DEVOLOPING AN EROSION MODEL OF SURIF, BEIT UMMAR, AND TARQUMYA CATCHMENT AREAS USING GEOGRAPHIC INFORMATION SYSTEM (GIS) SOFTWARE AND REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

BY

IYAD ZAMAREH **NAZEH QTET**

RAMI AL-ATAWNEH **TAHA ASAFRA**

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF

REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF ENGINEERING

IN

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

SUPERVISED BY

ENG. MAHER OWAIWI

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

COLLGE OF ENGINEERING AND TECHNOLOGY

PALESTINE POLYTECHNIC UNIVERSITY

HEBRON- WEST BANK

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JUNE - 2008

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CERTIFICATION

Palestine Polytechnic University

PPU

Hebron-Palestine

The Senior Project Entitled:

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Prepared By:

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In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Science in Engineering.

Project Supervisors **Department Chairman**

JUNE - 2008

Dedication

الإهـــــداء

إلى من تجسدت السعادة في أحضانها, وارتسمت الفرحة في عينيها، إلى ينبوع الحياة الدافئ، إلى الحياة وبدونها لا حياة:

إلى أمي

إلى الذي وعدته أن أكون فكنت، إلى الذي مد ذراعيه جسرا فعبرت، إلى رمز العطاء الدائم:

إلى أبي

إلى باقات الأمل، إلى من سكنوا مكان الروح من الجسد..............**إخوتي و أخواتي**

إلى مشاعل الوطن الكبير...............**شهداء الحق والحرية**

إلى رفاق دربي.............**أصدقائي**

إياد زماعره

طه عصافره

رامي العطاونة

نزيه اقطيط

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Team Work

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ARABIC ABSTRACT

DEVOLOPING AN EROSION MODEL OF SURIF, BEIT UMMAR, AND TARQUMYA CATCHMENT AREAS USING GEOGRAPHIC INFORMATION SYSTEM (GIS) SOFTWARE AND REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

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تعرية التربة واحدة من المشاكل الرئيسية التي تفصل جزيئات التربة عن بعضها البعض والتي تسببها الرياح والمياه.إذ تؤثر على الإنتاج الزراعي واستخدامات الأراضي، تعتبر الزراعة في فلسطين من أهم المصادر الاقتصادية الحيوية، وفي هذا المشروع محاولة لدراسة تأثير تعرية التربة على تدهور الأراضي ومحاولة حمايتها.

المعلومات التي تم جمعها عن تعرية التربة لمنطقة الدراسة استخدمت في المعادلة العامة لتآكل التربة **(RUSLE)** وبرنامج نظم المعلومات الجغرافية **(GIS)**، وجد أن قيم تعرية التربة المقدرة في معظمها دون قيمة ٣ طن / فدان / سنة والذي يدل على وجود منخفض جدا للتعرية؛ كما وجد أن المناطق ذات التعرية العالية حدثت في المناطق المنحدرة جدا وكانت قيمتها حوالي ١٤.٦% من منطقه الدراسة.

ENGLISH ABSTRACT

DEVOLOPING AN EROSION MODEL OF SURIF, BEIT UMMAR, AND TARQUMYA CATCHMENT AREAS USING GEOGRAPHIC INFORMATION SYSTEM (GIS) SOFTWARE AND REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

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Erosion is one of the major problems that detached soil particles and is caused by wind and water. It affects the aglicultural productivity and land use. In Palastine agriculture is the vital source of economic, at the same time erosion attack these lands. In this project a try to study the effect of erosion on lands degradation is conducted to protect it.

A spatial information of water soil erosion for the study area is conducted using Revised Universal Soil Loss Equation (RUSLE) and GIS software. I was found that the estimated erosion values are mostly below the used "tolerable soil loss" of 3 tons/acres/year which indicating a very low soil erosion risk. Also, it was found that the areas of highest erosion occurred in places where the slope at greatest and consists of a bout 14.6% of the study area.

CHAPTER ONE

BACKGROUND AND SITE DESCRIBTION

Chapter 1: Background and site Description

1.1 Summary

This chapter describes physical characteristics, hydrological parameters and geological formations of the study area. Physical characteristics include location of study area, topography, soil types, and landuse. Then hydrological parameters which contain climate, temperature and humidity, precipitation, evaporation, infiltration and finally runoff and catchment areas. After that we talk in brief about geological formations and the places where it found.

1.2 Background

Erosion is displacement of solids (soil, mud, rock and other particles) usually by many factors such as, wind and water.

Soil erosion is considered as one of the critical environmental problems. Weather, topography, geology and land use/cover are the most critical factors for acceleration or control of the erosion. The first three factors can be classified as natural, whereas the land use factor is mainly human-based and well known as the most critical component of the erosion processes. Because of its key role in soil conservation and high sensitivity to human activities, land use/cover has been considered as the most important parameter.

Since the problem of erosion modeling is not an easy task. There are very limited possibilities to control the natural conditions of the environment, but proper use or misuse of the land can act as an efficient tool for sustainable use of the land resources or their degradation.

The value of Geographic Information Systems (GIS) in today's world is well known, but their capabilities also make them ideal tools for the analysis of erosion modeling.

1.3 Problem Definition

Erosion adversely affects human health and his happiness, disrupts natural and human environments, reduces agricultural productivity, and damaged human infrastructure.

1.4 Location

The study area is part of Hebron district, which lies in the southern part of West Bank, Palestine. The study area lie in the north-west part of the Hebron district and extend from (144900) to (168730) east and from (106670) to (120060) north, on Palestine coordinate system, figure (1.1).

1.5 Topography

The elevation ranges from 300m above sea level at the western part of the study area to 1021m at the mid part of the study area (Halhoul Mountains). The general topography is hilly to sloppy at the western areas and the highland lies at eastern part of the study area.

1.6 Soil

The study area includes some types of soil but there are three major types of soil association, figure (1.2), it is classify as the following:

Terra Rossa, Brown Rendzinas and Pale Rendzinas: the vital materials from which this soil was originally initated are mainly dolomate and limestone. This soil is characteristic of the hilltop areas with multi rock outcrops that could reach to about 30% to 50% of the soil content. Soil depths ranging from 0.5 to 2 meters are found in different areas of this type of soil. This soil type has a pH ranges between 7.5 to 8.1 with clay to clay loam soil texture. Land with these type of soil is used to cultivate field crops, mainly wheat and barley, olive and fruit trees.

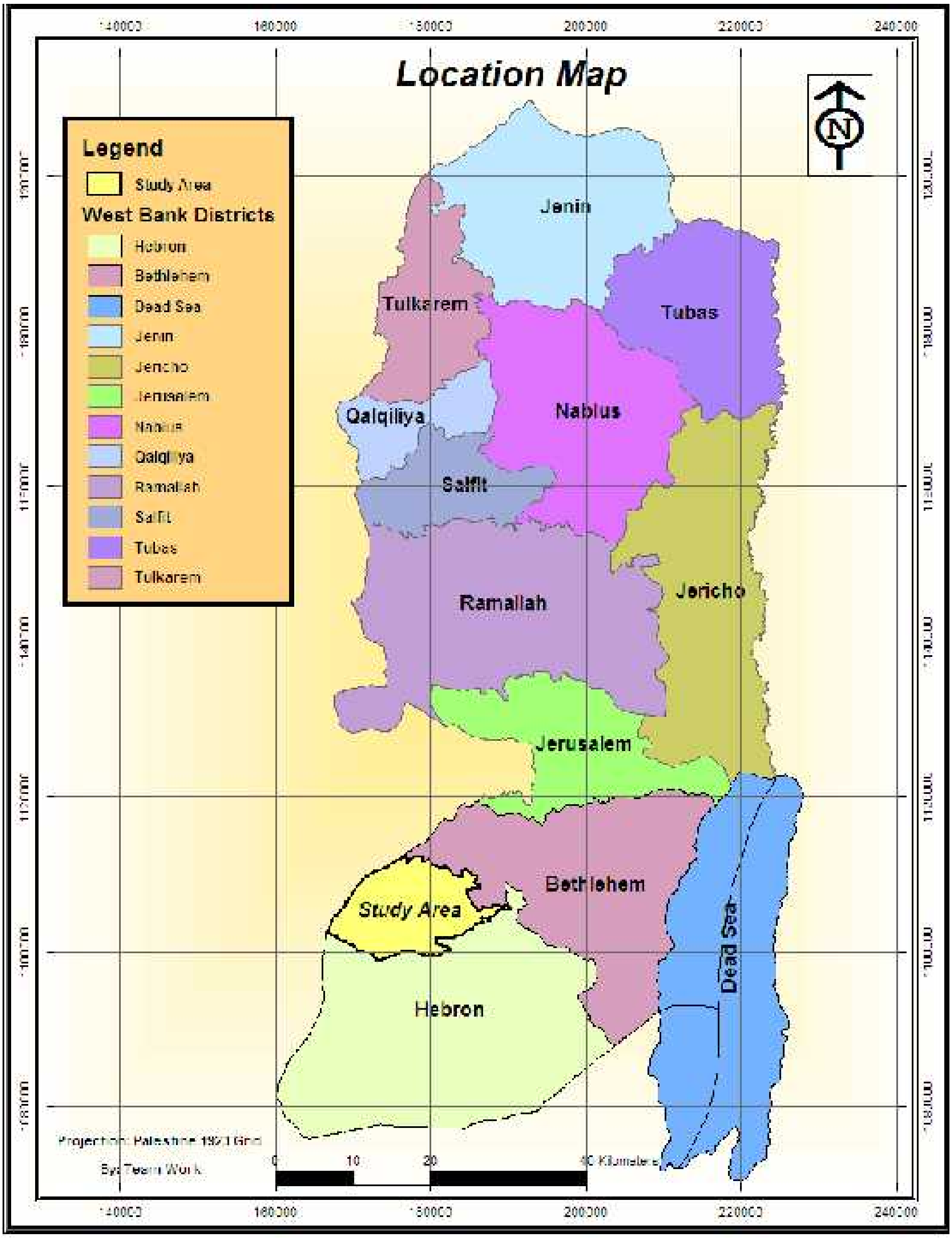

Figure (1.1): Location Map of the Study Area (PPU GIS Lab, 2007).

Brown Rendzinas and Pale Rendzinas: numerous rock outcrops are occupying like type of soil and ranges 20% to 50%. Slope grabiants vary greatly, ranging from 3% at the hilltops to 30% at the mountainous areas. The soil depths reaching 0.5 meter at the mountainous areas and rising to 2 meters at the hilltops. Basic materials are mostly hard and soft chalk. The pH is mainly neutral to slightly basic from 7.5 to 8. The main land uses is cultivation of graps and olives, field crops and grazing.

Dark Brown Soils: the parent materials from which this soil is origionated are fine aeolian sediments, calcareous sandstone, and medium to fine-textured alluvial deposits. It is found on the moderately slopping hills. This type of soil spread as elongated polygons on the western part of the study area. Primary natural vegetation on the soil was dameged. Table (1.1) shows the area in (km²) of each soil type in the study area:

Table (1.1): The Area in (km²) of Eeach Soil Type in the Study Area.

Soil Type	Area (km²)
Terra Rossa, Brown Rendzinas and Pale Rendzinas	89.2336
Brown Rendzinas and Pale Rendzinas	78.8216
Dark Brown Soils	7.1219
Total	**175.1771**

Figure (1.2) shows the major soil associations of each soil type and the places where it found in the study area.

1.7 Vegetation and Land Use

The study area contains several types of land use, arable land, heterogeneous agricultural area, permanent crops, urban fabric, forests, indusrial commercial, mine, dumps and construction site, open spaces with little or no vegetation, plastic houses, shrubs and herbaceous vegetation associations, figure (1.3). The main land use in the eastern part of study area contains heterogeneous agricultural areas, and the areas which open spaces with little or no vegetation concentrate in the middle and western part. Other land uses distribute in the target area as small areas. Table (1.2) shows the land use associations and the area in which it found and the percent to the total study area.

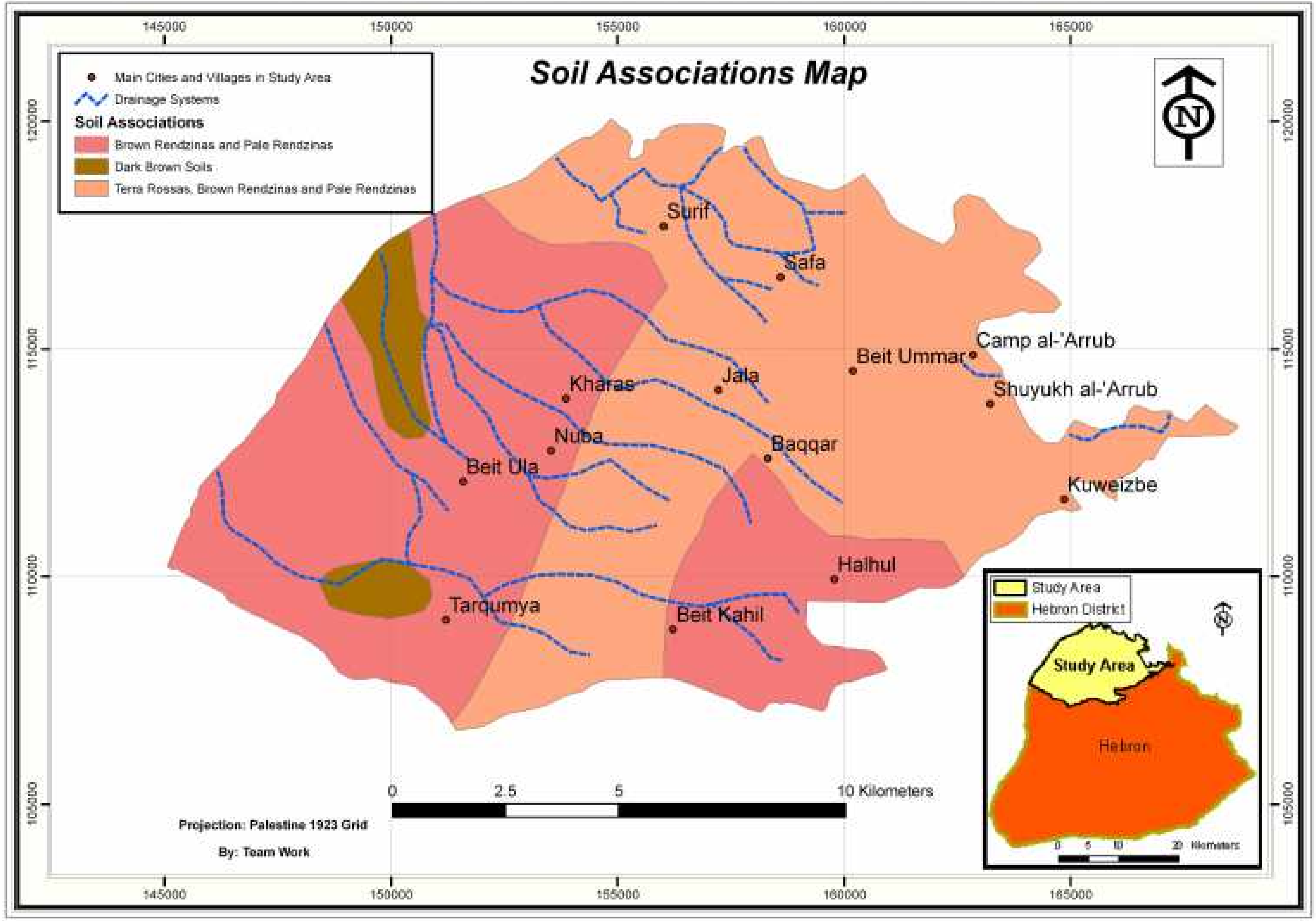

Figure (1.2): Soil Associations Map of the Study Area (Owaiwi, 2005).

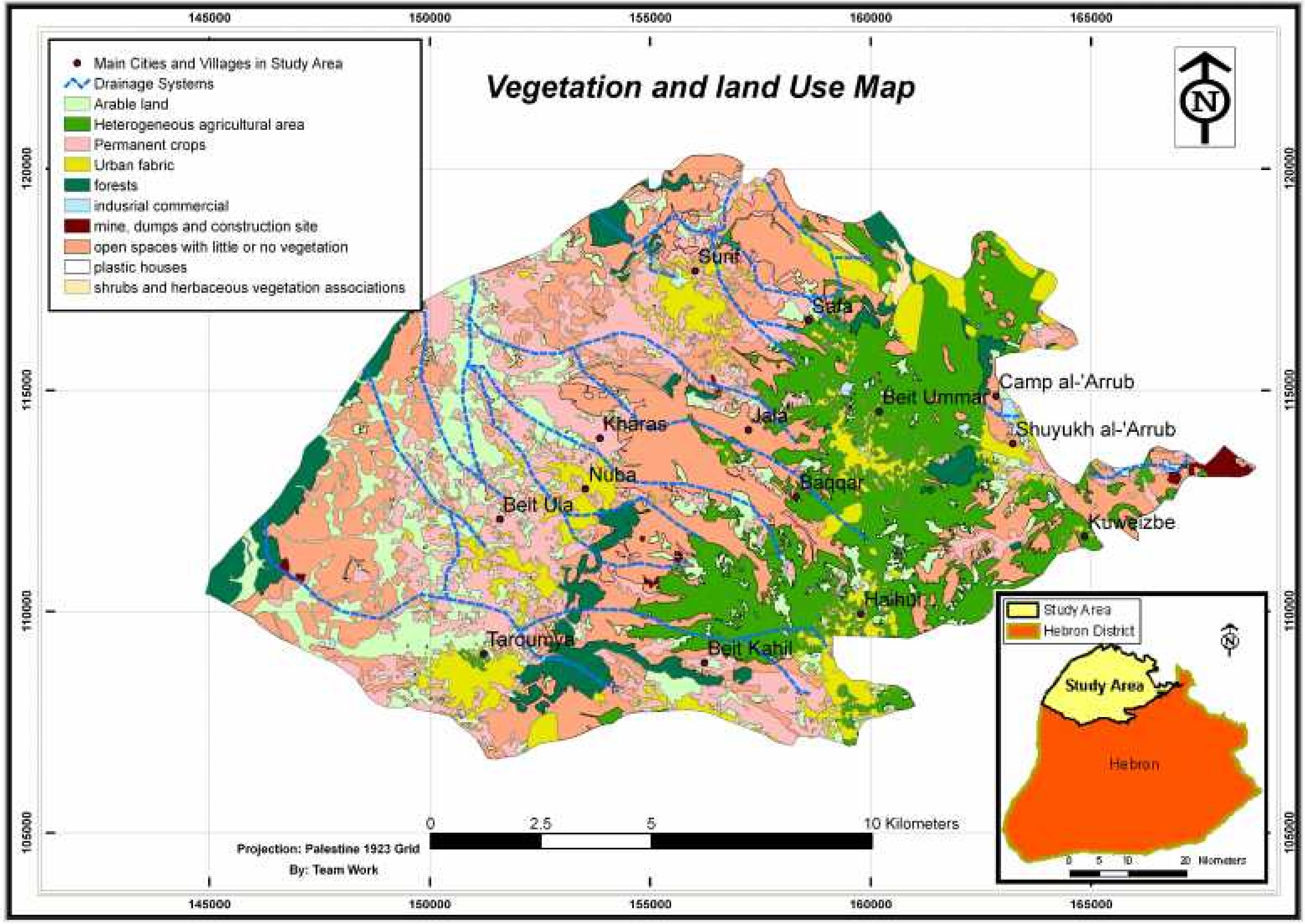

Figure (1.3): Vegetation and Land Use Map of the Study Area (PPU GIS Lab, 2007).

Table (1.2): The Area in (km²) of Each Land Use Type and its Percent to the Total Study Area.

Landuse Type	Area (km²)	Land(%)
Arable Land	2.7674	1.523252
Heterogeneous Agricultural Area	15.5621	8.565802
Permanent Crops	9.9152	5.457595
Urban Fabric	130.0176	71.56521
Forests	1.4816	0.815513
Industrial Commercial	0.859	0.472817
Mine, Dumps and Construction Site	3.470	1.909982
Open Spaces With Little or No Vegetation	8.4213	4.635312
Plastic Houses	0.1058	0.058235
Shrubs and Herbaceous Vegetation Associations	1.1245	0.618955
Total	**175.1771**	**100**

1.8 Population

The population in the study area was geographically distributed according to the population ranges and according to population density per build-up area (km²). The raw data was obtained from Palestinian Central Bureau of Statistic (2006), table (1.3).

Table (1.3): Population Density Per Build-up Area (km²) of Each Community in the Study Area (Raw Data From Palestinian Central Bureau of Statistic (2006), Projected Mid-Year Population for Hebron Governorate by locality 2006).

Community Name	Community Area (km²)	Population 2006	Population Density Per Build-up Area (km²)
'Irqan Turad	0.1270	509	4,007.8740
Al Jab'a	0.0029	906	312,413.7931

Al 'Arrub Camp	0.3240	8,358	25,796.2963
Beit Kahil	1.4490	5,859	4,043.4783
Beit Ula	1.8010	9,475	5,260.9661
Beit Ummar	1.4930	12,660	8,479.5713
Halhul	4.3990	21,803	4,956.3537
Hitta	0.3680	720	1,956.5217
Jala	0.1620	253	1,561.7284
Khirbet ad Deir	0.2240	299	1,334.8214
Kharas	0.5740	7,122	12,407.6655
Kuweizbe	0.1370	475	3,467.1533
Nuba	0.6610	4,477	6,773.0711
Qurnet ar Ras	0.0830	274	3,301.2048
Safa	0.5660	1,105	1,952.2968
Shuyukh al-'Arrub	0.0380	1,378	36,263.1579
Surif	1.7920	13,440	7,500
Total		**89,113**	

The previous table shows that Halhul is the only community exceeds 20,000 inhabitants, While Surif and Beit Ummar populations' ranges between 10,000-20,000 inhabitants. Beit Ula, Camp al-'Arrub, Kharas and Beit Kahil communities have population ranges between 5,000-10,000 inhabitants, and the other communities less than 5,000 inhabitants.

It was found that the population density per build-up area (km^2) of Al Jab'a, Shuyukh al-'Arrub villages and Camp Al 'Arrub are of the highest in the study area.

1.9 Hydrological Parameters

This section describes the main factors that affect the water balance which contains rainfall, temperature and humadity, evaporation and infiltration. Identification drainage systems and surface catchment areas are vital in estimating how much water reaches each catchment area.

1.9.1 Climate

The study area is highly affect by the meditarranean climate, which classified as long, hot and dry in summer and short, cool, rainy in winter. Rainfall is limited to the winter and spring months, mostly between November and March; summer is completely dry. Snow and hail may occur over highland areas such Halhul and Beit Ummar.

1.9.2 Temperature and Humidity

The annual mean temperature in the western part of study area (Tarqumya and Beit Ula) varies from 19 to 21ºC, and decreases to 15ºC at mountainous regions (Halhul and Beit Ummar). The average monthly temperature reaches 8ºC in winter and 26ºC in summer, with maximum and minimum average monthly temperature 38 and -3ºC, respectively.

The annual mean relative humidity ranges from 55% to 60 % at the western parts of study area, and decreases to about 50% at mountainous regions.

1.9.3 Precipitation

The study area has a semi-arid. The average annual rainfull increases from 300 mm at western part of target area to about 600 mm at the eastern part (Halhul and Beit Ummar), figure (1.4) shows the average annual precipitation map in (mm/hour).

1.9.4 Evaporation

Evaporation is the transfer of water from the liquid to the vapor state from open water surfaces. Evaporation is principally strong in summer as a result of high temperature, intensive sunshine and low humidity. The evaporation rate in the mountain region, such as Halhul and Beit Ummar is lower than in other regions.

