# CHAPTER IV

# ANALYSIS

## 4.1. Integrating Data and Data Management

The role of integrated strategy in project task, involving remote sensing such as landsat TM, ASTER, geology, and topographical data are being increasingly appreciated. Broadly, the data includes storage, retrieval of all types of data at a particular geographic location. The mainly segments are input, management, processing and output.

### 4.1.1. Topographic data

Topographical data (1:50,000 scale map) constitutes the primary information. Usually, topographical map forms the basic on which other types of geodata are registered to develop a GIS . Data on elevation, slope, aspect ( ie. Slope direction), DEM (3 D modeling) also form point data , linear data or areal data for GIS interpretation. Other data are map server, web and literature (eg. Reports, maps, articles, books etc) read references page.

### 4.1.2. Remote sensing data

Landsat TM and ASTER image are the most important input data sources in this paper. The various methods of spectral data acquisition (VNIR, SWIR, TIR) have been used. Multi spectral data are acquired using spectral signature pattern of minerals, rock units. The ASTER Digital Elevation Model is a product that is generated from a pair of ASTER Level 1A images. This Level 1A input includes bands 3N ( nadir) and 3B (aft-viewing) from the Visible Near Infra-Red telescope's along-track stereo data. All of these data are stored together with metadata in one HDF file.

### 4.1.3. Geological data

Geological map of Burma and geological map of Thailand ( Department of Mineral Resources) are important type of data. There can be in the form of lithology or structure description (bedding, faults, and lineaments, etc) at point or in the form of map

### 4.1.4. Metadata

(i) ASTER data
Short Name : AST3A01
Granule ID : AST3A1 0302100407380305100997
Processing Level : 3
Acquisition Date : 20030210
Processing Date Time : "2003-05-10T18:04:16.000Z"
Source Data Product : ASTL1A 0302100407380303070454
Observation Mode : VNIR1-ON, VNIR2-ON, SWIR-ON, TIR-ON
Scene ID : [131, 134, 1]
Scene Center : 18.331977, 97.488710
Scene Upper Left : 18.651178, 97.122344

Scene Upper Right : 18.657009, 97.844797
Scene Lower Right : 18.012155, 97.849071
Scene Lower Left : 18.006540, 97.129290
Orbit No. : 16744
Flying Direction : "DE"
Solar Direction : 142.606585, 49.303226
Pointing Angle : VNIR=-8.580000, SWIR=-8.553000, TIR=-8.557000
Path, Row, Swath : 131, 134, 1
Cloud Coverage : 0
MapProjectionName : "Universal Transverse Mercator"
Spatial Resolution : (15, 30, 90)
EllipsoidandDatum1 : ("WGS84", "WGS84")
DatumPara1 : (6378137.000000, 298.257220, 0.000000, 0.000000, 0.000000)
MPMethod1 : "UTM"
UTMZoneCode1 : 47
SpacingSize1 : 15
PixelSpacing1 : (15.000000, 15.000000)
SWIR
SpacingSize4 : 30
PixelSpacing4 : (30.000000, 30.000000)
Incl : 0.217400
>>>>>>TIR
TIR10
SpacingSize10 : 90
Unit10 : "M"
PixelSpacing10 : (90.000000, 90.000000)
>>>>>>DEMZ
ImageDataInformationV : (5082, 4758, 2)
ImageDataInformationS : (2541, 2379, 2)
ImageDataInformationT : (847, 793, 2)
EllipsoidandDatumV : ("WGS84", "WGS84")
DatumParaV : (6378137.000000, 298.257220, 0.000000, 0.000000, 0.000000)
SpacingSizeV : 15
SpacingSizeS : 30
SpacingSizeT : 90



(ii). Landsat TM data

Commonly referred to as metadata gives information on the contents of the dataset. This information allows users to establish the existence of a dataset and facilitate data access. There are metadata such as file name, file creation date, file creator, origin of the data, project name, description, method of conversion, software information, data type (coverage, image, grid), projection information ( Universal Transverse Mercator, WGS 84, Zone number), associated files and data status were specified in each geographic layer.

