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Surface Soil Wash due to Forest Degradation in Ngalaik Watershed Area

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ငလိုက်ဆည်ရေဝေရေလဲဧရိယာအတွင်း သစ်တောများပြုန်းတီး ပျက်စီးလာခြင်းကြောင့် မြေဆီလွှာတိုက်စားမှုကိုလေ့လာခြင်း

ဘီလီနေဝင်း M.Sc. (GIS in Watershed)
သုတေသနလက်ထောက် -၂
သစ်တောသုတေသနဌာန၊ ရေဆင်း

စာတမ်းအကျဉ်းချုပ်

လွန်ခဲ့သောနှစ်များအတွင်း ငလိုက်ဆည်ရေဝေရေလဲဧရိယာအတွင်းတွင် လူဦးရေတိုးတက်လာခြင်း၊ ရွှေ့ပြောင်းလာသော လူဦးရေတိုးတက်လာခြင်း၊ လူနေထိုင်မှုအဆောက်အဦးများ များလာခြင်းနှင့် လယ်ယာမြေတိုးချဲ့လာခြင်းကြောင့် သစ်တောမြေအချို့တို့သည် လယ်ယာမြေနှင့် ရွှေ့ပြောင်းတောင်ယာများရှိပါသည်။ သစ်နှင့်ထင်းလိုအပ်ချက်များကြောင့် အချို့သစ်တောများမှာ တန်ဖိုးနည်းတောပျက်များအဖြစ်ရောက်ရှိခဲ့ပါသည်။ ဤစာတမ်းတွင် ကောင်းကင်ဓါတ်ပုံကို ဖတ်ရှုလေ့လာခြင်းဖြင့် ငလိုက်ဆည်ရေဝေရေလဲဧရိယာအတွင်း ၇၉၂၂၆ဧကခန့်အတွင်း သစ်တောပြောင်းလဲမှုများကို ခန့်မှန်းတွက်ချက်ထားခြင်းဖြစ်ပါသည်။ ထိုပြောင်းလဲမှုများကြောင့် မြေဆီလွှာတိုက်စားမှုပေါ်တွင် အကျိုးသက်ရောက်မှုကို erosion pin အသုံးပြု၍၄င်း၊ sediment တိုင်းတာခြင်းကို water sample ယူ၍ particle ပါဝင်မှုကို တိုင်းတာ၍၄င်း တွက်ချက်ထားပါသည်။ ငလိုက်ဆည်ရေဝေရေလဲဧရိယာသည် သဲနုံးဆန်သောမြေအမျိုးအစားဖြစ်သော်လည်း မိုးရေချိန်နှင့်အပေါ်ယံမြေဆီလွှာတိုက်စားခြင်းတို့သည် တိုက်ရိုက်အကျိုးသက်ရောက်မှုရှိပြီး ground cover နှင့် နုံးပို့ချမှုတို့သည် ဆက်စပ်လျှက်ရှိကြောင်း တွေ့ရှိရပါသည်။

Surface Soil Wash due to Forest Degradation in Ngalaik Watershed Area

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Abstract

In the past decades, many watersheds in Myanmar have undergone serious degradation due to increase in population in the watershed area, encroachment, unsuitable land use practices particularly resource depleting activities such as shifting cultivation, uncontrolled timber extraction techniques, forest fires and many others. This paper tries to evaluate the rate and magnitude of land cover changes that had taken place during a period of 10 years in the Ngalaik watershed area of 79226 acres using satellite image by digital classification method. In degraded area, surface soil wash is estimated by using erosion pin method, and measurement of sedimentation while analyses of the components of particles in water samples are also included. In this study, although Ngalaik Watershed area is mostly composed with sandy loam soil, relationship between rainfall intensity and surface soil-loss is highly correlated, while ground cover density and sediment deposited is also correlated in degraded Ngalaik Watershed Area.

Contents

1. Introduction

The government has constructed several dams and reservoirs all over the countries and it is of paramount importance to maintain the watershed areas of these dams and reservoirs. Maintaining a good forest cover of the watershed areas can reduce water erosion, soil erosion and siltation. It can also maintain the quality and quantity of water and the expected life span of the dams. Only then, the farmers and people who depend on these dams for their livelihood can have a stable environment.