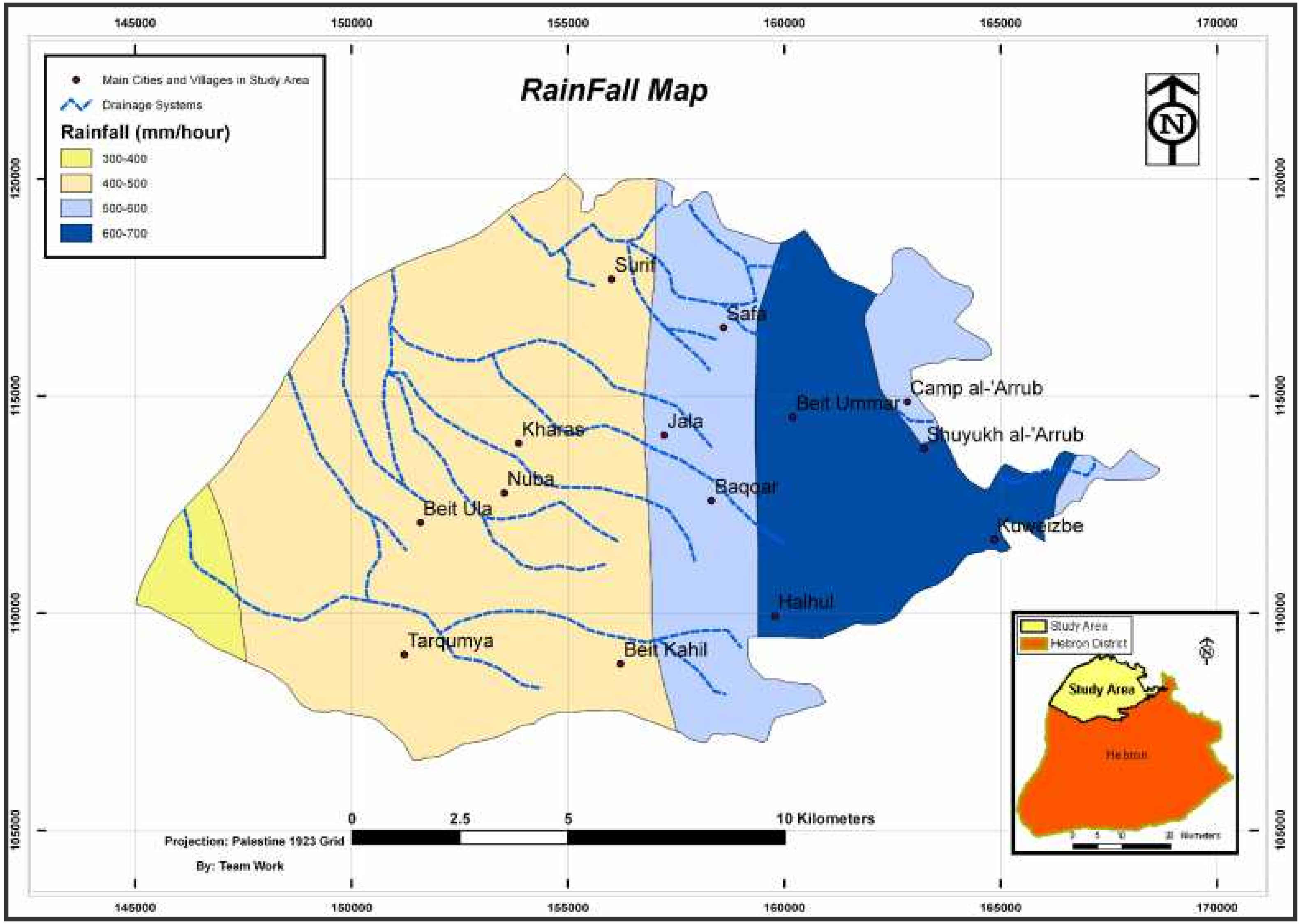

Figure (1.4): Mean Annual Precipitation Map (Owaiwi, 2005).

1.9.5 Runoff and Surface Catchment Areas

All the drainage systems origionated from the inland mountains and are largely controlled by a few flowing westwords, some of which have cut deeply into the highlands with their numerous main stream lines, therefore nearly all the water flowing in study area watersheds comes from the relatively high rainfall regions of the mountains, figure (1.5).

The drainage systems are of dendrite type, which means that the area is subjected to a long-term erosion process, despite of the many tectonic events, which affected to the study area.

1.9.6 Infiltration

Infiltration is a movement of water from the surface of ground into the soil. In a rainstorm, infiltration normally begins at a high rate and decreases to a minimum as rain continues. Infiltration capacity depends on many factors such as; topography, soil type, moisture content, compactor, due to rain, man, and animals, vegetative cover, and temperature. The limiting value of infiltration capacity is controlled by the soil permeability and can be determined experimentally by subjecting an experimental plot to rainfall rates in excess of infiltration capacity and by measuring surface runoff. The other method is by use of infiltrometer of which there are many different types. The lower of infiltration rate through soil, this needed more time for the water to percolate to the ground water. The infiltration of water to the ground water is thought to be mostly through karstic structures, fractures, faults and joints, as exist in most of the carbonate rocks in study area.

1.10 Geology and Stratigraphy

The stratigraphy and lithology of study area consists of several formations, which were formed during the different geological ages. The geology of the target area is composed of sedimentary carbonate rocks of Albian to Eocene age, figure (1.6).

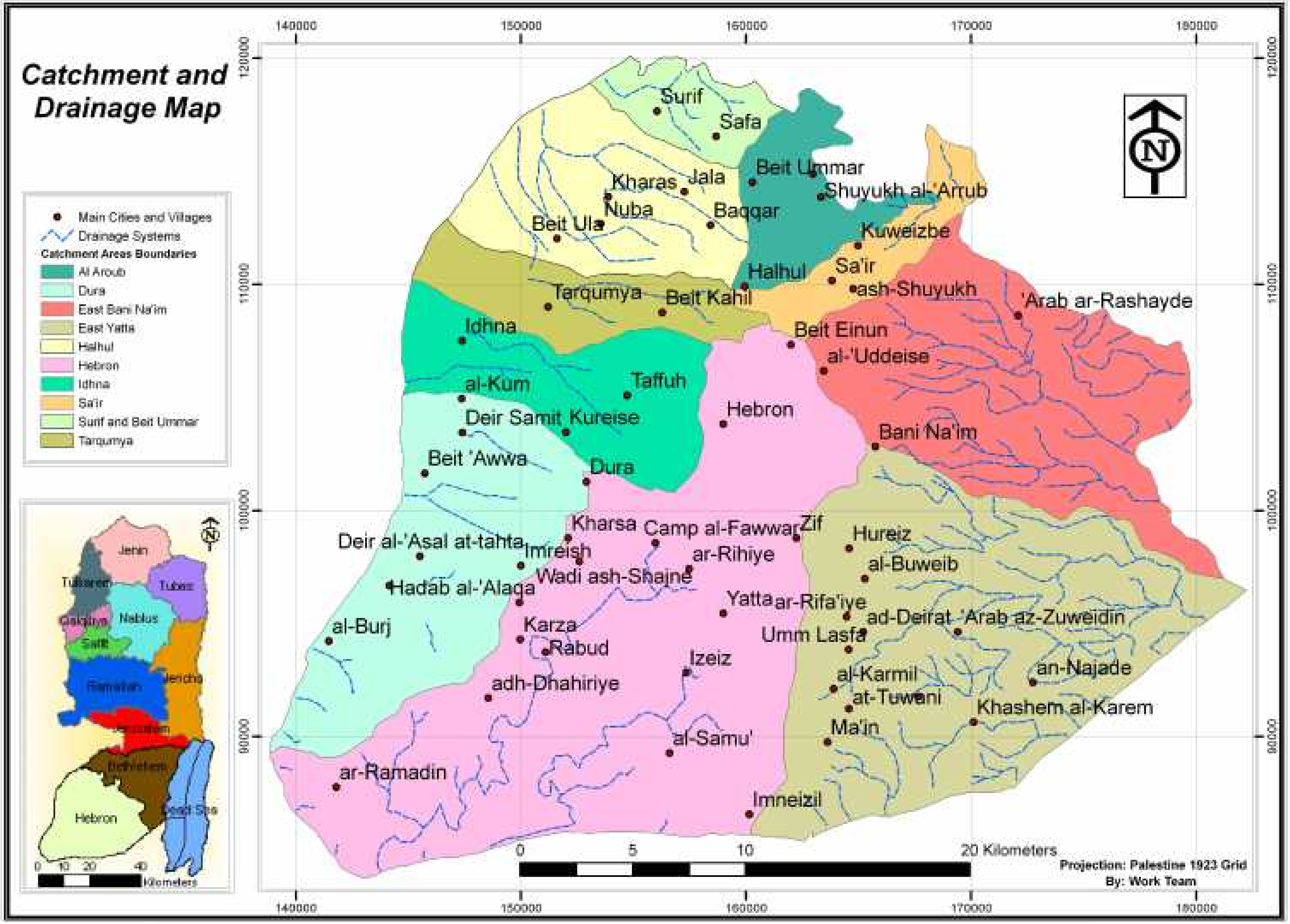

Figure (1.5): Drainage and Surface Catchments Areas Map of Hebron (Owaiwi, 2005).

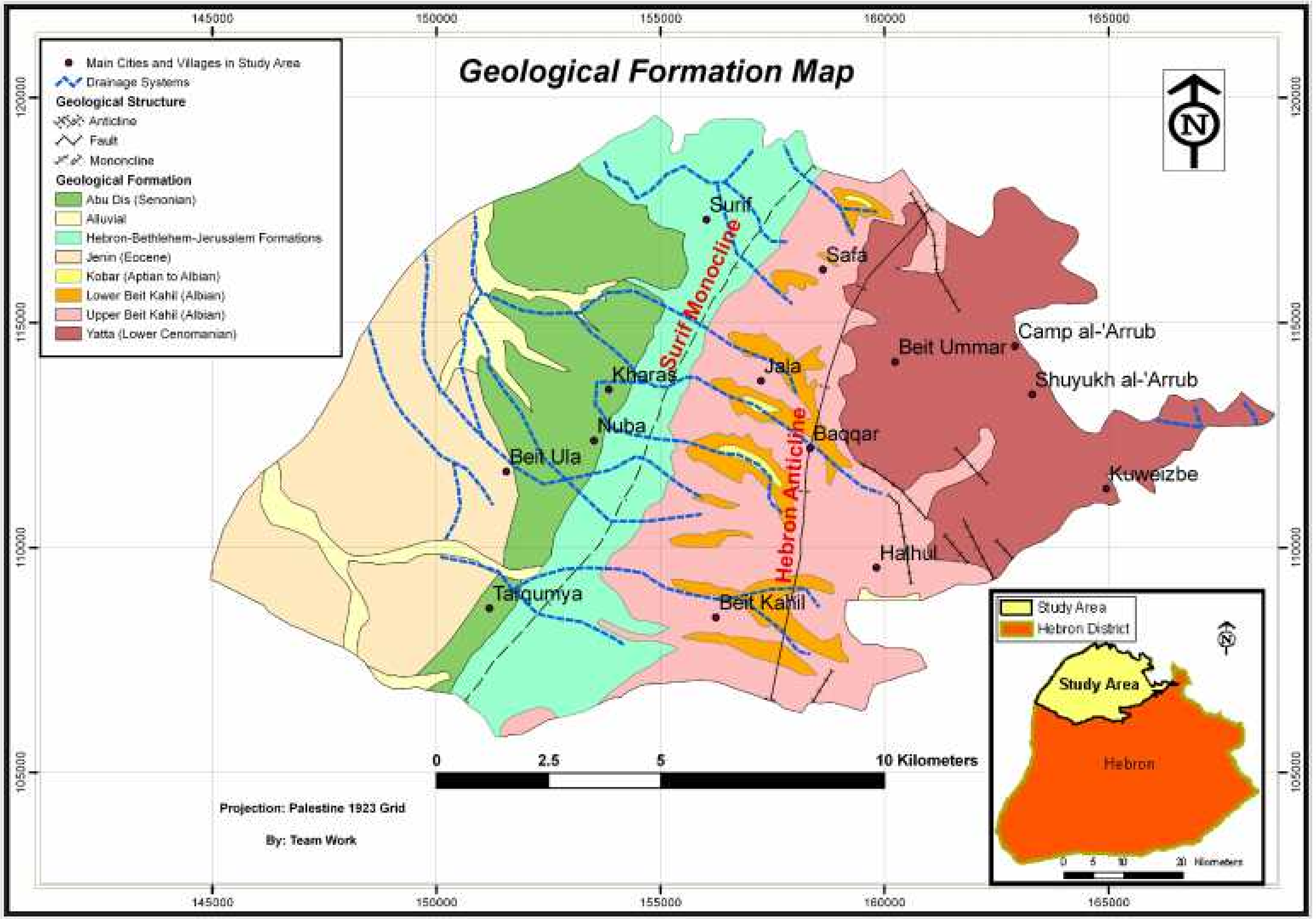

Figure (1.6): Geological and Structrual Map of the Study Area (Owaiwi, 2005).

The following paragraphs give an introduction to the general lithostratigraphy of the study area. The lithology, thicknes and othe features relevant to the aquifer sharacteristics are presented briefly.

1.10.1 Kobar Formation (Aptian to Albian)

Kobar formation is expected to be exposing near Jala village and to the west of Halhul town. It consists mainly of marl, marly limestone, and limestone. In some locations it comprises of limestone and intercalation of marl.

1.10.2 Lower Beit Kahil Formation (Albian)

Lower Beit Kahil Formation consists mainly of limestone, which is well bedded, fine crystalline and highly karstic, and sometimes dolomitic in the upper part. This formation has sometimes intermediate marl layers, and marl increases in downward direction. Its thickness ranges from 120-280 m. In some places the Lower Beit Kahil formation has dark grey dolomate, massively bedded, fine crystalline and hard. It is highly fractured and karstic, though less than lower part. In the study area this formation is exposed in Beit Kahil, Jala and Baqqar villages.

1.10.3 Yatta Formation (Lower Middle Cenomanian)

Yatta formation consists of yellowish and brown and contains fine to medium crystalline dolomate and limestone, with marly intercalation, marly at bottom. In some places it consists of marly limestone, usually highly enriched with fossilized fauna. Its thickness lies between 50 m to 130 m. In the study area this formation is the dominated one in the areas north east of Halhul, Beit Ummar.

1.10.4 Upper Middle Cenomanian-Turonian Rocks

In the study area these rocks are exposed east of Tarqumya, Kharas, Nuba, Surif.

1.10.4.1 Hebron Formation (Upper Middle Cenomanian)

Hebron formation consists of hard and nassive dolomate or limestone. It is highly karstic. Its thickness ranges from 20-120 m.

1.10.4.2 Bethlehem Formation (Upper Cenomanian)

Bethlehem formation consists of limestone and dolomate, chalky limestone, with marl and rich in faunal remains. In some places it is build up of dolomate, massive and coarse crystalline limestone lenses, well bedded. The thickness is 80-270 m.

1.10.4.3 Jerusalem Formation (Upper Cenomanian-Turonian)

Jerusalem formation consists mainly of limestone, soft, thin-bedded, dolomatic, chalk, and marly limestone. In some places it consists of limestone, hard and massive. In order places it consists of hard limestone, dolomatic limestone and marl. Its thickness ranges from 90 m to 130 m.

1.10.5 Abu Dis Formation (Senonian)

Abu Dis formation consists mainly of chalks, chert and marls of Santonian age. The chalk is usually white but in some part of the formation it is dark due to the presence of bituminous materials. The thickness of this formation ranges between 0-450 m. In the study area this formation is located at Surif village and the surrounding areas.

1.10.6 Tertiary (Eocene)

The Eocene age rocks are composed mainly of limestone, chalky limestone, chalks, marls and siltstone which are limited and thicknes. The thickness of this formation ranges between 0-630 m. In the study area this formation is exposed in Beit Ula, Kharas, Nuba and Tarqumya areas.

1.10.7 Alluvium Formation(Quaternary)

Alluvium deposit and other unconsolidated sediments, such as clay, silt, gravel and conglomerate are deposited in the floors of all wadis in the studt area with thickness reaches 10's of meters. The red color of the alluvium is due to its origion from limestone. In the study area this formation is exposed in Beit Ula, west Tarqumya and south Halhul and other places.

1.10.8 Nari Formation (Quaternary)

The carbonate rocks in the study area are highly subject to caliche weathering process called Nari. Nari formation forms asurface crust over limestone, narl and chalk. This formation consists of rocks remnant and insoluble residues which are well cemented togother. This formation is created by the action of percolating CO2-rich water which dissolves the carbonates. The bicarbonate water returns to the surface by capillary action where it evaporates leaving behined carbonate sediments with non-dissolved remnants. Some time this process (Karstification) formed 10's meters of good aquifer.

1.11 Geological Structure of study area

1.11.1 Folds

Two main folding are distinguished in the study area. These are Hebron Anticline and Surif Monocline. Hebron Anticline is considered as the main fold structure in the southeren part of West Bank. It trends north-south and passes from Jerusalem to the south of Hebron. Hebron Anticline is a symmetrical; the western limb is sharply dipping compared to the gentle dipping of its eastern side, which also forms minor folds. Surif Monocline trends north-south and formed on the western steeper limb of Hebron Anticline.

1.11.2 Faults

Faults in the study area either trend north-south or north west-south east. The fault that forming the Surif Monocline is the main fault in the study area and trends north-south. In many cases fault change their direction from one place to another.

1.11.3 Joints

The rocks in the study area are highly affected by joints and fractures. This due to the intensive structure history of the region. Joints are developed and associated with the forming of folding and faulting structure or shriking of limestone rocks by Dolomitization process. Karstic caves structures are dominated and mainly affected the limestone and dolomate rocks of the study area. When joints are intensive, the secondary porosity of the rocks increases and determines the adequacy of the formation as an aquifer.

CHAPTER TWO

OBJECTIVES AND METHODOLOGY

2.1 Duration of the study

2.2 Objectives

2.3 Expected results and outputs

2.4 Expected Benefits

2.5 Methodology

2.6 Field work

2.7 Laboratory Work

2.8 Literature review

Chapter 2: Objectives and Methodology

2.1 Duration of the study

Table (2.1) shows the time table of the project main tasks.

Table (2.1): Time Table of Project Tasks.

Phase No.	Task	Duration(monthly)							
		2007			2008				
		10	11	12	1	2	3	4	5
One	Review of literature and other survey work	■	■	■	■	■			
Two	Preparation of maps and organization of data		■						
Three	Field work					■	■	■	
Four	Laboratory works					■	■	■	
Five	Analysis and results							■	■
Six	Writing the report							■	■

2.2 Objectives

The main objective of this project is developing an erosion model for estimating the amount of soil that will be removed from the wadi outlet using GIS program to draw attention for this problems.

The specific objectives may be summarized as follows:

1. Define the study area.
2. Estimating amount of water rainfall in the study area.
3. Identify the soil types in the study area.
4. Identify the soil equation that we will be used in the project.
5. Collect any necessary information from the field.
6. Analyzing data obtained from the field.
7. Preparing maps and necessary information.
8. Estimating the size of the problem in the study area.
9. Estimate the equation factors.
10. Suggesting some strategies that may resolve the project problem.
11. Compare simulation results with measured data to calibrate the model of specific study area.

2.3 Expected Results and Outputs

In our project we expect to achieve the following results and outputs:

1. Developing erosion model for the study area by using (GIS) program and estimating the amount of soil erosion.
2. Classify the soil erosion into five categories in the study area.

2.4 Expected Benefits

Our project achieves such benefits to be useful for:-

1. Giving farmers a view about the situation of their lands to take the required steps to protect their land from soil erosion like:

- Build walls to prevent soil moving to another place
- Construct channels to gather rain water in suitable wells to be used for plants irrigation.
- Planting trees in their lands in order to held soil by the roots.

2. Pointing areas that were attacked by soil erosion to find the best solutions to protect it.
3. Developing database to show soil erosion in the projected area in Hebron District.
4. Increasing people awareness about risks of soil erosion to protect their lands.

2.5 Methodology

The project consists of three parts arranged as follows:

1. Data collection and survey:

In this part we will collect data that will be used to take a view about the project problem and the literature studies about soil erosion.

These data categorized as follows:

a) Cartographic data: like topographical maps, agricultural maps, and hydrological maps.
b) Text data: such as (soil data, erosion data…).
c) Statistical data: like population, amount of rainfall data, and temperature.
d) Field data: these data will be taken from the field work by taking samples of soil form different places inside the project area.

2. Design of erosion model:

In this part it is necessary to estimate erosion soil quantity in the projected area to start designing erosion model, figure (2.1), so that we will take these steps:

a- Estimate soil erosion equation factors.
b- Estimate erosion soil quantity in tons per year.
c- Preparing necessary programs needed in the modeling like Arc GIS program.
d- Start modeling by analyzing data in Arc View (part of Arc GIS program).

e- Preparing the final map, figure (2.1)

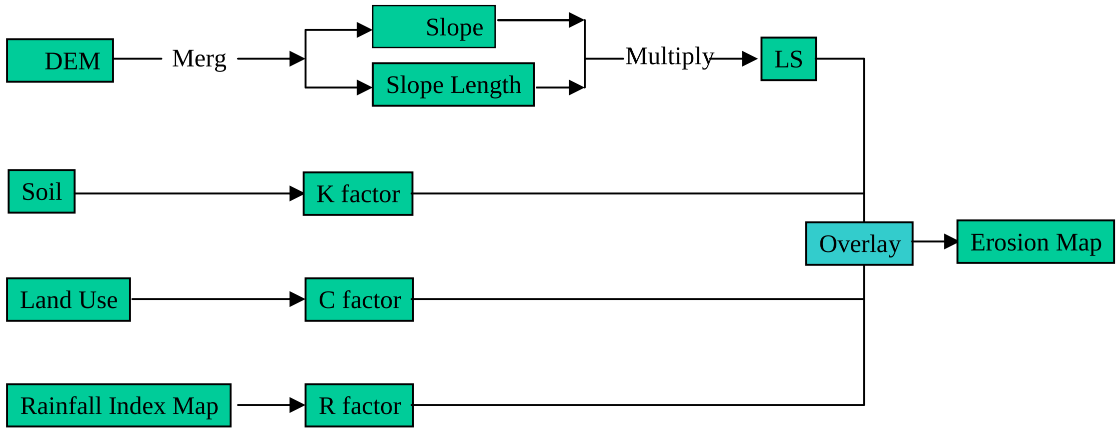

Figure (2.1): Flowchart of Designing Erosion Model (Reference 7).

3. writing report and other related job:

After finishing design modeling map, the project team will prepare the text book, specified maps, and model.

The report of the project is prepared and submitted to the department of civil and architectural engineering of Palestine Polytechnic University.

Field Work

In the field work of this project we use these instruments:

1- Hand GPS.
2- Infiltration device.
3- Stopwatch.
4- Ruler scale.
5- Hummer.
6- Shovel and fez.
7- Map of study area.
8- Recording sheet and pen.
9- Quantity of rain water or clean water suitable for irrigation.

To complete the field work in this project we done the following steps:

1. Distribute number of points regularly in the study area like (take point each 3 Km), this achieved by putting the grid on the map of the study area and take some points on the crossing grid.
2. After determine the points we will do the infiltration test for each point.

Infiltration Rate

- The infiltration rate is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface will take one hour to infiltrate. Table (2.2) shows the base infiltration rates for various soil types.
- In dry soil, water infiltrates rapidly. This is called the initial infiltration rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic infiltration rate
- The infiltration rate depends on soil texture (the size of the soil particles) and soil structure (the arrangement of the soil particles.
- The most common method to measure the infiltration rate is by a field test using a cylinder or ring infiltrometer.

Table (2.2): Basic Infiltration Rates for Various Soil Types (Reference 11).

Soil type	Basic infiltration rate (mm/hour)
sand	less than 30
sandy loam	20 - 30
loam	10 - 20
clay loam	5 - 10
clay	1 - 5

Field infiltration test

Equipment required:

1- Shovel/hoe
2- Hammer (2 kg)
3- Watch or clock
4- liter bucket
5- Timber (75 x 75 x 400)
6- Hessian (300 x 300) or jute cloth
7- At least 100 liters of water

Ring infiltrometer, figure (2.2), of 30 cm diameter and 60 cm diameter. Instead of the outer cylinder a bund could be made to prevent lateral water flow. Measuring rod graduated in mm (e.g. 300 mm ruler).

