EVALUATION OF SEDIMENT YIELD FROM INTERILL EROSION USING WATER EROSION PREDICTION PROJECT (WEPP) SIMULATION MODEL

BY

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2003/14885EA

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FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NIGER STATE.

NOVEMBER, 2008

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BEING A FINAL YEAR PROJECT SUBMITTED

IN PARTIAL FUILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NOVEMBER, 2008.

DECLARATION

I hereby declare that this Project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

24/11/08

SALIFU GABRIEL | DATE

(Student)

DEDICATION

I dedicate this work to baby Chegbe and the rest of the Family.

CERTIFICATION

This Project entitled "Evaluation of Sediment Yield from Interill Erosion using WEPP model" by Salifu Gabriel Ojima meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG) degree of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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Dr. (Mrs.) Osunde D. Z. — Date

(H. O. D.)

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External Examiner — Date

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I give thanks to God almighty for His Grace that deems me fit and His mercies that sees me Beautiful.

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To my family, you are one in a million. Chegbe for her understanding, Naomi for being matured beyond expectation, Okolo for being simple enough for me to be a little complex, Odoma for sacrificing everything for us, and to my mum for standing up to the challenge and proofing herself. I love you all.

To my pals Ugbes, Ojoka Ekele and Elageche, you were Nitrous Oxide in my Shelby.

ABSTRACT

Rapid removal of sediments from an agricultural field results in accelerated erosion which deforms the soil structure reducing the plant root support capability of the field. To estimate the Average Annual Sediment Yield from a 20 by 30 study field in School of Agric Farm Lot, Federal University of Technology Minna, Gidan Kwano campus, a site survey was carried out which gave a slope percentage steepness of 4.1%. A textural class analysis showed that the field had a Sand, Clay and Silt composition of 57%, 28.1% and 15.56% respectively corresponding to a Sandy-Clay-Loam Textural Class. These data sets were used together with the climate data for the study area to simulate the Annual Sediment Yield using Water Erosion Prediction Project (WEPP) model. The simulation output gave an Average Annual Precipitation of 1376.5 mm, Average Annual Runoff of 61.16 mm, Average Annual Soil Loss of 0.047 kg/m^2, and an Average Annual Sediment Yield of 0.0469 kg/m^2. From the result of the analysis, it shows that an average annual precipitation of 1376.5 mm will cause a surface runoff of 61.16 mm on the study field and this amount of runoff is capable of causing an Average Annual Sediment Yield of 0.0469 kg/m^2.

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1.0 INTRODUCTION

1.1 Background

Soil erosion is the detachment, transportation, and deposition of soil particles (Britannica, 2008). A broad application of the term erosion embraces the general wearing down and molding of all land forms on the earth surface, including the weathering of rocks in its original state, the transport of weathered materials - a process which can also be called denudation or degradation and includes mass movement process (Basil J.M., 1983).

A narrow and somewhat limiting definition of erosion by water includes the transportation of sediment from the point of detachment to the point of deposition such as locations lower in elevation to points of detachment, nearby streams and its tributaries. The total amount of soil particles exported from a given field under investigation to new locations is its sediment yield and it is generally expressed in two ways: either as a volume or as a weight – i.e. as acre-feet (one foot depth of material over one acre), or as tons.

Soil is a vital resource for the production of renewable resources for the necessities of human life, such as food and fiber. Soils however, essentially are non-renewable recourses (Troch, 1995).

According to Golubev (1991), the area of cultivated land in the world is 14.8 million km^2. In cultivated areas, drastic changes in vegetation have occurred and instead of dense natural vegetation cover, bare soils often is exposed for most of the years with spars crop vegetation existing for a few months. These changes in vegetation cover are the main reasons for the increase of soil erosion on cropland as compared to that on natural landscape (Bagarella, 1995).

1.2 Statement of the problem

In the past and to a considerable degree even now, soils have not been managed effectively. Those exposed through cultivation to the erosive effect of the wind have been blown away; those laid bare on sloping ground have been washed down hill by rainfall impact and surface which's combined effect result in detachment of top soil particles (Anthony, 1991). These layers of the soil contain minerals derived from living or dead plant materials necessary for the growth of plant and agric crops. Rapid removal of these sediments results in accelerated erosion which deforms the soil structure, hence, reducing the plant root support capability of the soil.

This gives rise to the need for an adequate prediction method for the rate of removal of these sediments, the possibility of carrying out farming operations on such farm land, and the projected number of years before the soil deteriorates to an unproductive state.

1.3 Aims and Objectives

1.3.1 Aims

This project is aimed at determining the amount of sediment lost to interill erosion in a given farm land using the Water Erosion Prediction Project (WEPP) simulation model.

1.3.2 Objectives

i. To determine the factors responsible for particle detachment and transportation downhill.

ii. To evaluate the annual sediment yield using WEPP model.

iii. To establish the crop yielding potential of the field.

1.4 Justification

To maximize agricultural productivity on a farm land it is necessary to know the slope steepness or gradient, the cover factor and the field's hydraulic properties such as the erodibility of the soil. Knowledge of these properties will help the farmer to choose the best management practice to ensure that his crops are not washed away by erosion after planting, and also ensure that the soil nutrient are conserved to improve crop yield. Verifying that the WEPP model can be used for evaluating Sediment Yield gives a fast a most economic means of predicting Sediment Yield.

1.5 Scope and Limitation

The following were the Scope and Limitations for this study:

1. Only a 600 square meters study field with grass cover was used for the research
2. The simulation was run for 10 years using Nigerian Meteorological (NIMET) rainfall data between years 1997 – 2007.
3. The actual rainfall amount for 18th September 2008 was used for the single storm simulation.

CHAPTER TWO

2.0 LITERATURE REVIEW

Early methods used in the determination of the amount of sediment lose to a particular storm involves practical-on site processes to collect the actual amount of sediment deposited at points within and around the field and analyzing in the laboratory to get the estimated annual yield. Other methods with considerable amount of accuracy and which are still in use involves the use of measuring pins on the site to measure the change in deposites at the lower end of the slope (Gilley *et al*, 1992).

Results of computation by Golubev shows that soil erosion in the world is 5.5 times more than during the pre agricultural periods. Acoording to Brown (1991), the world is currently loosing 23 billion tones of soil from cropland in excess of new soil formation each year (Bagarella, 1995).

2.1 Mechanics of Water Erosion

Soil erosion by water is fundamentally a three step process:

Detachment of soil particles – this is dislodging of particles or soil pegs from either a rain drop impact or from the shearing forces of water and air flowing over the surface (Nyle, *et al* 1999).

Transportation of detached particles – transportation of particles downhill could be by floatation, rolling, dragging, and splashing (Nyle, 1997).

Transport by runoff across the surface does not generally occur until the rainfall rate exceeds the infiltration capacity of the soil. Once rainfall occurs, the quality and size of soil particles transported becomes a function of the velocity of the flow (Barfield *et al*, 1981).

Raindrop splash can also be a cause of soil transportation to a micro scale.

Deposition of particles - this is usually at points lower in elevation to the point of detachment. It usually results in size and density sorting of eroded soil particles with increasingly smaller sized particles being deposited downslope or downstream (Stanley, 2001).

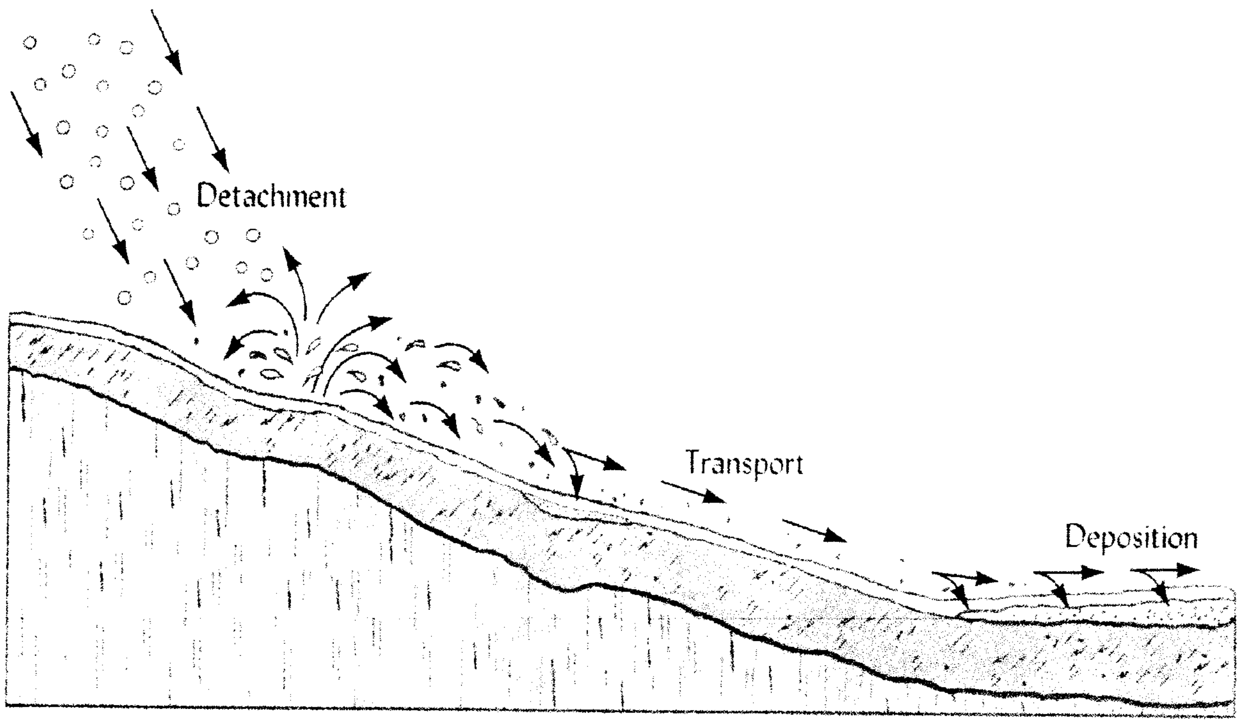


PLATE 1: Mechanics of water Erosion – Detachment, Transportation, Deposition.
Source: USDA Natural Resources Conservation Services, 1991