Myanmar is a tropical country in continental South East Asia, having a total land area of 6761553 Km^2 of which about 43.3 % is covered with closed forest, 7.5 % with degraded forest, and 22.8 % with forest under shifting cultivation. The annual change of the forest area has increased by 517000 ha and the annual rate of forest degradation is 14%. If the degradation of forest goes on at this rate, with no remedial measure being taken, large area of forest will become degraded in the future, and the problem of soil erosion will have greatly increased in all parts of the Myanmar especially in up land area. Myanmar, being an agriculture-based country, whose economy largely depends on a agriculture and forest products, need ample water resources and good fertile land for cultivation and better economic development. So, it is of utmost importance to solve the problems of forest degradation and to rehabilitate the degraded forest area.

Watershed degradation is fairly widespread in Myanmar, while abundance and stability still prevails in most part of the country. Effects of watershed degradation are serious in both upland and lowlands. Degradation of watershed dries up streams and rivers, as well as ground water recharge. All of the catchments that supply water for irrigation, hydropower, industrial and domestic uses will need sustainable management of forest and natural resources to maintain a stable ecological balance between man and soil-plant-atmosphere continuum.

2. Objective of the study

1. To identify land use and land cover changes between 1990 and 2000.
2. To observe the situation of soil erosion in the Ngalaik Watershed Area due to forest degradation.
3. To describe means and ways for perpetual conservation of land cover and for reducing sedimentation to maintain the expected life span of Ngalaik Dam.
4. To maintain stable and productive soil, high quality water and vegetation cover within individual watershed.

3. Literature Review

The land use and land cover change dynamics is highly driven by the human activities. Further more, any alternation produced at any location in upstream of watershed, result on a common impact on downstream. Thus watershed area is increasingly viewed as an appropriate unity for planning, management, and research.

Win and Eh Dah (1991) conducted a survey on forest degradation and changes in cover types in 17,000 acres of the East Bago Yoma Region. Interpretation was made from black and white aerial photographs convening two different time periods. The earlier photography was taken in 1953-54 at a scale of 1:25000. Four broad forest types, cultivated areas, forest plantations and, the reminder, grouped as others, were defined in this study. Results showed that forest degradation increased by 550 acres annually.

Soil erosion is a universal problem where soil is bare and uncovered. But the severity of erosion differs widely depending upon the present or past methods of land-use practices. Ellison (1947) defined soil erosion as “the process of detachment and transportation of the soil materials by erosive agents”. To this “deposition” can be added as an integrated part of soil erosion. Detachment, transportation and deposition can be natural processes or they can be induced by such human interference as mining, high ways construction, over-grazing, uncontrolled logging, burning and breaking of soil cover by ploughing, etc.

Forest vegetation minimized soil erosion largely by the effect of plants crown and litter in eliminating the destructive physical effects by raindrops. Without protection, soil aggregates broken down and infiltration rates decrease resulting in surface run-off and erosion.

The water erosion processes begins when rain-drops strike the surface of the soil and break down the clods and aggregates. During rainfall, both falling raindrops and flowing water are very active in tearing loose soil particles and transporting them, usually down-slope. But in steep slope (25-30°) covered with good vegetative cover are not susceptible to erosion and vice versa gentle slope although devoid of vegetation cover also have minimal erosion impact (Billy, 2004).

Soil erosion in Thailand has been categorized into five-classes in terms of amount of soil loss in tons per hectare per year, which are respectively < 6.25, 6.25- 31.25,31.25-125,125-625 and > 625 (Srikhajon et al, 1981). Erosion situation as evaluated in Thailand is that as least one –third of the land area of the country losing from 31.25ton/ ha/yr of the top soil. (Samram Sombatpanit, 1995.)

Sein Thet (1981) studied surface soil wash (sheet wash erosion) at East Pegu Yoma Plantation Project Area (Kabaung Reserve, Compartment 21). Located five (0.2 hectare) plots subjectively at first year plantation site based on slope steepness and aspect and used Erosion Pin (Peg) method for sheet wash erosion, found that sheet wash erosion was directly correlated with the slope steepness, but not aspect.