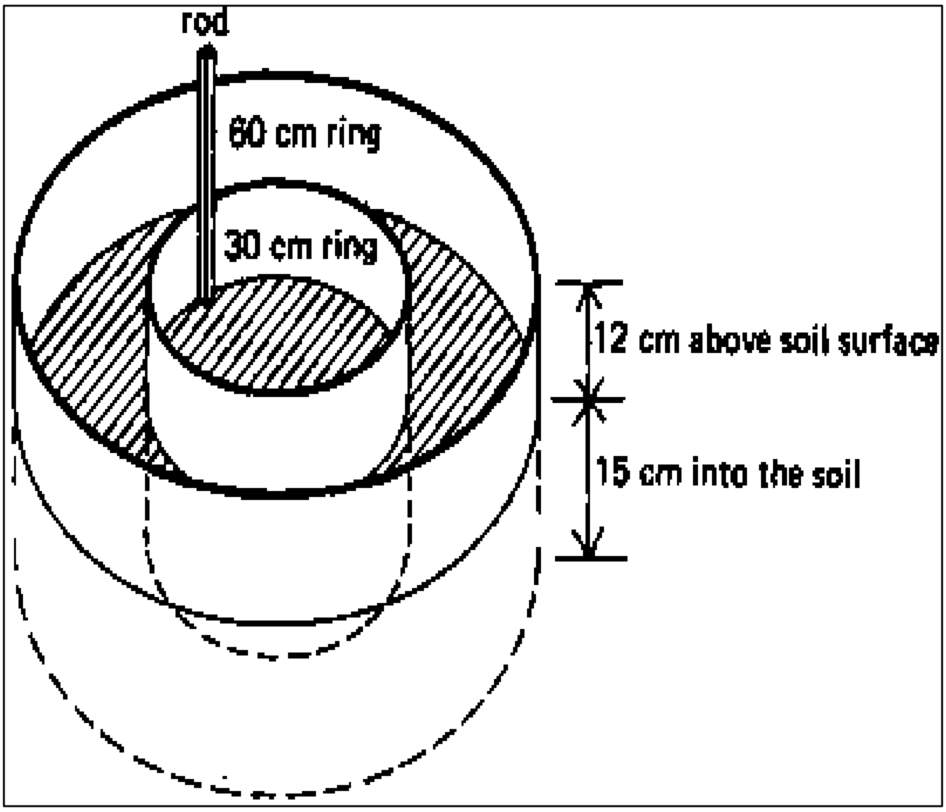

Figure (2.2): Iinfiltration Device (Reference 11).

Method of infiltration test:

Step 1:

Hammer the 30 cm diameter ring at least 15 cm into the soil. Use the timber to protect the ring from damage during hammering. Keep the side of the ring vertical and drive the measuring rod into the soil so that approximately 12 cm is left above the ground.

Step 2:

Hammer the 60 cm ring into the soil or construct an earth bund around the 30 cm ring to the same height as the ring and place the Hessian inside the infiltrometer to protect the soil surface when pouring in the water

Step 3:

Start the test by pouring water into the ring until the depth is approximately 70-100 mm. At the same time, add water to the space between the two rings or the ring and the bund to the same depth. Do this quickly. The water in the bund or within the two rings is to prevent a lateral spread of water from the infiltrometer.

Step 4:

Record the clock time when the test begins and note the water level on the measuring rod.

Step 5:

After 1-2 minutes, record the drop in water level in the inner ring on the measuring rod and add water to bring the level back to approximately the original level at the start of the test. Record the water level. Maintain the water level outside the ring similar to that inside.

Step 6:

Continue the test until the drop in water level is the same over the same time interval. Take readings frequently (e.g. every 1-2 minutes) at the beginning of the test, but extend the interval between readings as the time goes on (e.g. every 20-30 minutes).

Laboratory Work:

Laboratory work is achieved through:

2.7.1 Soil lab

Three soil test where conducted, these testes are:

1- Texture test.
2- Moisture test.
3- Organic test.

1-Texture Test

This test is done by using sieves analysis, figure (2.3).

Purpose: Soil texture refers to the relative proportion of mineral particles of various sizes (soil fractions): sand, slit, and clay expressed as a percentage. The basis of the test is the particle size and it's mass, as related to settling time when dispersed in solution. Table (2.3) shows the size classes according to their particle diameter are listed in the table below:

Table (2.3): Size Classes According to Particle Diameter (Reference 7).

Size Class	Particle Diameter (mm)
Very coarse sand	2.0-1.0
Coarse sand	1.0-0.5
Medium sand	0.5-0.25
Fine sand	0.25-0.10
Very fine sand	0.10-0.05
Silt	0.05-0.002
Clay	Less than 0.002

Test procedure

1. Take a representative oven dried sample of soil that weighs about **500** g. (this is normally used for soil samples the greatest particle size of which is 4.75 mm).
2. If soil particles are lumped or conglomerated crush the lumped and not the particles using the pestle and mortar.
3. Determine the mass of sample accurately. W_t (g)
4. Prepare a stack of sieves. Sieves having larger opening sizes (i.e. lower numbers) are placed above the ones having smaller opening sizes (i.e. higher numbers). The very last sieve is #400 and a pan is placed under it to collect+ the portion of soil passing #400 sieves. Here is a full set of sieves. (#s 4 and 400 should always be included), table (2.4).

Table (2.4): Sieve Number and their Opening Size (Reference 15)

Sieve Number	Opening Size (mm)
4	4.75
6	3.35
8	2.36
12	1.68
16	1.18
20	0.85
30	0.6
40	0.425
50	0.3
60	0.25
80	0.18
100	0.15
140	0.106
200	0.075
270	0.053
330	0.045
400	0.038

Figure (2.3): Arraingement of Sieves Set (Reference 12).

2-Moisture Test

Apparatus:

1. Oven that capable of maintaining a temperature between 105 °C and 110 °C.
2. A balance readable and accurate to 0.01 g.
3. Suitable corrosion-resistant container.

Procedure:

1. Clean and dry the container and weigh (W1). Place a sample of soil in the container and weigh (W2).
2. Place the container in the oven and dry between 105 °C and 110°C a constant weight.
3. After drying, remove the container from the oven and allow cooling.
4. Weigh the container with contents to 1 g (W3).

Calculation:

Calculate the moisture content of the soil as a percentage of the dry soil weight by this equation:

$$MC\% = \frac{W_2 - W_3}{W_3 - W_1} x\,100$$

Where:

W1 = Weight of tin (g)

W2 = Weight of moist soil + tin (g)

W3 = Weight of dried soil + tin (g)

3-Organic test:

Apparatus:

1- Oven that capable of maintaining a temperature between 400 °C and 500 °C.

2- A balance readable and accurate to 0.01 g.

3- Suitable corrosion-resistant container.

Procedure:

1- Clean and dry the container and weigh (W1). Place a sample of soil in the container and weigh (W2).

2- Place the container in the oven and dry between 400 °C and 500°C a constant weight.

3- After drying, remove the container from the oven and allow cooling.

4- Weigh the container with contents to 1 g (W3).

Calculation:

Calculate the moisture content of the soil as a percentage of the dry soil weight by this equation:

OC %=(W2-W3) / (W3-W1)

Where:

W1 = Weight of tin (g)

W2 = Weight of moist soil + tin (g)

W3 = Weight of dried soil + tin (g)

2.7.2 GIS lab

The application of geographical information systems (GIS) in modeling runoff and erosion in catchments offers considerable potential like:

1- Erosion estimates using RUSLE-type models.

2- Estimating RUSLE and runoff factors.

3- Making maps for each soil test.

4- Design soil erosion model.

2.8 Literature review:

Many studies had been conducted about soil erosion because of the serious, one of the projects is made by mahmoud wahadeen and ra'fat Abu saymah and is supervised by eng. Maher Owaiwi in south Hebron District using GIS to develop erosion model.

In other hand, there are hundreds of studies about erosion and its effect on soil, in different area, and so, we will some of them to tack knowledge about how to use soil erosion equation and GIS to develop a model for our projected area.

CHAPTER THREE

GIS SOFTWARE OVERVIEW

3.1 GIS Definition

3.٢ ArcGIS Basic

3.3 GIS Application Areas

3.4 Data as A part Of System Components

3.5 GIS Function

3.6 Triangulated Irregular Network (TIN)

3.7 Digital Elevation Model (DEM)

3.8 Realation Between Erosion, GIS and remote sensing

3.9 Global Positioning System

CHAPTER 3: GIS Software Overview

3.1 GIS Definition

3.1.1 A Geographic Information System (GIS)

Is a computer passed tool for mapping and analyzing thing that exist and event that happen on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and graphic analysis benefit offered by maps.

3.1.2 What is the meaning of each part of (GIS)?

Geographic…

This term is used because GIS tend to deal primarily with geographic or spatial features. These objects can be referenced or related to specific location in space. The object may be physical, cultural or economic in nature. Feature on a map for instance are pictorial representation of spatial object in the real world. Symbols, colors and line style are used to represent the different spatial features on the two dimensional map.

Information:-

This represents the large volume of data, which are usually handled within a GIS .all real world object have there own particular set of characteristics or descriptive attributes.

System:-

This term is used to represent the system approach taken by GIS, whereby complex environments are broken down into their component part for ease of understanding and handling.

3.1.3 Why Use GIS?

- Make maps.
- Improve organizational integration.
- Make better decisions.

Making Maps

Maps have a special place in GIS, figure (3.1). The process of making maps with GIS is much more flexible than other traditional manual or automated cartography approaches. It begins with database creation. Existing paper maps can be digitized and computer-compatible information can be translated into the GIS. The GIS-based cartographic database can be both continuous and scale free. Map products can then be created centered on any location, at any scale, and showing selected information. The characteristics of atlases and map series can be encoded in computer programs and compared with the database at final production time. Digital products for use in other GIS's can also be derived by simply copying data from the database. In a large organization, topographic databases can be used as reference frameworks by other departments.

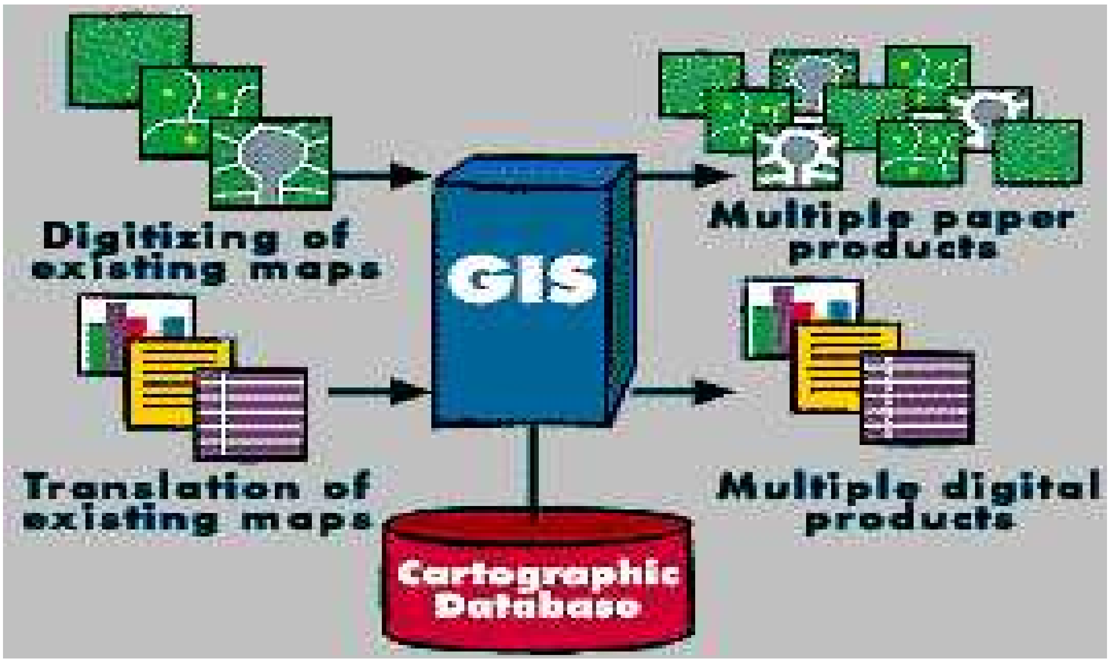

Figure (3.1): The Way to Make a Map (Reference 2)

3.٢ ArcGIS Basic

ArcGIS itself is not GIS Application; it is a set of software product for building Arc GIS system. ArcGIS is composed of client and server applications, each software application can create manage, analyze, server data stored in one or more format, figure (3.2):-

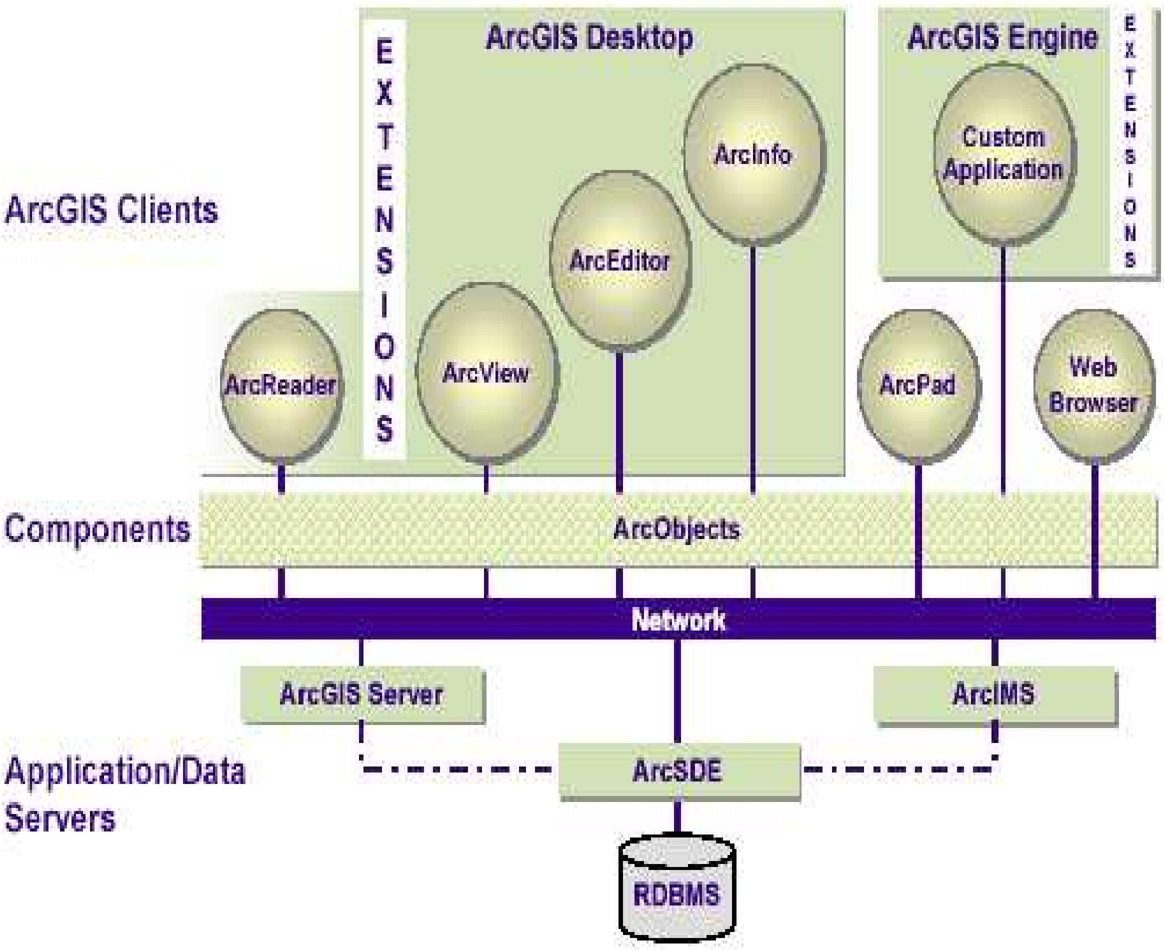

Figure (3.2): Arc GIS bas and its Component (Reference 4)

3.3 GIS Application areas

GIS has many applications in different areas, some of which are:

1. Water, agriculture, sewer, storm sewer, forestry and wildlife management.
2. National, state, county, regional, localmapping, and geographic inventory.

3. Archaeology, Geology, oil and gas exploration.
4. Municipal applications, streets, properties/cadastre.
5. Facilities, Utilities, Electric, Telephone.
6. Environment, areas/districts.

3.4 Data as apart of system components

An outline map may just be available as an AutoCAD DXF format file. The GIS shod at minimum be capable of absorbing the DXF file without further modification.
Attributes may already be stored in DBF format, and should be absordable either directly or through the generic ASC11 format. From the above two point Support for data format is important to GIS when data are to be brought from outside. The GIS software should be able to read common data formats for both raster:-
(DEN, GIFF, TIFF, JPEG, EPS)
And vector:-
(TIGER, HBGL, DXF, DLG).

3.5 GIS Function

Any GIS should be capable of the following fundamental operations in order to be useful for finding solutions to real-world problems.

3.5.1 Capturing data

A GIS must provide methods for inputting geographic (coordinate), tabular (attribute) data and hardcopy map, figure (3.3).

- **Modes of data input in GIS program**

1- Automated devices such that scanning.
2- Manual locating devices such that Digitizers and computer mouse.
3- Conversion directly from other digital sources.

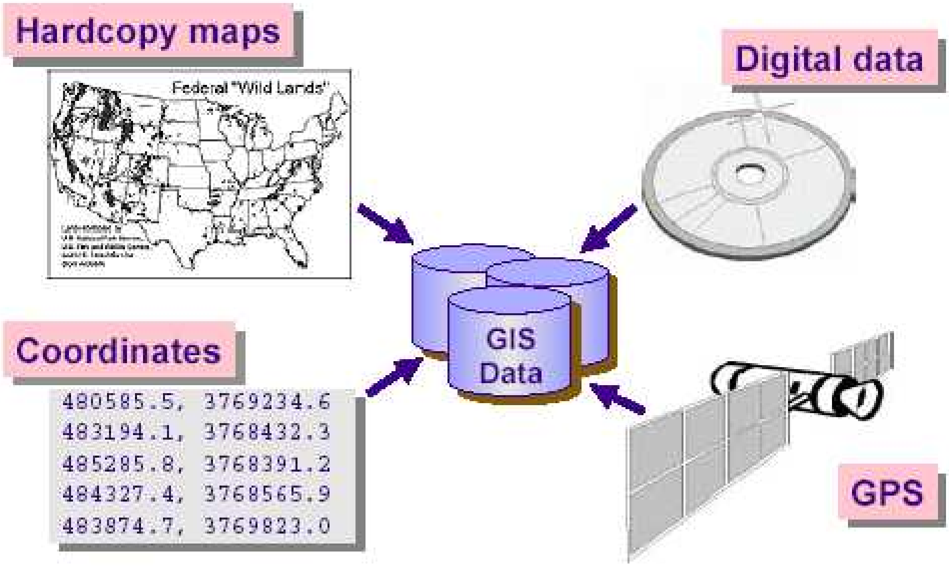

Figure (3.3): Capturing Data to GIS Program (Reference 4)

From above text one of modes data input is using scanning method and this mode we used it in our project to scanning a map of Hebron District then digitizing the study area which contain:- (Surif, BeitUmmer, Kharas, Nuba, BeitUla, Sair, Halhul, Tarqumiya and Beit Kahil).

Scanner

Scanner are used in GIS to input map and photo information ,the quality of the information on the map is related to the quality of the scanner and the quality of the base being scanned.

The map to be scanned should consist of only features that are to be input. But most maps include graphic and text features such as contour line, roads, building location, river and text. Scanning map that contains multiple features creates a data cleanup problem since it is desirable that each of these features be located in separate database.

It is important that the map to be scanned must be clean. Line on the map should be wide enough and with enough contrast to be detected by the scanner.

The map is stored in raster format with pixel representing the location of feature, if a vector product is required lie tracing algorithms must be used to convert the raster to vector. This process may input error depending of the quality of the line-trace algorithm.

The step of map scanning is the following:-

a) Prepeparation of the map.
b) Scanning using high resolution scanner (25µm-50µm).
c) Editing of data.
d) Vectorisation (raster to vector).

3.5.2 Storing data

There are two basic data models for geographic data storage:-
Vector data: is data model represents geographic features much the same way maps do using points, lines, and areas, figure (3.4):-

-Point: is the simplest graphical representation of an object. Points have no dimensions but may indicate on map or displayed on screens by using symbols.

-Line: connect at least tow point and are used to represent objects which may be defined in one dimension object.

-Area: is used to represent objects defined in two diminutions. The area is defined by at least three connecting line.

Raster Data: representing features by their x,y coordinates, the raster data model assigns values to cells that cover coordinate locations. The amount of detail you can show for a particular feature depends on the size of the cells in the grid, figure (3.5).

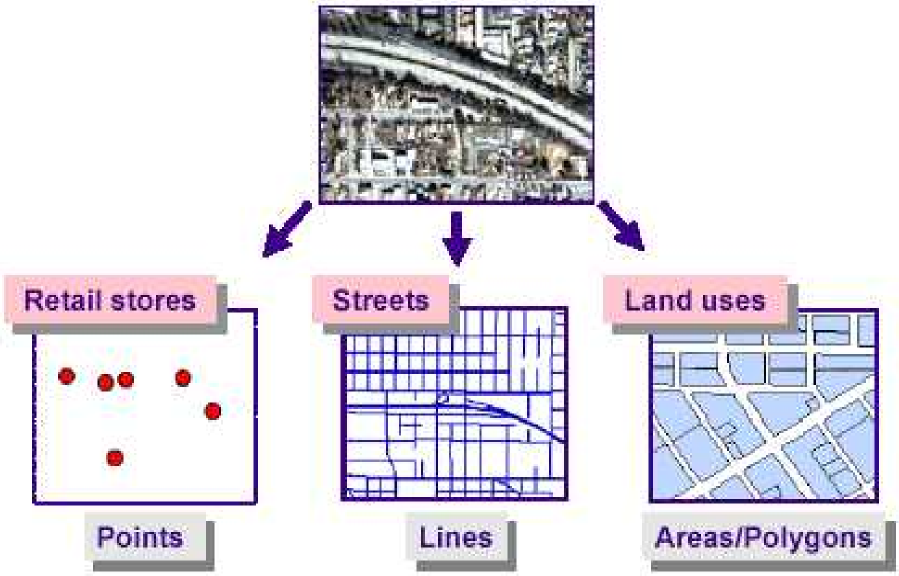

Figure (3.4): Using Point, Line and Area on the Map (Reference 5)

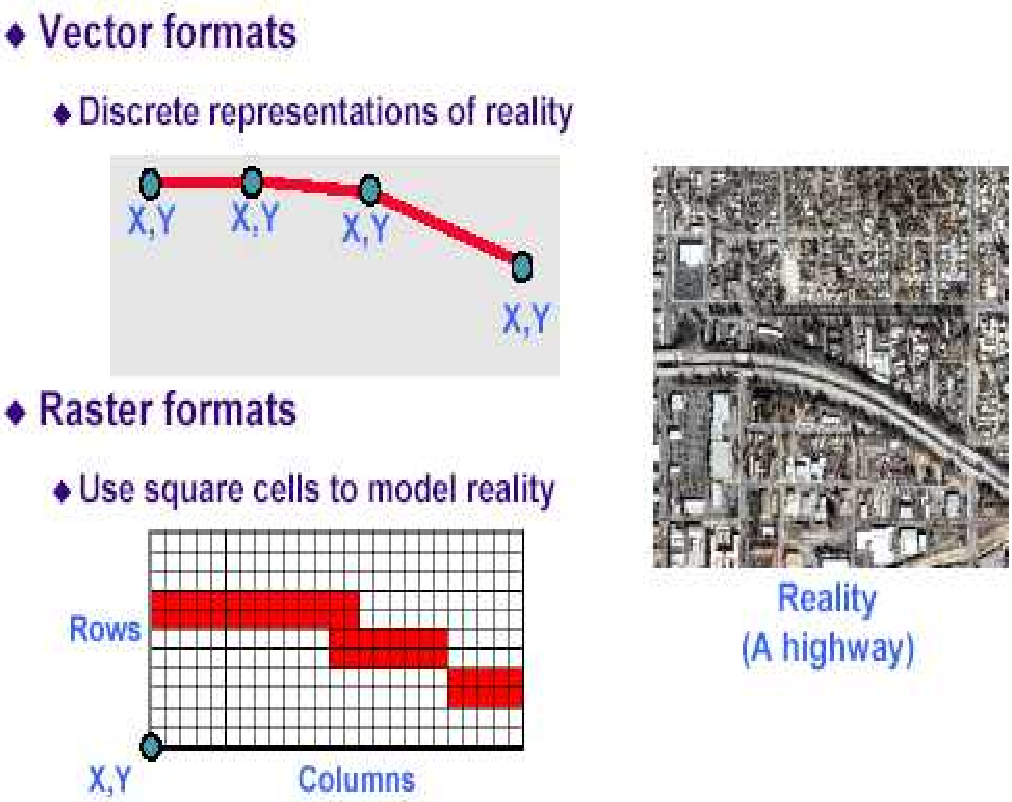

Figure (3.5): Vector and Raster Format (Reference 4)

3.5.3 Querying data

A GIS must provide utilities for finding specific features based on location or attribute value.

One common type of GIS query is to determine what exists at a particular location (Identifying specific features).this can be accomplished with GIS because the spatial features are linked to the descriptive characteristics, figure (3.6).