2.2 Types of Water Erosion

There are five classifications of water erosion:

2.2.1 Raindrop/Splash Erosion

This is caused by the impact of raindrop on bare soil due to its kinetic energy. It is the detachment and airborne movement of small particles caused by the impact of raindrop on the soil (Foster *et al*, 1981). A raindrop accelerates until it reaches terminal velocity. Terminal velocity is the speed at which the friction between the drop and the air balances the force of gravity. Larger raindrops fall faster, reaching a terminal velocity of about 30*km/h* or 2 to 3 times as fast as a person can run. As the speeding raindrops impact the soil with explosive force, they transfer their high kinetic energy to the soil particles. Very heavy raindrop may splash as much as 225 *mg/ha* of soil on a soil subject to easy detachment. Some of the particles splashing as much as 0.7*m* vertically and 2*m* horizontally. If the land is sloppy or if the wind is blowing, splashing may be greater in one direction, leading to considerable net horizontal movement of soil (Nyle, 1999).

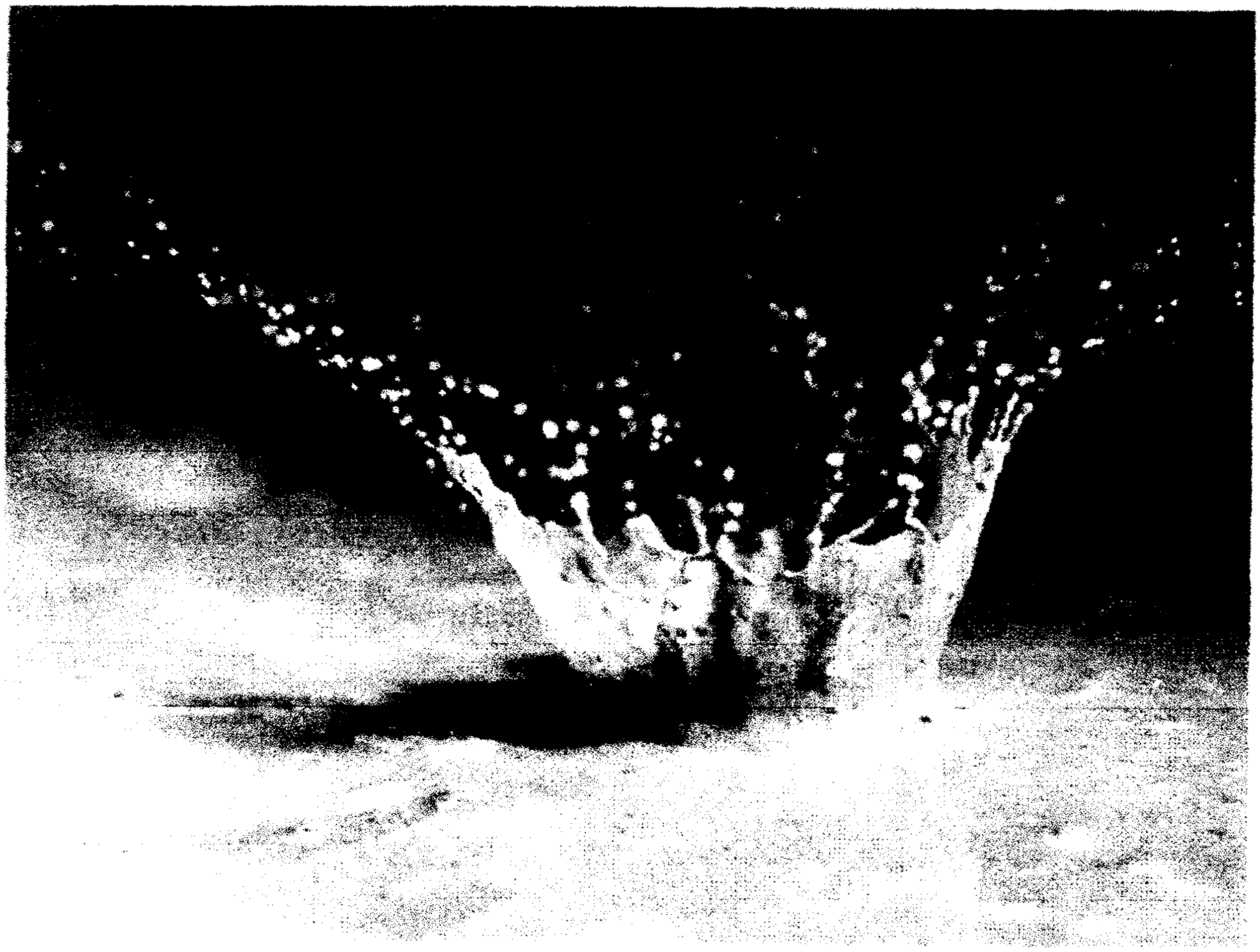


PLATE 2: Raindrop/ Splash Erosion

Source: Nyle, 1999

2.2.2 Sheet Erosion

This is the detachment of soil particles by raindrop impact and their movement down slope by water flowing overland as a sheet instead of in definite channels (Yair, 1990). A more or less uniform layer of fine particles is removed from the entire surface of an area, sometimes resulting in an extensive loss of rich top soil. Sheet erosion commonly occurs on recently ploughed fields or on other sites having poorly consolidated soil materials with scanty vegetative water cover.

Some sources may categorise raindrop/splash erosion and sheet erosion as one type of erosion, but for the purpose of this study, raindrop and sheet erosion will be considered separately since raindrop also has the potential of moving detached sediments up to a distance between 0.7*m* – 2*m* horizontally (Musgrave *et al,* 1997).

PLATE 3: Sheet Wash Erosion: the inset pencil is to give a sence of scale
Soure: Nyle, 1999

2.2.3 Rill Erosion

Rills are small channels formed on the surface as a result of increasing amount of runoff. Detachment occurs in rills by the shear forces of flowing water in the rill. The number of rills and the amount of rill erosion increases as the slope or the amount of surface runoff increases (Yair, 1990). Rills can generally be removed by ordinary tillage equipment or from light grading.

