EROSION IN CHAYOTE FIELDS FOCUSING ON CHARACTERISATION, PERCEPTION AND DEVELOPMENT OF EROSION FIELD TOOL IN SHILAN, LA TRINIDAD, BENGUET, PHILIPPINES

A.M.C. van Miltenburg[1]

ABSTRACT

Soil erosion at chayote fields is grown in generally steep slopes of Shilan, La Trinidad, Benguet. Soil erosion is severe because of little soil cover and few soil conservation techniques. To measure soil erosion within chayote fields in Barangay Shilan, the Morgan, Morgan and Finney (MMF) model and the Assessment of Current Erosion Damage (ACED) was used. The erosion risk according to the MMF prediction is in the range of 5.7 kg/m^2 to 12.7 kg/m^2 per average year. The ACED method measured a soil loss of 13.5 kg/m^2 and 96.3 kg/m^2 in case of a gully. Both methods show severe erosion and are comparable in case of the erosion features rills and channels. However, only the MMF method takes into account sheet erosion. The ACED method includes a longer period than one average year. This makes the ACED more suitable to measure gully formation.

Interviewed chayote farmers in the area revealed their perception about erosion. Some did not notice erosion in their fields while others have slight knowledge about erosion processes. However, they noted that high rainfall and steep slopes are contributors of erosion. A difference of land management was observed, like the undergrowth of grasses. Grass left underneath the chayote plants results in less risk on erosion. Unfortunately, most farmers remove grasses because of the expected competition for moisture and nutrients with chayote. Only few farmers understood that grasses are necessary to reduce the risk on erosion. None of the farmers attended land conservation trainings.

Because of the little knowledge about erosion processes, an erosion tool was developed in this research. This can help to investigate the erosion process. The data gathered from the erosion field tool will be used in a database and the results can increase the knowledge about erosion processes. The database will be used by farmers, extension workers, students and teachers of the University. By using the database, the links between for instance, vegetation cover, rainfall, and steepness can be related with soil loss. Understanding the influence of different factors on erosion risk is important and can be recorded by use of a simple database.

KEYWORDS: soil erosion, chayote fields, erosion field tool, ACED erosion model, MMF erosion model, steep slopes

INTRODUCTION

Soil erosion is a major threat to soil fertility, productivity and to food production (Herweg, 1996). Erosion is mainly caused by the intervention of humans. The combination of population growth, deforestation, and cultivation on steep slopes has a large impact on soils. The largest soil degradation area (around 550 million hectares) in the world is in the Asia-Pacific region (UNEP, 2000). Poudel et al. (2000) stated that erosion, coupled with productivity decline, is considered a major constraint to sustainable vegetable production in Southeast Asian steep lands, yet soil conservation technologies acceptable to vegetable growers have not been developed.

The low productivity of agricultural soils is due to soil fertility constraints of which

[1]*Graduate student in Netherlands who conducted her thesis prequesite in La Trinidad, Benguet. Contact email address : saskiamiltenburg@ hotmail.com*

