Term Paper

Remote Sensing's impact on GIS: Soil Erosion Hazard Modelling

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Table content

Abstract

Remote sensing and geographic information systems (GIS) are being increasly used in various disciplines. Remote sensing can provide near-real time information about different feature of earth surfaces .Therefore, this term paper focused on modern remote sensing techniques that have positive impact on GIS system. The remote sensing technique / principle and some application which we believe it is useful for the GIS users any where in the world have been identified. Also, in this paper the case study shown GIS, by using satellite (IRS-1A LISS I) remote sensor, as an aid to soil erosion hazard assessment

1- Introduction:

Remote sensing affords us the capability to see the invisible. From remote sensing's aerial or space point we can obtain synoptic view of earth recourses. However, we should know that the successful application of remote sensing is based on integration of multiple, interrelated data and analysis procedure. So, all design of successful remote sensing efforts involve at minimum: 1.Clear definition of the problem should be at hand. 2. Potential for addressing the problem with remote sensing techniques should be evaluated. 3. The remote sensing data acquisition procedures appropriate to the task should be identified. 4. Determination of data acquisition procedures to be employed and the reference data needed. 5. Identification of criteria by which the quality of the information collected can be judged.

By incorporating remote sensing data in to a GIS, remote sensing and GIS technologies were initially developed for different purposes. However, both of the theses sources can provide information about earth's recourses. Now, it possible for data from these sources to be easily integrated by advanced computer's hardware and software technology.

Most GIS software packages allow remotely sensed data to be imported or at least viewed within the software application. This ability allows the analyst to overlay remote sensing data layers with other spatial data layers. Analysts use remotely sensed imagery with GIS data sets for a variety of reasons including providing continuous regional view of the areas and extracting GIS data layers . So, there is considerable potential for the use of GIS technology as an aid to soil erosion hazard assessment

In case study, inventory on soil erosion hazard is vital for effective soil conservation plans of a watershed for sustainable development. The potential utility of remotely sends data in the forms of aerial photographs and satellite sensors data have been well recognized, in mapping and assessing landscape attributes controlling soil erosion, such as physiography, soils, landuse/ land cover, relief, soil erosion pattern

2 - Objectives:

This term paper was prepared with objective to understand what is remote sensing technique and types. Also, to understand the ideal remote sensing terms and discuss an application of remote sensing's which is shown how it positively effects on GIS data management.

Moreover, the case study was undertaken with the objective to assess and map soil erosion hazard following GIS scalogram modelling approach using satellite remote sensing derived physiography- soil and land cover and DEM derived slope maps and ancillary data of soil characteristics and rainfall as inputs.

3- Remote sensing:

A- Definition: Remote Sensing (RS) is the science and art of acquiring information (spectral, spatial, and temporal) about material objects, area, or phenomenon, without coming into physical contact with the objects, or area, or phenomenon under investigation. Without direct contact, some means of transferring information through space must be utilized.

B-How does it function? In remote sensing, information transfer is accomplished by use of electromagnetic radiation (EMR). EMR is a form of energy that reveals its presence by the observable effects it produces when it strikes the matter. EMR is considered to span the spectrum of wavelengths from 10-10 mm to cosmic rays up to 1010 mm, the broadcast wavelengths, which extend from 0.30-15mm (see figure 1).

C- Bands Used in Remote Sensing

A known that gas Atoms consist of a positively charged nucleus surrounded by orbiting electrons, which have discrete energy states. Transition of electrons from one energy state to the other leads to emission of radiation at discrete wavelengths. The resulting spectrum is called line spectrum. Molecules possess rotational and vibrational energy states. Transition between which leads to emission of radiation in a band spectrum. The wavelengths, which are emitted by atoms/molecules, are also the ones, which are absorbed by them.

Emission from solids and liquids occurs when they are heated and results in a continuous spectrum. This is called thermal emission and it is an important source of EMR from the viewpoint of remote sensing.

The Electro-Magnetic Radiation (EMR), which is reflected or emitted from an object, is the usual source of Remote Sensing data. However, any medium, such as gravity or magnetic fields, can be used in remote sensing.

Remote Sensing Technology makes use of the wide range Electro-Magnetic Spectrum (EMS) from a very short wave "Gamma Ray" to a very long 'Radio Wave'.