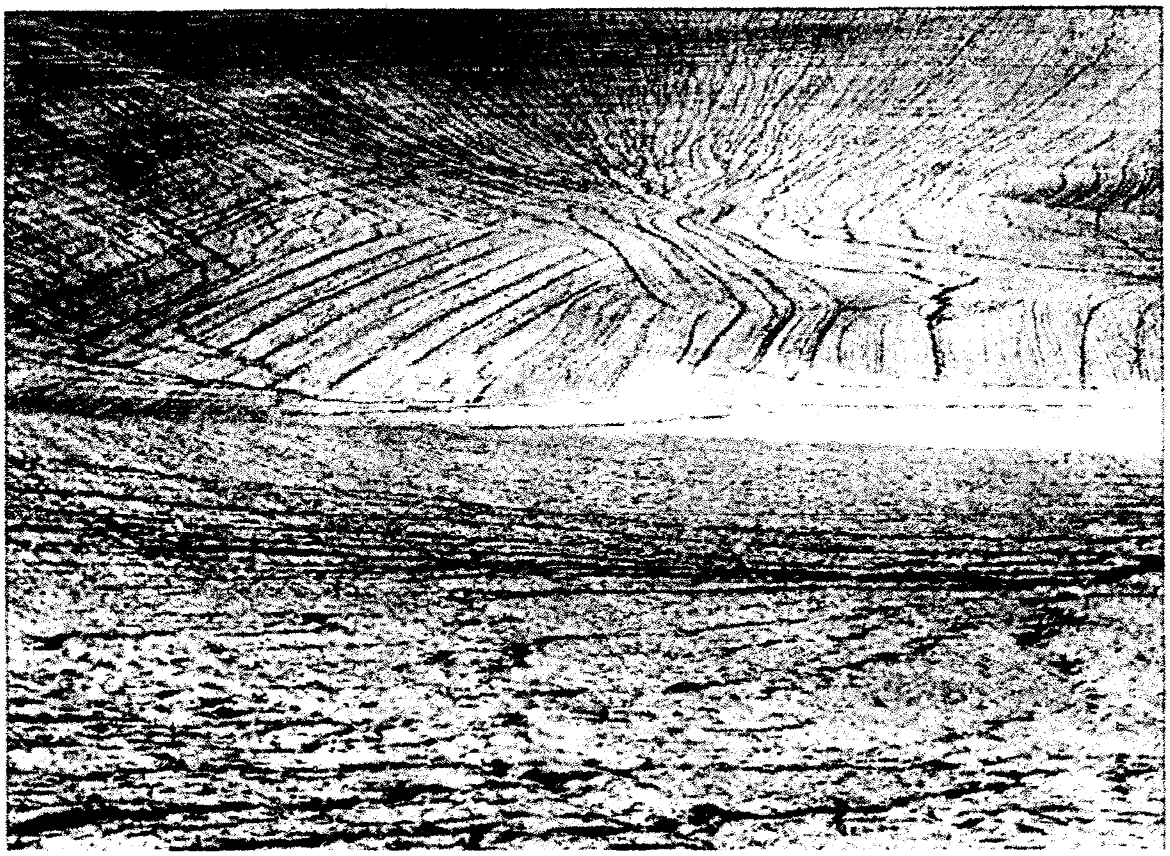


PLATE 4: Rill Erosion

Source: Nyle, 1999

2.2.4 Gully Erosion

Gullies can either be continuous or discontinuous channels that form in response to runoff events. By definition, gullies differ from rills in that they cannot be removed by ordinary tillage or grading practices. Gullies may be temporary features by being erosively active or in a state of "healing" where annual deposition within the gully is greater than the detachment and transport of eroded materials (EPA, 2003). Erosion in gullies occure primarily from the shear forces of flowing water. Foster *et al* (1985) however indicated that the amount of erosion from gullies is usually less than the amount that occurs from rills. This is because the amount of erodible particles is quickly removed from the gully channel, where rills are established on an actively eroding surface.

PLATE 5: Gully Erosion

Source: Nyle, 1999

2.2.5 Stream Channel Erosion

Stream channels differ from gullies in that they are permanent channels that transport surface water. Stream channels can be perennial, ephemeral or intermittent. In stable stream channels, erosion and deposition is controlled by transport capacity of a given stream flow, which is in turn governed by the velocity of the flow and by local variations in shear stress in the channel (EPA, 2003). Detachment and entrainment of soil particles will occur along the stream bed and sides of a channel when the transport capacity is greater than the sediment load being transported. Deposition occurs when the transport capacity is less than the sediment load being transported (EPA, 2003).

Water plays an important role in erosion by carrying away material that has been weathered and broken down. When an area receives more water (in the form of rain, melting snow, or ice) than the ground can absorb, the excess water flows to the lowest level, carrying loose material with it. Gentle slopes are subject to *sheet* and *rill* erosion, in which the runoff removes a thin layer of topsoil without leaving visible traces on the eroded surface. This erosion may be balanced by the formation of new soil. Often, however, especially in arid areas having little vegetation, the runoff leaves a pattern of gullies formed by rivulets. Water can even erode solid rock, especially along streambeds where the stones that are carried with the current scour and abrade. Every year rivers deposit about 3.5 million tons of eroded material into the oceans (Encarta, 2008)

2.3 Interill Erosion

Interill erosion is described as a process of soil detachment by raindrop impact, transport by shallow sheet flow, and sediment delivery to rill channels (Flanagan, 1995). Sediment delivery rate to rill flow areas is assumed to be proportional to the product of rainfall intensity and interill runoff rate (Flanagan, 1995). The primary erosive force in interill areas is raindrop impact, where increasing detachment and erosion rates occurs with increasing drop size and drop velocity. The secondary erosive force is sheet wash which further carries detached particles in a uniform surface flow depositing the particles at different points along the slope.

2.4 Sediment Yield

This is the total amount of erosion debris eroded from a drainage basin to nearby streams and its tributaries. It is generally expressed in two ways: either as a volume (acre-feet: one foot depth of materials over one acre) or as tons. In order to adjust for the various sizes of drainage basins, the yield is frequently espressed as volume or weight per unit area of drainage basin. E.g. as acre-feet per square mile or as tons per square kilometer. The conversion between the two forms of expression is obtained by getting an average weight for the sediment and calculating the total weight for the measured volume of sediment. Sediment yield can be measured in a period of years and the result expressed as annual average (Williams, 1995).

2.4.1 Factors Affecting Sediment Yield

The quality and type of sediment moving through a stream channel are intimately related to the following:

1. The Geology (geographic location)
2. Topography (slope characteristics)
3. Climate
4. Vegetation cove and
5. The land use within the drainage basin (Encarta, 2008).

2.5 Models for Prediction of Sediment Yield

Land managers, policy makers and soil and water conservationists have many needs to predict the extent of soil erosion, some of which include:

(a) To plan for the best management of a nations soil and water resources.

(b) To evaluate the consequences of alternate tillage practices.

(c) To determine compliance with environmental regulations.

(d) To develop sediment control plans for construction projects (EPA, 2003).

To achieve the above needs, characterization of mine sites and agricultural farms require the accurate calculation of sediment yield on a large water shed basis. To predict potential adverse impacts from sedimentation requires spatial and areal characterization of gross erosion and sediment yield.

Several analytical software programs are available to predict sediment yield and sediment transport in large watersheds. Some of these can be incorporated into Global Information System (GIS) applications to provide spatial evaluation of erosion potential and sediment yield for one or more watersheds (Flanagan, 1995). Most software models and GIS applications that are commonly used to predict erosion and sediment yield apply the Universal Soil Loss Equation (USLE), Modified USLE (MUSLE), or Revised USLE (RUSLE) algorithms.

Some of the universally recognized software models include Agricultural Non-point source pollution models (AGNPS), AREAL Non-point Source Water Response Simulation Model (ANSWRS), Water Erosion Prediction Project (WEPP), Generalised Stream Tube Model for Alluvial River Simulation (GSTARS), Scour and Deposition Model (HEC-6), Hydrology and Sedimentation Model (Sedimot-II), Sediment Computer Aided Design (SEDCAD), Decision Support System for Agro-technology Transfer (DSSAT) etc. The

WEPP model has been chosen for this project because of its ability to generate data(s) which are mathematically or logically related to other input file and its uniqueness in determination of Sediment Yield on hillslope (Williams, 1995).

2.6 Research Questions

To select the appropriate model, the following questions modified from Maclean, (1997) can be used to determine the type and level of modeling efforts needed and software model to evaluate erosion and sedimentation at any site.

i. What are the basic assumptions and methods applied in the method.

ii. Is the output suitable to make the evaluation and analysis required and is the accuracy sufficient for characterisation impact analysis and detection monitoring.

iii. What are the temporal and spatial scales of the analysis?

iv. What are the input data requirements of the software model?

v. What data are required for model calibration and verification?

vi. Are the required data available, and are they at the correct scale.

vii. What input data are the most important (i.e. have the most sensitivity).

viii. Can surrogates be used for missing data without compromising an accurate analysis?

ix. If the model used empirical (i.e. statistical) relationships, under what conditions are these formed.

Answering these questions will help the hydrologist or conservationist to select appropriate techniques and models and to design adequate sampling programs to obtain the required input data.

2.7 **Water Erosion Prediction Project (WEPP)**

The USDA - Water Erosion Prediction Project (WEPP) model represents a new erosion prediction technology based on fundamentals of stochastic weather generation, infiltration theory, hydrology, soil physics, plant science, hydraulics, and erosion mechanics. The hillslope or landscape profile application of the model provides major advantages over existing erosion prediction technology. The most notable advantages include capabilities for estimating spatial and temporal distributions of soil loss (net soil loss for an entire hillslope or for each point on a slope profile can be estimated on a daily, monthly, or average annual basis), and since the model is process-based it can be extrapolated to a broad range of conditions that may not be practical or economical to field test. In watershed applications, sediment yield from entire fields can be estimated. The figure below depicts a small watershed on which the WEPP erosion model could be applied (Flanagan, 1995).

