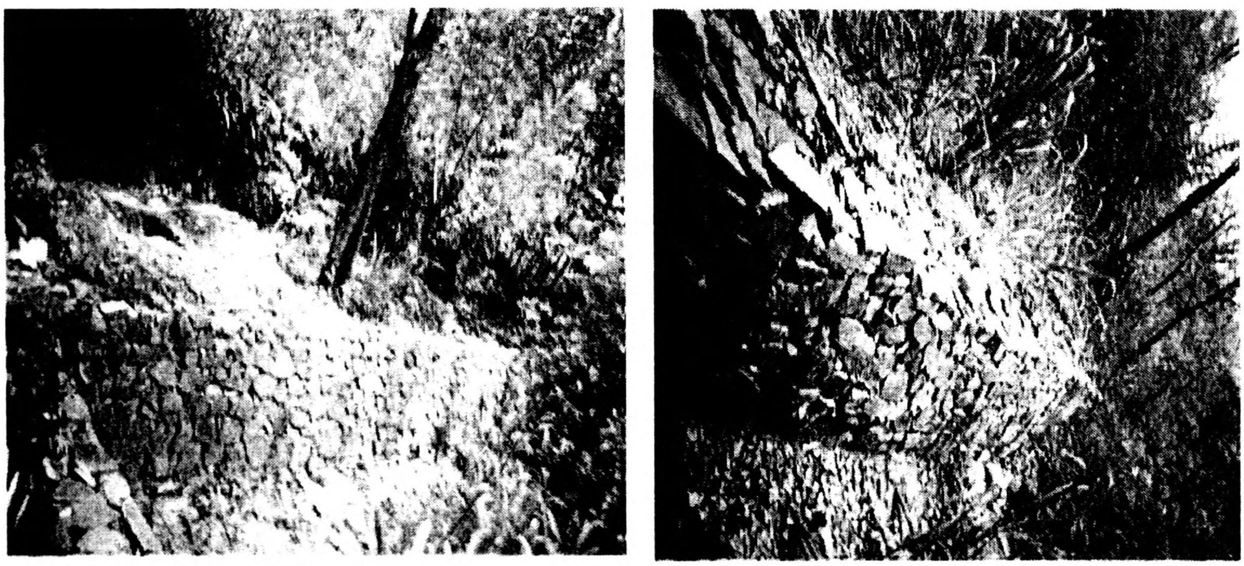


Figure 3.3: stone walls

Before established stonewalls, there were made a rock fill foundation. The depth of the foundation was 22 cm dept and walls were applied on this foundation. Width and height of stonewall were exactly 60 cm and 45 cm separately. Thus, height was measured from uphill side of the slop.

The main objectives of the stonewall soil conservation system were, reduce surface runoff and trap the sediment load on the land, without wash off in to the down streams. It was suitable for lands with medium depth and moderate slop.

3.5.1.3 Contour stages

According to the crop due to cultivated, the distance between two stages was varied. That means, the distance of the two-crop plants was equal to the distance of the two stages. Width was 1.7 m. the cut and fills method were used for stage construction. Though reduce runoff and by increasing infiltration reduce the soil erosion was the main target of the contour stages. The grass cover in between two stages was not removed when the construction of the stages.

It was Suitable for lands with a deep depth and steep slop and to fruit crops on the sloppy lands.

3.5.1.4 Individual stages

Usually the stages were 2 m long and 1m-width half circle shape occurred structures. If the land is too steep and irregular, these structures were more suitable. When the land has shallow depth and more rock and bolder the perennial crops can plant on this type of stages. Grassland between stages has been well managed. Thus, the less land area is exposed to the rain drops will caused to reduce the erosion speed of the land.

3.5.2 Biological methods

- Vertiver strips (Gliracedia fences)

3.5.2.1 Vertiver strip

As farmer used the VS as a soil conservation measure, there were used various types of biological material to makd the fences. These are Gliracidia, Nanthasuria, Caliandra, Plemengia etc. In this case, gliracidia plant sticks were standed out in a same line with 45cm width between two lines and distance between two sticks was about 6cm. While the 60cm height of the stick from the surface soil to its top, the buried depth of the sticks in to the soil was about15cm. The important thing of this manner was the all sticks would have regenerating ability (regrowing ability), after standed out on the site. Using unnecessary debris have been shown on the land, it was filled up in to this gap between two fences to trap the sediments from runoff water and reduce the runoff rate by the surface soil.

3.5.3 Cultivation methods

There were no special structures used effectively as the main target was as soil conservation. But there were significant values to conserve the soil during the cultivation time by the farmer. Some times it would be very simply. But most of the times they are very important.

