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Soil erosion magnitude of upland farming practices in Bataan

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There are factors affecting erosion such as climate, soil type, vegetation and topography. Upland areas are denuding exponentially due to the fact that those people looking for livelihood had little concern and awareness on environmental sustainability and management. Upland farming practices that are easy like weeding, pest control and fertilization were often carried out without soil erosion control and water management. The result of the study revealed that an area with intercropped permanent crops has less amount of soil eroded or tolerable annual soil loss. But the areas with short duration crops (cash crops) and which adopted the same cropping pattern from the previous season resulted to severe soil erosion. Calculated annual soil erosion are 3.33, 4.57, 23.18, 0.31 tons and zero erosion for Site 1, Site 2, Site 3, Site 4, and Site 5, respectively.

Key words: Intercrop, severe erosion, tolerable erosion, Bataan Philippines.

INTRODUCTION

Soil erosion caused by rainfall result application of energy from two distinct sources, namely (a) the falling raindrops and (b) the surface flow. The energy of falling raindrop is applied slantingly or vertically from above, whereas the surface flow is applied more or less horizontally along the surface of the ground. The chief role of the falling raindrop is to detach soil particles, whereas that surface flow (outside the rills and gullies) is to transport the soil. The falling raindrop also makes a major contribution to the movement of the soil on unprotected sloping lands during the periods of heavy impact storms, by splashing large quantities downslope and by imparting transporting capacity to the surface water by keeping it turbid.

The amount of erosion in one site depends on the range of factors including steepness of slope, soil type, percentage and type of vegetation which covers the area, slope length, amount of rainfall, soil moisture levels prior to specific rainfall events, and condition of soil surface.

Major interest would be to compare the amount of soil erosion at different farming system in the upland of different crops at a given rainfall and to find out if this is more beneficial to farmers.

The study generally aims to determine the magnitude of soil erosion in upland areas of Bataan directly from the

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field where different cultivation practices and crop production are employed specifically: to determine the magnitude of soil eroded at specific area, slope, slope length and vegetation; to determine the farming practices and cropping pattern used in the upland areas of Bataan, and to determine the prevalent problems and advantages encountered on specific practice.

RELATED LITERATURE

The total splash (sum of up, down and across) increased with slope, indicating that splash detachment increased as the slope increased (Grosh and Jarret, 1994). This was likely due to the kinetic energy of rebounding splash droplets at the steeper slopes. More than 99% of the splash soil moved downslope at the 85% slope. Net downslope splash increased at a second order polynomial rate relative to slope.

Kinnell (1990) stated that it is possible to examine the effects of rain, flow and particle characteristics on the movement of soil material from a surface eroded by shallow rain-impacted flows that are incapable of entraining soil particles without the aid of raindrop impact.

According to Agarwal and Dickinson (1991) that unit sediment transport capacity has been observed to be influenced by the unit discharge, flume slope, and median particle diameter of soil. The exponent of the power relationship between unit sediment transport capacity and flume slope appear to vary with the median particle diameter.

The power relationship was also used to relate unit sediment transport capacity to median particle diameter of the input as well as the transport soil. The median particle diameter of transported soil, as well as of input soil, influenced the exponents of the power relationship between unit sediment transport capacity, flume slope, and unit discharge. Sediment transport capacity in overland interrill flow can be represented with the variables unit discharge, flume slope, and median particle diameter of soil.

The conservation bench terrace (CBT) system has been found effective in reducing runoff and soil loss by over 80 and 90%, respectively, as compared to the conventional system (Sharda et al., 2002). The CBT system registered 7.4% of rainfall as runoff and 1.19 Mg ha^{-1} of soil loss as compared to 36.3% and 10.1 Mg ha^{-1} in the conventional system of sloping borders.

As stated by Gilley et al. (1990) that for most of the soil, the total runoff amount during the wet simulation run was similar. However, significant differences in soil loss were found between sites. Thus, substantial variations in soil erodibility existed between many of the study locations.

Ho et al. (2004) stated that the increasing rainfall may accelerate water erosion in watersheds and raise the probability of flooding events in the urban areas. The impacts include environmental and social-economic conditions.

METHODOLOGY

The study area

Bataan province of Region III is a peninsula of around 80.9% upland areas. These areas are suited for tropical crops like pineapple and orchard crops. The valleys and hilltops cover about 63,000 hectares of varying slopes ranging from 2% or less than 8%. On the other hand, the lowland areas are devoted to lowland-based crop for additional production of the province. Bataan has two distinct seasons: the rainy and dry season. The rainy season starts around May and ends sometime October. The rest of the year is dry with occasional rains dispersed widely throughout the province. Typhoons visit the area especially during the months of June to September. Floods occur annually in lowland areas due to heavy rains and clogging of heavily silted outlets to Manila Bay attributed to severe erosion in the uplands.