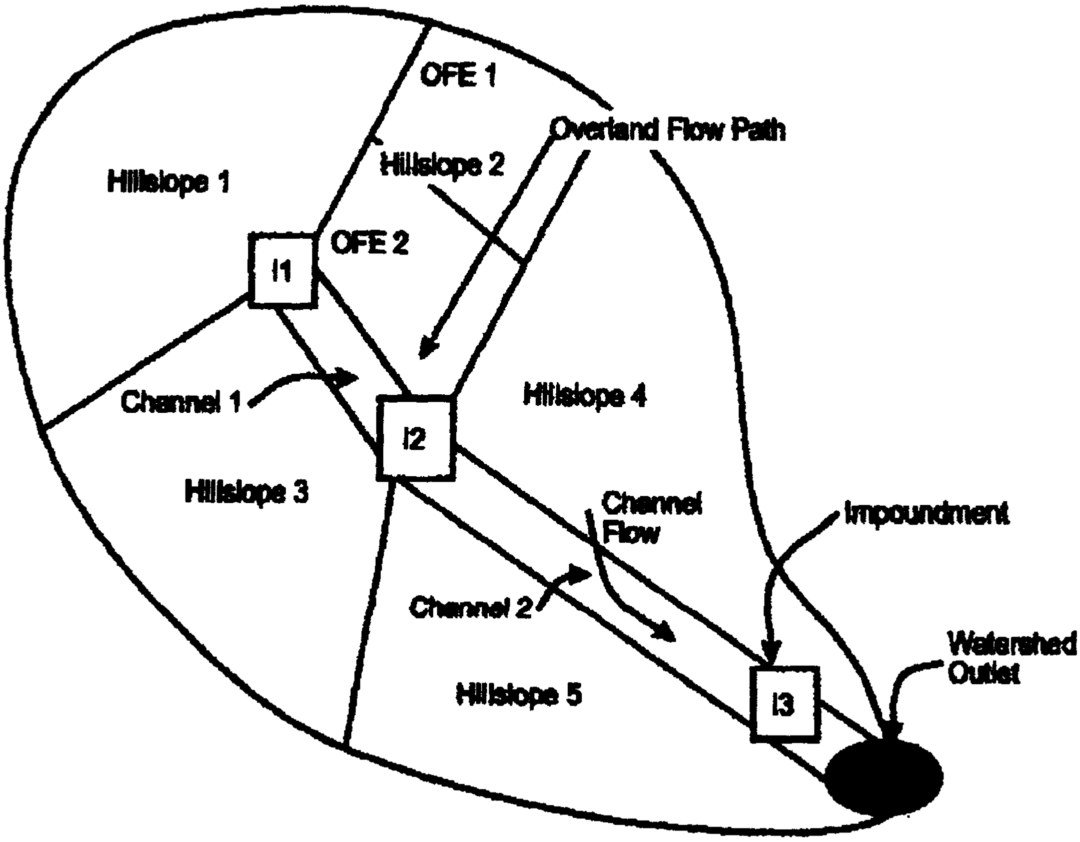


Figure 1: Schematic of a small watershed which the WEPP erosion model could be applied to. Individual hillslopes (1 to 5), or the entire watershed (composed of 5 hillslopes, 2 channel segments, and 3 impoundments) could be simulated.

2.8. Requirements of WEPP

For a successful simulation, the user must collect and enter a minimum of four basic WEPP input files. These are in the categories:

1. Climate
2. Management
3. Slope and
4. Soil

If irrigation is being simulated, its input files must also be specified.

It is worth noting that the WEPP model readily provides the above data classes for over 2000 weather stations in the USA. All the user has to do is select the weather station that represents his field of investigation and all the needed files will be loaded and ready for use. Nevertheless, if WEPP is to be used for a place where these input files are not available, WEPP provides an interface where any of the stations can be selected and edited to fit the data profile of the field to be investigated.

2.8.1 Climate Data

The climate data required by the model includes values for Precipitation, temperature, solar radiation, and wind information. A stand alone program called *CLIGEN* is used to generate either continuous simulation climate files or single storm climate files. A station file and a state database containing climate information of the state can be chosen and edited to the values obtained from a study field where the data for the field is not preset in WEPP model. The climate data window is as shown below:

2.8.2 Management Data

The management editor allows you to enter the information that WEPP needs to describe to management practices which will occur during the years of simulation. This information is seen in form of a timeline indicating graphically the operations that are being carried out and their dates. These files include the initial conditions, cropland plant database (annual and perennial), tillage operations database, drainage database, contouring, cropland grazing etc.

2.8.3 Slope Profile Data

This provides information about the landscape geometry, the required information include slope orientation, slope length and steepness. This information can be viewed in a 2D or 3D graphical format.

2.8.4 Soil Data

This set of data includes soil properties for a soil subsection. Information on soil properties to a maximum depth of 1.8meters are input to the WEPP model through the soil file. WEPP internally creates a new set of soil layers based on the original parameter set. Accurate estimation of soil properties and hydrological parameters is essential when using WEPP.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of Study Area

A 20m*30m study field located between latitude 9°32.2232′ N – 9°32.2411′ N and longitude 6°26.9258′ E – 6°26.9328′ E within the animal farm lot at Federal University of Technology Minna, Gidan kwano campus, Niger State of Nigeria was used as the research site. The site is characterised by two distinct seasons; a dry season which lasts from November to March and a wet season which lasts from April to October. It has a maximum mean annual temperature of 33.2°C and a minimum mean annual temperature of 22.3°C with a relative humidity of 59.0%.

3.2 Materials

3.2.1 Site Survey

A survey work was carried out to determine the field length, width and slope steepness. The materials used for the survey work were:

i. Measuring tape

ii. Wooden pegs

iii. Dumpy level

iv. Tripod stand

v. Levelling staff

3.2.2 Measuring Tape

This is flexible survey instrument used to measure the length and width or breathe of the field. One end of the field was fixed at the highest left hand corner of the field and the tape was rolled out downslope to the lowest point on the field. The breath of the field was also measured using the same procedure from one side to the other.

3.2.3 Wooden Pegs

These are short wooden tools of about 0.5m in length and pointed at one end used to mark points on the field. The pegs were inserted at four corners of the field and marked A, B, C, and D from the top left to the lower left and the lower right to the top right corners respectively.

3.2.4 Dumpy Level

The Level is a survey instrument used to obtain a horizontal surface above ground level from the line of sight of a telescope adjusted into the horizontal position. Together with the levelling staff, it is used to obtain the change in height along a slope.

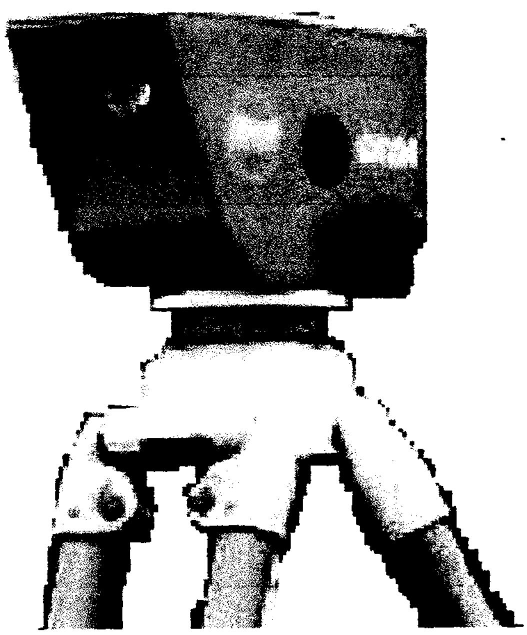


Plate 6: The Dumpy Level

3.2.5 Tripod Stand

The tripod is an adjustable stand on which the level can be mounted. It is equipped with three adjustable legs to give a stable mounting on rough grounds.

3.2.6 Levelling Staff

This is a graduated scale on which the change in height along a slope can be read from the level telescope. It is most commonly graduated in meters.

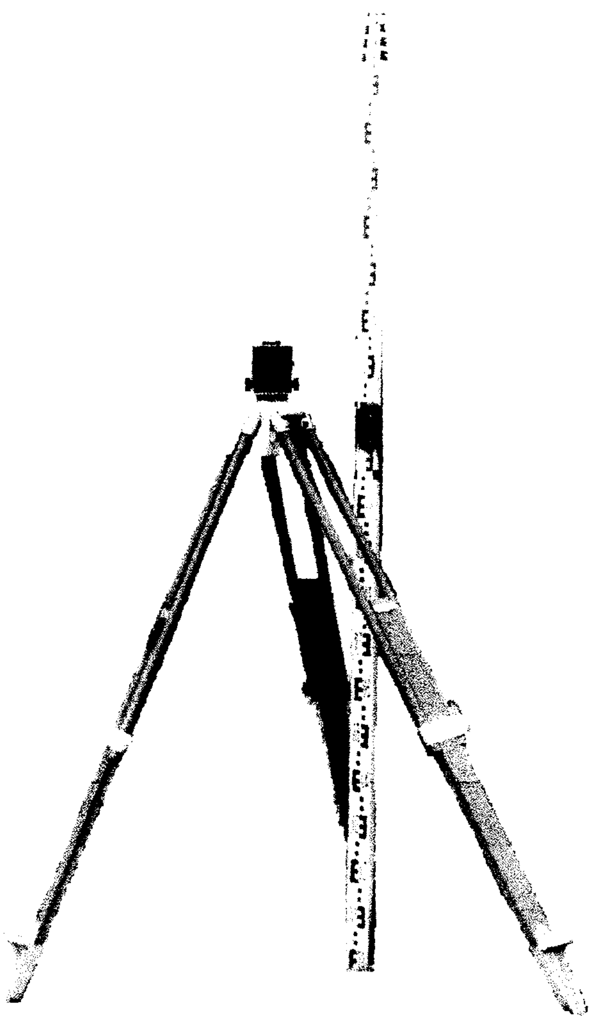
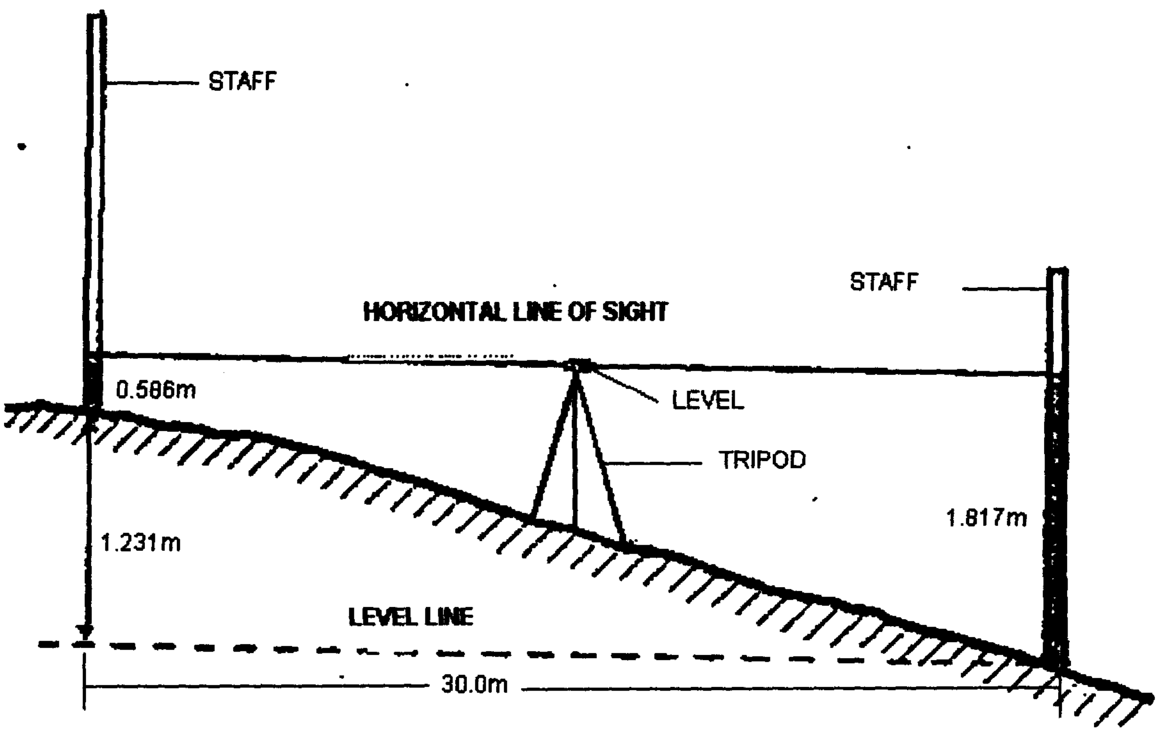