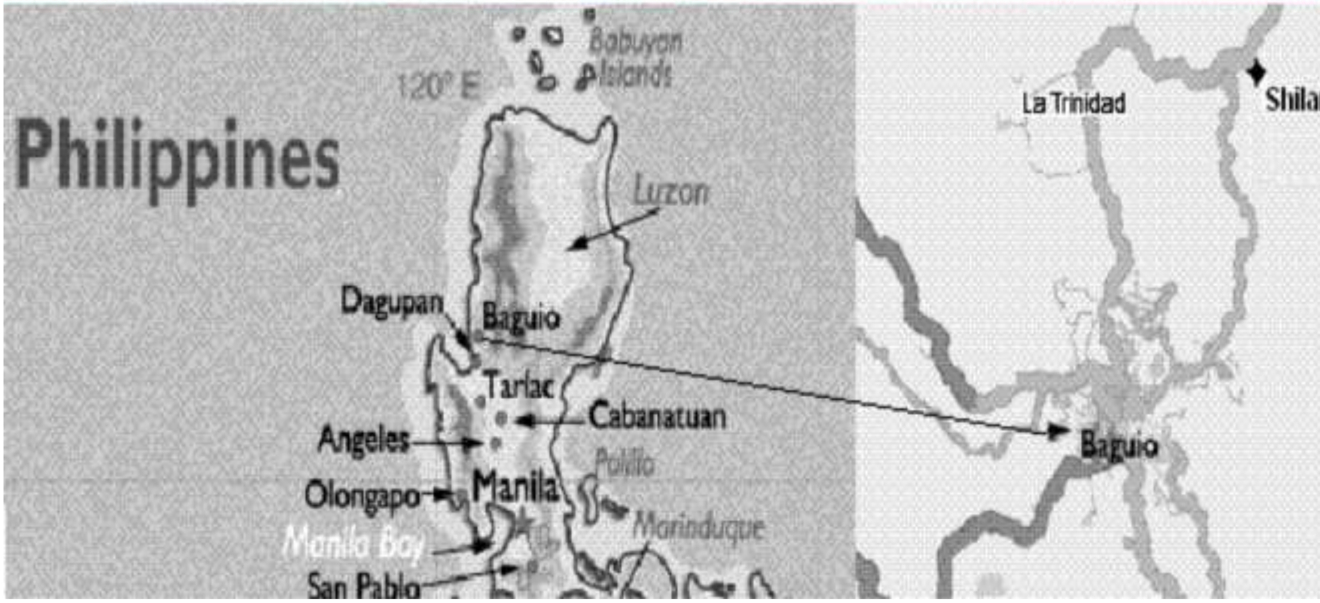

Figure 1. Research location

erosion is one important factor responsible for soil and nutrient losses (Laurean, 2004). This is especially the case in mountainous areas and in sloping fields. The chayote plants in Shilan are only planted on steep slopes since it is difficult to plant other vegetables in these areas. Chayote is a vine crop which results in little direct soil cover. The plantation on steep slopes with little conservation practices results in erosion features. The soil is especially vulnerable to erosion at the start of the rainy season (April or May) when crops are planted (Payangdo, 2008).

This research is valuable for understanding erosion processes and to recommend conservation techniques which can alter nutrient decline. Monitoring of erosion features by a simple erosion field tool can give insight in the erosion process. Better understanding of erosion processes is necessary, since it results in a higher adaptation of conservation techniques to limit the erosion risk. This research is part of the two years master international land and water management and specialisation erosion and soil & water conservation at the Wageningen University in the Netherlands and conducted together with the research assistance of the Soil Science Department (SSD) of the College of Agriculture (CA) at the Benguet State University (BSU), La Trinidad, Benguet, Philippines.

Study Site

The research was conducted in Barangay Shilan (Coordinates: 16°27’47”N 120°37’29”E) in the municipality of La Trinidad, Benguet province which is approximately 260 km north of Manila.

Barangay Shilan (Figure 1) is located east of La Trinidad, north of Tublay, south and southeast of Barangay Beckel, southwest of Barangay Lubas, and west of Bahong and Tawang (Municipality of La Trinidad, 2008). The region is characterized by increasing agriculture on steep slopes. Elevation ranges from 1100 to 1500 meters above sea level. Shilan’s total land area consists of 750 hectares of which 77 ha are used as vegetable area by 536 farmers in 1998 (Municipality of La Trinidad, 2008). The soil type in Shilan is clay loam with depths varying from 60 to 80 cm.

The average annual rainfall in La Trinidad according to the closest weather station to Shilan is reported to be an average of 4342 mm per year (BSU-PAGASA AgroMeteorological Station in La Trinidad, Benguet). The maximum average temperature is 23_{0}Celsius and minimum average temperature is 16_{0}C. Intensive rainfall in the raining period, moisture deficiency in other periods, high cost of farm inputs, and low selling price are the main agricultural problems in the region according to the municipality. In the area, different crops are planted but on the steep slopes mainly chayote is planted. The focus in this research is therefore on chayote fields situated on steep slopes in Shilan.