- Cover soil from mulches
- Contour cropping
- Minimum tillage
- Selective weeding
- Use organic fertilizer (eg.compost)
- Perennial crops cultivation

3.5.3.1 Cover soil from mulches

Normally, covered the root surfaces of the plant by using organic debris. When the farmers have enough organic materials, there was no matter used for to cover the whole land. Green mulches, hay or any grass species have been used as mulches. This is not only a soil conservation system, it also protect the moisture level of the soil, improve the microbial activity of the soil and improved the soil structure.

3.5.3.2 Contour cropping

The crops cultivated thought the contour lines on the land, it was very important to reduce the runoff, increase sediment trap and increase infiltration capacity.

3.5.3.3 Minimum tillage

By tilling, reduced the compaction of the soil and topsoils become loosely arranged materials. From the splash and runoff action of the raindrops would led to wash off these loose particles from the topsoil. With minimum or zero tillage cultivation, there reduce these adverse effects to the soil from the erosion action.

3.5.3.4 Selective weeding

In this manner, it was cleared the land only surrounding the crop plants when remaining other weed plants of the land. This was very important in the sloppy lands conservation.

Use organic fertilizers; by adding the organic fertilizer in to the soil, it was improved its structure and water holding capacity. It would be a positive effect to reduce the soil erosion.

3.5.3.5 Perennial crops cultivation

Steeply sloppy lands were not suitable for short-term agriculture crops (e.g. Vegetable), because more and more tillage practices were caused to leads the soil erosion. Thereby low tillage practices occurred perennial crops cultivation was most suitable for this type of land.

CHAPTER – 4

4. Results and discussion

4.1 Sample collecting and analysis

Using the XRF analytical instrumental method, the soil samples are analyzed to identify the various levels of soil cations in conserved and non-conserved lands in the catchment. In the case of there were analyzed exactly 20 samples from each type of lands.

To identify the weight percentage of ion Na, K, Ca and Mg of the conserved and non-conserved lands, samples were collected at 0 – 15 cm soil depth to clearly identify the runoff effect on the non -conserved lands and conserved lands separately. The table 4.1 shows the ionic percentage of the four cations in such different land types.

The sample are collected in the same elevation, that is all samples are collected above 540 m from the sea level in the catchment and the all specific lands are used to collect the samples were same sloppy (between 30 % - 50 %), to reduce the error can effects by the runoff difference thought high sloppy lands.

Table 4.1-weight percentage of some cations of catchment lands

Conserved lands					Non conserved lands			
Cations	Na%	K%	Ca%	Mg%	Na%	K%	Ca%	Mg%
Sample No								
1	0.9	1.8	8.51	0.64	0.5	2.1	0.1	0.55
2	0.63	2.52	6.46	0.48	0.7	1.8	5.5	0.58
3	0.72	3	7.3	0.94	0.46	1.4	0.4	0.61
4	0.61	2.41	6.84	0.86	0.64	1.6	5.3	0.51
5	0.84	2.64	9.43	0.63	0.54	2.1	3.6	0.09
6	0.92	1.2	6.72	0.72	0.51	2	2.8	0.41
7	0.92	1.54	6.81	0.81	0.49	1.11	0.3	0.31
8	0.6	2.6	8.61	0.64	0.3	1.31	3.9	0.2
9	0.58	3.1	8.79	0.32	0.68	1.68	4.6	0.41
10	0.79	1.48	6.87	0.96	0.67	1.43	6.7	0.18
11	0.81	1.63	8.32	0.71	0.71	1.57	5.4	0.21
12	0.83	2.59	5.42	0.83	0.5	2.11	4.7	0.2
13	o.65	1.92	6.86	0.34	0.48	1.89	4.6	0.29
14	0.73	2.71	7.24	0.42	0.41	1.67	6.7	0.34
15	0.68	2.63	4.98	0.81	0.49	2.12	3.4	0.21
16	0.91	2.91	5.73	0.9	0.71	2.01	5.4	0.41
17	0.81	1.98	5.89	0.92	0.69	1.64	4.8	0.43
18	0.61	2	6.97	0.86	0.50	1	8.4	0.14
19	0.59	2	7.11	0.43	0.41	2	4.9	0.6
20	0.6	2.8	8.31	0.72	0.5	1.75	5.6	0.13
Mean value	0.738	2.273	7.162	0.697	0.544	1.714	4.35	0.341