The prevailing climatic condition is categorized under Type I. The average rainfall is 3,934 mm with an average of 133 rainy days a year. The annual mean temperature is at 27°C with May as the warmest month. The mean annual relative humidity is 79% which the highest in August at 87%.

Upland farming systems are prepared using carabao drawn plow after clearing shrubs, weeds and stumps. However, steep slopes have to be hoed since plowing is difficult. Planting along the slopes start from the highest part to the lower part of the field.

Contour lines are established as a basis of making furrows. The planting is done across the slope following the established contour lines are reference in establishing hill and row spacing.

The continued removal of plant cover and cultivation of the soil is one serious threat to the environment for these could accelerate erosion. Severe erosion lowers land fertility and eroded soil carried by runoff settles in drainage outlets resulting to floods.

Materials used

The use of survey materials such as bond papers, printer ink (refill), folders and envelops. At the field experiment, 70 L capacity drum, PE pipes, graduated stakes, digital weigher, transparent plastic bag, ruler, pad paper, ballpens, pencils and indigenous materials are used such as buho and madre cacao.

Vegetation in the experimental area was identified such as cogon, kalmot pusa, vetiver, carabao grass and other common grasses or weeds. Identified trees were madre cacao, hawili (tibig) and mahogany. Crops produce and established plantation by the farmers include pomelo, rambutan, banana, papaya, coconut, coffee, citrus, ube, ginger, pineapple, mango, calamansi and sweet potato.

The location of the experimental area is at hilly land, with the soil type of Antipolo clay (BSWM, 2003, Soil Survey Report, Bataan Province), and the soil slope or gradient ranges from 9 to 18° (15.83 to 32.49%) to determine the degree or amount of soil sediments eroded. Sites were select according to crops planted and farming practices. There were five sites selected accordingly (Figures 1 and 2).

The three sites were located at Bataan Peninsula State University (BPSU) Abucay campus where different vegetation and crops were grown in the area because of different slopes.

Preparation of the experimental area

Along the ranges of percent slope, gradient will be initially evaluated to attain the ease of gathering data. Experiments are laid out and established instrumentation like aliquots such as drum, established calibrated stakes and indigenous materials to ensure the gathering of samples. Every plot has to be established with

Figure 1. Location of on-site experiment.

Figure 2. Location of off-site experiment.

Table 1. Vegetation identified and calibrated stake reading from site 1.

1.2 m × 44.70 m 14° slope		Calibrated stake reading (cm)					
Vegetation	**Stake #**	**4/28/09**	**6/20/09**	**8/15/09**	**9/19/09**	**10/13/09**	**1/25/10**
1. Kalmot Pusa	1	25.5	25.0	25.0	24.5	25.0	R - 30.0
2. Cogon	2	24.5	23.5	24.0	24.5	24.0	23.5
3. Guava	3	23.5	23.5	24.0	23.5	24.0	24.0
4. Madre Cacao	4	23.0	22.5	22.5	22.5	22.5	22.5
5. Pomelo	5	-	20.5	20.5	20.0	19.5	20.0
6. Rambutan	6	-	21.0	21.0	20.5	20.5	20.5
7. Banana (lakatan)	7	-	23.5	23.5	23.5	24.0	23.5
8. Papaya	8	-	25.0	25.0	25.0	24.5	R - 19.5
9. Coconut	-	-	-	-	-	-	-
10. Vetiver	-	-	-	-	-	-	-
11. Grasses	-	-	-	-	-	-	-

instruments monitoring the soil erosion at specific gradient, farming practices and cropping pattern.

To analyze and evaluate results accurately and present the results of known measures of different variables, the sets of data were monitored and gathered. Data gathering was done on weekly basis to monitor the differences from the previous data and to find alternative solutions if problems rises during the study period.

Rainfall

Following the standard time for gathering agro-meteorological data, rainfall depth will be collected and measured at the established agro-meteorological station of BPSU. Rainfall intensity is also monitor during 8 AM and 2 PM of the day.

Depth of soil sediments

Depth of soil sediments eroded at certain area is monitored using the graduated stakes established. Gathering of data will be regular especially during the rainy season to gather efficient and reliable data for the analysis.

Vegetation

Grown grasses, weeds and trees are also monitored which also affected the amount of soil eroded at a given rainfall intensity.

Crop parameters

Crop parameters are also observed as a basis of reasoning such as the height, fruit diameters, weight of harvested crops, etc., and will also be observed to monitor the differences between such systems of planting, practices and cropping pattern.

The descriptive survey method of gathering data will be the research technique used in the analysis of farming practices and cropping pattern. Randomized Completely Block Design (RCBD) will be used in the analysis of data gathered to come up with reliable result of the experiment. Least Significant Mean Difference (LSMD) Test will also be used to evaluate the variations among treatment means. Experimental treatments will layout and randomly be distributed using the standard procedures of randomization and layout design.

