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Soil erosion in the marginal upland of Inopacan, Leyte, Philippines

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ABSTRACT

There is an urgent need for soil erosion data from marginal uplands in the country. This study evaluated the occurrences of soil erosion in the marginal uplands of Inopacan, Leyte. Field soil erosion indicators were assessed in different portions of the study site and erosion plots were established in the corn and sweetpotato fertilizer experiments to measure erosion rates. Field indicators of soil erosion such as rills, cracks across slopes, exposed rocks, thin surface soil and eroded sediments in waterways were common in various parts of the marginal upland studied. Soil erosion rates measured on erosion plots were higher from the corn field than from the sweetpotato field. Application of chicken manure and vermicast resulted in lower soil erosion rates due to improved soil structure. Plots without crop cover gave the highest erosion rates. The degree of soil erosion in the marginal upland can be considered as moderate to severe.

Keywords: soil erosion indicators, soil erosion rates, soil degradation

INTRODUCTION

Soil erosion is traditionally associated with agriculture and is important for its long-term effects on soil productivity and sustainable agriculture (Morgan 2005). Brady (1990) stated that no soil phenomenon is more destructive worldwide than soil erosion. Powers and McSorly (2000) explained that degradation of soil by erosion greatly affects fertility and productivity of soil because most of the organic matter and essential nutrients in the soil are established in the topsoil and it provides the best structure for aeration. Asio et al (2009) considered soil erosion as the most important process causing the degradation of upland soils in the Philippines. However, data are limited especially on soil erosion rates under various

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land use types in marginal uplands. According to Lal (1990 & 2001), the following important facts in relation to soil erosion are urgently needed: (a) the historic loss of soil C pool upon conversion from natural to managed ecosystems for major soils in principal eco-regions and (b) the fate of eroded soil carbon, especially with regard to mineralization of carbon redistributed over the landscape, transported by water and wind and deposited in depressional sites and aquatic ecosystems.

McCauley and Jones (2005) defined soil erosion as the physical movement of soil particles from one location to another, primarily due to forces of water or wind which contains three main phases: detachment, transport and deposition. Bakker et al (2005) noted that erosion affects soil depth and other soil processes. In addition, they found that aside from reducing the soil depth, erosion degrades the soil hydrologic conditions and decreases plant available water capacity. They noted that sealing of the surface reduces the infiltration capacity of the soil and thus, also the soil moisture. The resulting overland flow washes away nutrients and organic matter together with the fine, most fertile soil fraction and the water holding capacity decreases with increasing soil erosion. Thus, erosion leads to nutrient depletion, reduction in soil organic carbon and a negative alteration of the soil physical properties in terms of nutrient and water-holding capacity (Bakker et al 2005).

Hudson, one of the leading soil erosion experts, emphasized three decades ago that in the battle against soil erosion, we are losing on every front (Hudson 1977). This statement is still valid at present. According to him, what we need are practical control measures. The primary objective of soil erosion research must be to obtain the information required to design or develop appropriate measures. Greenland and Lal (1977) reported that it is essential to have a clear understanding of the causes of soil erosion and the quantitative information on the factors, in order to design appropriate soil management systems for the humid tropics and appropriate methods for erosion control. Lal (2001) stated that results of field erosion measurements are often dependent on the techniques and erosion models employed. There is a need for field validation since runoff plot techniques are not standardized. He mentioned the use of quick field techniques to assess soil loss like the buried nail or plate techniques, exposure of plant roots and depth of deposition of sediments along fence lines.

This study aimed to evaluate the occurrences of soil erosion in the marginal uplands in Inopacan, Leyte. This information is relevant for the formulation of soil management strategies appropriate for such lands.

MATERIALS AND METHODS

Study Area

The study was conducted in the marginal upland of Sitio Batuan, Linao, Inopacan, Leyte (Figures 1). It was a component of the SEQEMU (Soil and Environmental Quality Enhancement in Climate Change-vulnerable Marginal Uplands) Project under the PHERNET (Philippine Higher Education Research Network) Program on Enhancing Marginal uplands, implemented by the Visayas State University and funded by the Commission on Higher Education.