4.2 Discussion

4.2.1 Graphical presentation of the ion content in two different land types

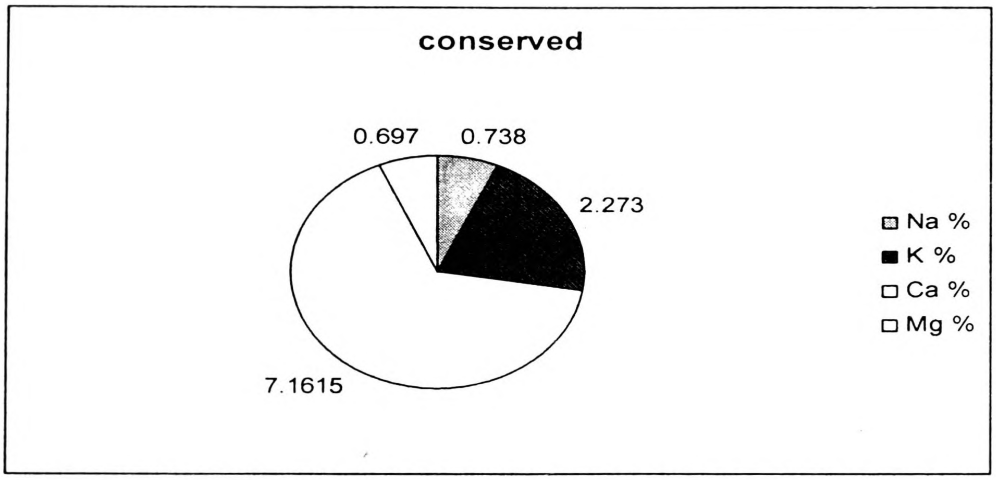


Figure 4.1: pie chart of mean value distribution in percentage of conserved lands

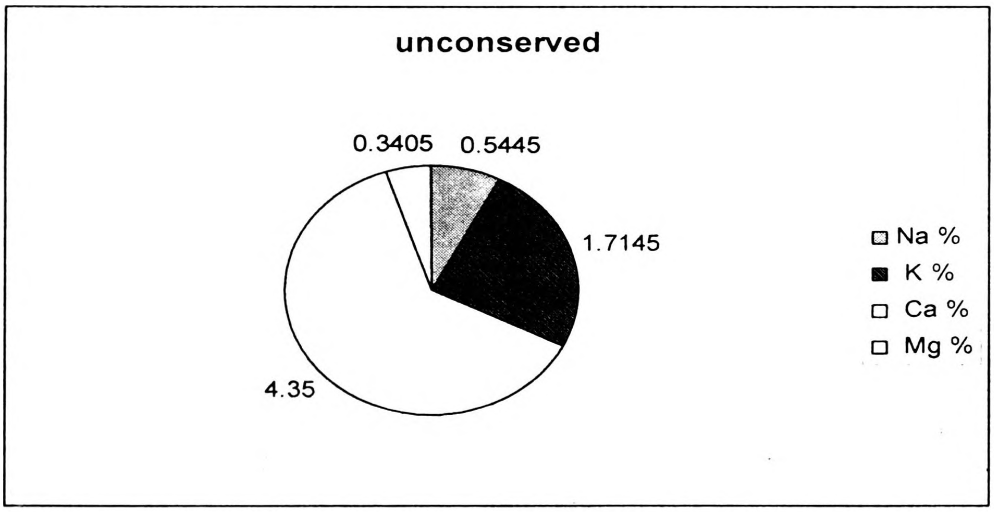


Figure 4.2: pie chart of mean value distribution in percentage of non-conserved lands.

Ca percentage of the both conserved and non-conserved lands are higher than that of the other cations. That observation could be representing the important evident, us to get an idea about the parent material of the soil in the catchment land. That means we can assume the soil of the catchmenmt is made up of calcic based parent rock.

In order to decreasing the percentage value of the four cations is same in both conserved and non-conserved lands of the Ice Peella catchment, that is Ca, K, Na and Mg.

The declining of the soil cations by the washed off thought runoff process can effectively observable in the chart 4.3 – 4.6 in the below.

