LAND USE CHANGE AND SUSPENDED SEDIMENT YIELD ANALYSIS USING RS AND GIS

a case study in Uromieh lake area(Shar-chi catchment)

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FEBRUARY 2003

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By

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Thesis submitted to the International Institute for Geo-information Science and Earth Observation in partial fulfilment of the requirements for the degree of Master of Science in Natural Resource Management.

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ACKNOWLEDGMENTS

This study could not have been realized without the contribution, suggestion and supports of many people and organization. I am extremely indebted for their painstaking effort.

-Ministry of Jihad agricultural for preparation of this course and providing the necessary materials for all of the requirements.

-Deputy of Education and Manpower development for their effort in providing all of the necessities they could afford for better functioning of the course.

-Soil conservation and Watershed Management Research centre of West Azerbaijan province, which their official and colleagues offered kindly helps during fieldwork.

-Pro.Dr.A.M.J. Meijerink for his guidance effective advises, valuable recommendation during field-work and preparation of thesis, his intellectual encouragement, and his suggestion, which contributed much to the development of ideas and the result of this study.

-Dr. J. Ghoddousi (Iranian supervisor) for his guidance and help solving problems.

In giving assistance during field and office works.

-My special thanks to Mr. R. Sokouti, Mr.J. Khani, Mr. E. Broshke, Mr. E. Norozi, and Mr. Khalily, for help and cooperation.

ABSTRACT

Influence of land cover/use change on variation of suspended sediment yield in Shar-chi catchment river basin, located in the north-western part of Iran, was studied based on the analysis of available data for the period of 1974-1999.

The main problem of this catchment is conversion of rangelands to rainfed crops in hilly land with no conservation practices. That causes high erosion because most of the fields are located on steep slopes and the ploughing is done in the direction of the slope

This thesis can be divided in two main parts:

First part deals with identifying land cover/use change the lower part of the catchment where accelerated erosion occurs. In order to detect land use changes of area two different Landsat image (ETM, Jun., 2000 & TM 9, Aug, 1990), an ASTER image (24,jul, 2000) and aerial photographs (1956) were used.

Various, Multi-spectral classification methods with original and transformed bands and visual interpretation were used for preparing land cover/use maps. The accuracies were assessed with control set. It was found that the maximum likelihood classification based on the original bands (ETM 2000) visual interpretation of the ASTER image for determining the upland field boundaries gave the best results.

Multispectral classification only has limitations because rainfed cultivation could not be separated from other classes. A large increase in rainfed-cultivated lands at the expense of rangelands was observed since the 1950 when the aerial photos were taken. The rainfed area was 1822 hectares. Most of the increase took place after the revolution in 1979 the statistics obtained all of approximate nature because no visual interpretation of the TM 1990 image could be done because of the 30 meter resolution, and a large difference was noted between the spectral classification of ETM 2000 and the visual interpretation of the ASTER 2000. We believe the latter gave more accurate results.

Second part deals with the sediment yield cannot be assessed accurately because not many samples were taken during high discharges. Therefore the sediment yield estimates obtained are probably too low. Segmentation of the data set for establishing monthly or seasonal rating curves of suspended sediment concentrations and discharge did not gave meaningful results.

A relationship between discharge and the sediment transport was finally used, and for the low discharge the arithmetic average of the sediment concentrations were used, but for the high discharges an exponential function.

The land use change took place in the lower part of the catchment, termed the Hills, and the effect on the sediment yield could be analysed by subtracting the sediment yield from the upstream station (Mirabad) from the downstream station (Band). The estimated annual sediment yield of the Hills varied from 390 to 6529 ton/km^2/y. In the period 1989 to 1996 the yields varied from 1446 to 1298 ton/km^2/y, during the wet years from 1991 to 1992 a large increase was noted with a maximum of 6529 ton/km^2/y, but during the dry years of 1997 to 1999 the yields were 390 ton/km^2/y.

A trend line fitted through the time series from 1974 to 1999 did show an increase in the sediment yield from the hills, but no such trend was found for the upper catchment. The sediment yields from the upper catchment can be considered as a control set because there no land use conversion took place.

The high sediment yield from the Hills not only proves the serious erosion problems, which has led to abandoning of some fields; it also affects the sedimentation in the newly created reservoir and in the Lake Uromieh wetland. Steps should be taken to implement soil conservation and restrict cultivation of the lands with steep slopes.

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Chapter 1: INTRODUCTION:

Introduction:

Many factors influence the sediment production in natural catchments. Factors such as rainfall intensity, local soil, geomorphology, cover type and farming practices will exert an important influence on the precise magnitude of the increase in sediment yield that will occur in particular area as a result of land use activities.
Other factor related to deposition in a catchment can reduce the sediment yield.
The effect of land use on sediment yields are closely linked to those of climate and physiography. Its effects can be isolated and it is clear that major contrasts in sediment yield may be attributed to the influence of land use (Hadley, 1985).
The world is now losing an estimated 23 billion tons of soil from croplands in excess of new soil formation. (Brown, 1984)
Crop yield from rainfed areas might decrease by 29 percent over the next 25 years. (Higgins, 1982)
In semi-arid climates, plants growth is severely restricted and there is corresponding little plant litter. This results in small ground protection with sparse vegetative cover; there may be substantial sediment transport, even from ungrazed areas (Jansson, 1982).
Because of climatic and geographical characteristics Iran is encounters soil erosion problems.
Natural processes or geological removal of the soil causes some of this problem but large areas are affected by accelerated erosion caused by removal natural vegetation cover.
Reduction in vegetation cover can be caused by cultivation, over grazing of rangelands, forest removal and other reasons.

1.1. Problem definition*:*

During the two last decades, population growth in the study area has led to a high demand for food and low income.
This led to an increase of the cultivated area, by converting rangelands to rainfed crop on sloping lands (the more than 15%).
Reduction of rangelands led to accelerate erosion has already created some barren lands. The climate in the study area is semi-arid and the structure of the soils and geological features make the area susceptible to erosion, especially the hills of sedimentary rocks in the eastern part because these hills consists of sand stone, shale, marl.
The consequences of removal of topsoil can be summarized follows:

- **Off-site:**

-Washing out topsoil to the rivers, shallowing their depth widening the bed, threatening the farmland and villages round the riverbed by flooding.
-Accumulation of sediment in reservoirs, which this effect has a high importance in the study area because of construction of a new dam on the Shar-chi River .its life time depends on the erosion in the catchment.

- **On site**:

-Decreasing of soil fertility and rooting depth (water holding capacity) as a result, decreasing crop yield of farms.
With due attention to these and other negative effect of land use on sediment yield analysis make it necessary to make detailed study about catchment characteristics, find the relationship between land

use change and sediment yield and by knowing these, finding the best suggestion most suitable for each land use and better soil conservation practices. Figure 1.1 is showing the procedure of the production sediment yield in the study area.

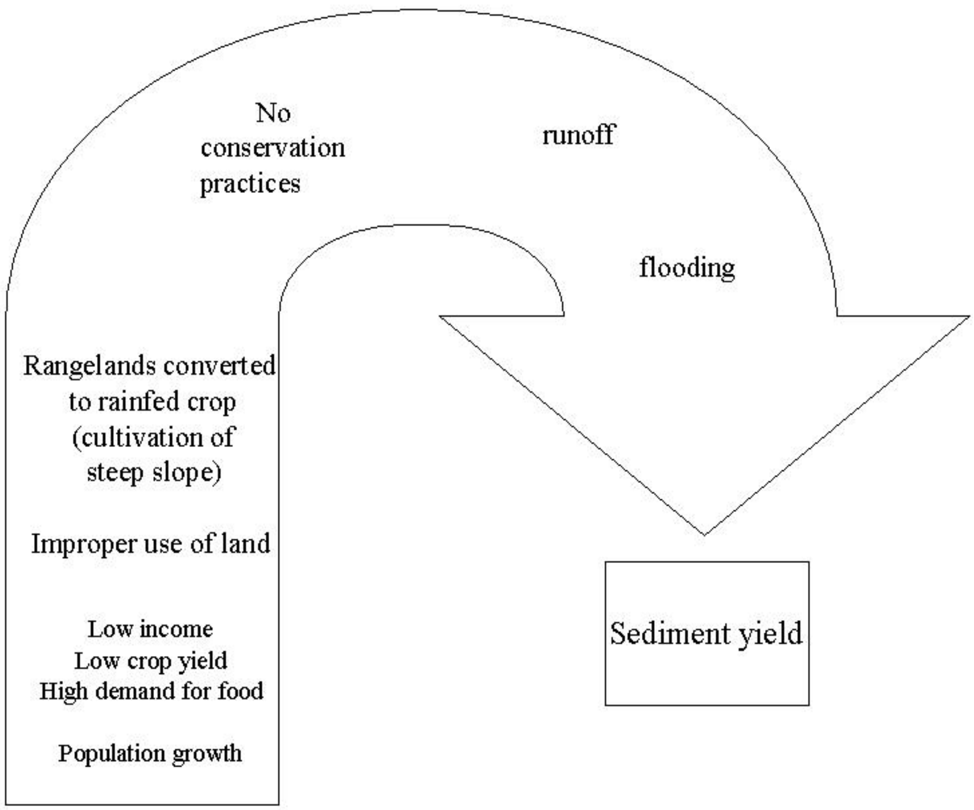


Figure 1.1: procedure of the production sediment yield in Shar-chi catchment

1.2. Study objectives:

The aims of this study area to determine the feasibility and accuracy of using remotely sensed data and other information to detect land use change and its relationship between sediment yield (if any) and land cover change. Field observation, interpretation of aerial photographs and satellite images, data set hydrological stations and sediment data in combination with GIS techniques are used in this research as follows:

- Aerial photo interpretation and satellite images for classification of spatial and spectral of characteristics. In combination with ground data is used for determining land cover change, and assessment of accuracies
- The capabilities of GIS (ILWIS software) for creating different spatial data for catchment area (e.g. DEM, slope map, aspect map, drainage pattern, land use map and etc).

1.3. Literature review:

Many research have been done in the area of land use and impact in sediment yield variation through the world.

When studying the effect of land use on sediment yield, the temporal dimension must also be considered in many areas of the world, the impact of human activity may be relatively recent, whereas others may have experienced a long history of land use change extending back over several thousand years.

The absence of long-term records of sediment yield generally precludes detailed analysis of the effects of a documented history of land use change on the records of sediment yield, although a study of sediment load records from the Colorado river undertaken by Hadley (1974) was able to suggest that the 50 percent reduction in loads after 1941 resulted from a reduction in grazing pressure.

Meade and Trimble (1974) were also able to undertake tentative comparisons of sediment loads during years near 1910 and 1970 for several rivers draining to the Atlantic coast of the USA, but they found it difficult decipher the influence of improve land management practice in recent years due to the effect of remobilisation of sediment deposited in valley bottoms during earlier periods of accelerated erosion.

The natural variability of long-term records of annual sediment yield may also obscure trends produced by changes in land use.

Vernhoff and Yaksich (1982) were unable to detect any significant modification in sediment regime of the Maumee River at Waterville Ohio ‘USA’ over the period 1951-1977 despite significant urbanization and changes in land management.

Also with relation between climate and land has been investigated.

In the case of tributaries of the Yellow River, the presence of highly erodible loss soils, the lack of vegetation cover and semi-arid climate re major controlling variable (Walling, 1981).

Dunne (1979) and Schumm and Harvey (1982) studied about the relationship between the magnitudes of sediment yield and climatic parameters. They concluded:

- Reduce the uncertainly surrounding the effects of land use by representing relationship between sediment yield and annual runoff for individual land use classes.
- The positive trend of the relationship between annual sediment yield and precipitation and runoff suggests that the increase in erosivity. Associated with increased precipitation or runoff levels is not off set by increased protection by the vegetation cover, although the effect of human activity and land use practices in reducing this cover must also be considered.

A useful general perspective on the influence of human activity of erosion fields above the natural base line can be obtained by considering the various parameters employed in the universal soil loss equation (USLE) (Wischmeyer and Smith, 1965,1978). In the equation the cover and management factor ‘C’ expresses the influence of land use practice.

Wilson's (1973,348): the most important on-climatic variable influencing sediment yield is land use. The human influence on erosion processes is so pervasive that attempts to study sediment yield variation re likely to be unsuccessful unless land use factors are considered.
Evanano and Suwanna (1994) used multiple regression analysis for determining the relationship between land use changes and stream flow and suspended sediment they mentioned that the true form of the functional relationship between sediment yield and the, independent, variables is not known and can never be expected to be fully clarified.
Simple graphical correlations between dependent and independent variables are often used to test what type or relationship are the most appropriate (Yevjevich 1972).

CHAPTER 2 Material and Methodology

2.1. Materials:

The materials used in the research are as following:

-Topographic maps of the study area scale 1:50000 (1998).

-Aerial photographic of the area scale 1: 50,000 (1956).

-Satellite imagery: ASTER 24 Jul 2000,ETM 9 Jun 2000 and TM 9 august 1990.

- Hydrological data for Shar-chi River and the three gauging stations inside the catchment (26 Years from 1974-1999).
- Sediment load data for two stations (Band, Mirabad) for (26 years 1974-1999).
- Geology map.
- Vegetation map and report (Soil conservation & Watershed management research centre 1997).
- PC-based ILLWIS GIS package.
- Soil report (Soil conservation & Watershed management research centre 1997).

2.2. Methodology:

The procedure of research can be detailed within three steps.

A. Pre-fieldwork.

B. Fieldwork.

C. Post fieldwork.

A) Pre-fieldwork:

This step included:

- Collection of all existing data and information about the study area from previous works and several organizations (National Cartography centre "NCC", Ministry of power and Ministry of agriculture and Watershed Management Research Centre).
- Literature review about land cover/ use change and impact of land use on the sediment yield.
- Ariel photo interpretation for determining past land cover map (1956).
- Geocorrection satellite images.
- Unsupervised classification image for land use type from satellite images.
- Normalized density vegetation index (NDVI), Principle component analysis (PC ETM landsat 2000) and false colour composite with using edge enhancing filter to prepare a base map to produce a land use map.
- Digitising the contour map and drainage pattern map and creating digital elevation model (DEM).
- Creating slope map by using ILLWIS software.

B) Fieldwork:

This step mainly included:

- To check the location of sample area in the field
- Checking the land use map made on the basis of unsupervised classification, PC, FCC, and NDVI of ETM and ASTER images
- Interviewing local people in order to obtain information about dominant crop, rotation and other agricultural information in the study area.
- Collection of hydrological, climatologically and other necessary data.