RESULTS and DISCUSSION

Table 1 shows that there were eleven grass species found in the experimental site. The soil weight loss measured was 3,331 g (621.0 kg/ha) during the study. The R denotes the replacement of the calibrated stakes (erosion pin) lost or destroyed because of human activities. During the reading of calibrated stake, the measure was changed initially to reduce the fall, indicating the soil detachment, transport or soil erosion. Experimental site was comparable with other site due to its vegetation density.

Table 2 shows that the calibrated stake reading reduces showing the soil movement caused by the rainfall variation (Figure 3). The total soil weight loss measured was 4,569 g (1,487.3 kg/ha) during the study period. The established crops at the experimental site were permanent intercrop of banana, coffee and coconut, and they were productive.

Table 3 shows the minimal number and the density of vegetation grown as compared to other sites. The soil weight loss measured from this experimental site was 23,185 g (8,118.0 kg/ha), which is severe erosion happened in the site. The calibrated stake reading reduces continuously till the end of the study period. The strip cropping could not resist the soil erosion caused by water.

Table 4 shows the area was steep as compared to other site and productive. The number and density of vegetation also affects the amount of soil eroded in the area. As support basis using the calibrated stakes, there was a slight difference in readings prior to the establishment continuously. The soil weight loss is 311 g (34.56 kg/ha) during the study period. Crops were

Table 2. Vegetation identified and calibrated stake reading from site 2.

1.2 m × 25.6 m 16° Slope		Calibrated stake reading (cm)					
Vegetation	**Stake #**	**4/29/09**	**6/20/09**	**8/15/09**	**9/19/09**	**10/13/09**	**1/25/10**
1. Banana	1	25.5	25.0	25.0	26.0	25.5	25.0
2. Coffee	2	26.0	25.0	24.0	23.5	23.0	23.0
3. Coconut	3	27.0	26.5	26.5	26.5	26.5	26.5
4. Madre Cacao	4	26.0	26.0	26.0	25.5	25.5	25.5
5. Carabao grass	5	29.0	29.0	28.5	29.5	29.5	29.0
6. Hawili (tibig)	6	27.0	26.0	25.5	25.0	24.5	24.5
7. Citrus	7	25.0	lost	-	19.0	19.0	19.0
8. Antipolo (60 cm dia)	8	25.0	25.0	25.0	24.0	24.5	24.0
9. Grasses							

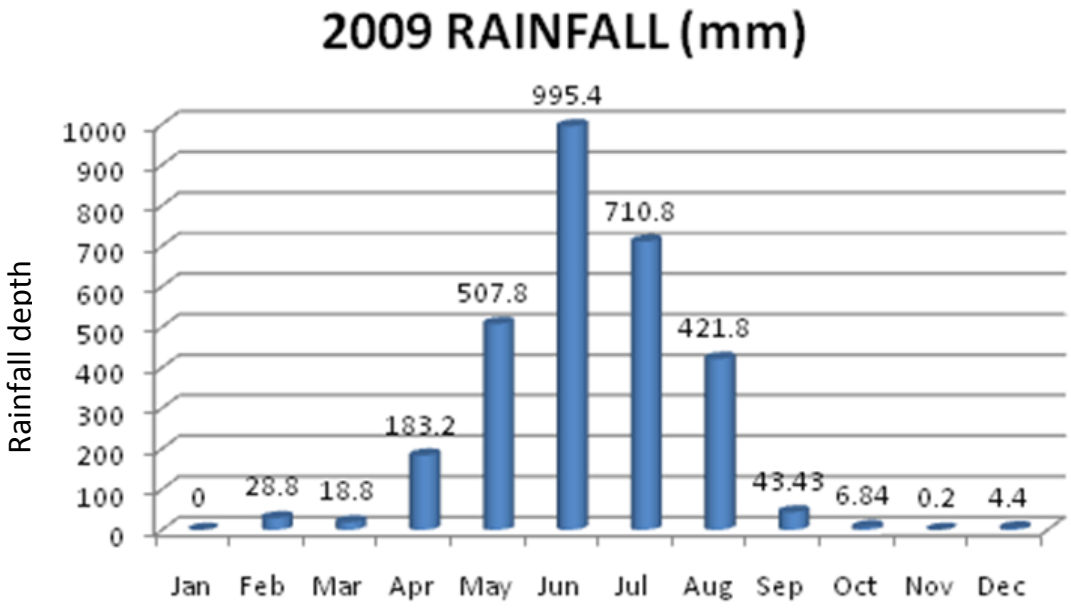

Figure 3. Rainfall depth (mm) for the study period.
Source: BPSU-BSWM AWS Abucay. Total RF=2921.5 mm

Table 3. Vegetation identified and calibrated stake reading from site 3.