Plate 7: Showing Level, Tripod and Staff set up.

Using the height of instrument method, a site survey was carried out to determine the slope of the field. The procedure is illustrated in plate 8 and 9 below.

Plate 8: Site survey showing the Tripod, Level and Staff setup. Note the grass vegetative cover.



LATE 9: Height of instrument method of slope determination on even slope
Source: Survey Handbook, 1991

3.3 Experimental Procedure

3.3.1 Determination of slope for the site

The level and tripod set up was mounted at the center of the field, the staff was then placed at the lowest point 'B' on the field and the reading taken from the level. The Staff was then moved to the highest point 'A' on the field and the reading taken. The difference in the two points (B – A) gives the change in height from A to B.

3.3.2 Textural Class Analysis (TCA)

To get the percentage sand, clay and silt and the textural classification of the field, four (4) soil samples (A, B, C, D) were collected at equal interval of 10m within the field and analysed in the laboratory.

3.3.3 Climate Database

3.3.3.1 Single Storm Rainfall

The material used for collecting the rainfall amount were

1. Rain gauge

A rain gauge (also known as a udometer or a pluviometer or a cup) is a type of instrument used by meteorologists and hydrologists to gather and measure the amount of liquid precipitation (as opposed to solid precipitation that is measured by a snow gauge) over a set period of time. Most rain gauges generally measure the precipitation in millimeters. The level of rainfall is sometimes reported as inches or centimeters.

2. **Measuring cylinder**

This is a graduated cylindrical glass that measures the amount of water collected from the rain gauge.

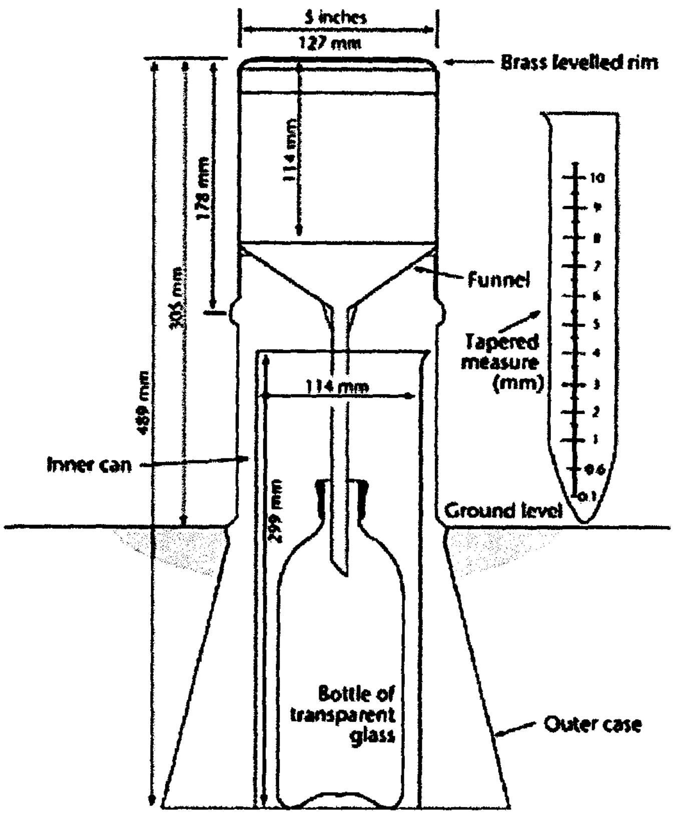


Plate 10: Design specification and mounting of a Rain Gauge and measuring cylinder

To get the average rainfall amount for the site, a rain gauge was mounted at the site and readings were taken after every effective storm. An effective storm is that amount of precipitation which is capable of eroding the soil, hence, causing sediment yield. Effective storm is mostly measured in terms of duration of rainfall since intensity is a function of duration.

$$Intensity = \frac{rainfall\ amount(mm)}{duration(\sec)} \qquad 3.1$$

The rainfall data collected from the rain gauge was used to create a single storm simulation database for Gidan kwanu in the WEPP model as shown in plate 10 below. This information include the storm date and year, the storm amount (mm), the duration (hours), and the intensity (mm/hr). It is imperative to use the average amount of effective rainfall, as using light showers for simulation will result in Gross Errors.

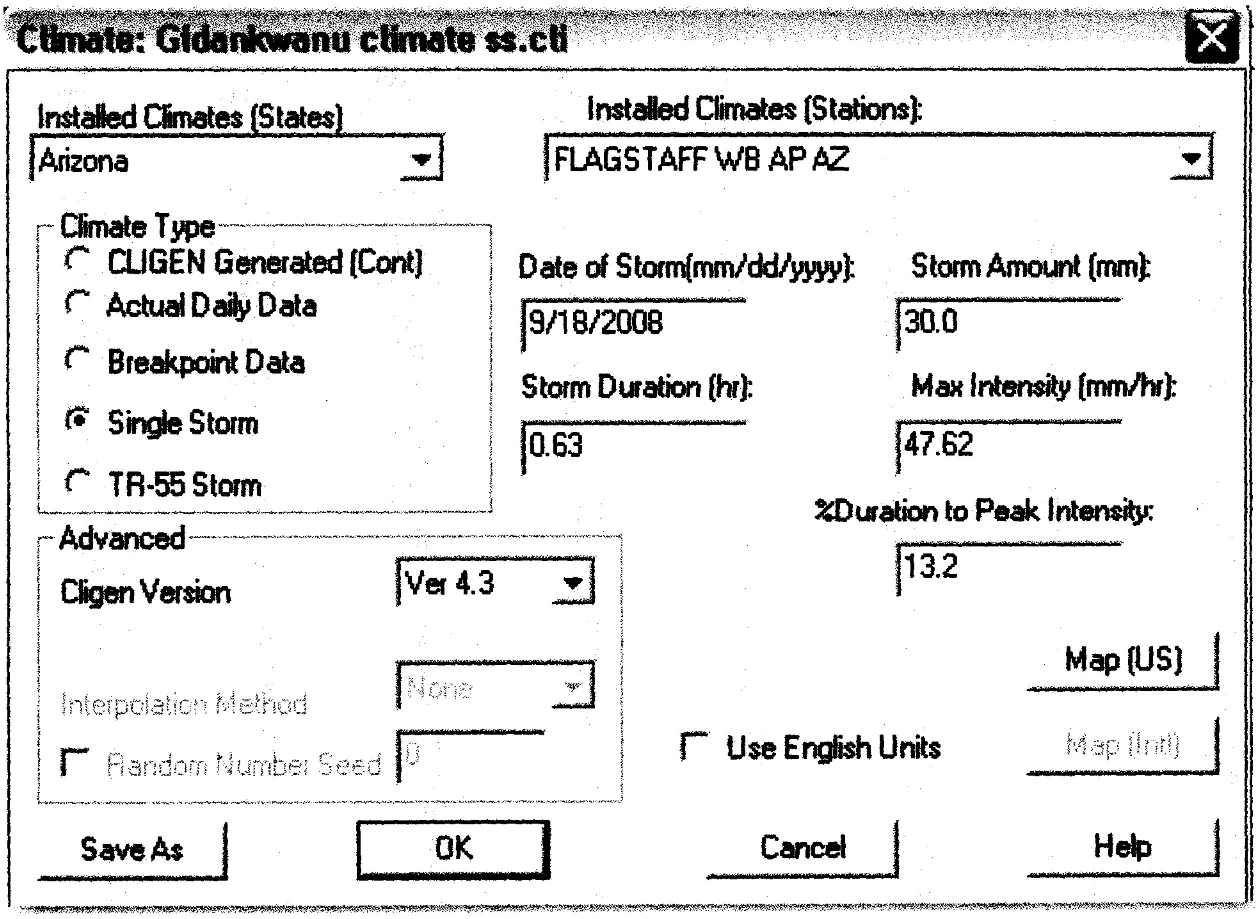


Plate 11: Climate database for single storm simulation

Source: WEPP model

3.3.3.2 Continuous Storm

For a continuous simulation, the mean rainfall amount over 5 wet seasons (5 years) from the Nigerian Meteorological Agency (NIMET), Minna Airport was used to create a continuous simulation database as shown below.