C) Post fieldwork:

This step involves data processing and analysis of data, as follows:

- Creating a data including land use types
- Supervised classification of Landsat ETM (2000) and transformed bands to make present land cover map.
- Supervised classification of landsat TM images (1990) for preparing past land cover and land use map.
- Determinations of land cover and land use in change percentage.

For determining land cover and land use change different methods and techniques is used for image classification.

These are multi spectral image classification and image enhancement techniques that can be also used for image classification.

- Principal component (PC) classification.
- Normalize density vegetation index (NDVI) classification.
- False colour composite (FCC) classification.
- Hue, Saturation, Intensity (HSI) classification.
- Maximum likelihood classification with different thresholds is used and the best threshold will be selected.
- Accuracy assessment for land cover map.

The method of accuracy assessment:

Sixty samples are selected as random from 120 samples then, a point map is created .The correlation coefficient matrix use for cross correlation for the two maps (classify map and raster of point map) shows the accuracy of classification.

This process has been done for different classification.

- Visual interpretation of Aster image (24 jul 2000)
- Analysis of hydrological and sediment data.
- To determine the possible relationship between sediment yield (variation in terms of sediment concentration) and land cover changes.

Figure 2.1 is showing the Methodology of study as flowchart.

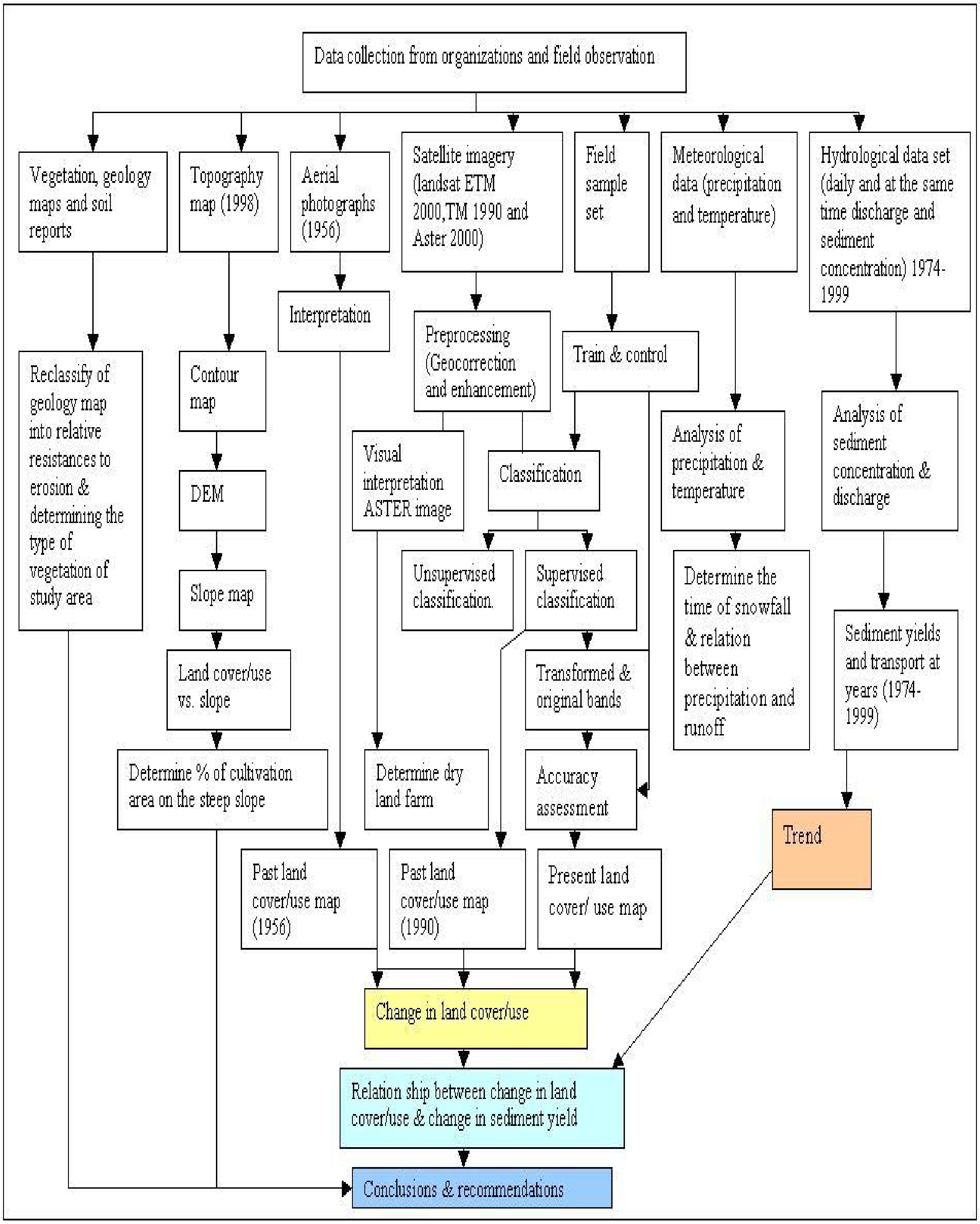


Figure2.1: methodology of study area as flowchart

CHAPTER 3: Characteristics of study area:

3.1. location:

The Shar-chi catchment is located in the north-western part of Iran and in west Azarbyjan province between the 37 ° 19′ 34″ to 37 ° 31′ 29″ east latitude and 44 °34′ 02″ to 45 ° 00′ 50″ north longitude and its size is 413.9 KM2.About 88% of catchments consist of hills and mountains only 12% consists of gentle slope. The altitude ranges from 1500 to more than 3600 m ASL. Location of study area is shown in figure3.1 and figure 3.2 shows the perspective of area.

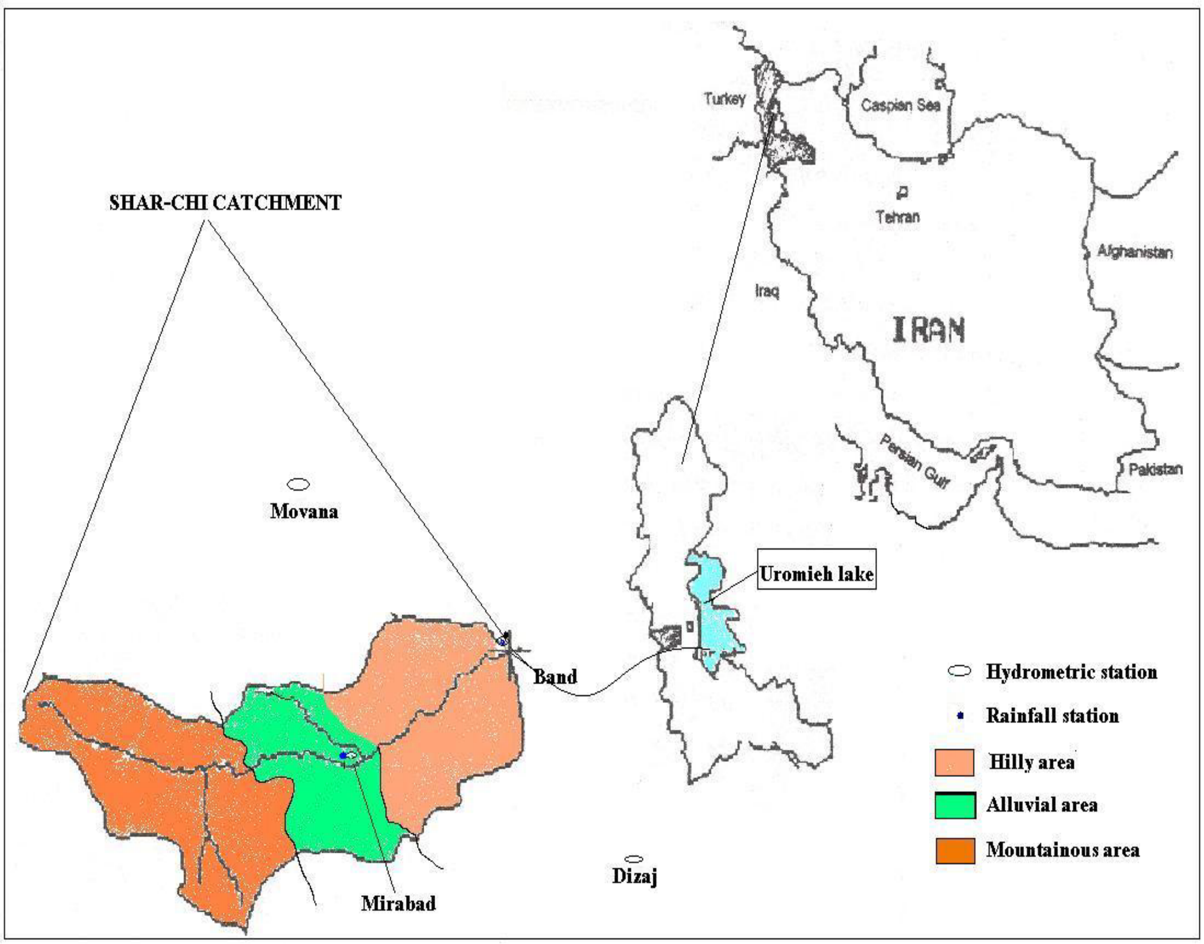


Figure 3.1:general map for study area (Shar-chi catchment)

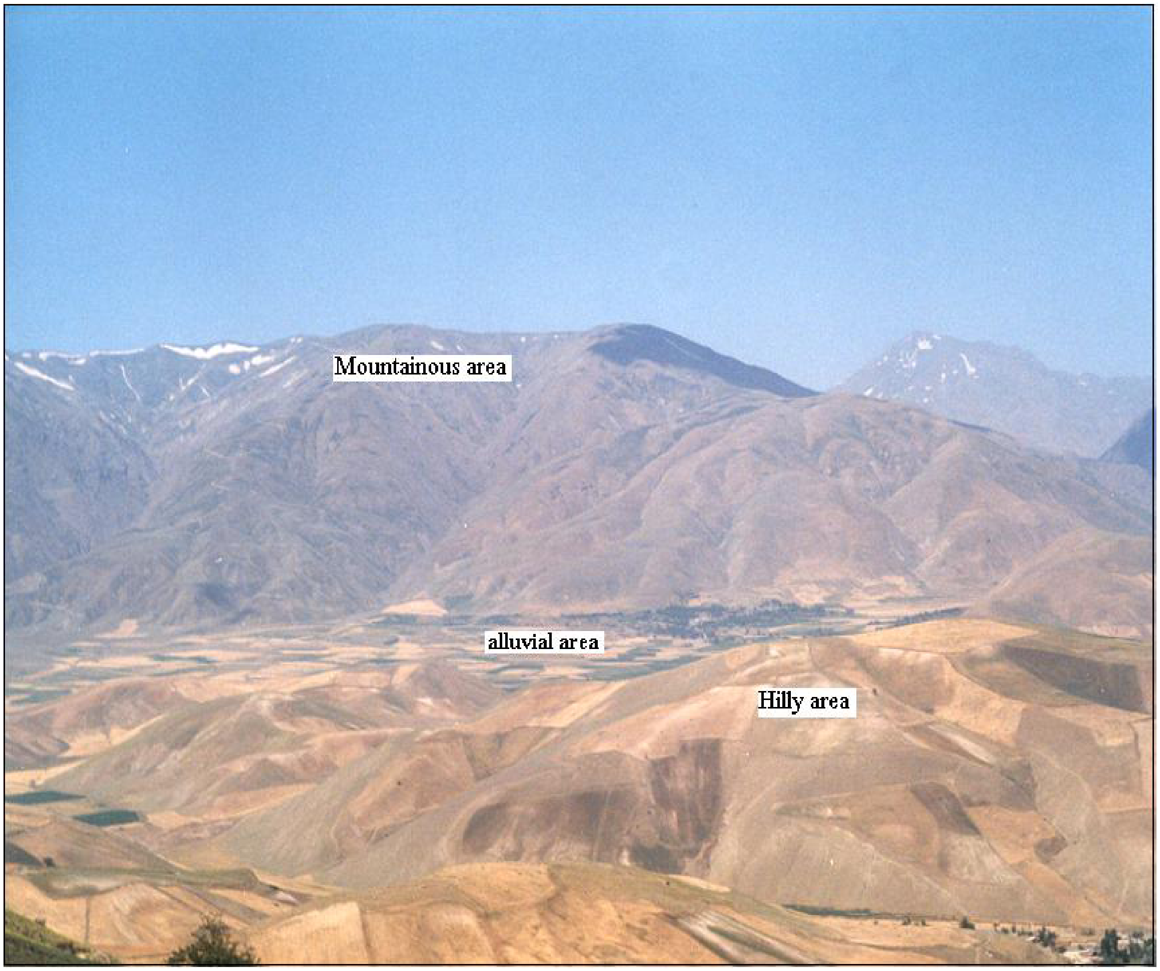


Figure 3.2: perspective of study area

3.2. *Climate:*

The study area (north west of Iran) has cold and moist winters and a mild temperature in summers. The Siberian cold and most anticyclones from north affect the climate of this area. When Pressure differences between the high-pressure Siberian anticyclone and the Low-pressure southern air above the Persian Gulf is high, the cold air from north comes to the area and makes it cold and cause snowfall in winter. Rain falls when the west winds from the Mediterranean Sea is dominant. The climate data including rainfall is obtained from the Mirabad and Band stations.

3.3. Temperature:

Monthly average temperature of the study area varies between 30.4 in July and –14.7 in February. According the table3.1 snowfall is generally concentrated in winter (January, February, 15 days of march) and snowmelt is started from April to the middle of summer season (august). Monthly temperature data for 17 years show in figure 3.3 in Mirabad station.