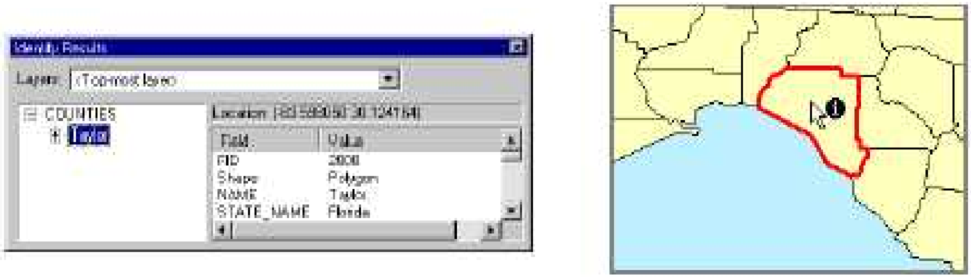

Figure (3.6): Finding Specific Features (Reference 4)

3.5.4 Analyzing data

A GIS must be able to answer questions regarding the interaction of spatial relationships between multiple datasets.

Types of geographic analysis are, figure (3.7):-

-Proximity analysis.

- Overlay analysis.

-Network analysis.

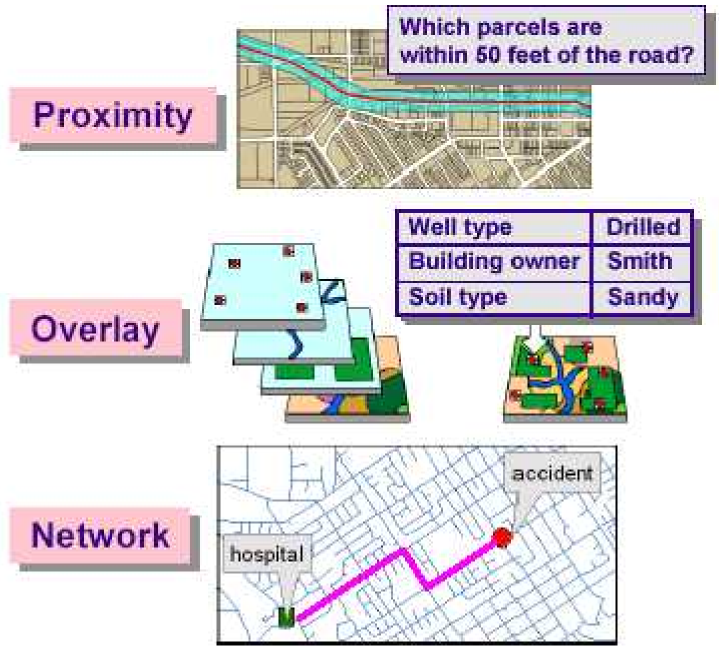

Figure (3.7): Types of Geographic Analysis Data (Reference 2)

3.5.5 Displaying data

A GIS must have tools for visualizing geographic features using a variety of symbology.

For many types of geographic operations, the end result is usually best visualized as a map or graph, figure (3.8).

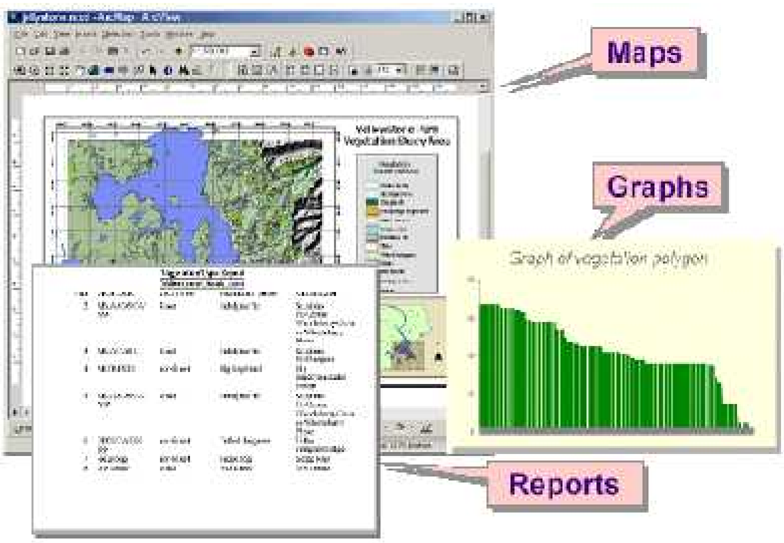

Figure (3.8): Displaying Data in GIS (Reference 2)

Map scale

Is one of the elements that are found on virtually all maps which describe as the ratio of map distance to ground distance.

The scale can be indicated in a variety of ways on a map in verbal, numeric or graphic form. The graphic form of representing scale is often preferred, when it is inserted in digital map, it will always maintain its relative size with respect to the digital map no mater how it is printed.
But in using verbal or numeric scale the map is printed at precisely the scale indicated.

The amount of detail that can be included is much dependent on the scale at which the map will be produced. Figure (3.9) describes the relationship between the map scale and the detail on the map; when the scale is small the detail on the map is small, and if the scale is large the detail is large.

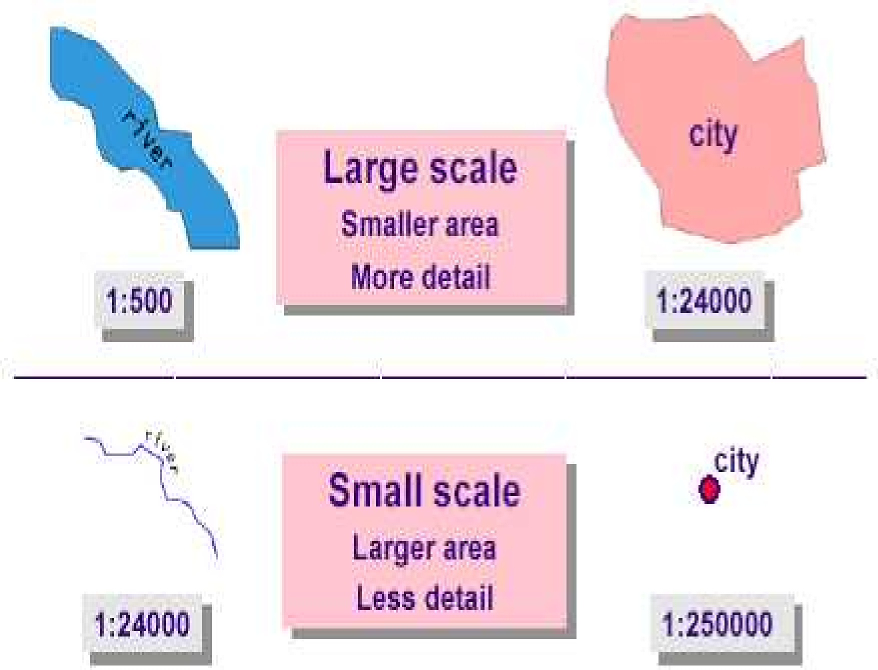

Figure (3.9): Relation Ship between Increasing and Decreasing Map Scale and Detail on the Map (Reference 4)

3.5.6 Output

A GIS must be able to display results in a variety of formats, such as maps, reports, and graphs, figure (3.10).

A map can include additional information, such as graphics and map Elements, that helps to explain its context and purpose.

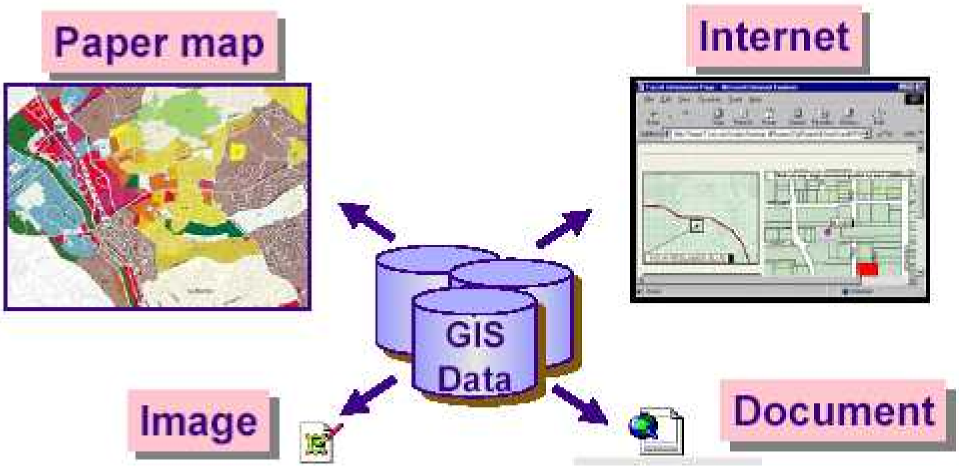

Figure (3.10): The Out Put of GIS Program (Reference 4)

3.6 Triangulated irregular network (TIN)

Is a digital data structure used in a geographic information system (GIS) for the representation of a surface. A TIN is a vector based representation of the physical land surface or sea bottom, made up of irregularly distributed nodes and lines with three dimensional coordinates (x,y, and z) that are arranged in a network of no overlapping triangles.

A TIN comprises a triangular network of vertices, known as mass points, with associated coordinates in three dimensions connected by edges to form a triangular tessellation. Three-dimensional visualizations are readily created by rendering of the triangular facets. In regions where there is little variation in surface height, the points may be widely spaced whereas in areas of more intense variation in height the point density is increased.

To form the triangles, all line segment are stored as edges of triangles then mass point (point known in x, y, z) are introduced in triangulation .the vertices of the triangles are the measured point these points are used for construction of the triangular net.

An advantage of using a TIN over a DEM in mapping and analysis is that the points of a TIN are distributed variably based on an algorithm that determines which points are most necessary to an accurate representation of the terrain.

Figure (3.11) Shows TIN Representation of DTM.

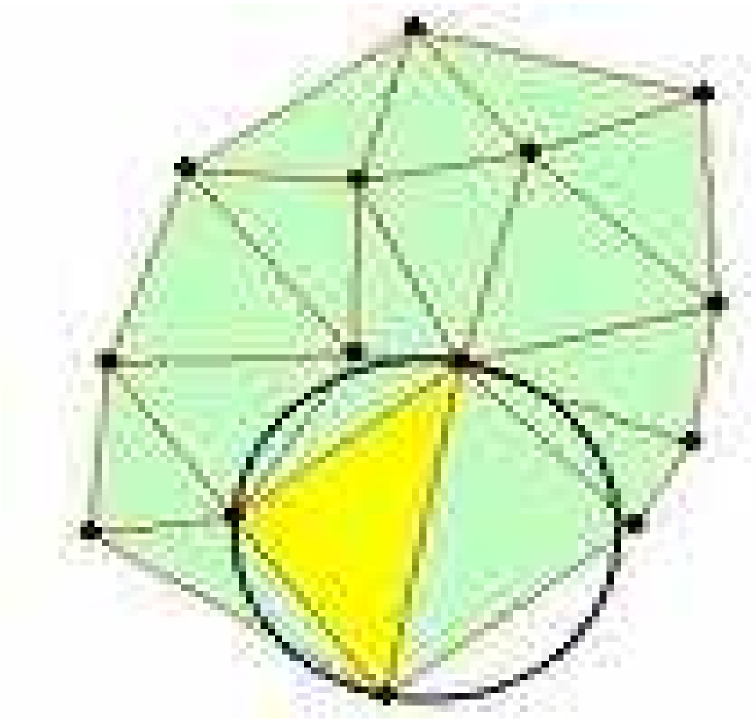

Figure (3.11): TIN Representation of DTM (Reference 2)

3.7 Digital elevation model (DEM)

DEM is a digital representation of ground surface topography or terrain. It is also widely known as a digital terrain model (DTM). A DEM can be represented as a raster (a grid of squares) or as a triangular irregular network.
DEM's are commonly built using remote sensing techniques; however, they may also be built from land surveying. DEM's are used often in geographic information systems, and are the most common basis for digitally-produced relief maps.

One of the most Common uses of DEM's includes modeling water flow or mass movement.

3.8 Realation Between Erosion , GIS and Remote sensing

Geographic Information System (GIS) is apowerful tool for handiling spatial and non spatil georeferenced data for preparation and visualization of input and out put data and for interaction with models.

Numerous models employing GIS techniques have been developed to assess landslide susceptibility and soil erosion risk, among other geomorphic processes. The ability to model and predict the behavior of landslides and soil erosion is useful for attempting to understand how external influences such as land use to modify the rate and magnitude at which these processes occur.

Remote sensed data has been well recognized in maping and assessing landscape attributes controlling soil erosion. Remote sensing can facilitate studying the factor enhancing the pross, such as soil typ, slop gradint, drainage, geology and land cover.

3.9 Global Positioning System

The Global Positioning System (GPS) is the most significant recent advance in navigation and positioning technology. GPS is an aerospace technology that uses satellites and ground equipment to determine positions any where on earth. Anyone with a small receiver can use the system at no cost.

The idea of working GPS is if the distances from the point on the earth (GPS receiver) to three GPS satellites are known along with the satellite locations, then the location of the point (receiver) can be determined by simply applying the concept of resection.

In order to calculate the distance to each satellite, Newton's low of motion is used:

Distance = velocity * time

Where:

Velocity: is the velocity of the radio signal. Radio waves travel at the speed of light, 290,000 km per second.

Time: is the time taken for the radio signal to travel from the satellite to the GPS receiver.

There is some type of GPS handheld receiver one of this receiver is Magellan handheld GPS receiver this receiver is low cost and simple that any one can used it such that soldiers in military system, in navigation and survey to find any point on the ground by using grid map, the expected positioning accuracy is 16m for horizontal component and 23m for the vertical component.

Because line of sight does not have to be established between GPS stations, major cost savings can be realized in large projects involving a large number of survey teams over a limited area (say, 100 sq miles). A single GPS receiver can be set up as a reference station which can be used by any number of surveyors, each of which can be working a job. This contrasts with conventional survey equipment in which at least two people must be working the same job (one for each end).

The figure below describes how to calculate the position of the user by hand held GPS receiver.

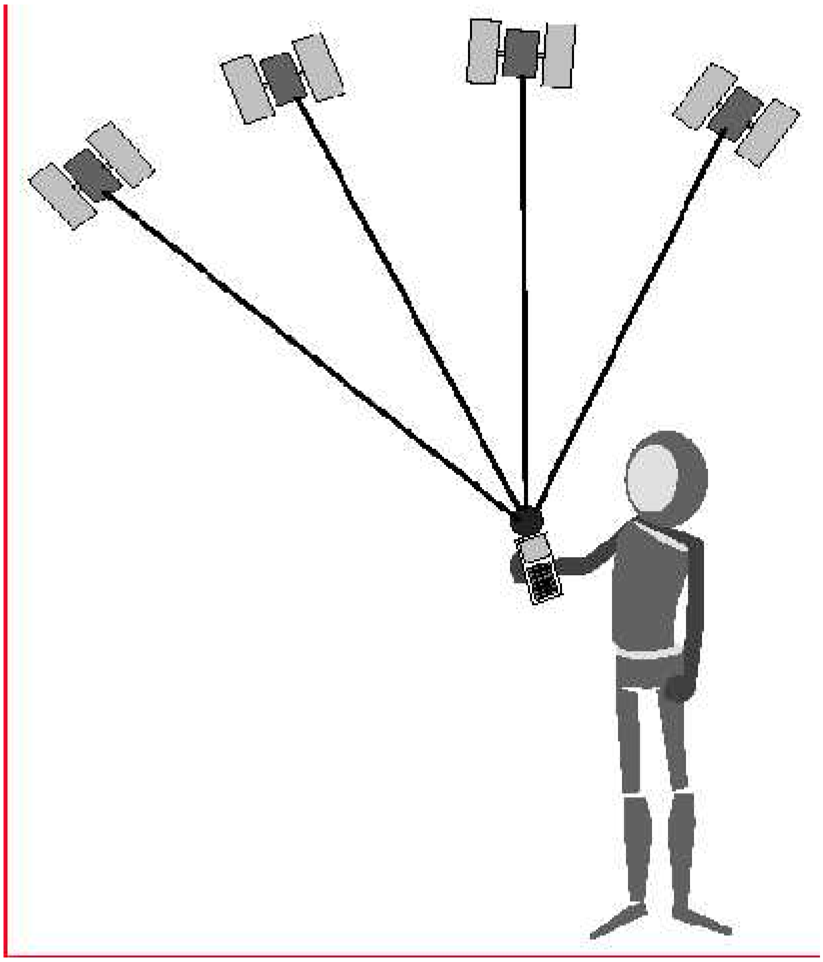

Figure (3.12) Using GPS Handheld Receiver to Calculate the Position of the User (Reference 5)

CHAPTER FOUR

SOIL EROSION

Chapter 4: Erosion definition

4.1 Soil Erosion Definition

Soil Erosion is displacement of solids (soil, mud, rock and other particles) usually by the agents of currents such as, wind, water, or ice by downward or down-slope movement in response to gravity or by living organisms, figure (4.1).

The rate of erosion depends on many factors, including the amount and intensity of precipitation, the texture of the soil, the gradient of the slope, ground cover from vegetation, rocks, land use, and possibility of erosion from speed of a stream.

The factor that is most subject to change is the amount and type of ground cover. In an undisturbed forest, is the mineral soil is protected by a litter layer and an organic layer. These two layers protect the soil by absorbing the impact of rain drops.

In many places erosion is increased by human land use. Poor land use practices include deforestation overgrazing, unmanaged construction activity and road or trail building. However, improved land use practices can limit erosion, using techniques like terrace building and tree planting.

Figure (4.1): Erosion Sample (Reference 3)

4.2 Types of Soil Erosion:

There are three main types of soil erosion:-

1- Water erosion.
2- Wind erosion.
3- Gravity erosion.

4.2.1 Water Erosion: is caused by the kinetic energy of rain falling on the soil surface and by the mechanical force of runoff. Water is the most important erosional agent and erodes most commonly as running water in streams. However, water in all its forms is erosional. Raindrops create splash erosion that moves tiny particles of soil.

Water erosion is the most important type of erosion it divided into main type that describe below:-

1- **Splash erosion**: Splash erosion or rain drop impact represents the first stage in the erosion process. Splash erosion results from the bombardment of the soil surface by rain drops. Rain drops behave as little bombs when falling on exposed or bare soil, displacing soil particles and destroying soil structure, figure (4.2).

Splash is only effective if the rain falls with sufficient intensity. If it does, then their kinetic energy is able to detach and move soil particles a short distance.

Studies in America have shown that splashed particles may rise as high as 0.6 meters above the ground and move up to 1.5 meters horizontally.

2- Sheet erosion: When rain falls faster than the soil can absorb it, water begins to collect and flow over the ground surface. Sheet erosion begins when this surface water begins to carry along particles that were detached by raindrops.

Sheet erosion is responsible for extensive soil loss in both cultivated and non-cultivated environments. It occurs as a shallow 'sheet' of water flowing over the ground surface, resulting in the removal of a uniform layer of soil from the soil surface.

Figure (4.2) Splash Erosion (Reference 10)

Figure (4.3) below shows the sheet erosion and show how it effected on the ground surface.

Figure (4.3): Sheet Erosion and Its Effects (Reference 10)

3- Rill erosion: results from the concentration of surface water (sheet erosion) into deeper, faster-flowing channels. As the flow becomes deeper the velocity increases detaching soil particles and scouring channels up to 30cm deep. Rill erosion represents the intermediate process between sheet and gully erosion.

Flowing water will soon establish paths. As in the figure below if the soil is unprotected, some of these paths become rills, small eroding channels. Water flowing through a rill easily detaches soil from its sides and bottoms. As it moves further down slope, flow in rills becomes more erosive, causing the rills to enlarge and join with others.

Figure (4.4) shows two type of rill erosion the left figure shows large rill erosion and the right figure shows small rill erosion.

Figure (4.4): Left Image Show Large Rill and the Right Image Show Small Rill (Reference 10)

Gully Erosion: Gully erosion is responsible for removing vast amounts of soil. Soil is rapidly removed by water gushing over the surface of the gully, water removing soil material that has slumped from the gully's sidewalls. The slope at the head cut is nearly vertical, causing the runoff flowing over it be highly erosive so that the gully advances upslope.

Figure (4.5) shows an image of gully erosion.

Figure (4.5): Gully Erosion (Reference 10)

There is other part of water erosion such that Tunnel Erosion which caused by the movement of excess water through a dispersive subsoil, and mass erosion or slumping which occurs where a hillside becomes so saturated by water that large areas of soil slide or creep down hill.

4.2.2 Wind Erosion: Wind erosion is the removal soil particles by the force and kinetic energy of the wind. These soil particles are transported and deposited when the wind energy drops. It involves the detachment, transportation and redeposition of soil particles by wind. It is common on flat, bare areas with dry, sandy soils, or anywhere that the soil is loose.

Wind erosion physically removes the lighter, less dense soil constituents such as organic matter, clays, and silts. Thus it removes the most fertile part of the soil and lowers soil productivity. This loss in productivity has been masked or compensated for over the years by improved crop varieties and increased fertilization. Thus wind erosion reduces potential soil productivity and increases economic costs.

Prevention and Control of wind erosion: Most soils require at least 30 per cent ground cover to prevent wind erosion. Vegetation and crop residues prevent wind erosion by reducing soil drying by evaporation, reducing wind speed at ground level and anchoring soil particles. In crop areas methods such as stubble retention, direct drilling, herbicide weed control and chemical fallows reduce the risk and extent of wind erosion by maintaining residue cover. In addition, crops with little ground cover can employ cover crops of oats or Lucerne may be grown through fallow periods to provide short term protection.

Wind detaches and transports soil particles according to size:

- 1 mm move by rolling (soil creep)
- 0.1– 1 mm move by salutation, caused by the collision by entrained particles
- < 0.1 mm detach into suspension.

Figure (4.6) describes how Wind detaches and transports soil particles according to deferent particle size.

There is many factor that effected wind erosion such that, asperse or subset vegetative cover a loose, dry and smooth soil surface ,large field and strong winds all increase of the risk of wind erosion.

How can we control erosion from running water and wind?

- Contour plowing
- Terraces on a hillside
- Planting groundcovers; roots hold the soil.
- Windbreaks a barrier or baffle that causes the wind to slow down. When wind speed is decreased, the load carried by the wind is dropped.

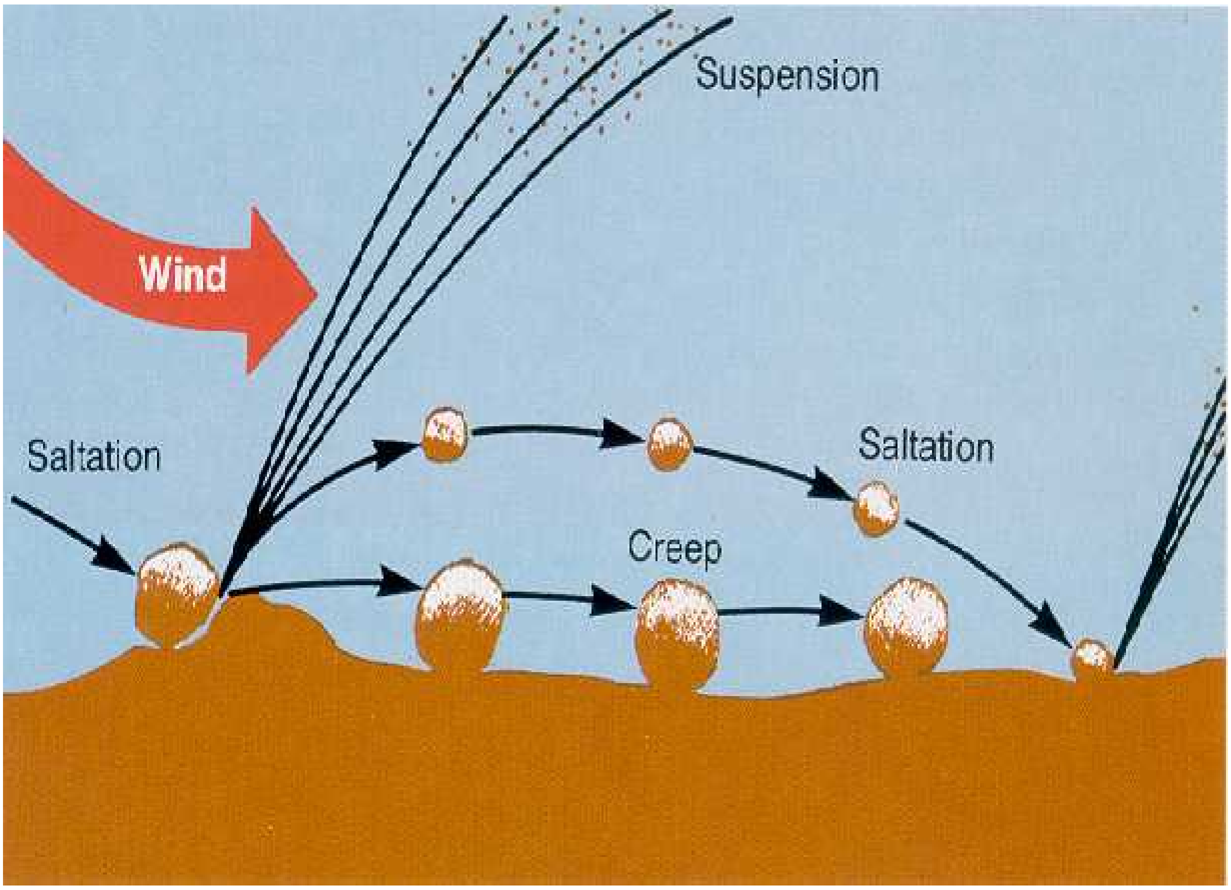

Figure (4.6): Effect of Wind on Deferent Part of Dry Soil (Reference 3).