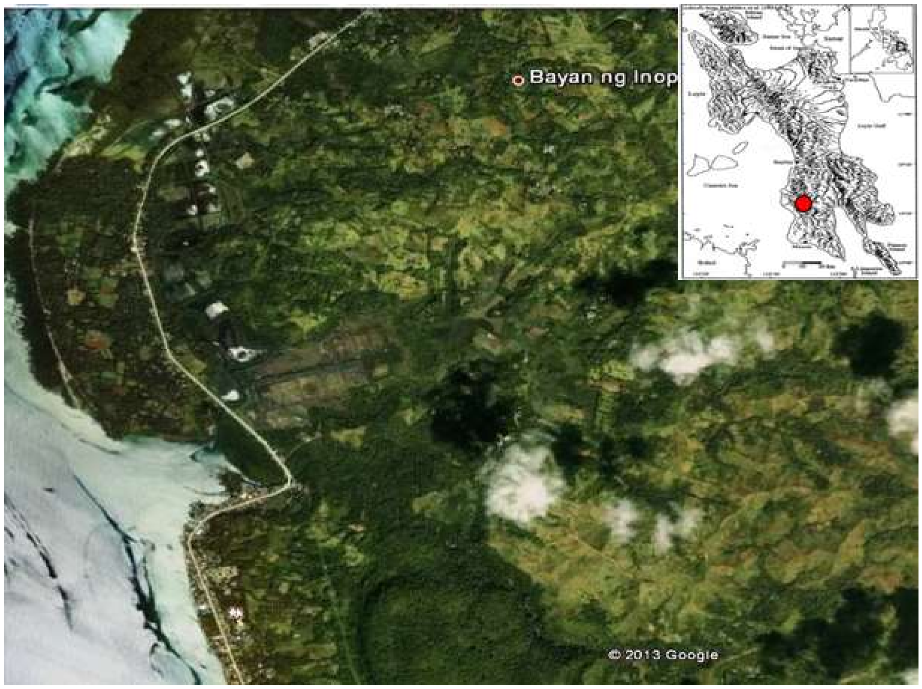

Figure 1. Location of the study area in Sitio Batuan, Inopacan, Leyte

The Municipality of Inopacan is located at the southwestern portion of Leyte. It lies between the latitudes 10°28' and 10°33'10” and longitudes 124°43'15” and 134°53'45”. According to the Modified Coronas Climatic Classification, the municipality falls under the 4th type of climate which means that rainfall is more or less distributed throughout the year and the annual average rainfall is about 1,638mm. The geology of the area could be described as dominated by mixed sediments and pyroclastics, particularly basalt and andesite. The landform is predominantly rolling to steep volcanic hills. The area is degraded and only small patches are cultivated for crop production. The dominant vegetation consists of *Melastoma malabathricum* (Hantutuknaw), *Imperata cylindrica* (Cogon), *Chromolaena odorota* (Hagunoy), *Andropogon* sp. (Amorseco), *Saccharum spontaneum* Linn., *Elephantopus tomentosus* (Malasambung) and *Calopogonium muconoides* (Malabatong) (Figure 2). These plants are indicators of degraded or marginal uplands (Asio 1996, Asio 2007, Asio et al 2009).

Figure 2. Photo of the marginal upland of Sitio Batuan, Inopacan, Leyte

Soil Erosion Evaluation

To evaluate the occurrence of soil erosion in the study site, two methods were employed. The first one was the use of field indicators such as occurrence of rills and eroded sediments, thickness of surface soil and exposed rocks on soil surface. This method is widely used by geomorphologists. The second method was the use of erosion plots measuring 5mx5.25m (equal to 26.25m^2). The size of the plots was not standard (22m long & 1.8m wide, according to Morgan [2005]) since these were established using the fertilizer experiments on corn and sweet potato. For the erosion study, additional plots were established for the "no crop" treatment, with and without natural vegetative strips. Thus, the erosion plots had the following treatments: no crop, no crop but with natural vegetative strips, chicken dung, vermicast and chemical fertilizer. For the plots without crop, field operation was done as in the other plots planted to corn and sweet potato but the weeds were allowed to grow normally during the cropping period. The corn experiment had a slope gradient of about 25 percent while the sweet potato experiment had a slope of 15 percent. The experiments were located about 30m apart on the same east-west oriented ridge. Because of some problems during establishment, only one erosion plot per treatment was established (not replicated). Eroded sediment was collected weekly from each plot for one cropping (3 months). This was air-dried, weighed and recorded. The eroded soil from each plot was converted to per hectare and annual basis.