The Soil loss on a steep runoff plot in a clean-weeded tea plantation was 32 ton/ha/yr when measured in 1999. It is indicated in several publication that annually 800,000 cubit meters (22 million cubit feet) of sedimentation are transported into Inle Lake (Sein Moe 2002). The annual soil loss determined by the Irrigation Department is 1.6 acres per miles of catchments area (equal to 10 ton/ha/yr). However, the actual soil loss will be higher than the prediction given by the department due to taking account from end of streams (GAF, 1996).

Erosion peg (or pin) method, is the most primitive, but most widely used method to assess soil loss on bare or nearly bare sloping lands for sheet, rill, and gully erosion. A certain number of pegs are vertically placed into ground and the distance is measured between the head of a peg and the soil surface. Sein Thet (2002) stated the advantages and disadvantages of erosion pin method as follow:

The advantages are

- ➢ direct understanding of the erosion reality;
- ➢ it is relatively cheap in cost;
- ➢ there is no need to prepare or buy special equipment; and
- ➢ it is an easy practice for measuring and recording.

The disadvantages are

- ✓ Limitation in accuracy/practically the minimum measurable unit is 1 mm level with an ordinary measuring tape or ruler;
- ✓ a difficulty in keeping pegs in a stable condition, especially in farming land, and
- ✓ pegs being obstacle in farming practices.

In 1992/93, the study of sedimentation was carried out by IAEA. The Australian Nuclear Science and Technology, representative of IAEA program, stated, based on the results of soil tests that annual sedimentation rates in the Inle watershed were 0.37 g/cm^3 (upto 1958), 3.14g/cm^3 (1958 to 1972) and 1.00 g/cm^3 (1972-1996) (Sein Moe 2002).

The rate of soil erosion increased when plowning to a depth of 150 mm to erode 20 tons/ha/year and then the GAF(1996), stated the acceptable soil loss rate in bed-eroded area is greater than 10 tons/ha/yr.

4. Materials and Methods

4.1 Description of the study area

The study area of Ngalaik watershed area is a part of the East Bago Yoma range with a forest cover of about over 7 thousands acres. It is located, in the central part of the country, about 17 miles west of Pyinmana, consisting of 3 townships, namely Pyinmana, Takkone and Towntwingyi. It has many hills of Bago Yoma ranging from 300 to 3000 feet above sea level. Majority of people living in the watershed area are Bama, Kayin and Chin. Ngalaik chaung and watershed provides water resources for Ngalaik dam which is constructed in 1995-1996. The dam, served to irrigate more than 30,000 acres of cultivated lands for double and triple cropping.

The topography is generally flat with sandy clay loam texture and the area are well drained and gently flows from east to west; included are some cultivated ploughed area. It is approximately situated at 19º 96'N and 95º 56'E. The soils are mostly yellow brown forest soil.

The rainy season is from May to October with ample rainfall arriving from the Bay of Bengal. From the end of October to April, the air current changes its direction and flows from the Northeast towards Southwest, causing the dry season. The rainfall record of Moswe weather station during 2004 showed that the number of rainy days to be around (75) and the total annual rainfall is 50.66 inches.

4.2 Land cover changes

The land cover of area was classified into following (6) classes and land cover changes are studied by using satellite image of TM 1990 and ETM 2000.

(1) Closed Forest
(2) Degraded Forest
(3) Scrub Land
(4) Agriculture
(5) Shifting Cultivation
(6) Water Body

4.3 Selection of Study Plots

The study area is located in Ngalaik watershed area compartment No. 72 and 9. They are part of the degraded forest area. Firstly, three sub watersheds area were chosen in this degraded forest area. For the purpose of studying the soil loss and sedimentation test, three experimental plots at ridge, middle and lowland areas, which were located at each sub-watershed.

4.4 Soil Loss Measurement

To observe the soil erosion rate at each plot, the experiment was made by erosion pin method, to record soil-wash.

Plot size	-	5m x 4 m
Total number of erosion pins	-	28 per plot
Pattern of striking	-	Alternative system

Stake (30 cm x dia 0.5cm) with a mark at the center are driven into the soil until the mark leveled with the ground at the time of instillation. During the raining period sheet wash erosion from around and beneath the mark lowered the ground level. The difference between the mark and the ground level provides a measure of sheet wash erosion rate during the period. The measurement was carried out once in a week for eleven weeks. The rainfall record from Moswe Weather Station was also taken whenever the measurement of erosion was made.