Objectives of the study

The study was conducted to gather the following :

1. Characterize erosion by use of the Morgan, Morgan and Finney (MMF) method and the Assessment of Current Erosion Damage (ACED).
2. Develop an erosion field tool to quantify erosion damage and achieve a database to increase the knowledge about erosion processes.
3. Determine farmer's perception about erosion.

MATERIALS AND METHODS

This research was conducted from January to May 2009 in Barangay Shilan, La Trinidad, Benguet. The study area is characterised by steep slopes and chayote plantations. In different fields each with its own parameters, the erosion risk was computed with known and investigated parameters by the MMF method. When erosion features were present the current erosion damage was measured in the field with the ACED method.

Several farmers were interviewed with the use of a survey questionnaire to gather their perception about erosion. Farmers' perception related to erosion processes was included in this research since understanding of erosion processes increases awareness and successful application of conservation techniques.

The answers were related to education, tenure status and age. Other questions were associated with the causes and effects of erosion. Such as heavy rain, steep slopes, loose soils, run-on, wide spacing of crops and up down tillage. The questions about effects of erosion included rills, gullies formations, splash pedestals, stoniness, root exposure and sedimentation.

Morgan et al. (1984) developed the MMF model to predict annual soil loss from agricultural fields on hill slopes. To measure the erosion prediction by the MMF method, rain data, topography, soil and vegetation parameters are needed (Table 1). The annual rainfall and days of rain from 2000 to 2008 of the BSU- PAGASA Agrometeorological station were used. The rainfall intensity of 30 mm/h is chosen according to the input parameters of the MMF method for strongly seasonal climates like monsoons which occur in the Philippines. The soil parameters moisture content, soil detachability, cohesion, and hydraulically depth were taken from MMF tables by using the soil standards for a loamy clay soil (Morgan et al., 1982; Morgan, 2001). The bulk density was determined after drying ten soil samples at 100$_0$C for 24 hrs. The other parameters are a combination of the worst case scenario, the comparison with the vine as similar crop and observation in the chayote fields.

The MMF can be divided into water phase and sediment phase. First, the water phase was calculated using the following formulas:

$ER = R \times (1-A)$ Effective rainfall (mm)

$LD = ER \times CC$ leaf drainage (mm)

$DT = ER - LD$ Direct throughfall (mm)

$KE\ (DT) = DT\ (29.8-(127.5/I))$ Kinetic energy of direct throughfall(J/m$_2$).

This formula is developed by Hudson (1965) in Zimbabwe and is used for tropical climates.

$KE\ (LD) = LD\ ((15.8 \times PH_{0.5})-5.87$ Kinetic energy of leaf drainage(J/m$_2$)

$KE = KE(DT) + KE(LD)$ Kinetic energy of rainfall (J/m$_2$)

The estimation of the annual runoff is based on the method by Kirby (1976).

$Rc = 1000\ MS \times BD \times EHD\ (Et/Eo)^{0.5}$ Soil moisture storage capacity

$Ro = R / Rn$ Average rain per day (mm)

$Q = R \exp(-Rc/Ro)$ Volume of overland flow (mm)

Secondly, the sediment phase was calculated with the next formulas:

$F = K \times KE \times 10^{-3}$ Annual rate of soil detachment by raindrop impact (kg/m^2)

$Z = 1/(0.5COH)$ Resistance of the soil

$H = ZQ^{1.5} \sin S (1-GC) \times 10^{-3}$ Annual rate of soil detachment by runoff (kg/m^2)

$TC = CQ^2 \sin S \times 10^{-3}$ Annual transport capacity of overland flow (kg/m^2)

$J = F + H$ Annual rate of total soil particle detachment (kg/m^2)

The soil loss was observed in different chayote fields by the ACED method developed by Herweg (1996). The length, width, and depth of rills, channels or gullies were measured to obtain the soil loss. Some fields rills, channels, and gullies were observed. To classify the erosion damage by the ACED method, the following formulas were used:

Soil loss in m^3 = Length in m x average width in m x average depth in m

Converted soil loss in kg /m^2 = Soil loss in m^3 x 1.3 kg/m^2

Area of actual damage in m^2 = Length in m x average width in m

The soil loss needs to be converted to kilograms per square meters to compare the erosion values of the ACED method with other measurements or methods. Ten random soil samples were taken and used to measure their weight. The soil was measured an average weight of 1.3 kg/m^2. This value is multiplied with the soil loss of the ACED method.