Wavelength regions of electro-magnetic radiation have different names ranging from Gamma ray, X-ray, Ultraviolet (UV), Visible light, Infrared (IR) to Radio

Wave, in order from the shorter wavelengths.

The optical wavelength region, an important region for remote sensing applications, is further subdivided as follows (see table 1).

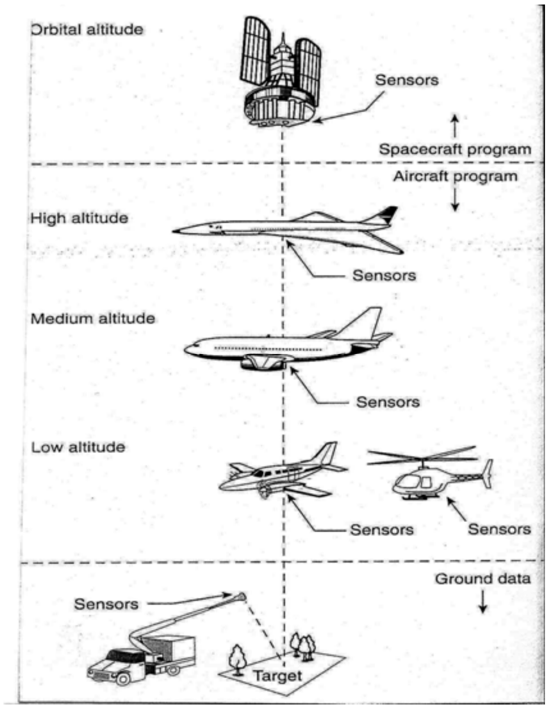

Figure 1

Name	Wavelength (mm)
Optical wavelength	0.30-15.0
Reflective portion	0.38-3.00
(i) Visible	0.38-0.72
(ii) Near IR	0.72-1.30
(iii) Middle IR	1.30-3.00
Far IR (Thermal, Emissive)	7.00-15.0

Table 1 wavelength

- Microwave region (1mm to 1m) is another portion of EM spectrum that is frequently used to gather valuable remote sensing information.

4 - Energy Interactions in Satellite Imagery

All substance is composed of atoms and molecules with particular compositions. Therefore, matter will emit or absorb electro-magnetic radiation on a particular wavelength with respect to the inner state. All substance reflects, absorbs, penetrates and emits Electro-magnetic radiation in a unique way (see figure 2). Electro-magnetic radiation through the atmosphere to and from matters on the earth's surface are reflected, scattered, diffracted, refracted, absorbed, transmitted and dispersed. For example, the reason why a leaf looks green is that the chlorophyll absorbs blue and red spectra and reflects the green. The unique characteristics of matter are called spectral characteristics.

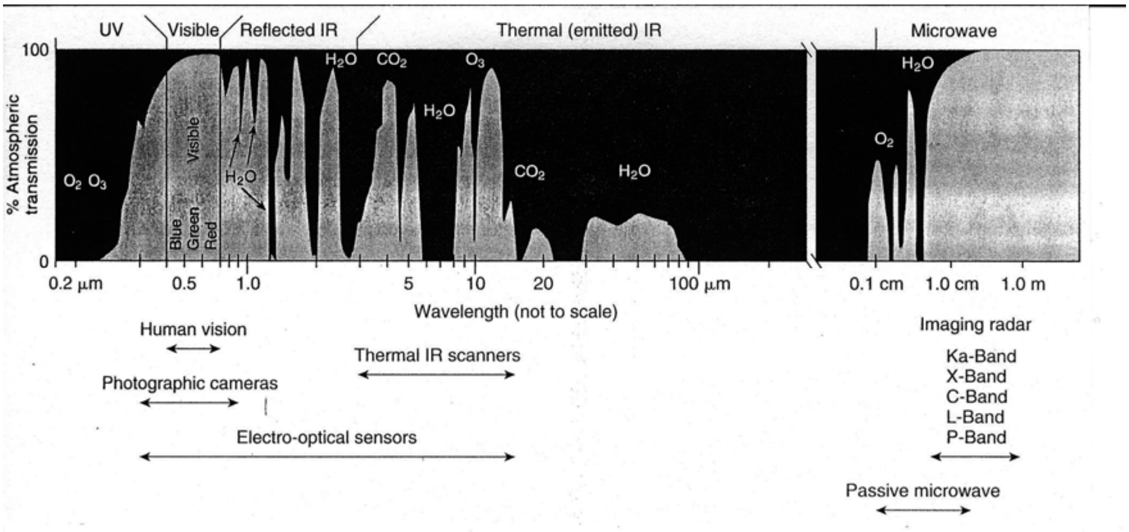

Figure 2 Atmosphere Transmission Vs Wavelength

When electro-magnetic energy is incident on any given earth surface feature, three fundamental energy interactions with the feature are possible (see figure 3).