4.5 Sediment Measurement

At each sub-watershed area, a check-dam was built at the base of the study plot. A pit was dug at the base and the water samples were collected with plastic bottles when it is raining. Then, the water samples were taken to the FRI Lab and analyses were made for the contents of particles included in run-off water.

The following steps were carrying out to collect water sample;

- ❖ Each check dam was made behind three sample plots at all three sub-watershed by bamboo shingles.
- ❖ At the base of each check dams, 4′x 4′ x 3′ pit was dug.
- ❖ Water samples were taken out from the pits with the plastic bottles at the time of raining.
- ❖ Three water samples were collected from each sample plot.
- ❖ The plastic bottles used were labeled with date, time and number; and brought to the laboratory.
- ❖ At the Forest Research Institute laboratory; water samples were analyzed to observe the particle contents included in it.

4.6 Soil Sample Collection

In each of the chosen sub watershed area, soil samples at nine places were taken and analyzed them at the FRI laboratory. Only two surface soil layers (0-10 cm, 40-50cm) were collected for analysis.

4.7 Ground Cover Survey

To calculate the volume of the plants grown in the study area, 5 sample plots each having 5m x 5m in size were laid out by systematic sampling for each sub-watershed area. To emphasize the measurement of soil loss, undergrowth plants under 1 foot are enumerated for ground cover.

5. Analysis

5.1 Land Cover Changes

For land cover classification, the following steps were carried out.

(1) Scanning of the map

(2) Delineation of the watershed boundary by digitizing

(3) Preparation for aerial photo

(4) Making the land cover classification using TNT mips software

Ground checking was made to observe the true ground condition before distinguishing the land cover from Aerial Photo and then the land cover was marked by GPS. The classified land cover from Aerial Photo was checked by ground truth data.

5.2 Soil Loss Measurement

The study was carried out during the rainy season. Three samples plots were chosen and 28 erosion pins were installed in each plot. The pins were measured in cm after a week of installation and were carried out once a week for eleven weeks. To find the result, an average soil loss in cm is calculated from the total sum of soil descending in cm during the rainy season and the number of pegs.

5.3 Sediment Measurement

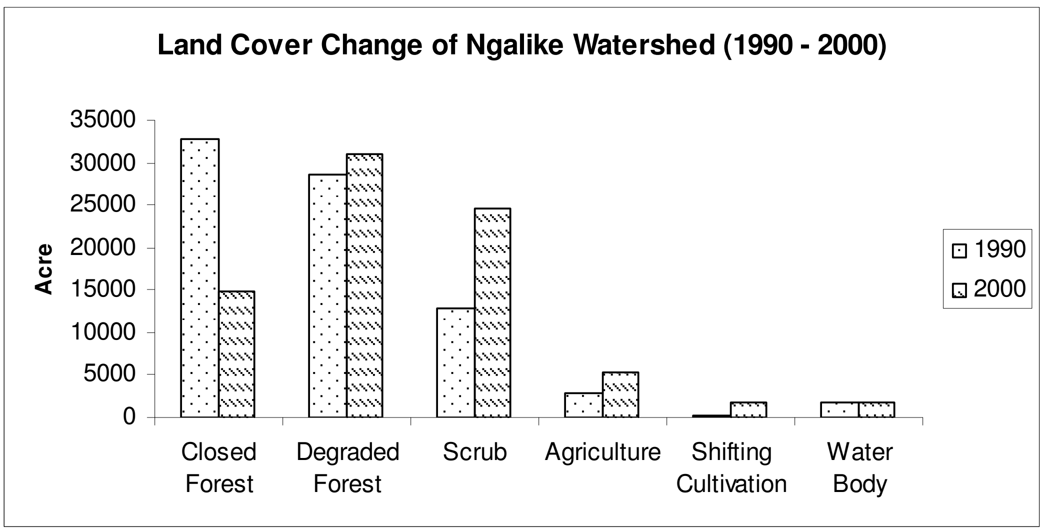
At the FRI laboratory, water samples are allowed to ovendry and measure the magnitude of particles included in run-off water.