DATA_SET_TYPE=EDC_TM;
PRODUCT_NUMBER=01400083100100018;
PIXEL_FORMAT=BYTE;
BITS_PER_PIXEL=8;
PIXELS_PER_LINE=6895;
LINES_PER_DATA_FILE=5984;
DATA_ORIENTATION=UPPER_LEFT/RIGHT;
NUMBER_OF_DATA_FILES=7;
DATA_FILE_INTERLEAVING=BSQ;
START_LINE_NUMBER=1;
RECORD_SIZE=6895;
UPPER_LEFT_CORNER=0961540.7794E,0194046.4483N,17931444.284,190197.943;
UPPER_RIGHT_CORNER=0980642.5153E,0192437.0565N,17944416.738,386248.223;
LOWER_RIGHT_CORNER=0975134.1515E,0175319.9034N,18114560.172,374989.99
9;
LOWER_LEFT_CORNER=0960130.6235E,0180920.7876N,18101587.718,178939.719;
REFERENCE_POINT=SCENE_CENTER;
REFERENCE_POSITION=0970352.6643E,0184709.4346N,18023002.228,282593.975,
3448.00,2992.50;
REFERENCE_OFFSET=69.93,-0.39;
ORIENTATION=-86.214313;
MAP_PROJECTION_NAME=SPACE_OBLIQUE_MERC;
USGS_PROJECTION_NUMBER=22;
HORIZONTAL_DATUM=WGS84;
EARTH_ELLIPSOID_SEMI-MAJOR_AXIS=6378137.000;
EARTH_ELLIPSOID_SEMI-MINOR_AXIS=6356752.314;
EARTH_ELLIPSOID_ORIGIN_OFFSET=0.000,0.000,0.000;
EARTH_ELLIPSOID_ROTATION_OFFSET=0.000000,0.000000,0.000000;
PIXEL_SPACING=28.5000,28.5000;
PIXEL_SPACING_UNITS=METERS;
RESAMPLING=CC;
PROCESSING_DATE/TIME=2000-09-05T15:14:04;
NUMBER_OF_BANDS_IN_VOLUME=7;
WRS=132/047;
ACQUISITION_DATE/TIME=1989-02-10T03:27:53Z;
SATELLITE_INSTRUMENT=TM;
SUN_ELEVATION=43.05;
SUN_AZIMUTH=133.01;
BAND1_WAVELENGTHS=0.45,0.52;
BAND1_RADIOMETRIC_GAINS/BIAS=0.6024314,-1.5200000;
BAND2_WAVELENGTHS=0.52,0.60;
BAND2_RADIOMETRIC_GAINS/BIAS=1.1750981,-2.8399999;
BAND3_WAVELENGTHS=0.63,0.69;
BAND3_RADIOMETRIC_GAINS/BIAS=0.8057647,-1.1700000;
BAND4_WAVELENGTHS=0.76,0.90;
BAND4_RADIOMETRIC_GAINS/BIAS=0.8145490,-1.5100000;

```
BAND5_WAVELENGTHS=1.55,1.75;
BAND5_RADIOMETRIC_GAINS/BIAS=0.1080784,-0.3700000;
BAND6_WAVELENGTHS=10.40,12.50;
BAND6_RADIOMETRIC_GAINS/BIAS=0.0551584,1.2377996;
BAND7_WAVELENGTHS=2.08,2.35;
BAND7_RADIOMETRIC_GAINS/BIAS=0.0569804,-0.1500000;
END_OF_HDR;
```

| Layer | Source data | Scale | Data type |
|---|---|---|---|
| Landsat TM | Landsat TM | 30 | Image |
| ASTER | ASTER | 15, 30,90 | Image |
| Contour line | Topographic map | 1: 50,000 | coverage |
| Stream/River | Topographic map | 1: 50,000 | coverage |
| Road | Topographic map | 1: 50,000 | coverage |
| DEM | Topographic map, ASTER | 1: 50,000 | Grid, multispectral |
| Slope | DEM | 1: 50,000 | Grid |
| Aspect | DEM | 1: 50,000 | Grid |
| Lithology | Geological map | 1:500,000&20000,000 | coverage |
| Fault /lineament | Geological map | 1:500,000&20000,000 | coverage |

Table-4.1.Constructed GIS layers in study area.

| Thematic data | Data layers | Spatial elements | Non-spatial elements |
|---|---|---|---|
| Geology | rock unit | polygon | formation ID<br>formation name<br>group ID / name<br>lithology ,age |
| | structure | line/point | Structure ID<br>Structure group<br>Structure type |
| Geography | contour | line/point | contour ID<br>contour type<br>elevation value |
| | Drainage (stream, river) | line | Stream /river ID<br>Stream/river name<br>Stream/river name |

Table -4.2. Spatial and non-spatial elements of GIS data layers in the study area

| Field name | width | Field type |
|---|---|---|
| code | 6 | string |
| Rock formation | 100 | string |
| Description | 100 | string |
| Age | 33 | string |

Table -4.3.Additionnal field properties in the lithologic unit

## 4.2. Digital Elevation Modelling ,Data Sources and Structures

There are two main classes of source topographic data such as topographic map $A_0$ size (1:50,000 scale, Edition 2-RTSD series L7017) , and ASTER image VNIR band 3Nand 3B.They consists of contour value. Digital Elevation Modeling (DEM) consist of a sampled array of elevations for a number of ground positions at regularly spaced intervals. These are still the most common terrain data source for larger areas and the conversion of contour maps to digital form is a major activity of mapping. Contours can also be generated automatically from photogrammetric stereo models, although these methods may be subject to error due to variations in surface cover and the paucity of contour lines in areas of low relief.