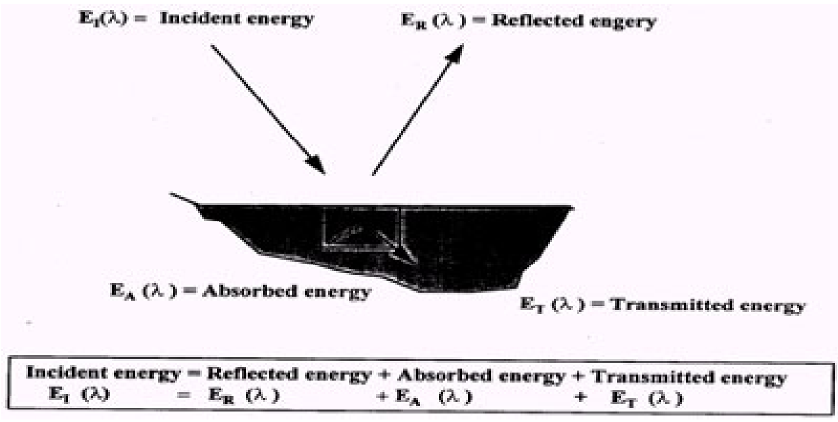

Figure 3 Energy Interactions

Two points about the above given relationship (expressed in the form of equation) should be noted.

- The proportions of energy reflected, absorbed, and transmitted will vary for different earth features, depending upon their material type and conditions. These differences permit us to distinguish different features on an image.
- The wavelength dependency means that, even within a given feature type, the proportion of reflected, absorbed, and transmitted energy will vary at different wavelengths.

Thus, two features may be distinguishable in one spectral range and be very different on another wavelength brand. Within the visible portion of the spectrum, these spectral variations result in the visual effect called COLOUR. For example we call blue objects 'blue' when they reflect highly in the 'green' spectral region, and so on. Thus the eye uses spectral variations in the magnitude of reflected energy to discriminate between various objects.

A graph of the spectral reflectance of an object as a function of wavelength is called a spectral reflectance curve.

The lines in this figure4 represent average reflectance curves compiled by measuring large sample features. It should be noted how distinctive the curves are for each feature. In general, the configuration of these curves is an indicator of the type and condition of the features to which they apply. Although the reflectance of individual features will vary considerably above and below the average, these curves demonstrate some fundamental points concerning spectral reflectance.

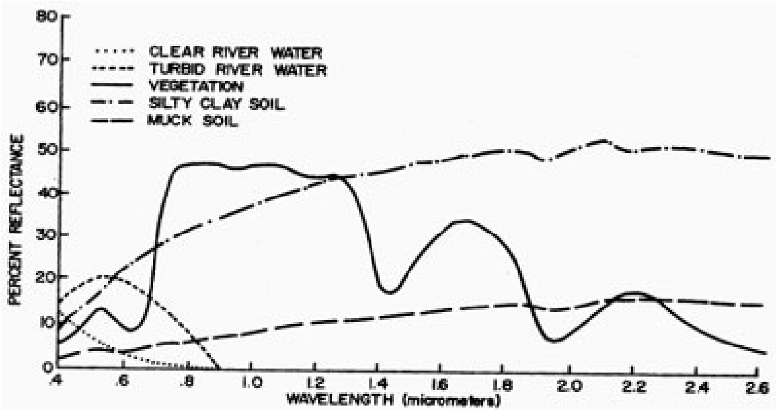

Figure 4 REFLECTION Vs WAVELENGTH

Band	**Wavelength (mm)**	**Principal applications**
1	0.45-0.52	Sensitive to sedimentation, deciduous/ coniferous forest cover discrimination, soil vegetation differentiation
2	0.52-0.59	Green reflectance by healthy vegetation, vegetation vigour, rock-soil discrimination, turbidity and bathymetry in shallow waters
3	0.62-0.68	Sensitive to chlorophyll absorption: plant species discrimination, differentiation of soil and geological boundary
4	0.77-0.86	Sensitive to green biomass and moisture in vegetation, land and water contrast, landform/ geomorphic studies.

