Soil physical properties in relation to soil degradation rates in the Usambara Mountains, northeast Tanzania

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Summary

Soil erosion is one of the world's most serious environmental problems (Jankauskas et al, 2008). It can cause extensive losses of crop yields and cultivated and potentially productive soils (Fullen & Catt, 2004; Morgan, 1995; Skoien, 1995). Soils which are highly eroded are more easily subjected to a redundancy of productivity and are poor environments for root growth, due to a degraded structure and lower organic matter contents (Frye et al., 1982; Lindstrom et al., 1994).

The mountains and highlands of East Africa are facing the problems of land degradation as well, mainly due to the human impact on the natural ecosystems (Ezaza, 1992). This is enhanced by the high population density. Also deforestation of new land even on steep slopes and over-exploitation of mountain resources, due to the high population density has led to high soil erosion rates (Ezaza, 1988). Because this area is characterized by a steep and rugged topography and most people rely on agriculture due to the fertile soils and favorable agro-climate, many farms suffer from serious soil erosion.

The aim of this research was to determine the relation of soil physical properties (i.e. aggregate stability, soil texture, bulk density, porosity, infiltration rate and soil cohesion) and soil erosion rates of several hill slopes with sparse vegetation in the Lushoto district situated in the West Usambara Mountains, Tanzania. To achieve this objective the soil physical properties of four highly erosive and four less erosive soils of hill slopes has been determined to find out which of the soil physical properties are contributing most to soil erosion. These hill slopes were approximately equal in amount of vegetation and slope angle. The MMF erosion model has been used to quantify the soil erosion for each hill slope where no erosion measurements are performed. The model has been validated on six other fields for which erosion measurements are performed by Wickama (2010).

Aggregate stability was significantly higher for the non-erodible fields for both wet- and dry-aggregates and is the most important soil physical property for erodibility of these fields. Difference between erodible and non-erodible fields for wet-aggregate stability is even more pronounced than the difference between these for dry-aggregate stability and shows that water is more important in eroding the soils than wind.

Infiltration capacity values were equal higher for the erodible than non-erodible fields. This is contradicting with the aggregate stability values. Due to the installation of the double ring infiltrometer in the crust, which is formed by the disruption of aggregates, the crust is disturbed and infiltration can occur more easily than normally. Variation in profile depth and the occurrence of rubbers and plastics in the soils could have had a minor role in effecting the infiltration rates.

Differences between soil texture for erodible and non-erodible fields are only apparent for the fine sand when both depth layer were taken together. For all eight research fields silt and clay content were such that the soils were not vulnerable to erosion with respect to soil texture.

The eight fields of investigation, when compared for the erodible fields and non-erodible fields, were quite similar with respect to soil profiles. The erodible soils were somewhat more red and less yellow or brown. From this it can be concluded that on the erodible fields leaching of minerals has occurred leaving only iron and/or aluminium oxides in the soil.

No differences occur with respect to soil cohesion and shear strength on the erodible and non-erodible fields. The same applies for bulk density and porosity.

The MMF erosion model shows that the erodible and non-erodible fields are approximately equal in erosion rates in case of average rainfall, though when the ratio between rainfall and amount of rain days increases (rain intensity), which is predominantly the case when the amount of rainfall is above average, differences in the amount of erosion become clear: the erodible fields experience more erosion than the non-erodible fields. Protection of the fields to erosion is predominantly due to a high aggregate stability.

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1. Introduction

The mountains and highlands of Tanzania are facing several problems of land degradation, mainly due to the human impact on the natural ecosystems (Ezaza, 1992). This is enhanced by a high population density. People prefer the highlands of Tanzania because of minimal occurrence of diseases such as malaria (Reiter, 2005) and because of adequate water, reliable precipitation, good agricultural conditions and rich vegetation cover (Berry and Turner, 1990), which causes a considerably higher potential for crop productivity than any other biographical region in Tanzania. For the highlands in Lushoto district, Northeast Tanzania, the carrying capacity has been calculated to be approximately 140 000 people, which equals approximately 50% of the population 30 years ago (Moore, 1971). Although these are not recent values and it is almost impossible to calculate the carrying capacity, it does show that this area is severely overpopulated. Especially when it is taken into account that the population growth at that time was high (2.8%, 1978) (Lundgren, 1980). In 2002, the population was counted to be 420,000 (Tanzania National Census). The high population density has resulted in intensive cultivation, and together with the increasing population density, this has led to serious soil erosion and soil fertility deterioration in Lushoto district (Lundgren & Lundgren, 1979). Also deforestation of new land even on steep slopes and over-exploitation of mountain resources, due to the high population density has led to high soil erosion rates (Ezaza, 1988). Because this area is characterized by a steep and rugged topography and most people rely on agriculture due to the fertile soils and favorable agro-climate, many farms suffer from serious soil erosion.

The factors controlling soil erosion can be divided in four main groups: the erosivity of the eroding agent, the erodibility of the soil, the slope of the land and the nature of the plant cover (Morgan, 2005). For the Lusotho district the erosivity is almost homogeneous, since the amount and intensity of the rainfall will not show large differences. On several soils in the Lushoto district, erosion is not a serious problem. These soils are equal in slope and vegetation cover when compared to very erodible soils. So since the slope and plant cover are about the same, the factors causing soil erosion at one place and not at the other should be due to the erodibility of the soil. The erodibility is partly determined by the soil physical properties and these are expected to be the cause of the different erosion rates. Especially, the small-aggregate stability seems to be high on some soils, which reduces surface crusting and enhances infiltration rates (Lundgren, 1980).

One of the soil physical properties that decreases the vulnerability of slopes to erosion is a higher organic matter, which results in an increase of the aggregate stability and soil cohesion, while bulk density decreases. A high aggregate stability reduces surface crusting and enhances infiltration rates. This is because the aggregates provide larger soil pores, reduce soil density and enhance water infiltration and aeration, thereby reducing the amount of runoff and thus erosion (Jankauskas et al., 2008). A decrease in bulk density or an increase in porosity causes the water to infiltrate more easily as well. When soil texture is mainly silt or fine sands it is exposed to erosion as silts and fine sand are not cohesive (Richter & Negendank, 1977). Clay particles combine with organic matter to form soil aggregates and decrease erosion rates (Morgan, 2005). If it is known which soil physical properties affect the amount of erosion on hill slopes, measures could be taken to improve the soil physical properties and prevent erosion on these farmers'fields.

The aim of this research was to quantify the relation of soil physical properties (i.e. aggregate stability, soil texture, bulk density, porosity, infiltration rate and soil cohesion) and soil erosion rates on several hill slopes with sparse vegetation in the Lushoto district. To achieve this objective the soil physical properties of 4 highly erodible and 4 less erodible soils of hill slopes have been determined to determine which of the soil physical properties are contributing most to soil erosion. These hill slopes are approximately equal in amount of vegetation and slope angle. The MMF erosion model, applied for predicting annual soil loss from field-sized areas on hill slopes, has been used for quantification of the soil erosion for each hill slope where no erosion measurements are performed. By performing this, erosion rates can be compared quantitatively for the erosive and non-erosive soils instead of only vissually. The model has been calibrated on six other fields for where erosion measurements are performed by Wickama (2010).

2. Study area

This study has been performed within Lushoto district which is situated in the Usambara Mountains, northeast Tanzania, within the latitudes 4° 05’ to 5° 00’ and longitudes 38° 5’ to 38° 40’ (Ezaza, 1992). It occupies about 70 percent of the West Usambara highlands. It is characterized by a steep and rugged topography, fertile soils, favorable agro-climate and a high population density. The topography is mountainous with the altitude ranging from 600 meters to 2300 meters above sea level (Wickama, 2010).

The district has an area of approximately 3500 km^2 of which 2000 km^2 is arable land (Mowo et al., 2002) on which tea, coffee, maize, banana, beans, sugar cane and several other fruits are grown. Most of this cultivation is taking place in the valley bottoms. The area is dominated by smallholder farming and due to the population growth, landholdings have shrunk to one hectare or less per household (Lyamchai et al., 1998; Pfeiffer, 1990). The population was counted in 2002 and was 420,000 (National Bureau of Statistics, 2002) which means a population density of 120 people per km^2 (Wickama, 2010).

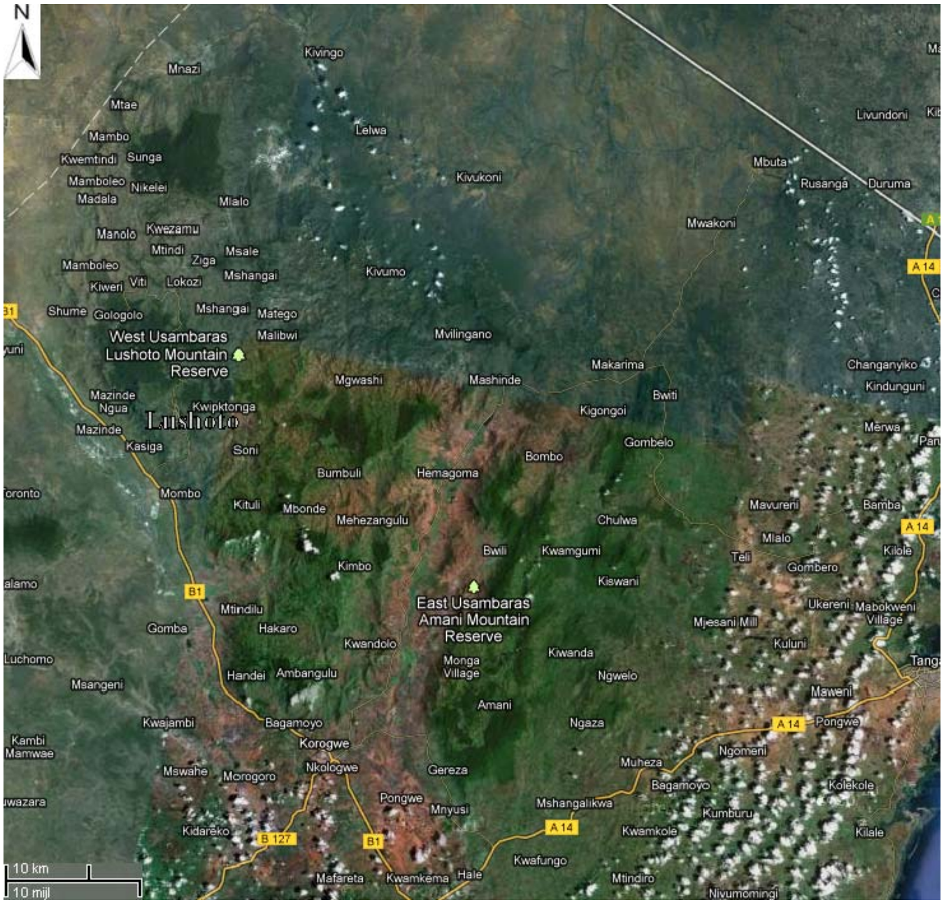
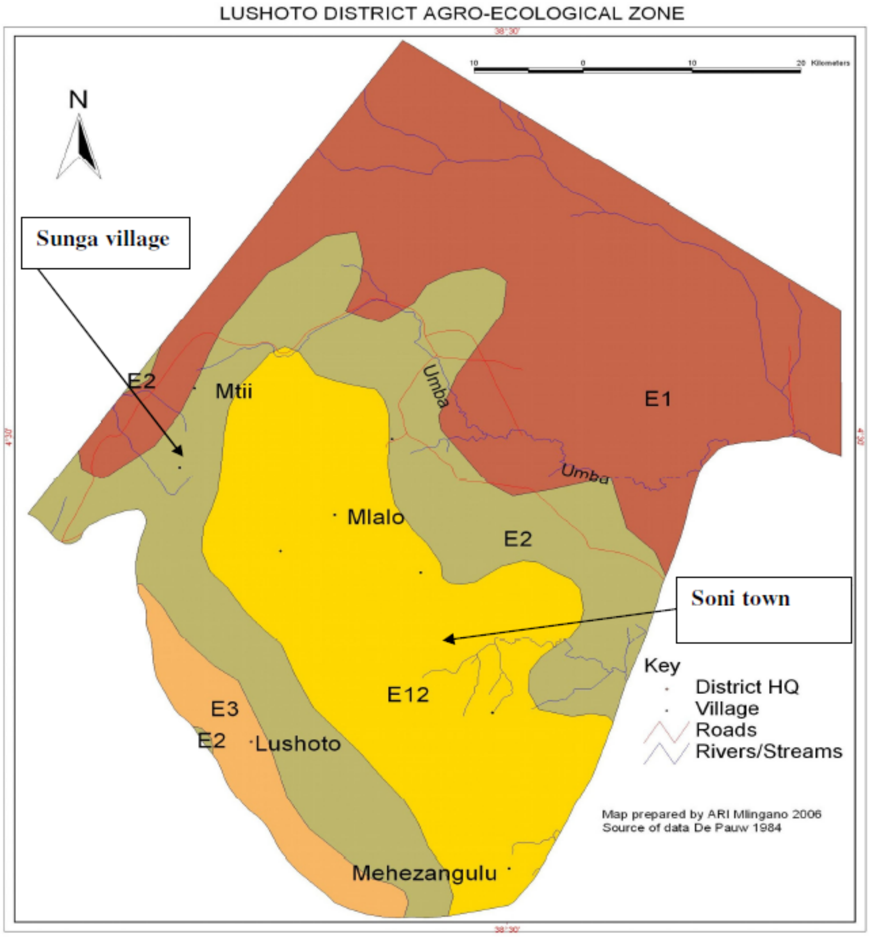


Figure 1: West and East Usambara Mountains divided by a valley in between Korogwe and Mashinde (Google Earth, 2012)

Lushoto district has a number of protected natural forests on which most of the naturally occurring vegetation is found (Lyamchai et al., 1998; Pfeiffer 1990). These are protected due to the clearing for cultivation before, which has reduced the forest area considerably. The forest reserves occupy an area of approximately 340 km^2 (Lundgren, 1978). On the seaward slopes of the Usambara mountains between the elevation range of about 750-1400 m.a.s.l. submontane evergreen forest is present. In areas above 1400-1500 meter altitude montane evergreen forest is found (Pócs, 1976).



Map prepared by ARI Mlingano 2006
Source of data De Pauw 1984

Aez_code	Altitude (masl)	Rainfall (mm/year)	Physiography
E1	500-1200	400 - 500	Gently undulating to rolling plains and plateaux developed on gneisses
E12	1000-2000	800 - 1000	Dissected, rolling /hilly mountains plateaux in parts affected by water-erosion
E2	500-1200	800 - 1000	Undulating to rolling plains and plateaux alti 500-1200 m developed on gneiss
E3	200-750	800 - 1000	Flat to rolling plains low altit developed on intermediate metamorphic rocks

Figure 2: The agro-ecological zones of Lushoto and surroundings according to De Pauw (1984).

The Usambara Mountains consist of two large mountain massifs of Precambrian rocks. One of these is referred to as the West Usambara mountains in which Lusotho district is situated (Lundgren, 1980). Lushoto and Soni town, where research was conducted in a 10x10 km block around it, are situated in the southwest part of the West Usambara Mountains (Figure 1). The area is characterized by metamorphic rocks such as schists and gneisses and these are the dominant substrates of the soils in Lushoto (Ngailo et al, 1998). The major soil types are humic, haplic and chromic acri-, luvi- and lixisoils for most of the mountainous uplands, while fluvi- with some pockets of gleysoils dominate the valley bottoms (Meliyo et al., 2002). Texturally, the soils have a high sand and clay (25-60%) content, but are low in silt. They are red to yellowish in colour with a darker shade in the topsoil due to organic matter content. Kaolinite dominates the clay fraction. Sometimes strongly weathered pieces of gneiss are found in the upper 50 cm. Rock outcrops do occur but are not common (Lundgren, 1980).

Rainfall shows a bimodal distribution, the long rains from March to May and the short rains from October to December (Kabanda & Jury, 1999). The precipitation rates vary from 900 to 1300 millimeters per year depending on the agro-ecological zone. For Lushoto district De Pauw (1984) reported four agro-ecological zones, each with distinct altitude, rainfall and physiography (Figure 2). Near Soni town (Figure 2) an area has been selected of 10x10 km where measurements of soil physical properties have been performed. This area is situated in the E12 area with altitudes ranging from 1000-2000 meters. Annual rainfall is between 800-1000 millimeters and the physiography is described as dissected, rolling/hilly mountains plateaux in parts affected by water erosion.

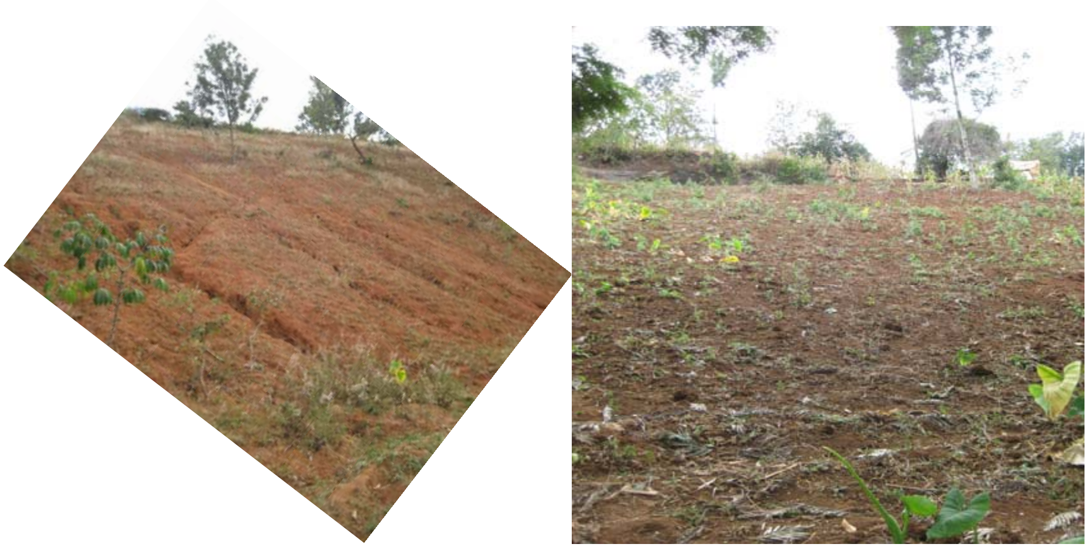


Figure 3: Two fields in the 10 x 10 km block near Soni town. Left: field categorized as erodible, right: fields categorized as non-erodible

On 6 fields, pre-defined by Wickama (2010) measurements have been performed to calibrate the MMF erosion model. Here, 3 fields have been selected where sustainable land management is performed and next to these fields a control plot is situated without sustainable land management. Soil physical properties and soil erosion on these fields have been quantified by Wickama (2010). These are bulk densities, soil texture and erosion rates, measured using Gerlach troughs. Eight other fields, also located in the 10x10 km area around Soni, were selected for determination of the soil physical properties and for modelling. Four fields with visual erosion features and four without erosion features were selected (Figure 3). The slope, vegetation type and amount of vegetation were approximately the same for the 8 fields. Research has been performed on the soil physical properties and input parameters of the MMF erosion model and are described in the following chapters.

Table 1 and Table 2 show the names of the villages to where the 14 fields are closely located. Fields used for the MMF erosion model are indicated with ‘M’ and its field number, the 8 fields used for determining the soil physical properties are only indicated by a number. The name of the farmers of the six fields can be found in Table 1. On these fields distinction is made between fields with and without sustainable land management (SLM) measures. These are paired in couples from which one is a control field and lay next to eachother (Wickama, 2010). Names for the 8 fields used for soil property measurements are not known, but Table 2 shows which of those fields were affected by erosion, and which were not.

Table 1: Names and location of the 6 fields used for the MMF erosion model.

Field number	**Field/farmers name**	**Location**	**SLM measures**
M1	Amiri Rajabu	Shashui	Control
M2	Athumani Ramadhani	Shashui	Terrace + annual crops
M3	Iddi Nasoro	Shashui	Control
M4	Mzee Magogo	Shashui	Terrace + agro-forestry + annual crops
M5	Nyangasa	Kisiwani	Control
M6	Shabani Omari	Kisiwani	Grass strips + annual crops

Table 2: Erosivity and location for the 8 fields used for determining soil physical properties.

Field number	**Erosion class**	**Location**
1	Erodible	Shashui
2	Erodible	Shashui
3	Erodible	Shashui
4	Erodible	Shashui
5	Non-erodible	Shashui
6	Non-erodible	Kisiwani
7	Non-erodible	Kisiwani
8	Non-erodible	Kisiwani

3. Methods

For each of the eight fields, 5 sampling places were chosen, located at the four corners and the middle of the field. All measurements were performed on these five places, except the soil profile description and the soil texture, which were only performed in the middle of the field. The samples were taken from the upper soil layer (0-15 cm). Only for soil texture an extra sample of the subsoil was taken (15-30 cm). Parameters used for the model were determined in these fields, as well as in the fields where Gerlach troughs have been placed by Wickama (2010) by using the same sampling scheme.

3.1. Soil profile description

Soil profile descriptions were made in the middle of all 8 fields for the toplayer of approximately 35 cm in depth. The structure of the soil was described together with colours, mottles, layers and the occurrence of roots and/or stones.

3.2. Soil texture

Samples of soil texture were taken in the middle of each field. Two samples were taken at a depth of 0-15 cm and 15-30 cm to display potential changes in depth. Soil texture were determined according to the pipette method (Gee & Or, 2002). Soil texture classes were determined with the use of Figure 4.

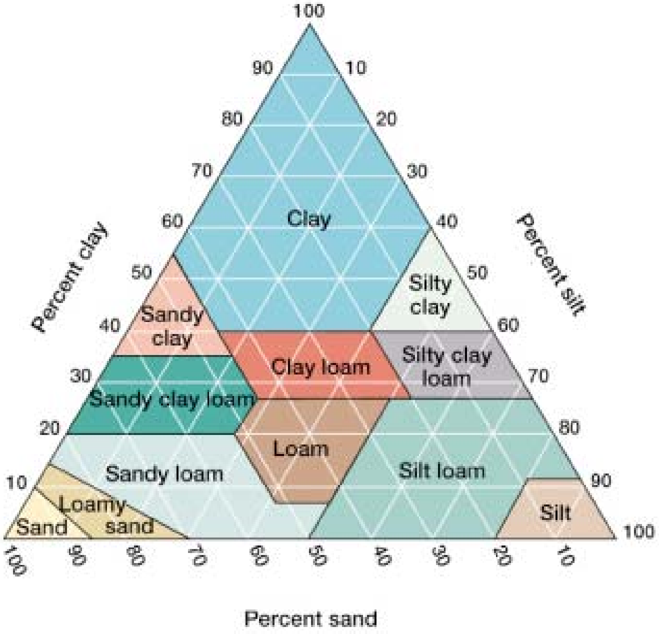


Figure 4: Soil texture triangle (McKnight & Hess, 2008).

3.3. Bulk density and porosity

The core sampling method was used to determine bulk density. Samples were obtained with a cylinder of 50 mm in diameter and 100 cm^3 in volume and were inserted into the soil with the use of a hammer. Bulk density was determined by weighing the dry weight core and the ring. The latter was extracted from the dry weight core and this was divided by the volume of the core sampler.

The porosity was calculated from the bulk density and particle density. The bulk density was measured as described above. According to Lundgren (1980) kaolinite dominates the clay fraction in the Usambara Mountains while the larger grain size fractions consist mainly of quartz. Both of these have a particle density of 2.65 g/cm^3, which was, for that reason, used in this study (Blake & Hartge, 1986; Lide, 1999).

3.4. Aggregate stability

The aggregate stability was determined by the water-drop test (Imeson & Vis, 1984) and was measured for both dry- and wet-aggregates. For measuring the dry-aggregate stability, the 4-4.8 mm fraction of soil aggregates was used. Water-drops of 0.1 g in weight fell from 1 m in height on the aggregate. The number of drops was counted until the aggregate fell apart and was able to fall through the 2.8 mm sieve. This was repeated for 20 aggregates of each sample (5 per field). For measuring the wet aggregate stability, the aggregates were pre-wetted during 24 hours at pF=1.0 and after this, the same procedure as for measuring dry-aggregate stability was followed. However, prior to aggregate stability measurements, core samples have been taken to the lab for determining the soil moisture content at pF=1.0 to be able to add the correct amount of water to the aggregates. For each field only 2 or 3 samples were taken to determine soil moisture content because not enough core sample rings were available to take the before mentioned five samples for each field. For each field an average soil moisture content has been determined at pF=1.0.

3.5. Soil infiltration rate and capacity

A double-ring infiltrometer with an inner cylinder radius of 18.6 cm and an outer cylinder radius of 36.5 cm was used for determining the soil infiltration rate and capacity. The height of the used cylinder is 15.3 cm. At the start, the cylinder was first levelled and water was poured into the outer cylinder to pre-wet the soil for 5 min. Time started when the inner cylinder was completely filled with water and the change in water height was measured for time intervals of 5, 10 or 20 min, which increased during the measurement, until the infiltration rate reached quasi-steady flow. For determining the infiltration capacity two distinct methods were used. For the first, the quasi-steady infiltration rate is taken equal to the infiltration capacity. However, this usually produces higher estimates of the infiltration capacity as it does not account for the hydrostatic pressure and soil capillarity components of flow out of the infiltrometer (Reynolds et al., 2002). For this reason, a second equation has been used:

$$K_{fs} = \frac{q_s}{[H/(C_1 d + C_2 a)] + \{1/[\alpha^* (C_1 d + C_2 a)]\} + 1} \qquad [1]$$

where K_{fs}=infiltration capacity (L T^{-1}), q_s=quasi-steady infiltration rate (L T^{-1}), H= average depth of water ponding, d=cylinder insertion depth, a=cylinder radius, α* is a parameter estimated from the soil texture and structure categories displayed in Table 3. C_1 and C_2 are constants, 0.316π and 0.184π, respectively (Reynolds et al., 2002).

Table 3: Soil texture-structure categories for site-estimation of α (Reynolds et al., 2002).*

Soil texture and structure category	α* (cm^{-1})
Compacted, structureless, clayey or silty materials such as landfill caps and liners, lacustrine, or marine sediments.	0.01
Soils that are both fine structured (clayey or silty) and unstructured; may also include some fine sands.	0.04
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12
Coarse and gravelly sands; may also include highly structured or aggregated soils, as well as soil with large and/or numerous cracks, macropores.	0.36

Kfs=Qs will still be used as it will be able to perform as a control, since equation 1 consist of several parameters which might result in values other than expected when parameters are not sufficiently accurate.

3.6. Soil cohesion and shear strength

Measurements of soil cohesion were performed with a torvane. For each sample, five measurements were done. The highest and lowest value were discarded and the average of the three middle values has been taken. The forces of soil cohesion depend strongly on the water content and this affects the cohesive forces (Dane & Hopman, 2002). So to avoid apparent cohesion (suction), the soil was saturated beforehand.

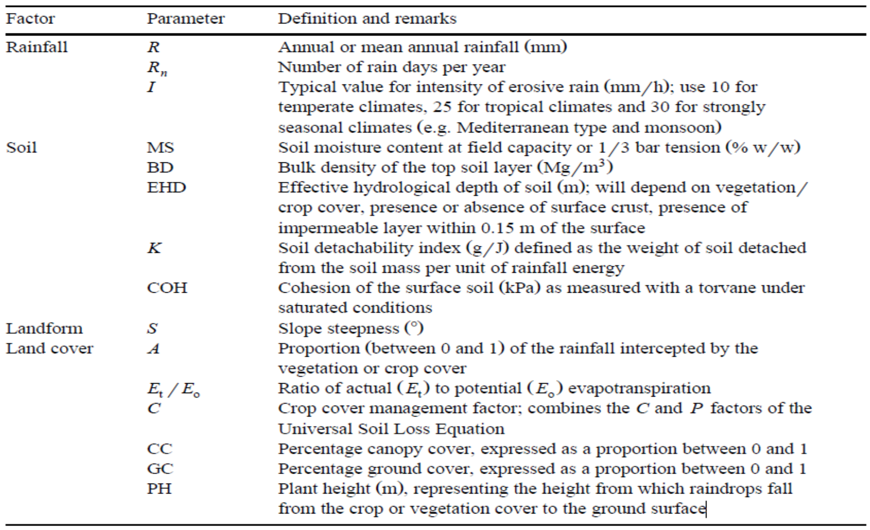
3.7. Statistical analysis

Statistical analysis were performed with the t-test on all soil characteristics for two groups, the 4 sites with severe erosion and the 4 sites without a noticeable amount of erosion (from now on these sites will be referred to as erodible and non-erodible respectively). For statistical analysis α used equalled 0.05, so that the hypothesis that the means are the same can be assumed ($p>0.05$) or rejected ($p<0.05$) at an error level of 5%. Correlation analyses were also performed on a few of the distinct soil properties (Wonnacott & Wonnacott, 1990).
P-values, means, variances can be found in appendix A.

3.8. Modelling parameters

Several parameters are required as input for the model and were determined for both the six fields used to validate the MMF erosion model and the 8 fields to determine the soil physical properties in relation to soil degradation rates. These parameters are shown in Table 4. Modelling of the erosion on the hill slopes has been performed for each slope with the MMF erosion model to quantify the erosion on each of the slopes. The model has been calibrated with the use of six other slopes for which the soil erosion rates have been measured with the use of Gerlach troughs. A description of the model can be found in Table 5 and Table 6, input parameters in appendix D.

Table 4: Input parameters to the Morgan-Morgan-Finney method of prediction soil loss (Morgan, 2005).



Factor	Parameter	Definition and remarks
Rainfall	R	Annual or mean annual rainfall (mm)
	R_n	Number of rain days per year
	I	Typical value for intensity of erosive rain (mm/h); use 10 for temperate climates, 25 for tropical climates and 30 for strongly seasonal climates (e.g. Mediterranean type and monsoon)
Soil	MS	Soil moisture content at field capacity or 1/3 bar tension (% w/w)
	BD	Bulk density of the top soil layer (Mg/m^3)
	EHD	Effective hydrological depth of soil (m); will depend on vegetation/crop cover, presence or absence of surface crust, presence of impermeable layer within 0.15 m of the surface
	K	Soil detachability index (g/J) defined as the weight of soil detached from the soil mass per unit of rainfall energy
	COH	Cohesion of the surface soil (kPa) as measured with a torvane under saturated conditions
Landform	S	Slope steepness (°)
Land cover	A	Proportion (between 0 and 1) of the rainfall intercepted by the vegetation or crop cover
	E_t/E_o	Ratio of actual (E_t) to potential (E_o) evapotranspiration
	C	Crop cover management factor; combines the C and P factors of the Universal Soil Loss Equation
	CC	Percentage canopy cover, expressed as a proportion between 0 and 1
	GC	Percentage ground cover, expressed as a proportion between 0 and 1
	PH	Plant height (m), representing the height from which raindrops fall from the crop or vegetation cover to the ground surface

Water phase

$ER=R \times (1-A)$ eq. 2

ER = effective rainfall (mm)
R = annual or mean annual rainfall (mm)
A = proportion (between 0 and 1) of the rainfall intercepted by the vegetation or crop cover

Annual or mean annual rainfall

Hourly rainfall data of the Soni area was collected from an automatic weather station, which has been installed at the test site in Shashui. For the six fields needed to calibrate the model, rainfall data was used of the particular year in which measurements of soil erosion were performed. For the other 8 fields for which the soil physical properties were determined, a yearly average was taken. Yearly rainfall data were available from 1928-2006. Data for these 8 fields were not used from the data collected at Shashui but were gathered from a rain gauge at Sakarani which is situated nearby.

Proportion of the rainfall intercepted by the vegetation or crop cover

The proportion of the rainfall intercepted by the vegetation cover or crop cover (A) was determined by the estimation of the main vegetation cover. In appendix D the typical values of the proportion of the rainfall intercepted for several vegetation types are shown. If a crop occurred on a field for which no value was listed in appendix D, another vegetation type which was quite similar to the one on the field was chosen or an average was taken of the other crops growing on the field. This procedure was chosen when no particular crop listed in the table could resemble the one in the field. Because these crops, for which no value was available, were all quite similar to the other plants in size and leave. It can be assumed that the amount of rainfall that can be intercepted is probably similar. Furthermore, these crops which were not listed in the table were never very abundant and thus they did not have a high impact on the calculated value of A. In this way a best guess was made. For bushes initially (prior to calibrating) an average was taken of grasses and trees.

$LD = ER \times CC$ eq. 3

$DT = ER \times LD$ eq. 4

LD = leaf drainage (mm)
CC = percentage canopy cover expressed as proportion between 0 and 1
DT = direct throughfall (mm)

Proportion canopy cover, proportion ground cover and plant height

The land cover parameters; proportion canopy cover, plant height (eq. 6) and proportion ground cover (eq.13) were determined from estimations in the field. The land cover parameters used in the MMF erosion model are variable as crops are changing during the season both in type and height. Also during the fieldwork period, crop parameters changed due to harvesting or due to clearing of the land to use the remnants of dead plants which covered and protected the soil before. For this reason estimation of the land cover values were made instead of accurate measurements which are highly time consuming. Besides this, the model predictions are most sensitive to changes in annual rainfall and soil parameters if erosion is transport-limited and when erosion is detachment-limited it is most sensitive to changes in annual rainfall and rainfall interception. For this reason, good information on rainfall and soils is more important than land cover. Though, land cover parameters are important in explaining differences between plots (Morgan, 2005).

$KE(DT) = DT(11.9 + 9.7\log(I))$ eq. 5

$KE(LD) = LD \times ((15.8 \times PH^{0.5}) - 5.87$ eq. 6

$KE = KE\,(DT) + KE(LD)$ eq. 7

KE = kinetic energy of the rainfall (J/m^2)
I = typical value for intensity of erodible rain (mm/h)
PH = plant height (m), representing the height from which raindrops fall from the crop or vegetation cover to the ground surface

Typical value for intensity of erodible rain

The rainfall intensity was estimated at 25 mm/h as no measurements were performed for this parameter. This is a typical value for tropical climates (Morgan, 2005).

$Rc = 1000MS \times BD \times EHD(Et/Eo)^{0.5}$ eq. 8

$Ro = R/Rn$ eq. 9

$Q = R \times e^{-Rc/Ro}$ eq.10

MS = soil moisture content at field capacity (wt %)
BD = bulk density of the top soil layer (Mg/m^3)
EHD = effective hydrological depth of soil (m); the value depends on vegetation/crop cover, presence or absence of surface crust and the presence of an impermeable layer within 0.15 m of the surface
E_t/E_o = Ratio of actual (E_t) to potential (E_o) evapotranspiration
Rn = number of rain days per year
Q = volume of the overland flow (mm)

Soil moisture content at field capacity (wt %)

The soil moisture content at field capacity was measured by taking core samples as described previously. For the six fields with the Gerlach troughs only one sample was taken instead of five as for the other fields. This is because a limited amount of core samplers was available and soil moisture content was already measured for these fields at four places (Wickama, 2010; appendix E), which makes a total of five samples. The soil moisture content was determined according to the pressure cell methodology (Dane & Hopman, 2002). The moisture content at pF=2.0 was taken as field capacity.

Bulk density of the top soil layer (Mg/m^3)
The bulk density was determined for the 8 fields according to the core method as described previously to determine the soil physical properties in relation to soil degradation rates. Four samples for bulk densities have already been taken previously at the six fields which are used to validate the MMF erosion model and are used from the database of Wickama (2010) (Appendix E). So, one additional measurement was made to make a total of five samples as has been done at the other fields.

Effective hydrological depth of the soil (m)
The value of the effective hydrological depth depends on vegetation or crop cover, the presence or absence of a surface crust and the presence of an impermeable layer within 0.15 m of the surface. Appendix D gives guide values for the EHD. Where terracing is used, 0.01 was added to the EHD according to Morgan (2005) to take account of the resulting increase in water storage. Recommended values for the EHD by Morgan (2001) can be found in appendix D.

Ratio of actual (Et) to potential (Eo) evapotranspiration
The ratio of actual to potential evaporation was determined from values determined by Morgan et al. (1982) (Appendix D) by estimating the main vegetation cover. If a crop occurred on a field and the value was not listed in the in this table (Appendix D), the same procedure was performed as described for the A-parameter. Again, if the plants not listed by Morgan et al. (1982) were not very abundant and all quite similar in size and leaves, which means that the amount of actual and potential evaporation is probably close to the chosen values as well, this method could be applied again. For values for which Morgan prescribed a range, the average was taken.

Number of rain days per year
The amount of rain days per year was determined from the same weather station at Sakarani as has been used for the mean annual rainfall. Data for the number of rain days were available form 1992-2006.

Sediment phase

$$F = K \times KE \times 10^{-3} \qquad \text{eq.11}$$

F = annual rate of soil particle detachment by raindrop impact (kg/m^2)
K = soil detachability index (g/J) defined as the weight of soil detached from the soil mass per unit of rainfall energy

Soil detachability index (g/J)
The soil detachability index was based on the soil texture (Morgan, 2005), which was determined for each field. The soil texture for the six fields with Gerlach troughs was determined by taking the field average of data collected by Wickama (2010) (Appendix E). Typical values for soil detachability can be found in appendix D.

$Z = 1/(0.5 \times COH)$ eq.12

$H = Z \times Q^{1.5} \times \sin S(1 - GC) \times 10^{-3}$ eq.13

COH = Cohesion of the surface soil (kPa) as measured with a torvane under saturated conditions
H = annual rate of soil particle detachment by runoff (kg/m^2)
S = slope steepness (º)
GC = percentage ground cover, expressed as a proportion between 0 and 1

Cohesion

This parameters has been described in §3.6

Slope steepness (º)

Slope steepness was measured with an inclinometer at the top of the fields looking downwards.