6. Results and Discussion

6.1 Land Cover Changes

The land cover changes were found as shown the following histogram.

Graph (1)



The following Table (1) shows the reciprocal changes in different categories of cover types as estimated from 1990 to 2000 satellite image of the watershed area.

Table (1)

Name	1990	2000
Closed Forest	32695	14927
Degraded Forest	28679	30956
Scrub	12894	24583
Agriculture	2975	5226
Shifting Cultivation	258	1684
Water Body	1725	1850
Total Acre	**79226**	**79226**

As seen in the Table (1), the forested area of (32695) acres in 1990 had been reduced (17768)acres, or (54%), to (14927)acres in 2000, with an annual loss of (1776.8) acres.

Table (2)

Acre	2000						
1990	CF	DF	SC	AG	Sh	WD	**Grand Total**
CF	14927	11597	4989	551	631		**32695**
DF		19359	7935	882	503		**28679**
SC			11535	818	415	125	**12894**
AG				2975			**2975**
Sh			123		135		**258**
WD						1725	**1725**
Grand Total	**14927**	**30956**	**24583**	**5226**	**1684**	**1850**	**79226**

CF= Closed Forest
DF= Degraded Forest
SC= Scrub land
Ag= Agriculture
Sh= Shifting Cultivation
WD=Water Body

In Table (2) from (32695) acres of closed forest in 1990, (4989) acres had been reduced to scrub, (631) acres to shifting cultivation while (551) acres had been transformed to cultivated land in 2000. In the same period, out of (28679) acres of degraded forest, (7935)acres had been reduced to scrub, and (503) acres to shifting cultivation while 882 acre had been replaced by agriculture land.

In the 10 year period, scrub land increased from 12894 acres to 24583 acres, while degraded forest had been increased from 28679 to 30956 acres. Shifting cultivation expended spaciously from 258 acres to 1684 acres whereas cultivated land increase at a modest rate from 2975 to 5226 acres.

6.2 Soil Properties

The soil occuring in summit slope and summit sites appear under vegetation of grass. The soil has received 50.66 inches total annual rainfall. In this study area, soil texture is usually dominated by sandy loam although some are sandy clay and loamy sand. Soil reaction range is acidic to natural (pH 4.24 – 7.44). Total nitrogen, organic matter and exchangeable potassium content are subjected to a medium level; however available phosphorus is noted as on low level for normal growth. Some physical and chemical properties of study area are described in Appendix (3).

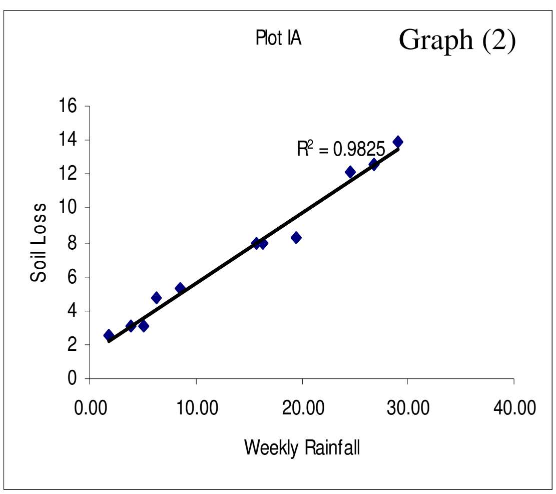
6.3 Rainfall Intensity and surface soil-loss Relationship in Degraded Forest

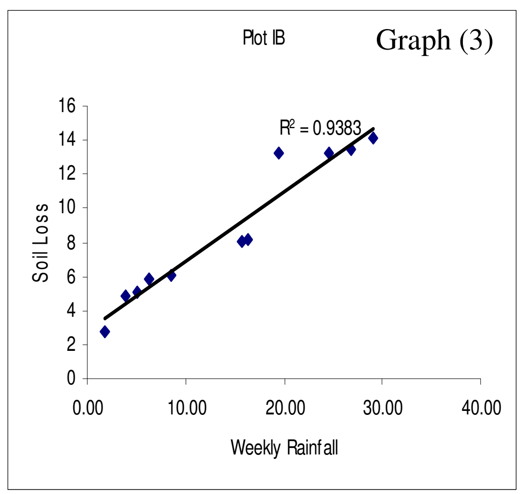
All surface soil wash data area entered into Excel Worksheets as the basic data for analyses. Soil deterioration was related to the weekly rainfall data recorded. The relationship between soil erosion and rainfall was observed by drawing the regressing line in the excel worksheet.