5- **Types of Remote Sensing**

A - Based on the type of Energy Resources, we have two types of sensors:

- Passive Remote Sensing: Makes use of sensors that detect the reflected or emitted electro-magnetic radiation from natural sources.

- Active Remote Sensing: Makes use of sensors that detect reflected responses from objects that are irradiated from artificially-generated energy sources, such as radar.

B- Based on the Wavelength Regions

Remote Sensing is classified into three types in respect to the wavelength regions

- Visible and Reflective Infrared Remote Sensing
- Thermal Infrared Remote Sensing
- Microwave Remote Sensing

C- Remote Sensing Satellites

A satellite with remote sensors to observe the earth is called a remote-sensing satellite, or earth observation satellite. Remote-Sensing Satellites are characterized by their altitude, orbit and sensor.

IRS(Indian Remote Sensing Satellite); India has launched several satellite includes IRS 1A, IRS 1B, IRS 1C, IRS 1D, IRS P 2,IRS P 3, IRS P 4 for different applications.

Landsat ; It is established at an altitude of 700 kms is a polar orbit and is used mainly for land area observation.

Other remote sensing satellite series in operations are: SPOT, MOS, JERS, ESR, RADARSAT, IKONOS etc

6- AN IDEAL REMOTE SENSING SYSTEM

The basic components of an ideal remote sensing system are shown these include the following:

1. A uniform energy source.

This source would provide energy over all wave-lengths, at a constant, known, high level of output, irrespective of time and place.

2. A non-interfering atmosphere.

This would be an atmosphere that would not modify the energy from the source in any manner, whether that energy were on its way to the earth's surface or coming from it. Again, ideally, this would hold irrespective of wavelength, time, place, and sensing altitude involved.

3. A series of unique energy/matter interactions at the earth's surface.

These interactions would generate reflected and/or emitted signals that not only are selective with respect to wavelength, but also are known, invariant, and unique to each and every earth surface feature type and subtype of interest.

4. A super sensor.

This would be a sensor, highly sensitive to all wavelengths, yielding spatially detailed data on the absolute brightness (or radiance) from a scene as a function of wavelength, throughout the spectrum. This super sensor would be simple and reliable, require virtually no power or space, and be accurate and economical to operate.

5. A real-time data handling system.

In this system, the instant the radiance versus wavelength response over a terrain element were generated, it would be processed into an interpretable format and recognized as being unique to the particular terrain element from which it came. This processing would be performed nearly instantaneously ("real time"), providing timely information. Because of the consistent nature of the energy/matter interactions, there would be no need for reference data in the analysis procedure. The derived data would provide insight into the physical-chemical-biological state of each feature of interest.

6. Multiple data users.

These people would have knowledge of great depth, both of their respective disciplines and of remote sensing data acquisition and analysis techniques. The same set of "data" would become various forms of "information" for different users, because of their wealth of knowledge about the particular earth resources being sensed. This information would be available to them faster, at less expense, and over larger areas than information collected in any other manner. With this information, the various users would make profound, wise decisions about how best to manage the earth resources under scrutiny and these management decisions would be implemented – everyone's delight!

Unfortunately, an ideal remote sensing system as described above does not exist. Real remote sensing systems fall far short of the ideal at virtually every point in the sequence outlined.

7- Case study:

North of India, there are many factors effect on soil such as rain, terrain and etc. All these factors contribute to soil erosion. For that, GIS system has been used as aid to classify the soil erosion hazard based on data received from remote sensor.

8 - Study Area and tools of study

The study area constitutes Doon Valley of dehradun district Uttar Pradesh and lies between 77 35' to 78 19' E longitudes and 29 57' 30' to 30 30' 00' N latitudes approximately. It has sub-tropical climate with mean annual rainfall varying from 1600 mm (hills and piedmont plains area) TO 2000 TO 2200 mm (mountainous areas) and mean annual temperature of 24 c. the soil moisture and temperature regimes are characterized by udic and Hypeerthermic and Thermic (in mountains),respectively.

The various types of data used in this study are: multi-temporal satellite (IRS-1A LISS I) FCCS; Survey of India Topographical maps (1:250,000 and 1:50,000scales), agro meteorological data of rainfall and air temperature recorded at meteorological stations and field soil and land use surveys and laboratory analyzed soil data of organic matter soil texture of soil samples collected from soil scape units of the area.