Month /temperatures (0C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average maximum	3.8	0.5	7.5	14.1	19.1	24.7	30.4	29.9	29.6	22.4	15.6	8.4	17.5
Average minimum	-13.1	-14.7	-9.2	-0.1	4	6.6	8.6	8.8	6.9	2.5	-2.3	-8	1.8
Mean	-3	-2.9	1	7.8	12.2	17.4	20.5	20.7	18.9	13.4	8.1	2.2	9.7

Table 3 .1: temperatures in the Mirabad station

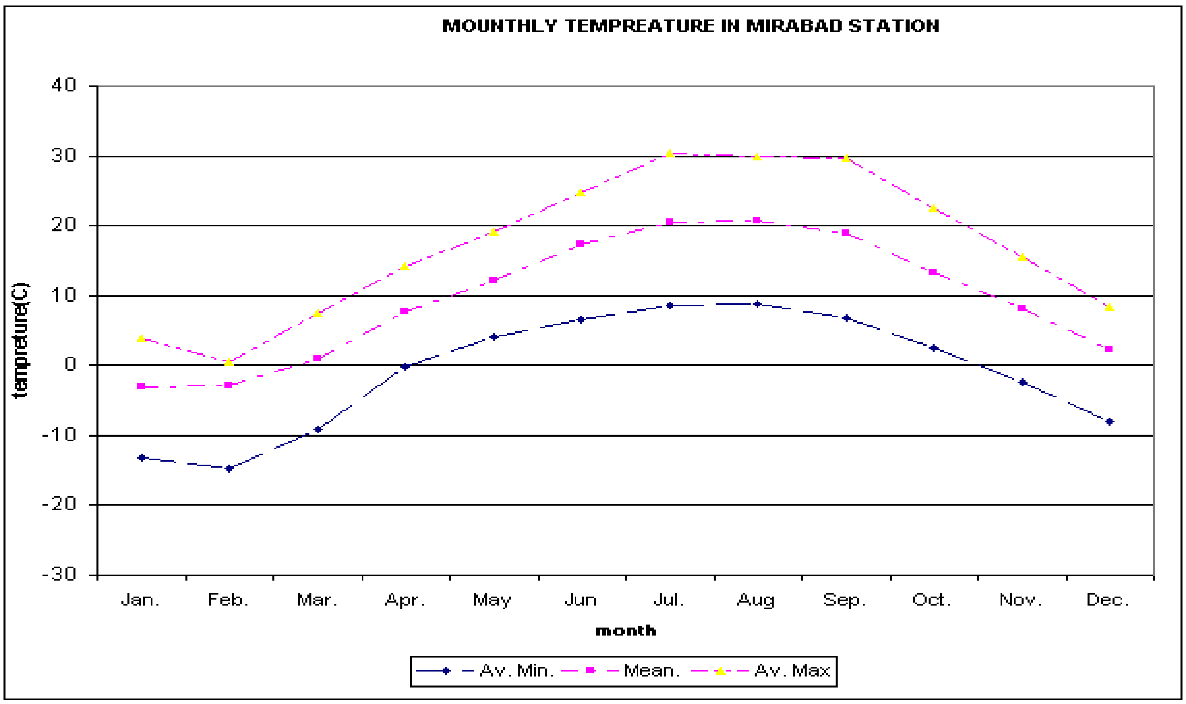


Figure3.3: monthly temperature (°C) in Mirabad station

3.4. Precipitation:

Precipitation in the winter is in the form of snow in all catchments. The amount of it depends in the height because winter snowfall in 2700 m elevations and higher, can be seen patches until middle of the summer. Depth of the snow cover varies in different elevation and at the end of winter this depth in some of area is more than 2m(there is no station for measuring of snow fall in study area. By gradual increasing of temperature in spring, snow begins to melt and caused runoff production teak in rain days in effective increasing of peak flow and spring and middle of summer time runoff values are move than other season. The annual precipitation and mean rainfall is shown for Mirabad and band stations in appendix 1. Also annual precipitation data of Mirabad and Band stations are in appendix 2.

3.5:Hydrology:

3.5.1:Discharge:

The annual precipitation-runoff (annual precipitation-runoff data of Mirabad and Band stations are in appendix 3) relationship is shown in the scatter plot of figure 3.4 for upper catchment (Mirabad station and entire catchment (Band station). The correlation coefficient and linear relationship are as follows:

Band station: $r = 0.84$ $Q= 1.43*P-186.5$

Mirabad station: $r = 0.89$ $Q =1.80*P-304.4$

As it can be seen the discharges at the upstream when expressed in mm are higher than those in down stream. There are two explanations for this difference:

A: The high altitude of the catchment upstream of Mirabad, resulting in low evapotranspiration losses. The lower part has higher temperatures, but also therefore the initial losses are more when compared with the upstream part.

B: In between the Mirabad and the Band gauging stations, water is divided at several places for irrigation and just upstream of Band, there is the water intake for Uromieh town.

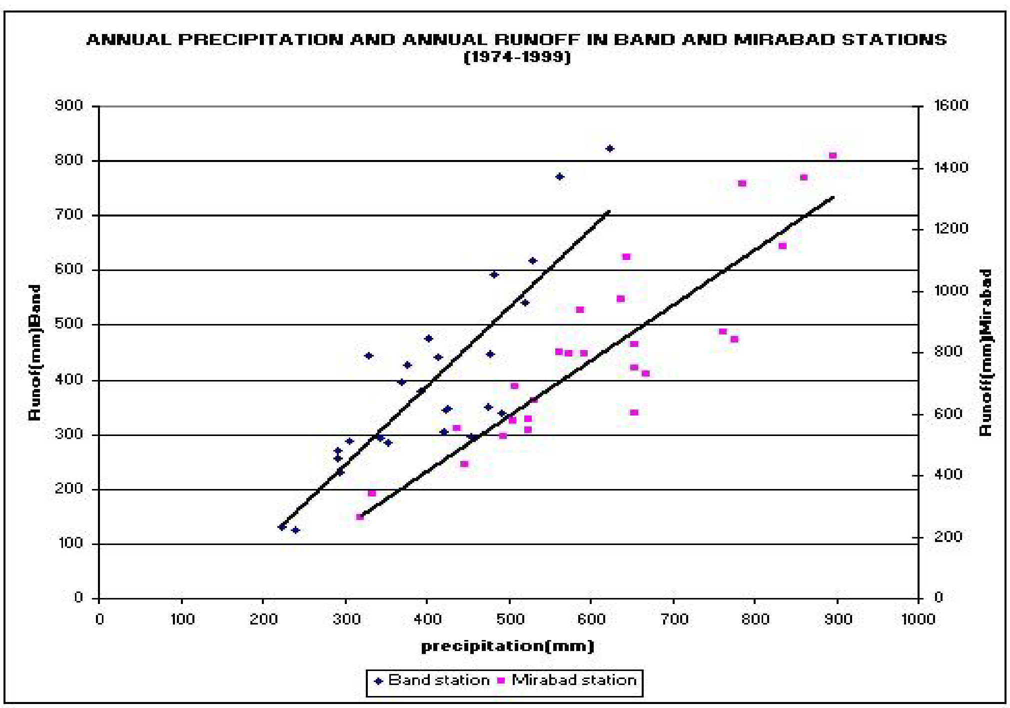


Figure 3.4:annual precipitation and annual runoff relation in Band and Mirabad station

3.5.2. Runoff:

Figure 3.5 shows the relationship between precipitation (mm) and runoff (mm) for two stations. There is more value (P and Q) for Mirabad station. As it can be seen in the figure 3.6 from December to middle of March precipitation is in form of snow so Runoff is less. In spring rainfall increases and snowmelt starts which cause increases Runoff. In autumn, snowmelt reaches to its minimum; the result Runoff is the sum of the Base flow and rainfall. In summer number of rainy days is very low and area is without snow in August, so runoff from March till July are affected by snowmelt too. Daily discharge for tow station is in appendix 4.

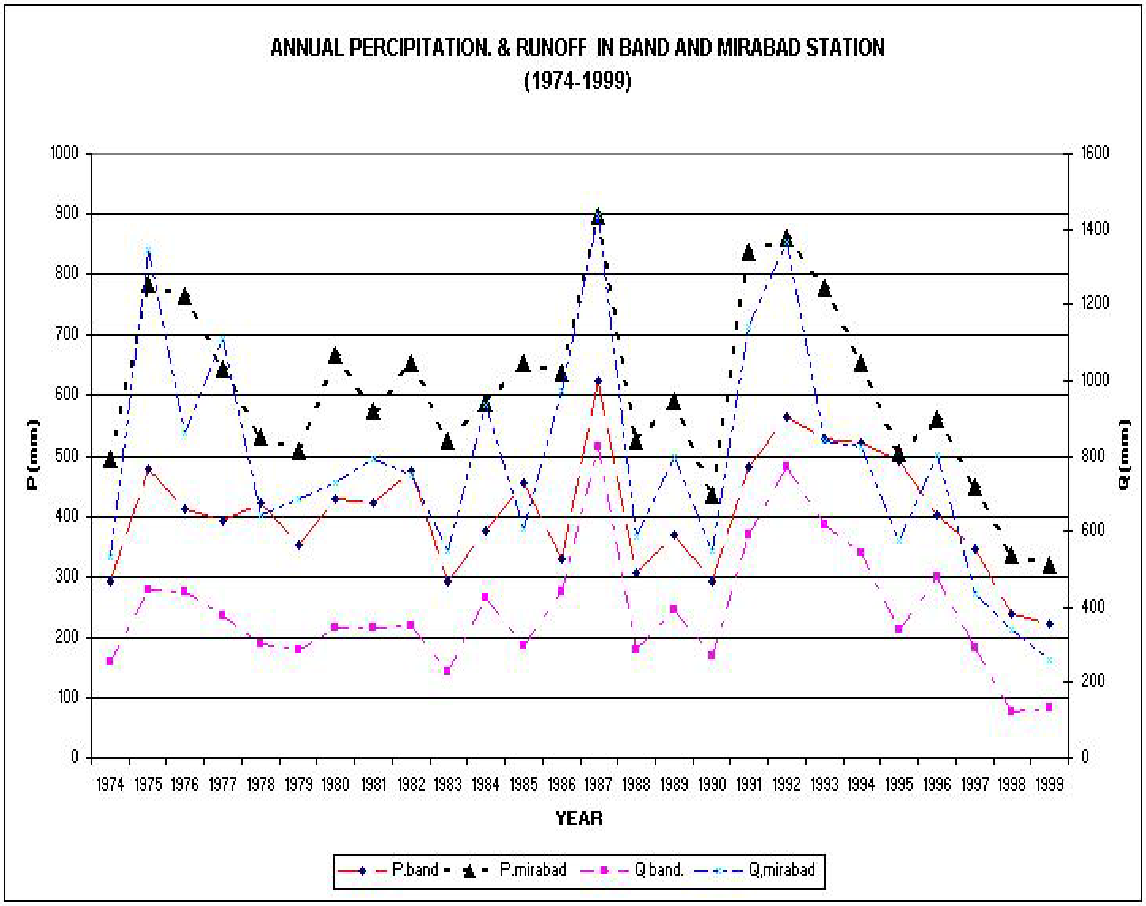


Figure 3.5: annual precipitation and runoff in Band and Mirabad station

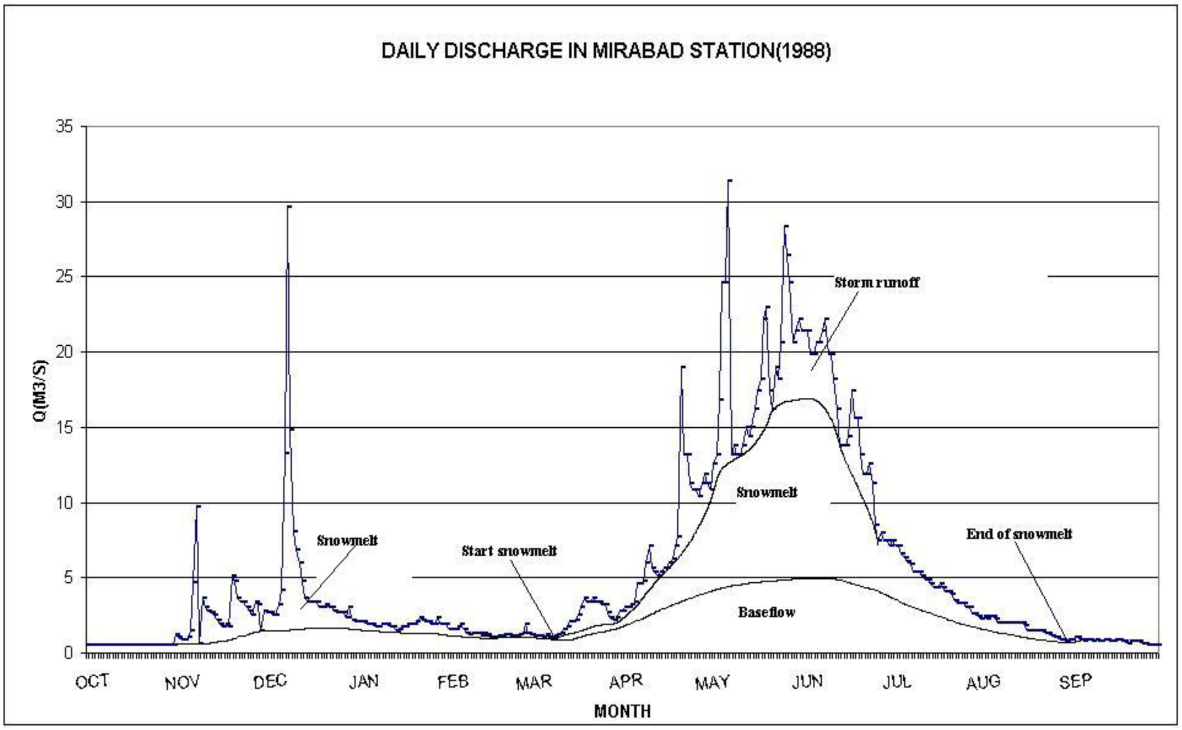


Figure 3.6: daily discharge in Mirabad station (1988-1989)

3.6. Geology:

Three parts of the Catchments Mountain, hills and alluvial have following lithologius (table 3.2):

Mountains:

Silvana complex is the oldest litho logical unit. It accrues on the west elevation, near the borderline with turkey and consists of high, medium and low resistance rocks to erosion such as:

- High resistance: limestone and metamorphosed quartzite.
- Medium resistance: Porphyry, gneiss (named as volcanic complex), and metamorphosed andesitic lava.
- Medium resistance: schistosic acid tuff, phylite and slate.

Hills:

The hills consist of Dorud and Rutheh formation. These are sedimentary rocks, Tertiary age consisting of sandstone, quartzite and shale with some marls and conglomerates.

Alluvium:

The main agricultural areas located in this part of the region due to gentle slopes and its productive soils. This part includes fan and terrace deposits. Because of gentle slope and high permeability little erosion occurs. Figure 3.7 shows geology of the catchment and is reclassified into relative resistances to erosion.