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4.2.3 Gravity erosion: is the down slope movement of rock, regality, and soil, under the influence of gravity Mass movement of soil occurs on steep. The process involves the transfer of slope-forming materials from higher to lower grounds due to self weight.

Types of mass wasting

1-Rapid movement.

2- Slow movement.

Rapid movement: it divided into different type as described below:-

1- Rock fall: The free fall of detached pieces of material of any size; may fall directly downward or bounce and roll. May occur as result of freeze thaw, or the loosening action of plant roots.

2- Slump: Slumps involve a mass of soil or other material sliding along a curved rotational surface. And sometimes seen along interstate highways where the graded soil on the sides of the road is a little too steep.

Figure (4.7): Rapid Movement (Slump), (Reference 10)

3- Rockslide: Occurs when blocks of rock, or masses of unconsolidated material slide down a slope. These are among the most destructive of mass movements. May be triggered by rain or melting snow, or earthquakes.

5- Earth flow: Form in humid areas on hillsides following heavy rain or melting snow, in fine grained materials (clay and silt).

- **Slow movement:** it divided into different type as described below:-

1- Creep: a slow downhill movement of soil and regality. Creep results in tree trunks that are curved at the base, tilted utility poles, fence posts, and tombstones, and causes retaining walls to be broken or overturned.

2- Solifluction: Occurs in areas underlain by permafrost. Occurs in the active surface layer that thaws in summer.

Finally there is other type of erosion such that Wave Erosion and Ice Erosion .but these tow type is not so important in our project.

4.3 Revised Universal Soil Loss Equation (RUSLE)

4.3.1 History of RUSLE

Research on soil erosion and its effect on agricultural productivity started in 1930s. During 1940 and 1956, research scientists began to develop a quantitative procedure for estimating soil loss in the Corn Belt in the United States. Several factors were introduced to an early soil loss equation, in which slope and practice were primarily considered. It was recognized that a soil loss equation could have a great value for farm planning and the Corn Belt equation could be adapted for other regions. In 1946, a group of erosion specialists held a workshop in Ohio to reappraise the factors previously used and added a rainfall factor. U.S. Department of Agriculture, Agricultural Research Service (ARS) established the National Runoff and Soil Loss Data Center at Purdue University in 1954 to locate, assemble, and consolidate all available data throughout the United States. More than 10,000 plot-years of basic runoff and soil loss data were then collected from U.S. federal-state cooperative research projects in 49 U.S. locations.

Based on the data assembled at the Data Center and previous studies, Wischmeier, Smith, and others developed the Universal Soil Loss Equation (USLE). An Agriculture Handbook (No. 537) describing USLE was published in 1965 and revised in 1978. With a widespread acceptance, USLE has become the major conservation planning tool which is used in the United States and other countries in the world.

The Revised Universal Soil Loss Equation (RUSLE) predicts the long term average annual rate of erosion on a field slope based on rainfall pattern, soil type, topography, crop system and management practices.

RUSLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion.

4.3.2 RUSLE Formula and Factors

Five major factors are used to calculate the soil loss for a given site. Each factor is the numerical estimate of a specific condition that affects the severity of soil erosion at a particular location. The erosion values reflected by these factors can vary considerably due to varying weather conditions. Therefore, the values obtained from the RUSLE more accurately represent long-term averages.

Revised Universal Soil Loss Equation (RUSLE) formula:

RUSLE equation formed as:

A =R x K x LS x C x P *(Reference 12)*

Where:

- A is the computed soil loss (tons/acre/year).
- R is the rainfall-runoff erosivity factor (hundreds of ft.tonsf.in/acre.hr.year].
- K is the soil erodibility factor (tons per acre per unit R] = [tons.acre.hr/hundreds.acre.ft.tonsf.in).
- LS is the slope length factor (Dimensionless).
- S is the slope steepness factor (Dimensionless).
- C is the cover-management factor (Dimensionless).
- P is the supporting practices factor (Dimensionless).

4.3.2.1 R factor:

It is the average annual summation (EI) values in a normal year's rain. The erosion-index is a measure of the erosion force of specific rainfall. When other factors are constant, storm losses from rainfall are directly proportional to the product of the total kinetic energy of the storm (E) times its maximum 30-minute intensity (I). Storms less than 0.5 inches are not included in the erosivity computations because these storms generally add little to the total R value. R factors represent the average storm EI values over a 22-year record. R is an indication of the two most important characteristics of a storm determining its erosivity: amount of rainfall and peak intensity sustained over and extended period.

To calculate rainfall-runoff erodibilty factors we will be use the following equation:

$R = 3.85 + 0.35(P)$ *(Reference 12)*

Where:
R is rainfall-runoff erodibilty.
P is average annual rainfall (mm/year).

4.3.2.2 K Factor:

K factor is soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition. Soils high in clay have low K values, about 0.05 to 0.15, because they resistant to detachment. Coarse textured soils, such as sandy soils, have low K values, about 0.05 to 0.2, because of low runoff even though these soils are easily detached. Medium textured soils, such as the silt loam soils, have a moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4.

Organic matter reduces erodibility because it reduces the susceptibility of the soil to detachment, and it increases infiltration, which reduce runoff and thus erosion. Addition or accumulation of increased organic matter through management such as incorporation of manure is represented in the C factor rather than the K Factor.

Extrapolation of the K factor nomograph beyond an organic matter of 4% is not recommended or allowed in RUSLE. In RUSLE, factor K considers the whole soil and factor Kf considers only the fine-earth fraction, the material of <2.00mm equivalent diameter. For most soils, Kf = K (look at table 4.1).

Table (4.1): K Factor Data (Organic Matter Content)

Textural Class	Average	Less than 2 %	More than 2 %
Clay	0.22	0.24	0.21
Clay Loam	0.30	0.33	0.28
Coarse Sandy Loam	0.07	--	0.07
Fine Sand	0.08	0.09	0.06
Fine Sandy Loam	0.18	0.22	0.17
Heavy Clay	0.17	0.19	0.15
Loam	0.30	0.34	0.26
Loamy Fine Sand	0.11	0.15	0.09
Loamy Sand	0.04	0.05	0.04
Loamy Very Fine Sand	0.39	0.44	0.25
Sand	0.02	0.03	0.01
Sandy Clay Loam	0.20	--	0.20
Sandy Loam	0.13	0.14	0.12
Silt Loam	0.38	0.41	0.37
Silt Clay	0.26	0.27	0.26
Silt Clay Loam	0.32	0.35	0.30
Very Fine Sand	0.43	0.46	0.37
Very Fine Sandy Loam	0.35	0.41	0.33

4.3.2.3 LS factor:

L is the slope length factor, representing the effect of slope length on erosion. It is the ratio of soil loss from the field slope length to that from a 72.6-foot (22.1-meter) length on the same soil type and gradient. Slope length is the distance from the origin of overland flow along its flow path to the location of either concentrated flow or deposition. Fortunately, computed soil loss values are not especially sensitive to slope length and differences in slope length of + or – 10% are not important on most slopes, especially flat landscapes.

S is the slope steepness. Represents the effect of slope steepness on erosion. Soil loss increases more rapidly with slope steepness than it does with slope length. It is the ratio of soil loss from the field gradient to that from a 9 percent slope under otherwise identical conditions. The relation of soil loss to gradient is influenced by density of vegetative cover and soil particle size.

This table explains LS factor values at some values of Slope Length and Slope Length.

Table (4.2): LS Factor Calculation

Slope Length ft (m)	**Slope (%)**	**LS Factor**
100 ft (31 m)	10	1.3800
	8	0.9964
	6	0.6742
	5	0.5362
	4	0.4004
	3	0.2965
	2	0.2008
	1	0.1290
	0	0.0693
200 ft (61 m)	10	1.9517
	8	1.4092
	6	0.9535
	5	0.7582
	4	0.5283
	3	0.3912
	2	0.2473
	1	0.1588

	0	0.0796
400 ft (122 m)	10	2.7602
	8	1.9928
	6	1.3484
	5	1.0723
	4	0.6971
	3	0.5162
	2	0.3044
	1	0.1955
	0	0.0915
800 ft (244 m)	10	3.9035
	8	2.8183
	6	1.9070
	5	1.5165
	4	0.9198
	3	0.6811
	2	0.3748
	1	0.2407
	0	0.1051
1600 ft (488 m)	10	5.5203
	8	3.9857
	6	2.6969
	5	2.1446
	4	1.2137
	3	0.8987
	2	0.4614
	1	0.2964
	0	0.1207
3200 ft (975 m)	10	7.8069
	8	5.6366
	6	3.8140

	5	3.0330
	4	1.6015
	3	1.1858
	2	0.5680
	1	0.3649
	0	0.1386

4.3.2.4 C factor:

C is the cover-management factor. The C-factor is used to reflect the effect of cropping and management practices on erosion rates. It is the factor used most often to compare the relative impacts of management options on conservation plans. The C-factor indicates how the conservation plan will affect the average annual soil loss and how that soil-loss potential will be distributed in time during construction activities, crop rotations or other management schemes.

The C-factor is based on the concept of deviation from a standard, in this case an area under clean-tilled continuous-fallow conditions. The Soil Loss Ratio (SLR) is then an estimate of the ratio of soil loss under actual conditions to losses experienced under the reference conditions.

4.3.2.5 P factor:

P is the support practice factor. The RUSLE P-factor reflects the impact of support practices and the average annual erosion rate. It is the ratio of soil loss with contouring and/or strip-cropping to that with straight row farming up-and-down slope.

As with the other factors, the P-factor differentiates between cropland and rangeland or permanent pasture. Both options allow for terracing or contouring, but the cropland option contains a strip-cropping routine whereas the rangeland/permanent-pasture option contains an "other mechanical disturbance" routine.

For the purpose of this factor, the rangeland/permanent-pasture option is based on the support operation being performed infrequently, whereas in the cropland option the support operation is part of the annual management practice.

4.3.2.6 T value:

T is soil loss tolerance expressed in tons per acre per year.

The T value is not directly used in RUSLE. However, it is important in the use of the soil loss equation for conservation planning. Soil loss tolerance is the maximum amount of soil loss in tons per acre per year that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely.

Table (4.5): T value

Soil Erosion Class	**Potential Soil Loss (tons/acre/year)**
Very Low (tolerable)	<3
Low	3 - 5
Moderate	5 - 10
High	10 - 15
Severe	>15

4.3.7 Management Strategies to Reduce Soil Losses:

The table below explains the Management Strategies to Reduce Soil Losses (look at table 4.6).

Table (4.6): Management Strategies to Reduce Soil Losses

Factor	**Management Strategies**	**Example**
R	The R Factor for a field cannot be altered.	--
K	The K Factor for a field cannot be altered.	--

LS	Terraces may be constructed to reduce the slope length resulting in lower soil losses.	Terracing requires additional investment and will cause some inconvenience in farming. Investigate other soil conservation practices first.
C	The selection of crop types and tillage methods that result in the lowest possible C factor will result in less soil erosion.	Consider cropping systems that will provide maximum protection for the soil. Use minimum tillage systems where possible.
P	The selection of a support practice that has the lowest possible factor associated with it will result in lower soil losses.	Use support practices such as cross slope farming that will cause deposition of sediment to occur close to the source.

CHAPTER FIVE

DATA PREPARATION AND ANALYSIS

5.1 Summary

5.2 Filed Samples

5.3 Soil Texture (Sieve Analysis).

5.4 Soil Texture Classification.

5.5 Measurements of Infiltration.

5.6 Soil Moisture.

5.7 Organic Matter.

CHAPTER 5: DATA PREPARATION AND ANALYSES

5.1 Summary

This chapter describes the field sampling procedure, soil lab tests which contain texture test, infiltration test, moisture content test and finally organic test.

5.2 Field samples

42 soil samples have been collected from the field. At least tow sample has been collected for each soil association, figure (5.1).

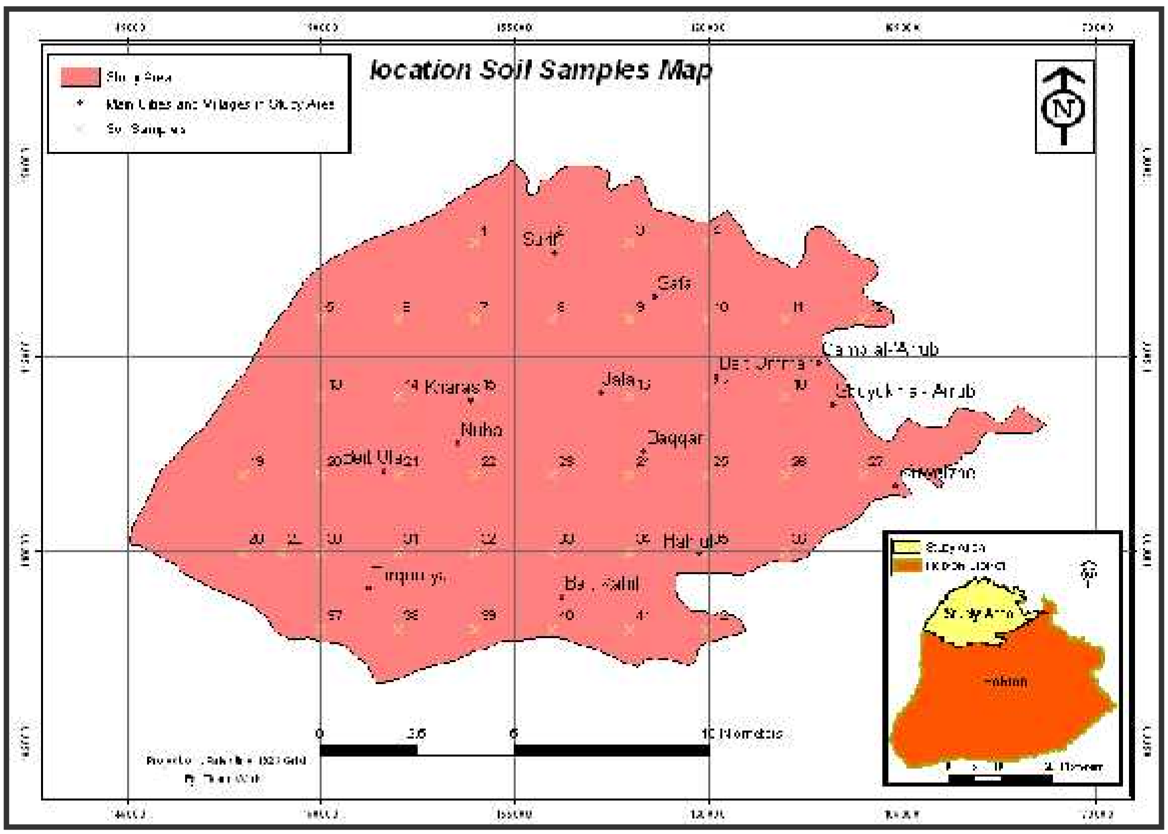

Figure (5.1): location Soil Samples

Table (5.1) shows the coordinates of the soil samples:

Table (5.1): Coordinates of Soil Samples.

Point #	X	Y	Point #	X	Y
1	154000	118000	22	154000	112000
2	156000	118000	23	156000	112000
3	158000	118000	24	158000	112000
4	160000	118000	25	160000	112000
5	150000	116000	26	162000	112000
6	152000	116000	27	164000	112000
7	154000	116000	28	148000	110000
8	156000	116000	29	149000	110000
9	158000	116000	30	150000	110000
10	160000	116000	31	152000	110000
11	162000	116000	32	154000	110000
12	164000	116000	33	156000	110000
13	150000	114000	34	158000	110000
14	152000	114000	35	160000	110000
15	154000	114000	36	162000	110000
16	158000	114000	37	150000	108000
17	160000	114000	38	152000	108000
18	162000	114000	39	154000	108000
19	148000	112000	40	156000	108000
20	150000	112000	41	158000	108000
21	152000	112000	42	160000	108000

5.3 Soil Texture (Sieve Analysis).

A sieve analysis is a practice or procedure used to assess the particle size distribution of a granular material. The size distribution is often of critical importance to the way the material performs in use. It can be used for any type of non-organic or organic granular round materials including sands, clays, granite, feldspars, coal, soil, and a wide range of manufactured powders.

Table (5.3) shows the calculation for one sample by using sieve analysis.

Table (5.3): Sieve Analyses for One Sample

Point #	Sieve Number	Weight (g)	Percent of Weight (%)	Percent of Weight (cum.)	Total Pass (%)
1	4	119.2	11.92	11.92	88.08
	10	222.8	22.28	34.2	65.8
	20	231.6	23.16	57.36	42.64
	40	175.9	17.59	74.95	25.05
	80	139.5	13.95	88.9	11.1
	140	49.1	4.91	93.81	6.19
	230	43	4.3	98.11	1.89
	Pan	18.9	1.89	100	0

All other calculations are shown in appendix A.

5.4 Soil Texture Classification.

Because of the leak of sieve number 325 and 400, the soil association published by maher owaiwi and wael awadallah (2005), is used to identify the type of the soil texture, table (5.4).

Table (5.4): Soil Association Published by Maher Owaiwi and Wael Awadallah.

Soil Type	Texture
Brown Rendzinas and Pale Rendzinas	Silt Clay
Dark Brown Soils	Sand
Terra Rossas, Brown Rendzinas and Pale Rendzinas	Silt Clay

Table (5.5) shows the soil texture for each soil sample, the soil texture for each field sample is determined using GIS overlay technique between soil sample shapefile and the soil as association shapefile.

Table (5.5): Soil Texture

Point #	Type	Point #	Type
1	Silt clay	22	Silt clay
2	Silt clay	23	Silt clay
3	Silt clay	24	Silt clay
4	Silt clay	25	Silt clay
5	Silt clay	26	Silt clay
6	Silt clay	27	Silt clay
7	Silt clay	28	Silt clay
8	Silt clay	29	Sand
9	Silt clay	30	Sand
10	Silt clay	31	Silt clay
11	Silt clay	32	Silt clay
12	Silt clay	33	Silt clay
13	Sand	34	Silt clay
14	Silt clay	35	Silt clay
15	Silt clay	36	Silt clay
16	Silt clay	37	Silt clay
17	Silt clay	38	Silt clay
18	Silt clay	39	Silt clay
19	Silt clay	40	Silt clay
20	Sand	41	Silt clay
21	Silt clay	42	Silt clay

5.5 Measurement of Infiltration.

One of the most important of catchments characteristics is the infiltration rate which is helped to classify the soil. It is usually measured by the depth in (mm) of the water layer that can be entered the soils in one hour (mm/hr).

Initial infiltration rate described dry soil where the water infiltrates rabidly. At the same time water replaces the air in the pores, and the water infiltrate become slowly and eventually reaches a steady rate which is called the basic infiltration rate. The size of soil particles (soil texture) and soil structure (the arrangement of the soil particles) control the infiltration rate.

Table (5.6) shows the results of infiltration rate test for the different soils samples by locations.

Table (5.6): Infiltration Table

Point #	**Infiltration rate(mm/hour)**	**Point #**	**Infiltration rate(mm/hour)**
1	144	22	19.8
2	128.4	23	37.2
3	Rock Point	24	99.6
4	112	25	20.4
5	4	26	66.6
6	22	27	138
7	24.5	28	111
8	32	29	24.6
9	90	30	4.5
10	83.8	31	4.9
11	113.3	32	20
12	93.6	33	58.2
13	5	34	19.6
14	19.7	35	12.9
15	21.9	36	18.5
16	77.5	37	22
17	55.9	38	19.3
18	87.4	39	17.3
19	25.5	40	90
20	16.9	41	48
21	112	42	25.2

5.6 Soil Moisture

Soil moisture can be estimated by butting the sample in furnace at (150 C^0) the difference in the weight is the soil moisture, table (5.7) shows the calculations procedure for soil moisture.

Table (5.7): Soil Moisture.

Point #	Plate Empty (g)	Plate and Wet Soil (g)	Plate and Dry Soil (g)	Water Weight (g)	Dry Weight (g)	Moisture Content (%)
1	10.77	1300	1110.43	189.57	1289.23	14.70413
2	10.67	1300	1089.42	210.58	1289.33	16.33251
3						
4	10.9	1300	1189.94	110.06	1289.1	8.53774
5	10.75	1300	1096.24	203.76	1289.25	15.80454
6	10.75	1300	1077.07	222.93	1289.25	17.29145
7	10.93	1300	1157.05	142.95	1289.07	11.08939
8	10.85	1300	1160.02	139.98	1289.15	10.85832
9	11.35	1300	1076.79	223.21	1288.65	17.32123
10	10.85	1300	1102.75	197.25	1289.15	15.30078
11	10.88	1300	1041.51	258.49	1289.12	20.05166
12	10.66	1300	1093.43	206.57	1289.34	16.02138
13	10.92	1300	1115.19	184.81	1289.08	14.33658
14	10.66	1300	1085.35	214.65	1289.34	16.64805
15	10.88	1300	1132.12	167.88	1289.12	13.02284
16	10.66	1300	1092.87	207.13	1289.34	16.06481
17	10.82	1300	1113.73	186.27	1289.18	14.44872
18	10.68	1300	1060.23	239.77	1289.32	18.59662
19	11	1300	1108.64	191.36	1289	14.84562
20	11.15	1300	1058.85	241.15	1288.85	18.71048
21	10.85	1300	1159.8	140.2	1289.15	10.87538
22	10.81	1300	1090.6	209.4	1289.19	16.24276
23	10.7	1300	1136.54	163.46	1289.3	12.6782
24	10.85	1300	1119.66	180.34	1289.15	13.98906
25	10.71	1300	1121.83	178.17	1289.29	13.81923
26	10.83	1300	1093.68	206.32	1289.17	16.0041
27	10.85	1300	1125.36	174.64	1289.15	13.54691
28	11.8	1300	1094.25	205.75	1288.2	15.9719
29	10.96	1300	1086.2	213.8	1289.04	16.58599
30	10.8	1300	1091.99	208.01	1289.2	16.13481
31	10.8	1300	1094.31	205.69	1289.2	15.95486
32	10.86	1300	1065.76	234.24	1289.14	18.17025
33	10.93	1300	1055.32	244.68	1289.07	18.98113
34	10.85	1300	1150.46	149.54	1289.15	11.59989
35	10.9	1300	1149.83	150.17	1289.1	11.64921
36	10.85	1300	1083.15	216.85	1289.15	16.82116
37	10.86	1300	1085.08	214.92	1289.14	16.67158
38	10.9	1300	1044.99	255.01	1289.1	19.78202

39	10.9	1300	1080.68	219.32	1289.1	17.01342
40	10.9	1300	1133.16	166.84	1289.1	12.94236
41	10.85	1300	1094.93	205.07	1289.15	15.90738
42	10.72	1300	1068.51	231.49	1289.28	17.95498

5.7 Organic Matter

In this of test the samples are burn at (400 C^0), and then the difference in the weight is the organic content, table (5.8), illustrate the procedure of calculating the organic content.

Table (5.8): Organic Matter.