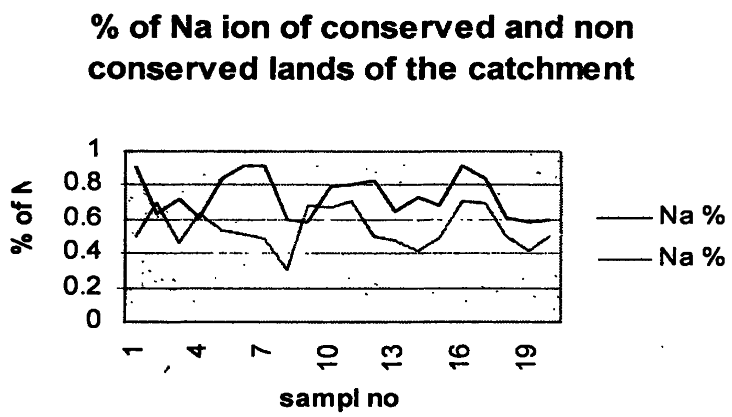


Figure 4.3: difference of Na ion weight percentage

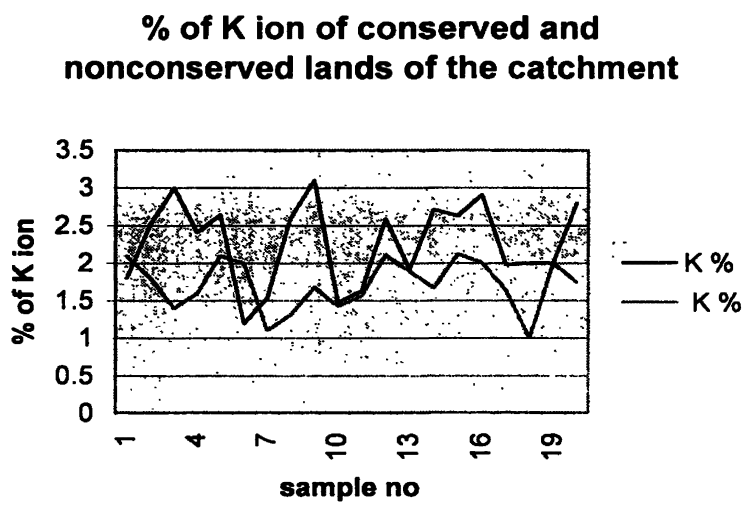


Figure 4.4: difference of K ion weight percentage

For the figures 4.1 – 4.4

Higher value represents the ion content of conserved lands and lower values represent the ion content of the non - conserved.

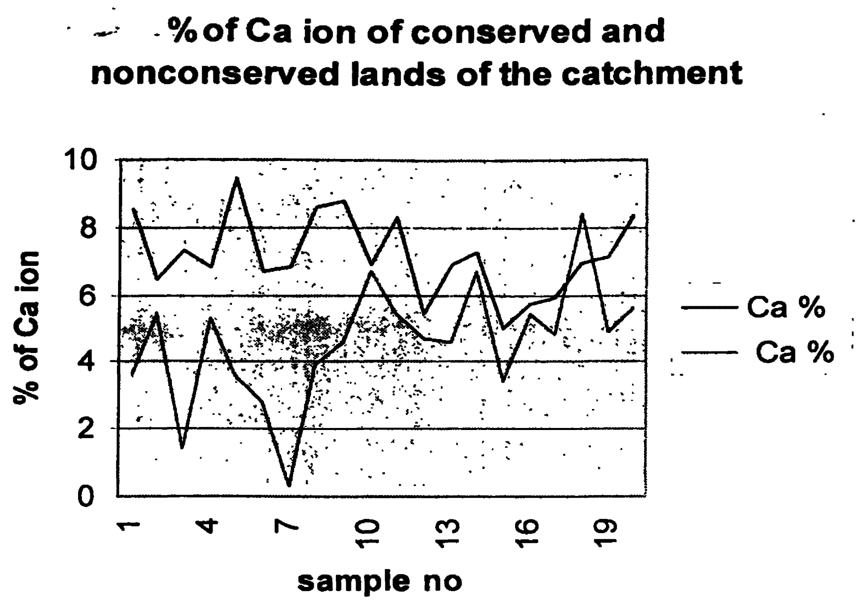


Figure 4.5: difference of Ca ion weight percentage

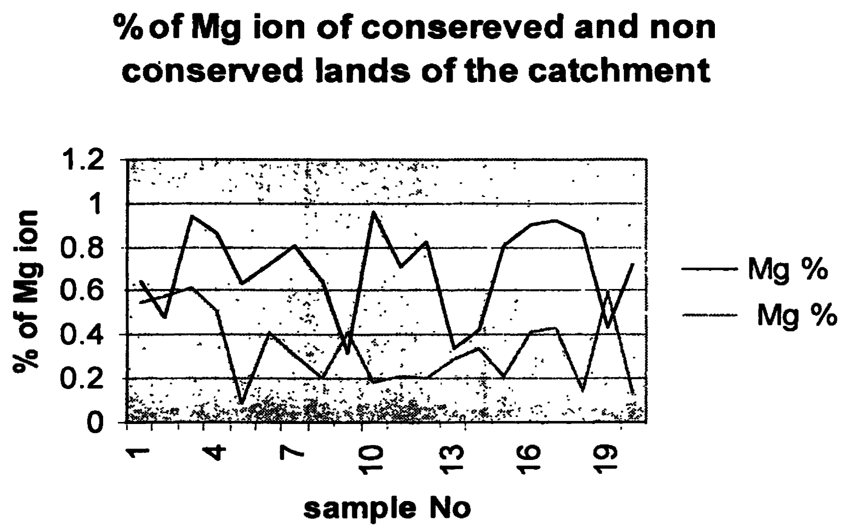


Figure 4.6: difference of Mg ion weight percentage

Ca is the most prominent among above cations in catchment lands; it is mostly observable situation in calcareous soils. Fertility decline thought runoff process is more, which lands have not been used the soil conservation measures to reduce the runoff. The comparison the mean values have been got for the above chemical analysis and above chart represent the real situation soil cation concentration in between such two types of lands.