Soil erosion in the marginal upland

Figure 3. Erosion plots established in the sweetpotato fertilization experiment

Figure 4. Erosion plots established in the corn fertilization experiment

Figure 5. Trench constructed at the lower end of each erosion plot for collecting eroded soil

RESULTS AND DISCUSSION

Field Indicators of Soil Erosion

Erosion rills, exposed rocks, thin surface soil, cracks across the slopes and eroded sediments in waterways and gullies are widely known erosion indicators that were observed in the marginal upland, particularly in formerly cultivated slopes (Figures 6-8). In many parts of the landscape, soil surface horizons have been completely removed, although the grass vegetation hides this from the observer. Only by digging the soil can one observe the presence of the thin A horizon or its complete absence. Based on the FAO Guidelines of Soil description (Jahn et al 2006), the degree of erosion in the marginal upland can be classified as moderate to severe.

Soil erosion in the marginal upland

Figure 6. Erosion rills and cracks across the slope are common in several slopes of the marginal upland

Figure 7. Eroded sediments on waterways can be found after heavy rainfall events

Figure 8. Exposed rocks indicate soil erosion

Soil Erosion Rates

Table 1 shows the soil erosion rates as influenced by the different treatments using corn as test crop. Plots without a standing crop registered the highest rate of 98.8t ha^{-1} yr^{-1}. In contrast, the plot with no standing crop but having natural vegetative strips resulted in the lowest erosion rate of 61.34t ha^{-1} yr^{-1}. In both plots, the grasses were allowed to grow naturally during the growing season which probably prevented higher erosion rates than what were measured in other studies with bare soil (up to 150t ha^{-1} yr^{-1} as reported by Asio [1996]). Results also revealed that plots applied with chicken manure gave lower soil erosion rates compared to plots applied with inorganic fertilizer only. Improved soil structure resulting from the application of chicken manure explains this finding.

Table 1. Soil erosion rates under different soil fertility management practices in the marginal upland using corn as test crop

Treatments	Soil Erosion t ha^{-1} yr^{-1}
1. 90-60-60kg ha^{-1} (chemical fertilizer)	82.98
2. Chicken dung (15t ha^{-1})	74.83
3. 45-30-30 + chicken dung (7.5t ha^{-1})	76.85
4. No crop	98.81
5. No crop but with natural vegetative strips (NVS)	61.34

Note: The values are from one erosion plot per treatment only.

Soil erosion in the marginal upland

Table 2 shows the soil erosion rates as influenced by the different treatments using sweetpotato as test crop. As can be observed, plots without sweet potato crop gave the highest erosion rate of 64.68t ha^{-1} yr^{-1}. Plots without crop cover but having natural vegetative strips resulted in higher erosion rates than plots with sweetpotato crop. Plots planted with sweetpotato resulted in lower erosion rates compared to those with no sweetpotato, regardless of fertilizer application. This indicates that sweetpotato can minimize soil erosion since it protects the soil from raindrops impact and it slows down surface runoff. This result supports the widely held view that sweetpotato crop is suitable for typhoon-prone areas.

Table 2. Soil erosion rates under different soil fertility management practices in the marginal upland using sweetpotato as test crop

Treatments	Soil Erosion t ha^{-1} yr^{-1}
1. 45-30-30kg ha^{-1} (chemical fertilizer)	44.34
2. Chicken dung (15t ha^{-1})	39.71
3. Vermicast (15t ha^{-1})	38.34
4. No crop	64.68
5. No crop but with natural vegetative strips (NVS)	52.60

Note: The values are from one erosion plot per treatment only.