Table 1. Morgan - Morgan - Finney (MMF) parameters

MMF	Parameter	Formula	Values
Rainfall	Annual rainfall	R (mm)	4342
	Days of rain	Rn (days)	157
	Intensity	I (mm/h)	30
Soil	Moisture content	MS (wt %)	0.4
	Bulk density	BD (mg / m^3)	1.1
	Soil detachability	K (g / J)	0.7
	Cohesion	COH (kPa)	10
	Soil depth	SD (m)	Depend on situation
	Hydrological depth	EHD (m)	0.12
	Slope steepness	S (degrees)	Depend on situation
Vegetation	Rainfall interception by vegetation	A (between 0-1)	0.25
	Actual and potential evapotranspiration	Et/Eo (between 0-1)	0.3
	Crop management factor	C (between 0-1)	0.01 due to grass undergrowth
	Canopy cover	CC (between 0-1)	Depend on situation
	Ground cover	GC (between 0-1)	Depend on situation
	Plant height	PH (m)	Depend on situation

RESULTS AND DISCUSSION

The erosion data gathered by the ACED method depends on observed erosion features in the field. Rills results in a soil loss around 14kg/ m_2 at a slope till 65%. The method revealed a soil loss of 97 kg/m_2 in case of a gully at a slope of 30%. Erosion calculation by the MMF method predicts on slopes of 25% to 65% a soil loss of 6 to 13 kg/m_2. The steeper the slope, the more erosion will take place according to the MMF method. Although observed with the ACED, the biggest soil loss is at a slope of 30%. Thus, the slope is not the only parameter which influences the erosion risk. The MMF has limitations since erosion is limited by the transport capacity. The steepness is in this case the determining parameter which influences the erosion risk. Changing other parameters in the model did not result in reasonably erosion risk changes only the steepness factor changed the erosion risk in the area according to MMF calculations.

Both methods show severe erosion and are comparable in case of the erosion features rills and channels. The MMF method gives lower values for soil erosion compared to the ACED because it takes into account average weather data for one year. On the other hand, the ACED observes accumulated soil loss which can be caused over a longer period. For this reason the values from both methods are not comparable. The MMF is generally used to predict erosion. The advantage of this model is that even without a rain event, the erosion risk can be calculated. However, it cannot predict the effect of unusual heavy rains which occurs in the Philippines. For this cause the ACED method is more reliable since it measures erosion features direct after heavy rainfall.

Interviews revealed that some farmers did not know about causes and effects of erosion. Three out of the eleven interviewed farmers did not experience erosion while there were erosion features. Farmers with a college or high school degree who are all landowners have more knowledge about the erosion causes and indicators. All interviewed farmers noticed high rainfall and steep slopes as contributors to cause erosion. The other reactions of the farmers are part of slight information about erosion. None of the farmers followed training related to conservation measurements.

The difference of land management like the undergrowth of grasses were observed in the field. The farmers often remove grass underneath the chayote plants because they believe that grasses reduce moisture and nutrients. Only a few farmers understood that grasses are necessary to reduce the risk on erosion. There is little knowledge about erosion processes. Therefore in this research an erosion field tool is developed which is related to the ACED method and can be easily used. The erosion field tool gathers erosion data which results in an erosion data base.