9- Methodology:

The various steps of the methodology adopted in this study:

1. preparation of small scale hypsography- soil map: this was accomplished by visual interpretation of multi-temporal FCCS of IRS- LISS-I based on image elements supplemented with terrain information on hypsography landuse, drainage pattern et.

2. Preparation of landuse / land cover map: landuse/ land cover map with level -I and level-II land cover classes of the area was prepared by visual analysis of satellite FCCs based on image characteristics supplemented with judicious field check.

3. Generation of terrain slops map: the terrain slope map was created from DEM (Digital Elevation Model) following elevation matrix filtering technique and reclassification
4. Creation of digital data based of thematic maps: The digital data bases of physiography soils and land cover were created by digirtizing these maps.
5. Creation of soil erosion hazard factors data bases : Soil erosivity and soil depth erosivity factors map layers were generated by linking attributes data of soil Erodibillty factor and soil depth soil mapping units digital soil map data ------and reclassification using GIS.
6. Soil erosion hazard assessment and mapping: Soil Erosion Hazard Index (EHI) was computed by integration of soil erosivity factors layers using spatial modeling module of ILWIS GIS package,. Finally, soil erosion hazard map was generated by reclassification of EHI map using GIS.

10 - Discussion:

- Soils, soils and soil depth erosivity; Ten soilscape units representing Himalya mountain siwealik hills piedmont plains and terrace are delineated and mapped in the study area using satellite data. Broadly at order level the Entisols Inceptisols, Mollisols and Alfisols soils ae found in different soilscape units of the area ranged from 0.32 to 0.45. fine textured soils (fine loamy coarse loamy /Fine loamy) high (3,k= 0.40 to 0.45) soil erosivity (fig. 1 (b). Upper piedmonts plains and mountains and hills have medium (2 k= 0.35 to 0.45) and low (1.k = 0.33 to 0.35 soil erosivity respectively because of dominance of coarse textured soils (coarse loamy: :Loamy skeletal/ coarse loamy) (Fig 5 (b)).

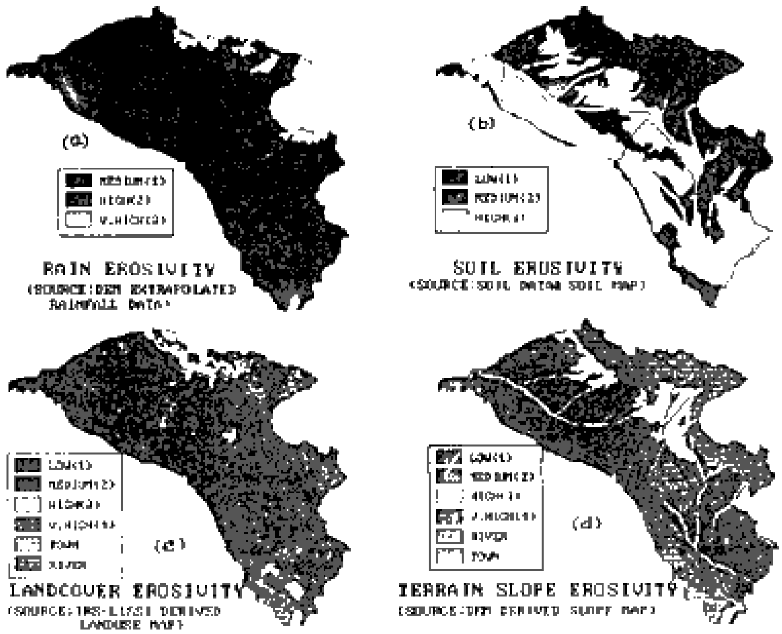

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Figure 5 Erosion Hazard Factors (Doom Valley, Dehradun)

- Landuse/land cover and erosivity : The various landuse/ land cover types identified and mapped using satellite are: Low intensity and high intensity culotivated lands dense forest degraded forest open forest and barren / open scrub. Dense forest and high intensity cultivated lands have low (1) erosivity because of soil erosion protecting good canopy cover. Degraded forestry and low intensity cultivated land have medium erosivity (2) and very high (4) erosivity, respectively (Fig. 5 (c)) becausse these lands are prone to high soil erosion.
- Rain and terrain slope erosivity : The study area consists of three distinct zones of rain erosivity - very high (3, rainfall : 2000 to 2200 mm); high (2 rainfall : 1800 mm) to 2000 mm) and medium (1, rainfall : 1600 mm to 1800mm)(Fig 5 (a)). Mountain region of the area is under high to very high rain erosivity because of higher rainfall. DEM derived terrain slope

erosivity map (Fig 6. (d) indicates that the area has four classes of slope erosivity : Low (1 slope : 1-2 % & 2-4%) medium (2, slope: 5-10%) high (3 slope: 10-15% and very high (4 slope: >25).