All cations participate for the cation exchange reactions with soil colloids and almost some amount of these ions are in the soil solution. If the rain sufficient for occurs a runoff, the ionic solution with contains above ions, easily washed off from the soil solution. Rate of the surface flowing water, gradually decreases when apply barriers or any interruption on the topsoil through soil conservation measures. It may cause to less harm occur in the rainy season by reducing runoff rate and increasing the infiltration rate. As numerically calculated values (see appendix ii) the cation removable ability of non-conserved lands is more of Na 26 %, K 24 %, Ca 39 % and Mg 51 % than that of conserved lands. More details are listed in appendix **I,** with descriptive statistics graphs.

The cultivation of plant crops without applying any soil conservation measures, it will cause to damage the good ionic balance of the soil and reduce the crop production of the land system. Thought my observation removing magnesium ions from lands through runoff process is present the highest decline value. One of the functions of Mg is to participate produce chlorophyll in plant leaves, by declining the Mg ions from the land rapidly there is more contribution to low productivity of crop lands. Otherwise the Ca is the main problem of drinking water at Wellawaya. The higher accumulation of Ca ions from catchment lands because mismanagement of soil in to the water treatment plant is a big health problem in the area. In the case of less soil management practices by farmer of the catchment, the low-lying paddy fields, which are irrigated from catchment water, will increase their salinity and any other problems regarding with it.

CHAPTER – 5

5. Conclusion and recommendation

5. 1 Conclusion

According to the study there is high potential to degradate the non-conserved sloppy agriculture lands with comparing to the conserved lands. By the process of soil conservation, the degradation occur by surface runoff can be reduce. The chena cultivation lands, which have not been applied any soil conservation can be vulnerable easily in the high rainy seasons Yala and Maha. Mechanical soil conservation structures are most suitable for the catchment land, but farmers should protect their lands by applying agronomic measures any time he can does.

5 .2 Recommendations

1). Prohibit deforestation for chena cultivation of the catchment forest.

2). Introduce large-scale soil conservation project in to this area.

3). Introduce least soil effected agro forest system into the catchment area.

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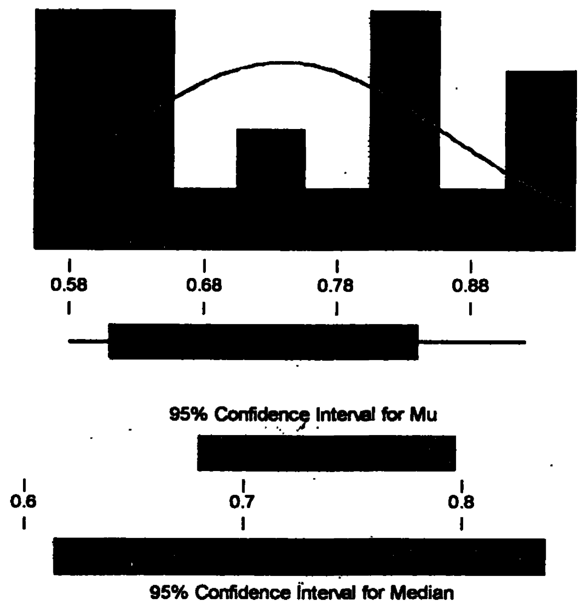
Appendix (I)