Relative erosion class	Symbol	Rock type	Area (ha)	Percent
Glacis deposits	GD	Young terraces and gravel fans	3495	8.5
Low to Medium High	L-M H	Shale with some marls and conglomerates Limestone	13655 534	33.3 1.3
High Medium	H M	Limestone, dolomitic limestone, some dolomite Sandstone, quartzite, red and pink, locally some shale and conglomerate	2673 699	6.5 1.7
Medium	M	Slate, phylite	10485	25.5
High	H	Dolomite and some limestone	863	2.1
Medium to low	M-L	Schist	2508	6.1
Medium to low	M-L	Schist	1850	4.5
High	H	Metamorphosed quartz-porphyry, schist and genesis	1275	3.1
Medium	M	Undifferentiated metamorphic rock (schist, gneiss, some schistose tuff)	2179	5.3
High	H	Diorite, grandiosity metamorphosed	904	2.1

Table3.2 shows lithology of the catchment and reclassified into relative resistances to erosion

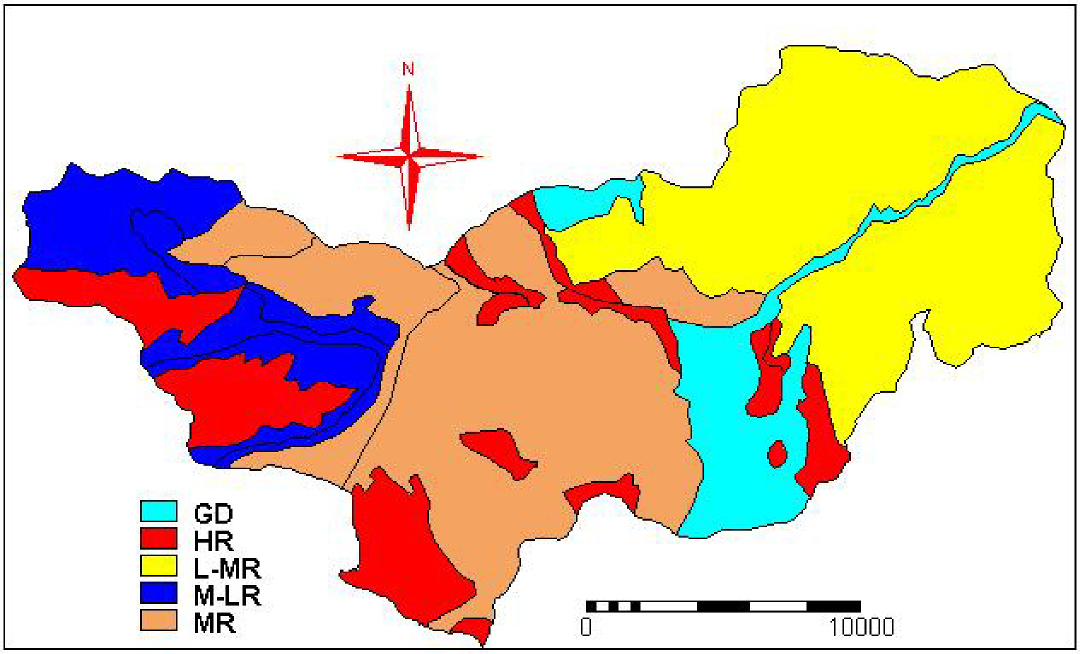


Figure 3.7:reclasifed of geology map of study area

3.7. Vegetation types:

The vegetation types in the study area vary according to the combined effect of climate, geomorphology, erosion, slope/aspect and types of soil. Some of the vegetation, which could be determined in the field area as follows:

- Xeranthemum squarrosum
- Achillea biebersteinii
- Helichrysum rubicundum
- Gallium verum
- Teucrium polium
- Sanguisorba minor
- Verbascum Sp.
- Marrubium crassidens
- Taeniatherum crinitum
- Contobeaster ovatus
- Acantholimon SP.
- Stipa
- Festuca (Ovina)

Figure3.8 shows the vegetation types of the study area

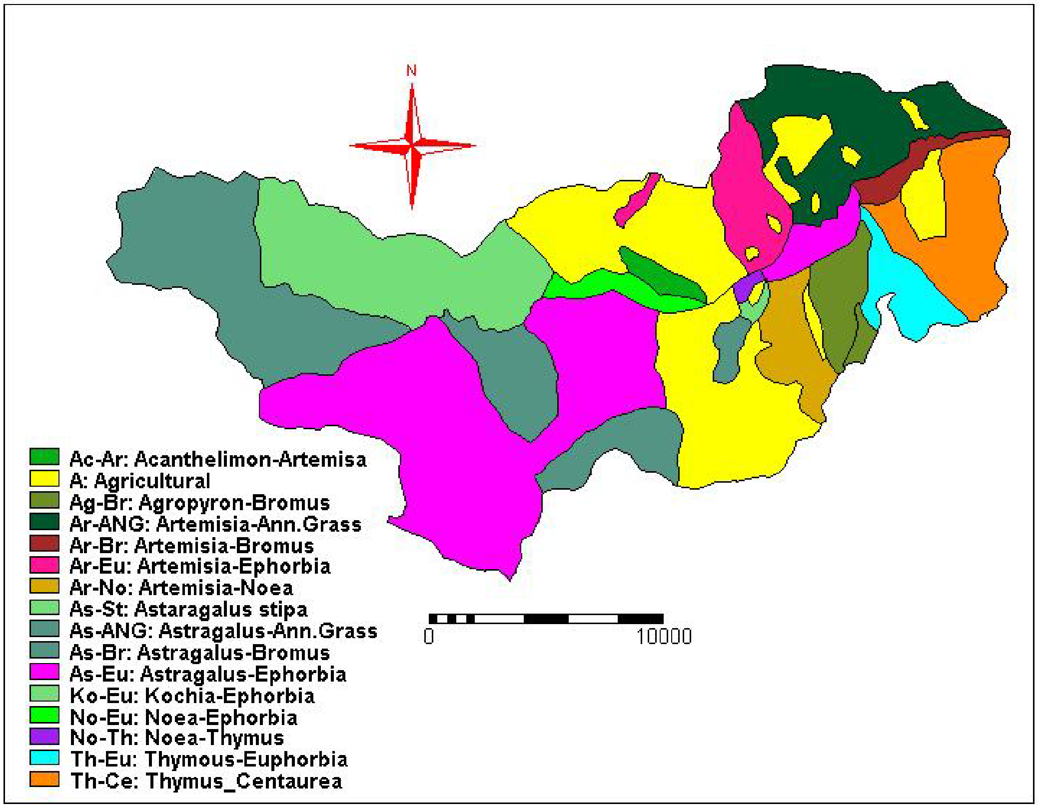


Figure3.8: vegetation types of the study area (source Soil conservation and Watershed Management Research Centre 1997).

The botanic comparison can be used to judge degradation. There is sequence from climax stage under undisturbed conditions to a fully degraded stage, as shown in figure 3.9. Reports of many years ago (soil conservation and Watershed management research centre 1997) mention process of index plants of the study area were Bromus tomentellus, Agropyron cristatum, Dactylis glomerata, Agropyron trichophorum, Sanguisorba minor and Medicago sativa in the many years ago. Their populations have declined only few species have remained.

The causes of this declination are as follows:

- Using rangelands without consideration of carrying capacity and potentially
- Overgrazing and cutting of bushes for fuel.
- Owner ship of rangelands is not clear.
- Conversion of rangelands to rainfed crops

These reason have affected the extent and quality of the vegetation leading to degradation by erosion.

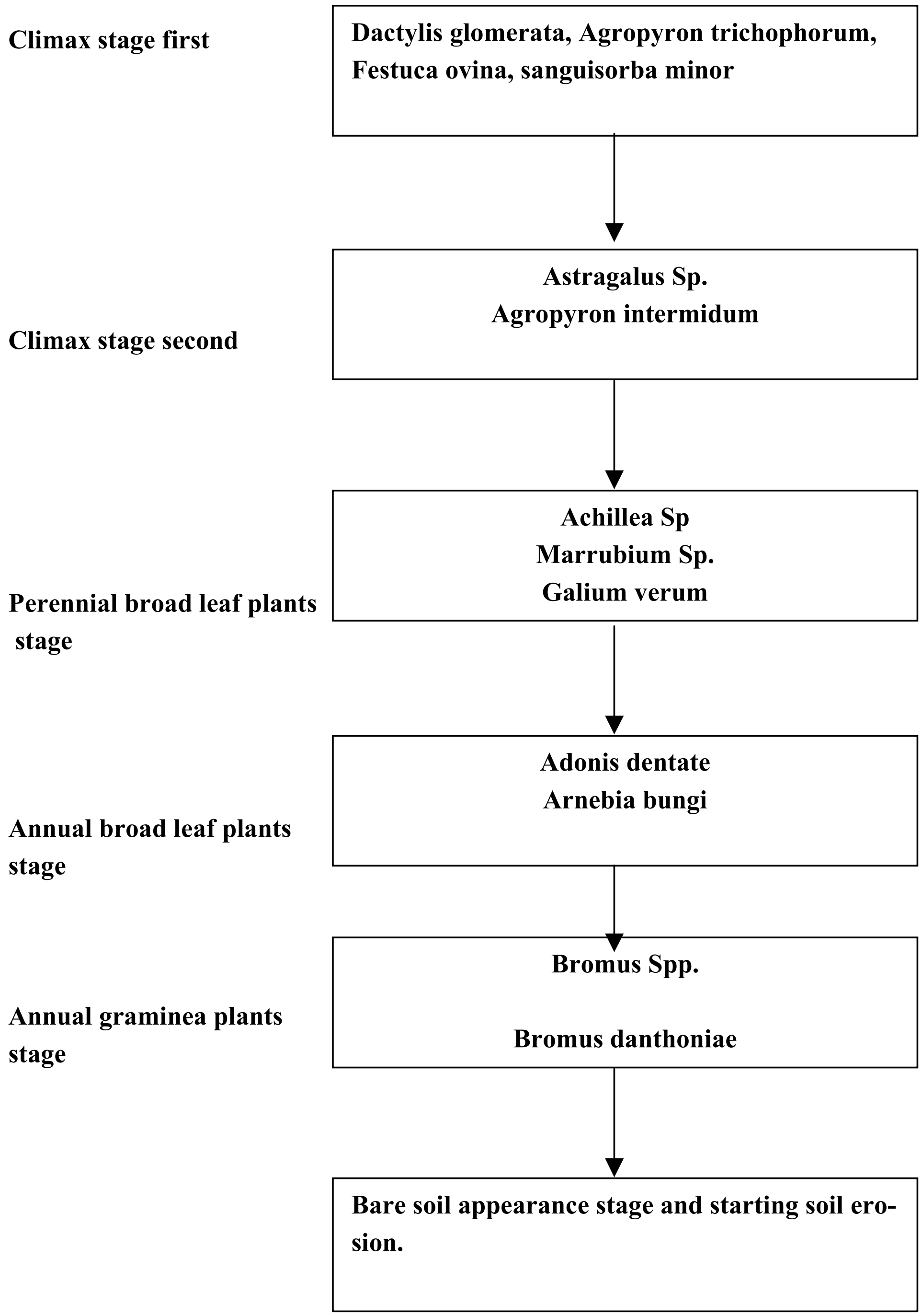


Figure3.9: sequence of vegetation of the study area

3.8. Geomorphology:

Five main units are distinguished in the area, namely mountain, hill land, piedmont, plateau and valley. This units are clearly associated with the geology, see map 3.7.

According to the digital elevation model (DEM), average elevation of the surveyed area is 2305 m ASL, where as predominate elevation is 3048 m ASL. In addition to that, slope map of area (figure3.10) is prepared from DEM, where slopes are grouped into seven classes.

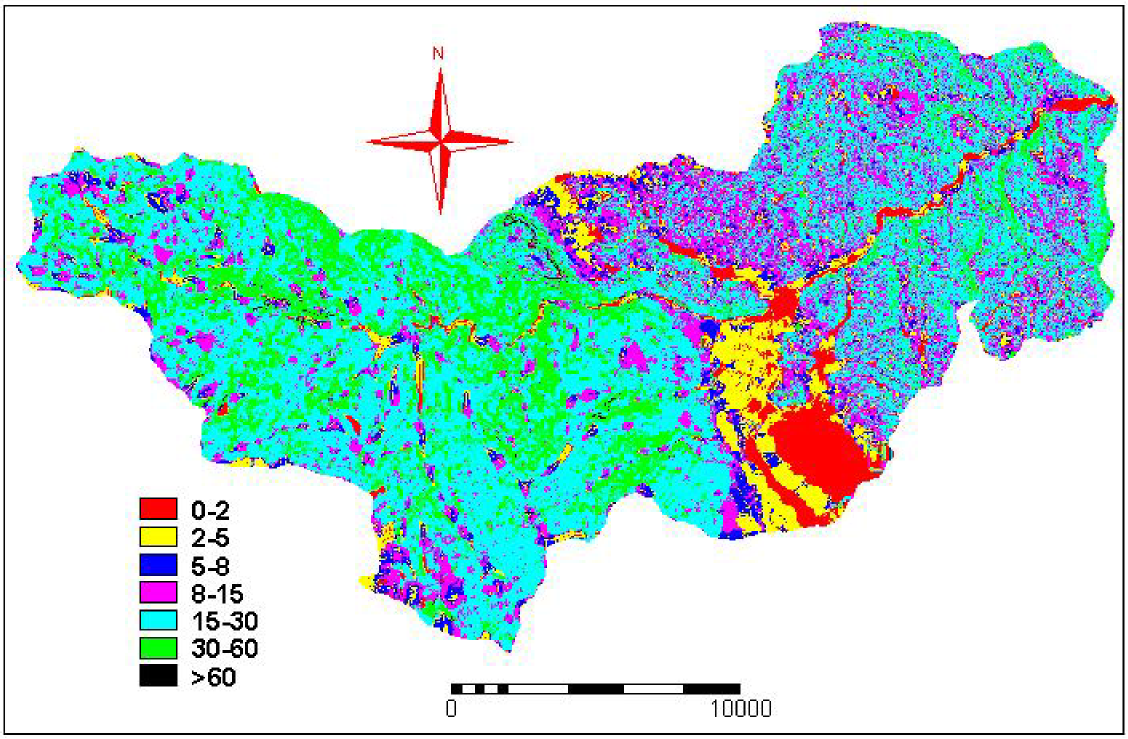


Figure3.10: slope map of study area

3.9. Soil:

On the basis of previous study (Soil conservation and Watershed Management Research Centre 1997) there are different soils in the different landscapes in the sharchi catchment.