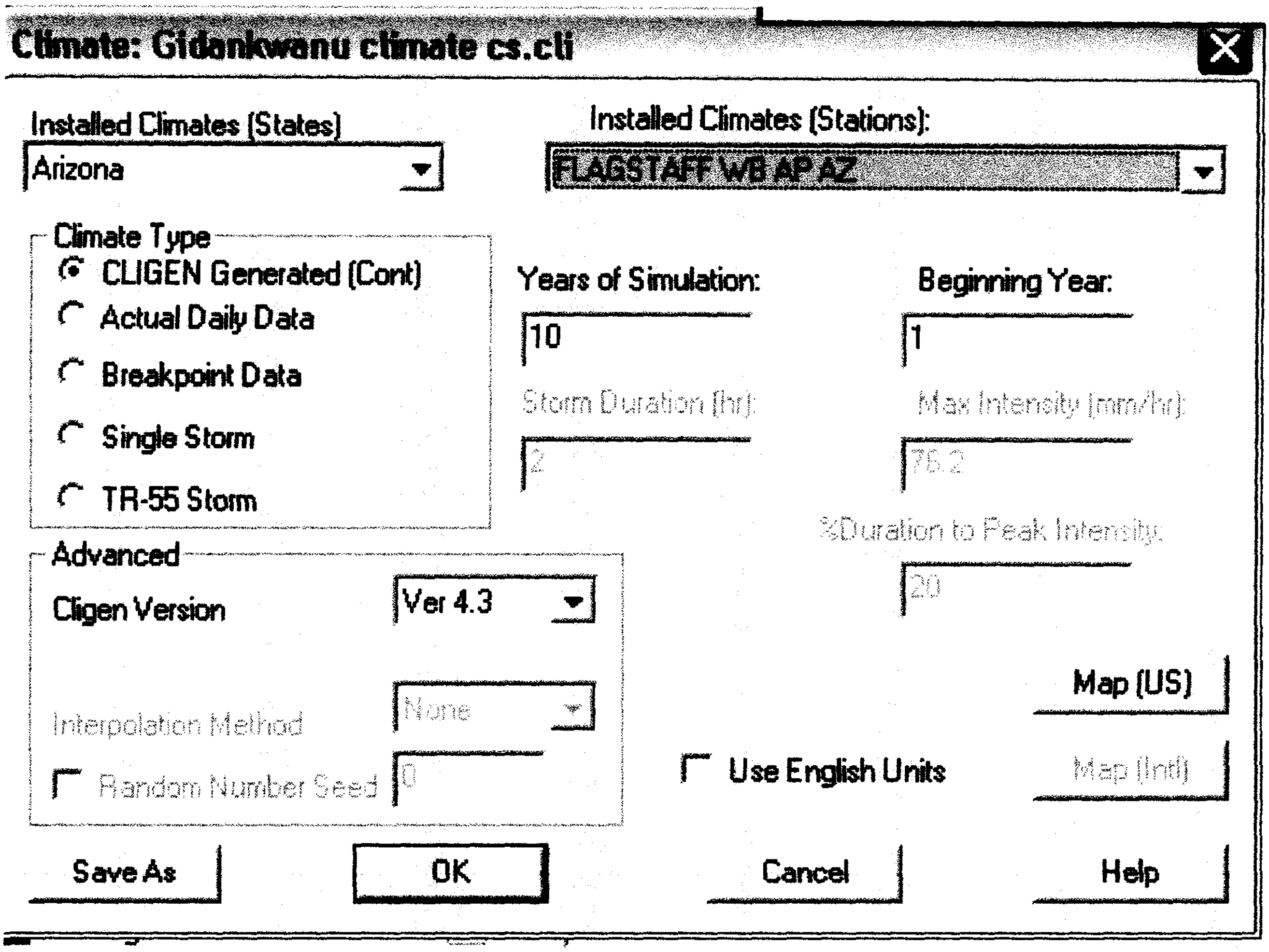


Plate 12: Gidankwano climate data for 10 years continuous simulation
Source: WEPP model

3.3.4 Slope Database

Using the result of the survey work carried out on the field, a field slope database was created in the WEPP model to be used for simulating either single storm or continuous storm simulation. The information required for this database includes the slope length (m), slope with (m), percentage steepness and shape. Plate 11 shows the slope database.

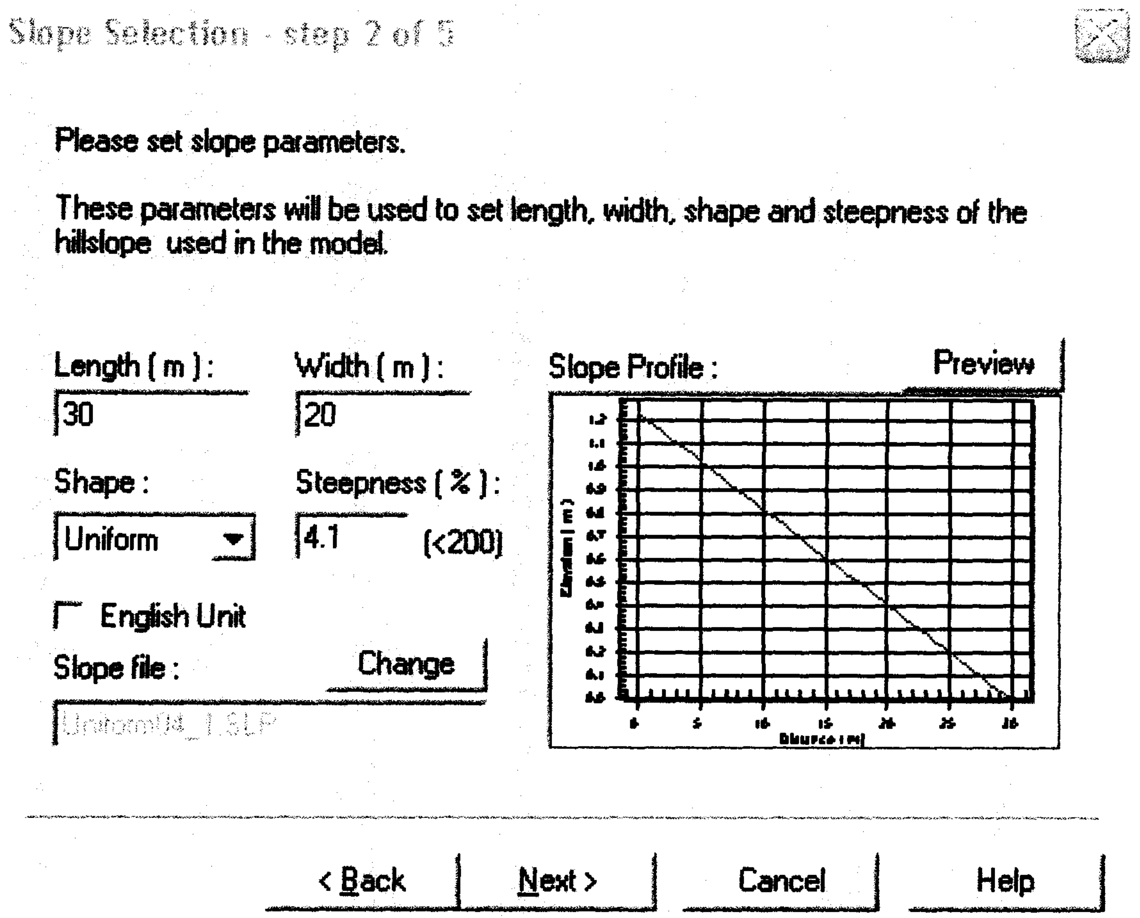


Plate 13: slope database showing the length, width, steepness and shape
Source: WEPP model

3.3.5 Soil Database

The information in the soil database include the tectural class, percentage sand, percentage clay percentage silt, initial saturation level, and albedo. Other data required for the simulation that will be generated by the model include the Interill erodibility, Rill erodibility, Critical shear and Effective Hydrolic Conductivity. Plate12 show the soil database window.