One of the most significant datasets used in this work is the Digital Elevation Model (DEM) of the area. The DEM of the test area was created using appropriate vector data (contour lines, elevation spots, river channels) and specialized procedures in the framework of the GIS used. Alternatively the DEM can be created by proper satellite data. A number of secondary geographical variables, which are very significant in morphometric analysis, were derived from the DEM. These variables are related to elevation measurements, slope, volumetric computations, and curvature.

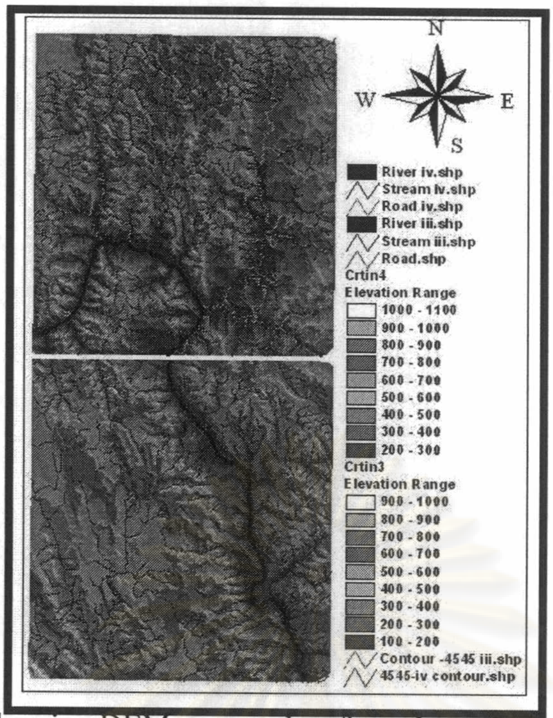



Figure-4.1. Showing DEM source data from the topographic map.

River morphometry is estimated through special computational procedures using mainly the DEM of the deltaic protrusion and the delta geometry. The DEM which is the main digital model used for the computations is created by using the internal GIS functionality of the prototype.

4.2.1.Topographic DEM

Topographic map of the area was obtained and retification points were changed so that points coincided with the 100m contour lines on this map (see Figure-4.1 ). Errors in the stereo matching were reduced to acceptable levels. In this sense the DEM distinguishes principally from the contour lines of a map. A contour line gives only a height information of the line element . The image of the contour lines should allow to get an impression of the morphology of the terrain. Smooth terrain will show smooth lines, rough terrain will give heavily undulating lines. Additionally the contour lines should represent small geomorphologic features by their typical forms and the family effect. This requires occasionally an exaggeration of certain terrain forms. Consequently contour lines are meant especially for the visualisation of the terrain, whereas the data for a DEM are intended to give a height information of the complete terrain in a computer readable form. DEM derived from contour lines of data set .

The contour lines are preferably digitized by scanning. The pixel maps are converted in vector format by automatic or manual line are stored in attribute table and shape file. Additionally the height of the contours is introduced. The digitizing process should be controlled be plotting the digitized contours and by comparing with the original contours.

4.2.2. Processing of ASTER DEM

We need the band 3N and 3B of VNIR for a pure DEM . Band 3n can be created a colour image , DEM and orthoimage generation. Band 3b can be created by ENVI.4 DEM generation. During the DEM generation process an option is available to get a score value for each pixel and this is the degree of correlation between the 3N and 3B images in a range of 0 to 255. ASTER DEM offers a very respectable 30m resolution. The image is approximately covering an area of about 60 square kilometers (see figure – 4.2). The elevation accuracy of ASTER DEM is about 15m (3N and 3B) that is consistent with the instrument system parameters.