Four main order of soil can be seen in the study area, consist of: Entisols, Inceptisols, Alfisols and Mollisols. Different lithology in parent material on mountains and hills are seen that make a top sequence with different slops (from 8 to >60%). The soils are shallow with high drainage and highly affected by erosion, coarse texture with high gravels, although they vary based on different parent material, in fact with acting erosion agents, eroded coarse and gravely materials move to the shoulder, back slope and foot slope with increasing in depth and inducing finer materials. For instance when we are faced with lower slope in back and foot slopes, the soils are more fines like as clayey skeletal, as it is expected, the piedmont landscape are located in the foot of high slope landscape (hill, mountain). Here the area faced with accumulation of eroded material from high slope landscape. These material can be colluvial or alluvial. These sides also have coarse texture with high gravel in apical part of fans (fragmental) but as moving toward distal part. There are medium and fine materials, (fragmental, clayey skeleted and fine loamy) that in fact, the last one is accumulation of alluvium material on geologic surface named glacis with sign of erosion. This part is accumulation glacis covered by new materials that they are influenced by erosion factors water agents in the lowest part that river can be seen, the alluvium materials are deposit parallel with river direction that can construct new terraces with changing in river direction (in low slopes) and deep erosion of river and making the new bed river, as the distance is increased from bed river, the soils would be come fines. In platues in fact when we are faced with geological surfaces, that make new surfaces with acting the erosion agents in lower part of platuae, it can be seen that some eroded material from upper parts (highly slopes 8-15%) are accumulate on Erosional terraces (5-8%) slopes.

Chapter4: Land cover /use

Introduction:

Land use is the result of a continuous field of tension created between available resources and human needs and acted upon by human efforts (Vink, 1975).
Land use can change over the years. The causes of the land use change are different.
In the studied area the main cause is the need for agricultural land and therefore range lands converted to cropping land.

Before the past tow decades, there was a restriction on that converting and no or little change took place. After that gradually parts of the hills and in sharchi catchment have been converted because the farmers used machinery equipment (tractor) for ploughing on the steep slope area.

By considering the objectives of this study that is the determining of the land cover changes specially converting rangelands to rainfed area in the hilly land this area was separated from mountain and alluvial area.
Variances methods have been used to explain the best way to classify cover types in the study area. Original bands and transformed bands have been used.

4.1. Application of GIS and RS:

A GIS has been variously defined in literature as follows:
A special case of information systems where the data consists of observation on spatially distributed features, activities or events (Dueker 1979,p.105); an interlay referenced, automated spatial information system designed for data management, mapping and analysis (Berry, 1987,p, 1405).
The past two three decades has seen a revolution in our ability to survey and map our global environment.
Digital sensors mounted on satellites scan vast areas of the earth's surface every day and night.
Remote sensing is the activity of generating data from measurements of spectral reflectance.
More general research has indicated that variations in reflected energy from vegetation are not necessarily linked to different species composition, but relate more to the combined effects of individual plants and the structure of the canopy as a whole (Currant, p.T.1984).
Desired information has to be collected from images, either by interpretation of aerial photograph or by satellite images. In many cases this extraction of information from RS data is done by (image/ photo/ picture) interpretation.
Constellations of satellites beam out signals, which enable us to accurately and rapidly position ourselves, and computers stores and process quantities of geographical data, which previously would have been completely unmanageable
The ability to accurately detect changes in land use / land cover pattern in central to the use of remotely sensed data for planning and resource management.
Although land use/land covers are different concept they are in many cases used synonymously.

Here, emphasis is on the agricultural and rangelands area. In this thesis changes of land cover and land use were determined by means of interpretation of aerial photos of 1956,image processing and classification of landsat ETM images (9-jun 2000) and TM (9 august 1990).

4.2. Image processing:

The procedure followed during the image processing phase are used as follows:

- Pre-processing: Geometric correction and image enhancement
- Image classification (unsupervised and supervised)

4.2.1:Geometric correction:

The simple way to link an image to a map projection system is to use a geometric transformation. The process of georeferencing in clouds two steps:

- Selection of the appropriate type of transformation
- Determination of the transformation parameters.

For the study area the available topographic maps was used with UTM projection. For georeferencing the TIE points method, UTM projection with Datum=European 1950(ED 50), Datum area=IRAN, Ellipsoid international 1924 and zone number=38 were used.
Several points were chosen on the image as control points. These points have to be located on the map as accurate as possible and therefore such points as confluences of drainage lines and intersection of roads were selected.
An Affine transformation was used to match the geometry of the satellite image with the UTM geometry of the map. The differences between the actual control point's locations and their position on the imagery are used to determine the geometric transformation required to resample the image. The original pixels are resampled to match the correct geometric coordinates. The nearest neighbour method was used because changes of digital number are avoided. Through the procedure of selective removing control points, the standard deviation (sigma) of the X and Y differences was calculated. Till the least value of 0.6 sigma was obtained, using 13 control points.

4.2.2. Image enhancement:

The goal of image enhancement is to improve the visual interpretation of an image by increasing the apparent distinction between the features in the scene (Lillesand & Kiefer 1994).
In this study this technique was used for edge enhancement, principal components (PC), Hue Saturation, intensity and normalized difference vegetation index (NDVI).

4.3. Image classification:

The overall objective of image classification procedure is to automatically categorize all pixels in an image into land cover classes or themes. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. In this study unsupervised and supervised classification were used.

4.3.1. Unsupervised classification:

A clustering algorithm groups the spectral data in pre-defined number of classes.
The result with 10 clusters is shown in figure 4.1.Results are unsatisfactory. Equal clusters can be seen in different place of Hill area but on the basis of field observation crop types rangeland conditions differ.

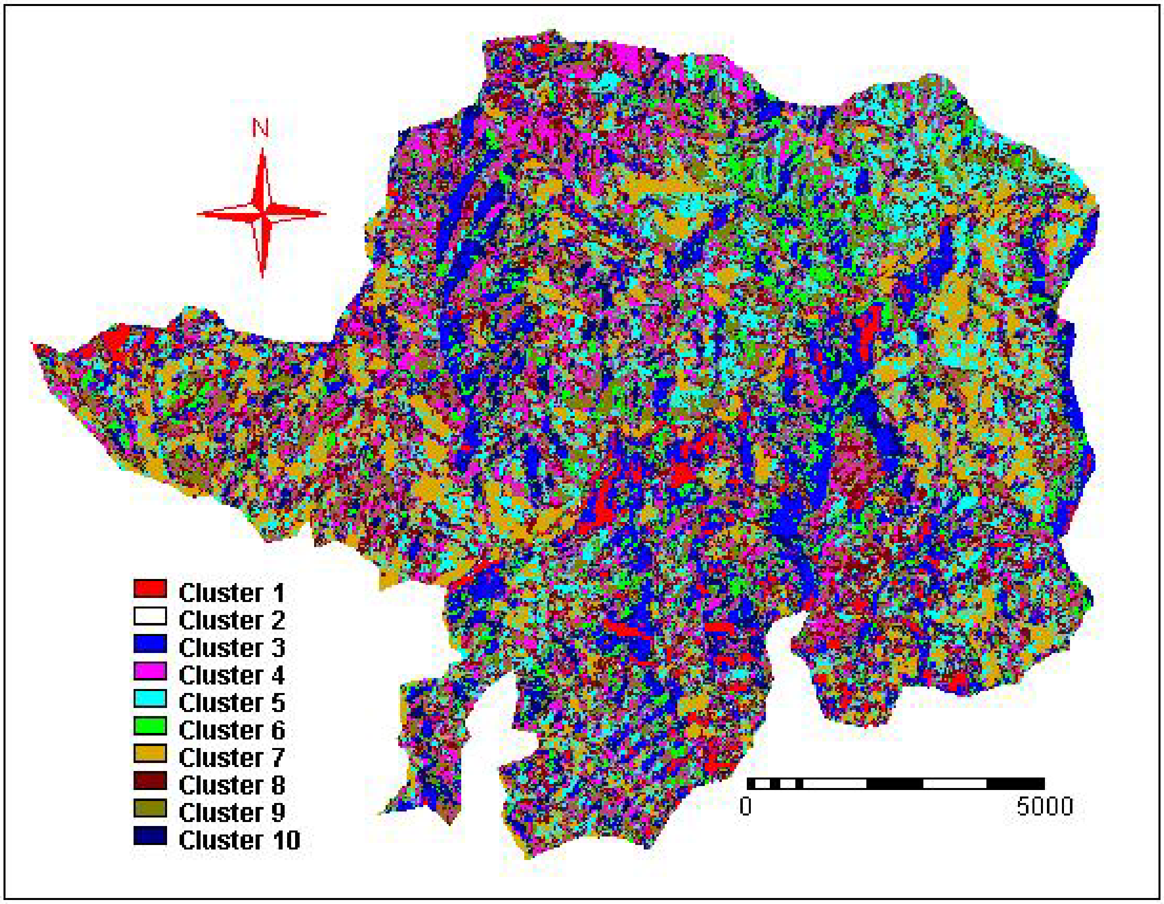


Figure4.1: unsupervised classification of the hilly area

4.3.2. Supervised classification:

A field data set cover types is used as a training set. Figure 4.2 shows the point map based on data collected from the field.

The crops in the study area are wheat, peas, alfalfa, orchard and locally vegetables includes potato, tomato and beans.

In case of spring and summer crops such as peas, alfalfa from May to June is allocated to land preparation. Also alfalfa is harvested 2-3 times per year. Figure 4.3 and 4.4 are showing crop calendar and rotation in the study area also figure 4.5 showing crops type picture.

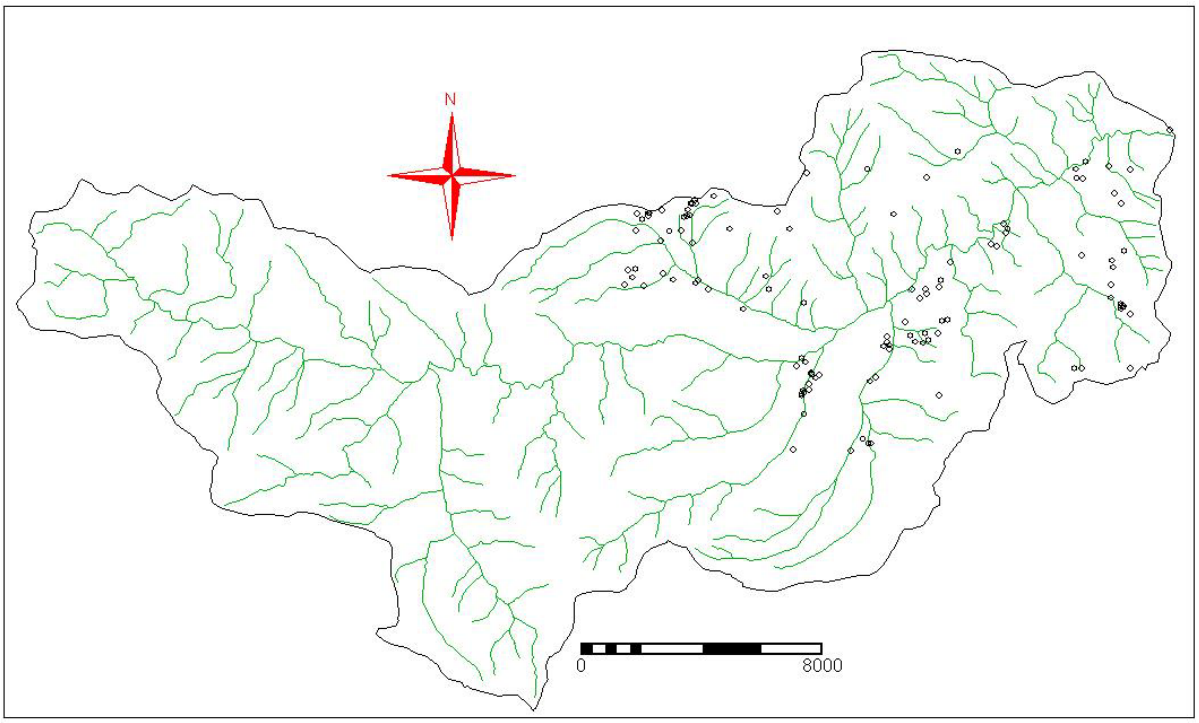


Figure 4.2:drainage pattern with distribution of sample set in the study area

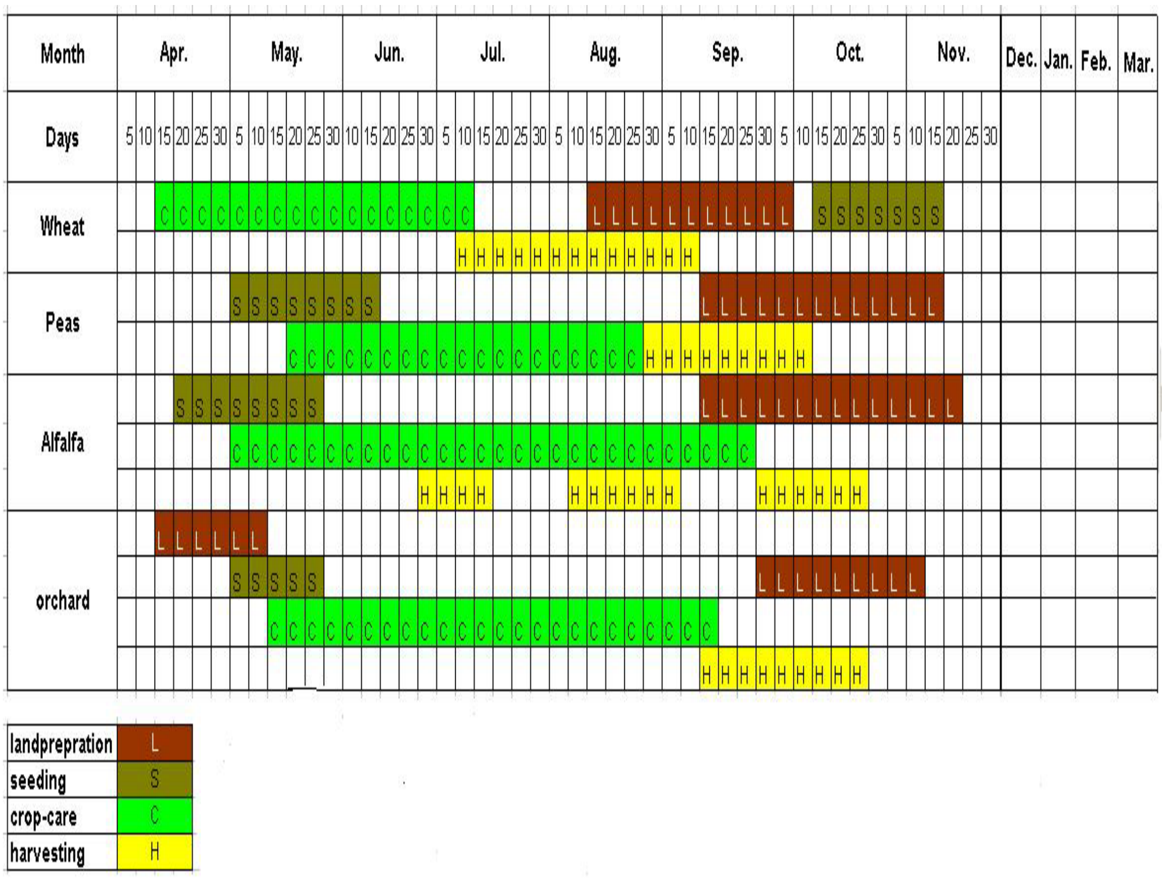


Figure 4.3: crop calendar

Cultivation type	Rotation type	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Rinfed	1	wheat or barley	peas	....	....	....	....
Irrigated farm	2	wheat	peas	alfalfa	alfalfa	alfalfa	alfalfa
	3	alfalfa	alflfa	alfalfa	alfalfa	...	...
	4	vegetable	potato	tomato	bean	...	...