Point #	Weight of Cup (g)	Weight Before Burn (g)	Weight After Burn (g)	Organic Content (g)
1	61.32	104.97	101.19	1.094808126
2	49.18	83.91	81.18	1.0853125
3				
4	62.13	97.98	95.29	1.081121834
5	67.38	99.75	97.69	1.067964368
6	49.34	93.62	90.56	1.074235808
7	65.15	104.8	100.55	1.120056497
8	65.08	92.82	89.92	1.116747182
9	65.57	101.64	98.37	1.099695122
10	66.47	102.46	101.59	1.02477221
11	66.79	99.63	97.42	1.072151485
12	65.39	97.79	95.37	1.08072048
13	64.63	91.86	90.07	1.070361635
14	63.58	82.44	81.08	1.077714286
15	67.21	99.4	96.85	1.086032389
16	71.31	101.93	99.63	1.081214689
17	73.25	107.77	104.9	1.090679305
18	65.6	92.7	90.54	1.086607859
19	58.62	90.7	88.71	1.066134929
20	51.73	71.09	69.63	1.081564246
21	72.44	104.91	103.02	1.061805101
22	67.63	106.05	102.8	1.092408303
23	63.39	82.55	81.17	1.077615298
24	68.29	108.17	106.04	1.056423841
25	63.1	97.32	95.19	1.066375818

26	47.04	90.31	86.32	1.101578411
27	64.22	93.87	90.99	1.107583115
28	78.02	110.95	108.61	1.076495587
29	77.91	109.45	107.32	1.072424345
30	68.06	101.64	99.63	1.063668039
31	60.9	86.73	84.52	1.093564776
32	68.96	105.61	103.77	1.052858374
33	69.78	104.58	102.16	1.074737492
34	74.37	106.24	104.59	1.054599603
35	65.28	107.2	105.45	1.043564849
36	50.69	78.72	77.05	1.063353566
37	59.38	103.72	100.15	1.087564386
38	69.97	89.63	88	1.090404881
39	51.15	71.42	70.14	1.067403897
40	50.57	77.85	76.11	1.068128426
41	59.78	85.24	83.13	1.090364026
42	65.62	102.63	100.12	1.072753623

CHAPTER SIX

ESTIMATION OF RUSLE FACTORS

CHAPTER 6: ESTIMATION OF RUSLE FACTORS

6.1 Summary

This chapter illustrates the procedure used to estimate the RUSLE factors, and describes the Soil Erosion Risk Map for the study area.

6.2 Rainfall-Runoff Erosivity factor (R)

Erosion is caused by both the energy of rainfall itself, and by overland flow runoff. The rainfall-runoff erosivity factor (R) estimates the erosive forces of rainfall and its associated runoff, and is directly related to the intensity and depth of rainfall. To calculate rainfall-runoff erosivity factors we will use the following equation:

R = 3.85 + 0.35(P) *(Reference 12***)**

Where:-

R = rainfall-runoff erosivity

P = Average annual rainfall (mm/year).

Figure (6.1) shows the calculation of (R) factor based on the value of rainfall stored in the rain_avg field of rainfall shapefile. The calculation is done using the Field Calculator tool in (ArcGIS 9.2).

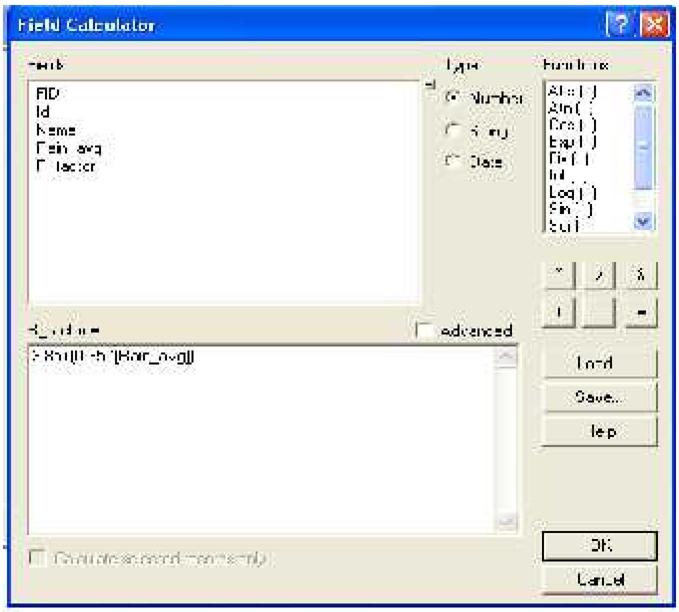

Figure (6.1): Calculation of R factor Using Field Calculator Tool in ArcGIS 9.2.

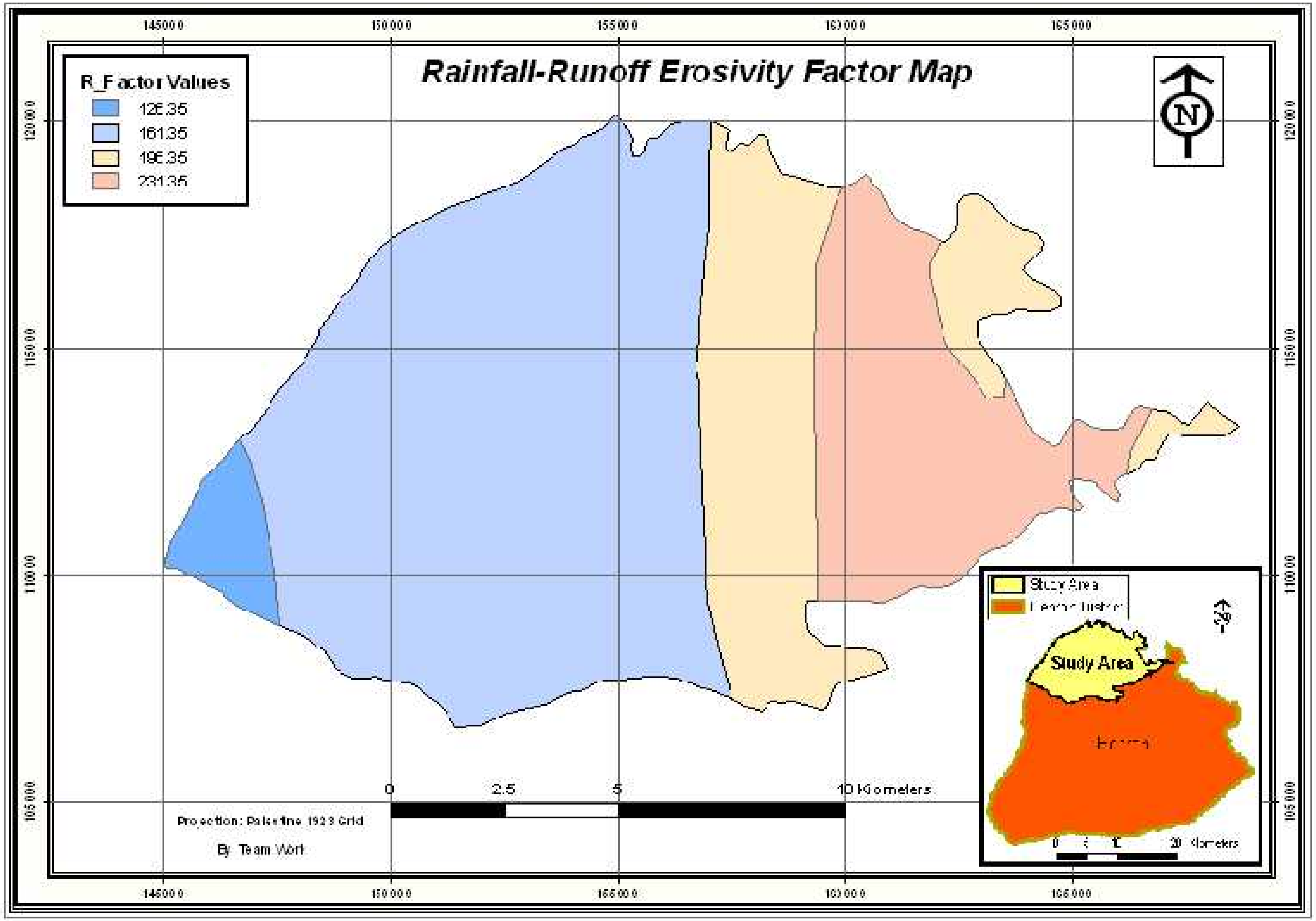

Figure (6.2): Rainfall-Runoff Erosivity Factor Map

6.3 Soil erodibility (K)

(K) is the soil erodibility factor. (Table (4.1): K Factor Data (Organic Matter Content)), It is the average soil loss in tons per unit area for a particular soils type, continuous fallow with an arbitrarily selected slope length of 22.13 m. and slope steepness of 9%. (K) is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting (K), but structure, organic matter and permeability also contribute

Soil map for study area is prepared by digitizing exiting soil map with scale 1:100000 figure (1.2). An intensive field sampling of soil sample is conducted to identify the soil class texture and infiltration rate, moisture content and organic matter percent.

An intensive field sampling of soil sample is conducted to identify the soil class texture, infiltration, organic matter percent and moisture content. Analyses of field results shows that the organic matter content of all soil types are less than 2% and the soil type are sand, loam and silty clay. And using table (4.1), the (K) factor is 0.27 for silty clay soil and 0.03 for sandy soil; Figure (6.3) shows the spatial distribution of the (K) factor in the study area.

6.4 Soil Length gradient factor (LS).

Both the length and steepness of a slope influence soil erosion and need to be part of the topographic factor (LS). The relationship of erosion to slope steepness is best defined by a quadratic equation:

Erosion = a(slope)^2 + b(slope) + c *(Reference 12)*

(Where a, b, and c are constants).

And in other form it can be presented by the next formula:

LS = (L(0.065+0.045*S+0.0065*S^2))^0.5)/22.13 *(Reference 12)*

When L is slope length in meter and S slope steepness in percent.

By using this equation and a contour map we will be able to estimate (LS) factor.

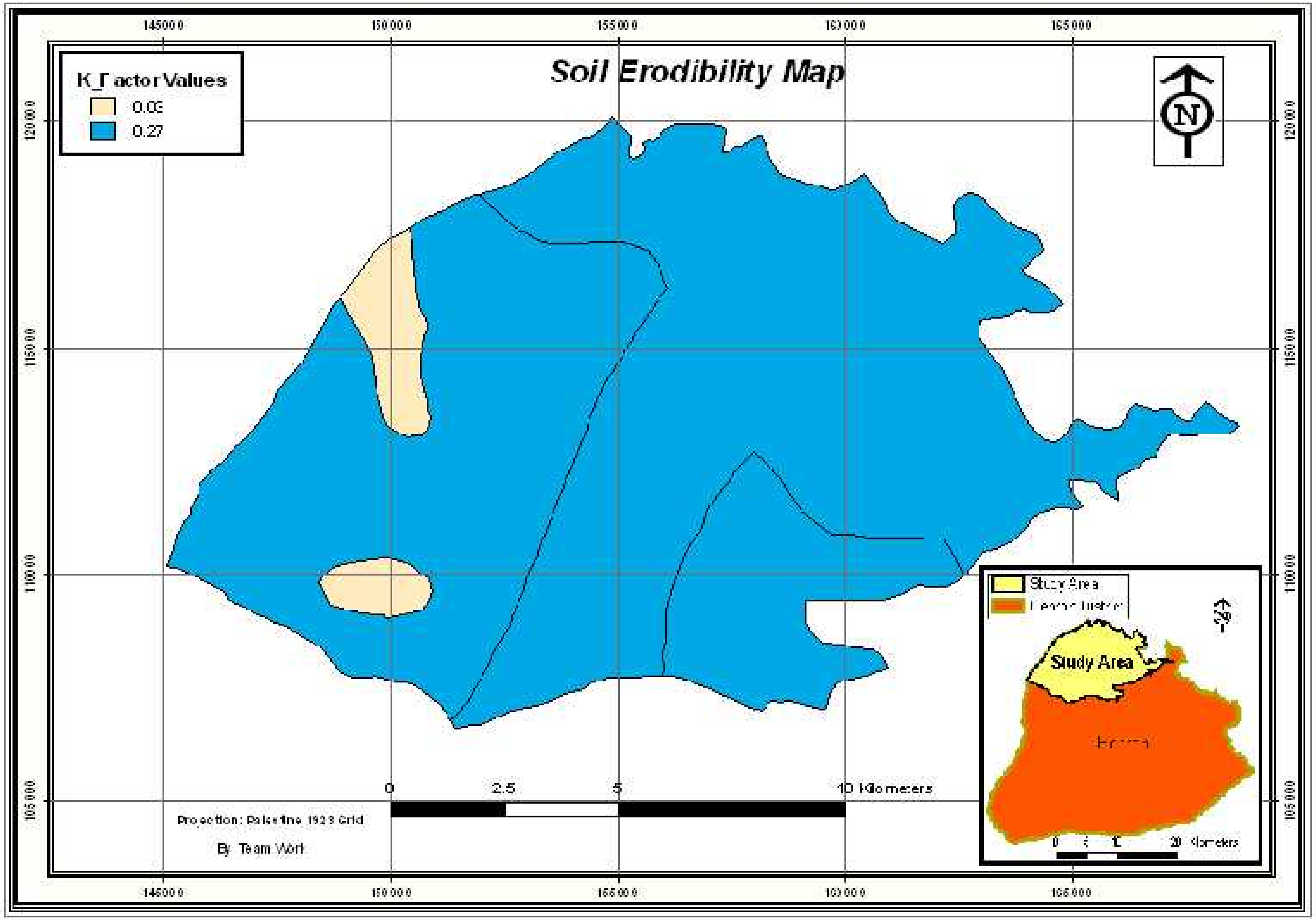

Figure (6.3) The Spatial Distribution of the K Factor in the Study Area.

The (LS) factor can be estimated from the slope model which is in turn derived from DEM, figure (6.4) shows the digital elevation model in the study area which is created from the contour map for Hebron district.

Make the DEM active, figure (6.5), select the Surface pull down menu as shown below and select the Derive Slope option.

The derived slope is shown in figure (6.6). The slope units are degrees. (Note that this is only true if the units are consistent, e.g. if Palestine coordinates are used, elevation values should be in meters).

The following script shows how to estimate (LS) factor using the previous equation and ArcView:

```
(' Calculate Slope length of Slope Grid
'TanThita = Rise/Run
'CosThita = Run/r ' R is the Diameter
'
'*****************************************************************
*****************************
'Constructing of Digital Elevation Model (DEM) and building the LS map

'A Digital Elevation Map (DEM) will be
'created using the 3D Analyst Extension of ArcView. A slope degree grid model was
drive from the DEM.
'And then calculate the slope length (L) and slope steepness (S) from the slope degree
grid model to produce the LS map.
'LS values will be computed from equation (1) (Morgan, 1986):

'LS = (L(0.065+0.045*S+0.0065*S^2))^0.5)/22.13                                    (1)
'where, L is slope length in meter and S is slope steepness in percent (%).

theView = av.GetActiveDoc

' get active theme
t = theView.GetActiveThemes.Get(0)

' turn grid or tin into slope grid

if (t.GetClass.GetClassName = "GTheme") then

  g = t.GetGrid
```

```
end

'
' check if output is ok
if (g.HasError) then
  return NIL
end
  Grid.SetVerify(#GRID_VERIFY_OFF)

 g = g.int

 if (g.isInteger) then   ' beging of if

  g.buildVAT

 myvtab = g.getvtab

If (myVtab =nil)then
 end
run =  g.GetCellSize

  myVtab.seteditable(True)
'*****************************************************************
*
SlengthF = Field.Make( "Slengh",#FIELD_CHAR, 15, 0 )
PSlopeF =  Field.Make( "PSlope",#FIELD_CHAR, 15, 0 )
LSF =  Field.Make( "LS",#FIELD_DOUBLE, 15, 3 )

Fieldlist = {}
Fieldlist.add(SlengthF)
Fieldlist.add(PSlopeF)
Fieldlist.add(LSF)

SlenghtF = myVtab.AddFields(Fieldlist)

ValueF = myVtab.FindField("Value")
L = myVtab.FindField("Slengh")
s = myVtab.FindField("PSlope")
LS = myVtab.FindField("LS")

  for each i in myvtab
        thita = myVtab.ReturnValue(ValueF,i)
            r = run / thita.AsRadians.cos
            Rise = run * thita.AsRadians.tan
            PercentSlope = (Rise/Run) * 100

      'Calculate LS
           X =  0.0065 * (PercentSlope^2)
            X1 = (0.045 * PercentSlope)
             X2 =  (0.065 + X1 + X)
```

```
            X3 =  (r * x2)^0.5
             LS_Vallue = X3/22.13

         myVtab.SetValue( L, i, r.AsString )
         myVtab.SetValue( S, i, PercentSlope.AsString )
         myVtab.SetValue( LS, i, LS_Vallue.AsString )
'********************************************************************
****************************************
  end

'  Msgbox.info(mygCellsize.AsString,"Value")
' check if output is ok

 if (g.HasError) then

  return NIL
end
 r = SourceManager.PutDataSet(GRID,"", "maher".AsFilename,TRUE)
 ' check for Cancel from dialog
   if (r = NIL) then
   return NIL
    end
 g.Rename(r)
' create a theme
gthm = GTheme.Make(g)

' set name of theme

' add theme to the specifiedView
theView.AddTheme(gthm)

end      ' end of if   )
```

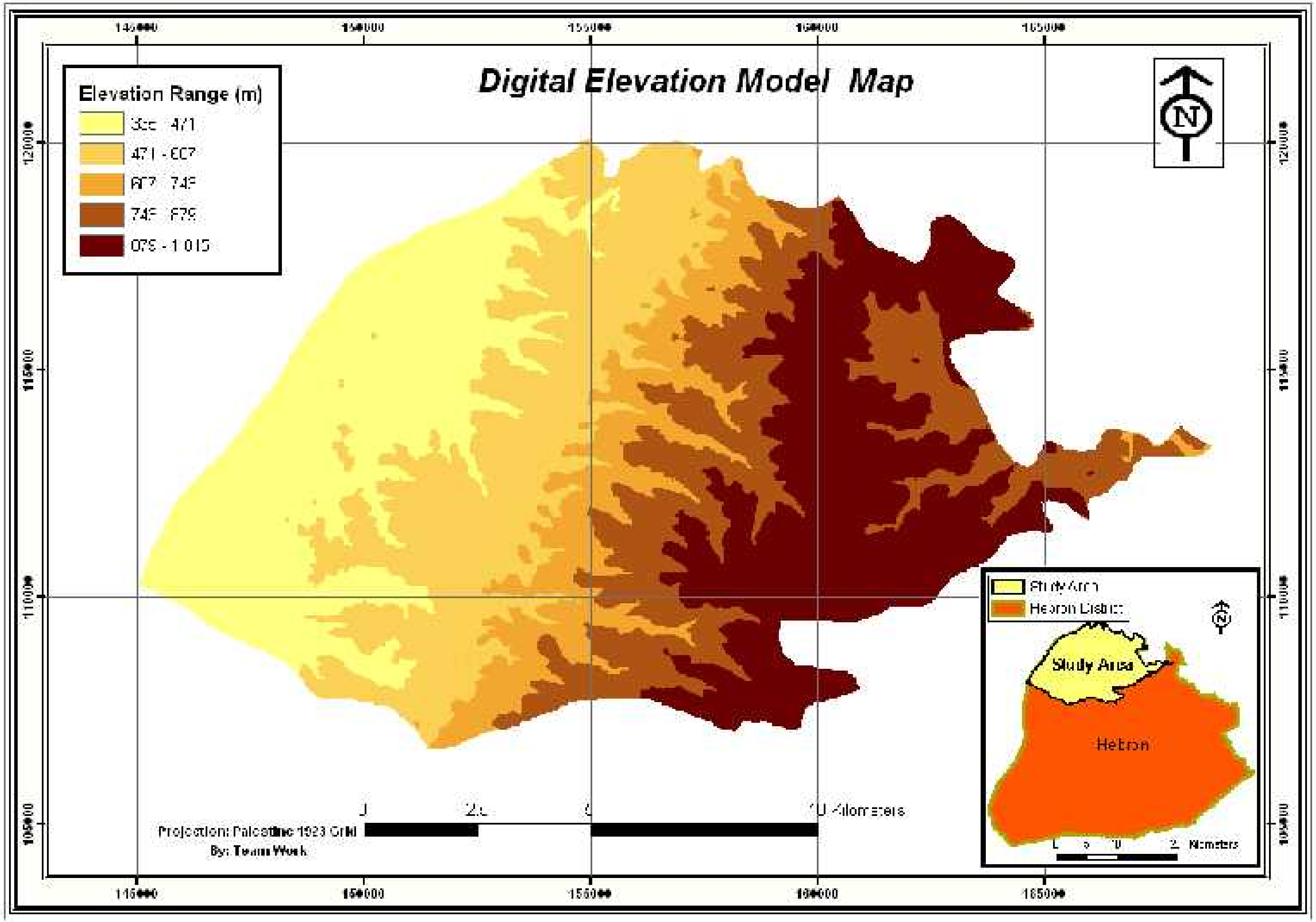

Figure (6.4): Digital Elevation Model

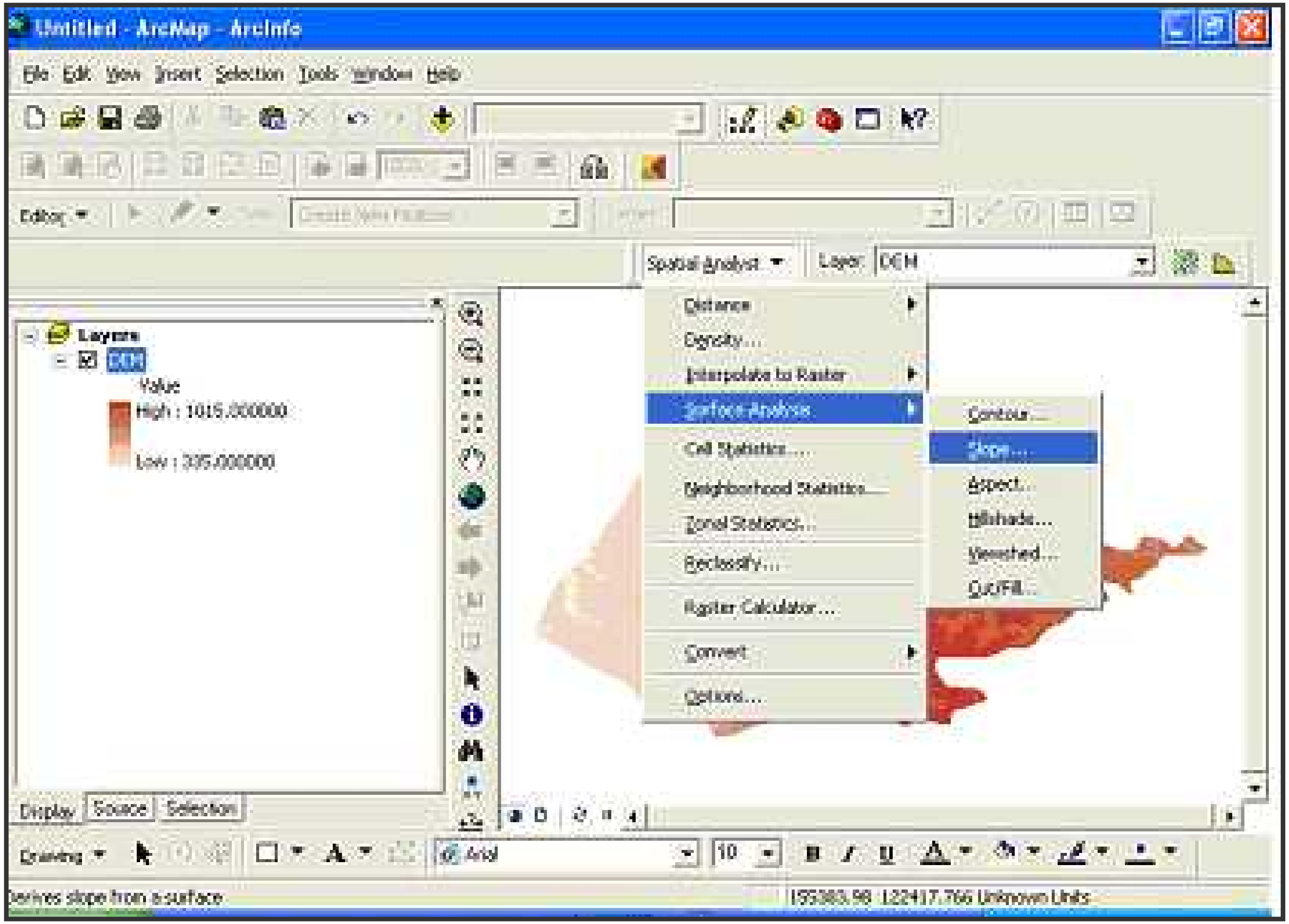

Figure (6.5): Derive Slop from the DTM Map.