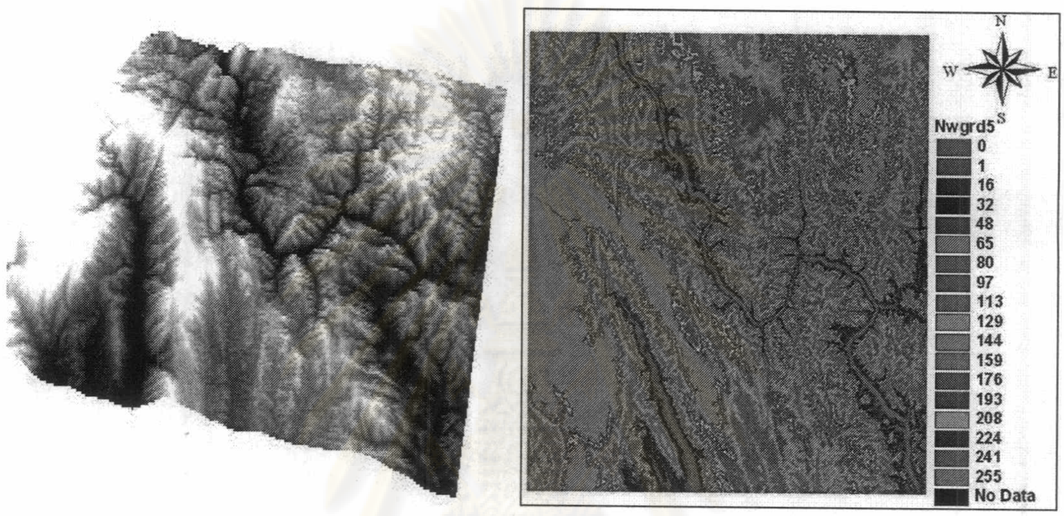



Figure-4.2. Image showing the DEM (a) ASTER DEM and (b) Grid DEM source from ASTER 3B and 3N band.

4.2.3. Creating Hill Shading

Creating a Hill Shade image from ASTER image provides data fusion by adding topographic information to our image. The value band is replaced with a shaded relief image that was calculated from the DEM using the input sun angles, sun azimuth angle and the color image is transformed back to RGB space.

Hillshading is variation in tone from light to dark to delineate the form of the land. The shading should be used to suggest the surface material, such as topography or geomorphology. Map can be automated through the use of grey scales and continuous tone.

Contour lines and hillshading are often used together because they complement eachother. Hillshading gives an overall impression of the terrain but without mathematical accuracy. While contours give heights mathematically, but have information gaps. There demonstrate the skill of visualizing terrain from contours by imagining statues (See Figure-4.3 ) . The level of detail used to produce a hillshaded image should be more detailed than the level of detail needed to produce contour lines because shading should reveal the terrain between contour lines.

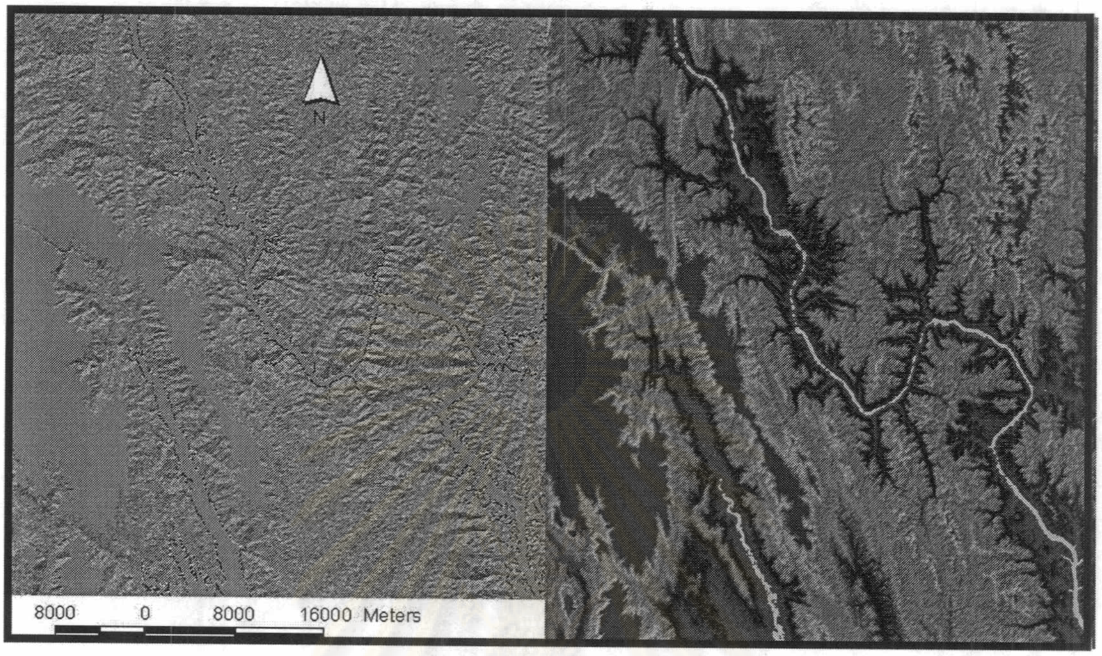



Figure-4.3. Shade relief map and DEM of study area

To produce a shaded relief map we need estimates of the orientation of a given surface element (i.e. the components of slope) and a model of how the surface element will reflect light when illuminated by a light source placed 45 degrees high to the north-west. The apparent brightness of a surface element depends on its orientation with respect to the light source and also on the material. Often reflectance values are obtained from a look-up table where slopes are converted to reflectance.