Figure 4.4:rotation crops

Figure 4.5: upper photo: harvesting wheat in face ground and ploughed fields (up-classes slope) in background.

Lower photo: view of the harvesting in the background and sloping cultivated lands in face ground close to covers is a field with yellow flowering Euphorbia.

4.3.2.1. Classification using original landsat ETM bands:

A sample set was created based on field observations.

The feature space of band 4 and band 3 of landsat shows the best separation of clusters of sample set (figure 4.6). There is no overlap between the classes. Observation in the field learned that different trees (Salix, Puplus.alba and Puplus.nigra) are presented in the class “orchard” (Apple and Walnut) and that the orchards have a basic cover of grasses and herbs. Hence variation in this cluster can be expected.

The types of rainfed crops are peas and wheat in rotation, as shown in figure 4.4.some of peas are green and has weed so the value of this cluster for near infrared band a little bit more. The difference between the classes (fallow, rock out crop and poor rangeland) is gradual, so the location of these clusters on the feature spaces is in one line, which can be continued as the “ spectral soil-line”.

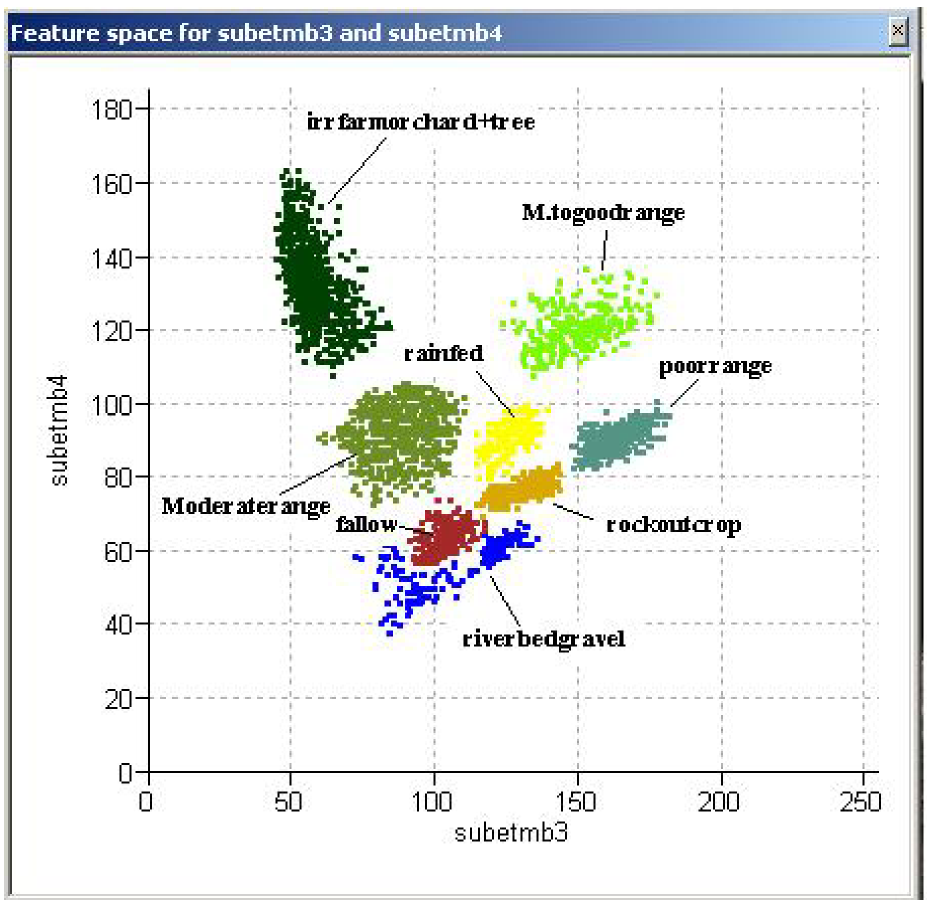


Figure 4.6: feature spaces of the pixel value of band 3 and band 4 of landsat ETM image.

For classification of this sample set the Box, Minimum distance and Maximum likelihood methods were learned (figure 4.7,4.8 and 4.9).

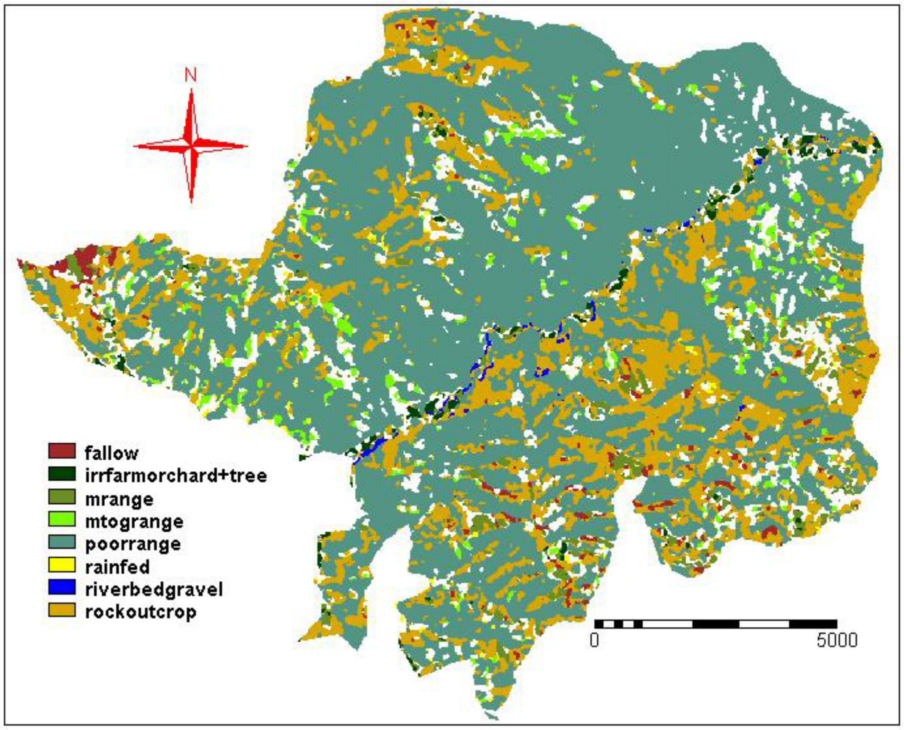


Figure 4.7: box classification

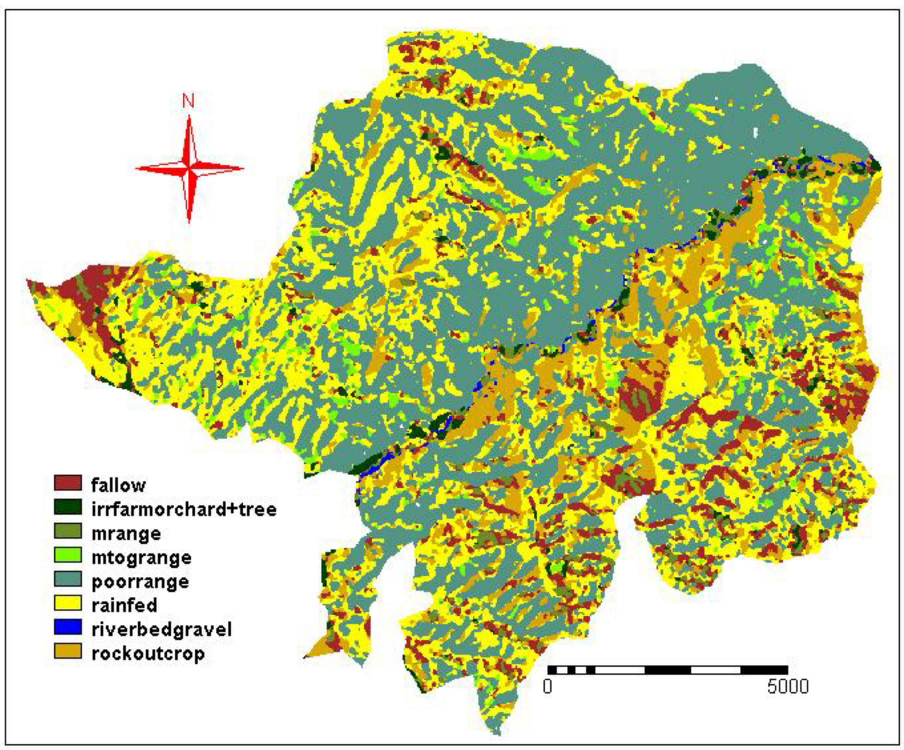


Figure 4.8: minimum-distance classifications

The result of Box and Minimum distance classifier was unsatisfactory. The Box classifier the overlap area of sample clusters is divided, so unknown pixel observations that occur in the overlap areas will be classified as "not sure" or be arbitrarily placed in one of the two overlapping classes such as riverbed gravel, rock out crop and poor rangeland classes.

The minimum distance is mathematically simple and computationally, it is insensitive to different degrees of variance in the spectral response data. In the figure 4.5 the pixel value near the" fallow" class would be assigned by the distance- to mean classifier to the "riverbed gravel" category in spite of the fact suggests that "fallow" would be a more appropriate class assignment. Because of such problems, this classifier is not used.

The maximum likelihood method was selected.

This method gave the best result. Because of the Maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel (figure 4.9).

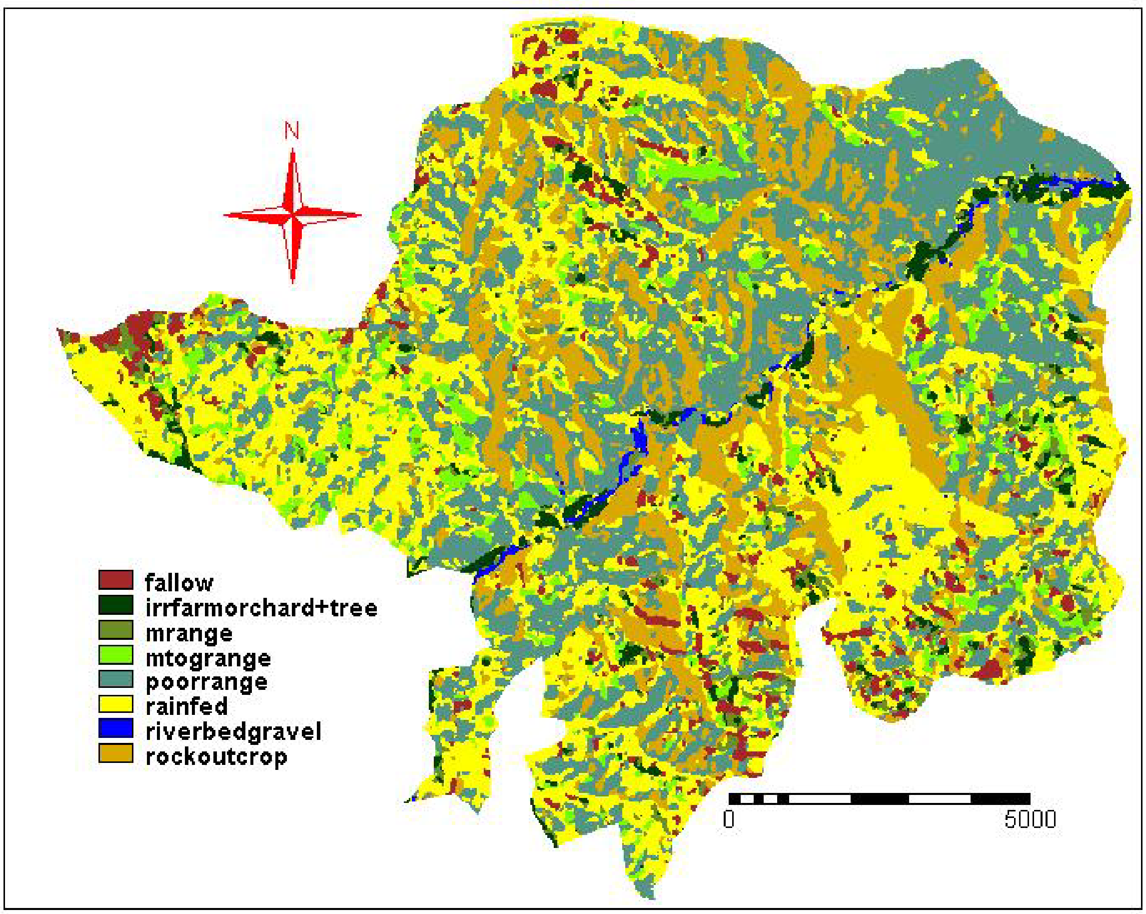


Figure4.9: maximum likelihood classification (ETM landsat 2000)(spectral classification)

4.3.2.2. Accuracy assessment:

Because of the empirical approaches, the results of spectral classification need to be assed for accuracy. To calculate the accuracy of the classification of ETM image the confusion matrix method was used.
For determination of overall accuracy of this classification 60 ground truth sample were gathered, which have not been used to train the classifier.
Crossing the raster map of this sample set with the classified image gives the confusion matrix below:

- The rows containing the results of the classification and columns the control set (ground truth).
- The diagonal elements in the matrix represent the number of correctly classified pixels of each class.
- The off diagonal elements represent misclassified pixels or the classification errors.