Comparing the erosion rates in the two experiments, the corn experiment generally resulted in higher erosion rates than the sweetpotato experiment. Aside from the better soil protection provided by the sweetpotato being a creeping plant compared to the corn crop, the results can also be attributed to the lower slope gradient of the sweetpotato experiment which was 15 percent compared to the corn field which was 25 percent. It should be mentioned, however, that the erosion values in Tables 1 and 2 should be taken with caution because of the absence of a statistical comparison of means, since the erosion plots were not replicated.

Asio et al (2015) reported lower erosion rates under sweetpotato than under cassava in the degraded uplands of Sta Rita, Samar. They also concluded that soil erosion resulted in considerable soil and nutrient losses from the cultivated fields. In their study in the Manupali watershed in northern Mindanao, Poudel et al (2000) observed an annual soil loss from 42 percent slopes with superimposed researcher-managed high-value contour hedgerows treatment of 45.4t ha^{-1}, compared to the conventional practice of up-and-down cultivation with 65.3t ha^{-1}. They also found that the annual soil loss in farmers' plots ranged from 1.4t ha^{-1} to 52.5t ha^{-1} on slopes ranging from 16 to 65 percent. As in our study, no statistical analysis was done by Poudel et al (2000) on their measured erosion rates.

CONCLUSIONS

Field indicators of soil erosion such as rills, cracks across slopes, exposed rocks, thin surface soil and eroded sediments in waterways were common in various parts of the marginal upland studied. Soil erosion rates measured on erosion plots showed that soil erosion was higher from the corn field than from the sweet potato field. Application of chicken manure and vermicast resulted in lower soil erosion rates. Plots without crop cover gave the highest erosion rates. The degree of soil erosion in the marginal upland can be considered as moderate to severe.

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REFERENCES

Asio VB. 1996. Characteristics, weathering, formation, and degradation of soils from volcanic rocks in Leyte, Philippines. Hohenheimer Bodenkundliche Hefte 33, Stuttgart, Germany

Asio VB. 2007. Characteristics, fertility status, and management of degraded upland soils in Leyte. In: PARRFI Professorial Chair Lectures 1992-2006, Philippine Agricultural Resources Research Foundation Incorporated (PARRFI). Laguna

Asio VB, Jahn R, Perez FO, Navarrete IA & Abit SM Jr. 2009**.** A review of soil degradation in the Philippines. *Annals of Tropical Research* 31(2):69-94

Asio VB, KLB Demain, DT Olguera & Villasica LJD. 2015. Characteristics and nutrient status of two degraded upland soils in Samar, Philippines. *Annals of Tropical Research* 37(1):142-166

Bakker MM, Govers G, Kosmas C, Vanacker V, Van Oost K & Rounsevell M. 2005. Soil erosion as a driver of land-use change. *Agriculture, Ecosystem and Environment* 105:467-481

Brady NC. 1990. Nature and Properties of Soils (10th edn). John Wiley and Sons, Inc., New York, USA

Greenland DJ and Lal R. 1977. Soil conservation and management in the humid tropics. CAB International, England

Hudson N. 1977. In Greenland DJ and Lal R (eds) *Soil conservation and management in the humid tropics* . CAB International, England

Jahn R, Blume HP, Asio VB, Spaargaren O & Schad P. 2006. Guidelines for soil description (4th edn). FAO, Rome

Lal R. 1990. Soil Erosion in the Tropics, Principles and Management. McGraw-Hill, Inc., USA

Lal R. 2001. Soil degradation by erosion. *Land Degradation and Development* 12:519-539

McCauley FG and Jones RG. 2005. Soil Conservation, Principles and Application. Wiley and Sons Printing Press, New York

Morgan RPC. 2005. Soil Erosion and Conservation (3rd edn). Malden, MA, USA

Powers LG and McSorly NM. 2000. Soil and Environment Fundamental. Pearson Education Printing Press, Inc. Upper Saddle River, New Jersey

Poudel DD, Midmore DJ & West LT. 2000. Farmer participatory research to minimize soil erosion on steepland vegetable systems in the Philippines. *Agriculture, Ecosystems and Environment* 79(2000):113–127