There are two main methods:

a. Digitizing of contour lines

b. Scanning of contour lines and raster or Stereogrammetry from ASTER DEM.

The model is built from contour maps, which already have generalization and error built in it. The light source is fixed so that features parallel to the light rays may disappear. Relief features throw unwanted shadows and reflected light upon eachother.

4.2.4. Analytical approach to hill shading

The thickness of and distance between lines are varied so that variations in light and dark so as express variations in the slope of the terrain. The light intensity at every point that uses the cosine of the angle between the light incidence and a normal to the surface. This method wasn't feasible until computers could handle the bulky calculations.

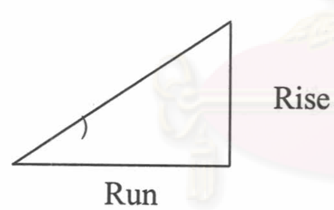
There introduced the algorithmic means of hill shading (analytical hill shading):

- The dot size is proportional to elevation.
- The reflectance is proportional to the cosine of the angle of incidence with line normal to surface.
- Illumination is adjusted to local relief.

Computer graphics produce analytically-based shading, the application of uniform rules to depict light and shadow. Graphics shading is more concerned with the overall effect the shading produces and evaluates the result by how well it simulates reality. Hillshading always maintains a location attached to each elevation , surface analysis such as slope and aspect, and is most concerned with revealing the most possible information about the terrain. Algorithmic concerns that computer graphics have in common are: creating a diffused light source to soften shadows, atmospheric perspective, shading of convex and concave surfaces, and optimally revealing a surface shadowing by local light adjustments. Areas applicable mainly to computer graphics are depicting shadows, transparency, multiple fixed light sources, surface textures, and surface smoothing.

4.2.5. Slope

Slope is defined by a plane tangent to the surface as modelled by the DEM at any given point and is comprised of two components, gradient, the maximum rate of change of altitude.




Calculated in degrees between adjacent pixels or from TIN.
Slope (degrees) = angle opposite rise/run
varies between 0 (flat) and 90 degrees (vertical); 1 to 1 slope is 45 degrees
Slope (percent) = rise/run * 100
varies from 0 (flat) to infinite (cliff); 1 to 1 slope is 100%

4.2.6. Aspect

Aspect is the compass direction of this maximum rate of change. Gradient (in %) and aspect (in degrees) are the derivative of the altitude surface. Calculated in degrees of azimuth from north in a clockwise direction, hence north is both 0 and 360. Cardinal directions are 90 degree (E), 180 degree (S), 270 degree (W), 0 and 360 degree (N). Steps are necessary in numerical analysis to deal with North having both extreme values (1,2, 359,360, etc) (see figure-4.4).