The overall accuracy of the classification of present land use map is 80.72%

4.3.4. Classifying with transformed bands:

4.3.4.1-Principal component:
Considering the aim of this study, which is classification of land use and land cover for the principal component transformation was examined.
Principal components analysis can be used for several purposes:
-Data compression, such as seven TM bands using principle components most of the variance in seven bands TM data set can be explained in two or three components.
-Pre-processing procedure prior to classification of the data.
-To find targets of interest of interest (Mather, 1987).
The out put matrix (table4.1) that it contains the eigenvectors of the calculated covariance matrix the best band combination selected (PC1, PC2, PC3).

	subetmb1	subetmb2	subetmb3	subetmb4	subetmb5	subetmb7
PC 1	0.373	0.382	0.45	0.339	0.497	0.388
PC 2	0.289	0.234	0.04	0.61	-0.409	-0.566
PC 3	-0.203	-0.283	-0.576	0.594	0.436	0.063
PC 4	-0.729	-0.151	0.593	0.299	-0.056	-0.03
PC 5	-0.014	0.049	-0.154	0.25	-0.624	0.723
PC 6	0.452	-0.833	0.297	0.087	-0.062	0.046
Variance per band:	14595.22	216.13	164.24	13.15	3.49	1.81
Variance % per band:	97.34	1.44	1.10	0.09	0.02	0.01

Table 4.1: coefficient matrixes of principal components for study area, landsat ETM

As it can be seen, the PC1 contains nearly (97%the spectral variance. this is due to the weight of the intensity component due to relief effect (sun light, shadow), (Dueker, K.J, and D.Kjerne 1987).
A colour composite consisting by of PC1, PC2 and PC3 were used for location of samples. Sample set is shown in figure 4.10,which shows a scatter graph (feature space) of the pixel values of PC1 and PC2.

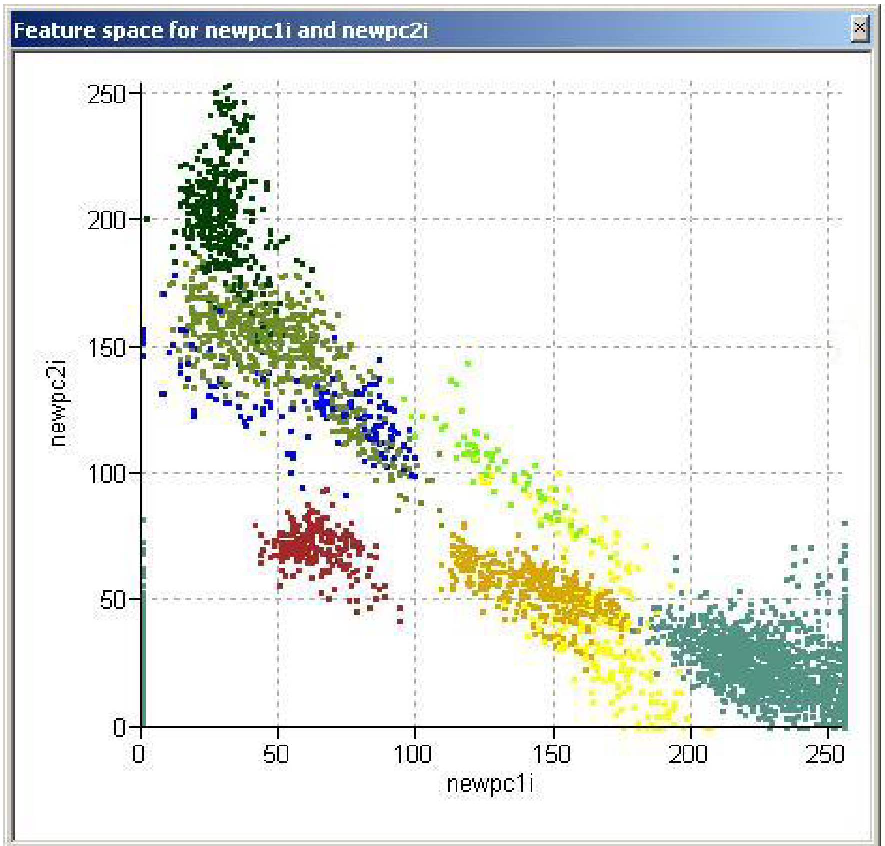


Figure 4.10: feature space of the pixel value of PC1 and PC2 of ETM landsat image.

It can be seen on the feature space, there is overlap (confusion) between all classes except fallow class.
Maximum likelihood classification of this sample set gave unsatisfactory results because moderate rangelands was wrongly classified in many cases e.g. near the main valley. Also the overall accuracy of this classify was 73.49%.
Figure 4.11 shows the result of classification:

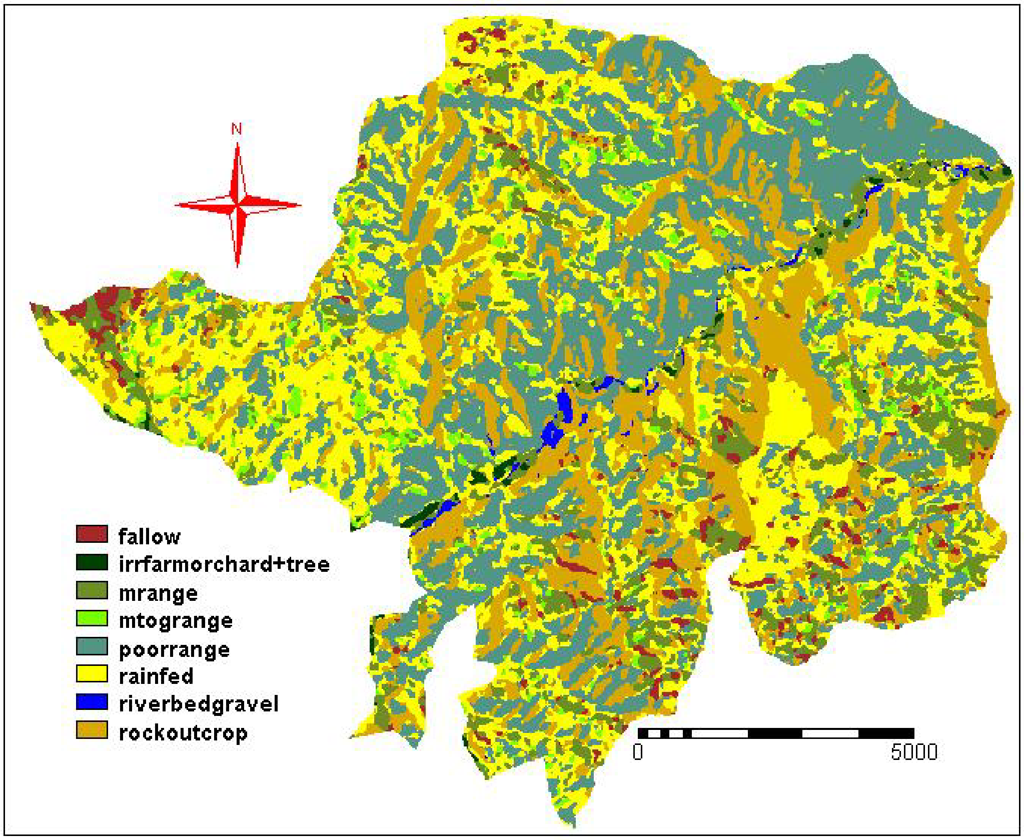


Figure 4.11: land cover map from PC classification

4.3.4.2. NDVI (Normalized Density Vegetation Index):

NDVI is calculated from the visible and near-infrared light reflected by vegetation. Healthy vegetation absorbs most of the incoming visible light, and reflects a large portion (about 25%) of the near infrared (NIR) light, but a low portion in the red band (RED). Unhealthy or sparse vegetation reflects more visible light and less NIR light.

For making the NDVI following formula were used:

NDVI=(NIR-RED)/(NIR+ RED)

Calculation of NDVI for a given pixel always results in a number that ranges from minus one (-1) to plus one (+1): Bare soils give a value close to zero and very dense, green vegetation have values close to +1 (0.8-0.9).

For classification the NDVI is transformed to image values following formula were used.

NDVI =(NDVI+1)*127

This NDVI classified with using bands 2 and 3 of landsat ETM image. As the feature spaces of the sample set from ndvi, 2 and 3 bands shows irrigated farm orchard + tree, moderate to good and moderate rangelands clusters are separated from the other clusters (figure 4.12).

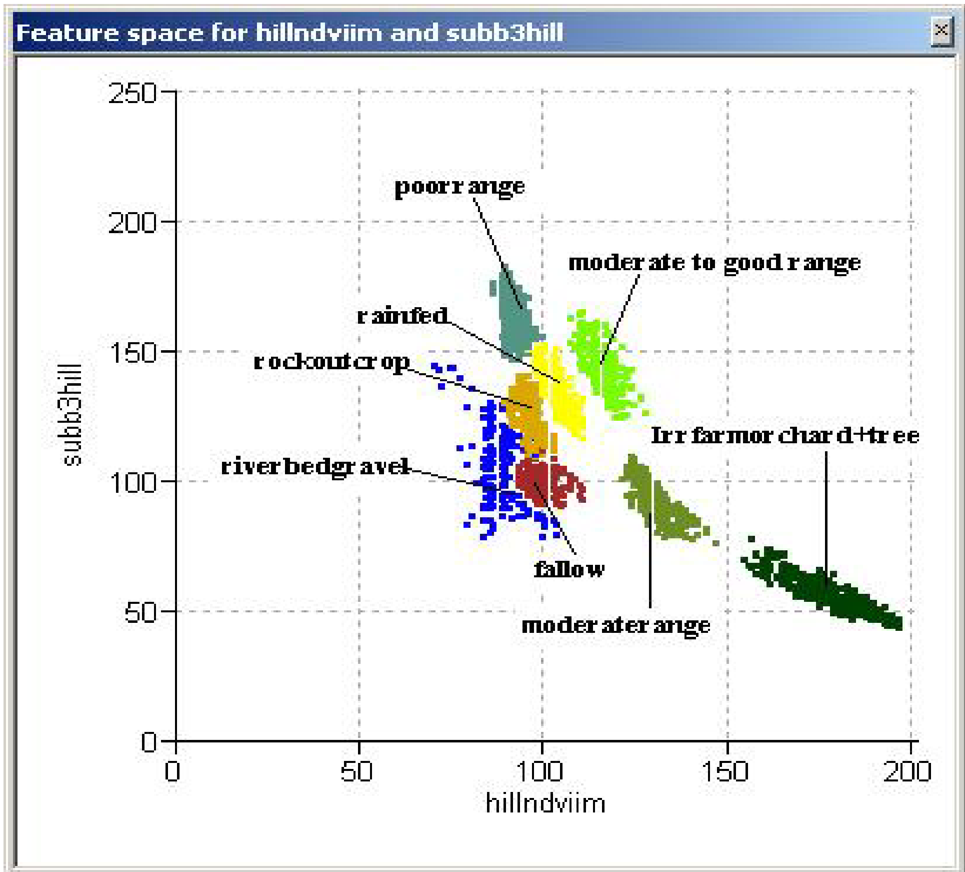


Figure 4.12: feature spaces of the pixel value of band 3 and Ndvi of landsat ETM image

This technique gives a good result for determining of rangelands area but still seems that it cannot be used well for rainfed area and other clusters. That is apparent from inspection of the classification (Maximum likelihood) of this sample set (figure 4.13). Also the overall accuracy of this classify was 76.31%.

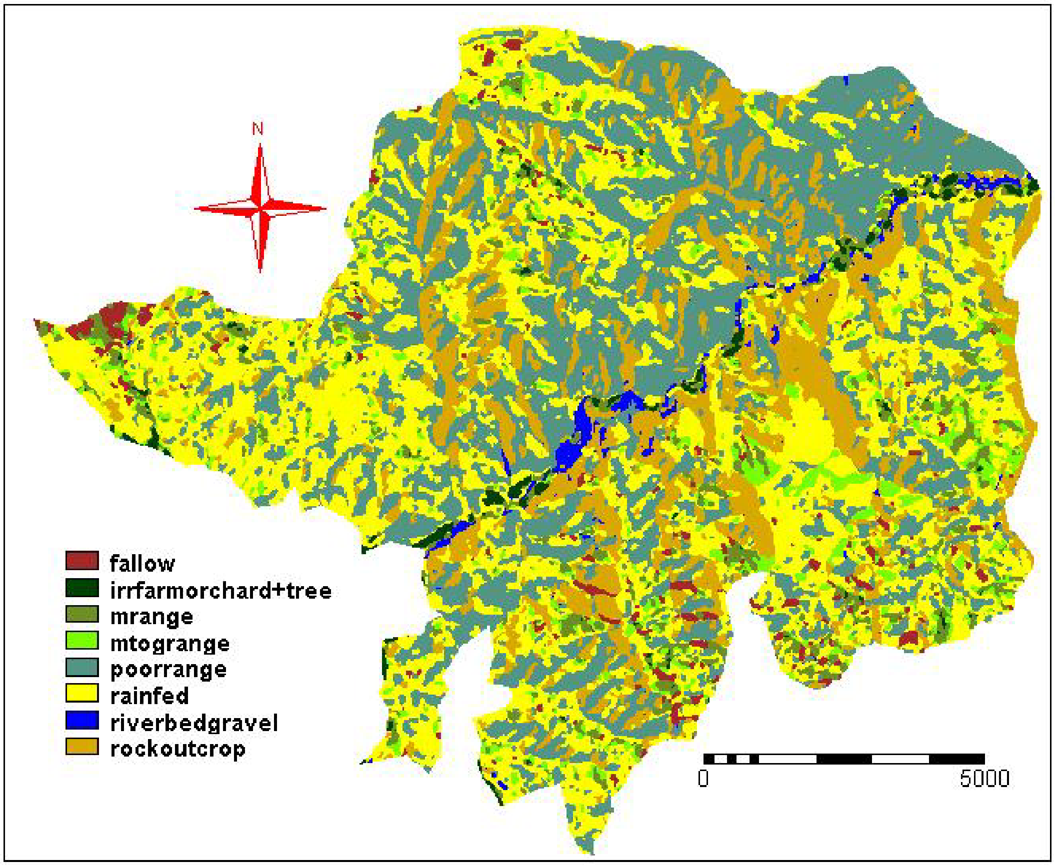


Figure 4.13:NDVI classifications using maximum likelihood method

4.3.4.3:Hue, Saturation, Intensity (HSI):

An alternative to describing colours by their RGB components is the use of the Hue- Saturation - Intensity system. “Intensity” relates to the use of brightness of a colour. “Hue” refers to the dominant or average wavelength of light contributing to a colour. “Saturation” specifies the purity of colour relative to gray (Lillesand & Kiefer 1994)

The advantage of the HIS system is that simple linear distances can be used defining Hue and colour coding of single image (Meijerink 1994).

As it can be seen in the feature spaces of the sample set from HSI that there is overlap between moderate rangelands with moderate to good range and irrigated farm orchard + trees classes (figure 4.14).