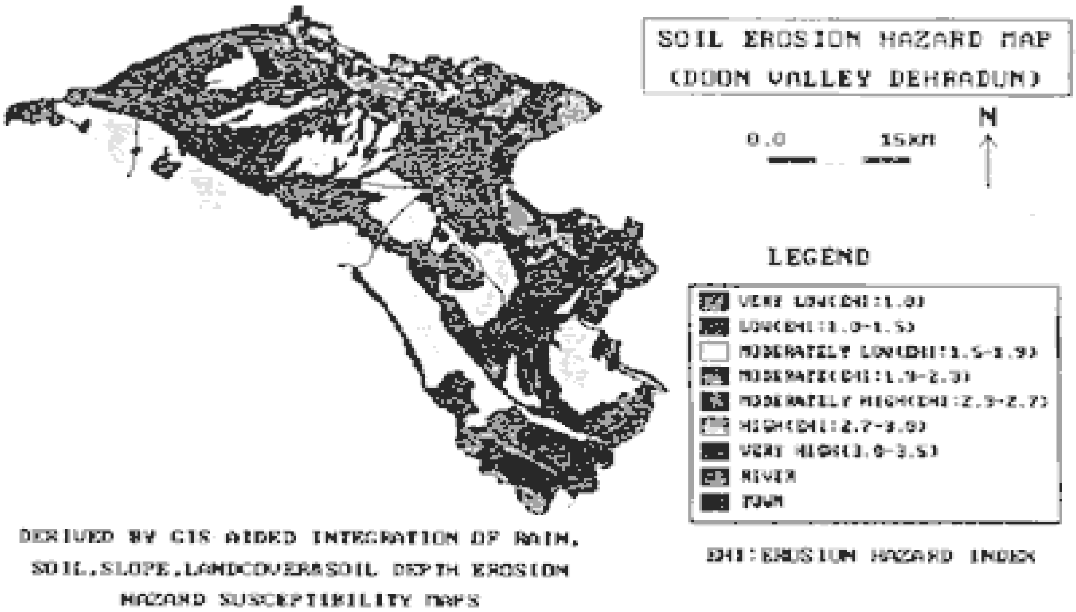

Figure 6 Soil Erosion Hazard Map (Doon Valley Dehradun)

- Soil erosion hazard assessment : GIS based the scalogram modeling approach resulted in sefen soil erosion hazard classes in the study area (Fig6.) with numerical scores of Erosion hazard Indes (EHI) ranging between I (very low hazard) to 3.5 9very high hard). The data pertaining to Fig.2 indicate that in the study area 23.1%,28.6%, 29.5%, 7.1%,5.1% areas have been found under very low to low: moderately low, moderate to moderately high and very high soil erosion hazard classes, respectively.

The present study indicate that soilscapes belonging to moderately high , high and very high soil erosion hazard categories are critical from the point of view of soil erosion control. These areas are extremely denuded by frequent landslides , excessive exploitation of forest cover on the steep to very steep slopes. The control measures for these areas consists of forestation for restoration of vegetative cover; control of landslides by suitable engineering and vegetative measures; gully plugs and check dams to control run off. The moderate erosion hazard areas are mostly under low intensity cultivation and degraded forest land. The soil erosion of these areas can be controlled by improvement of bounding and terrace, improved agrounomic practices and forest management.

11- Conclusion:

In this term paper demonstrate the remote sensor technically and identified their types .Also, this study demonstrates that satellite remote sensing and GIS techniques are indeed valuable tools in assessment and mapping of soil erosion hazard following scalogram modeling approach by integration of soil erosion controlling soilscape terrain and climatic parameters.
Moreover, every one convinced that GIS system is more important since it is applied to many fields that related to development.

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