$J=F+H$ eq.14

J = annual rate of total soil particle detachment (kg/m^2)

$G = CQ^2 \sin S \times 10^{-3}$ eq.15

C= crop cover management factor; combines the C and P factors of the Universal Soil Loss Equation
G= annual transport capacity of overland flow (kg/m^2)

Crop cover management factor

This factor is equal to the product of the C and P factor of the Universal Soil Loss Equation (USLE) (Wischmeier & Smith, 1978). C values are shown in appendix D. The crop management factor is determined by the ratio of soil loss under a given crop to bare soil. Here, the same procedure as described for the A-parameter was used again since these crops, for which no value is available, were all quite similar to the other plants in size and leaves and probably their root system as well. Also not many of these crops were present.

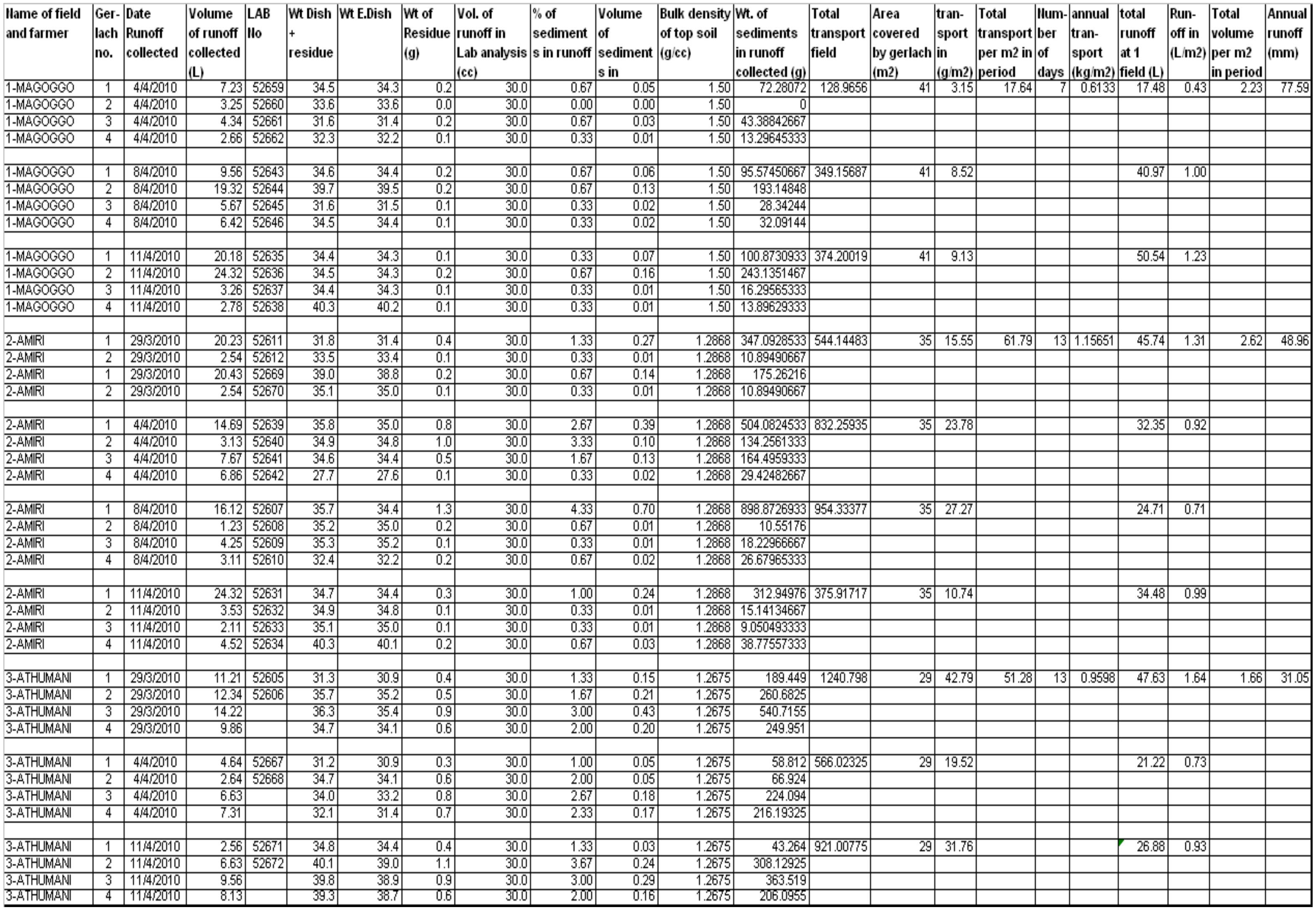
$E = \min[J,G]$

E= erosion rate in kg/m^2

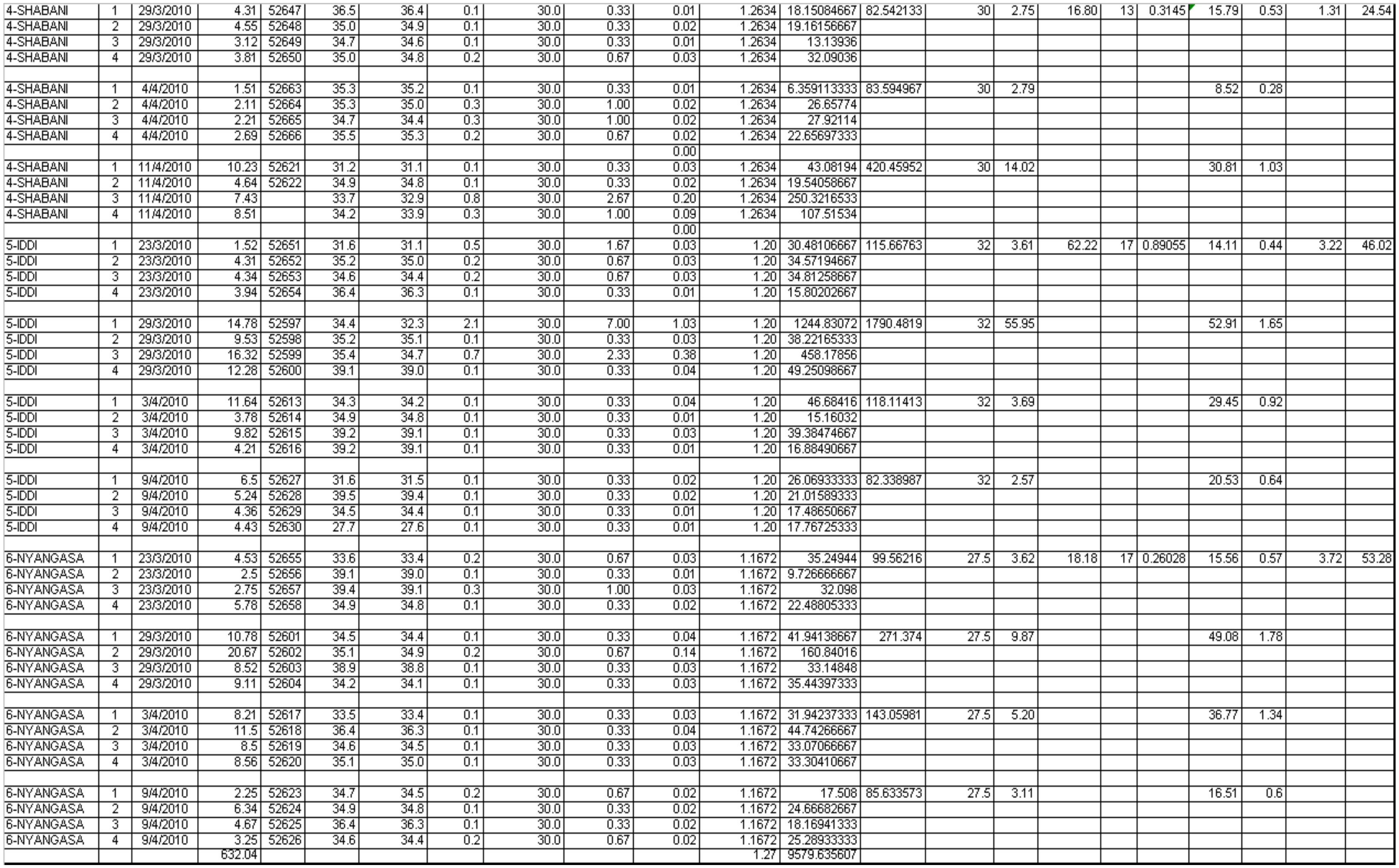
Runoff and erosion rates

To be able to calibrate the MMF erosion model, measurements to runoff and erosion had to be performed on the six fields where Gerlach troughs have been placed. These were used to collect data for runoff and sediment transport by Wickama (2010) during the long rains (March-April 2010) and short rains (November 2010-Februari 2011). Runoff and erosion data can be found in Table 5 and Table 6 and are representative for one year.

Table 5: Runoff and erosion rates long rains for the 6 fields with Gerlach troughs (Wickama, 2010)

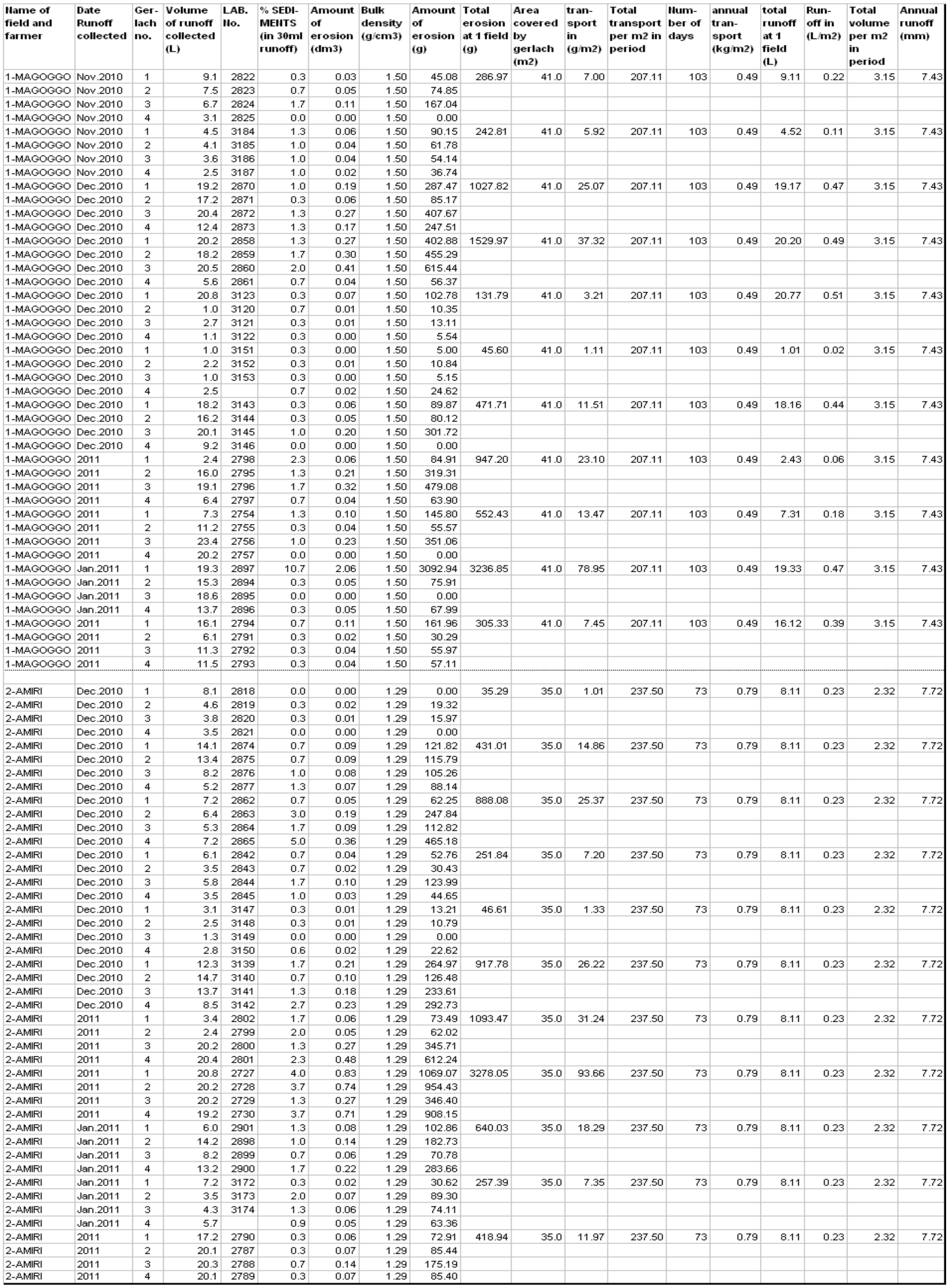


Name of field and farmer	Ger-lach no.	Date Runoff collected	Volume of runoff collected (L)	LAB No	Wt Dish + residue	Wt E.Dish	Wt of Residue (g)	Vol. of runoff in Lab analysis (cc)	% of sediments in runoff	Volume of sediments in	Bulk density of top soil (g/cc)	Wt. of sediments in runoff collected (g)	Total transport field	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
1-MAGOGGO	1	4/4/2010	7.23	52659	34.5	34.3	0.2	30.0	0.67	0.05	1.50	72.28072	128.9656	41	3.15	17.64	7	0.6133	17.48	0.43	2.23	77.59
1-MAGOGGO	2	4/4/2010	3.25	52660	33.6	33.6	0.0	30.0	0.00	0.00	1.50	0										
1-MAGOGGO	3	4/4/2010	4.34	52661	31.6	31.4	0.2	30.0	0.67	0.03	1.50	43.38842667										
1-MAGOGGO	4	4/4/2010	2.66	52662	32.3	32.2	0.1	30.0	0.33	0.01	1.50	13.29645333										
1-MAGOGGO	1	8/4/2010	9.56	52643	34.6	34.4	0.2	30.0	0.67	0.06	1.50	95.57450667	349.15687	41	8.52				40.97	1.00		
1-MAGOGGO	2	8/4/2010	19.32	52644	39.7	39.5	0.2	30.0	0.67	0.13	1.50	193.14848										
1-MAGOGGO	3	8/4/2010	5.67	52645	31.6	31.5	0.1	30.0	0.33	0.02	1.50	28.34244										
1-MAGOGGO	4	8/4/2010	6.42	52646	34.5	34.4	0.1	30.0	0.33	0.02	1.50	32.09144										
1-MAGOGGO	1	11/4/2010	20.18	52635	34.4	34.3	0.1	30.0	0.33	0.07	1.50	100.8730933	374.20019	41	9.13				50.54	1.23		
1-MAGOGGO	2	11/4/2010	24.32	52636	34.5	34.3	0.2	30.0	0.67	0.16	1.50	243.1351467										
1-MAGOGGO	3	11/4/2010	3.26	52637	34.4	34.3	0.1	30.0	0.33	0.01	1.50	16.29565333										
1-MAGOGGO	4	11/4/2010	2.78	52638	40.3	40.2	0.1	30.0	0.33	0.01	1.50	13.89629333										
2-AMIRI	1	29/3/2010	20.23	52611	31.8	31.4	0.4	30.0	1.33	0.27	1.2868	347.0928533	544.14483	35	15.55	61.79	13	1.15651	45.74	1.31	2.62	48.96
2-AMIRI	2	29/3/2010	2.54	52612	33.5	33.4	0.1	30.0	0.33	0.01	1.2868	10.89490667										
2-AMIRI	1	29/3/2010	20.43	52669	39.0	38.8	0.2	30.0	0.67	0.14	1.2868	175.26216										
2-AMIRI	2	29/3/2010	2.54	52670	35.1	35.0	0.1	30.0	0.33	0.01	1.2868	10.89490667										
2-AMIRI	1	4/4/2010	14.69	52639	35.8	35.0	0.8	30.0	2.67	0.39	1.2868	504.0824533	832.25935	35	23.78				32.35	0.92		
2-AMIRI	2	4/4/2010	3.13	52640	34.9	34.8	1.0	30.0	3.33	0.10	1.2868	134.2561333										
2-AMIRI	3	4/4/2010	7.67	52641	34.6	34.4	0.5	30.0	1.67	0.13	1.2868	164.4959333										
2-AMIRI	4	4/4/2010	6.86	52642	27.7	27.6	0.1	30.0	0.33	0.02	1.2868	29.42482667										
2-AMIRI	1	8/4/2010	16.12	52607	35.7	34.4	1.3	30.0	4.33	0.70	1.2868	898.8726933	954.33377	35	27.27				24.71	0.71		
2-AMIRI	2	8/4/2010	1.23	52608	35.2	35.0	0.2	30.0	0.67	0.01	1.2868	10.55176										
2-AMIRI	3	8/4/2010	4.25	52609	35.3	35.2	0.1	30.0	0.33	0.01	1.2868	18.22966667										
2-AMIRI	4	8/4/2010	3.11	52610	32.4	32.2	0.2	30.0	0.67	0.02	1.2868	26.67965333										
2-AMIRI	1	11/4/2010	24.32	52631	34.7	34.4	0.3	30.0	1.00	0.24	1.2868	312.94976	375.91717	35	10.74				34.48	0.99		
2-AMIRI	2	11/4/2010	3.53	52632	34.9	34.8	0.1	30.0	0.33	0.01	1.2868	15.14134667										
2-AMIRI	3	11/4/2010	2.11	52633	35.1	35.0	0.1	30.0	0.33	0.01	1.2868	9.050493333										
2-AMIRI	4	11/4/2010	4.52	52634	40.3	40.1	0.2	30.0	0.67	0.03	1.2868	38.77557333										
3-ATHUMANI	1	29/3/2010	11.21	52605	31.3	30.9	0.4	30.0	1.33	0.15	1.2675	189.449	1240.798	29	42.79	51.28	13	0.9598	47.63	1.64	1.66	31.05
3-ATHUMANI	2	29/3/2010	12.34	52606	35.7	35.2	0.5	30.0	1.67	0.21	1.2675	260.6825										
3-ATHUMANI	3	29/3/2010	14.22		36.3	35.4	0.9	30.0	3.00	0.43	1.2675	540.7155										
3-ATHUMANI	4	29/3/2010	9.86		34.7	34.1	0.6	30.0	2.00	0.20	1.2675	249.951										
3-ATHUMANI	1	4/4/2010	4.64	52667	31.2	30.9	0.3	30.0	1.00	0.05	1.2675	58.812	566.02325	29	19.52				21.22	0.73		
3-ATHUMANI	2	4/4/2010	2.64	52668	34.7	34.1	0.6	30.0	2.00	0.05	1.2675	66.924										
3-ATHUMANI	3	4/4/2010	6.63		34.0	33.2	0.8	30.0	2.67	0.18	1.2675	224.094										
3-ATHUMANI	4	4/4/2010	7.31		32.1	31.4	0.7	30.0	2.33	0.17	1.2675	216.19325										
3-ATHUMANI	1	11/4/2010	2.56	52671	34.8	34.4	0.4	30.0	1.33	0.03	1.2675	43.264	921.00775	29	31.76				26.88	0.93		
3-ATHUMANI	2	11/4/2010	6.63	52672	40.1	39.0	1.1	30.0	3.67	0.24	1.2675	308.12925										
3-ATHUMANI	3	11/4/2010	9.56		39.8	38.9	0.9	30.0	3.00	0.29	1.2675	363.519										
3-ATHUMANI	4	11/4/2010	8.13		39.3	38.7	0.6	30.0	2.00	0.16	1.2675	206.0955										



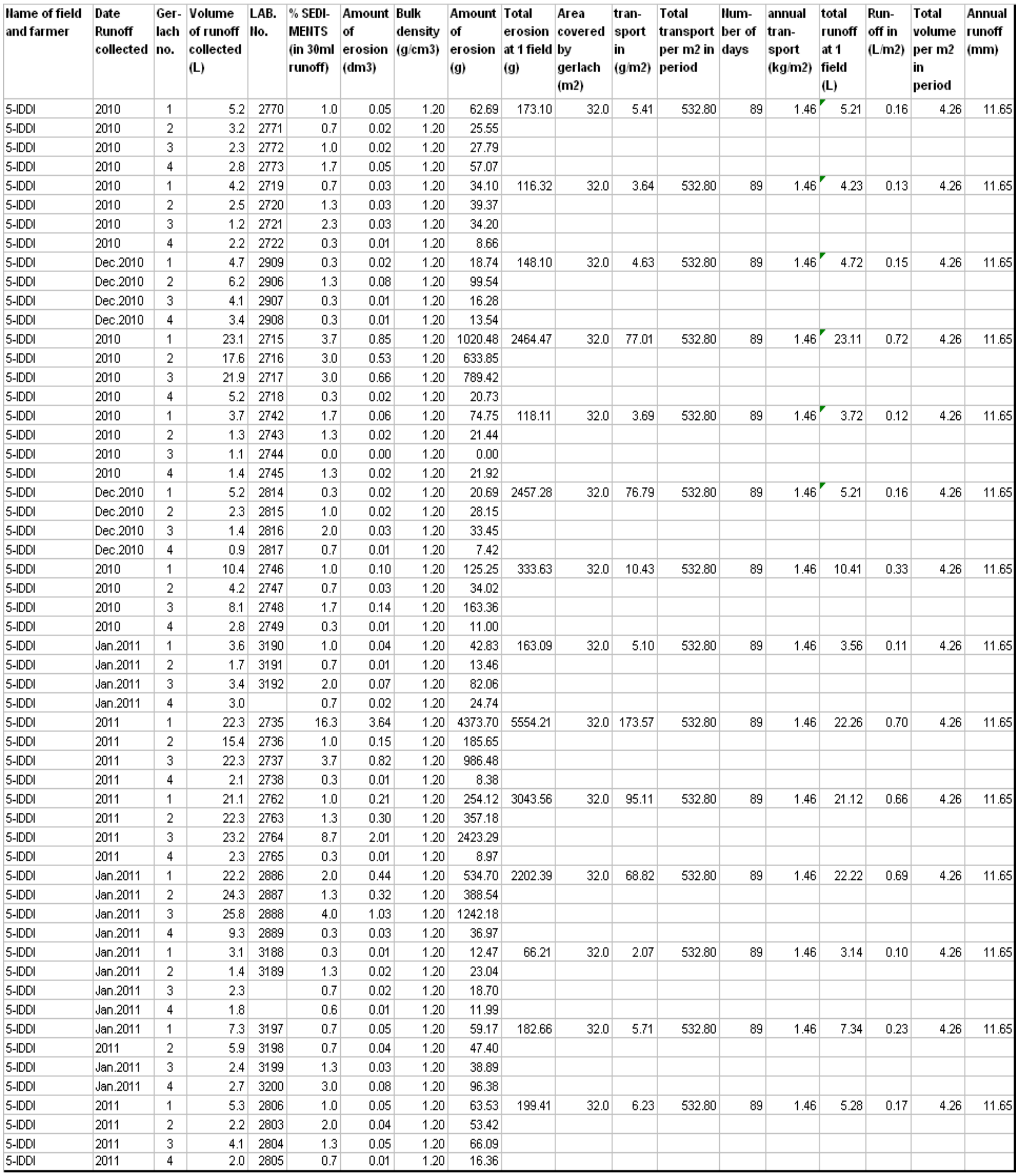
4-SHABANI	1	29/3/2010	4.31	52647	36.5	36.4	0.1	30.0	0.33	0.01	1.2634	18.15084667	82.542133	30	2.75	16.80	13	0.3145	15.79	0.53	1.31	24.54
4-SHABANI	2	29/3/2010	4.55	52648	35.0	34.9	0.1	30.0	0.33	0.02	1.2634	19.16156667										
4-SHABANI	3	29/3/2010	3.12	52649	34.7	34.6	0.1	30.0	0.33	0.01	1.2634	13.13936										
4-SHABANI	4	29/3/2010	3.81	52650	35.0	34.8	0.2	30.0	0.67	0.03	1.2634	32.09036										
4-SHABANI	1	4/4/2010	1.51	52663	35.3	35.2	0.1	30.0	0.33	0.01	1.2634	6.359113333	83.594967	30	2.79				8.52	0.28		
4-SHABANI	2	4/4/2010	2.11	52664	35.3	35.0	0.3	30.0	1.00	0.02	1.2634	26.65774										
4-SHABANI	3	4/4/2010	2.21	52665	34.7	34.4	0.3	30.0	1.00	0.02	1.2634	27.92114										
4-SHABANI	4	4/4/2010	2.69	52666	35.5	35.3	0.2	30.0	0.67	0.02	1.2634	22.65697333										
										0.00												
4-SHABANI	1	11/4/2010	10.23	52621	31.2	31.1	0.1	30.0	0.33	0.03	1.2634	43.08194	420.45952	30	14.02				30.81	1.03		
4-SHABANI	2	11/4/2010	4.64	52622	34.9	34.8	0.1	30.0	0.33	0.02	1.2634	19.54058667										
4-SHABANI	3	11/4/2010	7.43		33.7	32.9	0.8	30.0	2.67	0.20	1.2634	250.3216533										
4-SHABANI	4	11/4/2010	8.51		34.2	33.9	0.3	30.0	1.00	0.09	1.2634	107.51534										
										0.00												
5-IDDI	1	23/3/2010	1.52	52651	31.6	31.1	0.5	30.0	1.67	0.03	1.20	30.48106667	115.66763	32	3.61	62.22	17	0.89055	14.11	0.44	3.22	46.02
5-IDDI	2	23/3/2010	4.31	52652	35.2	35.0	0.2	30.0	0.67	0.03	1.20	34.57194667										
5-IDDI	3	23/3/2010	4.34	52653	34.6	34.4	0.2	30.0	0.67	0.03	1.20	34.81258667										
5-IDDI	4	23/3/2010	3.94	52654	36.4	36.3	0.1	30.0	0.33	0.01	1.20	15.80202667										
5-IDDI	1	29/3/2010	14.78	52597	34.4	32.3	2.1	30.0	7.00	1.03	1.20	1244.83072	1790.4819	32	55.95				52.91	1.65		
5-IDDI	2	29/3/2010	9.53	52598	35.2	35.1	0.1	30.0	0.33	0.03	1.20	38.22165333										
5-IDDI	3	29/3/2010	16.32	52599	35.4	34.7	0.7	30.0	2.33	0.38	1.20	458.17856										
5-IDDI	4	29/3/2010	12.28	52600	39.1	39.0	0.1	30.0	0.33	0.04	1.20	49.25098667										
5-IDDI	1	3/4/2010	11.64	52613	34.3	34.2	0.1	30.0	0.33	0.04	1.20	46.68416	118.11413	32	3.69				29.45	0.92		
5-IDDI	2	3/4/2010	3.78	52614	34.9	34.8	0.1	30.0	0.33	0.01	1.20	15.16032										
5-IDDI	3	3/4/2010	9.82	52615	39.2	39.1	0.1	30.0	0.33	0.03	1.20	39.38474667										
5-IDDI	4	3/4/2010	4.21	52616	39.2	39.1	0.1	30.0	0.33	0.01	1.20	16.88490667										
5-IDDI	1	9/4/2010	6.5	52627	31.6	31.5	0.1	30.0	0.33	0.02	1.20	26.06933333	82.338987	32	2.57				20.53	0.64		
5-IDDI	2	9/4/2010	5.24	52628	39.5	39.4	0.1	30.0	0.33	0.02	1.20	21.01589333										
5-IDDI	3	9/4/2010	4.36	52629	34.5	34.4	0.1	30.0	0.33	0.01	1.20	17.48650667										
5-IDDI	4	9/4/2010	4.43	52630	27.7	27.6	0.1	30.0	0.33	0.01	1.20	17.76725333										
6-NYANGASA	1	23/3/2010	4.53	52655	33.6	33.4	0.2	30.0	0.67	0.03	1.1672	35.24944	99.56216	27.5	3.62	18.18	17	0.26028	15.56	0.57	3.72	53.28
6-NYANGASA	2	23/3/2010	2.5	52656	39.1	39.0	0.1	30.0	0.33	0.01	1.1672	9.726666667										
6-NYANGASA	3	23/3/2010	2.75	52657	39.4	39.1	0.3	30.0	1.00	0.03	1.1672	32.098										
6-NYANGASA	4	23/3/2010	5.78	52658	34.9	34.8	0.1	30.0	0.33	0.02	1.1672	22.48805333										
6-NYANGASA	1	29/3/2010	10.78	52601	34.5	34.4	0.1	30.0	0.33	0.04	1.1672	41.94138667	271.374	27.5	9.87				49.08	1.78		
6-NYANGASA	2	29/3/2010	20.67	52602	35.1	34.9	0.2	30.0	0.67	0.14	1.1672	160.84016										
6-NYANGASA	3	29/3/2010	8.52	52603	38.9	38.8	0.1	30.0	0.33	0.03	1.1672	33.14848										
6-NYANGASA	4	29/3/2010	9.11	52604	34.2	34.1	0.1	30.0	0.33	0.03	1.1672	35.44397333										
6-NYANGASA	1	3/4/2010	8.21	52617	33.5	33.4	0.1	30.0	0.33	0.03	1.1672	31.94237333	143.05981	27.5	5.20				36.77	1.34		
6-NYANGASA	2	3/4/2010	11.5	52618	36.4	36.3	0.1	30.0	0.33	0.04	1.1672	44.74266667										
6-NYANGASA	3	3/4/2010	8.5	52619	34.6	34.5	0.1	30.0	0.33	0.03	1.1672	33.07066667										
6-NYANGASA	4	3/4/2010	8.56	52620	35.1	35.0	0.1	30.0	0.33	0.03	1.1672	33.30410667										
6-NYANGASA	1	9/4/2010	2.25	52623	34.7	34.5	0.2	30.0	0.67	0.02	1.1672	17.508	85.633573	27.5	3.11				16.51	0.6		
6-NYANGASA	2	9/4/2010	6.34	52624	34.9	34.8	0.1	30.0	0.33	0.02	1.1672	24.66682667										
6-NYANGASA	3	9/4/2010	4.67	52625	36.4	36.3	0.1	30.0	0.33	0.02	1.1672	18.16941333										
6-NYANGASA	4	9/4/2010	3.25	52626	34.6	34.4	0.2	30.0	0.67	0.02	1.1672	25.28933333										
			632.04								1.27	9579.635607										

Table 6: Runoff and erosion rates short rains for the 6 fields with Gerlach troughs (Wickama, 2010

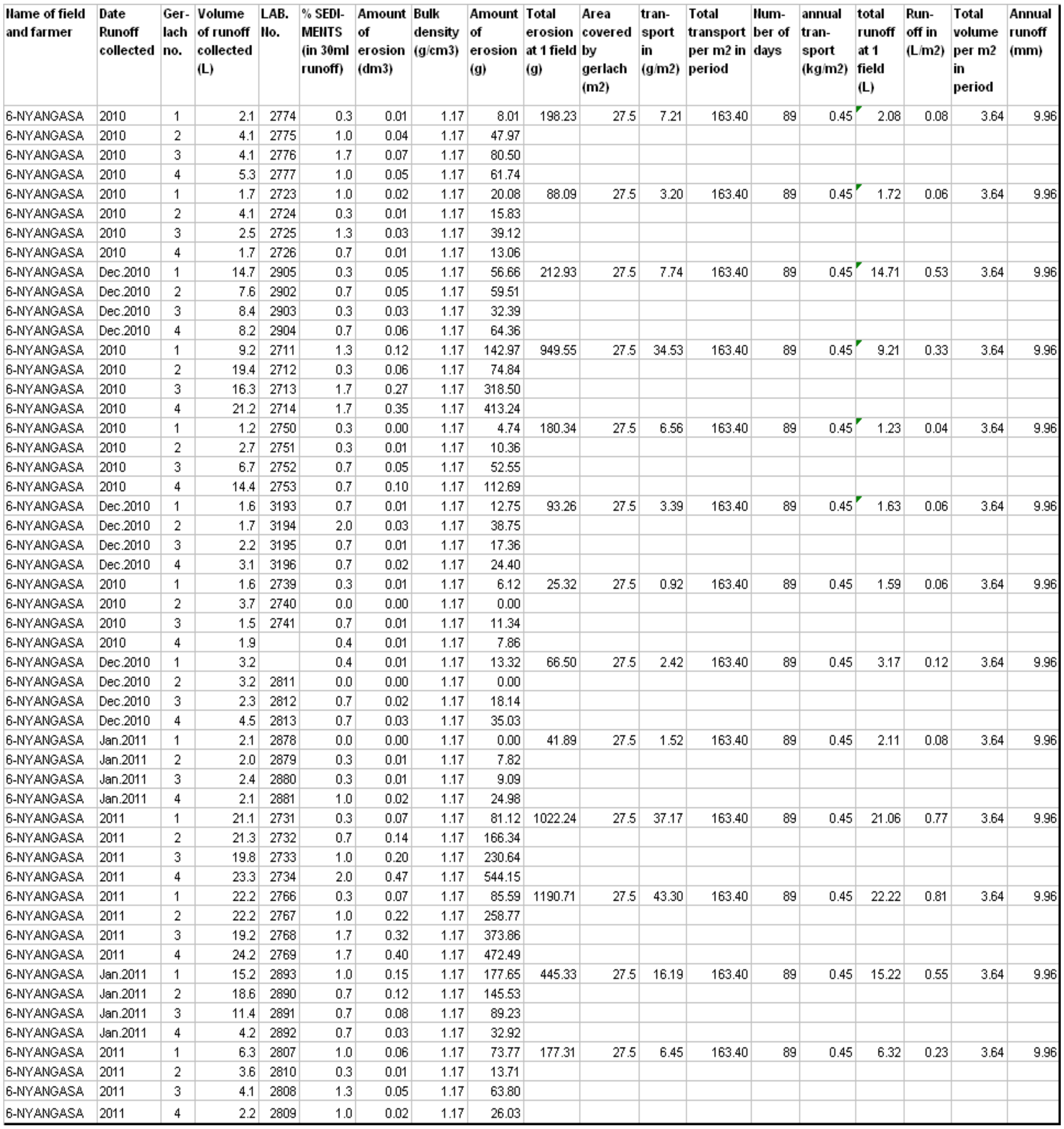


Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
1-MAGOGGO	Nov.2010	1	9.1	2822	0.3	0.03	1.50	45.08	286.97	41.0	7.00	207.11	103	0.49	9.11	0.22	3.15	7.43
1-MAGOGGO	Nov.2010	2	7.5	2823	0.7	0.05	1.50	74.85										
1-MAGOGGO	Nov.2010	3	6.7	2824	1.7	0.11	1.50	167.04										
1-MAGOGGO	Nov.2010	4	3.1	2825	0.0	0.00	1.50	0.00										
1-MAGOGGO	Nov.2010	1	4.5	3184	1.3	0.06	1.50	90.15	242.81	41.0	5.92	207.11	103	0.49	4.52	0.11	3.15	7.43
1-MAGOGGO	Nov.2010	2	4.1	3185	1.0	0.04	1.50	61.78										
1-MAGOGGO	Nov.2010	3	3.6	3186	1.0	0.04	1.50	54.14										
1-MAGOGGO	Nov.2010	4	2.5	3187	1.0	0.02	1.50	36.74										
1-MAGOGGO	Dec.2010	1	19.2	2870	1.0	0.19	1.50	287.47	1027.82	41.0	25.07	207.11	103	0.49	19.17	0.47	3.15	7.43
1-MAGOGGO	Dec.2010	2	17.2	2871	0.3	0.06	1.50	85.17										
1-MAGOGGO	Dec.2010	3	20.4	2872	1.3	0.27	1.50	407.67										
1-MAGOGGO	Dec.2010	4	12.4	2873	1.3	0.17	1.50	247.51										
1-MAGOGGO	Dec.2010	1	20.2	2858	1.3	0.27	1.50	402.88	1529.97	41.0	37.32	207.11	103	0.49	20.20	0.49	3.15	7.43
1-MAGOGGO	Dec.2010	2	18.2	2859	1.7	0.30	1.50	455.29										
1-MAGOGGO	Dec.2010	3	20.5	2860	2.0	0.41	1.50	615.44										
1-MAGOGGO	Dec.2010	4	5.6	2861	0.7	0.04	1.50	56.37										
1-MAGOGGO	Dec.2010	1	20.8	3123	0.3	0.07	1.50	102.78	131.79	41.0	3.21	207.11	103	0.49	20.77	0.51	3.15	7.43
1-MAGOGGO	Dec.2010	2	1.0	3120	0.7	0.01	1.50	10.35										
1-MAGOGGO	Dec.2010	3	2.7	3121	0.3	0.01	1.50	13.11										
1-MAGOGGO	Dec.2010	4	1.1	3122	0.3	0.00	1.50	5.54										
1-MAGOGGO	Dec.2010	1	1.0	3151	0.3	0.00	1.50	5.00	45.60	41.0	1.11	207.11	103	0.49	1.01	0.02	3.15	7.43
1-MAGOGGO	Dec.2010	2	2.2	3152	0.3	0.01	1.50	10.84										
1-MAGOGGO	Dec.2010	3	1.0	3153	0.3	0.00	1.50	5.15										
1-MAGOGGO	Dec.2010	4	2.5		0.7	0.02	1.50	24.62										
1-MAGOGGO	Dec.2010	1	18.2	3143	0.3	0.06	1.50	89.87	471.71	41.0	11.51	207.11	103	0.49	18.16	0.44	3.15	7.43
1-MAGOGGO	Dec.2010	2	16.2	3144	0.3	0.05	1.50	80.12										
1-MAGOGGO	Dec.2010	3	20.1	3145	1.0	0.20	1.50	301.72										
1-MAGOGGO	Dec.2010	4	9.2	3146	0.0	0.00	1.50	0.00										
1-MAGOGGO	2011	1	2.4	2798	2.3	0.06	1.50	84.91	947.20	41.0	23.10	207.11	103	0.49	2.43	0.06	3.15	7.43
1-MAGOGGO	2011	2	16.0	2795	1.3	0.21	1.50	319.31										
1-MAGOGGO	2011	3	19.1	2796	1.7	0.32	1.50	479.08										
1-MAGOGGO	2011	4	6.4	2797	0.7	0.04	1.50	63.90										
1-MAGOGGO	2011	1	7.3	2754	1.3	0.10	1.50	145.80	552.43	41.0	13.47	207.11	103	0.49	7.31	0.18	3.15	7.43
1-MAGOGGO	2011	2	11.2	2755	0.3	0.04	1.50	55.57										
1-MAGOGGO	2011	3	23.4	2756	1.0	0.23	1.50	351.06										
1-MAGOGGO	2011	4	20.2	2757	0.0	0.00	1.50	0.00										
1-MAGOGGO	Jan.2011	1	19.3	2897	10.7	2.06	1.50	3092.94	3236.85	41.0	78.95	207.11	103	0.49	19.33	0.47	3.15	7.43
1-MAGOGGO	Jan.2011	2	15.3	2894	0.3	0.05	1.50	75.91										
1-MAGOGGO	Jan.2011	3	18.6	2895	0.0	0.00	1.50	0.00										
1-MAGOGGO	Jan.2011	4	13.7	2896	0.3	0.05	1.50	67.99										
1-MAGOGGO	2011	1	16.1	2794	0.7	0.11	1.50	161.96	305.33	41.0	7.45	207.11	103	0.49	16.12	0.39	3.15	7.43
1-MAGOGGO	2011	2	6.1	2791	0.3	0.02	1.50	30.29										
1-MAGOGGO	2011	3	11.3	2792	0.3	0.04	1.50	55.97										
1-MAGOGGO	2011	4	11.5	2793	0.3	0.04	1.50	57.11										
2-AMIRI	Dec.2010	1	8.1	2818	0.0	0.00	1.29	0.00	35.29	35.0	1.01	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Dec.2010	2	4.6	2819	0.3	0.02	1.29	19.32										
2-AMIRI	Dec.2010	3	3.8	2820	0.3	0.01	1.29	15.97										
2-AMIRI	Dec.2010	4	3.5	2821	0.0	0.00	1.29	0.00										
2-AMIRI	Dec.2010	1	14.1	2874	0.7	0.09	1.29	121.82	431.01	35.0	14.86	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Dec.2010	2	13.4	2875	0.7	0.09	1.29	115.79										
2-AMIRI	Dec.2010	3	8.2	2876	1.0	0.08	1.29	105.26										
2-AMIRI	Dec.2010	4	5.2	2877	1.3	0.07	1.29	88.14										
2-AMIRI	Dec.2010	1	7.2	2862	0.7	0.05	1.29	62.25	888.08	35.0	25.37	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Dec.2010	2	6.4	2863	3.0	0.19	1.29	247.84										
2-AMIRI	Dec.2010	3	5.3	2864	1.7	0.09	1.29	112.82										
2-AMIRI	Dec.2010	4	7.2	2865	5.0	0.36	1.29	465.18										
2-AMIRI	Dec.2010	1	6.1	2842	0.7	0.04	1.29	52.76	251.84	35.0	7.20	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Dec.2010	2	3.5	2843	0.7	0.02	1.29	30.43										
2-AMIRI	Dec.2010	3	5.8	2844	1.7	0.10	1.29	123.99										
2-AMIRI	Dec.2010	4	3.5	2845	1.0	0.03	1.29	44.65										
2-AMIRI	Dec.2010	1	3.1	3147	0.3	0.01	1.29	13.21	46.61	35.0	1.33	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Dec.2010	2	2.5	3148	0.3	0.01	1.29	10.79										
2-AMIRI	Dec.2010	3	1.3	3149	0.0	0.00	1.29	0.00										
2-AMIRI	Dec.2010	4	2.8	3150	0.6	0.02	1.29	22.62										
2-AMIRI	Dec.2010	1	12.3	3139	1.7	0.21	1.29	264.97	917.78	35.0	26.22	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Dec.2010	2	14.7	3140	0.7	0.10	1.29	126.48										
2-AMIRI	Dec.2010	3	13.7	3141	1.3	0.18	1.29	233.61										
2-AMIRI	Dec.2010	4	8.5	3142	2.7	0.23	1.29	292.73										
2-AMIRI	2011	1	3.4	2802	1.7	0.06	1.29	73.49	1093.47	35.0	31.24	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	2011	2	2.4	2799	2.0	0.05	1.29	62.02										
2-AMIRI	2011	3	20.2	2800	1.3	0.27	1.29	345.71										
2-AMIRI	2011	4	20.4	2801	2.3	0.48	1.29	612.24										
2-AMIRI	2011	1	20.8	2727	4.0	0.83	1.29	1069.07	3278.05	35.0	93.66	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	2011	2	20.2	2728	3.7	0.74	1.29	954.43										
2-AMIRI	2011	3	20.2	2729	1.3	0.27	1.29	346.40										
2-AMIRI	2011	4	19.2	2730	3.7	0.71	1.29	908.15										
2-AMIRI	Jan.2011	1	6.0	2901	1.3	0.08	1.29	102.86	640.03	35.0	18.29	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Jan.2011	2	14.2	2898	1.0	0.14	1.29	182.73										
2-AMIRI	Jan.2011	3	8.2	2899	0.7	0.06	1.29	70.78										
2-AMIRI	Jan.2011	4	13.2	2900	1.7	0.22	1.29	283.66										
2-AMIRI	Jan.2011	1	7.2	3172	0.3	0.02	1.29	30.62	257.39	35.0	7.35	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	Jan.2011	2	3.5	3173	2.0	0.07	1.29	89.30										
2-AMIRI	Jan.2011	3	4.3	3174	1.3	0.06	1.29	74.11										
2-AMIRI	Jan.2011	4	5.7		0.9	0.05	1.29	63.36										
2-AMIRI	2011	1	17.2	2790	0.3	0.06	1.29	72.91	418.94	35.0	11.97	237.50	73	0.79	8.11	0.23	2.32	7.72
2-AMIRI	2011	2	20.1	2787	0.3	0.07	1.29	85.44										
2-AMIRI	2011	3	20.3	2788	0.7	0.14	1.29	175.19										
2-AMIRI	2011	4	20.1	2789	0.3	0.07	1.29	85.40										

Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
3-ATHUMANI	Dec.2010	1	3.4	3158	0.3	ATHUMA	Dec.2010	1578.83	1894.1	2209	2524.6	19123.99	73	63.75	3.44	0.00	0.03	0.10
3-ATHUMANI	Dec.2010	2	1.2	3159	0.3	ATHUMA	Dec.2010	1578.83	1894.1	2209	2524.7							
3-ATHUMANI	Dec.2010	3	3.8	3160	2.3	ATHUMA	Dec.2010	1580.83	1896.2	2212	2527.1							
3-ATHUMANI	Dec.2010	4	2.8		0.7	ATHUMA	Dec.2010	-0.45571	-1.6		-3.8							
3-ATHUMANI	Dec.2010	1	11.4	2838	1.0	ATHUMA	Dec.2010	1419.5	1702.2	1985	2267.5	273.11	73	0.91	11.44	0.01	2.12	7.08
3-ATHUMANI	Dec.2010	2	15.2	2839	1.3	ATHUMA	Dec.2010	1419.83	1702.0	1984	2266.4							
3-ATHUMANI	Dec.2010	3	5.2	2840	3.0	ATHUMA	Dec.2010	1421.5	1705.0	1988	2271.9							
3-ATHUMANI	Dec.2010	4	12.3	2841	4.3	ATHUMA	Dec.2010	1422.83	1705.8	1989	2271.7							
3-ATHUMANI	Dec.2010	1	1.0	2826	2.0	ATHUMA	Dec.2010	1414.5	1697.3	1980	2262.9	273.11	73	0.91	0.95	0.00	2.12	7.08
3-ATHUMANI	Dec.2010	2	3.4	2827	2.0	ATHUMA	Dec.2010	1414.5	1696.9	1979	2261.6							
3-ATHUMANI	Dec.2010	3	4.7	2828	1.3	ATHUMA	Dec.2010	1413.83	1695.7	1977	2259.3							
3-ATHUMANI	Dec.2010	4	2.6	2829	1.0	ATHUMA	Dec.2010	1413.5	1695.2	1977	2258.7							
3-ATHUMANI	Dec.2010	1	10.3	3161	3.0	ATHUMA	Dec.2010	1583	1898.7	2214	2530.0	273.11	73	0.91	10.31	0.00	2.12	7.08
3-ATHUMANI	Dec.2010	2	7.3	3162	2.0	ATHUMA	Dec.2010	1582	1897.5	2213	2528.4							
3-ATHUMANI	Dec.2010	3	9.2	3163	1.3	ATHUMA	Dec.2010	1581.33	1896.2	2211	2526.0							
3-ATHUMANI	Dec.2010	4	10.2	3164	3.3	ATHUMA	Dec.2010	1583.33	1898.5	2214	2528.9							
3-ATHUMANI	2011	1	17.3	2782	2.0	ATHUMA	2011	1392.5	1669.3	1946	2222.8	273.11	73	0.91	17.33	0.01	2.12	7.08
3-ATHUMANI	2011	2	3.2	2779	2.0	ATHUMA	2011	1390.5	1668.1	1946	2223.2							
3-ATHUMANI	2011	3	12.1	2780	8.3	ATHUMA	2011	1396.83	1675.2	1954	2232.0							
3-ATHUMANI	2011	4	15.2	2781	6.0	ATHUMA	2011	1394.5	1671.7	1949	2226.0							
3-ATHUMANI	Jan.2011	1	2.1	3128	2.0	ATHUMA	Jan.2011	1565.5	1878.4	2191	2504.2	273.11	73	0.91	2.11	0.00	2.12	7.08
3-ATHUMANI	Jan.2011	2	5.3	3129	2.3	ATHUMA	Jan.2011	1565.83	1878.3	2191	2503.2							
3-ATHUMANI	Jan.2011	3	20.1	3130	3.3	ATHUMA	Jan.2011	1566.83	1877.9	2189	2500.1							
3-ATHUMANI	Jan.2011	4	17.7	3131	1.3	ATHUMA	Jan.2011	1564.83	1875.4	2186	2496.4							
3-ATHUMANI	Jan.2011	1	13.2	2866	1.7	ATHUMA	Jan.2011	1434.17	1719.7	2005	2290.6	273.11	73	0.91	13.19	0.01	2.12	7.08
3-ATHUMANI	Jan.2011	2	10.6	2867	0.7	ATHUMA	Jan.2011	1433.17	1718.4	2004	2288.9							
3-ATHUMANI	Jan.2011	3	8.8	2868	0.7	ATHUMA	Jan.2011	1433.17	1718.4	2004	2288.8							
3-ATHUMANI	Jan.2011	4	6.9	2869	4.0	ATHUMA	Jan.2011	1436.5	1722.7	2009	2295.1							
3-ATHUMANI	Nov.2010	1	2.2	3136	0.3	ATHUMA	Nov.2010	1567.83	1881.0	2194	2507.4	273.11	73	0.91	2.18	0.00	2.12	7.08
3-ATHUMANI	Nov.2010	2	1.2	3137	0.3	ATHUMA	Nov.2010	1567.83	1880.9	2194	2507.1							
3-ATHUMANI	Nov.2010	3	2.8	3138	1.0	ATHUMA	Nov.2010	1568.5	1881.4	2194	2507.3							
3-ATHUMANI	Nov.2010	4	2.2		0.4	ATHUMA	Nov.2010	-0.93286	-2.1		-4.5							
3-ATHUMANI	Jan.2011	1	4.1	3175	0.7	ATHUMA	Jan.2011	1587.67	1904.7	2222	2538.6	273.11	73	0.91	4.11	0.00	2.12	7.08
3-ATHUMANI	Jan.2011	2	2.4	3176	0.3	ATHUMA	Jan.2011	1587.33	1904.2	2221	2537.9							
3-ATHUMANI	Jan.2011	3	3.8		0.3	ATHUMA	Jan.2011	-0.31429	-1.3		-3.4							
3-ATHUMANI	Jan.2011	4	4.0		0.7	ATHUMA	Jan.2011	-0.21286	-1.4		-3.7							
4-SHABANI	Nov.2010	1	2.8	3132	0.7	SHABANI	Nov.2010	1566.17	1879.0	2192	2504.6	2751.86	91	7.36	2.77	0.00	3.31	8.84
4-SHABANI	Nov.2010	2	3.7	3133	0.0	SHABANI	Nov.2010	1565.5	1877.8	2190	2502.5							
4-SHABANI	Nov.2010	3	2.5	3134	0.3	SHABANI	Nov.2010	1565.83	1878.2	2191	2502.9							
4-SHABANI	Nov.2010	4	3.4	3135	1.0	SHABANI	Nov.2010	1566.5	1878.8	2191	2503.3							
4-SHABANI	Dec.2010	1	3.0	3154	0.3	SHABANI	Dec.2010	1576.83	1891.7	2207	2521.5	231.55	91	0.62	3.01	0.00	3.41	9.11
4-SHABANI	Dec.2010	2	2.4	3155	0.3	0.01	1.26	10.17										
4-SHABANI	Dec.2010	3	2.1	3156	0.3	0.01	1.26	8.80										
4-SHABANI	Dec.2010	4	1.1	3157	0.3	0.00	1.26	4.67										
4-SHABANI	Dec.2010	1	3.1	2834	0.7	0.02	1.26	26.33	77.68	30.0	2.59	231.55	91	0.62	3.11	0.10	3.41	9.11
4-SHABANI	Dec.2010	2	3.8	2835	0.3	0.01	1.26	15.72										
4-SHABANI	Dec.2010	3	4.2	2836	0.7	0.03	1.26	35.64										
4-SHABANI	Dec.2010	4	8.8	2837	0.0	0.00	1.26	0.00										
4-SHABANI	Dec.2011	1	10.1	3165	0.4	0.04	1.26	52.37	124.74	30.0	4.16	231.55	91	0.62	10.11	0.34	3.41	9.11
4-SHABANI	Dec.2011	2	7.4	3166	0.3	0.02	1.26	30.98										
4-SHABANI	Dec.2011	3	4.6	3167	0.3	0.02	1.26	19.01										
4-SHABANI	Dec.2011	4	5.2		0.3	0.02	1.26	22.38										
4-SHABANI	Dec.2010	1	3.8	2913	4.3	0.16	1.26	206.79	927.36	30.0	30.91	231.55	91	0.62	3.78	0.13	3.41	9.11
4-SHABANI	Dec.2010	2	3.1	2910	0.3	0.01	1.26	13.01										
4-SHABANI	Dec.2010	3	20.1	2911	2.7	0.54	1.26	678.37										
4-SHABANI	Dec.2010	4	3.5	2912	0.7	0.02	1.26	29.20										
4-SHABANI	Dec.2010	1	4.1	2830	0.3	0.01	1.26	17.14	48.99	30.0	1.63	231.55	91	0.62	4.11	0.14	3.41	9.11
4-SHABANI	Dec.2010	2	1.5	2831	1.7	0.03	1.26	31.86										
4-SHABANI	Dec.2010	3	2.8	2832	0.0	0.00	1.26	0.00										
4-SHABANI	Dec.2010	4	3.7	2833	0.0	0.00	1.26	0.00										
4-SHABANI	Dec.2010	1	20.1	2882	0.3	0.07	1.26	83.88	567.19	30.0	18.91	231.55	91	0.62	20.12	0.67	3.41	9.11
4-SHABANI	Dec.2010	2	5.5	2883	0.0	0.00	1.26	0.00										
4-SHABANI	Dec.2010	3	22.4	2884	0.3	0.07	1.26	93.47										
4-SHABANI	Dec.2010	4	23.2	2885	1.3	0.31	1.26	389.83										
4-SHABANI	2011	1	20.2	2786	0.3	0.07	1.26	84.22	1144.08	30.0	38.14	231.55	91	0.62	20.20	0.67	3.41	9.11
4-SHABANI	2011	2	18.2	2783	1.3	0.24	1.26	305.82										
4-SHABANI	2011	3	19.3	2784	2.7	0.52	1.26	651.04										
4-SHABANI	2011	4	6.1	2785	1.3	0.08	1.26	103.00										
4-SHABANI	Jan.2011	1	14.1	3127	1.7	0.24	1.26	297.91	1213.30	30.0	40.44	231.55	91	0.62	14.12	0.47	3.41	9.11
4-SHABANI	Jan.2011	2	12.6	3124	1.0	0.13	1.26	159.44										
4-SHABANI	Jan.2011	3	14.1	3125	2.3	0.33	1.26	415.95										
4-SHABANI	Jan.2011	4	11.6	3126	2.3	0.27	1.26	340.00										
4-SHABANI	2011	1	7.2	2758	0.7	0.05	1.26	61.03	415.73	30.0	13.86	231.55	91	0.62	7.21	0.24	3.41	9.11
4-SHABANI	2011	2	11.3	2759	0.7	0.08	1.26	95.31										
4-SHABANI	2011	3	20.6	2760	0.7	0.14	1.26	174.54										
4-SHABANI	2011	4	20.4	2761	0.3	0.07	1.26	84.84										
4-SHABANI	Jan.2011	1	8.2	3168	1.0	0.08	1.26	103.60	1816.79	30.0	60.56	231.55	91	0.62	8.20	0.27	3.41	9.11
4-SHABANI	Jan.2011	2	7.2	3169	1.3	0.10	1.26	120.82										
4-SHABANI	Jan.2011	3	2.2	3170	2.3	0.05	1.26	63.29										
4-SHABANI	Jan.2011	4	19.1	3171	6.3	1.21	1.26	1529.09										
4-SHABANI	Jan.2011	1	6.1	3180	0.7	0.04	1.26	51.80	541.10	30.0	18.04	231.55	91	0.62	6.12	0.20	3.41	9.11
4-SHABANI	Jan.2011	2	5.2	3181	1.0	0.05	1.26	65.44										
4-SHABANI	Jan.2011	3	5.1	3182	4.3	0.22	1.26	279.54										
4-SHABANI	Jan.2011	4	3.4	3183	3.3	0.11	1.26	144.30										
4-SHABANI	Jan.2011	1	2.1	3177	0.3	0.01	1.26	8.80	33.19	30.0	1.11	231.55	91	0.62	2.11	0.07	3.41	9.11
4-SHABANI	Jan.2011	2	1.1	3178	0.3	0.00	1.26	4.71										
4-SHABANI	Jan.2011	3	2.1	3179	0.3	0.01	1.26	8.92										
4-SHABANI	Jan.2011	4	2.0		0.4	0.01	1.26	10.76										



Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
5-IDDI	2010	1	5.2	2770	1.0	0.05	1.20	62.69	173.10	32.0	5.41	532.80	89	1.46	5.21	0.16	4.26	11.65
5-IDDI	2010	2	3.2	2771	0.7	0.02	1.20	25.55										
5-IDDI	2010	3	2.3	2772	1.0	0.02	1.20	27.79										
5-IDDI	2010	4	2.8	2773	1.7	0.05	1.20	57.07										
5-IDDI	2010	1	4.2	2719	0.7	0.03	1.20	34.10	116.32	32.0	3.64	532.80	89	1.46	4.23	0.13	4.26	11.65
5-IDDI	2010	2	2.5	2720	1.3	0.03	1.20	39.37										
5-IDDI	2010	3	1.2	2721	2.3	0.03	1.20	34.20										
5-IDDI	2010	4	2.2	2722	0.3	0.01	1.20	8.66										
5-IDDI	Dec.2010	1	4.7	2909	0.3	0.02	1.20	18.74	148.10	32.0	4.63	532.80	89	1.46	4.72	0.15	4.26	11.65
5-IDDI	Dec.2010	2	6.2	2906	1.3	0.08	1.20	99.54										
5-IDDI	Dec.2010	3	4.1	2907	0.3	0.01	1.20	16.28										
5-IDDI	Dec.2010	4	3.4	2908	0.3	0.01	1.20	13.54										
5-IDDI	2010	1	23.1	2715	3.7	0.85	1.20	1020.48	2464.47	32.0	77.01	532.80	89	1.46	23.11	0.72	4.26	11.65
5-IDDI	2010	2	17.6	2716	3.0	0.53	1.20	633.85										
5-IDDI	2010	3	21.9	2717	3.0	0.66	1.20	789.42										
5-IDDI	2010	4	5.2	2718	0.3	0.02	1.20	20.73										
5-IDDI	2010	1	3.7	2742	1.7	0.06	1.20	74.75	118.11	32.0	3.69	532.80	89	1.46	3.72	0.12	4.26	11.65
5-IDDI	2010	2	1.3	2743	1.3	0.02	1.20	21.44										
5-IDDI	2010	3	1.1	2744	0.0	0.00	1.20	0.00										
5-IDDI	2010	4	1.4	2745	1.3	0.02	1.20	21.92										
5-IDDI	Dec.2010	1	5.2	2814	0.3	0.02	1.20	20.69	2457.28	32.0	76.79	532.80	89	1.46	5.21	0.16	4.26	11.65
5-IDDI	Dec.2010	2	2.3	2815	1.0	0.02	1.20	28.15										
5-IDDI	Dec.2010	3	1.4	2816	2.0	0.03	1.20	33.45										
5-IDDI	Dec.2010	4	0.9	2817	0.7	0.01	1.20	7.42										
5-IDDI	2010	1	10.4	2746	1.0	0.10	1.20	125.25	333.63	32.0	10.43	532.80	89	1.46	10.41	0.33	4.26	11.65
5-IDDI	2010	2	4.2	2747	0.7	0.03	1.20	34.02										
5-IDDI	2010	3	8.1	2748	1.7	0.14	1.20	163.36										
5-IDDI	2010	4	2.8	2749	0.3	0.01	1.20	11.00										
5-IDDI	Jan.2011	1	3.6	3190	1.0	0.04	1.20	42.83	163.09	32.0	5.10	532.80	89	1.46	3.56	0.11	4.26	11.65
5-IDDI	Jan.2011	2	1.7	3191	0.7	0.01	1.20	13.46										
5-IDDI	Jan.2011	3	3.4	3192	2.0	0.07	1.20	82.06										
5-IDDI	Jan.2011	4	3.0		0.7	0.02	1.20	24.74										
5-IDDI	2011	1	22.3	2735	16.3	3.64	1.20	4373.70	5554.21	32.0	173.57	532.80	89	1.46	22.26	0.70	4.26	11.65
5-IDDI	2011	2	15.4	2736	1.0	0.15	1.20	185.65										
5-IDDI	2011	3	22.3	2737	3.7	0.82	1.20	986.48										
5-IDDI	2011	4	2.1	2738	0.3	0.01	1.20	8.38										
5-IDDI	2011	1	21.1	2762	1.0	0.21	1.20	254.12	3043.56	32.0	95.11	532.80	89	1.46	21.12	0.66	4.26	11.65
5-IDDI	2011	2	22.3	2763	1.3	0.30	1.20	357.18										
5-IDDI	2011	3	23.2	2764	8.7	2.01	1.20	2423.29										
5-IDDI	2011	4	2.3	2765	0.3	0.01	1.20	8.97										
5-IDDI	Jan.2011	1	22.2	2886	2.0	0.44	1.20	534.70	2202.39	32.0	68.82	532.80	89	1.46	22.22	0.69	4.26	11.65
5-IDDI	Jan.2011	2	24.3	2887	1.3	0.32	1.20	388.54										
5-IDDI	Jan.2011	3	25.8	2888	4.0	1.03	1.20	1242.18										
5-IDDI	Jan.2011	4	9.3	2889	0.3	0.03	1.20	36.97										
5-IDDI	Jan.2011	1	3.1	3188	0.3	0.01	1.20	12.47	66.21	32.0	2.07	532.80	89	1.46	3.14	0.10	4.26	11.65
5-IDDI	Jan.2011	2	1.4	3189	1.3	0.02	1.20	23.04										
5-IDDI	Jan.2011	3	2.3		0.7	0.02	1.20	18.70										
5-IDDI	Jan.2011	4	1.8		0.6	0.01	1.20	11.99										
5-IDDI	Jan.2011	1	7.3	3197	0.7	0.05	1.20	59.17	182.66	32.0	5.71	532.80	89	1.46	7.34	0.23	4.26	11.65
5-IDDI	2011	2	5.9	3198	0.7	0.04	1.20	47.40										
5-IDDI	Jan.2011	3	2.4	3199	1.3	0.03	1.20	38.89										
5-IDDI	Jan.2011	4	2.7	3200	3.0	0.08	1.20	96.38										
5-IDDI	2011	1	5.3	2806	1.0	0.05	1.20	63.53	199.41	32.0	6.23	532.80	89	1.46	5.28	0.17	4.26	11.65
5-IDDI	2011	2	2.2	2803	2.0	0.04	1.20	53.42										
5-IDDI	2011	3	4.1	2804	1.3	0.05	1.20	66.09										
5-IDDI	2011	4	2.0	2805	0.7	0.01	1.20	16.36										



Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
6-NYANGASA	2010	1	2.1	2774	0.3	0.01	1.17	8.01	198.23	27.5	7.21	163.40	89	0.45	2.08	0.08	3.64	9.96
6-NYANGASA	2010	2	4.1	2775	1.0	0.04	1.17	47.97										
6-NYANGASA	2010	3	4.1	2776	1.7	0.07	1.17	80.50										
6-NYANGASA	2010	4	5.3	2777	1.0	0.05	1.17	61.74										
6-NYANGASA	2010	1	1.7	2723	1.0	0.02	1.17	20.08	88.09	27.5	3.20	163.40	89	0.45	1.72	0.06	3.64	9.96
6-NYANGASA	2010	2	4.1	2724	0.3	0.01	1.17	15.83										
6-NYANGASA	2010	3	2.5	2725	1.3	0.03	1.17	39.12										
6-NYANGASA	2010	4	1.7	2726	0.7	0.01	1.17	13.06										
6-NYANGASA	Dec.2010	1	14.7	2905	0.3	0.05	1.17	56.66	212.93	27.5	7.74	163.40	89	0.45	14.71	0.53	3.64	9.96
6-NYANGASA	Dec.2010	2	7.6	2902	0.7	0.05	1.17	59.51										
6-NYANGASA	Dec.2010	3	8.4	2903	0.3	0.03	1.17	32.39										
6-NYANGASA	Dec.2010	4	8.2	2904	0.7	0.06	1.17	64.36										
6-NYANGASA	2010	1	9.2	2711	1.3	0.12	1.17	142.97	949.55	27.5	34.53	163.40	89	0.45	9.21	0.33	3.64	9.96
6-NYANGASA	2010	2	19.4	2712	0.3	0.06	1.17	74.84										
6-NYANGASA	2010	3	16.3	2713	1.7	0.27	1.17	318.50										
6-NYANGASA	2010	4	21.2	2714	1.7	0.35	1.17	413.24										
6-NYANGASA	2010	1	1.2	2750	0.3	0.00	1.17	4.74	180.34	27.5	6.56	163.40	89	0.45	1.23	0.04	3.64	9.96
6-NYANGASA	2010	2	2.7	2751	0.3	0.01	1.17	10.36										
6-NYANGASA	2010	3	6.7	2752	0.7	0.05	1.17	52.55										
6-NYANGASA	2010	4	14.4	2753	0.7	0.10	1.17	112.69										
6-NYANGASA	Dec.2010	1	1.6	3193	0.7	0.01	1.17	12.75	93.26	27.5	3.39	163.40	89	0.45	1.63	0.06	3.64	9.96
6-NYANGASA	Dec.2010	2	1.7	3194	2.0	0.03	1.17	38.75										
6-NYANGASA	Dec.2010	3	2.2	3195	0.7	0.01	1.17	17.36										
6-NYANGASA	Dec.2010	4	3.1	3196	0.7	0.02	1.17	24.40										
6-NYANGASA	2010	1	1.6	2739	0.3	0.01	1.17	6.12	25.32	27.5	0.92	163.40	89	0.45	1.59	0.06	3.64	9.96
6-NYANGASA	2010	2	3.7	2740	0.0	0.00	1.17	0.00										
6-NYANGASA	2010	3	1.5	2741	0.7	0.01	1.17	11.34										
6-NYANGASA	2010	4	1.9		0.4	0.01	1.17	7.86										
6-NYANGASA	Dec.2010	1	3.2		0.4	0.01	1.17	13.32	66.50	27.5	2.42	163.40	89	0.45	3.17	0.12	3.64	9.96
6-NYANGASA	Dec.2010	2	3.2	2811	0.0	0.00	1.17	0.00										
6-NYANGASA	Dec.2010	3	2.3	2812	0.7	0.02	1.17	18.14										
6-NYANGASA	Dec.2010	4	4.5	2813	0.7	0.03	1.17	35.03										
6-NYANGASA	Jan.2011	1	2.1	2878	0.0	0.00	1.17	0.00	41.89	27.5	1.52	163.40	89	0.45	2.11	0.08	3.64	9.96
6-NYANGASA	Jan.2011	2	2.0	2879	0.3	0.01	1.17	7.82										
6-NYANGASA	Jan.2011	3	2.4	2880	0.3	0.01	1.17	9.09										
6-NYANGASA	Jan.2011	4	2.1	2881	1.0	0.02	1.17	24.98										
6-NYANGASA	2011	1	21.1	2731	0.3	0.07	1.17	81.12	1022.24	27.5	37.17	163.40	89	0.45	21.06	0.77	3.64	9.96
6-NYANGASA	2011	2	21.3	2732	0.7	0.14	1.17	166.34										
6-NYANGASA	2011	3	19.8	2733	1.0	0.20	1.17	230.64										
6-NYANGASA	2011	4	23.3	2734	2.0	0.47	1.17	544.15										
6-NYANGASA	2011	1	22.2	2766	0.3	0.07	1.17	85.59	1190.71	27.5	43.30	163.40	89	0.45	22.22	0.81	3.64	9.96
6-NYANGASA	2011	2	22.2	2767	1.0	0.22	1.17	258.77										
6-NYANGASA	2011	3	19.2	2768	1.7	0.32	1.17	373.86										
6-NYANGASA	2011	4	24.2	2769	1.7	0.40	1.17	472.49										
6-NYANGASA	Jan.2011	1	15.2	2893	1.0	0.15	1.17	177.65	445.33	27.5	16.19	163.40	89	0.45	15.22	0.55	3.64	9.96
6-NYANGASA	Jan.2011	2	18.6	2890	0.7	0.12	1.17	145.53										
6-NYANGASA	Jan.2011	3	11.4	2891	0.7	0.08	1.17	89.23										
6-NYANGASA	Jan.2011	4	4.2	2892	0.7	0.03	1.17	32.92										
6-NYANGASA	2011	1	6.3	2807	1.0	0.06	1.17	73.77	177.31	27.5	6.45	163.40	89	0.45	6.32	0.23	3.64	9.96
6-NYANGASA	2011	2	3.6	2810	0.3	0.01	1.17	13.71										
6-NYANGASA	2011	3	4.1	2808	1.3	0.05	1.17	63.80										
6-NYANGASA	2011	4	2.2	2809	1.0	0.02	1.17	26.03										

4. Results and discussion

Results of the research performed on the 8 fields will be described per parameter in the following paragraphs. More details on the data can be found in appendix C. At the end of this chapter the MMF erosion model results will be described. Details of the results of the six fields with Gerlach troughs can be found in appendix E.

4.1. Field and soil profile descriptions

When soil profiles of erodible sites are compared with profiles of non-erodible sites, the profiles of erodible sites are in general slightly redder; the other fields tend to be more yellow, gray or brown. These red soils show the presence of iron oxides and/or aluminium oxides. This means that these soils have been exposed to heavy rainfall, which has percolated down with all reactive minerals, leaving only iron and aluminium oxide as these are the minerals less vulnerable to dissolving and leaching (Marshak, 2005). Since nearly all minerals in the red soils have leached out due to the rain it shows that these are more erodible than the soils with brown, yellow and gray soils. The humus layer was not present or only a few centimeters. In general the humus layers of the non-erodible soils were slightly thicker. Differences in organic matter content could not be visually determined.

No clear differences are present for the erodible and non-erodible fields with respect to the occurrence of roots and macropores. Two fields (field 5 and 6, non-erodible) contain more and larger stones. Figure 5 shows the soil profiles for the erodible sites, Figure 6 for the non-erodible sites. The picture from site 1 was taken after a rain event, which causes the upper dark border just beneath the soil surface. Soil profile descriptions for each site can be found in appendix B.

Figure 5: Erodible fields 1 (upper left), 2 (upper right), 3 (lower left) and 4 (lower right)

Figure 6: Non-erodible fields 5 (upper left), 6 (upper right), 7 (lower left) and 8 (lower right)

4.2. Soil texture

While the larger particles are more resistant to transport because of the greater force required to entrain them, finer particles are more resistant to detachment due to their cohesiveness. The least resistant particles are for that reason the ones which fall between these: silts and fine sands. Hence, soils with a silt content of more than 40 % are highly erodible (Richter & Negendank, 1977). The investigated soils contain less than 40% silt on all eight fields (Table 7, Table 8). Also, from the perspective of determining the susceptibility of soils to erosion by looking for the amount of clay in a soil sample, the results of the soil texture analysis all show a value higher than 30% clay, while soils with clay content between 9 and 30% are the most susceptible to erosion (Evans, 1980), which is due to the lack of combining clay particles with organic matter to form soil aggregates (Morgan, 2005).

Table 7: Soil texture fractions in percentages for the upper 15 cm of the soil. Soil types can be found in the soil texture triangle (Figure 4).

Field/erosion class	Clay %	Silt %	Fine sand %	Coarse sand %	Texture class
1: erodible	40	10	4	46	Sandy clay
2: erodible	42	26	4	28	Clay
3: erodible	48	12	4	36	Clay/Clay loam
4: erodible	40	28	2	30	Clay
5: non-erodible	44	16	4	36	Clay
6: non-erodible	36	14	8	42	Sandy clay
7: non-erodible	44	14	6	36	Clay
8: non-erodible	34	14	4	48	Sandy clay loam

Table 8: Soil texture fractions in percentages for the soil 15-30 cm in depth. Soil types can be found in the soil texture triangle (Figure 4).

Field/erosion class	Clay %	Silt %	Fine sand %	Coarse sand %	Textures class
1: erodible	46	8	4	42	Clay
2: erodible	62	4	4	30	Clay
3: erodible	46	10	4	40	Clay
4: erodible	58	8	2	32	Clay
5: non-erodible	44	6	4	46	Sandy clay
6: non-erodible	36	14	6	44	Sandy clay
7: non-erodible	50	12	4	34	Clay
8: non-erodible	44	16	4	36	Clay

Comparing the erosive and non-erosive fields for the upper layer (0-15 cm) or for the lower layer (15-30 cm) with a t-test does not result in any significant differences. Comparing the soil texture results of the erodible and non-erodible fields for both depth samples taken together, shows only a difference between the erodible and non-erodible soils for the fine sand fraction (p=0.03), where the non-erodible soils contain more fine sands. When the erodible soils are compared for the 0-15 cm and 15-30 cm layer, the soil texture of the upper and lower layer are the same. This also applies for the non-erodible soils.

4.3. Bulk density and porosity

Distinction between the erodible and non-erodible fields with respect to bulk density (and porosity) was non-significant (p=0.10) (Figure 7). This is inconsistent with literature as bulk density decreases storage capacity and thus decreases the volume of overland flow and the amount of transport (Morgan, 2005; Lundgren, 1980).
Both bulk density and porosity (mean erodible fields: 0.50, mean non-erodible fields: 0.52) have average values for their particular soil texture (Morgan et al., 1982; Morgan, 2001; Hendriks, 2010).

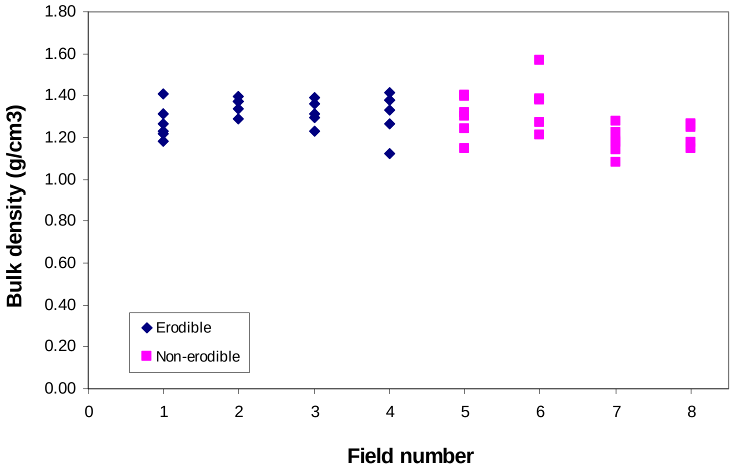


Figure 7: Bulk density of 8 fields based on 5 samples per field. Each dot displays one core sample

4.4. Aggregate stability

The measured values of aggregate stability showed clear differences between the erodible and non-erodible fields. Both the dry-aggregate stability (Figure 8) and wet-aggregate stability (Figure 9) were significantly different between the erodible and non-erodible fields.
For the measuring method used in this research, the water drops of 0.1 g in weight and falling from 1 meter in height used to disrupt the aggregate sufficiently to fall through a 2.8 mm sieve contained an energy impact being roughly equivalent to the energy of 2.18 mm of rain. This method means that when large numbers of water-drop impacts are applied on an aggregate, amounts of rainfall are much higher than those which would occur in nature (Imeson & Vis, 1984). Energy is transmitted to the aggregate by these drops and if the aggregate is not disrupted after 40 to 50 impacts (equivalent to the energy of 87-109 mm of rain), this usually means that the strength of the bonds retaining the elements from which the aggregate is composed, forms a threshold which is not to overcome by the discrete impacts of the individual drops (Imeson & Vis, 1984). This means that these aggregates will not easily be destroyed by a rain event and the soils are less susceptible to erosion.

Many times this threshold was not to overcome for the four non-erodible fields and this caused the variance to be higher (wet-aggregates: 6239 drops, dry-aggregates: 5285 drops) than for the erodible sites (wet-aggregates: 2359 drops, dry-aggregates: 2631 drops). This is due to the large amount of aggregates on the non-erodible fields that needed over 200 drops (counting stopped at 200 drops) to be disrupted while easily disrupted aggregates were also present. On the erodible soils most of the drops present disrupted before the threshold of 40 to 50 impacts. So, the erodible soils mostly contained aggregates for which the impact of the individual drops overcame the strength of the bonds retaining the elements, while the non-erodible soils existed of a variety of aggregates: part of these with a threshold too high to overcome by the water drop impacts (the number of drops will be about 200), others not (number of drop falls between 1-50). This also shows that the erodible soils apart from being compared with the non-erodible soils are also in general not very erodible, as highly erodible soils are considered to be those in which aggregate disruption occurs prior to 20-30 impacts (Imeson & Vis, 1984), while on the erodible fields on average more drops were needed to be disrupted.