Descriptive Statistics

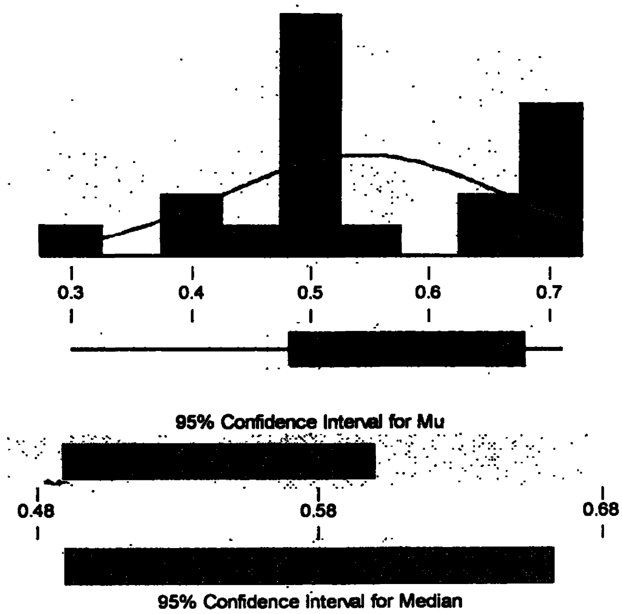
Sodium

Descriptive Statistics



Variable: Conserved

Anderson-Darling Normality Test	
A-Squared:	0.804
P-Value:	0.031
Mean	0.738000
StDev	0.125681
Variance	1.58E-02
Skewness	0.177712
Kurtosis	-1.61289
N	20
Minimum	0.580000
1st Quartile	0.610000
Median	0.725000
3rd Quartile	0.840000
Maximum	0.920000
95% Confidence Interval for Mu	
0.679179	0.796821
95% Confidence Interval for Sigma	
0.095579	0.183567
95% Confidence Interval for Median	
0.614705	0.837648

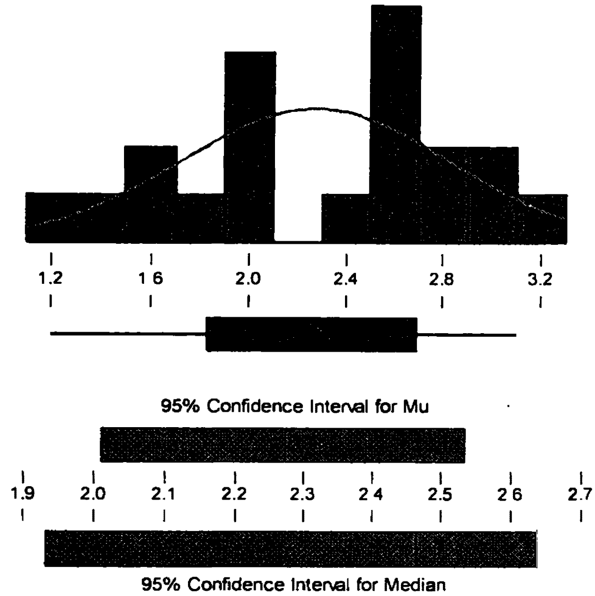


Variable: Nonconserved

Anderson-Darling Normality Test	
A-Squared:	0.933
P-Value:	0.014
Mean	0.544500
StDev	0.118254
Variance	1.40E-02
Skewness	6.02E-03
Kurtosis	-7.6E-01
N	20
Minimum	0.300000
1st Quartile	0.482500
Median	0.500000
3rd Quartile	0.677500
Maximum	0.710000
95% Confidence Interval for Mu	
0.489156	0.599844
95% Confidence Interval for Sigma	
0.089931	0.172718
95% Confidence Interval for Median	
0.490000	0.662943

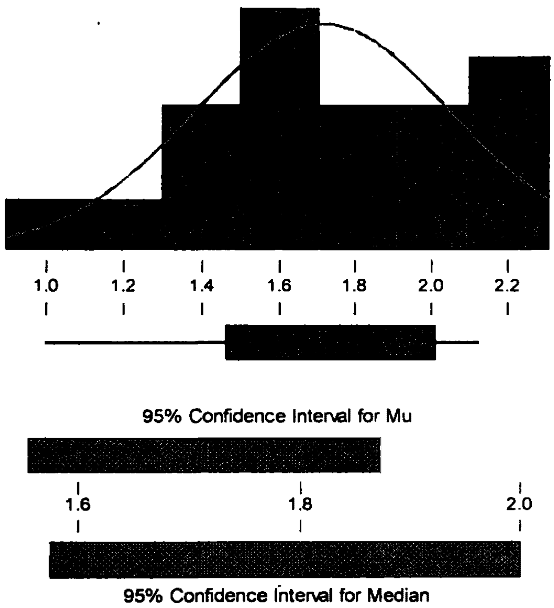
Potassium

Descriptive Statistics



Variable: Conserved

Anderson-Darling Normality Test	
A-Squared:	0.505
P-Value:	0.179
Mean	2.27300
StDev	0.55962
Variance	0.31318
Skewness	-3.3E-01
Kurtosis	-1.07184
N	20
Minimum	1.20000
1st Quartile	1.83000
Median	2.46500
3rd Quartile	2.69250
Maximum	3.10000
95% Confidence Interval for Mu	
2.01109	2 53491
95% Confidence Interval for Sigma	
0 42559	0 81737
95% Confidence Interval for Median	
1.93411	2.63765