Erosion Field Tool

The ACED method is most suitable in this area. The erosion field tool is a simplification of the ACED method and it involves fewer steps. The erosion is measured by using the vegetation density, slope and crop. The parameters of the erosion field tool are mentioned in Table 2. The gathered erosion data should be recorded in this table. The data could be collected and compared to increase the knowledge about erosion features. The database will be used by farmers, extension workers, students and teachers of the university. By use of the database the links between for instance, vegetation cover, rainfall, and steepness can be related with the soil loss. Understanding the influence of different factors on the erosion risk is important and is easily recorded by the use of a database. Year after year, the erosion can be recorded of one specific field by the erosion field tool.

Table 2. Data requirement for the erosion field tool, a simplified ACED

	Record per erosion feature		
1	Location and date		Precise location by GPS and date is important for future measurements.
2	Size of erosion feature in meter	Length	Take the total length of the rill, channel, or gully by using a measuring tape of at least 30m.
		Average width	Take over every meter length, the width by a measuring tape of 3m and calculate the average width
		Average depth	Measure over every meter length the depth by a measuring tape of 3m and calculate the average width of the erosion feature
3	Soil loss in m^3		Multiply the length, average width and depth of the erosion feature to get the soil loss
4	Field size in m^2		Ask the farmer about the total field size or measure the length and width of the field and multiply
5	Slope in %		Measure the slope by an inclinometer or Abney hand level
6	Crop type		Record the crop type. Crop type can influence the erosion risk
7	Crop height in cm		The average plant height from the soil to the top
8	Canopy cover in %		The percentage of crop density by comparing the figure with the crop.
9	Ground cover in %		The percentage of the crop covering the ground by comparing the figure with the crop covering the ground
10	Conservation techniques		This could be stone rows, diversion ditches, terraces, intercropping (mention which crops), agro forestry or others
11	Amount of rain in mm		The amount of rain causing the erosion feature. Usually take the last continues rainfall.

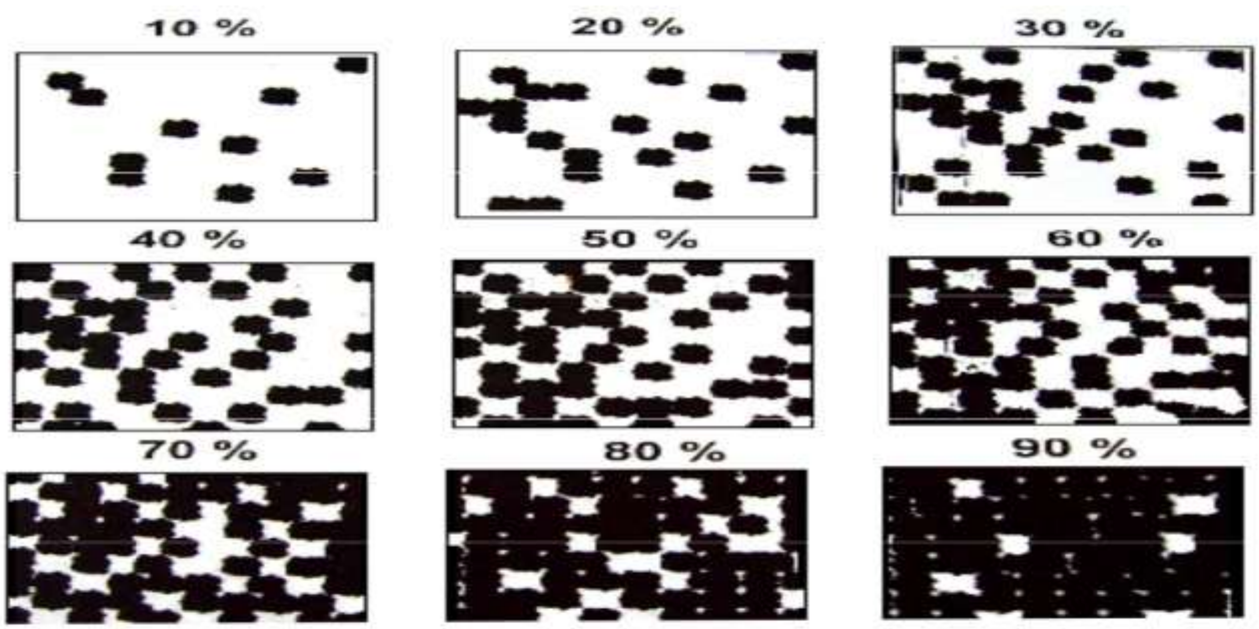

Figure 2 Estimate canopy and ground cover (Herweg, 1996)