3.3.6 Management Database

The cover of the field was observed to be grass in a continuous and evenly distributed order. WEPP provides a variety of cover factors to be chosen from and used for simulation. These range from agricultural cover such as alfalfa with cuttings, Barley, corn to GeoWEPP covers such as fallow, grass, winter Wheat and Rangeland covers such as range burn, range Herb, rangeland with high or low grazing etc. Plate 12 shows the management subsection of the field along with the time line for simulation.

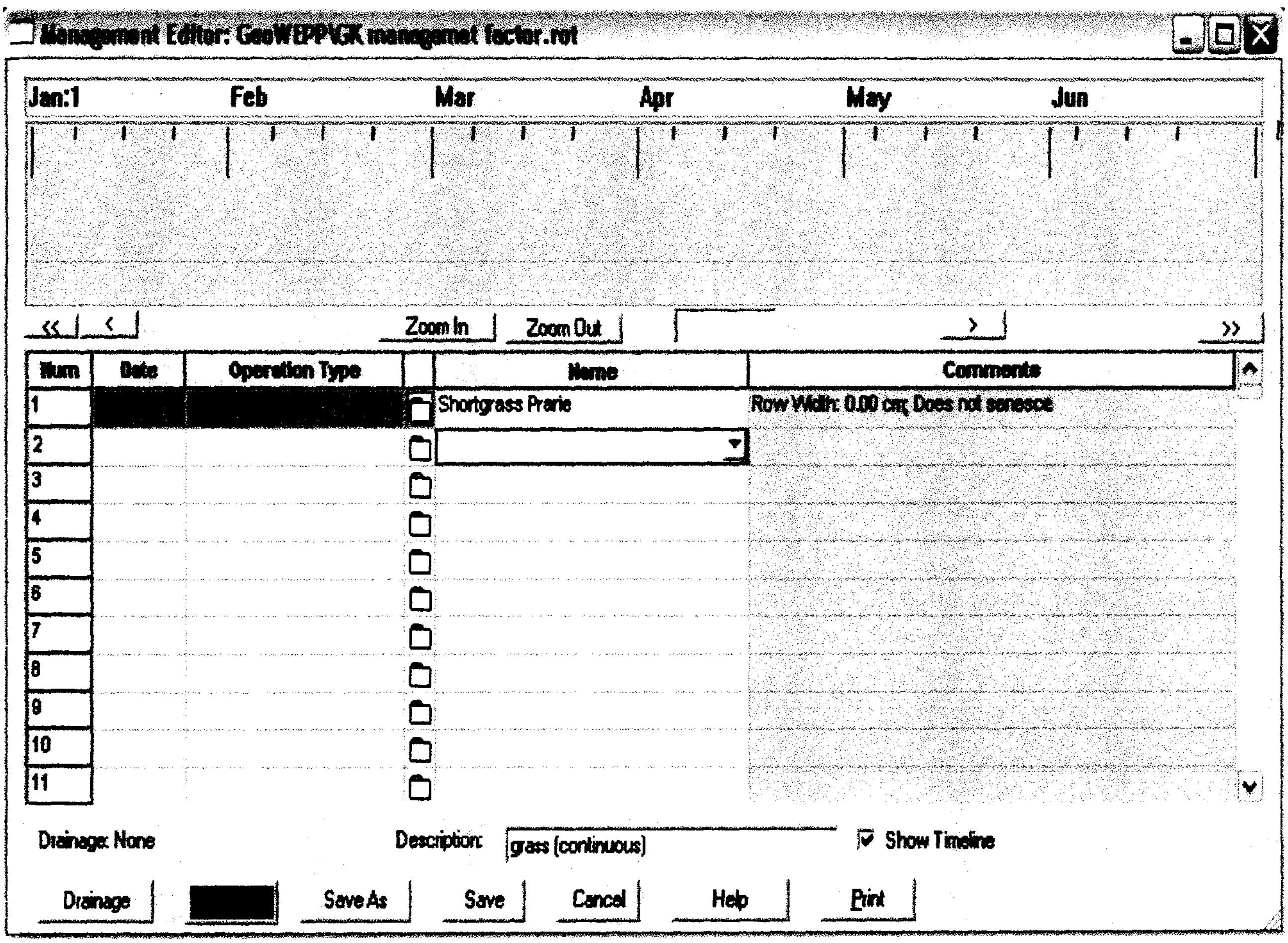


Plate 14: Management subsection showing continuous grass and a time line for simulation
Source: WEPP model

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The results obtained from sight survey, the textural class analysis, the rain gauge readings and the WEPP simulation are shown in tables below.

4.1 Survey Results

Table 4.1 shows the result of the survey work carried out to determine the slope gradient of the field.

Table 1: Change in height between points A and B

FIELD LENGTH (m)	STAFF READING-A (m)	STAFF READING – B (m)	CHANGE IN HEIGHT (B-A) (m)
30.0	0.586	1.817	1.231

From the table above, the slope is given as

$$slope = \frac{change\ in\ height(m)}{field\ lenght(m)} \qquad 4.1$$

$$= \frac{1.817 - 0.586}{30.0}$$

$$= \frac{1.231}{30}$$

$$= 0.041$$

Percentage slope $= 0.041 * 100 = 4.1\%$

This implies that for any 1m distance downslope, the ground level moves from the horizontal by 0.041m i.e. 4.1%.

4.2 Textural Class Result

Table 4.2 shows the laboratory result of the four soil samples collected from the site.

Table 2: Result of Textural Class Analysis

SAMPLE	% SAND	% CLAY	% SILT	TEXTURAL CLASS
A	53.84	29.60	16.56	**Sandy-Clay-Loam**
B	57.84	27.60	14.56	**Sandy-Clay-Loam**
C	57.84	27.60	14.56	**Sandy-Clay-Loam**
D	57.84	27.60	14.56	**Sandy-Clay-Loam**
AVERAGE	***57.84***	***28.1***	***15.56***	***Sandy-Clay-Loam***

Taking the percentage composition of all four samples, the % sand, % clay, and % silt were found to be 57.84%, 28.10%, and 15.56% respectively, giving a textural class of "Sandy-Clay-Loam". This information enebles WEPP to calculate the initial moisture content and the albedo of the soil.

4.3 Single Storm Data

The actual rainstorm reading for duration of 3 weeks is shown in table 3 below.

Table 3: Rainfall Data from 2nd to 27th september 2008

D A Y	AMOUNT (mm)	DURATION (hr)	INTENSITY (mm/hr)
02/09/08	24.0	0.78	$\frac{24}{0.78} = 30.77$
04/09/08	16.0	0.53	$\frac{16}{0.53} = 30.19$
07/09/08	26.0	0.61	$\frac{26}{0.61} = 42.62$
08/09/08	16.0	0.37	$\frac{16}{0.37} = 43.24$
11/09/08	30.0	1.13	$\frac{30}{1.13} = 26.55$
14/09/08	25.0	0.68	$\frac{25}{0.68} = 36.76$
15/09/08	15.0	0.27	$\frac{15}{0.27} = 55.56$
17/09/08	23.0	0.43	$\frac{23}{0.43} = 53.49$
18/09/08	30.0	0.63	$\frac{30}{0.63} = 47.62$
19/09/08	24.0	0.71	$\frac{24}{0.71} = 33.80$
22/09/08	19.0	0.73	$\frac{19}{0.73} = 26.03$
24/09/08	20.0	0.25	$\frac{20}{0.25} = 80.0$
26/09/08	20.0	0.48	$\frac{20}{0.48} = 41.67$
27/09/08	35.0	1.12	$\frac{35}{1.12} = 31.25$

Table 4 shows Ten (10) years Nigerian Meteorological Agency (NIMET) rainfall data for the study area from 1997 2007 that was used for the continuous storm simulation.

Table 4: Ten (10) Years rainfall data

YEAR/ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1997	0.0	0.0	3.1	81.0	238.7	231.0	173.6	409.2	204.0	114.7	0.0	0.0	1238.3
1998	0.0	0.0	0.0	93.0	120.9	222.0	155.0	257.3	201.0	213.9	0.0	0.0	1247.6
1999	0.0	8.4	0.0	36.0	103.3	165.0	244.9	192.2	237.	210.3	0.0	0.0	1238.3
2000	0.3	0.0	0.0	3 . 0	136.4	162.0	207.7	241.3	303.0	151.9	0.0	0.0	1274.0
2001	0.0	0.0	0.0	93.0	139.5	333.0	244.9	244.9	300.0	24.3	0.0	0.0	1364.0
2002	0.0	0.0	0.0	98.8	42.6	201.0	143.2	310.0	260.0	180.3	0.3	0.0	1159.0
2003	0.0	0.0	5.7	61.2	141.7	250.6	214.3	229.4	143.1	93.3	0.0	0.0	1112.6
2004	0.0	0.0	17.3	32.2	151.9	194.9	210.3	226.5	241.5	77.6	0.0	0.0	1119.8
2005	0.0	0.0	0.0	49.1	87.0	207.0	294.2	185.6	226.4	94.5	0.0	0.0	1086.3
2006	11.2	0.0	0.0	39.9	195.0	107.7	229.7	211.4	360.5	172.1	0.0	0.0	1423.2
2007	0.0	0.0	0.4	73.1	156.5	123.9	314.6	127.8	330.2	115.1	0.0	0.0	1423.4
MEAN	*0.5*	*0.4*	*2.1*	*55.3*	*156.2*	*182.1*	*206.9*	*256.5*	*233.3*	*122.3*	*3.4*	*1.8*	1220.8

Source: NIMET Agency, Minna Airport

4.4 Simulation Results

Using the above sets of data for the simulation, the result shown in table 5 below was obtained.