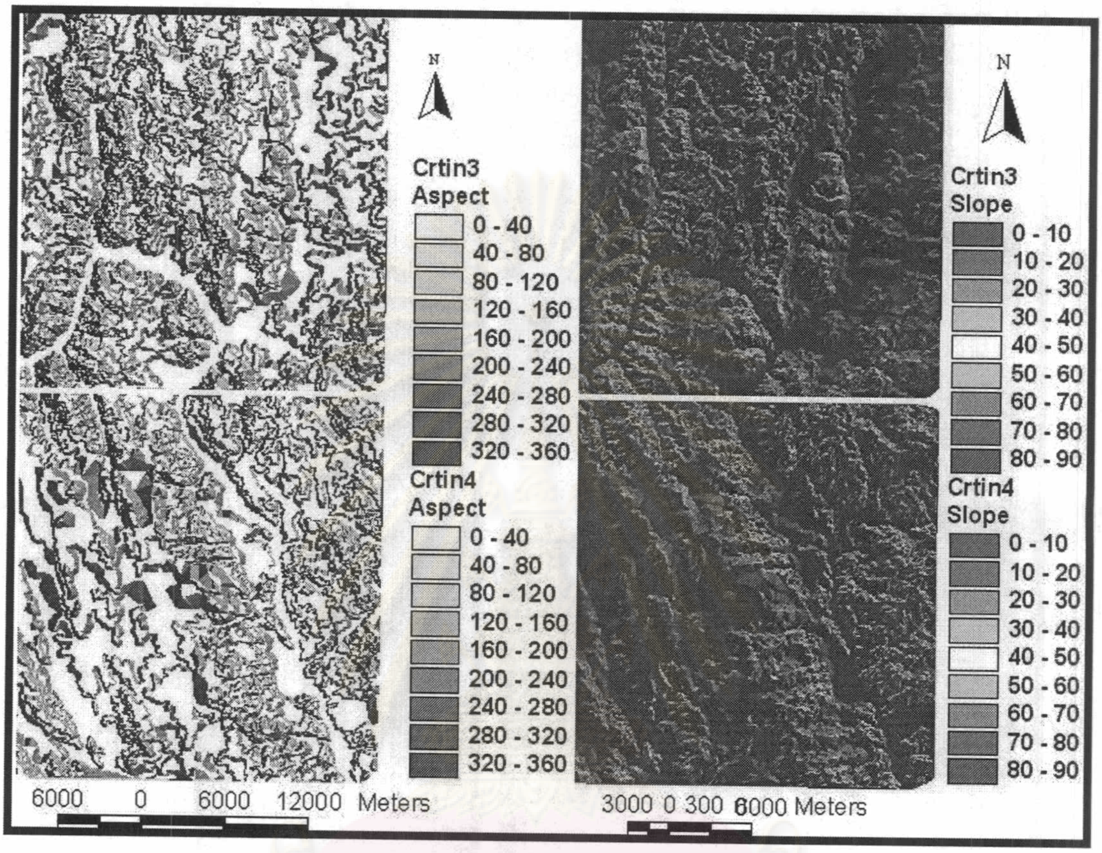



Fig-4.4. Map showing the (a) Aspect and (b) Slope of study area.

## 4.3. Geospatial Analysis

The GIS dataset generated keeping the exploration model in view are as follows:

- Lithology and favourable contacts: generated from existing compiled geological maps in different scales and attribute value updated.
- Lineament, fault, fold and thrust zone: generated from existing compiled maps.
- Host rock ,rock formation unit layer: generated from reports and maps.
- Common drainage patterns and their geological significance.

4.3.1. Structure lineaments

Lineaments are line features or patterns on earth's surface which reflect geological structure. Detection and mapping of lineaments is distinct physical feature, in the investigation of active fault patterns. On landsat TM images, lineaments usually appear as lines or linear formations whose pixels are either lighter or darker than the background pixels. The automatic lineament detection method has been applied with success using bands 7, 4 and 2 of a multispectral LandSat TM satellite image of study area of Thailand and Myanmar. A visual lineament identification was carried out by Thailand geological map 1:500,000 (1983 edition) and Geology of Burma 1:2000,000 (1981)map and the output was superimposed and digitized as shown in Figure-2.5.

We have also discussed how locational information of each point features of event can be extracted from ArcView 3.3sofrtware and utilized to describe their spatial characteristics. In a vector GIS database, linear features are best described as line objects. A line can be used to represent linear geographic features of various types. Some linear features do not have to be connected to form a network, such as fault lines of a geologically active area are probably non contiguous. These spatially noncontiguous linear features can be analyzed as individual objects without any topological relationships. Some fault lines are joined together for geological reasons. But topologically, there is no reason for these fault lines to be linked (see figure-4.5).

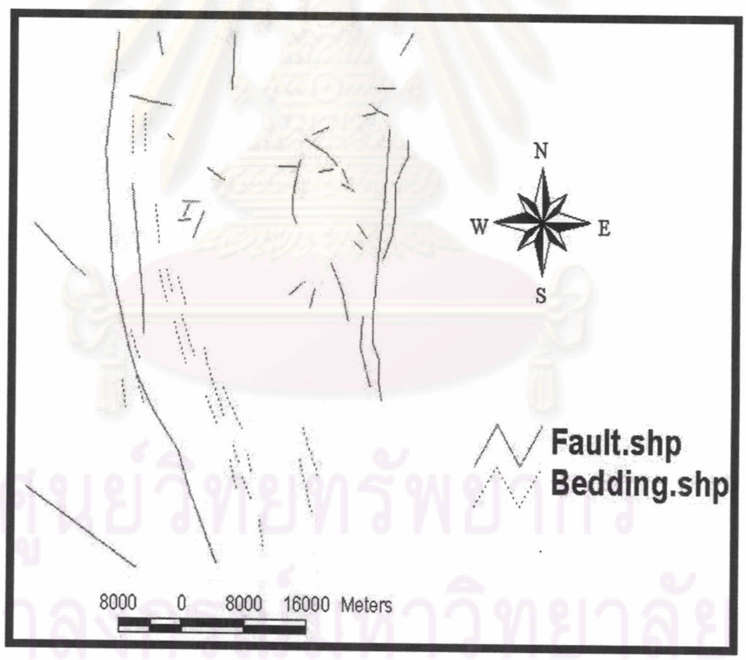



Fig-4.5. Structure lineaments of study area.