CONCLUSION AND RECOMMENDATIONS

Conclusion

In fields where chayote is planted on steep slopes without certain conservation measurements, erosion features can occur. The erosion data collected by the ACED method depends on available erosion features in the field. Rills resulted in 14 kg/m_2 soil loss at a slope till 65%. The method revealed a soil loss of 97 kg/m_2 in case of a gully at a slope of 30%. Erosion calculation by the MMF method on fields with slopes of 25% to 65% predicts a soil loss of 6 to 13 kg/m_2. The MMF illustrates that erosion risk increases with slope steepness. The MMF is limited by the transport capacity in this case. The steepness is the determining parameter which influences the erosion risk. Changing other parameters did not result in reasonably erosion risk changes.

The MMF method gives lower values for soil erosion compared to the ACED because it takes into account average weather data for one year. While the ACED observes accumulated soil loss, this can be a result of a longer period. For this reason the values from both methods are not comparable. The MMF is generally used to predict erosion. The advantage of this model is that even without a rain event the erosion risk can be calculated. However, it can not predict the effect of unusual heavy rains which occurs in the Philippines. For this reason the ACED method is more reliable since it measures erosion features caused by heavy rainfall, like typhoons. The ACED is therefore used as an example to develop the erosion field tool in this research.

Understanding the cause of the erosion features is important before conservation techniques can be established. The erosion field tool which is related to the ACED method will result into a database about erosion features. The database can be used to gain a better understanding about the formation of erosion features. Farmers have little knowledge about the erosion causes and effects. None of the farmers followed training related to conservation measurements. Training is necessary to make the farmers understand the erosion risk and to apply conservation measurements.

The data gathered from the erosion field tool will be used in a database and the results will increase the knowledge about erosion processes. The database will be used by students and teachers of the university. With the use of the database, the links between for instance, vegetation cover, rainfall, and steepness can be related with the erosion amount. Understanding the influence of different factors on the erosion risk is important and can be recorded by use of a database.

Recommendations

The erosion field tool can contribute to a better understanding of the erosion process of extension workers, students, and farmers. The use of the tool will help them to implement a certain conservation measure to reduce soil erosion. Different conservation measurements are possible but are limited by the investment a certain farmer can afford.

Undergrowth with grasses, agro-forestry, and intercropping with coffee trees are possibilities when taking into account the suitable conservation measurements in Shilan. All these measurements decrease the risk of erosion by reducing the velocity of water and loose soils. Commercial growth of coffee trees together with chayote is an option which should be investigated in the future researches. The farmer could have higher revenues from his field when planting more than one type of crop.

To reduce erosion, the cooperation and incentives of the local government and extension offices is also necessary. Extension workers could give trainings to farmers about erosion and conservation. The conservation measurements are often expensive. Incentives together with trainings are necessary to make adoption of conservation techniques possible. The local government assures in this way the future production capacity of the agricultural area and the safety of the inhabitants.

ACRONYMS

Acronyms used in the study:

ACED - Assessment of Current Erosion Damage
BSU - Benguet State University
CA - College of Agriculture MMF
- Morgan Morgan Finney
PAGASA - Philippine Atmospheric, Geophysical and Astronomical Services Administration
ssd - soil Science Department

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Figure 3. Overview of a chayote field in Shilan, La Trinidad. Chayote plants (about 2 months) are fully grown with more than 80% canopy cover.

Figure 4. Drainage canal dug by the farmer serves as a preventive measure against erosion.

Figure 5. Measuring gully erosion.

Figure 6. Measuring erosion by using the erosion field tool.

Figure 7. Measuring size of the gully.

Figure 8. Interviewing chayote farmers.

Figure 9. Visiting chayote field in Shilan.