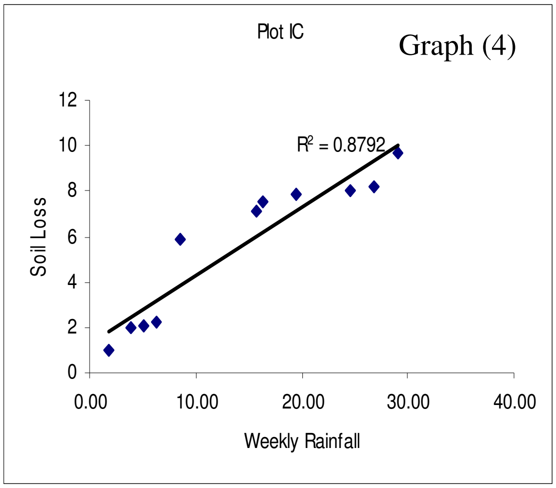
Table (4)

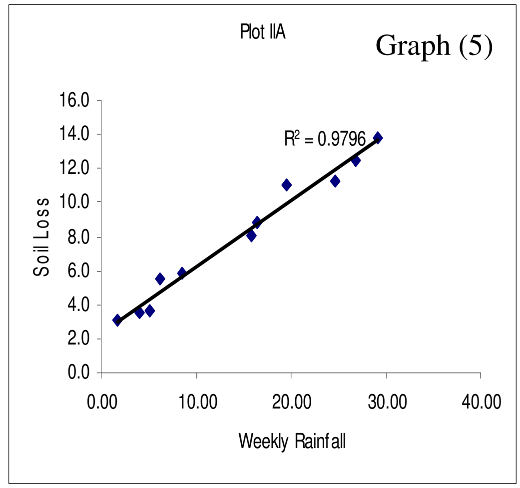
Cumulative Weekly Rainfall	Soil Loss (cm)								
	IA	IB	IC	IIA	IIB	IIC	IIIA	IIIB	IIIC
1.78	2.5	2.8	1	3.1	3.3	4	2.2	1.1	1.5
3.96	3.1	4.9	2	3.5	4.1	4.4	3.1	3.75	1.8
5.14	3.1	5.1	2.1	3.6	5.8	5.7	4.7	4.1	1.2
6.24	4.8	5.8	2.2	5.5	7.1	7.4	5.9	4.4	2
8.52	5.3	6.1	5.9	5.8	9.1	8	7.2	4.9	5.6
15.76	7.9	8.1	7.1	8.1	10.5	10	9.1	7.1	5.7
16.37	8	8.2	7.5	8.8	10.9	10.3	10.2	7.4	6.5
19.47	8.3	13.2	7.9	11.0	11.3	10.7	10.8	8.2	8.8
24.59	12.1	13.2	8	11.3	11.3	10.7	11.1	11.3	9.8
26.85	12.6	13.5	8.2	12.5	12.5	11.1	12	11.8	10
29.13	13.9	14.1	9.7	13.8	14.2	12.9	12.5	12.6	10.5

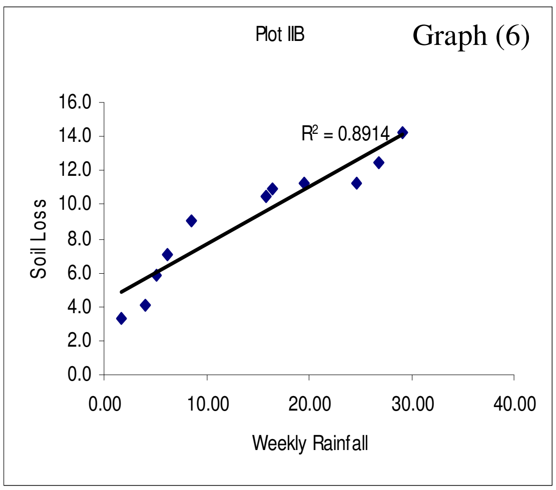
In table (4) it was found that the relationship between cumulative weekly rainfall and soil loss in each sub-plots. In plot II, the soil loss is higher that the other Plot I and III. The Plot I is on the ridge and Plot III is lowest. In this experiment, it is assumed that the ground cover in all three plots are the same. It showed that, in Ngalaik Watershed Area, rainfall intensity and surface soil loss is highly related.