4.3.2. Stream network

Drainage pattern is the spatial arrangement of stream and is in general very characteristic of the terrain. The drainage networks possess a geometric regularity of different types, which reveal the character of the geological terrain, and geological feature.

| **Type** | **Description** | **Geological significance** |
|---|---|---|
| Dendritic | Irregular branching of streams, haphazardly, resembling a tree | Homogenous materials and crystalline rocks horizontal beds gentle regional slope |
| Rectangular | Streams having right-angled bands | Joined/faulted rocks |
| Parallel | Channels running nearly parallel to each other | Steep slops: also in areas of parallel elongate landforms |
| Trellis | Main streams running parallel and minor tributaries joining the main streams nearly at right angles | Dipping or folded sedimentary or low grade meta-sedimentary rocks: areas of parallel fractures |

Table -4.4. Common drainage patterns and their geological significance.

4.3.3. Drainage density

Drainage density is a measure of stream spacing. Drainage density reflects basin's geology and climate. Basins underlain by resistant, permeable materials have low drainage density; basins underlain by weak, impermeable materials have high drainage density.

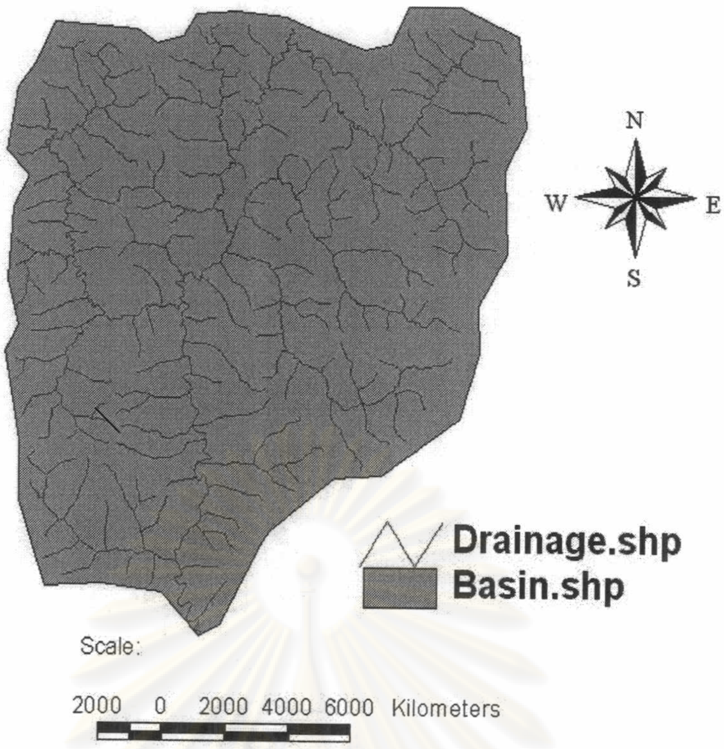



Figure-4.6. Map showing drainage density of Nam Mae Tae Luang .

Area (A) = 223 $km^2$
Relief (R) =1.1 km
Relief Ratio (RR) = Relief / Basin Length
= 0.06298
Drainage Density (DD) = Total Stream Length ( km) / Area ($km^2$ )
= 312.815 / 223
=1.4027 $km/km^2$
Ruggedness Number (HD) = DD. R= 1.54297



4.3.4. Fractals modeling and Spatial analysis

Scaling through a fractal dimension can also be used for estimating the spatial measure of stream pattern or fourth order analysis, such as the length of a geographic boundary or the area of a geographic region.

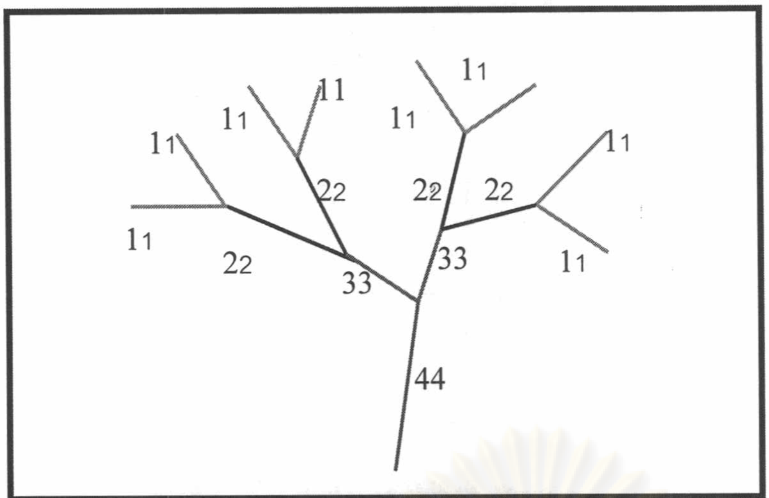



Figure-4.7 (a). Showing the fourth order pattern.