Furthermore, the difference between the erodible and non-erodible fields for wet-aggregate stability is even more pronounced than the difference between these fields for the dry-aggregate stability. This difference is relevant for crust formation. Therefore, these results show that the erodible fields might be more subjected to crust formation (Loch, 1994).

Bulk density depends partly on the organic matter content. A high organic matter content results in a low bulk density (Lundgren, 1980). As the non-erodible fields have a significantly higher aggregate stability than the erodible fields, one would also expect to see statistical differences between the erodible and non-erodible fields in the results of the bulk density measurements as an increase in organic matter would result in a better stability of aggregates. As the correlation between bulk density and wet- and dry-aggregate stability equals -0.23 and -0.35, respectively, it shows that a higher aggregate stability indeed results in a lower bulk density and probably a higher organic matter content. Though, the correlation is not strong and thus the stability of the aggregate can not be only determined by the organic matter content.

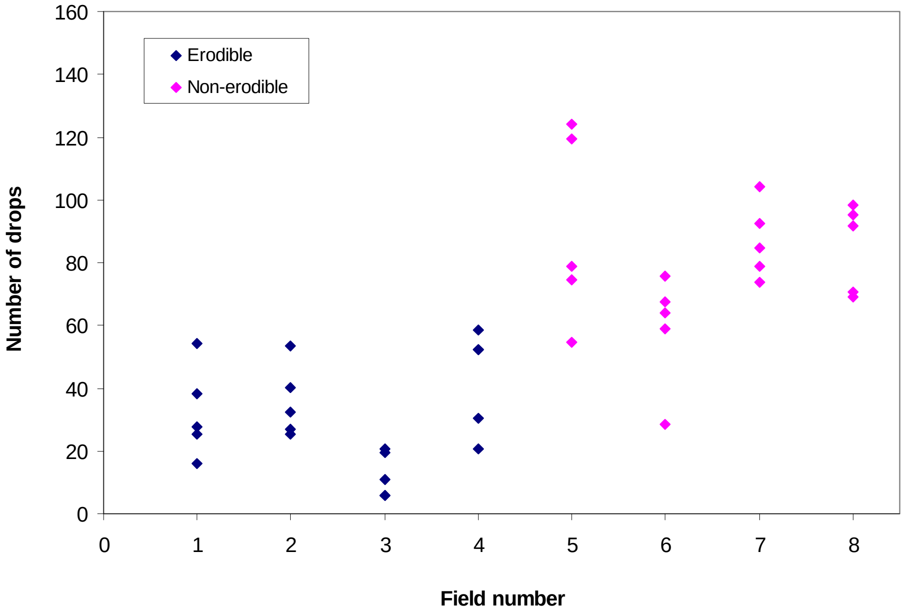


Figure 8: Wet-aggregate stability: number of drops needed to disrupt a 4-4.8mm aggregate sufficiently to fall through a 2.8 mm sieve. Each dot is the average of 20 aggregates taken on one of the five sampling sites of a field.

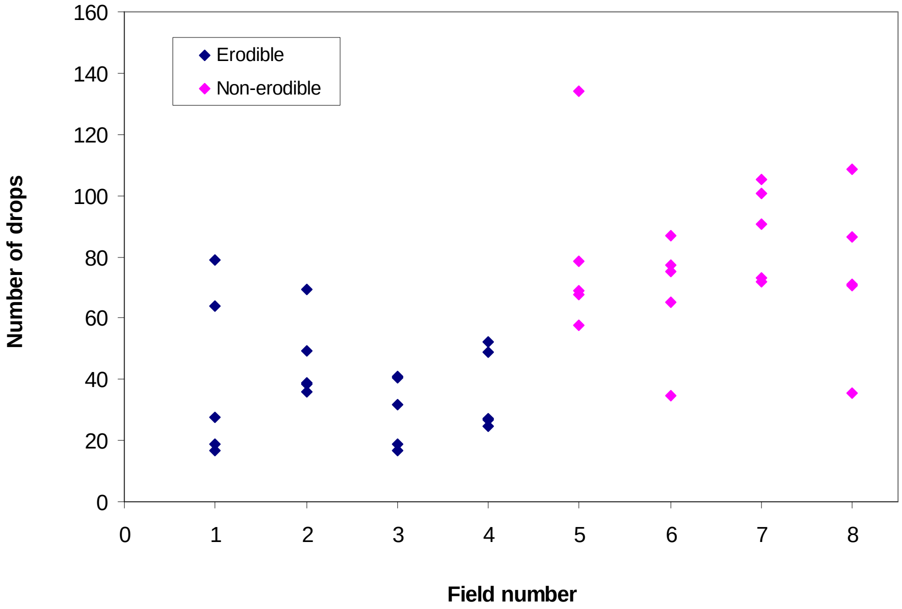


Figure 9: Dry-aggregate stability: number of drops needed to disrupt the 4-4.8 mm aggregate sufficiently to fall through a 2.8 mm sieve. Each dot is the average of 20 aggregates taken on one of the five sampling sites of a field.

4.5. Soil infiltration rate and capacity

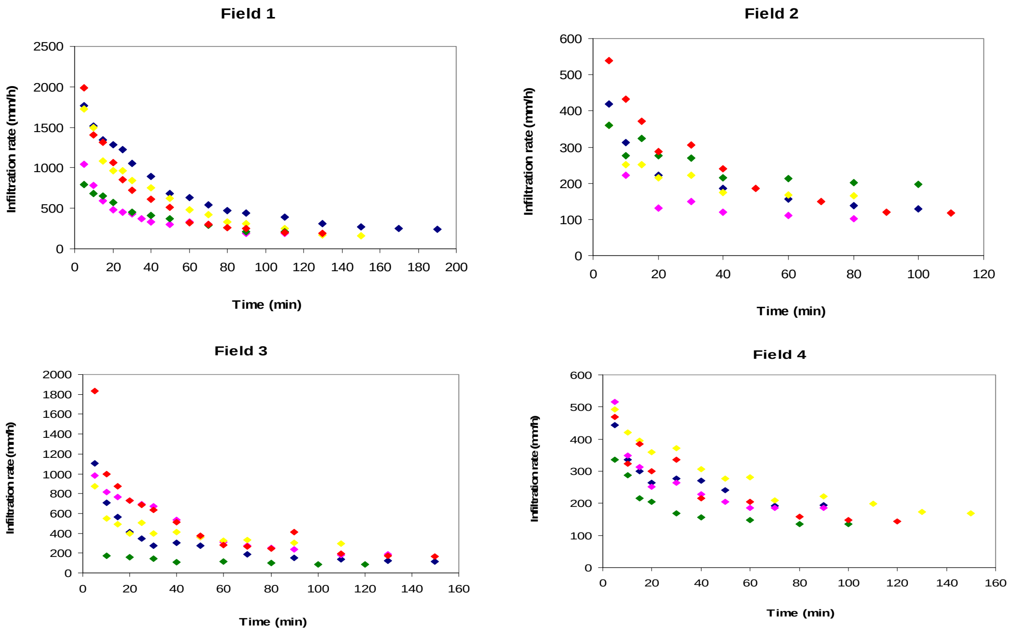
Figure 10 shows soil infiltration curves for the 8 research fields and Table 9 shows the average infiltration rates per field. The α^* used for most fields was 0.12, except field numbers 5 and 6, which were less structured than the other fields and got assigned an α^* of 0.04. Compared to other studies infiltration rates on these fields are low, as for tropical soils values normally range between 100 mm/h to 1000 mm/h (Greenland, 1977).

According to both formulae described in paragraph 3.5 the infiltration capacity has lower values for the non-erodible fields. A statistical analyse resulted for Kfs=Qs in a p-value of 0.05 and for the Kfs-formula (Eq.1) in $3.88*10^{-4}$. The difference here is caused by using several variable parameters in the Kfs-formula, where α^* is the most important. These parameters do have an effect on the p-value of the Kfs-formula with respect to Kfs=Qs, though the erodible and non-erodible fields are according to both formulae statistically different. However, one would expect higher erosion rates on the non-erodible fields instead of lower when infiltration capacities are low. As with low infiltration rates, runoff will sooner take place during a rain event and due to this, erosion rates will increase.

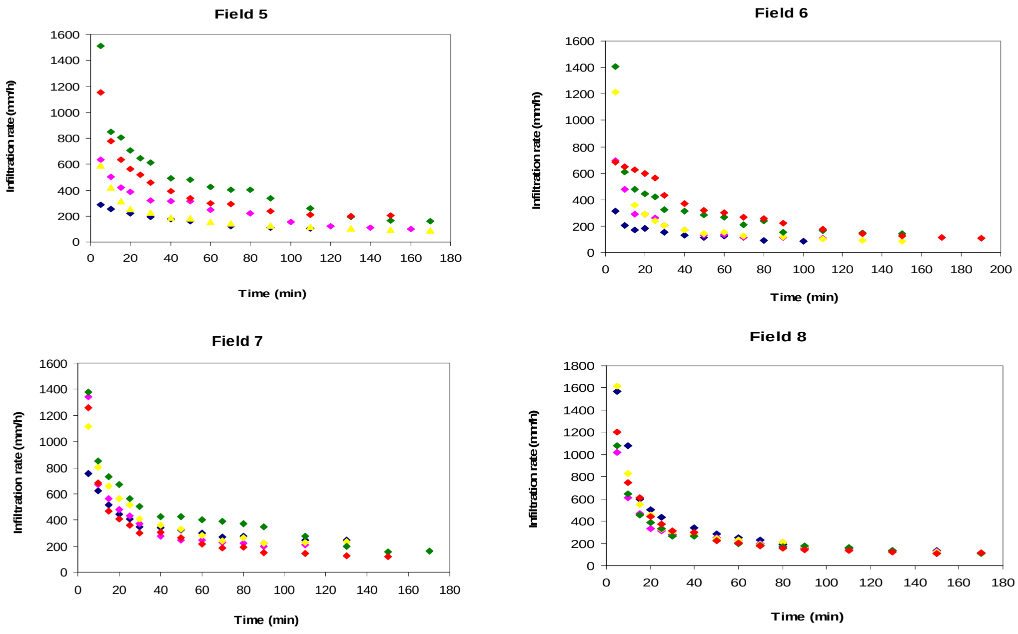
Comparison with the aggregate stability is not corresponding with the results of infiltration capacity, as infiltration capacity is strongly influenced by pore size and pore stability and these are larger and better maintained in soils with stable aggregates, which enhances water infiltration (Morgan, 2005; Jankauskas et al., 2008) (Figure 8, Figure 9). This is because when aggregates break down, microaggregates and primary soil particles from original structural units are produced. A seal is formed by their displacement and reorganization into a denser and more continuous structure resulting in lower infiltration capacities (Le Bissonnais & Arrouays, 1997).

The used measurement method can also cause results contradicting with the aggregate measurements. When erosion rates are high because of high runoff rates due to crust formation, this will not be noticed by the infiltration measurements performed by a double ring infiltrometer as the soil is disturbed by mounting the double ring infiltrometer into the ground and the crust will be destroyed, allowing water to infiltrate easily. Crust forming can occur due to the disruption of unstable aggregates (Le Bissonnais & Arrouays, 1997).
For the fields with low aggregate stability the infiltration rates are high and vice versa (Figure 8, Figure 9). As crust forming does not occur as frequent on the fields with more stable aggregates (non-erodible fields), the soil was less disturbed when mounting the infiltrometer into the soil in comparison with the fields where crust forming does occur (erodible fields). As a result, water infiltrates faster in the disturbed soils with unstable aggregates (erodible fields). Other minor effects could be variation in profile depth, as the horizon with the lowest infiltration capacity is critical (Morgan, 2005)or as the soils contained lots of rubbers and plastics, which were ploughed into the soil even into considerable depths, these could have influenced the measurements if present beneath the double ring infiltrometer.

Erodible:



Non-erodible:



Legend:

- ◆ Upper left
- ◆ Upper right
- ◆ Middle
- ◆ Lower left
- ◆ Lower right

Figure 10: Soil infiltration curves for the 8 research fields. Each curve displays one sampling site on a research field. Exact locations on the field can be found in the legend.

Furthermore, the difference between the erodible and non-erodible fields for wet-aggregate stability is even more pronounced than the difference between these for the dry-aggregate stability. This confirms that the instability of the aggregates causes relatively high measured infiltration rates occurring together with high erosion rates, as the stability of the wet-aggregates can be related to surface seal development and field infiltration (Loch, 1994).
As infiltration normally shows a correlation between porosity and bulk density – when bulk density is low, porosity and infiltration capacity are high (Lundgren, 1980), this is contradicting with the bulk density measurements as there is barely a correlation between bulk density and infiltration capacity (0.021 for Kfs=Qs and 0.135 for Kfs-formula). As bulk density depends on organic matter content and aggregate stability partly depends on this as well, it is plausible that no correlation is present for infiltration capacity and bulk density. This is because both are influenced by the aggregate stability, which cannot be taken into account sufficiently with infiltration measurements made by a double ring infiltrometer, and thus infiltration rates are not high while bulk densities are low.

Table 9: Infiltration capacities (mm/h) for Kfs=Qs and calculated according to equation 1 denoted in the methods of study section. Shown are the average values of the five measurements per field.

Field	Infiltration capacity Kfs=Qs (mm/h)	Covariance Kfs=Qs (mm/h)	Infiltration capacity Kfs-formula (mm/h)	Covariance Kfs-formula (mm/h)
1: erodible	200	585	90	78
2: erodible	142	1211	71	438
3: erodible	170	538	81	156
4: erodible	166	5067	82	1196
5: non-erodible	133	1895	63	478
6: non-erodible	105	439	34	55
7: non-erodible	194	2252	62	207
8: non-erodible	122	99	61	26
Average erodible	167		81	
Average non-erodible	138		55	

As can be seen in Figure 10 and Table 10 initial infiltration capacities are not equal. This is due to differences in initial conditions, because of changes in weather circumstances. After a rain event the soil was already pre-wetted (e.g. measurements on field one have been performed after a long period without rain, measurements on field 2 on a cloudy day after a full day of rain).

Table 10: Initial infiltration capacities (mm/h) for each individual measurement and averages.

Sampling position	Field number							
	1	2	3	4	5	6	7	8
a	1764	420	1104	444	288	312	756	1572
b	1044	222	984	516	636	696	1344	1020
c	1728	360	876	492	588	1212	1116	1620
d	792	360	174	336	1512	1404	1380	1080
e	1992	540	1836	468	1152	684	1260	1200
average	1464	380	995	451	835	862	1171	1298

4.6. Soil cohesion and shear strength

Figure 11 show the soil cohesion for the 8 fields and average values for erosive and non-erosive fields. The cohesion on both fields is the same, differences between these fields are not significant indicated by the t-test with a p-value of 0.052, although this is very close to the point were H_0 is rejected. However, the accuracy of the soil cohesion measurements is determined by many factors (CEP Instruments & Services, 2011) and for this reason measurements can be inaccurate. Although the highest and lowest values of the five measurements at each sampling place are not taken into account for this reason, the result can still be inaccurate and a higher confidence level than 95% could be required. In that case the rejection of H_0 will be more evincive. Nevertheless, without taken the upper and lower values into account, some outliers still occur in the data and could be caused by local differences in shear strength. As this latter is derived from several forces: -frictional resistance of particles when they are forced to slide over one another or to move out of interlocking position, -cohesive forces related to chemical bonding of clay minerals, -surface tension forces within the moisture films in unsaturated soil or absorbance of forces by solid-to-solid contact among particles (Dane & Hopman, 2002), any of these forces could have caused a local difference. Without taking the 3 unexplained outliers in the data (Figure 11: dots above 25 KPascal) the p-value would be 0.0004.

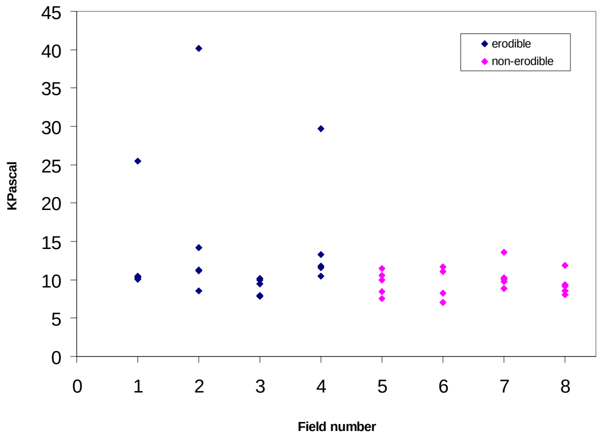
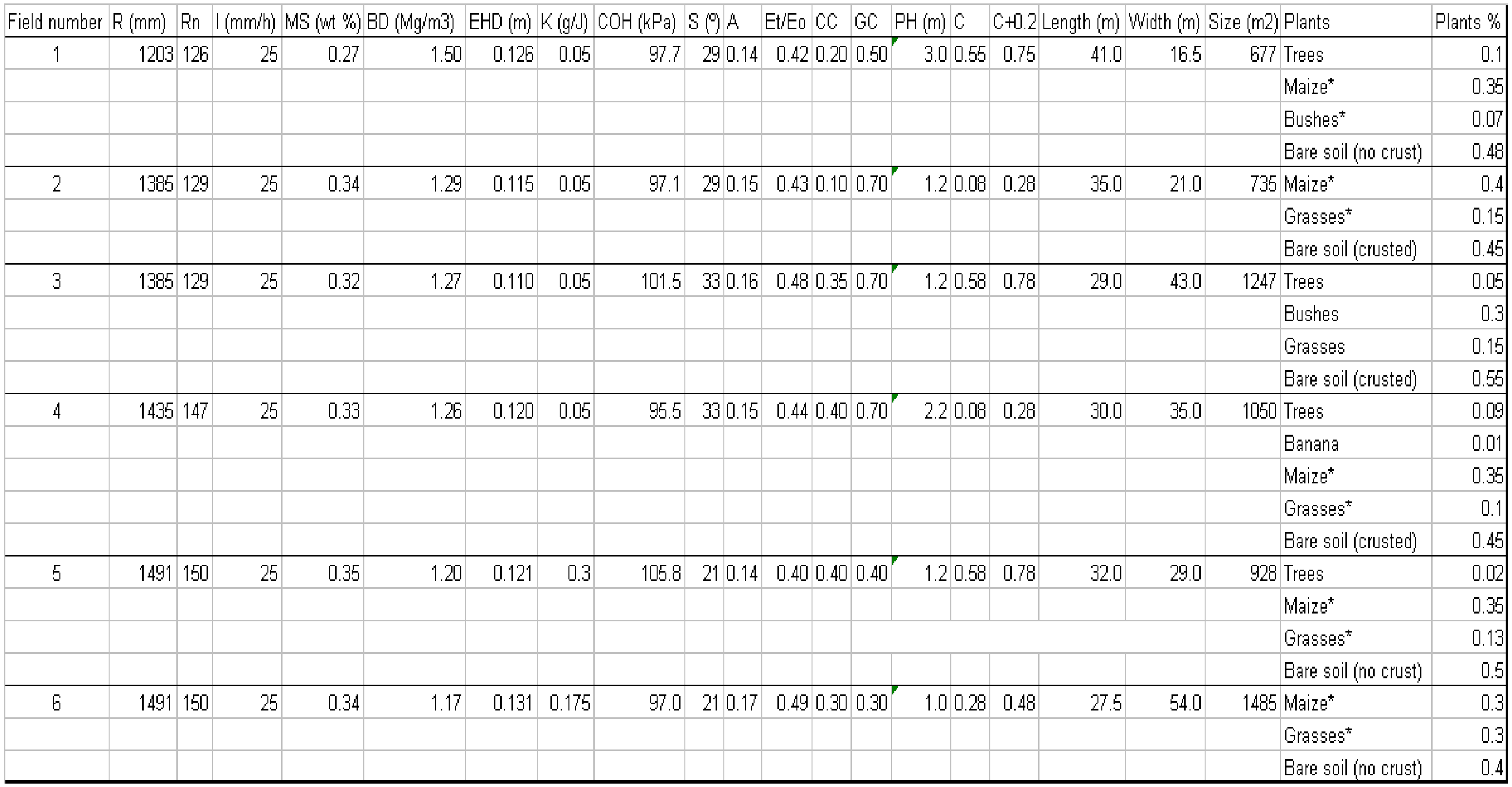


Figure 11: Soil cohesion in kPa. Each dot displays the average of the 3 middle values taken on one place.

4.7. MMF erosion model

Erosion rates and runoff rates have been modelled and measured for the six fields on which Gerlach troughs have been installed. Input parameters for the model and calculations of the model and can be found in Table 11 and appendix F, respectively. Amounts of rainfall shown in Table 11 are distinct due to different measurements periods of rainfall for each field.

*Table 11: Input parameters MMF erosion model. Six fields used for calibration. *=intercropped*



Field number	R (mm)	Rn	I (mm/h)	MS (wt %)	BD (Mg/m3)	EHD (m)	K (g/J)	COH (kPa)	S (°)	A	Et/Eo	CC	GC	PH (m)	C	C+0.2	Length (m)	Width (m)	Size (m2)	Plants	Plants %
1	1203	126	25	0.27	1.50	0.126	0.05	97.7	29	0.14	0.42	0.20	0.50	3.0	0.55	0.75	41.0	16.5	677	Trees	0.1
																				Maize*	0.35
																				Bushes*	0.07
																				Bare soil (no crust)	0.48
2	1385	129	25	0.34	1.29	0.115	0.05	97.1	29	0.15	0.43	0.10	0.70	1.2	0.08	0.28	35.0	21.0	735	Maize*	0.4
																				Grasses*	0.15
																				Bare soil (crusted)	0.45
3	1385	129	25	0.32	1.27	0.110	0.05	101.5	33	0.16	0.48	0.35	0.70	1.2	0.58	0.78	29.0	43.0	1247	Trees	0.05
																				Bushes	0.3
																				Grasses	0.15
																				Bare soil (crusted)	0.55
4	1435	147	25	0.33	1.26	0.120	0.05	95.5	33	0.15	0.44	0.40	0.70	2.2	0.08	0.28	30.0	35.0	1050	Trees	0.09
																				Banana	0.01
																				Maize*	0.35
																				Grasses*	0.1
																				Bare soil (crusted)	0.45
5	1491	150	25	0.35	1.20	0.121	0.3	105.8	21	0.14	0.40	0.40	0.40	1.2	0.58	0.78	32.0	29.0	928	Trees	0.02
																				Maize*	0.35
																				Grasses*	0.13
																				Bare soil (no crust)	0.5
6	1491	150	25	0.34	1.17	0.131	0.175	97.0	21	0.17	0.49	0.30	0.30	1.0	0.28	0.48	27.5	54.0	1485	Maize*	0.3
																				Grasses*	0.3
																				Bare soil (no crust)	0.4

The first calibration has been performed with parameters determined by Morgan (1982, 2001) and if not mentioned by Morgan (1982, 2001) it has been determined as described in the methods previously (§3.8). Figure 12 and Figure 13 show the results before calibration. Although runoff values fitted quite well (deviation ratios between 0.6 and 1.6), the runoff values were highly underestimated (deviation ratios between 0.04 and 0.6). Table 12 shows the adapted parameters.

Table 12: adapted parameters with respect to the empirical values determined by Morgan (1982, 2001),

Parameter	Vegetation	Initial value	Newly assigned value
EHD	Trees	0.20	0.22
	Maize	0.12	0.11
	Bare soil (no crust)	0.09	0.07
	Bushes	0.17	0.22
	Grasses	0.14	0.17
	Banana	0.18	0.15
A	Grasses	0.33	0.25
Et/Eo	Maize	0.69	0.64
	Banana	0.74	0.70
	Grasses	0.86	0.75
	Trees	0.95	0.85

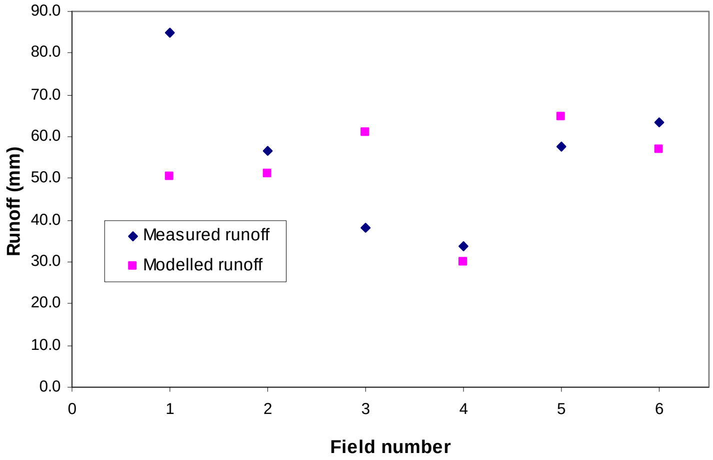


Figure 12: Measured and modelled runoff rates for the 6 fields with Gerlach troughs according to the MMF erosion model before calibration.

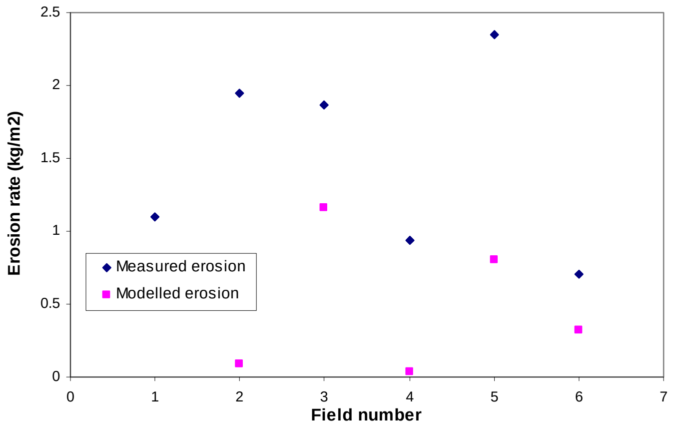


Figure 13: Measured and modelled erosion rates according to the MMF erosion model for the six fields with Gerlach troughs before calibration.

After calibration the measured values were still higher than most modelled values (Figure 14, Table 13). Deviation ratios were between 0.7 and 1.5 (Table 13). Though, when comparing modelled and measured erosion rates, modelled values were in general lower than measured values (Figure 15, Table 14). All underestimated values in Figure 15 are limited by transport capacity (appendix F), so C, Q and/or S from the transport capacity equation should be increased. As runoff already has been overestimated and the slope is assumed to be known, the C-factor can best be adjusted. An addition of 0.2 to the C-factor results in a good fit for all values (Figure 15, Table 14). As it can physically not be higher than 1, it might give problems when C-values are already high. Its applicability for this model and its good fit when adding 0.2 might be caused by underestimation of C due to the season in which measurements were performed as the C-value is estimated by weighting the percentage crop cover for each cropping season by the proportion of the mean annual rainfall occurring in that season (Morgan, 2005). As crop cover and amount of crop cover were determined during the dry season, values will deviate from yearly values and might result in lower C-values.

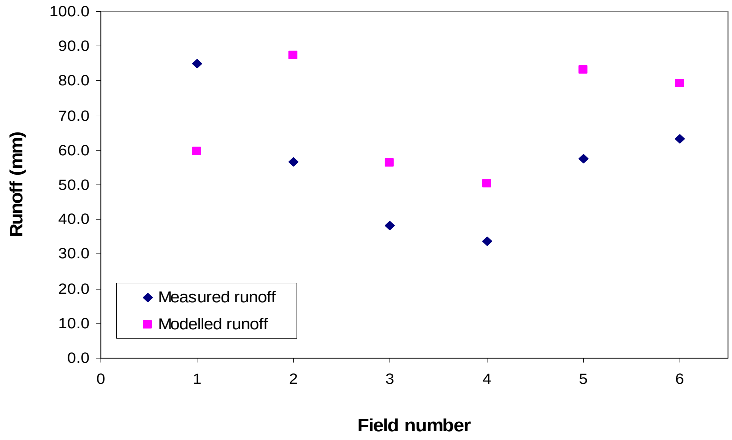


Figure 14: Measured and modelled runoff rates for the 6 fields with Gerlach troughs according to the MMF erosion model.

Table 13: Deviation ratios of the modelled runoff with respect to the measured runoff. The deviation ratio is the ratio of the predicted value divided by the measured value.

Field	Deviation ratio
M1	0.7
M2	1.5
M3	1.5
M4	1.5
M5	1.4
M6	1.3

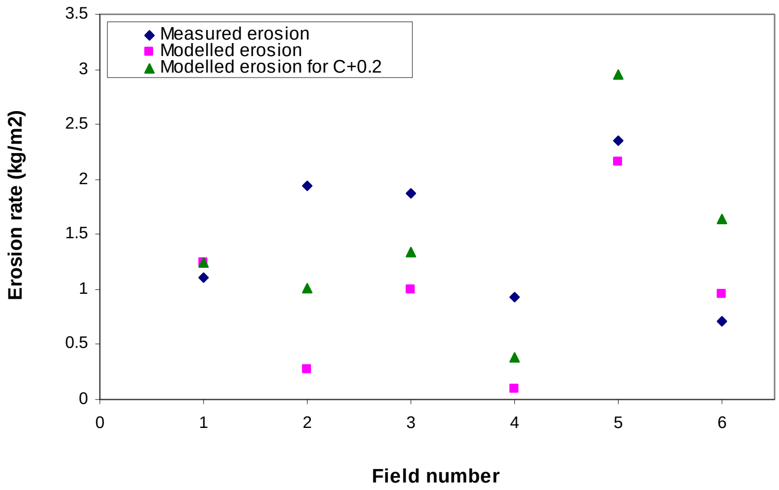


Figure 15: Measured erosion rates, modelled erosion rates according to the MMF erosion model and modelled erosion rates according to the MMF erosion model but when 0.2 has been added to the model. All erosion rates are for the six fields with Gerlach troughs.

Table 14: Deviation ratios of the modelled annual values and the modelled annual values when 0.2 has been added to the C-factor, with respect to the measured annual values. The deviation ratio is the ratio of the predicted value divided by the measured value.

Field	Deviation ratio	Deviation ratio
M1	0.8	1.0
M2	0.1	0.5
M3	0.5	0.7
M4	0.1	0.4
M5	0.6	0.8
M6	0.9	1.5

Table 15: Input parameters MMF erosion model for the eight research fields.

**=intercropped*

Field number	R (mm)	Rn	I (mm/h)	MS (wt %)	BD (Mg/m3)	EHD (m)	K (g/J)	K(aggr)	COH (kPa)	S (°)	A	Et/Eo	CC	GC	PH (m)	C	Length (m)	Width (m)	Size (m2)	Dates	Plants	Plants %
1	1053.9	83.5	25	0.39	1.26	0.14	0.30	0.08	13.3	31.0	0.13	0.42	0.15	0.75	0.7	0.74	42.0	27.5	1155	8/4/2011	Savanna/prairie grasses	0.35
Erodible																				8/5/2011	Trees	0.05
																					Bushes	0.10
																					Bare soil (no crust)	0.5
2	1053.9	83.5	25	0.34	1.35	0.11	0.05	0.07	17.1	26.0	0.07	0.24	0.05	0.10	0.6	0.96	37.0	24.5	907	8/5/2011	Grasses	0.25
Erodible																					Trees	0.02
																					Bare soil (no crust)	0.73
3	1053.9	83.5	25	0.41	1.32	0.10	0.13	0.13	9.1	26.0	0.11	0.34	0.15	0.50	0.7	0.83	30.5	27.5	839	8/8/2011	Cassava*	0.19
Erodible																				8/9/2011	Grasses*	0.20
																					Trees	0.01
																					Bare soil (no crust)	0.6
4	1053.9	83.5	25	0.38	1.32	0.13	0.05	0.07	15.4	24.0	0.12	0.37	0.05	0.70	0.4	0.79	38.5	41.0	1579	8/11/2011	Grasses	0.40
Erodible																				8/13/2011	Trees	0.01
																					Bushes	0.04
																					Bare soil (no crust)	0.55
5	1053.9	83.5	25	0.40	1.32	0.09	0.13	0.03	9.6	29.0	0.10	0.30	0.30	0.50	1.0	0.76	27.5	33.5	921	8/9/2011	Maize*	0.20
Non-erodible																				8/10/2011	Grasses*	0.20
																					Bare soil (no crust)	0.50
6	1053.9	83.5	25	0.32	1.36	0.11	0.23	0.04	9.0	33.0	0.17	0.42	0.35	0.40	1.3	0.74	33.5	24.0	804	8/17/2011	Banana	0.20
Non-erodible																					Beans	0.40
																					Bare soil (no crust)	0.40
7	1053.9	83.5	25	0.38	1.19	0.11	0.05	0.03	10.5	28.0	0.12	0.34	0.40	0.30	1.6	0.95	13.5	15.5	209	8/19/2011	Yam	0.30
Non-erodible																					Banana	0.02
																					Trees	0.08
																					Bare soil (no crust)	0.6
8	1053.9	83.5	25	0.38	1.23	0.12	0.20	0.04	9.4	29.0	0.08	0.27	0.15	0.20	1.3	0.92	34.0	15.5	527	8/22/2011	Grasses	0.2
Non-erodible																					Trees	0.05
																					Bushes	0.05
																					Bare soil (no crust)	0.7

The addition of 0.2 to the C-factor has also been added to the model when calculating the erosion rates of the 8 fields without Gerlach troughs. Input parameters are shown in Table 15 (including the addition of 0.2 for C). The results of the erosion rates calculated by the MMF erosion model were not as expected, as modelled erosion rates were higher for all non-erodible fields than for erodible fields (Figure 16).
Results of the measurements to soil physical properties described before show that aggregate stability is an important factor for the amount of erosion.

Soil detachability has been determined by soil type which gives a typical value for soil detachability (appendix D), in practice soil texture seems to influence this less than expected. This could be caused by the aggregate stability of the soil as the soil detachability decreases with increasing organic matter content (Ekwue, 1990) and, as this causes the aggregates to be more stable, with increasing aggregate stability (Fullen & Catt, 2004). Though, this is not taken into account in the MMF-erosion model, but for a good representation of the soil detachability and thus of the erosion rates, the aggregate stability should be taken into the model. This can be performed with the use of the LISEM model which uses a relationship to determine the soil detachability in g/J from the aggregate stability. Here, the aggregate stability has been taken as the median number of drops to decrease the aggregate by 50%. In this research the aggregate stability has been determined by decreasing the aggregate from 4-4.8 mm to 2.8 mm which is a decrease of 30 to 42 %. The conversion factor used by the LISEM model is defined as 2.82 divided by the aggregate stability (LISEM, 2012). However, as no aggregate stability measurements are performed for the six fields with Gerlach troughs the model cannot be calibrated. Although, for this reason Figure 17 does not show any quantitative information, it does give an impression how the fields differ from each other in the amount of erosion. Furthermore, as more energy or water drops are needed to decrease the aggregates with 50% instead of 30 to 42%, the amount of erosion would actually be lower than showed in Figure 17. Thereby, measurements of aggregate stability are sometimes inconsistent with runoff and erosion measurements and result in problems developing the model (Wischmeier et al., 1971; Boiffin, 1984; Trott & Singer, 1983; Ekwue, 1990; Loch & Foley, 1994). The results showed in Figure 17 do not show clear differences in erosion rates between the erodible and non-erodible fields. Only, field 2 shows a higher erosion rate, which is probably due to the lack of vegetation on this field. Soil erosion of field 8 has decreased which is due to the strong aggregate stability which is now taken into account. Clear differences in erosion rates do occur when taking a rainy year (sept.1997-aug.1998; 1596 mm, 111 rain days) instead of taking average rainfall and rain days (1054 mm, 84 rain days). Differences between erodible and non-erodible fields then become evincive (Figure 18, Table 16). This occurs when the ratio R/Rn increases. This shows that the erodible fields are in particular more erodible when showers become more clustered and longer, and that aggregate stability protects the fields against heavy erosion. The difference in amount of erosion for a year with normal rain and a year with rain above average are caused by an increase in the amount of rainfall and thus runoff and erosion. However, the amount of erosion increases in particular for field 1 and 4 and for this reason the differences in erosion rates become clear. From the erosion calculations of the MMF erosion model (appendix F) it can be seen that for field 1 and 4 the transport capacity was the limiting factor when taking a year with average rainfall. In case of a year with rainfall above average, the limiting factor changes towards the total detachment by rain splash and runoff. Differences between the fields do not become clear when rain parameters of this particular year ('97-'98) are used but not the aggregate stability.

Furthermore, the amount of vegetation changes during the year. The MMF erosion model uses the average vegetation cover of a year. This can give model results which are in contrast with the erosion rates, as plant cover details are noted at only one moment during the year and one can only guess what the plant cover is during the rest of the year. Thereby, vegetation parameters have been noted during the dry season, while erosion and runoff measurements are of course, performed during the rain season.

So, because the vegetation changes during the year and because the results of the model are not very distinct for the different fields, it is likely that erosion occurred during a particular time of the year when the soil was bare and vulnerable to erosion. This also explains the overestimated values for field M3 with respect to the runoff and the two different ways of erosion calculations. During the period of fieldwork no crops were growing on this field, which resulted in higher modelled erosion rates (due to a low vegetation input), than has been measured, probably in a period while crops were growing on this field.

In the case of field number 7 and 8 (without Gerlach troughs), the soil was bare during the time of field work but remains of other crops which have been growing before, were visible. Meaning that the soil was better protected to erosion during other periods of the year when crops were growing on these fields.

Another point of model quality is the erosion and runoff measurements. Since these are measured with Gerlach troughs, it is hard to determine the area covered by the Gerlach trough and sediments can easily fall into the trough when no runoff occurs as farmer can do this. Furthermore, the measurements are not performed during one complete year. So, not all the rain events can be taken into the model. However, most of the events will, as measurements are performed during the seasons of the long and short rains, while the dry season has been skipped.