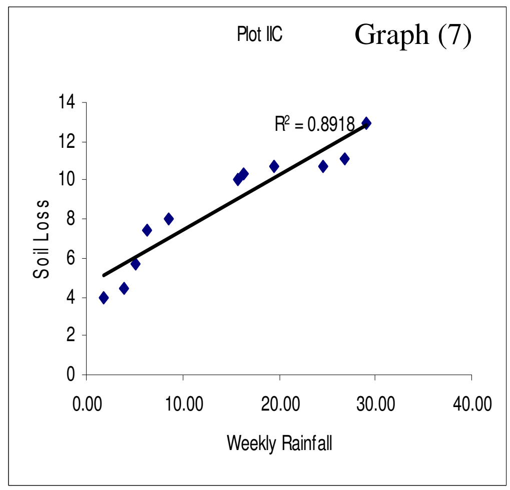


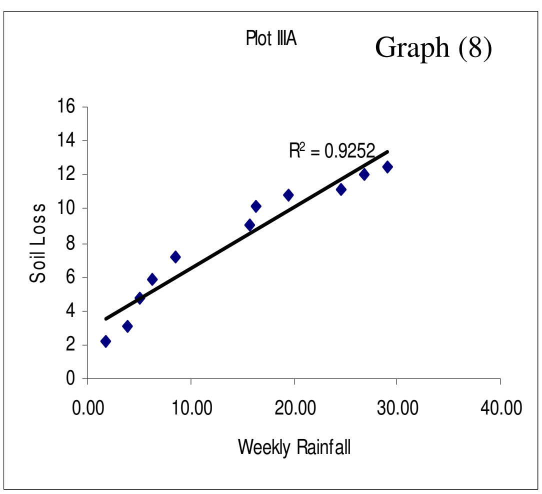


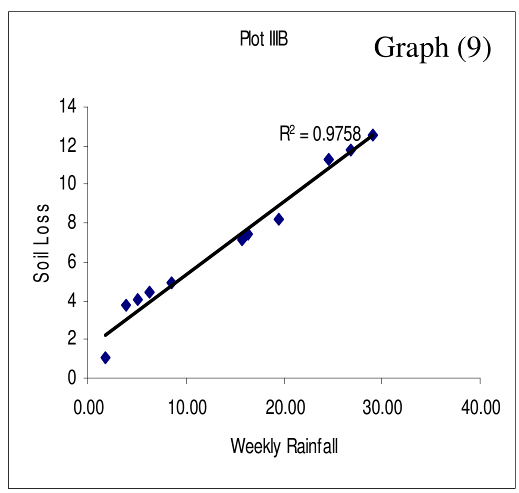

Plot IC
Graph (4)
$R^2 = 0.8792$
Soil Loss
0
2
4
6
8
10
12
0.00
10.00
20.00
30.00
40.00
Weekly Rainfall

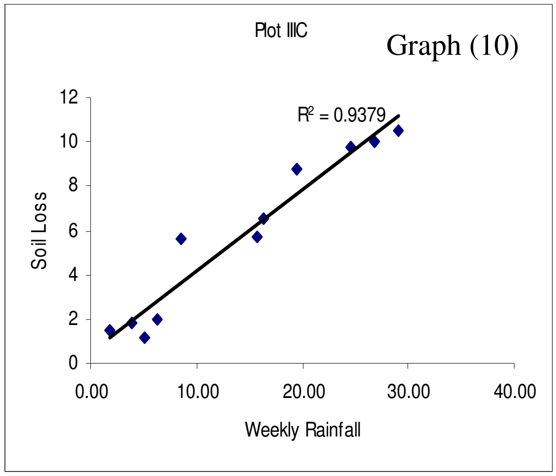

Plot IIA
Graph (5)
$R^2 = 0.9796$
Soil Loss
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
0.00
10.00
20.00
30.00
40.00
Weekly Rainfall