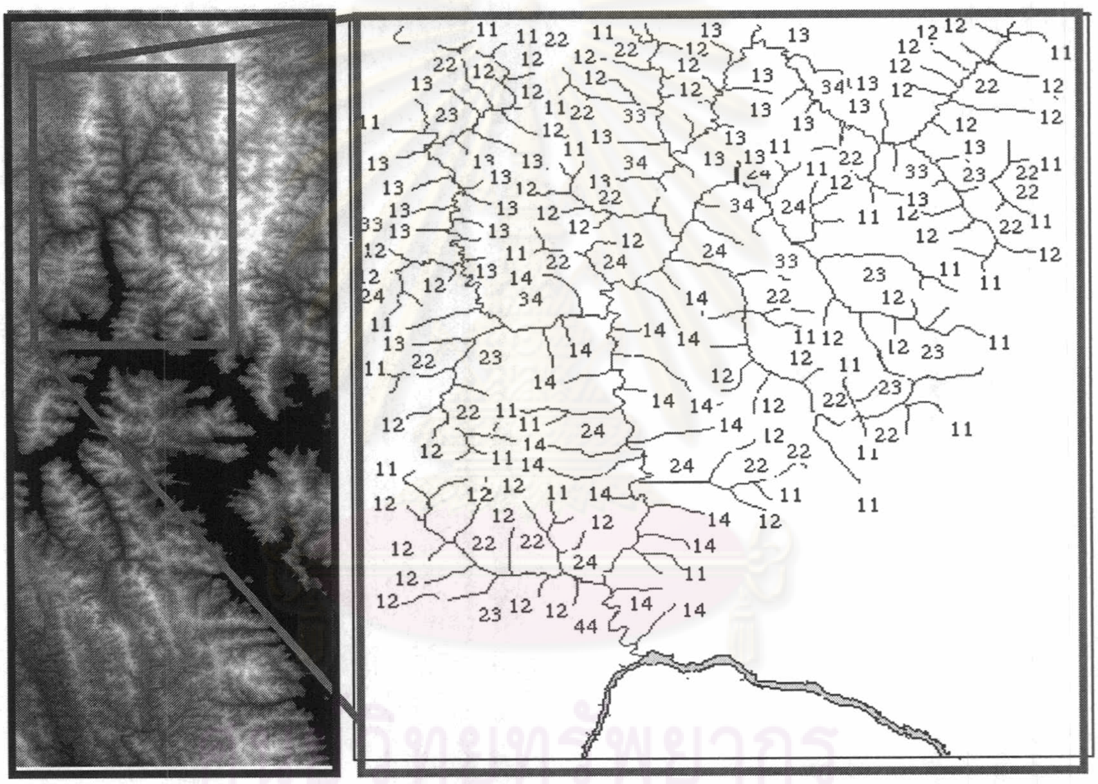


Figure-4.7. (b). Map showing ASTER DEM and the fractal analysis of Nam Mae Tae Luang

In fig-4.7.a and b, If $N_1=(N_{11}+N_{12}+N_{13}+N_{14})$ =first order
$N_2=(N_{22}+N_{23}+N_{24})$ =second rder
$N_3=(N_{33}+N_{34})$ =third order
$N_4=N_{44}$ =fourth order

$N_1=(N_{11}+N_{12}+N_{13}+N_{14})$
$= 60+48+27+16= 151$
$N_2=(N_{22}+N_{23}+N_{24})$
$=20+7+8$
$=35$
$R_b = N_i / (N_{i+1})$
$= 5$
$Rr = (r_{i+1}) / r_i$
$=2$

$N_3=(N_{33}+N_{34}) =4+4$

$N_4=N_{44}$
$=1$

$D= \ln R_b / \ln R_r$
$=2.322$

| | | | |
|---|---|---|---|
| 60 | 48 | 27 | 16 |
| | 20 | 7 | 8 |
| | | 4 | 4 |
| | | | 1 |

| | | | |
|---|---|---|---|
| $N_{11}$ | $N_{12}$ | $N_{13}$ | $N_{14}$ |
| | $N_{22}$ | $N_{23}$ | $N_{24}$ |
| | | $N_{33}$ | $N_{34}$ |
| | | | $N_{44}$ |

The representing geologic feature such as fault traces, faults, and geological contacts into line segments whose orientations can be summarized by vector mean calculations and represented as distribution of geostatistic value. This information can be used to determine the angular relationships between different types of geological data and to test rock distribution arrangement and their orientation (see figure-4.5).