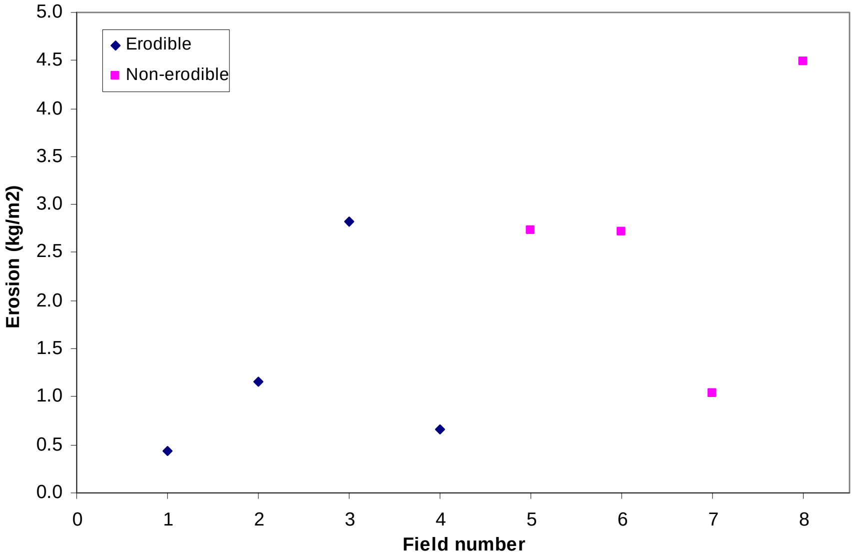


Figure 16: Erosion rates in kg/m^2 *calculated with the K-factor depending on soil texture according to Morgan et al. (1982) and Morgan (2001).*

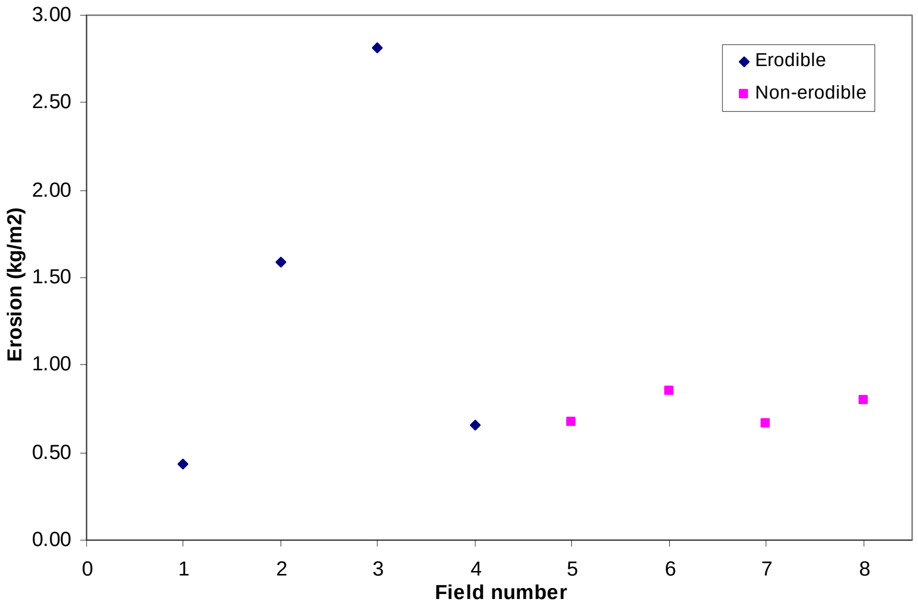


Figure 17: Erosion rates in kg/m^2 calculated with the K-factor depending on aggregate stability according to LISEM for a year with average rainfall and rain days.

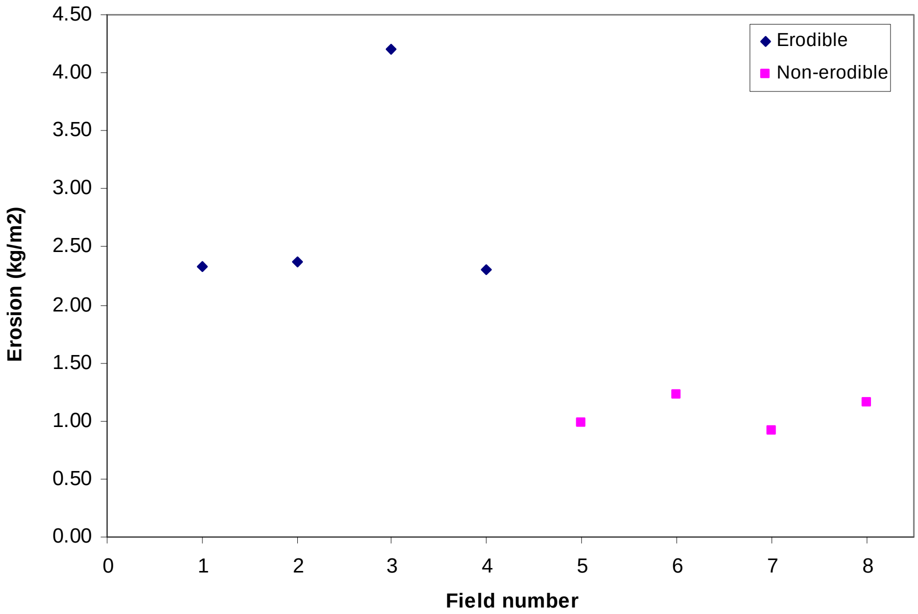


Figure 18: Erosion rates in kg/m^2 calculated with the K-factor depending on aggregate stability according to LISEM for a year with above average rainfall (september 1997 – august 1998).

Table 16: Model results for using the K-value corresponding with soil structure and K depending on aggregate stability for a year with average rainfall and above average. Values are annual in kg/m^2.

Field	Modelled erosion value with corresponding K-value for soil texture	Modelled erosion value with K depending on aggregate stability for a year with average rainfall	Modelled erosion value with K depending on aggregate stability for a year with rainfall above average
1: erodible	0.51	0.51	2.33
2: erodible	1.13	1.56	2.37
3: erodible	0.69	0.69	2.30
4: erodible	1.95	0.65	0.99
5: non-erodible	0.74	0.74	3.57
6: non-erodible	1.52	0.81	1.22
7: non-erodible	0.94	0.61	0.92
8: non-erodible	4.31	0.76	1.15
Average erodible	0.77	0.88	2.64
Average non-erodible	1.87	0.72	1.40

6. Conclusions

Aggregate stability was significantly higher for the non-erodible fields for both wet- and dry-aggregates and is the most important soil physical property for erodibility of these fields. Difference between erodible and non-erodible fields for wet-aggregate stability is even more pronounced than the difference between these for dry-aggregate stability and shows that water is more important in eroding the soils than wind.

Infiltration capacity values were equal higher for the erodible than non-erodible fields. This is contradicting with the aggregate stability values. Due to the installation of the double ring infiltrometer in the crust, which is formed by the disruption of aggregates, the crust is disturbed and infiltration can occur more easily than normally. Variation in profile depth and the occurrence of rubbers and plastics in the soils could have had a minor role in effecting the infiltration rates.

Differences between soil texture for erodible and non-erodible fields are only apparent for the fine sand when both depth layer were taken together. For all eight research fields silt and clay content were such that the soils were not vulnerable to erosion with respect to soil texture.

The eight fields of investigation, when compared for the erodible fields and non-erodible fields, were quite similar with respect to soil profiles. The erodible soils were somewhat more red and less yellow or brown. From this it can be concluded that on the erodible fields leaching of minerals has occurred leaving only iron and/or aluminium oxides in the soil.

No differences occur with respect to soil cohesion and shear strength on the erodible and non-erodible fields. The same applies for bulk density and porosity.

The MMF erosion model shows that the erodible and non-erodible fields are approximately equal in erosion rates in case of average rainfall, though when the ratio between rainfall and amount of rain days increases (rain intensity), which is predominantly the case when the amount of rainfall is above average, differences in the amount of erosion become clear: the erodible fields experience more erosion than the non-erodible fields. Protection of the fields to erosion is predominantly due to a high aggregate stability.

7. Recommendations

This research clearly showed the influence of the aggregate stability on the erosion rates of the 8 research fields. Though, it is not known which soil properties determine the differences in aggregate stability for these fields. In general, the aggregate stability is highly dependent on which clay minerals are present in the soil. Although, koalinite dominates the clay fraction in the Usambara Mountains (Lundgren, 1980) and makes aggregates more stable, the occurrence of halloysite, chlorite and fine grained micas can enhance this, while smectite and vermiculite make aggregates less stable (Morgan, 2005). Furthermore, organic constituents in the soil are important for the aggregate stability of 2-10 mm aggregates and if less than 2% organic matter is present in the soil, the soil will be highly erodible (Fullen & Catt, 2004). In a further research the amount of the organic matter content and the composition of the mineral content could be determined.

When erosion rates are high because of high runoff rates due to crust forming, this will not be noticed by the infiltration measurements performed by a double ring infiltrometer as the soil is disturbed by mounting the double ring infiltrometer into the ground and the crust will be destroyed, allowing water to infiltrate easily. So, to be able to notice the impact of the aggregate stability on the infiltration rates a measurement method is needed where minimal disturbance of the soil occurs such as a rainfall simulator (Hendriks, 2010), which has also as advantage that the way in which the water is added is more natural and water drips on the soil, as occurs in the same way for the aggregate stability measurements.

For a good representation of the MMF erosion model the aggregate stability should be taken into account in the model, as this has been shown to be the most important factor in determining the erosion rates. To be able to fit this in the model and to give quantitive information about the erosion on the 8 fields without Gerlach troughs, measurements of the aggregate stability should be performed on the six fields with Gerlach troughs so that the LISEM conversion can be calibrated.

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Appendices

Appendix A

T-tests with 95% confidence intervals

Soil texture:

0-15 cm and 15-30 cm:

Clay	*Erosive*	*Non-erosive*
Mean	47.75	41.5
Variance	66.78571429	30.57142857
Observations	8	8
Pooled Variance	48.67857143	
Hypothesized Mean Difference	0	
df	14	
t Stat	1.791600194	
P(T<=t) one-tail	0.047415528	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.094831056	
t Critical two-tail	2.144786681	

Silt	*Erosive*	*Non-erosive*
Mean	13.25	13.25
Variance	77.64285714	10.2142857
Observations	8	8
Pooled Variance	43.92857143	
Hypothesized Mean Difference	0	
df	14	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	1	
t Critical two-tail	2.144786681	

Fine sand	*Erosive*	*Non-erosive*
Mean	3.5	5
Variance	0.857142857	2.285714286
Observations	8	8
Pooled Variance	1.571428571	
Hypothesized Mean Difference	0	
df	14	
t Stat	-2.393172106	
P(T<=t) one-tail	0.015637564	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.031275127	
t Critical two-tail	2.144786681	

Coarse sand	*Erosive*	*Non-erosive*
Mean	38	37.75
Variance	45.71428571	39.3571429
Observations	8	8
Pooled Variance	42.53571429	
Hypothesized Mean Difference	0	
df	14	
t Stat	0.076664294	
P(T<=t) one-tail	0.469987723	
t Critical one-tail	1.761310115	
P(T<=t) two-tail	0.939975447	
t Critical two-tail	2.144786681	

0-15 cm:

Clay	*Erosive*	*Non-erosive*
Mean	42.5	39.5
Variance	14.33333333	27.66666667
Observations	4	4
Pooled Variance	21	
Hypothesized Mean Difference	0	
df	6	
t Stat	0.9258201	
P(T<=t) one-tail	0.195129254	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.390258508	
t Critical two-tail	2.446911846	

Silt	*Erosive*	*Non-erosive*
Mean	19	14.5
Variance	86.66666667	1
Observations	4	4
Pooled Variance	43.83333333	
Hypothesized Mean Difference	0	
df	6	
t Stat	0.961225454	
P(T<=t) one-tail	0.186779406	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.373558813	
t Critical two-tail	2.446911846	

Fine sand	*Erosive*	*Non-erosive*
Mean	3.5	5.5
Variance	1	3.666666667
Observations	4	4
Pooled Variance	2.333333333	
Hypothesized Mean Difference	0	
df	6	
t Stat	-1.8516402	
P(T<=t) one-tail	0.056765863	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.113531727	
t Critical two-tail	2.446911846	

Coarse sand	*Erosive*	*Non-erosive*
Mean	35	40.5
Variance	65.33333333	33
Observations	4	4
Pooled Variance	49.16666667	
Hypothesized Mean Difference	0	
df	6	
t Stat	-1.109282865	
P(T<=t) one-tail	0.154889506	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.309779012	
t Critical two-tail	2.446911846	

15-30 cm:

Clay	*Erosive*	*Non-erosive*
Mean	53	43.5
Variance	68	33
Observations	4	4
Pooled Variance	50.5	
Hypothesized Mean Difference	0	
df	6	
t Stat	1.890570661	
P(T<=t) one-tail	0.053783483	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.107566966	
t Critical two-tail	2.446911846	

Silt	*Erosive*	*Non-erosive*
Mean	7.5	12
Variance	6.333333333	18.66666667
Observations	4	4
Pooled Variance	12.5	
Hypothesized Mean Difference	0	
df	6	
t Stat	-1.8	
P(T<=t) one-tail	0.060976211	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.121952421	
t Critical two-tail	2.446911846	

Fine sand	*Erosive*	*Non-erosive*
Mean	3.5	4.5
Variance	1	1
Observations	4	4
Pooled Variance	1	
Hypothesized Mean Difference	0	
df	6	
t Stat	-1.414213562	
P(T<=t) one-tail	0.103515625	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.20703125	
t Critical two-tail	2.446911846	

Coarse sand	*Erosive*	*Non-erosive*
Mean	36	40
Variance	34.66666667	34.66666667
Observations	4	4
Pooled Variance	34.66666667	
Hypothesized Mean Difference	0	
df	6	
t Stat	-0.960768923	
P(T<=t) one-tail	0.186885271	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.373770543	
t Critical two-tail	2.446911846	

Erosive:

Clay	*0-15 cm*	*15-30 cm*
Mean	42.5	53
Variance	14.33333333	68
Observations	4	4
Pooled Variance	41.16666667	
Hypothesized Mean Difference	0	
df	6	
t Stat	-2.314362829	
P(T<=t) one-tail	0.029954851	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.059909702	
t Critical two-tail	2.446911846	

Silt	*0-15 cm*	*15-30 cm*
Mean	19	7.5
Variance	86.66666667	6.333333333
Observations	4	4
Pooled Variance	46.5	
Hypothesized Mean Difference	0	
df	6	
t Stat	2.384988898	
P(T<=t) one-tail	0.027198343	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.054396687	
t Critical two-tail	2.446911846	

Fine sand	*0-15 cm*	*15-30 cm*
Mean	3.5	3.5
Variance	1	1
Observations	4	4
Pooled Variance	1	
Hypothesized Mean Difference	0	
df	6	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	1	
t Critical two-tail	2.446911846	

Coarse sand	*0-15 cm*	*15-30 cm*
Mean	35	36
Variance	65.33333333	34.66666667
Observations	4	4
Pooled Variance	50	
Hypothesized Mean Difference	0	
df	6	
t Stat	-0.2	
P(T<=t) one-tail	0.424043496	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.848086992	
t Critical two-tail	2.446911846	

Non-erosive:

Clay	*0-15 cm*	*15-30 cm*
Mean	39.5	43.5
Variance	27.66666667	33
Observations	4	4
Pooled Variance	30.33333333	
Hypothesized Mean Difference	0	
df	6	
t Stat	-1.027105182	
P(T<=t) one-tail	0.171992279	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.343984558	
t Critical two-tail	2.446911846	

Silt	*0-15 cm*	*15-30 cm*
Mean	14.5	12
Variance	1	18.66666667
Observations	4	4
Pooled Variance	9.833333333	
Hypothesized Mean Difference	0	
df	6	
t Stat	1.127469042	
P(T<=t) one-tail	0.151301722	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.302603444	
t Critical two-tail	2.446911846	

Fine sand	*0-15 cm*	*15-30 cm*
Mean	5.5	4.5
Variance	3.666666667	1
Observations	4	4
Pooled Variance	2.333333333	
Hypothesized Mean Difference	0	
df	6	
t Stat	0.9258201	
P(T<=t) one-tail	0.195129254	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.390258508	
t Critical two-tail	2.446911846	

Coarse sand	*0-15 cm*	*15-30 cm*
Mean	40.5	40
Variance	33	34.66666667
Observations	4	4
Pooled Variance	33.83333333	
Hypothesized Mean Difference	0	
df	6	
t Stat	0.121566135	
P(T<=t) one-tail	0.453605912	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.907211825	
t Critical two-tail	2.446911846	

Bulk density (g/cm^3) and porosity(-):

Bulk density:

	Erosive	*Non-erosive*
Mean	1.311818182	1.263391304
Variance	0.006352346	0.011968067
Observations	22	23
Pooled Variance	0.009225506	
Hypothesized Mean Difference	0	
df	43	
t Stat	1.690675949	
P(T<=t) one-tail	0.0490681	
t Critical one-tail	1.681070704	
P(T<=t) two-tail	0.0981362	
t Critical two-tail	2.016692173	

Porosity:

	Erosive	*Non-erosive*
Mean	0.504974271	0.523248564
Variance	0.00090457	0.001704246
Observations	22	23
Pooled Variance	0.001313707	
Hypothesized Mean Difference	0	
df	43	
t Stat	-1.69067595	
P(T<=t) one-tail	0.0490681	
t Critical one-tail	1.681070704	
P(T<=t) two-tail	0.0981362	
t Critical two-tail	2.016692173	

Wet-aggregate stability (number of drops):

	Erosive	*Non-erosive*
Mean	30.8525	80.2675
Variance	2359.103503	6239.344305
Observations	400	400
Pooled Variance	4299.223904	
Hypothesized Mean Difference	0	
df	798	
t Stat	-10.65807484	
P(T<=t) one-tail	3.43975E-25	
t Critical one-tail	1.646765345	
P(T<=t) two-tail	6.8795E-25	
t Critical two-tail	1.962941151	

Dry-aggregate stabilitiy (number of drops):

	Erosive	*Non-erosive*
Mean	38.295	77.965
Variance	2631.341328	5284.725589
Observations	400	400
Pooled Variance	3958.033459	
Hypothesized Mean Difference	0	
df	798	
t Stat	-8.917383982	
P(T<=t) one-tail	1.6052E-18	
t Critical one-tail	1.646765345	
P(T<=t) two-tail	3.2104E-18	
t Critical two-tail	1.962941151	

Soil infiltration (mm/h):

For $k_{fs}=Q_s$:

	Erosive	*Non-erosive*
Mean	169.65	138.45
Variance	2399.186842	2410.365789
Observations	20	20
Pooled Variance	2404.776316	
Hypothesized Mean Difference	0	
df	38	
t Stat	2.011950312	
P(T<=t) one-tail	0.02567721	
t Critical one-tail	1.685954461	
P(T<=t) two-tail	0.05135442	
t Critical two-tail	2.024394147	

According to K_{fs}-formula:

	Erosive	*Non-erosive*
Mean	81.08405233	54.97842753
Variance	538.3035268	358.7247399
Observations	20	20
Pooled Variance	448.5141333	
Hypothesized Mean Difference	0	
df	38	
t Stat	3.898037614	
P(T<=t) one-tail	0.000190841	
t Critical one-tail	1.685954461	
P(T<=t) two-tail	0.000381683	
t Critical two-tail	2.024394147	

Soil cohesion (kPa):

	Erosive	*Non-erosive*
Mean	13.47758274	9.634986803
Variance	70.00462581	3.008451617
Observations	20	20
Pooled Variance	36.50653872	
Hypothesized Mean Difference	0	
df	38	
t Stat	2.011126509	
P(T<=t) one-tail	0.025722601	
t Critical one-tail	1.685954461	
P(T<=t) two-tail	0.051445202	
t Critical two-tail	2.024394147	

Appendix B

Soil profile descriptions

All soils become dark reddish brown when moist (except field 6) and are clayey with larger particles. Roots are in general very small (±0.1mm).

Field 1:
Total depth: 47 cm.
Upper 10-15 cm is on most places more open spaced than other parts of the soil profile due to the occurrence of roots. Though, these open spaces do not occur along the whole horizontal profile of the upper 10-15 cm.
Beneath this layer roots also occur but are less dominant and the soil is more compacted, though some voids and pores occur.
The colour of the whole profile is reddish or yellowish brown. Around the pores, the soil is somewhat browner and less compacted. The soil is homogeneous with sand and some gravel particles (2-6 mm). One rock occurs of 3.5 by 2.0 cm. One root is present which is somewhat larger (1 cm).
$\alpha^*=0.12$.

Field 2:
Total depth: 32 cm.
Only mineral layer: this layer is yellowish, greyish brown, contains a few roots and is more open spaced around these roots, red mottles are frequent and very variable in size. It contains some white and black spots (1mm). Clayey, some sands, very few gravels, homogeneous/structured.
Upper 5-15 cm is more open spaced and contains some roots.
$\alpha^*=0.12$.

Field 3:
Total depth: 25 cm.
The first upper centimeter is brown is less compacted or very loose soil. At the corners of the field (samples places a, b, d and e) this layer is thicker: about 5-10 cm.
The soil is red/yellowish brown and unstructured. Many stones (white, black, yellow, reddish) occur is variable sizes. Some open spaces are present due to roots until a depth of 10 cm.
$\alpha^*=0.04$.

Field 4:
Total depth: 30 cm.
Open spaces in upper 15 cm, but not everywhere. Some downward pores occur, made by roots. Colours at open spaces are reddish brown.
The more compacted soil is brownish red or brownish yellow.
Largest grains in soil are 2 mm, but most are smaller. White and black spots occur and are also maximal 2 mm. (So grains occur also in soil colours.) Those grains occur in both layers.
$\alpha^*=0.12$.

Field 5:
Total depth: 35 cm.
Open spaced, loose layer, where roots occur: 10-15 cm, yellowish brown.
The layer beneath is more compacted and has a reddish brown colour. Some small white spots occur and very few black, both smaller then 1 mm.
Pores of about 0.5 cm occur in both layers.
$\alpha^*=0.12$.

Field 6:
This soil does not become dark reddish brown when moist.
Total depth: 35 cm.
The soil is unstructured. Many stones (yellow, white, red, orange) occur with sizes varying from gravels to rocks of about 5 cm. The whole soil is a mixture of open spaced and compacted soils, but in general the soil is quite open spaced. Mottles occur from a few mm or less in varying colours: black, white, red and orange. Roots occur everywhere along the profile.
A mixed black and brown soil layer occurs around 15-20 cm in depth. It has a blocky structure and black. In this layer also many roots occur and it is more open spaced.
Above this layer the soil is brown and beneath its deep brown.
$\alpha^*=0.04$.

Field 7:
Total depth: 29 cm.
Homogeneous, reddish brown soil including many roots of which most in the upper 5-10 cm and with varying sizes (0.1 mm-1.2 cm). The soil is more open spaced around the small roots (0.1 mm) and also a bit more brown/less reddish. Mottles occur along the whole profile and are black, white or orange with size varying from 1 mm-1 cm. No stones or gravels present in the soil.
$\alpha^*=0.12$.

Field 8:
Total depth: 31 cm.
Yellowish brown soil, homogeneous in the upper soil layer. Beneath this layer, the soil is heterogeneous and more stony, as by inserting the ring infiltrometer the many stones prevented the ring infiltrometer to be put into the ground smoothly. (This layer can not be seen on the picture.) The soil is browner and looser around the roots, which are frequent in a layer of 17-21 cm in depth. Above this layer roots occurred as well, but more clustered. One big root of 10x5 cm occurs. The soil around this particular root is darker. Some downward pores made by roots occur. Beneath the before mentioned root layer, some deep brown or black spots occur. Along the whole soil profile small stones/gravels occur which are about 0.5 cm and all smaller than 1 cm. Sporadically a pore of about 0.5 cm occurs.
$\alpha^*=0.12$.

Appendix C

Soil texture

NATIONAL SOIL SERVICE

ANALYTICAL LABORATORY RESULT
Origin of Samples |LAURA GARTER (MSC-STUDENT)-2011

SAMPLE IDENT.	DEPT (CM)	LAB. NO	PARTICAL SIZE ANALYSIS				pH 01:02,5		ORG C %	TOTAL N %	C/N	AVAILABLE -	
			< 2	2 –20	20 -50	50 -2000						BRA-I OLSEN	
			u	um	um	um	H_2O	KCl				Mg/kg	Mg/kg
1C	0-15	3515	40	10	4	46							
2C	0-15	3516	42	26	4	28							
3C	0-15	3517	44	16	4	36							
4C	0-15	3518	40	28	2	30							
5C	0-15	3519	48	12	4	36							
6C	0-15	3520	36	14	8	42							
7C	0-15	3521	44	14	6	36							
8C	0-15	3522	34	14	4	48							
1C	15-30	3523	46	8	4	42							
2C	15-30	3524	62	4	4	30							
3C	15-30	3525	44	6	4	46							
4C	15-30	3526	58	8	2	32							
5C	15-30	3527	46	10	4	40							
6C	15-30	3528	36	14	6	44							
7C	15-30	3529	50	12	4	34							
8C	15-30	3530	44	16	4	36							

Wet-aggregate stabiliy

		Number of drops																					
Field number	Sample number	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Test 11	Test 12	Test 13	Test 14	Test 15	Test 16	Test 17	Test 18	Test 19	Test 20	Average number of drops	Field average
1	a	2	5	7	51	98	2	200	5	6	8	11	53	5	5	7	3	18	9	3	8	25,3	32,3
1	b	57	3	56	74	3	6	3	12	2	141	4	9	5	8	158	5	7	10	200	3	38,3	
1	c	7	5	200	2	19	20	57	80	7	28	6	31	5	18	36	4	5	7	12	7	27,8	
1	d	7	8	8	3	4	2	24	11	12	61	77	3	1	7	61	15	7	3	3	5	16,1	
1	e	21	156	181	83	12	8	28	8	4	200	11	67	24	28	69	12	7	26	129	9	54,2	
2	a	5	2	3	3	5	29	7	21	5	27	2	3	5	3	3	71	72	8	200	33	25,4	35,6
2	b	6	4	29	63	5	6	68	23	17	93	5	97	105	13	10	151	7	17	76	6	40,1	
2	c	15	94	86	101	62	12	65	63	2	68	13	200	14	61	6	52	27	21	101	7	53,5	
2	d	11	21	63	14	4	7	8	3	38	15	192	13	5	8	3	3	29	3	4	200	32,2	
2	e	4	20	173	6	14	4	4	28	74	35	23	6	4	26	34	67	3	4	5	7	27,1	
3	a	32	6	5	8	10	3	5	5	8	7	8	200	4	7	2	4	65	4	3	5	19,6	12,6
3	b	31	4	16	3	4	8	6	5	36	6	44	7	9	5	8	8	9	1	3	6	11,0	
3	c	21	5	4	4	5	5	3	5	5	3	4	10	3	9	4	7	3	3	4	8	5,8	
3	d	12	6	10	6	4	13	6	2	4	4	7	6	4	6	3	10	2	8	4	3	6,0	
3	e	11	5	6	43	6	16	8	5	20	8	17	9	62	57	18	67	39	5	5	9	20,8	
4	a	6	6	8	3	157	3	200	107	4	21	8	200	5	18	4	39	23	200	4	30	52,3	42,8
4	b	4	82	8	17	200	15	89	75	6	5	52	200	20	48	10	8	200	106	10	17	58,6	
4	c	6	6	7	6	7	4	18	106	10	2	3	81	103	3	41	23	49	6	121	6	30,4	
4	d	6	6	8	3	157	200	107	4	21	8	200	5	18	4	39	23	200	4	30	3	52,3	
4	e	13	15	26	6	3	33	54	3	7	40	33	4	28	50	4	7	2	7	68	9	20,6	
5	a	59	200	3	8	20	115	9	7	44	200	16	46	200	200	5	181	23	200	5	34	78,8	90,3
5	b	3	14	115	33	6	18	107	10	95	6	186	5	200	29	200	28	200	19	16	200	74,5	
5	c	8	36	10	27	200	9	200	157	200	36	200	52	200	5	182	200	200	67	200	196	119,3	
5	d	8	41	200	200	37	136	76	5	26	5	200	19	10	10	36	4	31	10	21	20	54,8	
5	e	15	200	200	200	200	103	53	7	200	38	62	191	147	10	193	157	75	200	34	200	124,3	
6	a	10	200	30	185	21	102	10	43	8	200	20	3	5	12	27	100	6	130	200	200	75,6	58,9
6	b	200	4	6	200	13	2	44	63	200	18	14	29	200	7	42	12	173	7	30	18	64,1	
6	c	16	8	2	6	10	14	5	26	27	20	12	200	5	41	12	22	12	39	68	22	28,4	
6	d	18	4	27	10	200	3	190	42	11	81	41	58	46	17	7	18	4	200	191	10	58,9	
6	e	3	9	12	59	4	200	200	103	9	9	185	200	200	19	14	6	39	13	15	51	67,5	
7	a	200	21	56	33	7	109	134	7	200	200	20	174	8	200	15	105	37	200	56	68	92,5	86,8
7	b	198	41	21	4	5	37	3	7	200	49	3	26	72	155	200	29	200	126	8	193	78,9	
7	c	9	43	8	17	197	200	200	4	58	109	200	70	13	32	22	26	200	32	124	131	84,8	
7	d	200	196	8	6	195	136	200	24	34	200	63	19	42	17	200	108	200	29	6	200	104,2	
7	e	8	9	39	16	7	200	48	16	14	15	200	120	4	200	114	13	11	200	43	200	73,9	
8	a	6	12	3	81	37	11	200	11	199	27	84	54	200	26	14	20	27	200	17	151	69,0	85,1
8	b	194	200	117	200	5	182	42	200	4	86	170	43	100	16	12	7	166	5	18	200	98,4	
8	c	19	200	91	6	110	12	16	200	10	190	200	27	200	45	109	3	133	4	200	60	91,8	
8	d	16	123	90	119	12	200	2	21	6	46	4	17	29	183	194	20	3	28	200	103	70,8	
8	e	109	59	21	46	5	200	200	200	67	43	200	27	7	47	130	200	89	13	45	200	95,4	

Dry-aggregate stability

		Number of drops																					
Field number	**Sample number**	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Test 6**	**Test 7**	**Test 8**	**Test 9**	**Test 10**	**Test 11**	**Test 12**	**Test 13**	**Test 14**	**Test 15**	**Test 16**	**Test 17**	**Test 18**	**Test 19**	**Test 20**	**Average number of drops**	**Field average**
1	a	53	9	6	3	20	14	10	48	10	24	15	95	28	57	61	7	6	15	46	24	27,6	41,2
1	b	106	10	31	200	23	18	6	41	50	38	200	13	165	25	69	51	59	25	29	118	63,9	
1	c	19	14	6	14	13	53	4	4	44	3	9	43	17	18	49	28	7	10	16	8	19,0	
1	d	4	30	6	10	6	8	89	5	39	9	55	5	6	7	3	9	5	5	22	15	16,9	
1	e	105	189	103	132	145	15	124	5	44	81	21	46	45	24	44	94	74	151	46	87	78,8	
2	a	97	114	32	31	6	7	14	9	9	7	38	41	143	19	45	3	75	28	33	15	38,3	46,3
2	b	9	17	7	185	20	12	56	11	7	8	33	39	22	27	43	8	154	17	14	84	38,7	
2	c	56	21	10	7	34	200	77	62	56	38	112	131	86	30	200	10	28	4	200	24	69,3	
2	d	21	4	54	5	3	19	4	25	3	200	3	195	2	30	10	3	119	3	5	7	35,8	
2	e	26	12	152	80	8	20	48	42	200	11	42	77	9	5	34	22	12	116	6	65	49,4	
3	a	200	7	15	8	18	200	2	5	5	3	18	200	3	86	3	4	19	4	4	4	40,4	29,7
3	b	9	2	5	9	3	2	2	4	11	4	200	3	8	32	3	20	6	3	8	4	16,9	
3	c	4	7	1	2	200	3	4	6	3	200	33	10	4	5	2	78	14	1	42	200	41,0	
3	d	2	2	40	4	29	19	5	5	200	7	2	3	4	14	3	3	24	3	2	5	18,8	
3	e	11	16	14	13	4	27	4	20	23	5	5	3	30	45	82	10	31	200	81	7	31,6	
4	a	11	58	16	29	37	61	51	200	24	32	90	11	10	17	16	9	20	32	200	122	52,3	36,0
4	b	45	27	10	11	77	101	69	127	9	109	13	32	19	11	31	6	49	200	5	27	48,9	
4	c	10	35	51	66	11	20	41	3	4	14	11	26	7	3	5	10	3	28	3	144	24,8	
4	d	5	8	57	58	86	69	6	4	6	4	9	16	45	5	113	9	5	6	18	4	26,7	
4	e	6	41	6	7	14	16	17	30	16	13	99	8	28	13	4	200	6	7	11	5	27,4	
5	a	5	16	185	49	12	200	146	46	139	92	200	40	2	6	9	7	5	183	191	36	78,5	81,4
5	b	22	200	74	200	120	200	53	200	42	20	96	10	8	9	8	6	9	30	40	9	67,8	
5	c	5	5	4	38	200	6	94	52	82	43	42	53	118	200	8	61	7	55	51	28	57,6	
5	d	81	6	20	55	174	104	109	46	200	19	200	66	16	81	12	4	122	12	26	26	69,0	
5	e	126	200	200	189	112	200	41	200	28	34	200	47	158	200	200	102	59	111	108	164	134,0	
6	a	76	10	139	7	5	7	200	178	200	34	2	3	7	8	200	3	12	6	7	200	65,2	67,8
6	b	200	200	16	128	51	141	113	200	94	22	12	44	14	68	15	200	53	30	2	132	86,8	
6	c	12	199	34	139	129	5	39	27	87	200	3	81	4	67	40	6	23	152	123	132	75,1	
6	d	21	28	20	6	8	15	5	11	4	6	42	200	45	8	200	20	9	7	10	27	34,6	
6	e	200	200	30	19	35	2	49	200	37	200	7	22	200	12	4	21	63	22	200	24	77,4	
7	a	155	13	193	19	21	200	14	14	24	40	116	45	31	62	9	144	11	99	92	137	72,0	88,3
7	b	200	47	18	68	142	106	194	119	129	200	94	200	58	73	46	47	48	200	10	18	100,9	
7	c	200	39	21	83	180	200	152	10	200	17	108	12	200	8	109	134	36	45	149	200	105,2	
7	d	23	6	200	41	137	43	63	117	200	28	155	200	6	23	66	23	200	200	48	31	90,5	
7	e	29	18	7	20	176	98	16	114	102	41	82	29	28	15	114	200	8	200	27	135	73,0	
8	a	136	184	50	21	22	6	69	13	200	55	38	200	145	19	57	46	24	200	148	99	86,6	74,4
8	b	73	35	46	129	197	62	200	33	6	111	74	31	80	191	94	14	11	7	19	7	71,0	
8	c	7	12	200	141	88	138	47	59	200	19	4	11	200	200	193	109	200	200	23	120	108,6	
8	d	200	6	8	11	8	8	13	12	4	31	12	16	8	24	17	164	5	5	127	28	35,4	
8	e	200	152	6	9	104	13	9	11	191	10	30	4	52	200	12	140	51	6	13	200	70,7	

Bulk density, porosity and field capacity

Core No	Pf 1.0	pF2.0	pF2.4	pF2.7	B.D(g/cc.)	Field average	Porosity	Field average
	mc (%)				g/cc	g/cc	(-)	g/cc
01A	42,2	41,8	41,4	36,5	1,18	1,27	0,55	0,52
01A		37,2			1,41		0,47	
01B	39,4	39,1	38,7	42,8	1,22		0,54	
01C	39,5	39,1	38,2	36,0	1,23		0,54	
01D		37,9			1,32		0,50	
01E		38,3			1,27		0,52	
02A	35,9	35,5	35,2	30,4	1,29	1,35	0,51	0,49
02B	33,0	31,9	31,4	28,2	1,34		0,49	
02C	30,1	29,4	29,0	26,6	1,37		0,48	
02D		39,7			1,40		0,47	
02E		35,6			1,37		0,48	
03A	41,5	41,2	40,7	38,6	1,23	1,32	0,54	0,50
03B		41,8			1,31		0,50	
03C	33,1	32,8	32,3	31,5	1,39		0,48	
03D		43,4			1,36		0,49	
03E		44,1			1,30		0,51	
04A	35,4	35,3	34,8	30,8	1,26	1,31	0,52	0,50
04B		38,8			1,38		0,48	
04C	38,5	38,1	37,2	32,7	1,12		0,58	
04C		41,7			1,41		0,47	
04D		38,7			1,33		0,50	
04E		39,4			1,38		0,48	
05A	39,6	39,5	39,3	37,5	1,24	1,30	0,53	0,51
05B		40,5			1,40		0,47	
05C	44,3	43,5	43,1	38,0	1,15		0,57	
05C		42,4			1,30		0,51	
05D		39,7			1,32		0,50	
05E		37,0			1,39		0,47	
06A	30,9	30,7	30,0	26,8	1,38	1,36	0,48	0,49
06B		33,1			1,21		0,54	
06C	36,9	35,6	35,5	34,8	1,27		0,52	
06D		28,6			1,57		0,41	
06E		31,2			1,38		0,48	
07A	38,6	38,5	38,1	35,7	1,28	1,18	0,52	0,55
07B		41,6			1,18		0,55	
07C	30,7	29,9	29,6	29,5	1,18		0,56	
07C		38,6			1,14		0,57	
07D		36,8			1,23		0,54	
07E		39,7			1,08		0,59	
08A	34,7	33,6	32,8	32,7	1,18	1,23	0,56	0,54
08B		45,0			1,26		0,53	
08C	31,4	30,2	29,5	29,1	1,15		0,57	
08C		39,2			1,26		0,53	
08D		37,1			1,25		0,53	
08E		39,2			1,27		0,52	