Table 5: Simulation Result

10 YEARS SIMULATION	VALUE	UNITS
Average Annual Precipitation	1376.5	mm
Average Annual Runoff	61.16	mm
Average Annual Soil Loss	0.047	kg/m2
Average Annual Sediment Yield	0.469	t/ha

Source: WEPP model

4.4.1 Average Annual Precipitation

From the 10 years simulation result shown in Table 5 it can be seen that the WEPP generated Average Annual Precipitation (1376.5mm) varies slightly from the NIMET Agency value (1233.06mm) by 143.44mm. This is be WEPP assumes an ideal rainfall efficiency where there is no loss or error in rain gauge and measuring cylinder readings. This minute losses and errors in meniscus reading could accumulate over a year to a substantial amount and account for the 143.44mm difference.

4.4.2 Average Annual Runoff

The Average Annual Runoff generated was 61.16 mm. This is the amount of water that flows over the 20*30 meters field under study, thus the amount of runoff that will cause the resulting soil loss and sediment yield in a year. This amount of runoff is considered negative as it is too small in value to cause severe damage to the field that may hinder agricultural practices.

4.4.3 Average Annual Soil Loss

The generated Average Annual Soil Loss from the field under investigation was 0.047 kg/m^2. This gives the actual amount of sand, clay and silt particles that will be detached from its original position by the action of interill erosion in one year. It implies that for every square meter (m^2) on the field, 61.16 mm of runoff amount will detach 0.047 kg of soil in one year.

4.4.4 Average Annual Sediment Yield

The generated Average Annual Sediment Yield was 0.469 t/ha (0.0469 kg/m^2). This gives the total amount of sediments constituting soil particles, decaying vegetative cover and other nutrients which will be washed totally from the 600 (20*30) square meters area. This value is usually greater than the average annual soil loss for a bare field without cover since all the detached soil and other soil compositions will be washed off the field. The 0.0001 kg/m^2 difference (0.047 – 0.0469) accounts for the amount that was trapped by the even grass cover.

4.5 Inference

This value is very low when compared with soil tolerance value assigned to moderately permeable soils for agricultural. The tolerance value ranges from 4 – 11 Mg/ha (i.e. 40 – 110 kg/m^2) (Mustapha, 2008). Considering the little amount of Annual Sediment Yield from the field, it can be seen that the field is suitable for most Agricultural practices.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The aim of evaluating Annual Sediment Yield from Interill erosion was achieved using WEPP model. The annual average runoff amounted to 61.16 mm, annual soil loss amounted to 0.047 kg/m^2, average annual Sediment Yield to 0.0469 kg/m^2. The difference in the amount of Soil Loss and Sediment Yield shows that the management practice on a given farm land determines to a great extent the total amount of sediments that will be transported from the field by runoff even when it has been completely detached by raindrop energy. The vegetative cover both acts as a shield to reduce the erosive force of water droplet and also as a trap to stop some particles from being moved down slope and also reduce the surface runoff thereby reducing the rate at which sediments are being transported down slope.

There is a direct correlation between the slope steepness, the type of vegetative cover, the rainfall amount and the resulting sediment yield. Altering the value for any of these factors within the WEPP model shows either an increase or a decrease in the sediment yield value. But in practice, the only parameter that can easily be altered is the cover factor. Thus, choosing the right management practice gives the farmer or soil conservationist a significant control on the amount of sediment yield from a field.

5.2 Recommendations

1. Before any field is put into farming operation, a Sediment Yield analysis should be carried out to determine the crop yielding potential of the field and also know what management practice to be employed.

2. Accurate and up-to-date climatic information for all distinct geographical locations should be made easily accessible to researchers as this will facilitate speedy and accurate investigation and similar analysis.
3. Where a field is to be used for non agricultural practices such as construction sites, the soil should be graded to reduce the slope steepness as this will reduce the runoff velocity thereby reducing the Sediment Yield.

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APPENDIXES

MEAN MONTHLY ANNUAL RAINFALL IN (mm) FOR MINNA AND ITS ENVIRONS FROM 187 – 2007

LATITUDE 09° 39' N LONGITUDE 06° 28' E

YEAR/ MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL TOTAL
1987	0.0	0.0	13.5	44.6	104.5	83.0	143.7	238.5	94.6	100.1	0.0	0.0	822.5
1988	0.0	0.0	0.0	0.0	81.5	132.0	218.3	350.1	403.6	33.1	0.0	0.0	1218.6
1989	0.0	0.0	5.0	49.5	287.8	193.7	193.7	248.7	202.6	79.0	0.0	0.0	1259.4
1990	0.0	0.0	0.0	177.2	225.2	80.5	256.3	185.8	145.6	110.5	0.0	0.0	1181.1
1991	0.0	0.0	0.0	15.0	334.8	180.0	193.2	269.3	192.0	34.1	0.0	0.0	1217.3
1992	0.0	0.0	0.0	1.2	158.1	177.0	161.2	195.3	231.0	229.4	48.0	37.2	1233.4
1993	0.0	0.0	0.0	0.0	173.6	171.0	189.1	269.7	177.0	62.0	0.0	0.0	1042.4
1994	0.0	0.0	0.0	75.0	114.7	240.0	142.6	195.3	261.0	207.0	0.0	0.0	1406.8
1995	0.0	0.0	0.0	102.0	124.0	144.0	155.6	269.7	189.0	136.4	24.0	0.0	1283.3
1996	0.0	0.0	0.0	48.0	104.3	225.0	260.4	365.3	192.0	127.1	0.0	0.0	1274.1
1997	0.0	0.0	3.1	81.0	238.7	231.0	173.6	409.2	204.0	114.7	0.0	0.0	1238.3
1998	0.0	0.0	0.0	93.0	120.9	222.0	155.0	257.3	201.0	213.9	0.0	0.0	1247.6
1999	0.0	8.4	0.0	36.0	103.3	165.0	244.9	192.2	237.	210.3	0.0	0.0	1238.3
2000	0.3	0.0	0.0	3.0	136.4	162.0	207.7	241.3	303.0	151.9	0.0	0.0	1274.0
2001	0.0	0.0	0.0	93.0	139.5	333.0	244.9	244.9	300.0	24.3	0.0	0.0	1364.0
2002	0.0	0.0	0.0	98.8	42.6	201.0	143.2	310.0	260.0	180.3	0.3	0.0	1159.0
2003	0.0	0.0	5.7	61.2	141.7	250.6	214.3	229.4	143.1	93.3	0.0	0.0	1112.6
2004	0.0	0.0	17.3	32.2	151.9	194.9	210.3	226.5	241.5	77.6	0.0	0.0	1119.8
2005	0.0	0.0	0.0	49.1	87.0	207.0	294.2	185.6	226.4	94.5	0.0	0.0	1086.3
2006	11.2	0.0	0.0	39.9	195.0	107.7	229.7	211.4	360.5	172.1	0.0	0.0	1423.2
2007	0.0	0.0	0.4	73.1	156.5	123.9	314.6	127.8	330.2	115.1	0.0	0.0	1423.4
IEAN	*0.5*	*0.4*	*2.1*	*55.3*	*156.2*	*182.1*	*206.9*	*256.5*	*233.3*	*122.3*	*3.4*	*1.8*	*1220.8*

Source: Nigerian Meteorological Agency (NIMET), Minna Airport, Minna.

MEAN MONTHLY TEMPERATURE OF MINNA AND ITS ENVIRONS BASED ON 20 YEARS RECORD (1987 – 2007)

LATITUDE $09^{O} 39^{I}$N LONGITUDE $06^{O} 28^{I}$E

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL MEAN
MAX. TEMP (°C)	32.1	37.5	38.5	37.3	33.9	31.1	39.7	28.3	31.0	32.1	33.3	34.0	33.2
MIN. TEMP (°C)	21.0	20.3	25.9	25.6	23.7	22.8	22.0	21.8	20.8	21.4	20.2	18.5	22.3

Source: Nigerian Meteorological Agency (NIMET), Minna Airport, Minna

MEAN MONTHLY RELATIVE HUMIDITY OF MINNA AND ITS ENVIRONS BASED ON 20 YEARS RECORD (1987 – 2007)

LATITUDE $09^{O} 39^{I}$N LONGITUDE $06^{O} 28^{I}$E

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL MEAN
RELATIVE HUMIDITY (%)	28.0	32.0	36.0	58.0	75.0	79.0	83.0	85.0	76.0	74.0	46.0	34.0	59.0

Source: Nigerian Meteorological Agency (NIMET), Minna Airport, Minna