1.2 m × 23.8 m 9° Slope		Calibrated stake reading (cm)					
Vegetation	**Stake #**	**5/14/09**	**6/20/09**	**7/24/09**	**9/19/09**	**10/13/09**	**1/25/10**
1. Ube	1	26.5	26.5	26.5	26.0	26.0	24.0
2. Ginger	2	23.5	23.5	23.5	22.5	22.5	22.5
3. Madre Cacao	3	24.0	23.5	23.5	22.0	22.0	22.0
4. Pineapple	4	26.5	24.0	24.0	28.0	28.0	27.5
5. Grasses	5	27.5	27.0	27.0	27.0	27.0	27.0
-	6	27.0	27.0	27.5	27.5	27.5	27.0
-	7	30.0	31.0	32.0	33.0	32.5	32.0
-	8	25.5	28.0	29.0	28.0	28.0	27.5

Table 4. Vegetation identified and calibrated stake reading from site 4.

1.2 m × 75.0 m 18° Slope	Calibrated stake reading (cm)							
Vegetation	**Stake #**	**4/16/09**	**6/11/09**	**7/9/09**	**10/8/09**	**11/27/09**	**1/27/10**	**5/28/10**
1. Pineapple	1	35.5	35.0	36.5	36.5	36.0	36.0	36.0
2. Coconut	2	23.0	23.0	22.0	22.0	22.0	22.0	22.0
3. Mango	3	29.0	29.5	29.5	29.0	29.0	29.0	29.5
4. Calamansi	4	20.0	19.0	19.5	20.0	20.5	20.5	20.5
5. Mahogany	9	-	20.0	17.5	17.5	17.5	17.5	18.0
6. Banana	10	-	21.0	16.5	16.5	16.0	16.5	17.0
7. Madre Cacao	-	-	-	-	-	-	-	-
8. Cogon	-	-	-	-	-	-	-	-
9. Grasses	-	-	-	-	-	-	-	-

Table 5. Vegetation identified and calibrated stake reading from site 5.

1.2 m ×12.5 m 18° Slope	Calibrated stake reading (cm)							
Vegetation	**Stake #**	**4/16/09**	**6/11/09**	**7/9/09**	**10/8/09**	**11/27/09**	**1/27/10**	**5/28/10**
1. Sweet Potato	5	28.0	27.5	27.5	27.5	28.0	27.5	-
2. Cogon	6	21.0	21.0	21.0	21	-	-	-
3. Mohogany	7	28.5	28.0	28.0	28.5	28.5	28.0	28.5
4. Grasses	8	23.5	23.5	23.5	24.0	24.0	24.0	23.5
-	11	-	25.0	24.0	24.5	24.5	24.5	24.5
-	12	-	20.0	19.5	19.5	20.0	20.0	19.5

planted in contour wherein the major crop is pineapple, and the permanent crops are coconut, mango and calamansi.

Table 5 is the same steepness with Site 4, 12.5 m slope length and the area was thickly dense with cogon. The only crop produced was sweet potato in strip of 3 m. There was no loss of soil in the area.

Figure 3 graph shows the monthly rainfall for the year 2009. It presents that during the months of May, June, July and August, it has deepest rainfall and more number of rainy days. The total rainfall depth for the year 2009 was 2921.5 mm, during the study period. Those months mainly affects the calibrated stake reading and the total wFeight of soil measured in every experimental site that has erosion observed.

Conclusions

At different slope, length of slope, vegetation and land use affect the erosion magnitude for specific sloping land. The activities regarding farm and crop improvement such as land preparations, weeding, cropping pattern and calendar are also considered in soil and water management of upland areas and affects the amount of soil eroded per year.

Site 1 was selected because of the long term or permanent intercrops established like rambutan (*Nephelium lappaceum*), pomelo (*Citrus maxima*), coconut (*Cocos nucifera*), coffee (Coffea) and banana (Musa). Even site 2 has long term intercrops under more steep slope and undisturbed soil. Site 3 has the highest soil erosion magnitude due to its seasonal crops production or cropping pattern done. Offsite 4 had soil erosion of 311 g as compared to zero of offsite 5 because of alley cropping made in offsite 5 and the strip was planted with pineapple with cogon grown.

Sites 1, 2 and 4 follow the intercropping of permanent crops. Also, established vegetation across the slope such as vetiver (*Chrysopogon zizanioides*), cogon (*Imperata cylindrical*), common grasses and even permanent crops reduce the soil erosion or soil movement downstream.

RECOMMENDATIONS

To manage soil erosion in the upland, intercropping of permanent crops across the slope, land use, planting system, selection of proper crops for the area and strip cropping must be established. Permanent productive

crops should be established and intercrop with cash crops using zero tillage if possible to maximize the area in the sloping areas.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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