Soil infiltration capacity

C1 0,9927
C2 0,5781

yellow= end level has been taken as start level for the next measurement

Qs (cm3/s)	240	195	165	207	195
Kfs (cm3/s)	78	85	89	104	94
Cylinder height (cm)	15,3				
Field and sample number	1a ######	1b	1c	1d	1e
Cylinder radius (cm)	9,4	18,6	18,6	18,6	18,6
Start level	12,6	12,5	9,0	10,5	11,0
Cylinder insertion depth (cm)	2,7	2,8	6,3	4,8	4,3
Depth of water ponding (cm)	8,6	9,3	6,3	7,1	7,8
Alfa-star	0,12	0,12	0,12	0,12	0,12

1a

min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
5	4,0	6,5	14,7	1764
10	0,0		12,6	1512
15	1,4		11,2	1344
20	1,9		10,7	1284
25	2,4		10,2	1224
30	3,8		8,8	1056
40	0,0	10,3	14,9	894
50	1,3		11,3	678
60	2,1		10,5	630
70	3,6		9,0	540
80	4,8		7,8	468
90	5,3		7,3	438
110	2,5	9,5	13,2	396
130	2,3		10,3	309
150	3,6		9,0	270
170	4,3		8,3	249
190	4,6		8,0	240

1b

min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
5	3,8		8,7	1044
10	6,0		6,5	780
15	7,6		4,9	588
20	8,5		4,0	480
25	8,7		3,8	456
30	9,8	11,6	3,6	432
35	9,4		3,1	372
40	9,7		2,8	336
50	7,5		5,0	300
60	7,0		5.5	330
70	7,4		5,1	306
90	6,0		6,5	195
110	6,0		6,5	195

1c

min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
5	1,0	2,6	14,4	1728
10	0,5	5,0	12,5	1500
15	0,0		9,0	1080
20	1,0		8,0	960
25	1,0		8,0	960
30	2,0		7,0	840
40	0,0	5,4	12,6	756
50	0,0	7,7	10,3	618
60	1,0		8,0	480
70	2,0		7,0	420
80	3,5		5,5	330
90	3,8		5,2	312
110	0,5		8,5	255
130	3,2		5,8	174
150	3,5		5,5	165

1d

min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
5	3,9		6,6	792
10	4,8		5,7	684
15	5,1		5,4	648
20	5,7		4,8	576
30	2,9		7,6	456
40	3,7		6,8	408
50	4,3		6,2	372
70	0,9		9,6	288
90	3,5		7,0	210
110	3,6		6,9	207

1e

min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
5	0,0	5,4	16,6	1992
10	2,0	8,3	11,7	1404
15	0,0		11,0	1320
20	2,1		8,9	1068
25	3,9		7,1	852
30	5,0		6,0	720
40	0,8		10,2	612
50	2,4		8,6	516
60	5,7		5,3	318
70	5,9		5,1	306
80	6,6		4,4	264
90	6,9		4,1	246
110	4,3		6,7	201
130	4,5		6,5	195

Qs (cm3/s)	129	102	165	198	117
Kfs (cm3/s)	62	45	83	105	60
Cylinder height (cm)	15,3				
Field and sample number	2a	2b	2c	2d	2e
Cylinder radius (cm)	18,6	18,6	18,6	18,6	18,6
Start level	10,5	11,5	10,1	9,5	9,5
Cylinder insertion depth (cm)	4,8	3,8	5,2	5,8	5,8
Depth of water ponding (cm)	8,4	9,8	7,4	6,2	7,6
Alfa-star	0,12	0,12	0,12	0,12	0,12

2a

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	7,0	3,5	420
10	7,9	2,6	312
20	6,8	3,7	222
40	4,3	6,2	186
60	5,3	5,2	156
80	5,9	4,6	138
100	6,2	4,3	129

2b

min	End level	Change in height (cm)	Infiltration rate (mm/h)
10	7,8	3,7	222
20	5,6	2,2	132
30	9,0	2,5	150
40	7,0	2,0	120
60	7,8	3,7	111
80	8,1	3,4	102

2c

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	7,1	3,0	360
10	5,0	2,1	252
15	8,0	2,1	252
20	6,2	1,8	216
30	6,4	3,7	222
40	3,5	2,9	174
60	4,5	5,6	168
80	4,6	5,5	165

2d

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	6,5	3,0	360
10	4,2	2,3	276
15	6,8	2,7	324
20	4,5	2,3	276
30	5,0	4,5	270
40	1,4	3,6	216
60	2,4	7,1	213
80	2,8	6,7	201
100	2,9	6,6	198

2e

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	5,0	4,5	540
10	5,9	3,6	432
15	6,4	3,1	372
20	4,0	2,4	288
30	4,4	5,1	306
40	5,5	4,0	240
50	6,4	3,1	186
70	4,5	5,0	150
90	5,5	4,0	120
110	5,6	3,9	117

Qs (cm3/s)	117	186	294	87	168
Kfs (cm3/s)	53	92	140	41	80
Cylinder height (cm)	15,3				
Field and sample number	3a	3b	3c	3d	3e
Cylinder radius (cm)	18,6	18,6	18,6	18,6	18,6
Start level	11,3	10,5	12,0	10,5	11,0
Cylinder insertion depth (cm)	4,0	4,8	3,3	4,8	4,3
Depth of water ponding (cm)	9,35	7,4	7,1	9,1	8,2
Alfa-star	0,12	0,12	0,12	0,12	0,12

3a

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	2,1	9,2	1104
10	5,4	5,9	708
15	6,6	4,7	564
20	7,9	3,4	408
25	8,4	2,9	348
30	6,1	2,3	276
40	6,3	5,0	300
50	6,7	4,6	276
70	5,0	6,3	189
90	6,2	5,1	153
110	6,8	4,5	135
130	7,3	4,0	120
150	7,4	3,9	117

3b

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	2,3	8,2	984
10	3,7	6,8	816
15	4,1	6,4	768
20	4,4	6,1	732
25	4,7	5,8	696
30	4,9	5,6	672
40	1,6	8,9	534
50	4,5	6,0	360
60	5,3	5,2	312
70	5,9	4,6	276
80	6,3	4,2	252
90	6,5	4,0	240
110	4,4	6,1	183
130	4,3	6,2	186

3c

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	4,7	7,3	876
10	7,4	4,6	552
15	7,9	4,1	492
20	4,6	3,3	396
25	7,8	4,2	504
30	4,5	3,3	396
40	5,2	6,8	408
50	6,0	6,0	360
60	6,6	5,4	324
70	6,5	5,5	330
90	2,0	10,0	300
110	2,2	9,8	294

3d

min	End level	Change in height	Infiltration rate (mm/h)
10	7,6	2,9	174
20	7,9	2,6	156
30	8,1	2,4	144
40	6,3	1,8	108
60	6,7	3,8	114
80	7,2	3,3	99
100	7,6	2,9	87
120	7,6	2,9	87

3e

min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
5	2,0	4,7	15,3	1836
10	2,7		8,3	996
15	3,7		7,3	876
20	4,9		6,1	732
25	5,3		5,7	684
30	5,7		5,3	636
40	2,4		8,6	516
50	4,8		6,2	372
60	6,3		4,7	282
70	6,6		4,4	264
80	6,9		4,1	246
90	3,5		6,9	414
110	4,6		6,4	192
130	5,2		5,8	174
150	5,4		5,6	168

Qs (cm3/s)	195	186	168	135	144
Kfs (cm3/s)	97	92	85	65	70
Cylinder height (cm)	15.3				
Field and sample number	4a	4b	4c	4d	4e
Cylinder radius (cm)	18,6	18,6	18,6	18,6	18,6
Start level	10,5	10,5	10,0	10,5	10,5
Cylinder insertion depth (cm)	4,8	4,8	5,3	4,8	4,8
Depth of water ponding (cm)	7,3	7,4	7,2	8,3	8,1
Alfa-star	0,12	0,12	0,12	0,12	0,12

4a

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	6,8	3,7	444
10	7,7	2,8	336
15	8,0	2,5	300
20	5,8	2,2	264
30	5,9	4,6	276
40	6,0	4,5	270
50	6,5	4,0	240
70	4,1	6,4	192
90	4,0	6,5	195

4b

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	6,2	4,3	516
10	7,6	2,9	348
15	7,9	2,6	312
20	5,8	2,1	252
30	6,1	4,4	264
40	6,7	3,8	228
50	7,1	3,4	204
60	7,4	3,1	186
70	4,3	3,1	186
90	4,3	6,2	186

4c

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	5,9	4,1	492
10	6,5	3,5	420
15	6,7	3,3	396
20	3,7	3,0	360
30	3,8	6,2	372
40	4,9	5,1	306
50	5,4	4,6	276
60	5,3	4,7	282
70	1,8	3,5	210
90	2,6	7,4	222
110	3,4	6,6	198
130	4,2	5,8	174
150	4,4	5,6	168

4d

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	7,7	2,8	336
10	5,3	2,4	288
15	8,7	1,8	216
20	7,0	1,7	204
30	7,7	2,8	168
40	5,1	2,6	156
60	5,6	4,9	147
80	6,0	4,5	135
100	6,0	4,5	135

4e

min	End level	Change in height (cm)	Infiltration rate (mm/h)
5	6,6	3,9	468
10	3,9	2,7	324
15	7,3	3,2	384
20	4,8	2,5	300
30	4,9	5,6	336
40	1,3	3,6	216
60	3,7	6,8	204
80	5,2	5,3	159
100	5,6	4,9	147
120	5,7	4,8	144

Qs (cm3/s)	105				102				90				162					204			
Kfs (cm3/s)	48				48				41				77					99			
Cylinder height (cm)	15,3																				
Field and sample number	5a				5b				5c				5d					5e			
Cylinder radius (cm)	18,6				18,6				18,6				18,6					18,6			
Start level	11,0				10,5				11,0				11,0					11,0			
Cylinder insertion depth (cm)	4,3				4,8				4,3				4,3					4,3			
Depth of water ponding (cm)	9,3				8,8				9,5				8,3					7,6			
Alfa-star	0,12				0,12				0,12				0,12					0,12			
	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)
	5	8,6	2,4	288	5	5,2	5,3	636	5	6,1	4,9	588	5	3,0	6,4	12,6	1512	5	1,4	9,6	1152
	10	6,5	2,1	252	10	6,3	4,2	504	10	7,5	3,5	420	10	3,9		7,1	852	10	4,5	6,5	780
	20	7,3	3,7	222	15	7,0	3,5	420	15	8,4	2,6	312	15	4,3		6,7	804	15	5,7	5,3	636
	30	7,8	3,2	192	20	7,3	3,2	384	20	6,3	2,1	252	20	5,1		5,9	708	20	6,3	4,7	564
	40	8,1	2,9	174	30	5,2	5,3	318	30	7,2	3,8	228	25	5,6		5,4	648	25	6,7	4,3	516
	50	8,3	2,7	162	40	5,3	5,2	312	40	7,9	3,1	186	30	5,9		5,1	612	30	7,2	3,8	456
	70	6,9	4,1	123	50	5,3	5,2	312	50	8,0	3,0	180	40	2,8		8,2	492	40	4,5	6,5	390
	90	7,3	3,7	111	60	1,2	4,1	246	60	8,4	2,6	156	50	3,0		8,0	480	50	5,4	5,6	336
	110	7,5	3,5	105	80	3,2	7,3	219	70	6,0	2,4	144	60	3,9		7,1	426	60	6,0	5,0	300
					100	5,4	5,1	153	90	6,7	4,3	129	70	4,3		6,7	402	70	6,1	4,9	294
					120	6,4	4,1	123	110	7,1	3,9	117	80	4,3		6,7	402	90	3,0	8,0	240
					140	6,9	3,6	108	130	7,5	3,5	105	90	5,4		5,6	336	110	4,0	7,0	210
					160	7,1	3,4	102	150	7,9	3,1	93	110	2,3		8,7	261	130	4,3	6,7	201
									170	8,0	3,0	90	130	4,5		6,5	195	150	4,2	6,8	204
													150	5,5		5,5	165				
													170	5,6		5,4	162				

Qs (cm3/s)	84				108				84					141					108			
Kfs (cm3/s)	27				35				25					46					35			
Cylinder height (cm)	15,3																					
Field and sample number	6a				6b				6c					6d					6e			
Cylinder radius (cm)	18,6				18,6				18,6					18,6					18,6			
Start level	10,0				10,0				11,0					10,0					10,0			
Cylinder insertion depth (cm)	5,3				5,3				4,3					5,3					5,3			
Depth of water ponding (cm)	8,6				8,2				9,6					7,65					8,2			
Alfa-star	0,04				0,04				0,04					0,04					0,04			
	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height	Infiltration rate (mm/h)	min	End level	Change in height	Infiltration rate (mm/h)
	5	7,4	2,6	312	5	4,2	5,8	696	5	3,0	8,9	10,1	1212	5	1,0	7,3	11,7	1404	5	4,3	5,7	684
	10	5,7	1,7	204	10	6,0	4,0	480	10	5,9		5,1	612	10	4,9		5,1	612	10	4,6	5,4	648
	15	8,6	1,4	168	15	7,6	2,4	288	15	8,0		3,0	360	15	6,0		4,0	480	15	4,8	5,2	624
	20	7,1	1,5	180	20	5,2	2,4	288	20	5,6		2,4	288	20	6,3		3,7	444	20	5,0	5,0	600
	30	7,4	2,6	156	25	7,8	2,2	264	25	9,0		2,0	240	25	6,5		3,5	420	25	5,3	4,7	564
	40	5,2	2,2	132	30	6,1	1,7	204	30	7,3		1,7	204	30	3,8		2,7	324	30	6,4	3,6	432
	50	8,1	1,9	114	40	7,2	2,8	168	40	8,2		2,8	168	40	4,8		5,2	312	40	3,8	6,2	372
	60	6,0	2,1	126	50	5,0	2,2	132	50	5,8		2,4	144	50	5,3		4,7	282	50	4,7	5,3	318
	80	6,9	3,1	93	60	7,7	2,3	138	60	8,4		2,6	156	60	5,5		4,5	270	60	5,0	5,0	300
	100	7,2	2,8	84	70	5,8	1,9	114	70	6,3		2,1	126	70	2,0		3,5	210	70	5,5	4,5	270
					90	6,2	3,8	114	90	7,0		4,0	120	80	6,0		4,0	240	80	5,7	4,3	258
					110	6,4	3,6	108	110	7,5		3,5	105	90	3,4		2,6	156	90	2,0	3,7	222
									130	8,0		3,0	90	110	4,5		5,5	165	110	4,2	5,8	174
									150	8,2		2,8	84	130	5,1		4,9	147	130	5,3	4,7	141
														150	5,3		4,7	141	150	5,8	4,2	126
																			170	6,2	3,8	114
																			190	6,4	3,6	108

Qs (cm3/s)	246				210					234				159					120				
Kfs (cm3/s)	79				69					72				53					39				
Cylinder height (cm)	15,3																						
Field and sample number	7a				7b					7c				7d					7e				
Cylinder radius (cm)	18,6				18,6					18,6				18,6					18,6				
Start level	11,0				10,5					11,5				10,0					10,0				
Cylinder insertion depth (cm)	4,3				4,8					3,8				5,3					5,3				
Depth of water ponding (cm)	6,9				7,0					7,6				7,4					8,0				
Alfa-star	0,04				0,04					0,04				0,04					0,04				
	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)
	5	4,7	6,3	756	5	2,0	7,8	11,2	1344	5	2,2	9,3	1116	5	1,0	7,5	11,5	1380	5	1,0	8,5	10,5	1260
	10	5,8	5,2	624	10	4,9		5,6	672	10	4,8	6,7	804	10	2,9		7,1	852	10	4,3		5,7	684
	15	6,7	4,3	516	15	5,8		4,7	564	15	6,0	5,5	660	15	3,9		6,1	732	15	6,1		3,9	468
	20	7,3	3,7	444	20	6,5		4,0	480	20	6,8	4,7	564	20	4,4		5,6	672	20	6,6		3,4	408
	25	7,6	3,4	408	25	6,9		3,6	432	25	7,2	4,3	516	25	5,3		4,7	564	25	7,0		3,0	360
	30	4,7	2,9	348	30	3,8		3,1	372	30	3,8	3,4	408	30	5,8		4,2	504	30	4,5		2,5	300
	40	5,3	5,7	342	40	5,9		4,6	276	40	5,5	6,0	360	40	2,9		7,1	426	40	4,9		5,1	306
	50	5,6	5,4	324	50	6,4		4,1	246	50	6,0	5,5	330	50	2,9		7,1	426	50	5,6		4,4	264
	60	6,0	5,0	300	60	6,4		4,1	246	60	6,8	4,7	282	60	3,3		6,7	402	60	6,4		3,6	216
	70	1,5	4,5	270	70	2,6		3,8	228	70	2,8	4,0	240	70	3,5		6,5	390	70	3,3		3,1	186
	80	6,4	4,6	276	80	6,8		3,7	222	80	7,1	4,4	264	80	3,8		6,2	372	80	6,8		3,2	192
	90	2,7	3,7	222	90	3,5		3,3	198	90	3,4	3,7	222	90	4,2		5,8	348	90	4,3		2,5	150
	110	2,9	8,1	243	110	3,5		7,0	210	110	3,9	7,6	228	110	0,9		9,1	273	110	5,3		4,7	141
	130	2,8	8,2	246						130	3,7	7,8	234	130	3,5		6,5	195	130	5,9		4,1	123
														150	4,9		5,1	153	150	6,0		4,0	120
														170	4,7		5,3	159					

Qs (cm3/s)	135					132				120					108					117			
Kfs (cm3/s)	69					64				59					55					58			
Cylinder height (cm)	15,3																						
Field and sample number	8a					8b				8c					8d					8e			
Cylinder radius (cm)	18,6					18,6				18,6					18,6					18,6			
Start level	9,5					10,5				10,0					9,5					10,0			
Cylinder insertion depth (cm)	5,8					4,8				5,3					5,8					5,3			
Depth of water ponding (cm)	7,3					8,3				8,0					7,7					8,1			
Alfa-star	0,12					0,12				0,12					0,12					0,12			
	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	2nd end level	Change in height (cm)	Infiltration rate (mm/h)	min	End level	Change in height (cm)	Infiltration rate (mm/h)
	5	1,5	4,4	13,1	1572	5	2,0	8,5	1020	5	1,5	5,0	13,5	1620	5	1,5	8,5	9,0	1080	5	0,0	10,0	1200
	10	0,5		9,0	1080	10	5,4	5,1	612	10	3,1		6,9	828	10	4,1		5,4	648	10	3,8	6,2	744
	15	4,5		5,0	600	15	6,6	3,9	468	15	5,4		4,6	552	15	5,7		3,8	456	15	4,9	5,1	612
	20	5,3		4,2	504	20	7,7	2,8	336	20	6,2		3,8	456	20	6,3		3,2	384	20	6,3	3,7	444
	25	5,9		3,6	432	25	7,9	2,6	312	25	7,3		2,7	324	25	6,7		2,8	336	25	6,9	3,1	372
	30	7,2		2,3	276	30	5,6	2,3	276	30	4,8		2,5	300	30	4,5		2,2	264	30	4,3	2,6	312
	40	3,8		5,7	342	40	5,9	4,6	276	40	5,4		4,6	276	40	5,1		4,4	264	40	5,0	5,0	300
	50	4,8		4,7	282	50	6,3	4,2	252	50	5,9		4,1	246	50	5,8		3,7	222	50	6,3	3,7	222
	60	5,3		4,2	252	60	6,6	3,9	234	60	6,1		3,9	234	60	6,2		3,3	198	60	6,6	3,4	204
	70	5,7		3,8	228	70	3,3	3,3	198	70	2,9		3,2	192	70	6,4		3,1	186	70	3,7	2,9	174
	80	6,3		3,2	192	80	7,0	3,5	210	80	6,5		3,5	210	80	6,7		2,8	168	80	7,4	2,6	156
	90	3,7		2,6	156	90	4,4	2,6	156	90	3,7		2,8	168	90	3,7		3,0	180	90	5,0	2,4	144
	110	4,4		5,1	153	110	5,5	5,0	150	110	5,5		4,5	135	110	4,1		5,4	162	110	5,5	4,5	135
	130	4,9		4,6	138	130	6,0	4,5	135	130	5,9		4,1	123	130	5,0		4,5	135	130	5,9	4,1	123
	150	5,0		4,5	135	150	6,1	4,4	132	150	6,0		4,0	120	150	5,8		3,7	111	150	6,3	3,7	111
															170	5,9		3,6	108	170	6,1	3,9	117

Soil cohesion

k (kg*cm) **15,206**

Field number	Sample number	Used torvane (1 small - 5 large)	Value torvane (Theta f)	Diameter vane (rod incl.) (D in cm)	Height vane (H in cm)	1/f (cm^3)	Shear strength (kg/cm^2)	Average of 3 (kg/cm^2)	Soil cohesion (kPa)	Average of 3
1a	1	middle	6,5	4,8	0,6	79,6	0,124	0,104	12,4	10,4
	2	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	3	middle	4,9	4,8	0,6	79,6	0,094		9,4	
	4	middle	3,5	4,8	0,6	79,6	0,067		6,7	
	5	middle	8,5	4,8	0,6	79,6	0,162		16,2	
1b	1	middle	5,0	4,8	0,6	79,6	0,095	0,104	9,5	10,4
	2	middle	5,5	4,8	0,6	79,6	0,105		10,5	
	3	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	4	middle	5,8	4,8	0,6	79,6	0,111		11,1	
	5	middle	6,7	4,8	0,6	79,6	0,128		12,8	
1c	1	middle	8,0	4,8	0,6	79,6	0,153	0,255	15,3	25,5
	2	middle	6,5	4,8	0,6	79,6	0,124		12,4	
	3	middle	7,3	4,8	0,6	79,6	0,139		13,9	
	4	2nd smallest	4,5	2,6	0,5	14,5	0,472		47,2	
	5	2nd smallest	5,3	2,6	0,5	14,5	0,555		55,5	
1d	1	middle	5,1	4,8	0,6	79,6	0,097	0,102	9,7	10,2
	2	middle	4,4	4,8	0,6	79,6	0,084		8,4	
	3	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	4	middle	6,8	4,8	0,6	79,6	0,130		13,0	
	5	middle	6,0	4,8	0,6	79,6	0,115		11,5	
1e	1	middle	6,4	4,8	0,6	79,6	0,122	0,101	12,2	10,1
	2	middle	3,9	4,8	0,6	79,6	0,074		7,4	
	3	middle	4,9	4,8	0,6	79,6	0,094		9,4	
	4	middle	7,7	4,8	0,6	79,6	0,147		14,7	
	5	middle	4,5	4,8	0,6	79,6	0,086		8,6	
2a	1	middle	3,5	4,8	0,6	79,6	0,067	0,086	6,7	8,6
	2	middle	4,6	4,8	0,6	79,6	0,088		8,8	
	3	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	4	middle	4,4	4,8	0,6	79,6	0,084		8,4	
	5	middle	5,2	4,8	0,6	79,6	0,099		9,9	
2b	1	2nd smallest	3,7	2,6	0,5	14,5	0,388	0,402	38,8	40,2
	2	2nd smallest	6,1	2,6	0,5	14,5	0,639		63,9	
	3	2nd smallest	3,0	2,6	0,5	14,5	0,314		31,4	
	4	2nd smallest	4,4	2,6	0,5	14,5	0,461		46,1	
	5	2nd smallest	3,4	2,6	0,5	14,5	0,356		35,6	
2c	1	2nd smallest	2,3	2,6	0,5	14,5	0,241	0,142	24,1	14,2
	2	2nd smallest	2,4	2,6	0,5	14,5	0,251		25,1	
	3	middle	4,6	4,8	0,6	79,6	0,088		8,8	
	4	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	5	middle	5,1	4,8	0,6	79,6	0,097		9,7	
2d	1	middle	5,2	4,8	0,6	79,6	0,099	0,112	9,9	11,2
	2	middle	6,2	4,8	0,6	79,6	0,118		11,8	
	3	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	4	middle	6,3	4,8	0,6	79,6	0,120		12,0	
	5	middle	6,2	4,8	0,6	79,6	0,118		11,8	
2e	1	middle	6,3	4,8	0,6	79,6	0,120	0,113	12,0	11,3
	2	middle	5,3	4,8	0,6	79,6	0,101		10,1	
	3	middle	5,5	4,8	0,6	79,6	0,105		10,5	
	4	middle	6,4	4,8	0,6	79,6	0,122		12,2	
	5	middle	5,9	4,8	0,6	79,6	0,113		11,3	

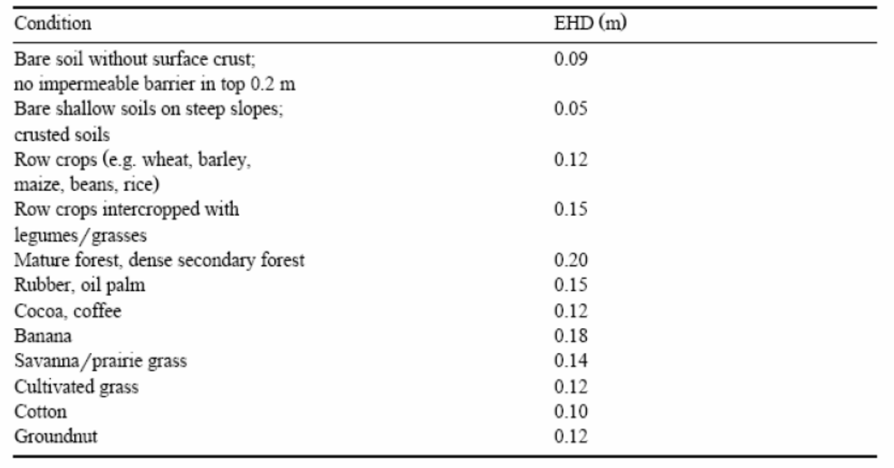
Field number	Sample number	Used torvane (1 small - 5 large)	Value torvane (Theta f)	Diameter vane (rod incl.) (D in cm)	Height vane (H in cm)	1/f (cm^3)	Shear strength (kg/cm^2)	Average of 3 (kg/cm^2)	Soil cohesion (kPa)	Average of 3
3a	1	middle	3,5	4,8	0,6	79,6	0,067	0,078	6,7	7,8
	2	middle	3,5	4,8	0,6	79,6	0,067		6,7	
	3	middle	4,3	4,8	0,6	79,6	0,082		8,2	
	4	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	5	middle	5,0	4,8	0,6	79,6	0,095		9,5	
3b	1	middle	3,0	4,8	0,6	79,6	0,057	0,080	5,7	8,0
	2	middle	3,4	4,8	0,6	79,6	0,065		6,5	
	3	middle	4,7	4,8	0,6	79,6	0,090		9,0	
	4	middle	4,4	4,8	0,6	79,6	0,084		8,4	
	5	middle	6,0	4,8	0,6	79,6	0,115		11,5	
3c	1	middle	4,6	4,8	0,6	79,6	0,088	0,099	8,8	9,9
	2	middle	5,6	4,8	0,6	79,6	0,107		10,7	
	3	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	4	middle	4,3	4,8	0,6	79,6	0,082		8,2	
	5	middle	5,6	4,8	0,6	79,6	0,107		10,7	
3d	1	middle	5,1	4,8	0,6	79,6	0,097	0,101	9,7	10,1
	2	middle	6,0	4,8	0,6	79,6	0,115		11,5	
	3	middle	5,8	4,8	0,6	79,6	0,111		11,1	
	4	middle	4,8	4,8	0,6	79,6	0,092		9,2	
	5	middle	5,0	4,8	0,6	79,6	0,095		9,5	
3e	1	middle	5,1	4,8	0,6	79,6	0,097	0,094	9,7	9,4
	2	middle	4,9	4,8	0,6	79,6	0,094		9,4	
	3	middle	4,8	4,8	0,6	79,6	0,092		9,2	
	4	middle	5,2	4,8	0,6	79,6	0,099		9,9	
	5	middle	4,5	4,8	0,6	79,6	0,086		8,6	
4a	1	middle	6,5	4,8	0,6	79,6	0,124	0,105	12,4	10,5
	2	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	3	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	4	middle	5,6	4,8	0,6	79,6	0,107		10,7	
	5	middle	5,9	4,8	0,6	79,6	0,113		11,3	
4b	1	middle	6,3	4,8	0,6	79,6	0,120	0,118	12,0	11,8
	2	middle	6,2	4,8	0,6	79,6	0,118		11,8	
	3	middle	6,4	4,8	0,6	79,6	0,122		12,2	
	4	middle	5,1	4,8	0,6	79,6	0,097		9,7	
	5	middle	6,0	4,8	0,6	79,6	0,115		11,5	
4c	1	2nd smallest	3,4	2,6	0,5	14,5	0,356	0,297	35,6	29,7
	2	middle	7,3	4,8	0,6	79,6	0,139		13,9	
	3	2nd smallest	3,3	2,6	0,5	14,5	0,346		34,6	
	4	2nd smallest	2,2	2,6	0,5	14,5	0,231		23,1	
	5	2nd smallest	3,0	2,6	0,5	14,5	0,314		31,4	
4d	1	middle	7,2	4,8	0,6	79,6	0,138	0,133	13,8	13,3
	2	middle	6,7	4,8	0,6	79,6	0,128		12,8	
	3	middle	7,0	4,8	0,6	79,6	0,134		13,4	
	4	middle	6,6	4,8	0,6	79,6	0,126		12,6	
	5	middle	7,4	4,8	0,6	79,6	0,141		14,1	
4e	1	middle	5,5	4,8	0,6	79,6	0,105	0,116	10,5	11,6
	2	middle	5,6	4,8	0,6	79,6	0,107		10,7	
	3	middle	5,8	4,8	0,6	79,6	0,111		11,1	
	4	middle	6,8	4,8	0,6	79,6	0,130		13,0	
	5	middle	7,8	4,8	0,6	79,6	0,149		14,9	

Field number	Sample number	Used torvane (1 small - 5 large)	Value torvane (Theta f)	Diameter vane (rod incl.) (D in cm)	Height vane (H in cm)	1/f (cm^3)	Shear strength (kg/cm^2)	Average of 3 (kg/cm^2)	Soil cohesion (kPa)	Average of 3
5a	1	middle	5,1	4,8	0,6	79,6	0,097	0,085	9,7	8,5
	2	middle	4,6	4,8	0,6	79,6	0,088		8,8	
	3	middle	4,0	4,8	0,6	79,6	0,076		7,6	
	4	middle	3,8	4,8	0,6	79,6	0,073		7,3	
	5	middle	4,7	4,8	0,6	79,6	0,090		9,0	
5b	1	middle	4,8	4,8	0,6	79,6	0,092	0,100	9,2	10,0
	2	middle	5,6	4,8	0,6	79,6	0,107		10,7	
	3	middle	6,2	4,8	0,6	79,6	0,118		11,8	
	4	middle	5,3	4,8	0,6	79,6	0,101		10,1	
	5	middle	4,8	4,8	0,6	79,6	0,092		9,2	
5c	1	middle	5,8	4,8	0,6	79,6	0,111	0,115	11,1	11,5
	2	middle	5,3	4,8	0,6	79,6	0,101		10,1	
	3	middle	5,9	4,8	0,6	79,6	0,113		11,3	
	4	middle	6,3	4,8	0,6	79,6	0,120		12,0	
	5	middle	7,4	4,8	0,6	79,6	0,141		14,1	
5d	1	middle	3,7	4,8	0,6	79,6	0,071	0,076	7,1	7,6
	2	middle	4,2	4,8	0,6	79,6	0,080		8,0	
	3	middle	3,6	4,8	0,6	79,6	0,069		6,9	
	4	middle	5,1	4,8	0,6	79,6	0,097		9,7	
	5	middle	4,0	4,8	0,6	79,6	0,076		7,6	
5e	1	middle	5,3	4,8	0,6	79,6	0,101	0,106	10,1	10,6
	2	middle	7,1	4,8	0,6	79,6	0,136		13,6	
	3	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	4	middle	5,9	4,8	0,6	79,6	0,113		11,3	
	5	middle	5,3	4,8	0,6	79,6	0,101		10,1	
6a	1	middle	4,0	4,8	0,6	79,6	0,076	0,083	7,6	8,3
	2	middle	3,9	4,8	0,6	79,6	0,074		7,4	
	3	middle	3,5	4,8	0,6	79,6	0,067		6,7	
	4	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	5	middle	5,1	4,8	0,6	79,6	0,097		9,7	
6b	1	middle	3,1	4,8	0,6	79,6	0,059	0,070	5,9	7,0
	2	middle	3,5	4,8	0,6	79,6	0,067		6,7	
	3	middle	3,8	4,8	0,6	79,6	0,073		7,3	
	4	middle	3,7	4,8	0,6	79,6	0,071		7,1	
	5	middle	4,5	4,8	0,6	79,6	0,086		8,6	
6c	1	middle	3,6	4,8	0,6	79,6	0,069	0,071	6,9	7,1
	2	middle	3,0	4,8	0,6	79,6	0,057		5,7	
	3	middle	3,0	4,8	0,6	79,6	0,057		5,7	
	4	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	5	middle	5,1	4,8	0,6	79,6	0,097		9,7	
6d	1	middle	6,1	4,8	0,6	79,6	0,116	0,117	11,6	11,7
	2	middle	4,6	4,8	0,6	79,6	0,088		8,8	
	3	middle	5,6	4,8	0,6	79,6	0,107		10,7	
	4	middle	6,7	4,8	0,6	79,6	0,128		12,8	
	5	middle	6,8	4,8	0,6	79,6	0,130		13,0	
6e	1	middle	6,3	4,8	0,6	79,6	0,120	0,111	12,0	11,1
	2	middle	5,7	4,8	0,6	79,6	0,109		10,9	
	3	middle	6,9	4,8	0,6	79,6	0,132		13,2	
	4	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	5	middle	4,5	4,8	0,6	79,6	0,086		8,6	

Field number	Sample number	Used torvane (1 small - 5 large)	Value torvane (Theta f)	Diameter vane (rod incl.) (D in cm)	Height vane (H in cm)	1/f (cm^3)	Shear strength (kg/cm^2)	Average of 3 (kg/cm^2)	Soil cohesion (kPa)	Average of 3
7a	1	middle	6,0	4,8	0,6	79,6	0,115	0,102	11,5	10,2
	2	middle	5,3	4,8	0,6	79,6	0,101		10,1	
	3	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	4	middle	5,5	4,8	0,6	79,6	0,105		10,5	
	5	middle	5,3	4,8	0,6	79,6	0,101		10,1	
7b	1	middle	8,6	4,8	0,6	79,6	0,164	0,136	16,4	13,6
	2	middle	7,1	4,8	0,6	79,6	0,136		13,6	
	3	middle	5,2	4,8	0,6	79,6	0,099		9,9	
	4	middle	7,8	4,8	0,6	79,6	0,149		14,9	
	5	middle	6,4	4,8	0,6	79,6	0,122		12,2	
7c	1	middle	5,3	4,8	0,6	79,6	0,101	0,098	10,1	9,8
	2	middle	5,5	4,8	0,6	79,6	0,105		10,5	
	3	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	4	middle	4,6	4,8	0,6	79,6	0,088		8,8	
	5	middle	6,0	4,8	0,6	79,6	0,115		11,5	
7d	1	middle	4,4	4,8	0,6	79,6	0,084	0,088	8,4	8,8
	2	middle	4,3	4,8	0,6	79,6	0,082		8,2	
	3	middle	4,1	4,8	0,6	79,6	0,078		7,8	
	4	middle	5,2	4,8	0,6	79,6	0,099		9,9	
	5	middle	5,2	4,8	0,6	79,6	0,099		9,9	
7e	1	middle	5,6	4,8	0,6	79,6	0,107	0,101	10,7	10,1
	2	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	3	middle	4,8	4,8	0,6	79,6	0,092		9,2	
	4	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	5	middle	6,5	4,8	0,6	79,6	0,124		12,4	
8a	1	middle	3,8	4,8	0,6	79,6	0,073	0,086	7,3	8,6
	2	middle	5,0	4,8	0,6	79,6	0,095		9,5	
	3	middle	4,2	4,8	0,6	79,6	0,080		8,0	
	4	middle	5,7	4,8	0,6	79,6	0,109		10,9	
	5	middle	4,3	4,8	0,6	79,6	0,082		8,2	
8b	1	middle	4,6	4,8	0,6	79,6	0,088	0,080	8,8	8,0
	2	middle	3,8	4,8	0,6	79,6	0,073		7,3	
	3	middle	4,2	4,8	0,6	79,6	0,080		8,0	
	4	middle	5,3	4,8	0,6	79,6	0,101		10,1	
	5	middle	3,8	4,8	0,6	79,6	0,073		7,3	
8c	1	middle	5,4	4,8	0,6	79,6	0,103	0,094	10,3	9,4
	2	middle	3,7	4,8	0,6	79,6	0,071		7,1	
	3	middle	4,8	4,8	0,6	79,6	0,092		9,2	
	4	middle	5,7	4,8	0,6	79,6	0,109		10,9	
	5	middle	4,5	4,8	0,6	79,6	0,086		8,6	
8d	1	middle	3,9	4,8	0,6	79,6	0,074	0,092	7,4	9,2
	2	middle	6,5	4,8	0,6	79,6	0,124		12,4	
	3	middle	4,5	4,8	0,6	79,6	0,086		8,6	
	4	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	5	middle	4,5	4,8	0,6	79,6	0,086		8,6	
8e	1	middle	6,2	4,8	0,6	79,6	0,118	0,118	11,8	11,8
	2	middle	5,4	4,8	0,6	79,6	0,103		10,3	
	3	middle	7,0	4,8	0,6	79,6	0,134		13,4	
	4	middle	6,5	4,8	0,6	79,6	0,124		12,4	
	5	middle	5,9	4,8	0,6	79,6	0,113		11,3	

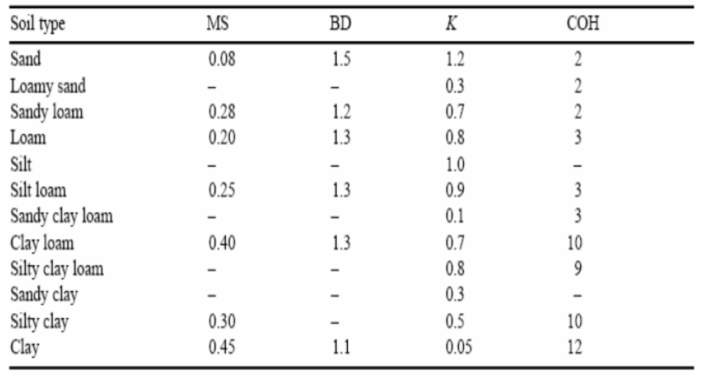
Appendix D

Recommended values for the Effective Hydrological Depth (m) in the MMF method for predicting soil loss (Morgan, 2001).