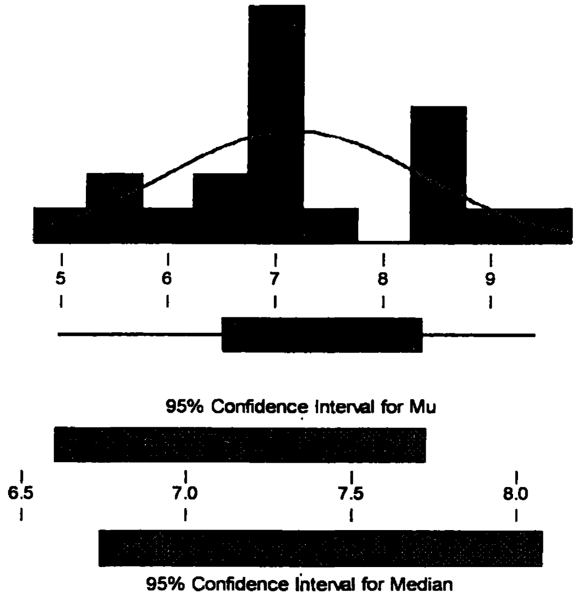


Variable: Nonconserved

Anderson-Darling Normality Test	
A-Squared	0.427
P-Value.	0.282
Mean	1.71450
StDev	0.33794
Variance	0.114205
Skewness	-5.9E-01
Kurtosis	-4.6E-01
N	20
Minimum	1.00000
1st Quartile	1.46500
Median	1.71500
3rd Quartile	2.00750
Maximum	2.12000
95% Confidence Interval for Mu	
1.55634	1.87266
95% Confidence Interval for Sigma	
0 25700	0.49359
95% Confidence Interval for Median	
1 57706	2.00000

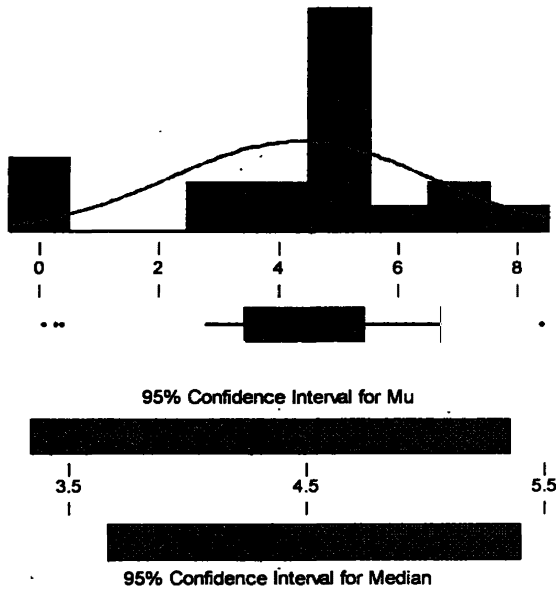
Calcium

Descriptive Statistics



Variable: Conserved

Anderson-Darling Normality Test	
A-Squared:	0.442
P-Value:	0.260
Mean	7.16150
StDev	1.19493
Variance	1.42787
Skewness	0.122957
Kurtosis	-5.6E-01
N	20
Minimum	4.98000
1st Quartile	6.52500
Median	6.92000
3rd Quartile	8.35750
Maximum	9.43000
95% Confidence Interval for Mu	
6.60225	7.72075
95% Confidence Interval for Sigma	
0.90874	1.74529
95% Confidence Interval for Median	
6.74117	8.08006

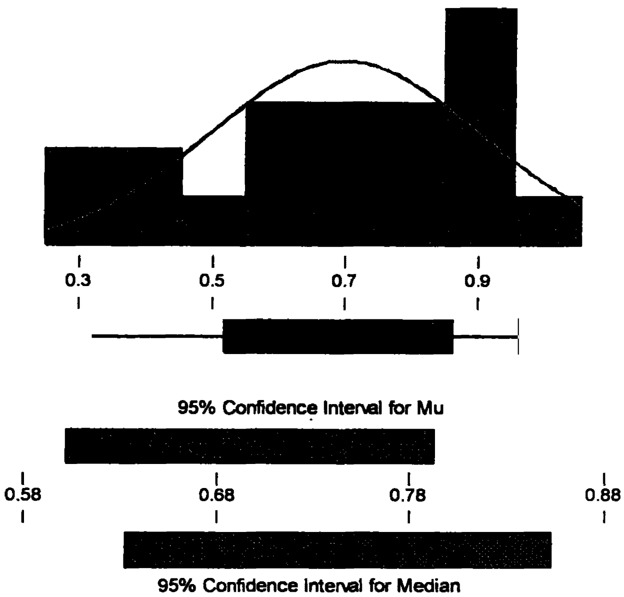


Variable: Nonconserved

Anderson-Darling Normality Test	
A-Squared:	0.779
P-Value:	0.036
Mean	4.35000
StDev	2.15345
Variance	4.63737
Skewness	-6.5E-01
Kurtosis	0.433914
N	20
Minimum	0.10000
1st Quartile	3.45000
Median	4.75000
3rd Quartile	5.40000
Maximum	8.40000
95% Confidence Interval for Mu	
3.34215	5.35785
95% Confidence Interval for Sigma	
1.63768	3.14528
95% Confidence Interval for Median	
3.67057	5.40000