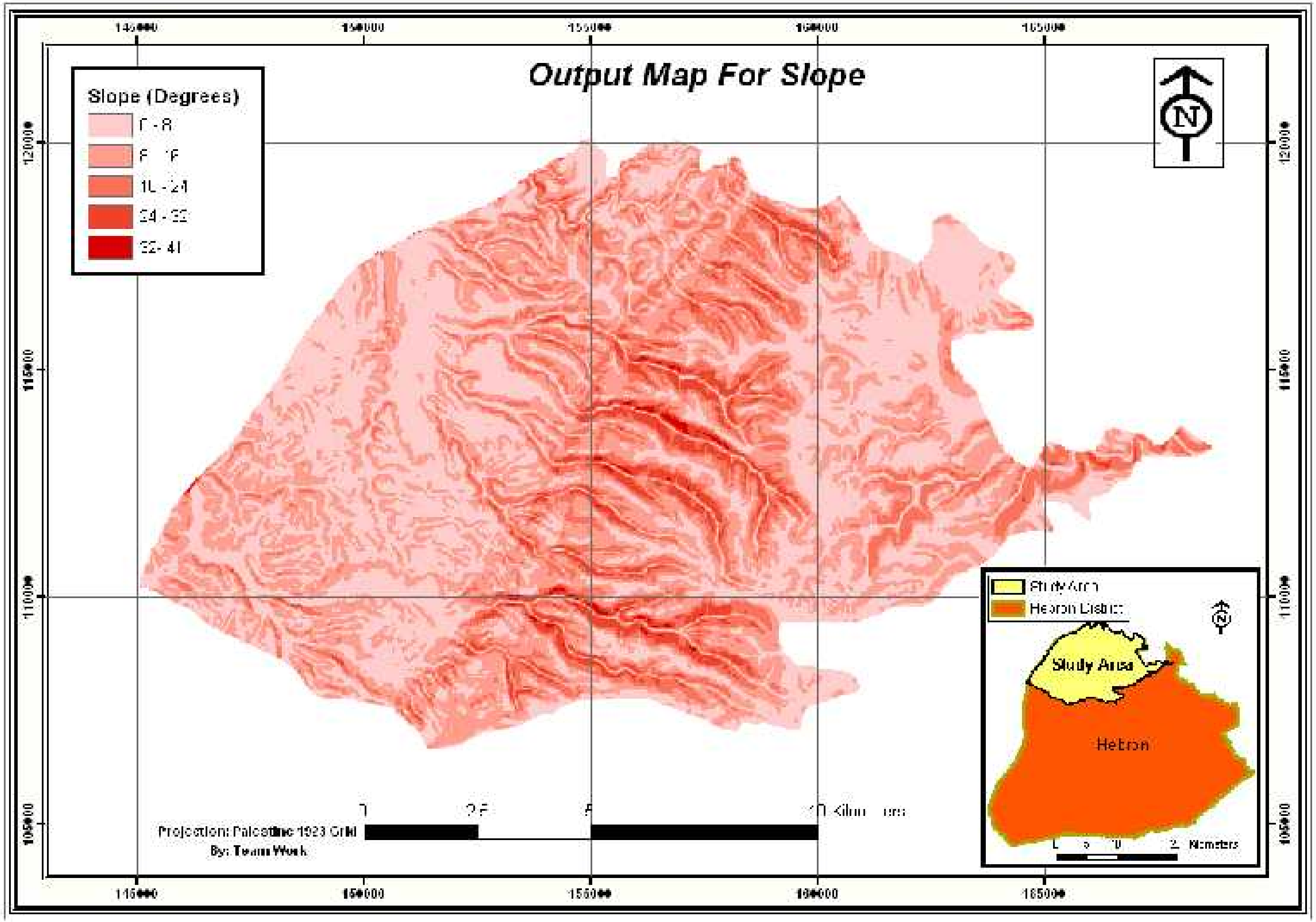

Figure (6.6): Output Map for Slope.

Figure (6.7), shows how to calculate the (LS) factor using the previous script in ArcView 3.2, and figure (6.8), shows the output.

Figure (6.7): Using ArcView 3.2 to Calculate (LS) Factor.

6.5 Cropping and Management (C)

The values of (C) factor for use in rational formula are given by Waniehista and Yousef (1995) and are given in table (6.2).

Table (6.1): C Factor

Land use Type	C_Factor
Arable Land	1
Heterogeneous Agricultural Area	0.08
Permanent Crops	0.08
Urban Fabric	1
Forests	0.08
Industrial Commercial	1
Mine, Dumps and Construction Site	0.8
Open Spaces With Little or No Vegetation	0.1
Shrubs and Herbaceous Vegetation Associations	0.1

Figure (6.9), shows the spatial distribution of the(C) Factor in the study area.

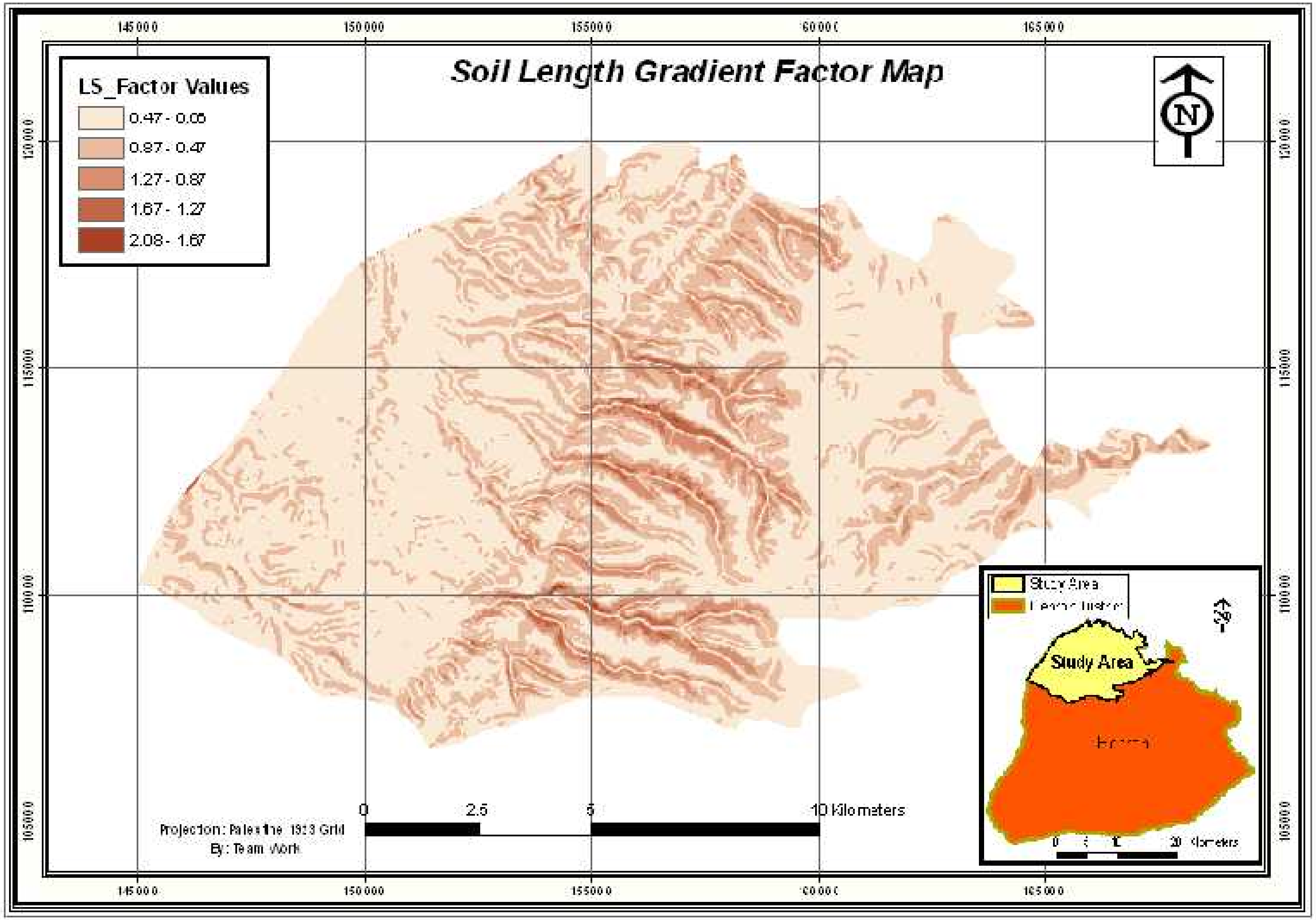

Figure (6.8): Resultant (LS) Factor Grid Map.

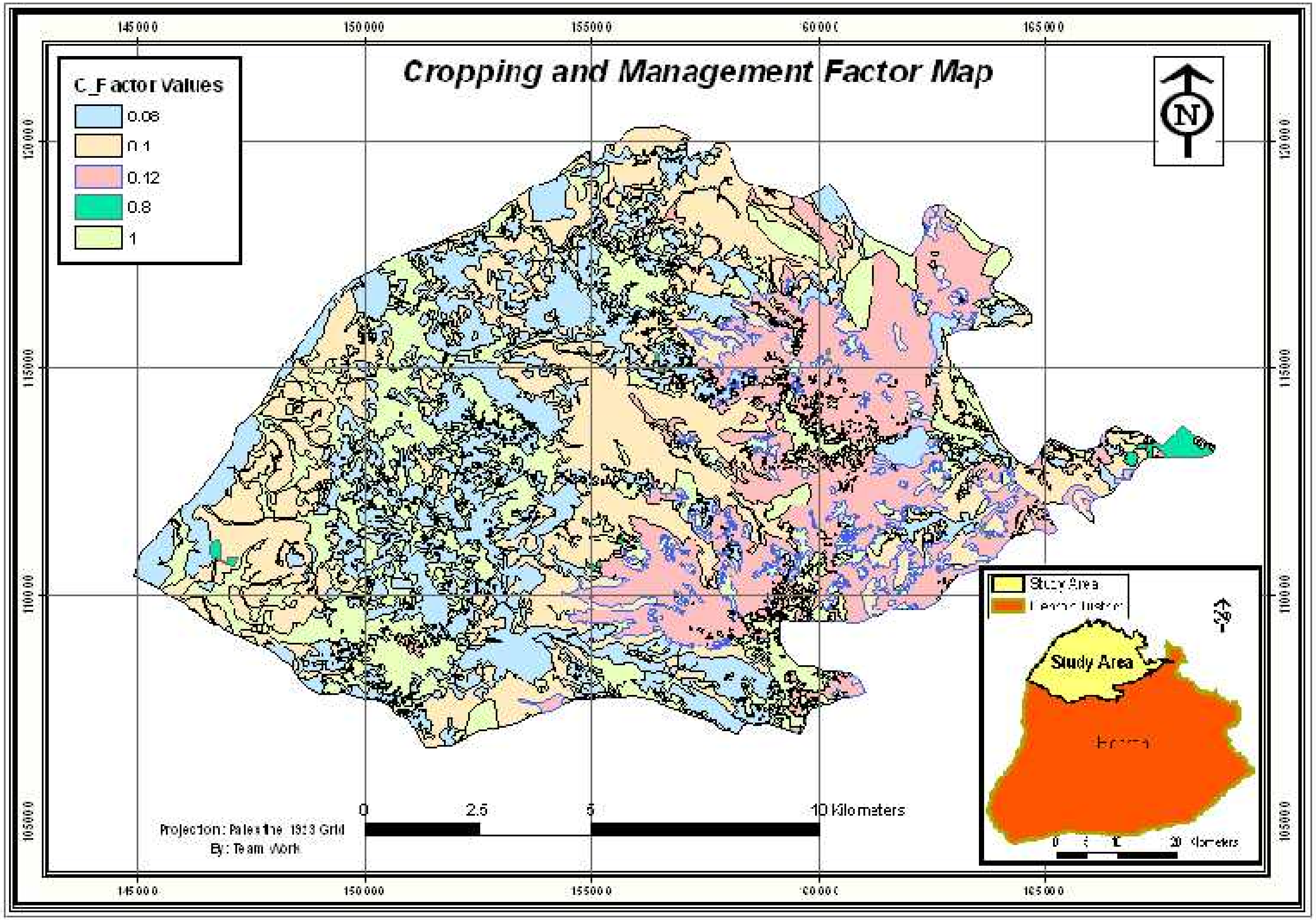

Figure (6.9): C Factor.

6.6 Conservation Practices (P)

Factor (P) represents soil conservation practices that essentially slow the runoff water and thus reduce the amount of soil it can carry, and it depend on the soil type, texture and farming way.

Table (6.2); shows relation between land use patterns and their most common (P) code values, Waniehista and Yousef (1993).

Table (6.2): P Factor

Land use Type	P_Factor
Arable Land	1
Heterogeneous Agricultural Area	0.12
Permanent Crops	0.8
Urban Fabric	1
Forests	0.8
Industrial Commercial	1
Mine, Dumps and Construction Site	0.8
Open Spaces With Little or No Vegetation	0.1
Shrubs and Herbaceous Vegetation Associations	0.1

Figure (6.10), shows the spatial distribution of the (P) Factor in the study area.

6.7 Final RUSLE Erosion Risk Map for study area

By multiplying all the five factors, using ArcGIS, the final erosion model is calculated, figure (6.11). Figure (6.12) shows the final Erosion Risk map using the RUSLE model in tons per acre per year.

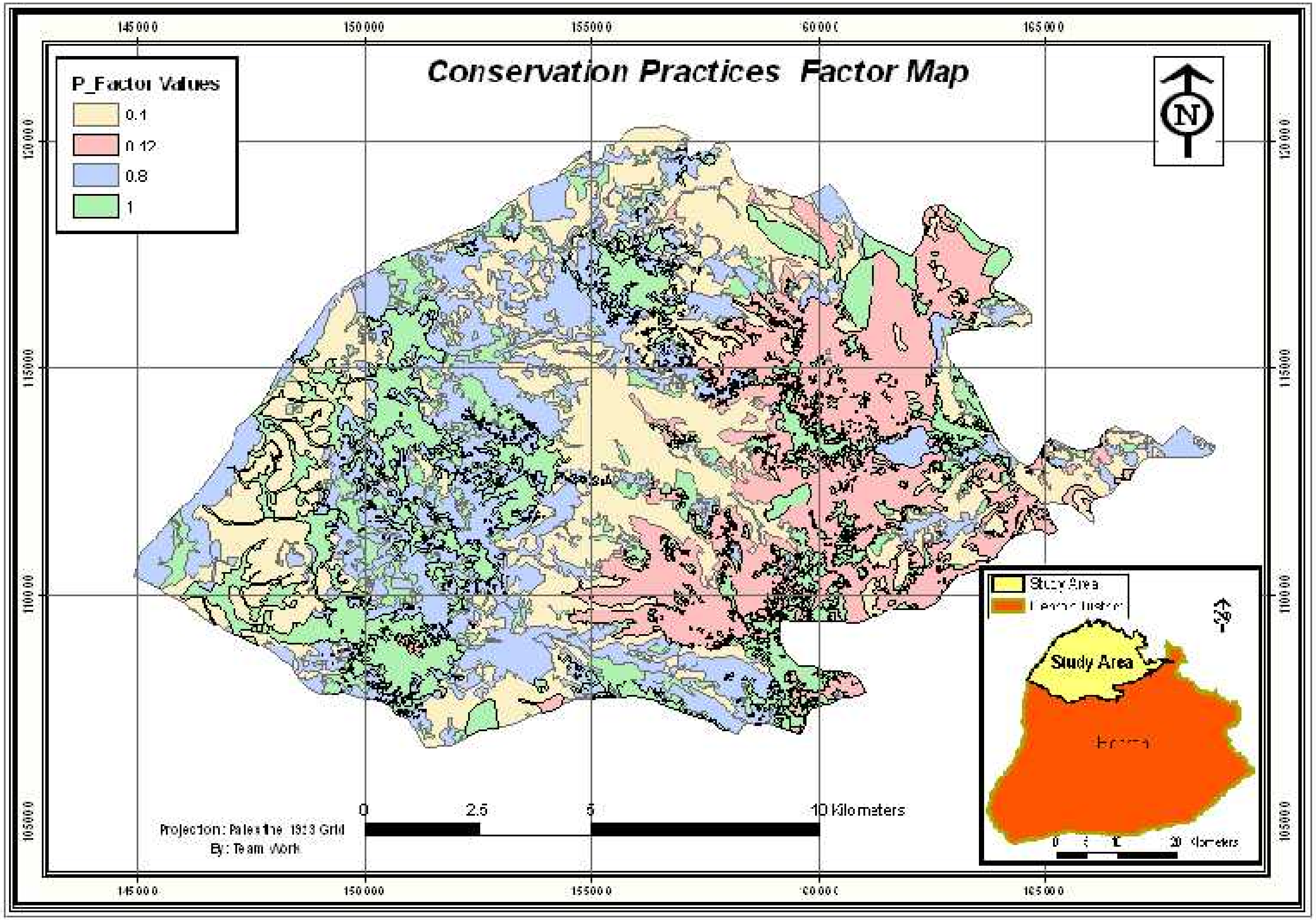

Figure (6.10): P Factor.

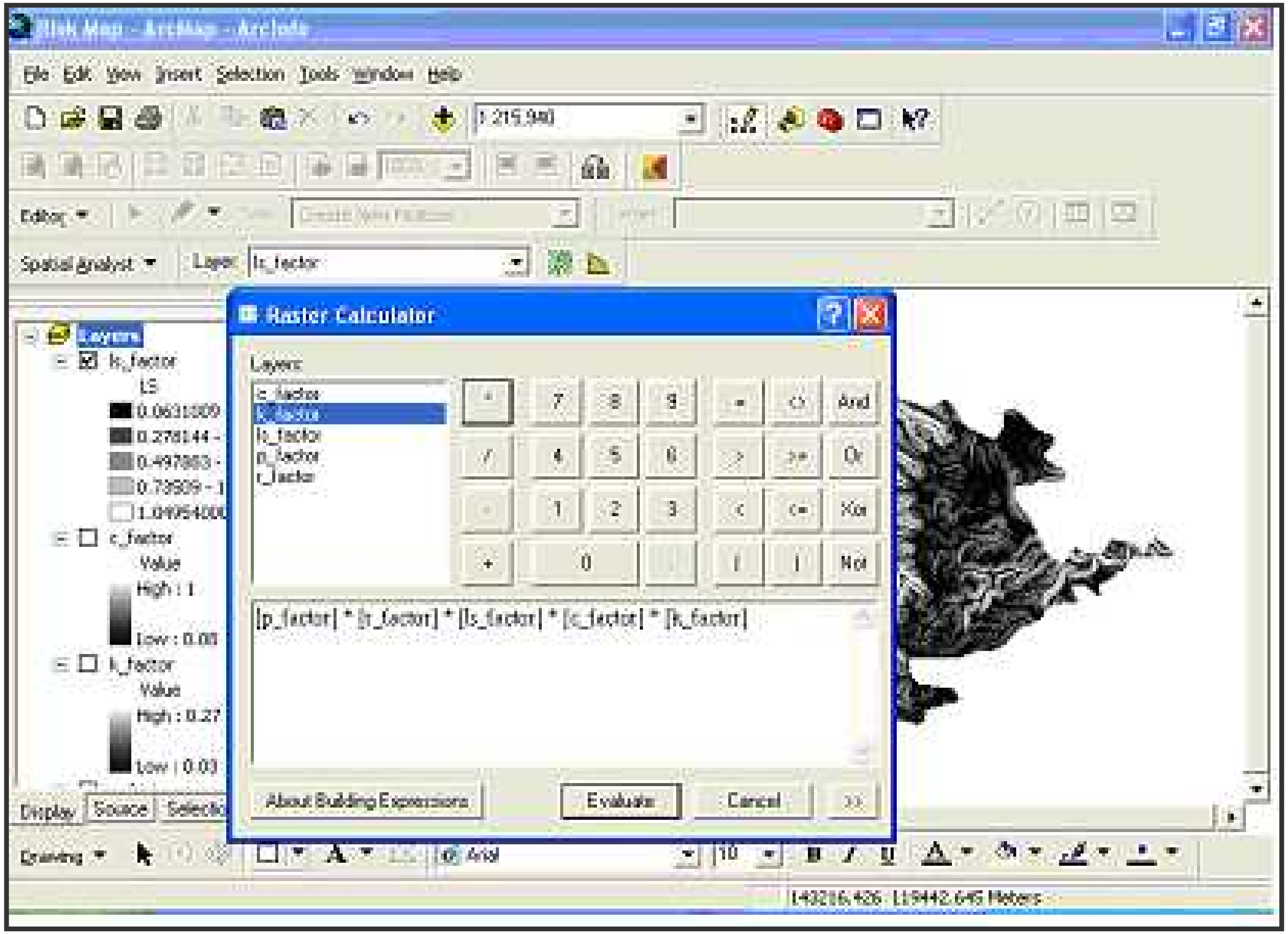

Figure (6.11): Calculating the Erosion Model Using ArcGIS.

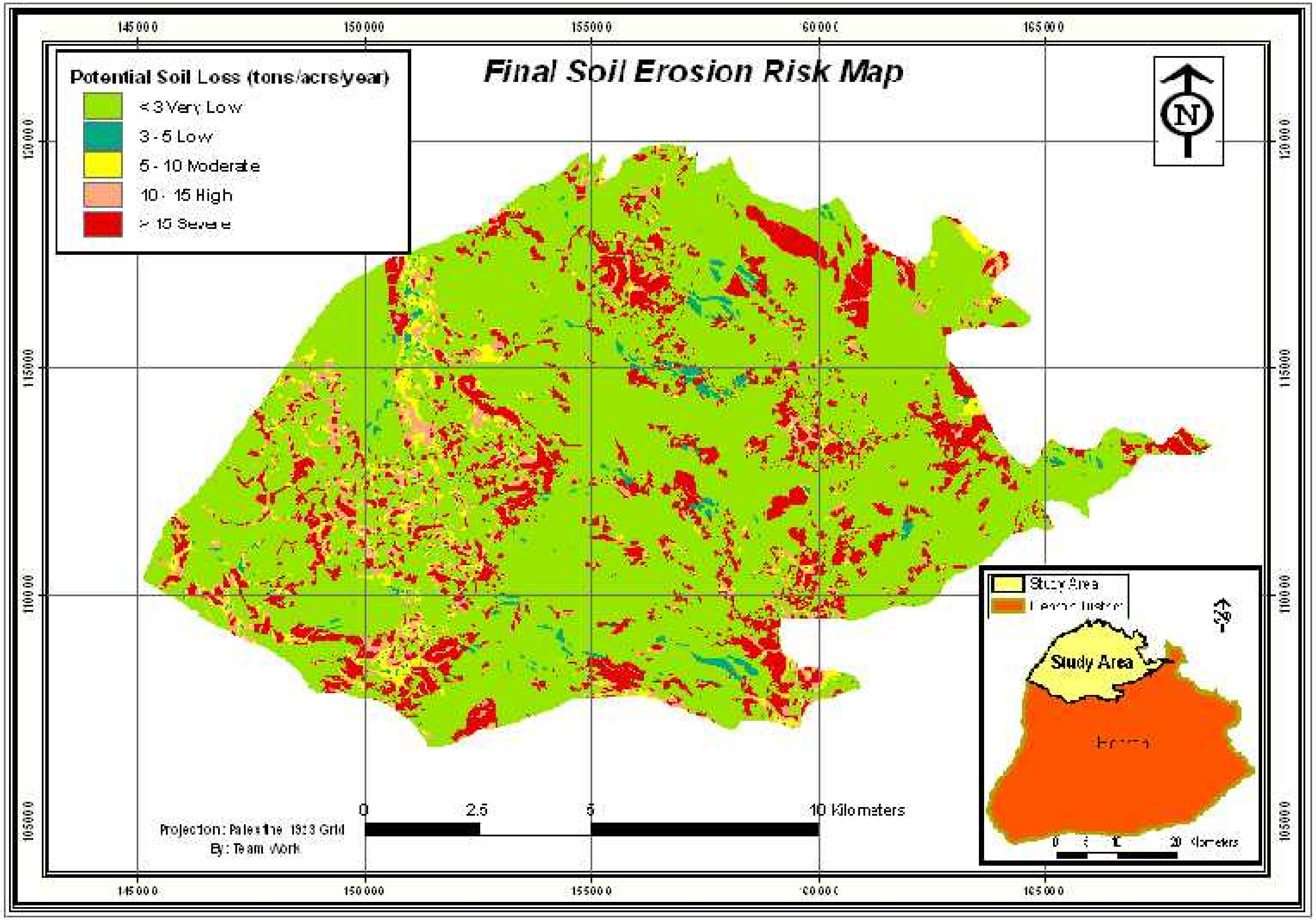

Figure (6.12): Final Erosion Risk Map.