Condition	EHD (m)
Bare soil without surface crust; no impermeable barrier in top 0.2 m	0.09
Bare shallow soils on steep slopes; crusted soils	0.05
Row crops (e.g. wheat, barley, maize, beans, rice)	0.12
Row crops intercropped with legumes / grasses	0.15
Mature forest, dense secondary forest	0.20
Rubber, oil palm	0.15
Cocoa, coffee	0.12
Banana	0.18
Savanna / prairie grass	0.14
Cultivated grass	0.12
Cotton	0.10
Groundnut	0.12

Typical values for soil parameters used in the MMF method predicting soil loss (Morgan et al., 1982; Morgan, 2001).



Soil type	MS	BD	*K*	COH
Sand	0.08	1.5	1.2	2
Loamy sand	–	–	0.3	2
Sandy loam	0.28	1.2	0.7	2
Loam	0.20	1.3	0.8	3
Silt	–	–	1.0	–
Silt loam	0.25	1.3	0.9	3
Sandy clay loam	–	–	0.1	3
Clay loam	0.40	1.3	0.7	10
Silty clay loam	–	–	0.8	9
Sandy clay	–	–	0.3	–
Silty clay	0.30	–	0.5	10
Clay	0.45	1.1	0.05	12

Typical values for plant parameters used in the MMF method of predicting soil loss (Morgan et al., 1982).

Plant/crop	**A**	**Et/Eo**	**C**
Wet rice		1.35	0.1-0.2
Wheat	0.43	0.59-0.61	0.1-0.2 (winter sown) 0.2-0.4 (spring sown)
Maize	0.25	0.67-0.70	0.2
Barley	0.30	0.56-0.60	0.1-0.2
Millet/sorghum		0.62	0.4-0.9
Cassava/yam			0.2-0.8
Potato	0.12	0.70-0.80	0.2-0.3
Beans	0.20-0.25	0.62-0.69	0.2-0.4
Groundnuts	0.25	0.50-0.87	0.2-0.8
Cabbage/Brussels sprouts	0.17	0.45-0.70	
Banana		0.70-0.77	
Tea		0.85-1.00	0.1-0.3
Coffee		0.50-1.00	0.1-0.3
Cocoa		1.00	0.1-0.3
Sugar cane		0.68-0.80	
Suger beet	0.12-0.22	0.73-0.75	0.2-0.3
Rubber	0.20-0.30	0.90	0.2
Oil palm	0.30	1.20	0.1-0.3
Cotton		0.63-0.69	0.3-0.7
Cultivated grass		0.85-0.87	0.004-0.01
Prairie/savanna grass	0.25-0.40	0.80-0.95	0.01-0.10
Forest/woodland		0.90-1.00	
-coniferous and tropical	0.25-0.35		
-temperate broad-leaved	0.15-0.25		
-with undergrowth			0.001-0.002
-no undergrowth			0.001-0.004
Bare soil		0.05	1.00

C values should be adjusted by the following P ratios if mechanical soil conservation measures are practiced: contouring, multiply by 0.6; contour strip-cropping, multiply by 0.35; terracing, multiply by 0.15 (Morgan et al., 1982)

Appendix E

Bulk density

Field	own measurement	Wickama (2010) (0-15) upslope	Wickama (2010) (15-30) upslope	Wickama (2010) (0-15) downslope	Wickama (2010) (15-30) downslope	Average
1	1,55	1,47	1,69	1,44	1,35	1,50
2	1,20	1,28	1,37	1,33	1,25	1,29
3	1,04	1,25	1,26	1,29	1,27	1,27
4	1,20	1,30	1,24	1,28	1,30	1,26
5	1,25	1,20	1,21	1,20	1,16	1,20
6	1,22	1,12	1,20	1,15	1,15	1,17

Soil moisture content at field capacity

Field	own measurement	Wickama (2010) (0-15) upslope	Wickama (2010) (15-30) upslope	Wickama (2010) (0-15) downslope	Wickama (2010) (15-30) downslope	Average
1	20,9	32,7	25,8	23,7	33,4	27,3
2	25,2	33,1	38,5	35,5	35,3	33,5
3	25,1	30,3	31,4	36,0	31,4	32,3
4	26,0	34,6	34,5	35,9	34,5	33,1
5	28,3	36,6	38,8	36,3	37,4	35,5
6	28,0	35,0	35,9	34,8	34,5	33,6

Soil cohesion

k (kg*cm) 15,206

Field number	Sample number	Used torvane (1 small - 5 large)	Value torvane (Theta f)	Diameter vane (rod incl.) (D in cm)	Height vane (H in cm)	1/f (cm^3)	Shear strength (kg/cm^2)	Average of 3	Soil cohesion (kPa)	Average of 3
1a	1	middle	3,4	4,8	0,6	79,62	0,06	0,096	64,9	96,1
	2	middle	5,8	4,8	0,6	79,62	0,11		110,8	
	3	middle	4,9	4,8	0,6	79,62	0,09		93,6	
	4	middle	6,0	4,8	0,6	79,62	0,11		114,6	
	5	middle	4,4	4,8	0,6	79,62	0,08		84,0	
1b	1	middle	4,5	4,8	0,6	79,62	0,09	0,081	85,9	80,8
	2	middle	4,8	4,8	0,6	79,62	0,09		91,7	
	3	middle	4,4	4,8	0,6	79,62	0,08		84,0	
	4	middle	3,7	4,8	0,6	79,62	0,07		70,7	
	5	middle	3,8	4,8	0,6	79,62	0,07		72,6	
1c	1	middle	4,7	4,8	0,6	79,62	0,09	0,097	89,8	97,4
	2	middle	5,1	4,8	0,6	79,62	0,10		97,4	
	3	middle	5,6	4,8	0,6	79,62	0,11		106,9	
	4	middle	4,6	4,8	0,6	79,62	0,09		87,9	
	5	middle	5,5	4,8	0,6	79,62	0,11		105,0	
1d	1	middle	5,2	4,8	0,6	79,62	0,10	0,101	99,3	101,2
	2	middle	5,0	4,8	0,6	79,62	0,10		95,5	
	3	middle	6,1	4,8	0,6	79,62	0,12		116,5	
	4	middle	5,7	4,8	0,6	79,62	0,11		108,9	
	5	middle	4,9	4,8	0,6	79,62	0,09		93,6	
1e	1	middle	5,4	4,8	0,6	79,62	0,10	0,113	103,1	112,7
	2	middle	4,7	4,8	0,6	79,62	0,09		89,8	
	3	middle	6,4	4,8	0,6	79,62	0,12		122,2	
	4	middle	5,9	4,8	0,6	79,62	0,11		112,7	
	5	middle	6,9	4,8	0,6	79,62	0,13		131,8	
2a	1	middle	4,3	4,8	0,6	79,62	0,08	0,083	82,1	82,8
	2	middle	4,8	4,8	0,6	79,62	0,09		91,7	
	3	middle	3,9	4,8	0,6	79,62	0,07		74,5	
	4	middle	4,1	4,8	0,6	79,62	0,08		78,3	
	5	middle	4,6	4,8	0,6	79,62	0,09		87,9	
2b	1	middle	5,1	4,8	0,6	79,62	0,10	0,108	97,4	108,2
	2	middle	5,9	4,8	0,6	79,62	0,11		112,7	
	3	middle	5,2	4,8	0,6	79,62	0,10		99,3	
	4	middle	5,9	4,8	0,6	79,62	0,11		112,7	
	5	middle	6,5	4,8	0,6	79,62	0,12		124,1	
2c	1	middle	3,5	4,8	0,6	79,62	0,07	0,094	66,8	93,6
	2	middle	4,4	4,8	0,6	79,62	0,08		84,0	
	3	middle	4,8	4,8	0,6	79,62	0,09		91,7	
	4	middle	5,6	4,8	0,6	79,62	0,11		106,9	
	5	middle	5,5	4,8	0,6	79,62	0,11		105,0	
2d	1	middle	4,7	4,8	0,6	79,62	0,09	0,104	89,8	103,8
	2	middle	5,7	4,8	0,6	79,62	0,11		108,9	
	3	middle	5,2	4,8	0,6	79,62	0,10		99,3	
	4	middle	6,6	4,8	0,6	79,62	0,13		126,0	
	5	middle	5,4	4,8	0,6	79,62	0,10		103,1	
2e	1	middle	5,0	4,8	0,6	79,62	0,10	0,097	95,5	97,4
	2	middle	4,3	4,8	0,6	79,62	0,08		82,1	
	3	middle	6,0	4,8	0,6	79,62	0,11		114,6	
	4	middle	3,8	4,8	0,6	79,62	0,07		72,6	
	5	middle	6,2	4,8	0,6	79,62	0,12		118,4	

Field number	Sample number	Used torvane (1 small - 5 large)	Value torvane (Theta f)	Diameter vane (rod incl.) (D in cm)	Height vane (H in cm)	1/f (cm^3)	Shear strength (kg/cm^2)	Average of 3	Soil cohesion (kPa)	Average of 3
3a	1	middle	4,9	4,8	0,6	79,62	0,09	0,097	93,6	96,8
	2	middle	5,4	4,8	0,6	79,62	0,10		103,1	
	3	middle	4,9	4,8	0,6	79,62	0,09		93,6	
	4	middle	7,4	4,8	0,6	79,62	0,14		141,3	
	5	middle	4,6	4,8	0,6	79,62	0,09		87,9	
3b	1	middle	4,9	4,8	0,6	79,62	0,09	0,101	93,6	100,6
	2	middle	4,5	4,8	0,6	79,62	0,09		85,9	
	3	middle	5,4	4,8	0,6	79,62	0,10		103,1	
	4	middle	6,0	4,8	0,6	79,62	0,11		114,6	
	5	middle	5,5	4,8	0,6	79,62	0,11		105,0	
3c	1	middle	3,5	4,8	0,6	79,62	0,07	0,088	66,8	88,5
	2	middle	2,5	4,8	0,6	79,62	0,05		47,7	
	3	middle	6,0	4,8	0,6	79,62	0,11		114,6	
	4	middle	5,0	4,8	0,6	79,62	0,10		95,5	
	5	middle	5,4	4,8	0,6	79,62	0,10		103,1	
3d	1	middle	5,6	4,8	0,6	79,62	0,11	0,111	106,9	110,8
	2	middle	6,0	4,8	0,6	79,62	0,11		114,6	
	3	middle	6,7	4,8	0,6	79,62	0,13		128,0	
	4	middle	5,0	4,8	0,6	79,62	0,10		95,5	
	5	middle	5,8	4,8	0,6	79,62	0,11		110,8	
3e	1	middle	4,3	4,8	0,6	79,62	0,08	0,111	82,1	110,8
	2	middle	6,3	4,8	0,6	79,62	0,12		120,3	
	3	middle	6,1	4,8	0,6	79,62	0,12		116,5	
	4	middle	5,0	4,8	0,6	79,62	0,10		95,5	
	5	middle	6,8	4,8	0,6	79,62	0,13		129,9	
4a	1	middle	6,2	4,8	0,6	79,62	0,12	0,096	118,4	96,1
	2	middle	5,1	4,8	0,6	79,62	0,10		97,4	
	3	middle	4,4	4,8	0,6	79,62	0,08		84,0	
	4	middle	5,3	4,8	0,6	79,62	0,10		101,2	
	5	middle	4,7	4,8	0,6	79,62	0,09		89,8	
4b	1	middle	5,3	4,8	0,6	79,62	0,10	0,104	101,2	103,8
	2	middle	7,0	4,8	0,6	79,62	0,13		133,7	
	3	middle	4,5	4,8	0,6	79,62	0,09		85,9	
	4	middle	3,7	4,8	0,6	79,62	0,07		70,7	
	5	middle	6,5	4,8	0,6	79,62	0,12		124,1	
4c	1	middle	4,5	4,8	0,6	79,62	0,09	0,088	85,9	88,5
	2	middle	4,4	4,8	0,6	79,62	0,08		84,0	
	3	middle	5,0	4,8	0,6	79,62	0,10		95,5	
	4	middle	3,9	4,8	0,6	79,62	0,07		74,5	
	5	middle	5,4	4,8	0,6	79,62	0,10		103,1	
4d	1	middle	5,4	4,8	0,6	79,62	0,10	0,101	103,1	100,6
	2	middle	5,2	4,8	0,6	79,62	0,10		99,3	
	3	middle	4,9	4,8	0,6	79,62	0,09		93,6	
	4	middle	5,5	4,8	0,6	79,62	0,11		105,0	
	5	middle	5,2	4,8	0,6	79,62	0,10		99,3	
4e	1	middle	4,9	4,8	0,6	79,62	0,09	0,088	93,6	88,5
	2	middle	4,8	4,8	0,6	79,62	0,09		91,7	
	3	middle	4,2	4,8	0,6	79,62	0,08		80,2	
	4	middle	4,0	4,8	0,6	79,62	0,08		76,4	
	5	middle	5,2	4,8	0,6	79,62	0,10		99,3	

Soil texture (Wickama, 2010)

Field	Depth (Cm)		Soil texture				
			Clay%	Silt%	Fine sand%	Coarse sand%	Category
1-MAGOGGO	0-15cm	upslope	45	11	4	40	Clay
1-MAGOGGO	15-30cm	upslope	49	14	4	33	Clay
1-MAGOGGO	0-15cm	downslope	46	12	3	39	Clay
1-MAGOGGO	15-30cm	downslope	50	14	4	32	Clay
2-AMIRI	0-15cm	upslope	43	12	2	43	Sandy Clay/Clay
2-AMIRI	15-30cm	upslope	51	14	3	32	Clay
2-AMIRI	0-15cm	downslope	46	10	2	42	Clay
2-AMIRI	15-30cm	downslope	52	13	2	33	Clay
3-ATHUMANI	0-15cm	upslope	44	12	3	43	Sandy Clay/Clay
3-ATHUMANI	15-30cm	upslope	49	14	2	35	Clay
3-ATHUMANI	0-15cm	downslope	47	13	2	38	Clay
3-ATHUMANI	15-30cm	downslope	54	16	2	28	Clay
4-SHABANI	0-15cm	upslope	46	11	3	40	Clay
4-SHABANI	15-30cm	upslope	52	12	3	33	Clay
4-SHABANI	0-15cm	downslope	48	13	3	36	Clay
4-SHABANI	15-30cm	downslope	54	15	2	29	Clay
5-IDDI	0-15cm	upslope	34	7	3	56	Sandy clay loam
5-IDDI	15-30cm	upslope	39	4	2	55	Sandy clay
5-IDDI	0-15cm	downslope	37	9	4	50	Sandy clay
5-IDDI	15-30cm	downslope	41	11	3	45	Sandy clay
6-NYANGASA	0-15cm	upslope	36	9	4	51	Sandy clay
6-NYANGASA	15-30cm	upslope	40	4	3	53	Sandy clay
6-NYANGASA	0-15cm	downslope	49	12	5	34	Clay
6-NYANGASA	15-30cm	downslope	51	14	4	31	Clay

Erosion rates long rains (Wickama, 2010)

Name of field and farmer	Ger-lach no.	Date Runoff collected	Volume of runoff collected (L)	LAB No	Wt Dish + residue	Wt E.Dish	Wt of Residue (g)	Vol. of runoff in Lab analysis (cc)	% of sediments in runoff	Volume of sediments in runoff (L)	Bulk density of top soil (g/cc)	Wt. of sediments in runoff collected (g)	Total transport field	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
1-MAGOGGO	1	4/4/2010	7,23	52659	34,5	34,3	0,2	30,0	0,67	0,05	1,50	72,3	129,0	41	3,15	17,64	7	0,6133	17,48	0,43	2,23	77,59
1-MAGOGGO	2	4/4/2010	3,25	52660	33,6	33,6	0,0	30,0	0,00	0,00	1,50	0,0										
1-MAGOGGO	3	4/4/2010	4,34	52661	31,6	31,4	0,2	30,0	0,67	0,03	1,50	43,4										
1-MAGOGGO	4	4/4/2010	2,66	52662	32,3	32,2	0,1	30,0	0,33	0,01	1,50	13,3										
1-MAGOGGO	1	8/4/2010	9,56	52643	34,6	34,4	0,2	30,0	0,67	0,06	1,50	95,6	349,2	41	8,52				40,97	1,00		
1-MAGOGGO	2	8/4/2010	19,32	52644	39,7	39,5	0,2	30,0	0,67	0,13	1,50	193,1										
1-MAGOGGO	3	8/4/2010	5,67	52645	31,6	31,5	0,1	30,0	0,33	0,02	1,50	28,3										
1-MAGOGGO	4	8/4/2010	6,42	52646	34,5	34,4	0,1	30,0	0,33	0,02	1,50	32,1										
1-MAGOGGO	1	11/4/2010	20,18	52635	34,4	34,3	0,1	30,0	0,33	0,07	1,50	100,9	374,2	41	9,13				50,54	1,23		
1-MAGOGGO	2	11/4/2010	24,32	52636	34,5	34,3	0,2	30,0	0,67	0,16	1,50	243,1										
1-MAGOGGO	3	11/4/2010	3,26	52637	34,4	34,3	0,1	30,0	0,33	0,01	1,50	16,3										
1-MAGOGGO	4	11/4/2010	2,78	52638	40,3	40,2	0,1	30,0	0,33	0,01	1,50	13,9										
2-AMIRI	1	29/3/2010	20,23	52611	31,8	31,4	0,4	30,0	1,33	0,27	1,29	347,1	544,1	35	15,55	61,79	13	1,15651	45,74	1,31	2,62	48,96
2-AMIRI	2	29/3/2010	2,54	52612	33,5	33,4	0,1	30,0	0,33	0,01	1,29	10,9										
2-AMIRI	1	29/3/2010	20,43	52669	39,0	38,8	0,2	30,0	0,67	0,14	1,29	175,3										
2-AMIRI	2	29/3/2010	2,54	52670	35,1	35,0	0,1	30,0	0,33	0,01	1,29	10,9										
2-AMIRI	1	4/4/2010	14,69	52639	35,8	35,0	0,8	30,0	2,67	0,39	1,29	504,1	832,3	35	23,78				32,35	0,92		
2-AMIRI	2	4/4/2010	3,13	52640	34,9	34,8	1,0	30,0	3,33	0,10	1,29	134,3										
2-AMIRI	3	4/4/2010	7,67	52641	34,6	34,4	0,5	30,0	1,67	0,13	1,29	164,5										
2-AMIRI	4	4/4/2010	6,86	52642	27,7	27,6	0,1	30,0	0,33	0,02	1,29	29,4										
2-AMIRI	1	8/4/2010	16,12	52607	35,7	34,4	1,3	30,0	4,33	0,70	1,29	898,9	954,3	35	27,27				24,71	0,71		
2-AMIRI	2	8/4/2010	1,23	52608	35,2	35,0	0,2	30,0	0,67	0,01	1,29	10,6										
2-AMIRI	3	8/4/2010	4,25	52609	35,3	35,2	0,1	30,0	0,33	0,01	1,29	18,2										
2-AMIRI	4	8/4/2010	3,11	52610	32,4	32,2	0,2	30,0	0,67	0,02	1,29	26,7										
2-AMIRI	1	11/4/2010	24,32	52631	34,7	34,4	0,3	30,0	1,00	0,24	1,29	312,9	375,9	35	10,74				34,48	0,99		
2-AMIRI	2	11/4/2010	3,53	52632	34,9	34,8	0,1	30,0	0,33	0,01	1,29	15,1										
2-AMIRI	3	11/4/2010	2,11	52633	35,1	35,0	0,1	30,0	0,33	0,01	1,29	9,1										
2-AMIRI	4	11/4/2010	4,52	52634	40,3	40,1	0,2	30,0	0,67	0,03	1,29	38,8										
3-ATHUMANI	1	29/3/2010	11,21	52605	31,3	30,9	0,4	30,0	1,33	0,15	1,27	189,4	1240,8	29	42,79	51,28	13	0,9598	47,63	1,64	1,66	31,05
3-ATHUMANI	2	29/3/2010	12,34	52606	35,7	35,2	0,5	30,0	1,67	0,21	1,27	260,7										
3-ATHUMANI	3	29/3/2010	14,22		36,3	35,4	0,9	30,0	3,00	0,43	1,27	540,7										
3-ATHUMANI	4	29/3/2010	9,86		34,7	34,1	0,6	30,0	2,00	0,20	1,27	250,0										
3-ATHUMANI	1	4/4/2010	4,64	52667	31,2	30,9	0,3	30,0	1,00	0,05	1,27	58,8	566,0	29	19,52				21,22	0,73		
3-ATHUMANI	2	4/4/2010	2,64	52668	34,7	34,1	0,6	30,0	2,00	0,05	1,27	66,9										
3-ATHUMANI	3	4/4/2010	6,63		34,0	33,2	0,8	30,0	2,67	0,18	1,27	224,1										
3-ATHUMANI	4	4/4/2010	7,31		32,1	31,4	0,7	30,0	2,33	0,17	1,27	216,2										
3-ATHUMANI	1	11/4/2010	2,56	52671	34,8	34,4	0,4	30,0	1,33	0,03	1,27	43,3	921,0	29	31,76				26,88	0,93		
3-ATHUMANI	2	11/4/2010	6,63	52672	40,1	39,0	1,1	30,0	3,67	0,24	1,27	308,1										
3-ATHUMANI	3	11/4/2010	9,56		39,8	38,9	0,9	30,0	3,00	0,29	1,27	363,5										
3-ATHUMANI	4	11/4/2010	8,13		39,3	38,7	0,6	30,0	2,00	0,16	1,27	206,1										
4-SHABANI	1	29/3/2010	4,31	52647	36,5	36,4	0,1	30,0	0,33	0,01	1,26	18,2	82,5	30	2,75	16,80	13	0,3145	15,79	0,53	1,31	24,54
4-SHABANI	2	29/3/2010	4,55	52648	35,0	34,9	0,1	30,0	0,33	0,02	1,26	19,2										
4-SHABANI	3	29/3/2010	3,12	52649	34,7	34,6	0,1	30,0	0,33	0,01	1,26	13,1										
4-SHABANI	4	29/3/2010	3,81	52650	35,0	34,8	0,2	30,0	0,67	0,03	1,26	32,1										
4-SHABANI	1	4/4/2010	1,51	52663	35,3	35,2	0,1	30,0	0,33	0,01	1,26	6,4	83,6	30	2,79				8,52	0,28		
4-SHABANI	2	4/4/2010	2,11	52664	35,3	35,0	0,3	30,0	1,00	0,02	1,26	26,7										
4-SHABANI	3	4/4/2010	2,21	52665	34,7	34,4	0,3	30,0	1,00	0,02	1,26	27,9										
4-SHABANI	4	4/4/2010	2,69	52666	35,5	35,3	0,2	30,0	0,67	0,02	1,26	22,7										
										0,00												
4-SHABANI	1	11/4/2010	10,23	52621	31,2	31,1	0,1	30,0	0,33	0,03	1,26	43,1	420,5	30	14,02				30,81	1,03		
4-SHABANI	2	11/4/2010	4,64	52622	34,9	34,8	0,1	30,0	0,33	0,02	1,26	19,5										
4-SHABANI	3	11/4/2010	7,43		33,7	32,9	0,8	30,0	2,67	0,20	1,26	250,3										
4-SHABANI	4	11/4/2010	8,51		34,2	33,9	0,3	30,0	1,00	0,09	1,26	107,5										
										0,00												
5-IDDI	1	23/3/2010	1,52	52651	31,6	31,1	0,5	30,0	1,67	0,03	1,20	30,5	115,7	32	3,61	62,22	17	0,89055	14,11	0,44	3,22	46,02
5-IDDI	2	23/3/2010	4,31	52652	35,2	35,0	0,2	30,0	0,67	0,03	1,20	34,6										
5-IDDI	3	23/3/2010	4,34	52653	34,6	34,4	0,2	30,0	0,67	0,03	1,20	34,8										
5-IDDI	4	23/3/2010	3,94	52654	36,4	36,3	0,1	30,0	0,33	0,01	1,20	15,8										
5-IDDI	1	29/3/2010	14,78	52597	34,4	32,3	2,1	30,0	7,00	1,03	1,20	1244,8	1790,5	32	55,95				52,91	1,65		
5-IDDI	2	29/3/2010	9,53	52598	35,2	35,1	0,1	30,0	0,33	0,03	1,20	38,2										
5-IDDI	3	29/3/2010	16,32	52599	35,4	34,7	0,7	30,0	2,33	0,38	1,20	458,2										
5-IDDI	4	29/3/2010	12,28	52600	39,1	39,0	0,1	30,0	0,33	0,04	1,20	49,3										
5-IDDI	1	3/4/2010	11,64	52613	34,3	34,2	0,1	30,0	0,33	0,04	1,20	46,7	118,1	32	3,69				29,45	0,92		
5-IDDI	2	3/4/2010	3,78	52614	34,9	34,8	0,1	30,0	0,33	0,01	1,20	15,2										
5-IDDI	3	3/4/2010	9,82	52615	39,2	39,1	0,1	30,0	0,33	0,03	1,20	39,4										
5-IDDI	4	3/4/2010	4,21	52616	39,2	39,1	0,1	30,0	0,33	0,01	1,20	16,9										
5-IDDI	1	9/4/2010	6,5	52627	31,6	31,5	0,1	30,0	0,33	0,02	1,20	26,1	82,3	32	2,57				20,53	0,64		
5-IDDI	2	9/4/2010	5,24	52628	39,5	39,4	0,1	30,0	0,33	0,02	1,20	21,0										
5-IDDI	3	9/4/2010	4,36	52629	34,5	34,4	0,1	30,0	0,33	0,01	1,20	17,5										
5-IDDI	4	9/4/2010	4,43	52630	27,7	27,6	0,1	30,0	0,33	0,01	1,20	17,8										
6-NYANGASA	1	23/3/2010	4,53	52655	33,6	33,4	0,2	30,0	0,67	0,03	1,17	35,2	99,6	27,5	3,62	18,18	17	0,26028	15,56	0,57	3,72	53,28
6-NYANGASA	2	23/3/2010	2,5	52656	39,1	39,0	0,1	30,0	0,33	0,01	1,17	9,7										
6-NYANGASA	3	23/3/2010	2,75	52657	39,4	39,1	0,3	30,0	1,00	0,03	1,17	32,1										
6-NYANGASA	4	23/3/2010	5,78	52658	34,9	34,8	0,1	30,0	0,33	0,02	1,17	22,5										
6-NYANGASA	1	29/3/2010	10,78	52601	34,5	34,4	0,1	30,0	0,33	0,04	1,17	41,9	271,4	27,5	9,87				49,08	1,78		
6-NYANGASA	2	29/3/2010	20,67	52602	35,1	34,9	0,2	30,0	0,67	0,14	1,17	160,8										
6-NYANGASA	3	29/3/2010	8,52	52603	38,9	38,8	0,1	30,0	0,33	0,03	1,17	33,1										
6-NYANGASA	4	29/3/2010	9,11	52604	34,2	34,1	0,1	30,0	0,33	0,03	1,17	35,4										
6-NYANGASA	1	3/4/2010	8,21	52617	33,5	33,4	0,1	30,0	0,33	0,03	1,17	31,9	143,1	27,5	5,20				36,77	1,34		
6-NYANGASA	2	3/4/2010	11,5	52618	36,4	36,3	0,1	30,0	0,33	0,04	1,17	44,7										
6-NYANGASA	3	3/4/2010	8,5	52619	34,6	34,5	0,1	30,0	0,33	0,03	1,17	33,1										
6-NYANGASA	4	3/4/2010	8,56	52620	35,1	35,0	0,1	30,0	0,33	0,03	1,17	33,3										
6-NYANGASA	1	9/4/2010	2,25	52623	34,7	34,5	0,2	30,0	0,67	0,02	1,17	17,5	85,6	27,5	3,11				16,51	0,6004		
6-NYANGASA	2	9/4/2010	6,34	52624	34,9	34,8	0,1	30,0	0,33	0,02	1,17	24,7										
6-NYANGASA	3	9/4/2010	4,67	52625	36,4	36,3	0,1	30,0	0,33	0,02	1,17	18,2										
6-NYANGASA	4	9/4/2010	3,25	52626	34,6	34,4	0,2	30,0	0,67	0,02	1,17	25,3										
			632,04								1,27	9579,6										

Erosion rates short rains (Wickama, 2010)

Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
1-MAGOGGO	8th	1	9,1	2822	0,3	0,03	1,50	45,08	286,97	41,0	7,00	207,11	103	0,49	9,11	0,22	3,15	7,43
1-MAGOGGO	8th	2	7,5	2823	0,7	0,05	1,50	74,85										
1-MAGOGGO	8th	3	6,7	2824	1,7	0,11	1,50	167,04										
1-MAGOGGO	8th	4	3,1	2825	0,0	0,00	1,50	0,00										
1-MAGOGGO	20th	1	4,5	3184	1,3	0,06	1,50	90,15	242,81	41,0	5,92	207,11	103	0,49	4,52	0,11	3,15	7,43
1-MAGOGGO	20th	2	4,1	3185	1,0	0,04	1,50	61,78										
1-MAGOGGO	20th	3	3,6	3186	1,0	0,04	1,50	54,14										
1-MAGOGGO	20th	4	2,5	3187	1,0	0,02	1,50	36,74										
1-MAGOGGO	10th	1	19,2	2870	1,0	0,19	1,50	287,47	1027,82	41,0	25,07	207,11	103	0,49	19,17	0,47	3,15	7,43
1-MAGOGGO	10th	2	17,2	2871	0,3	0,06	1,50	85,17										
1-MAGOGGO	10th	3	20,4	2872	1,3	0,27	1,50	407,67										
1-MAGOGGO	10th	4	12,4	2873	1,3	0,17	1,50	247,51										
1-MAGOGGO	21st	1	20,2	2858	1,3	0,27	1,50	402,88	1529,97	41,0	37,32	207,11	103	0,49	20,20	0,49	3,15	7,43
1-MAGOGGO	21st	2	18,2	2859	1,7	0,30	1,50	455,29										
1-MAGOGGO	21st	3	20,5	2860	2,0	0,41	1,50	615,44										
1-MAGOGGO	21st	4	5,6	2861	0,7	0,04	1,50	56,37										
1-MAGOGGO	22nd	1	20,8	3123	0,3	0,07	1,50	102,78	131,79	41,0	3,21	207,11	103	0,49	20,77	0,51	3,15	7,43
1-MAGOGGO	22nd	2	1,0	3120	0,7	0,01	1,50	10,35										
1-MAGOGGO	22nd	3	2,7	3121	0,3	0,01	1,50	13,11										
1-MAGOGGO	22nd	4	1,1	3122	0,3	0,00	1,50	5,54										
1-MAGOGGO	25th	1	1,0	3151	0,3	0,00	1,50	5,00	45,60	41,0	1,11	207,11	103	0,49	1,01	0,02	3,15	7,43
1-MAGOGGO	25th	2	2,2	3152	0,3	0,01	1,50	10,84										
1-MAGOGGO	25th	3	1,0	3153	0,3	0,00	1,50	5,15										
1-MAGOGGO	25th	4	2,5		0,7	0,02	1,50	24,62										
1-MAGOGGO	26th	1	18,2	3143	0,3	0,06	1,50	89,87	471,71	41,0	11,51	207,11	103	0,49	18,16	0,44	3,15	7,43
1-MAGOGGO	26th	2	16,2	3144	0,3	0,05	1,50	80,12										
1-MAGOGGO	26th	3	20,1	3145	1,0	0,20	1,50	301,72										
1-MAGOGGO	26th	4	9,2	3146	0,0	0,00	1,50	0,00										
1-MAGOGGO	5th Jan.	1	2,4	2798	2,3	0,06	1,50	84,91	947,20	41,0	23,10	207,11	103	0,49	2,43	0,06	3,15	7,43
1-MAGOGGO	5th Jan.	2	16,0	2795	1,3	0,21	1,50	319,31										
1-MAGOGGO	5th Jan.	3	19,1	2796	1,7	0,32	1,50	479,08										
1-MAGOGGO	5th Jan.	4	6,4	2797	0,7	0,04	1,50	63,90										
1-MAGOGGO	8th Jan.	1	7,3	2754	1,3	0,10	1,50	145,80	552,43	41,0	13,47	207,11	103	0,49	7,31	0,18	3,15	7,43
1-MAGOGGO	8th Jan.	2	11,2	2755	0,3	0,04	1,50	55,57										
1-MAGOGGO	8th Jan.	3	23,4	2756	1,0	0,23	1,50	351,06										
1-MAGOGGO	8th Jan.	4	20,2	2757	0,0	0,00	1,50	0,00										
1-MAGOGGO	10th	1	19,3	2897	10,7	2,06	1,50	3092,94	3236,85	41,0	78,95	207,11	103	0,49	19,33	0,47	3,15	7,43
1-MAGOGGO	10th	2	15,3	2894	0,3	0,05	1,50	75,91										
1-MAGOGGO	10th	3	18,6	2895	0,0	0,00	1,50	0,00										
1-MAGOGGO	10th	4	13,7	2896	0,3	0,05	1,50	67,99										
1-MAGOGGO	19th Feb.	1	16,1	2794	0,7	0,11	1,50	161,96	305,33	41,0	7,45	207,11	103	0,49	16,12	0,39	3,15	7,43
1-MAGOGGO	19th Feb.	2	6,1	2791	0,3	0,02	1,50	30,29										
1-MAGOGGO	19th Feb.	3	11,3	2792	0,3	0,04	1,50	55,97										
1-MAGOGGO	19th Feb.	4	11,5	2793	0,3	0,04	1,50	57,11										
2-AMIRI	8th	1	8,1	2818	0,0	0,00	1,29	0,00	35,29	35,0	1,01	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	8th	2	4,6	2819	0,3	0,02	1,29	19,32										
2-AMIRI	8th	3	3,8	2820	0,3	0,01	1,29	15,97										
2-AMIRI	8th	4	3,5	2821	0,0	0,00	1,29	0,00										
2-AMIRI	10th	1	14,1	2874	0,7	0,09	1,29	121,82	431,01	35,0	14,86	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	10th	2	13,4	2875	0,7	0,09	1,29	115,79										
2-AMIRI	10th	3	8,2	2876	1,0	0,08	1,29	105,26										
2-AMIRI	10th	4	5,2	2877	1,3	0,07	1,29	88,14										
2-AMIRI	21st	1	7,2	2862	0,7	0,05	1,29	62,25	888,08	35,0	25,37	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	21st	2	6,4	2863	3,0	0,19	1,29	247,84										
2-AMIRI	21st	3	5,3	2864	1,7	0,09	1,29	112,82										
2-AMIRI	21st	4	7,2	2865	5,0	0,36	1,29	465,18										
2-AMIRI	22nd	1	6,1	2842	0,7	0,04	1,29	52,76	251,84	35,0	7,20	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	22nd	2	3,5	2843	0,7	0,02	1,29	30,43										
2-AMIRI	22nd	3	5,8	2844	1,7	0,10	1,29	123,99										
2-AMIRI	22nd	4	3,5	2845	1,0	0,03	1,29	44,65										
2-AMIRI	25th	1	3,1	3147	0,3	0,01	1,29	13,21	46,61	35,0	1,33	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	25th	2	2,5	3148	0,3	0,01	1,29	10,79										
2-AMIRI	25th	3	1,3	3149	0,0	0,00	1,29	0,00										
2-AMIRI	25th	4	2,8	3150	0,6	0,02	1,29	22,62										
2-AMIRI	26th	1	12,3	3139	1,7	0,21	1,29	264,97	917,78	35,0	26,22	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	26th	2	14,7	3140	0,7	0,10	1,29	126,48										
2-AMIRI	26th	3	13,7	3141	1,3	0,18	1,29	233,61										
2-AMIRI	26th	4	8,5	3142	2,7	0,23	1,29	292,73										
2-AMIRI	5th Jan.	1	3,4	2802	1,7	0,06	1,29	73,49	1093,47	35,0	31,24	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	5th Jan.	2	2,4	2799	2,0	0,05	1,29	62,02										
2-AMIRI	5th Jan.	3	20,2	2800	1,3	0,27	1,29	345,71										
2-AMIRI	5th Jan.	4	20,4	2801	2,3	0,48	1,29	612,24										
2-AMIRI	8th Jan.	1	20,8	2727	4,0	0,83	1,29	1069,07	3278,05	35,0	93,66	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	8th Jan.	2	20,2	2728	3,7	0,74	1,29	954,43										
2-AMIRI	8th Jan.	3	20,2	2729	1,3	0,27	1,29	346,40										
2-AMIRI	8th Jan.	4	19,2	2730	3,7	0,71	1,29	908,15										
2-AMIRI	10th	1	6,0	2901	1,3	0,08	1,29	102,86	640,03	35,0	18,29	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	10th	2	14,2	2898	1,0	0,14	1,29	182,73										
2-AMIRI	10th	3	8,2	2899	0,7	0,06	1,29	70,78										
2-AMIRI	10th	4	13,2	2900	1,7	0,22	1,29	283,66										
2-AMIRI	20th	1	7,2	3172	0,3	0,02	1,29	30,62	257,39	35,0	7,35	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	20th	2	3,5	3173	2,0	0,07	1,29	89,30										
2-AMIRI	20th	3	4,3	3174	1,3	0,06	1,29	74,11										
2-AMIRI	20th	4	5,7		0,9	0,05	1,29	63,36										
2-AMIRI	19th Feb.	1	17,2	2790	0,3	0,06	1,29	72,91	418,94	35,0	11,97	237,50	73	0,79	8,11	0,23	2,32	7,72
2-AMIRI	19th Feb.	2	20,1	2787	0,3	0,07	1,29	85,44										
2-AMIRI	19th Feb.	3	20,3	2788	0,7	0,14	1,29	175,19										
2-AMIRI	19th Feb.	4	20,1	2789	0,3	0,07	1,29	85,40										