Plot IIB
Graph (6)
$R^2 = 0.8914$
Soil Loss
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
0.00
10.00
20.00
30.00
40.00
Weekly Rainfall


Plot IIC
Graph (7)
$R^2 = 0.8918$
Soil Loss
0
2
4
6
8
10
12
14
0.00
10.00
20.00
30.00
40.00
Weekly Rainfall


Plot IIIA
Graph (8)
$R^2 = 0.9252$
Soil Loss
0
2
4
6
8
10
12
14
16
0.00
10.00
20.00
30.00
40.00
Weekly Rainfall


Plot IIIB
Graph (9)
$R^2 = 0.9758$
Soil Loss
0
2
4
6
8
10
12
14
0.00
10.00
20.00
30.00
40.00
Weekly Rainfall



Correlation coefficient between soil loss and rainfall was tested (Graph 2 to 10) and it is found that these two factors are highly correlated with each other and for all plots (r square is between 0.93-0.87). It shows that the heavier the rainfall, the greater the soil loss. Analysis of variance for cumulative weekly rainfall and soil loss of study area are described in Appendix (4).

6.4 Sedimentation and ground cover

The plants grown in the area are only one year old and found as weeds in the rainy season. After the rainy season, these plants withered and the ground become uncovered.

Data of ground cover density is shown in Appendix (5) and water sample and sediment deposited data are shown in Appendix (6).

Ground cover density, water sample weight and sediment content are summarized in table (5).

Table (5)

Plot No.	Ground Cover Population	Water sample wt(g)	Sediment content (g)	%
I	207	750	2.5	0.33
		250	0.7	0.28
		300	2.1	0.70
II	172	750	5.6	0.75
		250	1.7	0.68
		300	2.0	0.67
III	236	750	0.9	0.12
		250	0.6	0.24
		300	0.7	0.23

In table (5) it was found that the sediment weight of plot II is greater than the other two plots.

It was found that ground cover at plot III is higher than the other two plots, where sedimentation is the least. While in the sample plot II, sedimentation is highest due to the least soil cover status.

7. Recommendation

(1) As the extension of agriculture and shifting cultivation has increased year by year, the land cover has also degraded gradually. Consequently, Forest Department and local authority should educate the community living near the Ngalaik Dam to become aware of the absolute importance of the role of forest for their welfare and their livelihood.

(2) As the sedimentation increase, the area very close to the Ngalaik Chaung and Ngalaik Dam should not allowed for cultivation.

(3) When the buildings are constructed within the watershed area, soil cover should be grown around the construction for the protection of ground surface. Generally, grass can grow faster and is more effective than any other plants.

(4) The measurement of sedimentation shows a fair amount of deposition. These sedimentation could create a serious disturbance to the capacity of the dam after some years. Check dams should therefore be constructed within watershed area to control the deposition.

(5) To assess soil loss, the measurement of soil loss should be made 2 or 3 years consecutively to acquire more precise or concrete data.

(6) In this study, only 3 sample plots are taken for a research purpose for soil erosion due to time and financial constraints. More sample plots should be taken to get a more accurate data for soil and water loss.

(7) The Forest Department and local authority need to earnestly educate the community in the watershed area to carry out agroforestry system to reduce forest degradation and surface soil deterioration.

(8) Within the study area, it is evident that surface soil loss resulted from shifting cultivation, degraded forest and scrub land area except closed forest area. So plantation should be established at these degraded forest, shifting cultivation areas and scrub land area with environmentally friendly species, best suited to the site.

8. Conclusions

(1) Although the erosion control measure is one of the most important elements in the study area, it may not be effective as a short term program. Consequently, a long-term program based upon sound technical judgment and ample input may be more suitable.

(2) The presence of good ground cover, which reduces the soil splash, and the maximization of infiltration, which again reduces the volume and velocity of surface run-off are the main elements for erosion control.

(3) Effective protection of up-stream with long-term efforts or program as stipulated in (1) will be required for sustainable management of the watershed to reduce the rate of sedimentation in the dam.