Magnesium

Descriptive Statistics



Variable: Conserved

Anderson-Darling Normality Test

A-Squared:	0.585
P-Value:	0.113
Mean	0.697000
StDev	0.204221
Variance	4.17E-02
Skewness	-5.8E-01
Kurtosis	-8.7E-01
N	20
Minimum	0.320000
1st Quartile	0.517500
Median	0.720000
3rd Quartile	0.860000
Maximum	0.960000

95% Confidence Interval for Mu

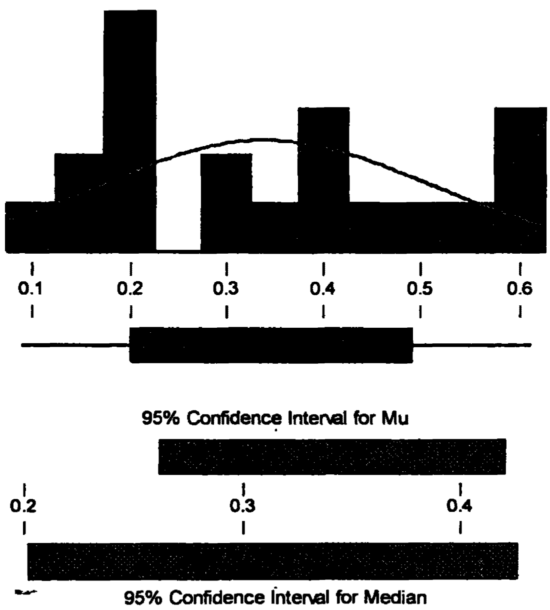
0.601422 0.792578

95% Confidence Interval for Sigma

0.155308 0.298280

95% Confidence Interval for Median

0.632352 0.852943



Variable: Nonconserved

Anderson-Darling Normality Test

A-Squared:	0.491
P-Value:	0.195
Mean	0.340500
StDev	0.168974
Variance	2.86E-02
Skewness	0.232546
Kurtosis	-1.27666
N	20
Minimum	0.090000
1st Quartile	0.200000
Median	0.325000
3rd Quartile	0.490000
Maximum	0.610000

95% Confidence Interval for Mu

0.261418 0.419582

95% Confidence Interval for Sigma

0.128503 0.246799

95% Confidence Interval for Median

0.202352 0.425295

APPENDIX (II)

Calculations-:

Calculated values for mean value difference for each cation separately

Mean value	conserved	non-conserved
Na	0.738	0.544
K	2.273	1.714
Ca	7.167	4.350
Mg	0.697	0.340

Sodium

$$\frac{0.738 - 0.544}{0.738} * 100 = 26.28\ \%$$

Potassium

$$\frac{2.273 - 1.714}{2.273} * 100 = 24.59\ \%$$

Calcium

$$\frac{7.161 - 4.35}{7.161} * 100 = 39.25\ \%$$

Magnesium

$$\frac{0.697 - 0.340}{0.697} * 100 = 51.14\ \%$$

APPENDIX (III)

Land characteristics of farmer field selected for the study

location	Farm land	Land slop	Soil type	Soil depth	Texture Surface	Texture subsurface
Ice peella	1	57	IBL	S-MD	GSCL	CL
	2	50	RYP	MD-D	SCL	CL
	3	65	RYP	MD	CL	CL
	4	40	IBL	MD	SL	CL
Medagoda	1	61	IBL	MD	GSCL	SL
	2	25	IBL	S-MD	SL	CL
	3	48	IBL	S-MD	SCL	SL
	4	54	RBL	D	GSCL	SCL
Malattawela	1	43	RBL	S-MD	GSCL	SL
	2	34	RYP	D	SCL	CL
	3	22	RYP	MD	SL	SCL
	4	48	IBL	MD	GSCL	CL
Ihala- malwattawela	1	50	IBL	D	GSCL	C
	2	43	RBL	D	SCL	C
	3	60	RBL	S-MD	GSCL	CL
	4	23	RYP	MD	SCL	SL
Netola	1	36	IBL	MD	SCL	CL
	2	42	RYP	D	SL	SCL
	3	50	RBL	D	SL	SCL
	4	51	RBL	MD	GSCL	GSCL

IBL – Immature Brown Loam soil, RYP –Red Yellow Podzolic soil, RBL – Redish Brown Latosolic soil, S – Shallow, MD – Moderately Deep, D – Deep, GSCL – Gravelly Sandy Clay Loam, SCL – Sandy Clay Loam, SL – Sandy Loam, CL – Clay Loam, C - Clay

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