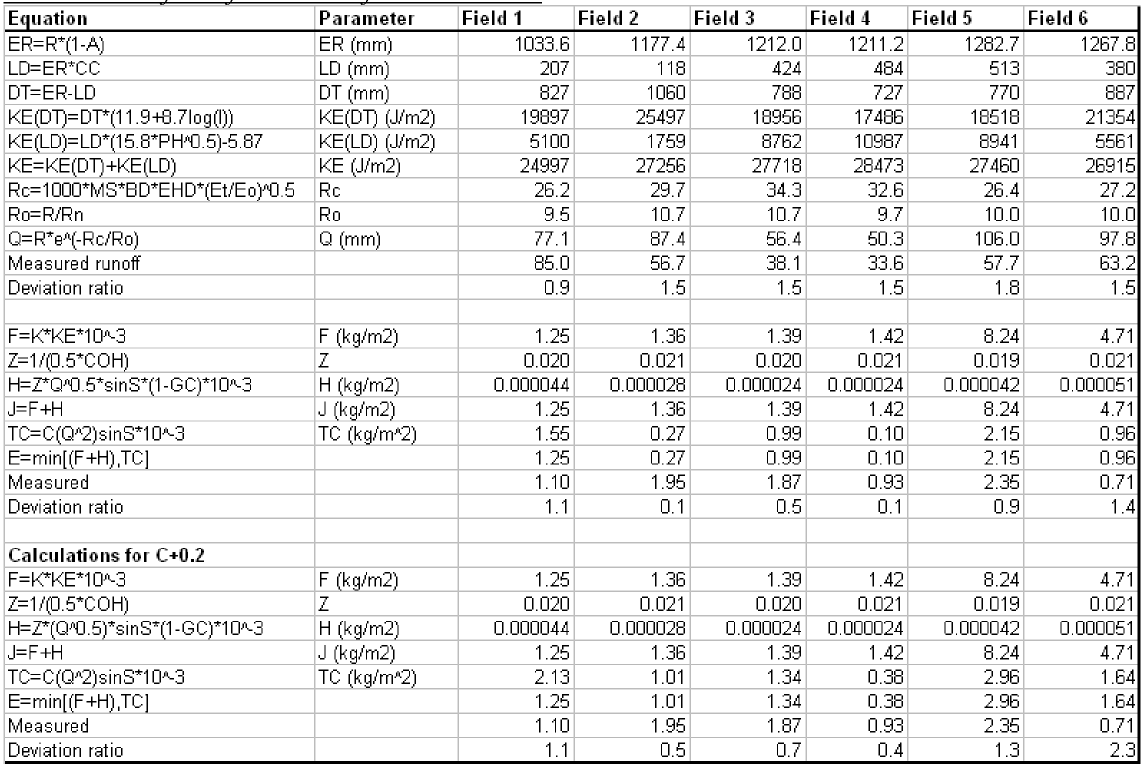
Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
3-ATHUMANI	8th	1	3,4	3158	0,3	0,01	1,27	14,39	155,62	29,0	5,37	273,11	73	0,91	3,44	0,12	2,12	7,08
3-ATHUMANI	8th	2	1,2	3159	0,3	0,00	1,27	5,10										
3-ATHUMANI	8th	3	3,8	3160	2,3	0,09	1,27	112,52										
3-ATHUMANI	8th	4	2,8		0,7	0,02	1,27	23,61										
3-ATHUMANI	10th	1	11,4	2838	1,0	0,11	1,27	145,00	1274,32	29,0	43,94	273,11	73	0,91	11,44	0,39	2,12	7,08
3-ATHUMANI	10th	2	15,2	2839	1,3	0,20	1,27	256,57										
3-ATHUMANI	10th	3	5,2	2840	3,0	0,16	1,27	196,59										
3-ATHUMANI	10th	4	12,3	2841	4,3	0,53	1,27	676,16										
3-ATHUMANI	22nd	1	1,0	2826	2,0	0,02	1,27	24,08	222,93	29,0	7,69	273,11	73	0,91	0,95	0,03	2,12	7,08
3-ATHUMANI	22nd	2	3,4	2827	2,0	0,07	1,27	87,20										
3-ATHUMANI	22nd	3	4,7	2828	1,3	0,06	1,27	78,56										
3-ATHUMANI	22nd	4	2,6	2829	1,0	0,03	1,27	33,08										
3-ATHUMANI	26th	1	10,3	3161	3,0	0,31	1,27	392,04	1162,96	29,0	40,10	273,11	73	0,91	10,31	0,36	2,12	7,08
3-ATHUMANI	26th	2	7,3	3162	2,0	0,15	1,27	185,56										
3-ATHUMANI	26th	3	9,2	3163	1,3	0,12	1,27	154,42										
3-ATHUMANI	26th	4	10,2	3164	3,3	0,34	1,27	430,94										
3-ATHUMANI	5th Jan.	1	17,3	2782	2,0	0,35	1,27	439,32	2955,51	29,0	101,91	273,11	73	0,91	17,33	0,60	2,12	7,08
3-ATHUMANI	5th Jan.	2	3,2	2779	2,0	0,06	1,27	80,87										
3-ATHUMANI	5th Jan.	3	12,1	2780	8,3	1,01	1,27	1278,61										
3-ATHUMANI	5th Jan.	4	15,2	2781	6,0	0,91	1,27	1156,72										
3-ATHUMANI	8th	1	2,1	3128	2,0	0,04	1,27	53,49	1355,93	29,0	46,76	273,11	73	0,91	2,11	0,07	2,12	7,08
3-ATHUMANI	8th	2	5,3	3129	2,3	0,12	1,27	155,93										
3-ATHUMANI	8th	3	20,1	3130	3,3	0,67	1,27	848,80										
3-ATHUMANI	8th	4	17,7	3131	1,3	0,23	1,27	297,71										
3-ATHUMANI	19th	1	13,2	2866	1,7	0,22	1,27	279,20	791,66	29,0	27,30	273,11	73	0,91	13,19	0,45	2,12	7,08
3-ATHUMANI	19th	2	10,6	2867	0,7	0,07	1,27	90,10										
3-ATHUMANI	19th	3	8,8	2868	0,7	0,06	1,27	74,56										
3-ATHUMANI	19th	4	6,9	2869	4,0	0,27	1,27	347,80										
3-ATHUMANI	20th	1	2,2	3136	0,3	0,01	1,27	9,12	59,26	29,0	2,04	273,11	73	0,91	2,18	0,08	2,12	7,08
3-ATHUMANI	20th	2	1,2	3137	0,3	0,00	1,27	4,85										
3-ATHUMANI	20th	3	2,8	3138	1,0	0,03	1,27	35,11										
3-ATHUMANI	20th	4	2,2		0,4	0,01	1,27	10,18										
3-ATHUMANI	25th	1	4,1	3175	0,7	0,03	1,27	34,90	97,57	29,0	3,36	273,11	73	0,91	4,11	0,14	2,12	7,08
3-ATHUMANI	25th	2	2,4	3176	0,3	0,01	1,27	9,87										
3-ATHUMANI	25th	3	3,8		0,3	0,01	1,27	16,02										
3-ATHUMANI	25th	4	4,0		0,7	0,03	1,27	36,78										
4-SHABANI	20th	1	2,8	3132	0,7	0,02	1,26	23,45	77,08	30,0	2,57	231,55	91	0,62	2,77	0,09	3,41	9,11
4-SHABANI	20th	2	3,7	3133	0,0	0,00	1,26	0,00										
4-SHABANI	20th	3	2,5	3134	0,3	0,01	1,26	10,55										
4-SHABANI	20th	4	3,4	3135	1,0	0,03	1,26	43,08										
4-SHABANI	8th	1	3,0	3154	0,3	0,01	1,26	12,55	36,19	30,0	1,21	231,55	91	0,62	3,01	0,10	3,41	9,11
4-SHABANI	8th	2	2,4	3155	0,3	0,01	1,26	10,17										
4-SHABANI	8th	3	2,1	3156	0,3	0,01	1,26	8,80										
4-SHABANI	8th	4	1,1	3157	0,3	0,00	1,26	4,67										
4-SHABANI	10th	1	3,1	2834	0,7	0,02	1,26	26,33	77,68	30,0	2,59	231,55	91	0,62	3,11	0,10	3,41	9,11
4-SHABANI	10th	2	3,8	2835	0,3	0,01	1,26	15,72										
4-SHABANI	10th	3	4,2	2836	0,7	0,03	1,26	35,64										
4-SHABANI	10th	4	8,8	2837	0,0	0,00	1,26	0,00										
4-SHABANI	19th	1	10,1	3165	0,4	0,04	1,26	52,37	124,74	30,0	4,16	231,55	91	0,62	10,11	0,34	3,41	9,11
4-SHABANI	19th	2	7,4	3166	0,3	0,02	1,26	30,98										
4-SHABANI	19th	3	4,6	3167	0,3	0,02	1,26	19,01										
4-SHABANI	19th	4	5,2		0,3	0,02	1,26	22,38										
4-SHABANI	21st	1	3,8	2913	4,3	0,16	1,26	206,79	927,36	30,0	30,91	231,55	91	0,62	3,78	0,13	3,41	9,11
4-SHABANI	21st	2	3,1	2910	0,3	0,01	1,26	13,01										
4-SHABANI	21st	3	20,1	2911	2,7	0,54	1,26	678,37										
4-SHABANI	21st	4	3,5	2912	0,7	0,02	1,26	29,20										
4-SHABANI	22nd	1	4,1	2830	0,3	0,01	1,26	17,14	48,99	30,0	1,63	231,55	91	0,62	4,11	0,14	3,41	9,11
4-SHABANI	22nd	2	1,5	2831	1,7	0,03	1,26	31,86										
4-SHABANI	22nd	3	2,8	2832	0,0	0,00	1,26	0,00										
4-SHABANI	22nd	4	3,7	2833	0,0	0,00	1,26	0,00										
4-SHABANI	26th	1	20,1	2882	0,3	0,07	1,26	83,88	567,19	30,0	18,91	231,55	91	0,62	20,12	0,67	3,41	9,11
4-SHABANI	26th	2	5,5	2883	0,0	0,00	1,26	0,00										
4-SHABANI	26th	3	22,4	2884	0,3	0,07	1,26	93,47										
4-SHABANI	26th	4	23,2	2885	1,3	0,31	1,26	389,83										
4-SHABANI	5th Jan.	1	20,2	2786	0,3	0,07	1,26	84,22	1144,08	30,0	38,14	231,55	91	0,62	20,20	0,67	3,41	9,11
4-SHABANI	5th Jan.	2	18,2	2783	1,3	0,24	1,26	305,82										
4-SHABANI	5th Jan.	3	19,3	2784	2,7	0,52	1,26	651,04										
4-SHABANI	5th Jan.	4	6,1	2785	1,3	0,08	1,26	103,00										
4-SHABANI	8th	1	14,1	3127	1,7	0,24	1,26	297,91	1213,30	30,0	40,44	231,55	91	0,62	14,12	0,47	3,41	9,11
4-SHABANI	8th	2	12,6	3124	1,0	0,13	1,26	159,44										
4-SHABANI	8th	3	14,1	3125	2,3	0,33	1,26	415,95										
4-SHABANI	8th	4	11,6	3126	2,3	0,27	1,26	340,00										
4-SHABANI	10th Jan.	1	7,2	2758	0,7	0,05	1,26	61,03	415,73	30,0	13,86	231,55	91	0,62	7,21	0,24	3,41	9,11
4-SHABANI	10th Jan.	2	11,3	2759	0,7	0,08	1,26	95,31										
4-SHABANI	10th Jan.	3	20,6	2760	0,7	0,14	1,26	174,54										
4-SHABANI	10th Jan.	4	20,4	2761	0,3	0,07	1,26	84,84										
4-SHABANI	10th	1	8,2	3168	1,0	0,08	1,26	103,60	1816,79	30,0	60,56	231,55	91	0,62	8,20	0,27	3,41	9,11
4-SHABANI	10th	2	7,2	3169	1,3	0,10	1,26	120,82										
4-SHABANI	10th	3	2,2	3170	2,3	0,05	1,26	63,29										
4-SHABANI	10th	4	19,1	3171	6,3	1,21	1,26	1529,09										
4-SHABANI	21st	1	6,1	3180	0,7	0,04	1,26	51,80	541,10	30,0	18,04	231,55	91	0,62	6,12	0,20	3,41	9,11
4-SHABANI	21st	2	5,2	3181	1,0	0,05	1,26	65,44										
4-SHABANI	21st	3	5,1	3182	4,3	0,22	1,26	279,54										
4-SHABANI	21st	4	3,4	3183	3,3	0,11	1,26	144,30										
4-SHABANI	25th	1	2,1	3177	0,3	0,01	1,26	8,80	33,19	30,0	1,11	231,55	91	0,62	2,11	0,07	3,41	9,11
4-SHABANI	25th	2	1,1	3178	0,3	0,00	1,26	4,71										
4-SHABANI	25th	3	2,1	3179	0,3	0,01	1,26	8,92										
4-SHABANI	25th	4	2,0		0,4	0,01	1,26	10,76										

Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
5-IDDI	21st Nov.	1	5,2	2770	1,0	0,05	1,20	62,69	173,10	32,0	5,41	532,80	89	1,46	5,21	0,16	4,26	11,65
5-IDDI	21st Nov.	2	3,2	2771	0,7	0,02	1,20	25,55										
5-IDDI	21st Nov.	3	2,3	2772	1,0	0,02	1,20	27,79										
5-IDDI	21st Nov.	4	2,8	2773	1,7	0,05	1,20	57,07										
5-IDDI	8th Dec.	1	4,2	2719	0,7	0,03	1,20	34,10	116,32	32,0	3,64	532,80	89	1,46	4,23	0,13	4,26	11,65
5-IDDI	8th Dec.	2	2,5	2720	1,3	0,03	1,20	39,37										
5-IDDI	8th Dec.	3	1,2	2721	2,3	0,03	1,20	34,20										
5-IDDI	8th Dec.	4	2,2	2722	0,3	0,01	1,20	8,66										
5-IDDI	9th	1	4,7	2909	0,3	0,02	1,20	18,74	148,10	32,0	4,63	532,80	89	1,46	4,72	0,15	4,26	11,65
5-IDDI	9th	2	6,2	2906	1,3	0,08	1,20	99,54										
5-IDDI	9th	3	4,1	2907	0,3	0,01	1,20	16,28										
5-IDDI	9th	4	3,4	2908	0,3	0,01	1,20	13,54										
5-IDDI	10th Dec.	1	23,1	2715	3,7	0,85	1,20	1020,48	2464,47	32,0	77,01	532,80	89	1,46	23,11	0,72	4,26	11,65
5-IDDI	10th Dec.	2	17,6	2716	3,0	0,53	1,20	633,85										
5-IDDI	10th Dec.	3	21,9	2717	3,0	0,66	1,20	789,42										
5-IDDI	10th Dec.	4	5,2	2718	0,3	0,02	1,20	20,73										
5-IDDI	21st Dec.	1	3,7	2742	1,7	0,06	1,20	74,75	118,11	32,0	3,69	532,80	89	1,46	3,72	0,12	4,26	11,65
5-IDDI	21st Dec.	2	1,3	2743	1,3	0,02	1,20	21,44										
5-IDDI	21st Dec.	3	1,1	2744	0,0	0,00	1,20	0,00										
5-IDDI	21st Dec.	4	1,4	2745	1,3	0,02	1,20	21,92										
5-IDDI	25th	1	5,2	2814	0,3	0,02	1,20	20,69	2457,28	32,0	76,79	532,80	89	1,46	5,21	0,16	4,26	11,65
5-IDDI	25th	2	2,3	2815	1,0	0,02	1,20	28,15										
5-IDDI	25th	3	1,4	2816	2,0	0,03	1,20	33,45										
5-IDDI	25th	4	0,9	2817	0,7	0,01	1,20	7,42										
5-IDDI	26th Dec.	1	10,4	2746	1,0	0,10	1,20	125,25	333,63	32,0	10,43	532,80	89	1,46	10,41	0,33	4,26	11,65
5-IDDI	26th Dec.	2	4,2	2747	0,7	0,03	1,20	34,02										
5-IDDI	26th Dec.	3	8,1	2748	1,7	0,14	1,20	163,36										
5-IDDI	26th Dec.	4	2,8	2749	0,3	0,01	1,20	11,00										
5-IDDI	5th	1	3,6	3190	1,0	0,04	1,20	42,83	163,09	32,0	5,10	532,80	89	1,46	3,56	0,11	4,26	11,65
5-IDDI	5th	2	1,7	3191	0,7	0,01	1,20	13,46										
5-IDDI	5th	3	3,4	3192	2,0	0,07	1,20	82,06										
5-IDDI	5th	4	3,0		0,7	0,02	1,20	24,74										
5-IDDI	7th Jan.	1	22,3	2735	16,3	3,64	1,20	4373,70	5554,21	32,0	173,57	532,80	89	1,46	22,26	0,70	4,26	11,65
5-IDDI	7th Jan.	2	15,4	2736	1,0	0,15	1,20	185,65										
5-IDDI	7th Jan.	3	22,3	2737	3,7	0,82	1,20	986,48										
5-IDDI	7th Jan.	4	2,1	2738	0,3	0,01	1,20	8,38										
5-IDDI	9th Jan.	1	21,1	2762	1,0	0,21	1,20	254,12	3043,56	32,0	95,11	532,80	89	1,46	21,12	0,66	4,26	11,65
5-IDDI	9th Jan.	2	22,3	2763	1,3	0,30	1,20	357,18										
5-IDDI	9th Jan.	3	23,2	2764	8,7	2,01	1,20	2423,29										
5-IDDI	9th Jan.	4	2,3	2765	0,3	0,01	1,20	8,97										
5-IDDI	10th	1	22,2	2886	2,0	0,44	1,20	534,70	2202,39	32,0	68,82	532,80	89	1,46	22,22	0,69	4,26	11,65
5-IDDI	10th	2	24,3	2887	1,3	0,32	1,20	388,54										
5-IDDI	10th	3	25,8	2888	4,0	1,03	1,20	1242,18										
5-IDDI	10th	4	9,3	2889	0,3	0,03	1,20	36,97										
5-IDDI	12th	1	3,1	3188	0,3	0,01	1,20	12,47	66,21	32,0	2,07	532,80	89	1,46	3,14	0,10	4,26	11,65
5-IDDI	12th	2	1,4	3189	1,3	0,02	1,20	23,04										
5-IDDI	12th	3	2,3		0,7	0,02	1,20	18,70										
5-IDDI	12th	4	1,8		0,6	0,01	1,20	11,99										
5-IDDI	17th	1	7,3	3197	0,7	0,05	1,20	59,17	182,66	32,0	5,71	532,80	89	1,46	7,34	0,23	4,26	11,65
5-IDDI	17th Jan.	2	5,9	3198	0,7	0,04	1,20	47,40										
5-IDDI	17th	3	2,4	3199	1,3	0,03	1,20	38,89										
5-IDDI	17th	4	2,7	3200	3,0	0,08	1,20	96,38										
5-IDDI	18th Feb.	1	5,3	2806	1,0	0,05	1,20	63,53	199,41	32,0	6,23	532,80	89	1,46	5,28	0,17	4,26	11,65
5-IDDI	18th Feb.	2	2,2	2803	2,0	0,04	1,20	53,42										
5-IDDI	18th Feb.	3	4,1	2804	1,3	0,05	1,20	66,09										
5-IDDI	18th Feb.	4	2,0	2805	0,7	0,01	1,20	16,36										

Name of field and farmer	Date Runoff collected	Ger-lach no.	Volume of runoff collected (L)	LAB. No.	% SEDI-MENTS (in 30ml runoff)	Amount of erosion (dm3)	Bulk density (g/cm3)	Amount of erosion (g)	Total erosion at 1 field (g)	Area covered by gerlach (m2)	tran-sport in (g/m2)	Total transport per m2 in period	Num-ber of days	annual tran-sport (kg/m2)	total runoff at 1 field (L)	Run-off in (L/m2)	Total volume per m2 in period	Annual runoff (mm)
6-NYANGASA	21st Nov.	1	2,1	2774	0,3	0,01	1,17	8,01	198,23	27,5	7,21	163,40	89	0,45	2,08	0,08	3,64	9,96
6-NYANGASA	21st Nov.	2	4,1	2775	1,0	0,04	1,17	47,97										
6-NYANGASA	21st Nov.	3	4,1	2776	1,7	0,07	1,17	80,50										
6-NYANGASA	21st Nov.	4	5,3	2777	1,0	0,05	1,17	61,74										
6-NYANGASA	8th Dec.	1	1,7	2723	1,0	0,02	1,17	20,08	88,09	27,5	3,20	163,40	89	0,45	1,72	0,06	3,64	9,96
6-NYANGASA	8th Dec.	2	4,1	2724	0,3	0,01	1,17	15,83										
6-NYANGASA	8th Dec.	3	2,5	2725	1,3	0,03	1,17	39,12										
6-NYANGASA	8th Dec.	4	1,7	2726	0,7	0,01	1,17	13,06										
6-NYANGASA	9th	1	14,7	2905	0,3	0,05	1,17	56,66	212,93	27,5	7,74	163,40	89	0,45	14,71	0,53	3,64	9,96
6-NYANGASA	9th	2	7,6	2902	0,7	0,05	1,17	59,51										
6-NYANGASA	9th	3	8,4	2903	0,3	0,03	1,17	32,39										
6-NYANGASA	9th	4	8,2	2904	0,7	0,06	1,17	64,36										
6-NYANGASA	10th Dec.	1	9,2	2711	1,3	0,12	1,17	142,97	949,55	27,5	34,53	163,40	89	0,45	9,21	0,33	3,64	9,96
6-NYANGASA	10th Dec.	2	19,4	2712	0,3	0,06	1,17	74,84										
6-NYANGASA	10th Dec.	3	16,3	2713	1,7	0,27	1,17	318,50										
6-NYANGASA	10th Dec.	4	21,2	2714	1,7	0,35	1,17	413,24										
6-NYANGASA	17th Dec.	1	1,2	2750	0,3	0,00	1,17	4,74	180,34	27,5	6,56	163,40	89	0,45	1,23	0,04	3,64	9,96
6-NYANGASA	17th Dec.	2	2,7	2751	0,3	0,01	1,17	10,36										
6-NYANGASA	17th Dec.	3	6,7	2752	0,7	0,05	1,17	52,55										
6-NYANGASA	17th Dec.	4	14,4	2753	0,7	0,10	1,17	112,69										
6-NYANGASA	17th	1	1,6	3193	0,7	0,01	1,17	12,75	93,26	27,5	3,39	163,40	89	0,45	1,63	0,06	3,64	9,96
6-NYANGASA	17th	2	1,7	3194	2,0	0,03	1,17	38,75										
6-NYANGASA	17th	3	2,2	3195	0,7	0,01	1,17	17,36										
6-NYANGASA	17th	4	3,1	3196	0,7	0,02	1,17	24,40										
6-NYANGASA	21st Dec.	1	1,6	2739	0,3	0,01	1,17	6,12	25,32	27,5	0,92	163,40	89	0,45	1,59	0,06	3,64	9,96
6-NYANGASA	21st Dec.	2	3,7	2740	0,0	0,00	1,17	0,00										
6-NYANGASA	21st Dec.	3	1,5	2741	0,7	0,01	1,17	11,34										
6-NYANGASA	21st Dec.	4	1,9		0,4	0,01	1,17	7,86										
6-NYANGASA	25th	1	3,2		0,4	0,01	1,17	13,32	66,50	27,5	2,42	163,40	89	0,45	3,17	0,12	3,64	9,96
6-NYANGASA	25th	2	3,2	2811	0,0	0,00	1,17	0,00										
6-NYANGASA	25th	3	2,3	2812	0,7	0,02	1,17	18,14										
6-NYANGASA	25th	4	4,5	2813	0,7	0,03	1,17	35,03										
6-NYANGASA	5th	1	2,1	2878	0,0	0,00	1,17	0,00	41,89	27,5	1,52	163,40	89	0,45	2,11	0,08	3,64	9,96
6-NYANGASA	5th	2	2,0	2879	0,3	0,01	1,17	7,82										
6-NYANGASA	5th	3	2,4	2880	0,3	0,01	1,17	9,09										
6-NYANGASA	5th	4	2,1	2881	1,0	0,02	1,17	24,98										
6-NYANGASA	7th Jan.	1	21,1	2731	0,3	0,07	1,17	81,12	1022,24	27,5	37,17	163,40	89	0,45	21,06	0,77	3,64	9,96
6-NYANGASA	7th Jan.	2	21,3	2732	0,7	0,14	1,17	166,34										
6-NYANGASA	7th Jan.	3	19,8	2733	1,0	0,20	1,17	230,64										
6-NYANGASA	7th Jan.	4	23,3	2734	2,0	0,47	1,17	544,15										
6-NYANGASA	9th Jan.	1	22,2	2766	0,3	0,07	1,17	85,59	1190,71	27,5	43,30	163,40	89	0,45	22,22	0,81	3,64	9,96
6-NYANGASA	9th Jan.	2	22,2	2767	1,0	0,22	1,17	258,77										
6-NYANGASA	9th Jan.	3	19,2	2768	1,7	0,32	1,17	373,86										
6-NYANGASA	9th Jan.	4	24,2	2769	1,7	0,40	1,17	472,49										
6-NYANGASA	10th	1	15,2	2893	1,0	0,15	1,17	177,65	445,33	27,5	16,19	163,40	89	0,45	15,22	0,55	3,64	9,96
6-NYANGASA	10th	2	18,6	2890	0,7	0,12	1,17	145,53										
6-NYANGASA	10th	3	11,4	2891	0,7	0,08	1,17	89,23										
6-NYANGASA	10th	4	4,2	2892	0,7	0,03	1,17	32,92										
6-NYANGASA	18th Feb.	1	6,3	2807	1,0	0,06	1,17	73,77	177,31	27,5	6,45	163,40	89	0,45	6,32	0,23	3,64	9,96
6-NYANGASA	18th Feb.	2	3,6	2810	0,3	0,01	1,17	13,71										
6-NYANGASA	2011	3	4,1	2808	1,3	0,05	1,17	63,80										
6-NYANGASA	2011	4	2,2	2809	1,0	0,02	1,17	26,03										

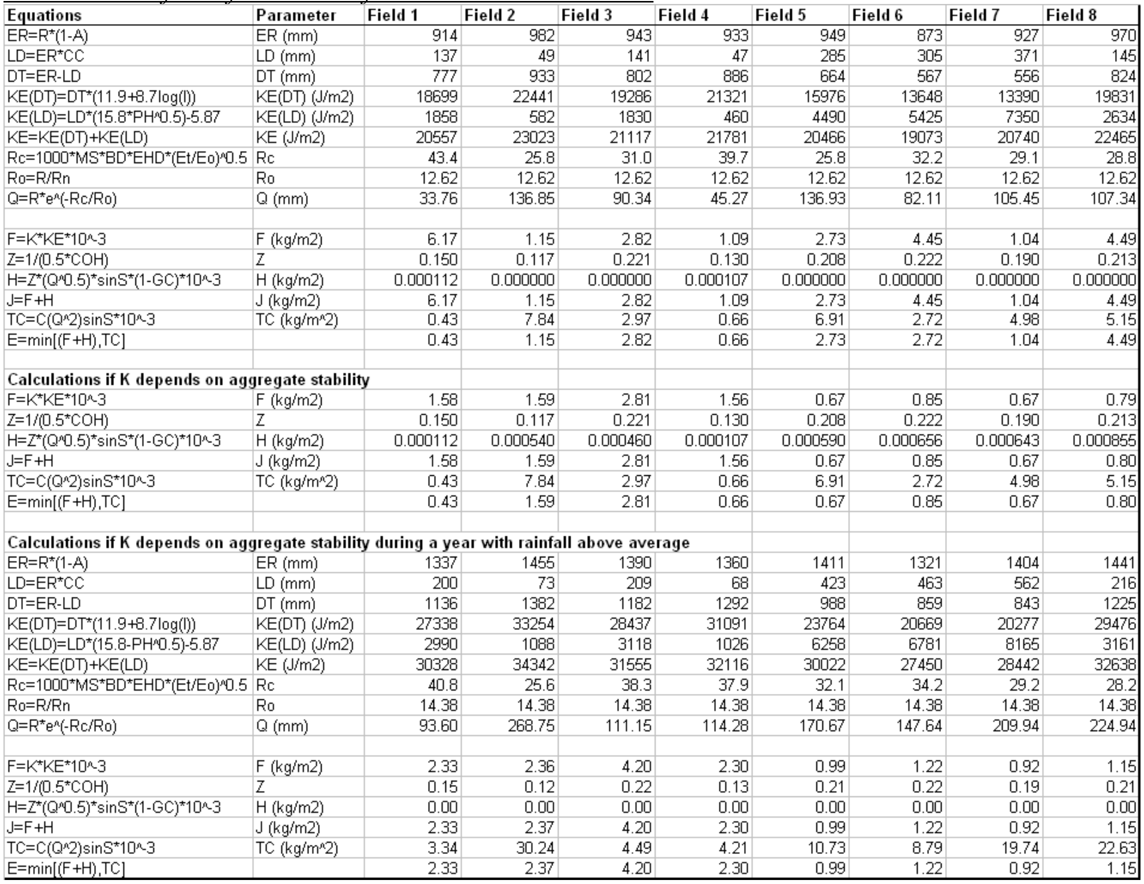
Appendix F

Calculations for 6 fields used for calibration



Equation	**Parameter**	**Field 1**	**Field 2**	**Field 3**	**Field 4**	**Field 5**	**Field 6**
ER=R*(1-A)	ER (mm)	1033.6	1177.4	1212.0	1211.2	1282.7	1267.8
LD=ER*CC	LD (mm)	207	118	424	484	513	380
DT=ER-LD	DT (mm)	827	1060	788	727	770	887
KE(DT)=DT*(11.9+8.7log(I))	KE(DT) (J/m2)	19897	25497	18956	17486	18518	21354
KE(LD)=LD*(15.8*PH^0.5)-5.87	KE(LD) (J/m2)	5100	1759	8762	10987	8941	5561
KE=KE(DT)+KE(LD)	KE (J/m2)	24997	27256	27718	28473	27460	26915
Rc=1000*MS*BD*EHD*(Et/Eo)^0.5	Rc	26.2	29.7	34.3	32.6	26.4	27.2
Ro=R/Rn	Ro	9.5	10.7	10.7	9.7	10.0	10.0
Q=R*e^(-Rc/Ro)	Q (mm)	77.1	87.4	56.4	50.3	106.0	97.8
Measured runoff		85.0	56.7	38.1	33.6	57.7	63.2
Deviation ratio		0.9	1.5	1.5	1.5	1.8	1.5
F=K*KE*10^-3	F (kg/m2)	1.25	1.36	1.39	1.42	8.24	4.71
Z=1/(0.5*COH)	Z	0.020	0.021	0.020	0.021	0.019	0.021
H=Z*Q^0.5*sinS*(1-GC)*10^-3	H (kg/m2)	0.000044	0.000028	0.000024	0.000024	0.000042	0.000051
J=F+H	J (kg/m2)	1.25	1.36	1.39	1.42	8.24	4.71
TC=C(Q^2)sinS*10^-3	TC (kg/m^2)	1.55	0.27	0.99	0.10	2.15	0.96
E=min[(F+H),TC]		1.25	0.27	0.99	0.10	2.15	0.96
Measured		1.10	1.95	1.87	0.93	2.35	0.71
Deviation ratio		1.1	0.1	0.5	0.1	0.9	1.4
Calculations for C+0.2							
F=K*KE*10^-3	F (kg/m2)	1.25	1.36	1.39	1.42	8.24	4.71
Z=1/(0.5*COH)	Z	0.020	0.021	0.020	0.021	0.019	0.021
H=Z*(Q^0.5)*sinS*(1-GC)*10^-3	H (kg/m2)	0.000044	0.000028	0.000024	0.000024	0.000042	0.000051
J=F+H	J (kg/m2)	1.25	1.36	1.39	1.42	8.24	4.71
TC=C(Q^2)sinS*10^-3	TC (kg/m^2)	2.13	1.01	1.34	0.38	2.96	1.64
E=min[(F+H),TC]		1.25	1.01	1.34	0.38	2.96	1.64
Measured		1.10	1.95	1.87	0.93	2.35	0.71
Deviation ratio		1.1	0.5	0.7	0.4	1.3	2.3

Calculations for 8 fields used for erosion calculations



Equations	Parameter	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8
ER=R*(1-A)	ER (mm)	914	982	943	933	949	873	927	970
LD=ER*CC	LD (mm)	137	49	141	47	285	305	371	145
DT=ER-LD	DT (mm)	777	933	802	886	664	567	556	824
KE(DT)=DT*(11.9+8.7log(I))	KE(DT) (J/m2)	18699	22441	19286	21321	15976	13648	13390	19831
KE(LD)=LD*(15.8*PH^0.5)-5.87	KE(LD) (J/m2)	1858	582	1830	460	4490	5425	7350	2634
KE=KE(DT)+KE(LD)	KE (J/m2)	20557	23023	21117	21781	20466	19073	20740	22465
Rc=1000*MS*BD*EHD*(Et/Eo)^0.5	Rc	43.4	25.8	31.0	39.7	25.8	32.2	29.1	28.8
Ro=R/Rn	Ro	12.62	12.62	12.62	12.62	12.62	12.62	12.62	12.62
Q=R*e^(-Rc/Ro)	Q (mm)	33.76	136.85	90.34	45.27	136.93	82.11	105.45	107.34
F=K*KE*10^-3	F (kg/m2)	6.17	1.15	2.82	1.09	2.73	4.45	1.04	4.49
Z=1/(0.5*COH)	Z	0.150	0.117	0.221	0.130	0.208	0.222	0.190	0.213
H=Z*(Q^0.5)*sinS*(1-GC)*10^-3	H (kg/m2)	0.000112	0.000000	0.000000	0.000107	0.000000	0.000000	0.000000	0.000000
J=F+H	J (kg/m2)	6.17	1.15	2.82	1.09	2.73	4.45	1.04	4.49
TC=C(Q^2)sinS*10^-3	TC (kg/m^2)	0.43	7.84	2.97	0.66	6.91	2.72	4.98	5.15
E=min[(F+H),TC]		0.43	1.15	2.82	0.66	2.73	2.72	1.04	4.49
Calculations if K depends on aggregate stability									
F=K*KE*10^-3	F (kg/m2)	1.58	1.59	2.81	1.56	0.67	0.85	0.67	0.79
Z=1/(0.5*COH)	Z	0.150	0.117	0.221	0.130	0.208	0.222	0.190	0.213
H=Z*(Q^0.5)*sinS*(1-GC)*10^-3	H (kg/m2)	0.000112	0.000540	0.000460	0.000107	0.000590	0.000656	0.000643	0.000855
J=F+H	J (kg/m2)	1.58	1.59	2.81	1.56	0.67	0.85	0.67	0.80
TC=C(Q^2)sinS*10^-3	TC (kg/m^2)	0.43	7.84	2.97	0.66	6.91	2.72	4.98	5.15
E=min[(F+H),TC]		0.43	1.59	2.81	0.66	0.67	0.85	0.67	0.80
Calculations if K depends on aggregate stability during a year with rainfall above average									
ER=R*(1-A)	ER (mm)	1337	1455	1390	1360	1411	1321	1404	1441
LD=ER*CC	LD (mm)	200	73	209	68	423	463	562	216
DT=ER-LD	DT (mm)	1136	1382	1182	1292	988	859	843	1225
KE(DT)=DT*(11.9+8.7log(I))	KE(DT) (J/m2)	27338	33254	28437	31091	23764	20669	20277	29476
KE(LD)=LD*(15.8-PH^0.5)-5.87	KE(LD) (J/m2)	2990	1088	3118	1026	6258	6781	8165	3161
KE=KE(DT)+KE(LD)	KE (J/m2)	30328	34342	31555	32116	30022	27450	28442	32638
Rc=1000*MS*BD*EHD*(Et/Eo)^0.5	Rc	40.8	25.6	38.3	37.9	32.1	34.2	29.2	28.2
Ro=R/Rn	Ro	14.38	14.38	14.38	14.38	14.38	14.38	14.38	14.38
Q=R*e^(-Rc/Ro)	Q (mm)	93.60	268.75	111.15	114.28	170.67	147.64	209.94	224.94
F=K*KE*10^-3	F (kg/m2)	2.33	2.36	4.20	2.30	0.99	1.22	0.92	1.15
Z=1/(0.5*COH)	Z	0.15	0.12	0.22	0.13	0.21	0.22	0.19	0.21
H=Z*(Q^0.5)*sinS*(1-GC)*10^-3	H (kg/m2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
J=F+H	J (kg/m2)	2.33	2.37	4.20	2.30	0.99	1.22	0.92	1.15
TC=C(Q^2)sinS*10^-3	TC (kg/m^2)	3.34	30.24	4.49	4.21	10.73	8.79	19.74	22.63
E=min[(F+H),TC]		2.33	2.37	4.20	2.30	0.99	1.22	0.92	1.15