6.8 T value

(T) is soil loss tolerance expressed in tons per acre per year. The (T) value is not directly used in RUSLE. However, it is important in the use of the soil loss equation for conservation planning. Soil loss tolerance is the maximum amount of soil loss in tons per acre per year, which can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely.

Table (6.3): T value

Soil erosion class	Potential soil loss (tons/acrs/year)
Very low (tolerable)	**<3**
Low	**3-5**
Moderate	**5-10**
High	**10-15**
Severe	**>15**

The Final Erosion Risk Map is classify to five Soil Erosion Classes, figure (6.12), these are Very low, Low, Moderate, high, and Severe areas**:**

Table (6.4): Soil Erosion Classes by Area Present

Soil Erosion Classes	**Area (m^2)**	**Area (km^2)**	**% of Area**
Very low	131373000	131.373	75.02416
Low	3250800	3.2508	1.856459
Moderate	6481800	6.4818	3.70161
High	8433000	8.433	4.815896
Severe	25569000	25.569	14.60188
Sum	**175107600**	**175.1076**	**100**

Figure (6.13) shows chart of the soil erosion classes by area present, figure (6.14) displays the contribution of each value to a total.

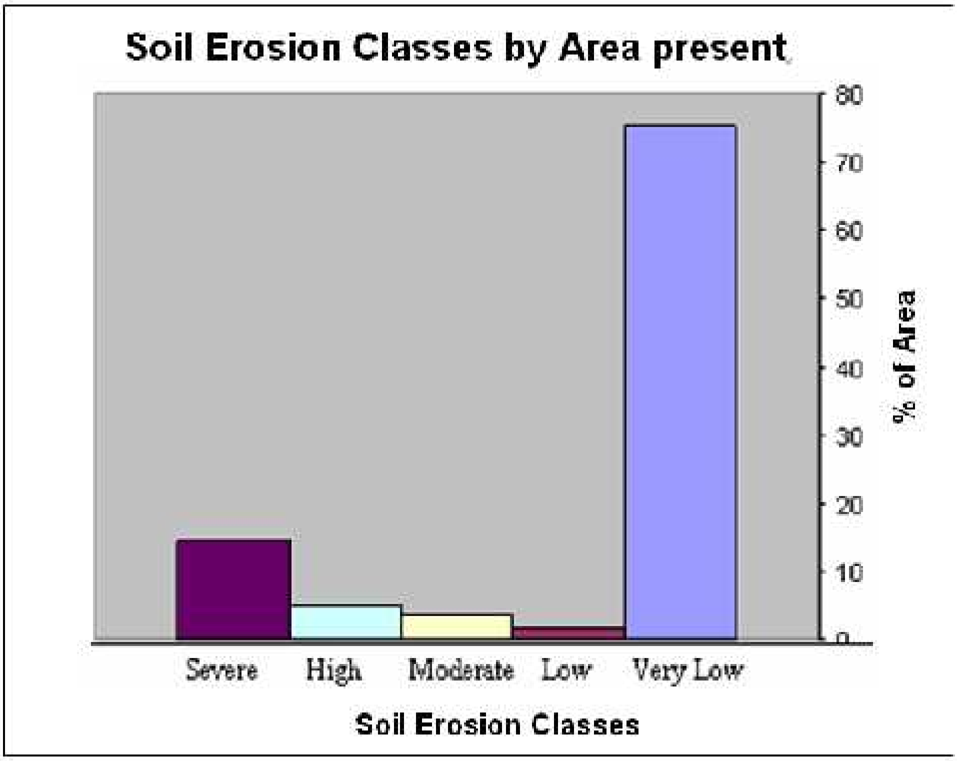

Figure (6.13): Flowchart of Soil Erosion Classes by Area Percent.

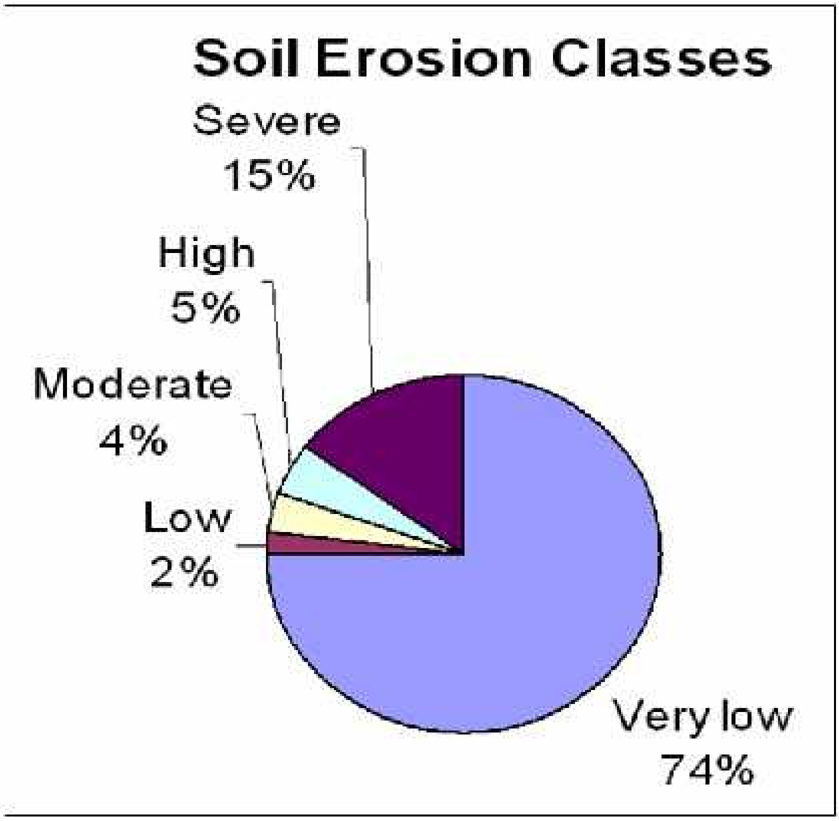

Figure (6.14): Pie of Soil Erosion Classes by Area Percent.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS.

7.2 RECOMMENDATIONS.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

7.1 **CONCLUSIONS**

1. The visual analysis indicates that the most critical factors in the RUSLE are:
   a. The topographic (LS) factor; and
   b. The soil erodibility (K) factor.

2. The RUSLE was used to predict soil erosion in the Study Area. As seen from the derived erosion map, figure (6.12), most areas have minor soil erosion which is less than 3 tons/acre/year (about 75% of study area). The areas of highest erosion occurred in the places where the slopes are the greatest and consist a bout 14.6% of the study area.

3. The estimated erosion values mostly are below the usual “tolerable soil loss” of 3 tons/acre/year.

4. GIS is very useful compared to traditional methods by breaking up the land surface into many small cells which enables an analysis to be performed on both large regions as well as discrete areas. This study demonstrates that GIS is a valuable tool in assessing soil erosion modeling and in assisting the estimation of erosion. Also, cell size is very important for the data.

Sources of Errors in the Model:

1. Error in this estimation can occur because the RUSLE is an empirical equation that does not mathematically represent the physical processes of soil erosion.

2. The equation predicts the amount of erosion but due to deposition the actual amount of sediment reaching a given point may be less.

3. Many of the values used to calculate erosion are assumed or estimated.

4. The use of the RUSLE may not be a good predictive model for erosion in this study area because the extreme slopes throughout the watershed do not correlate well with the RUSLE model, which was originally developed for mild slopes in agricultural areas. In particular, the LS values will be overweighted in this analysis.

5. The absolute value of the estimation is not helpful. However, the relative results from different years may still be useful to predict the trend of soil erosion.

7.2 RECOMMENDATIONS

1. An erosion control plan can be suggested. For example, some land forming practices such as terraces on the steep slopes to reduce the slope lengths (LS factors), which will slow down the runoff velocities.

2. It is highly recommend repeating this study for all catchments in Hebron District.

3. Soil Texture analyses using sieve test is not completed because of missing of sieves number 330 and 400. It is highly recommend purchasing a complete set of sieves.

4. A field test of soil erosion is highly recommended to be conducted at least for different soil associations. The results will be used to calibrate the model.

Appendix A

Point #	Sieve Number	Weight (g)	Percent Of Weight %	Percent Of Cum	Total Pass %
1	4	119.2	11.92	11.92	88.08
	10	222.8	22.28	34.2	65.8
	20	231.6	23.16	57.36	42.64
	40	175.9	17.59	74.95	25.05
	80	139.5	13.95	88.9	11.1
	140	49.1	4.91	93.81	6.19
	230	43	4.3	98.11	1.89
	Pan	18.9	1.89	100	0
		1000	100		
2	4	214.1	21.41	21.41	78.59
	10	261.2	26.12	47.53	52.47
	20	225.5	22.55	70.08	29.92
	40	147.4	14.74	84.82	15.18
	80	95.7	9.57	94.39	5.61
	140	25	2.5	74.34	25.66
	230	23.5	2.35	99.24	0.76
	Pan	7.6	0.76	100	0
		1000	100		
4	4	190.2	19.02	19.02	80.98
	10	241.9	24.19	43.21	56.79
	20	281.2	28.12	71.33	28.67
	40	149.3	14.93	86.26	13.74
	80	80	8	96.38	3.62
	140	21.2	2.12	96.38	3.62
	230	17.5	1.75	98.13	1.87
	Pan	18.7	1.87	100	0
		1000	100		
5	4	164.6	16.46	16.46	83.54
	10	216.8	21.68	38.14	61.86
	20	229.4	22.94	61.08	38.92
	40	169	16.9	77.98	22.02
	80	145.5	14.55	92.53	7.47
	140	39.4	3.94	96.47	3.53
	230	19.9	1.99	98.46	1.54
	Pan	15.4	1.54	100	0
		1000			
6	4	149.6	14.96	14.96	85.04
	10	164.7	16.47	31.43	68.57
	20	198.2	19.82	51.25	48.75
	40	180.6	18.06	69.31	30.69
	80	197.9	19.79	89.1	10.9
	140	61.7	6.17	95.27	4.73
	230	31.7	3.17	98.44	1.56
	Pan	15.6	1.56	100	0
		1000			
7	4	256.5	25.65	25.65	74.35
	10	164.6	16.46	42.11	57.89

Point #	Sieve Number	Weight (g)	Percent Of Weight%	Percent Of Cum	Total Pass %
	20	226.5	22.65	64.76	35.24
	40	149.1	14.91	79.67	20.33
	80	102.6	10.26	89.93	10.07
	140	39.8	3.98	93.91	6.09
	230	38.7	3.87	97.78	2.22
	Pan	22.2	2.22	100	0
		1000			
8	4	269.1	26.91	26.91	73.09
	10	321.5	32.15	59.06	40.94
	20	227.6	22.76	81.82	18.18
	40	87.4	8.74	90.56	9.44
	80	49.1	4.91	95.47	4.53
	140	17	1.7	97.17	2.83
	230	13.5	1.35	98.52	1.48
	Pan	14.8	1.48	100	0
		1000			
9	4	371.1	37.11	37.11	62.89
	10	190.7	19.07	56.18	43.82
	20	189.5	18.95	75.13	24.87
	40	119.4	11.94	87.07	12.93
	80	86.1	8.61	95.68	4.32
	140	22.2	2.22	97.9	2.1
	230	11.8	1.18	99.08	0.92
	Pan	9.2	0.92	100	0
		1000			
10	4	462.4	46.24	46.24	53.76
	10	222.9	22.29	68.53	31.47
	20	141.5	14.15	82.68	17.32
	40	57.6	5.76	88.44	11.56
	80	88.6	8.86	97.3	2.7
	140	7.8	0.78	98.08	1.92
	230	12.4	1.24	99.32	0.68
	Pan	6.8	0.68	100	0
		1000			
11	4	209.1	20.91	20.91	79.09
	10	259	25.9	46.81	53.19
	20	255.6	25.56	72.37	27.63
	40	145.2	14.52	86.89	13.11
	80	75.1	7.51	94.4	5.6
	140	22.6	2.26	96.66	3.34
	230	19.3	1.93	98.59	1.41
	Pan	14.1	1.41	100	0
		1000			
12	4	222.8	22.28	22.28	77.72
	10	256.7	25.67	47.95	52.05
	20	249.8	24.98	72.93	27.07
	40	141.9	14.19	87.12	12.88
	80	86.5	8.65	95.77	4.23
	140	19.7	1.97	97.74	2.26
	230	16.1	1.61	99.35	0.65

Point #	Sieve Number	Weight (g)	Percent Of Weight%	Present Of Cum	Total Pass %
	Pan	6.5	0.65	100	0
		1000			
13	4	260.9	26.09	26.09	73.91
	10	183.1	18.31	44.4	55.6
	20	209	20.9	65.3	34.7
	40	157.1	15.71	81.01	18.99
	80	128.6	12.86	93.87	6.13
	140	33.4	3.34	97.21	2.79
	230	19.1	1.91	99.12	0.88
	Pan	8.8	0.88	100	0
		1000			
14	4	292	29.2	29.2	70.8
	10	256.7	25.67	54.87	45.13
	20	221.2	22.12	76.99	23.01
	40	124.1	12.41	89.4	10.6
	80	72.7	7.27	96.67	3.33
	140	14.2	1.42	98.09	1.91
	230	10.2	1.02	99.11	0.89
	Pan	8.9	0.89	100	0
		1000			
15	4	153.7	15.37	15.37	84.63
	10	236.4	23.64	39.01	60.99
	20	210.3	21.03	60.04	39.96
	40	178.2	17.82	77.86	22.14
	80	143.6	14.36	92.22	7.78
	140	38.1	3.81	96.03	3.97
	230	23.9	2.39	98.42	1.58
	Pan	15.8	1.58	100	0
		1000			
16	4	340.3	34.03	34.03	65.97
	10	242.3	24.23	58.26	41.74
	20	180.7	18.07	76.33	23.67
	40	107.5	10.75	87.08	12.92
	80	81.2	8.12	95.2	4.8
	140	17	1.7	96.9	3.1
	230	19.6	1.96	98.86	1.14
	Pan	11.4	1.14	100	0
		1000			
17	4	302	30.2	30.2	69.8
	10	186.5	18.65	48.85	51.15
	20	191.7	19.17	68.02	31.98
	40	139.1	13.91	81.93	18.07
	80	114.1	11.41	93.34	6.66
	140	31.9	3.19	96.53	3.47
	230	18.4	1.84	98.37	1.63
	Pan	16.3	1.63	100	0
		1000			

Point #	Sieve Number	Weight (g)	Percent Of Weight %	Percent Of Cum	Total Pass %
18	4	231.2	23.12	23.12	76.88
	10	219.1	21.91	45.03	54.97
	20	234.4	23.44	68.47	31.53
	40	165.5	16.55	85.02	14.98
	80	92.1	9.21	94.23	5.77
	140	29.9	2.99	97.22	2.78
	230	24.5	2.45	99.67	0.33
	Pan	3.3	0.33	100	0
		1000			
19	4	135.1	13.51	13.51	86.49
	10	206	20.6	34.11	65.89
	20	244.3	24.43	58.54	41.46
	40	203.1	20.31	85.94	14.06
	80	145.1	14.51	93.36	6.64
	140	34.3	3.43	96.79	3.21
	230	20.6	2.06	98.85	1.15
	Pan	11.5	1.15	100	0
		1000			
20	4	379.6	37.96	37.96	62.04
	10	243.2	24.32	62.28	37.72
	20	191	19.1	81.38	18.62
	40	98.1	9.81	91.19	8.81
	80	54.1	5.41	96.6	3.4
	140	14.6	1.46	98.06	1.94
	230	8.7	0.87	98.93	1.07
	Pan	10.7	1.07	100	0
		1000			
21	4	93.9	9.39	9.39	90.61
	10	217.6	21.76	31.15	68.85
	20	269.7	26.97	58.12	41.88
	40	160.5	16.05	74.17	25.83
	80	134.2	13.42	87.59	12.41
	140	53.9	5.39	92.98	7.02
	230	48.7	4.87	97.85	2.15
	Pan	21.5	2.15	100	0
		1000			
22	4	405.7	40.57	40.57	59.43
	10	135.6	13.56	54.13	45.87
	20	165.4	16.54	70.67	29.33
	40	94.8	9.48	80.15	19.85
	80	120.3	12.03	92.18	7.82
	140	33.3	3.33	95.51	4.49
	230	26.4	2.64	98.15	1.85
	Pan	18.5	1.85	100	0
		1000			
23	4	221.4	22.14	22.14	77.86
	10	225.4	22.54	44.68	55.32
	20	204	20.4	65.08	34.92
	40	187.5	18.75	83.83	16.17
	80	127	12.7	96.53	3.47

Point #	Sieve Number	Weight (g)	Percent Of Weight %	Present Of Cum	Total Pass %
	140	15.5	1.55	98.08	1.92
	230	12.4	1.24	99.32	0.68
	Pan	6.8	0.68	100	0
		1000			
24	4	190	19	19	81
	10	189.7	18.97	37.97	62.03
	20	226.2	22.62	60.59	39.41
	40	167.8	16.78	77.37	22.63
	80	144	14.4	91.77	8.23
	140	33.5	3.35	95.12	4.88
	230	30.8	3.08	98.2	1.8
	Pan	18	1.8	100	0
		1000			
25	4	243.2	24.32	24.32	75.68
	10	208.2	20.82	45.14	54.86
	20	199.6	19.96	65.1	34.9
	40	153.1	15.31	80.41	19.59
	80	128.1	12.81	93.22	6.78
	140	28.4	2.84	96.06	3.94
	230	20.6	2.06	98.12	1.88
	Pan	18.8	1.88	100	0
		1000			
26	4	178.6	17.86	17.86	82.14
	10	215	21.5	39.36	60.64
	20	205.4	20.54	59.9	40.1
	40	168.5	16.85	76.75	23.25
	80	149.6	14.96	91.71	8.29
	140	35.6	3.56	95.27	4.73
	230	29	2.9	98.17	1.83
	Pan	18.3	1.83	100	0
		1000			
27	4	297.4	29.74	29.74	70.26
	10	224	22.4	52.14	47.86
	20	196.2	19.62	71.76	28.24
	40	125.7	12.57	84.33	15.67
	80	98.1	9.81	94.14	5.86
	140	29.1	2.91	97.05	2.95
	230	18.5	1.85	98.9	1.1
	Pan	11	1.1	100	0
		1000			
28	4	168.1	16.81	16.81	83.19
	10	210.6	21.06	37.87	62.13
	20	214.3	21.43	59.3	40.7
	40	157.2	15.72	75.02	24.98
	80	155.8	15.58	90.6	9.4
	140	51.4	5.14	80.16	19.84
	230	28.6	2.86	98.6	1.4
	Pan	14	1.4	100	0
		1000			
29	4	155.1	15.51	15.51	84.49

Point #	Sieve Number	Weight (g)	Percent Of Weight %	Percent Of Cum	Total Pass %
	10	201.2	20.12	35.63	64.37
	20	247.1	24.71	60.34	39.66
	40	177.1	17.71	78.05	21.95
	80	150.9	15.09	93.14	6.86
	140	39.2	3.92	97.06	2.94
	230	20.9	2.09	99.15	0.85
	Pan	8.5	0.85	100	0
		1000			
30	4	131.8	13.18	13.18	86.82
	10	177.5	17.75	30.93	69.07
	20	254	25.4	56.33	43.67
	40	206.4	20.64	76.97	23.03
	80	158.9	15.89	92.86	7.14
	140	37.4	3.74	96.6	3.4
	230	28.8	2.88	99.48	0.52
	Pan	5.2	0.52	100	0
		1000			
31	4	252.2	25.22	25.22	74.78
	10	218.6	21.86	47.08	52.92
	20	224.9	22.49	69.57	30.43
	40	155	15.5	85.07	14.93
	80	72.7	7.27	92.34	7.66
	140	50.6	5.06	97.4	2.6
	230	12.3	1.23	98.63	1.37
	Pan	13.7	1.37	100	0
		1000			
32	4	267.7	26.77	26.77	73.23
	10	269.8	26.98	53.75	46.25
	20	248.2	24.82	78.57	21.43
	40	123.1	12.31	90.88	9.12
	80	59.6	5.96	96.84	3.16
	140	14.3	1.43	98.27	1.73
	230	9	0.9	99.17	0.83
	Pan	8.3	0.83	100	0
		1000			
33	4	115	11.5	11.5	88.5
	10	226.4	22.64	34.14	65.86
	20	251.1	25.11	59.25	40.75
	40	176.2	17.62	76.87	23.13
	80	151.1	15.11	91.98	8.02
	140	41.4	4.14	96.12	3.88
	230	26.8	2.68	98.8	1.2
	Pan	12	1.2	100	0
		1000			
34	4	272.6	27.26	27.26	72.74
	10	208.7	20.87	48.13	51.87
	20	202.7	20.27	68.4	31.6
	40	142.6	14.26	82.66	17.34
	80	118.9	11.89	94.55	5.45
	140	22.3	2.23	96.78	3.22

Point #	Sieve Number	Weight (g)	Percent Of Weight %	Present Of Cum	Total Pass %
	230	18.9	1.89	98.67	1.33
	Pan	13.3	1.33	100	0
		1000			
35	4	212.7	21.27	21.27	78.73
	10	134.6	13.46	34.73	65.27
	20	158.9	15.89	50.62	49.38
	40	127.3	12.73	63.35	36.65
	80	161.6	16.16	79.51	20.49
	140	103.1	10.31	89.82	10.18
	230	70.5	7.05	96.87	3.13
	Pan	31.3	3.13	100	0
36	4	179.5	17.95	17.95	82.05
	10	164.3	16.43	34.38	65.62
	20	236.7	23.67	58.05	41.95
	40	170.2	17.02	75.07	24.93
	80	190.7	19.07	94.14	5.86
	140	30.5	3.05	97.19	2.81
	230	16.4	1.64	98.83	1.17
	Pan	11.7	1.17	100	0
		1000			
37	4	156.5	15.65	15.65	84.35
	10	221.5	22.15	37.8	62.2
	20	234.2	23.42	61.22	38.78
	40	167.5	16.75	77.97	22.03
	80	134.3	13.43	91.4	8.6
	140	41.2	4.12	95.52	4.48
	230	26.6	2.66	98.18	1.82
	Pan	18.2	1.82	100	0
		1000			
38	4	207.9	20.79	20.79	79.21
	10	242.2	24.22	45.01	54.99
	20	248.8	24.88	69.89	30.11
	40	168.5	16.85	86.74	13.26
	80	93.4	9.34	96.08	3.92
	140	18.5	1.85	97.93	2.07
	230	8.8	0.88	98.81	1.19
	Pan	11.9	1.19	100	0
		1000			
39	4	317.4	31.74	31.74	68.26
	10	228.4	22.84	54.58	45.42
	20	214.9	21.49	76.07	23.93
	40	136.5	13.65	89.72	10.28
	80	64.7	6.47	96.19	3.81
	140	17.5	1.75	97.94	2.06
	230	11.3	1.13	99.07	0.93
	Pan	9.3	0.93	100	0
		1000			
40	4	331.3	33.13	33.13	66.87
	10	222.4	22.24	55.37	44.63
	20	212.2	21.22	76.59	23.41

Point #	Sieve Number	Weight (g)	Percent Of Weight %	Percent Of Cum	Total Pass %
	40	126.7	12.67	89.26	10.74
	80	71.9	7.19	96.45	3.55
	140	15.6	1.56	98.01	1.99
	230	9.4	0.94	98.95	1.05
	Pan	10.5	1.05	100	0
		1000			
41	4	297	29.7	29.7	70.3
	10	210.4	21.04	50.74	49.26
	20	174.7	17.47	68.21	31.79
	40	116.4	11.64	79.85	20.15
	80	151.7	15.17	95.02	4.98
	140	24.1	2.41	97.43	2.57
	230	16.8	1.68	99.11	0.89
	Pan	8.9	0.89	100	0
		1000			
42	4	345.3	34.53	34.53	65.47
	10	281.2	28.12	62.65	37.35
	20	124.2	12.42	75.07	24.93
	40	115.3	11.53	86.6	13.4
	80	67.2	6.72	93.32	6.68
	140	18.6	1.86	95.18	4.82
	230	21.1	2.11	97.29	2.71
	Pan	27.1	2.71	100	0
		1000			

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