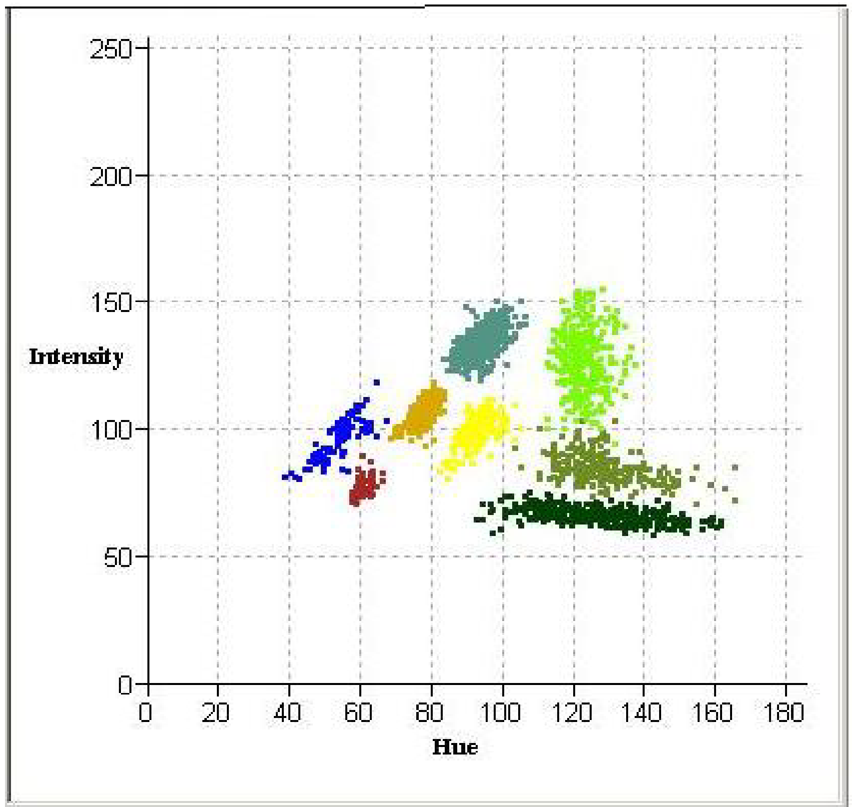


Figure 4.14: feature space of the pixel value of Hue and Intensity.

This sample set was classified by using Maximum likelihood method with threshold 50 (figure 4.15). The overall accuracy of this classify is 72.42%.

This sample set gave unsatisfactory results because the area of moderate to good rangeland is high. On the basis of field observation the area of this class is not much.

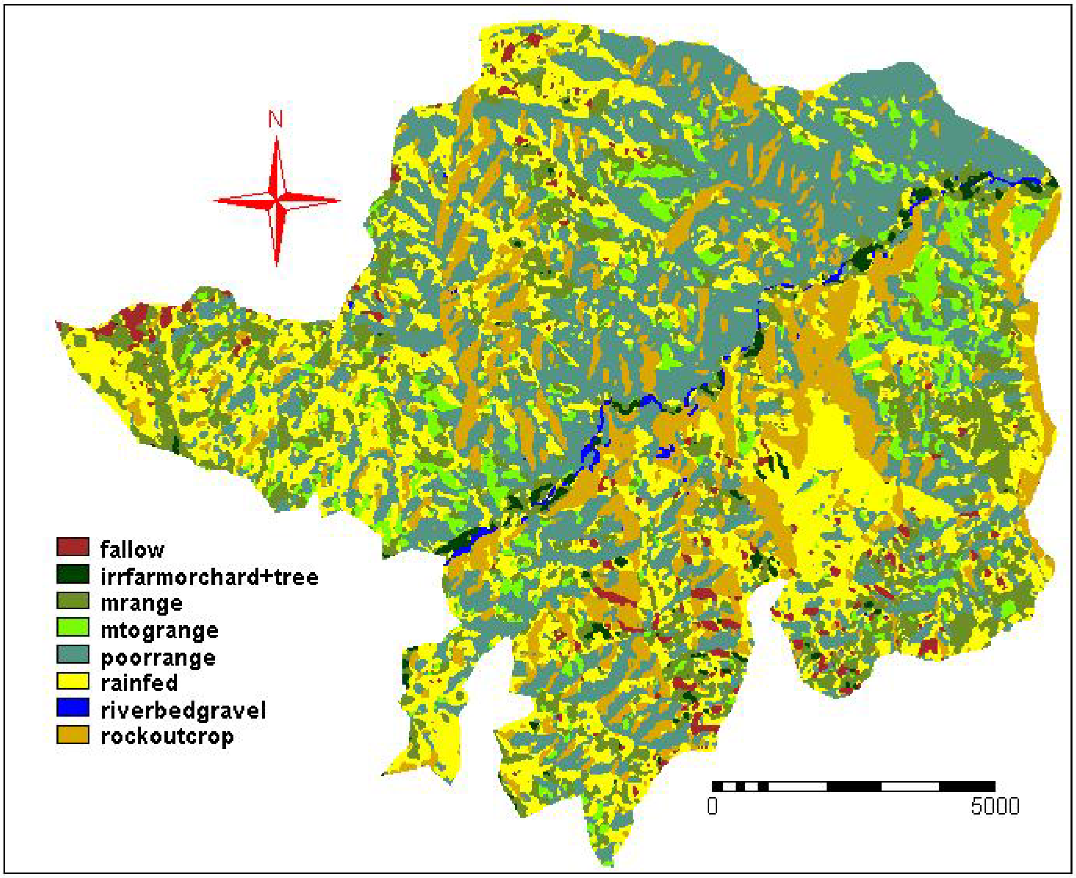


Figure 4.15:land-cover map from HIS classification

4.4. Visual interpretation of ASTER image:

The band (1,2,3) of this image after Geocorrection was filtered using edge enhancement filters, because this method is used for enhancing the imagery for pattern, not spectral. During the fieldwork most of rainfed areas have been delineated by used the FCC (3,2,1) of these bands. Boundaries of the rainfed area were drawn upon the colours and also field experiences.

The resulting map contains units, which compared to field observation, were reasonably representing dry land farms areas (figure 4.16). Using resample operation in Ilwis software new rainfed area with 30 meters pixel size is generated. Figure 4.17 shows present land cover map of study area.

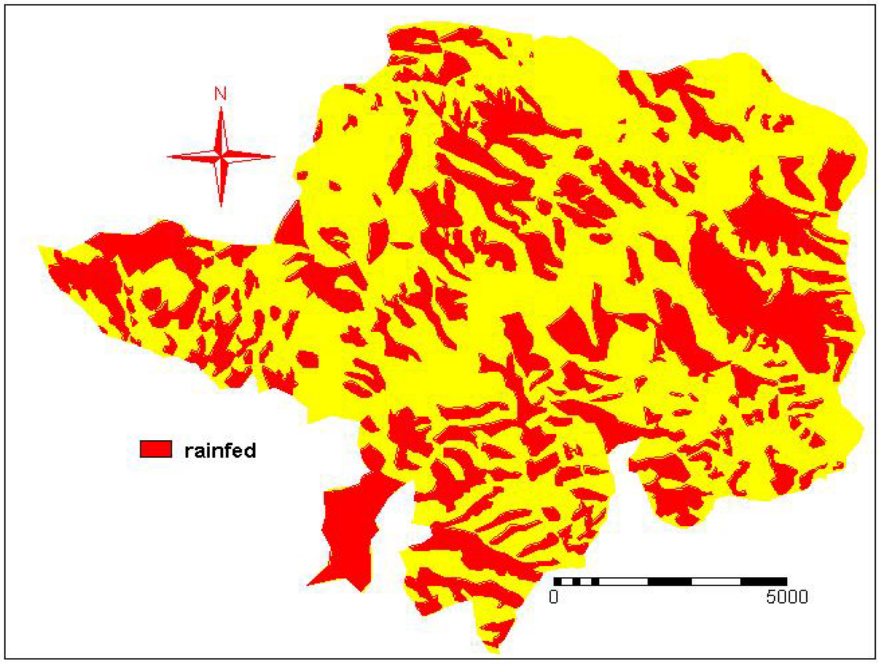


Figure 4.16: rainfed areas map based on visual interpretation using enhanced ASTER images (15 m resolution) resampled to 30 meters.

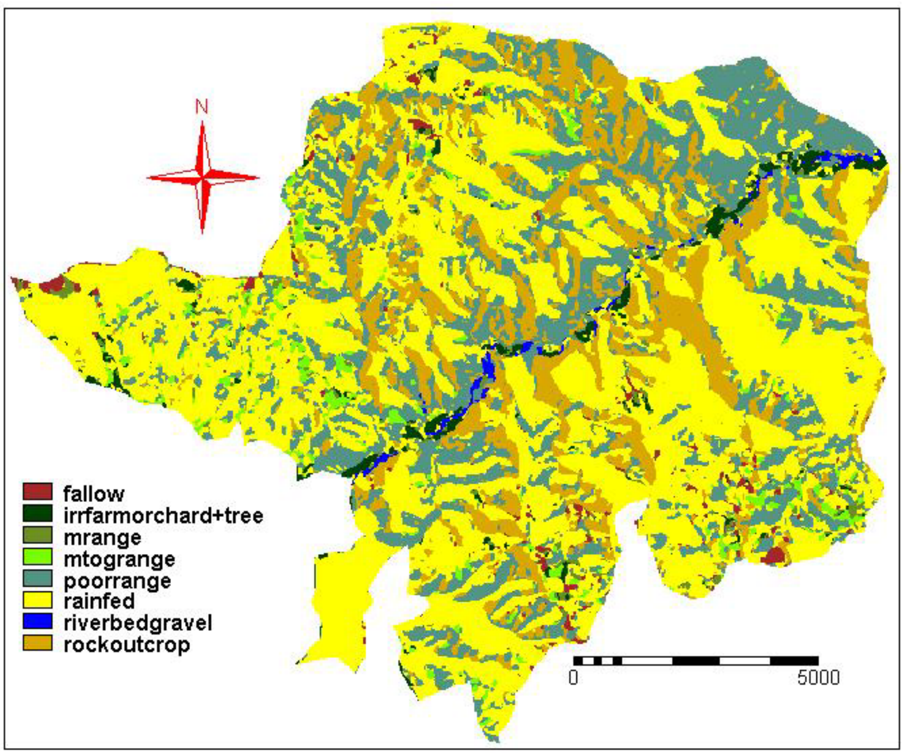


Figure 4.17:present-land-cover map of study area based on multispectral classification (maximum likelihood) of ETM 2000 data with visually interpreted class “rainfed” added

4.5. Past land cover map:

The past land cover map was carried out by classifying the Landsat TM image of 9 Aug 1990 that is 12 years ago. A sample set was created in which the relevant data regarding input bands (map list 4,3,2). Using pattern and interviewing with farmers samples was taken from this sample set.

This sample set classified. Maximum likelihood classification, which assumes that the feature vectors of each class are (statistically) distribution according to a "multivariate normal probability density function" and threshold 100 was used as the method of the classification (figure 4.18).

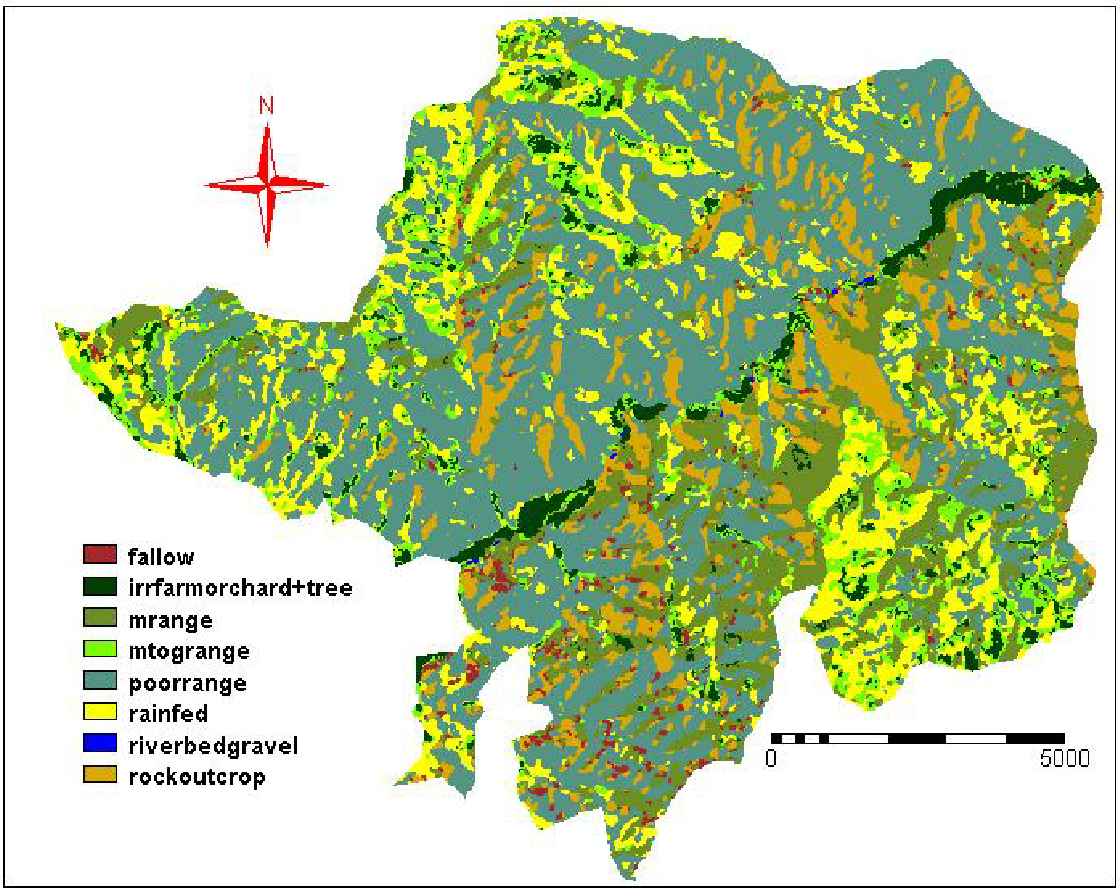


Figure4.18: land-cover map from TM landsat image

4.6. Arial photo interpretation:

The past land cover pattern survey was carried out by interpretation of aerial photos of 1956. Photo interpretation with field inventories led to produce the past land use pattern map (Figure 4.19).

It was possible to only distinguish the major land uses that seems to be sufficient for the purpose of land use changes during the period mentioned.

The main part of the area consists of rangelands with a surface area 36591 hectare.

It means more than 88% of the total area was occupied by rangelands. The remaining surface area belonged to the cultivated area.

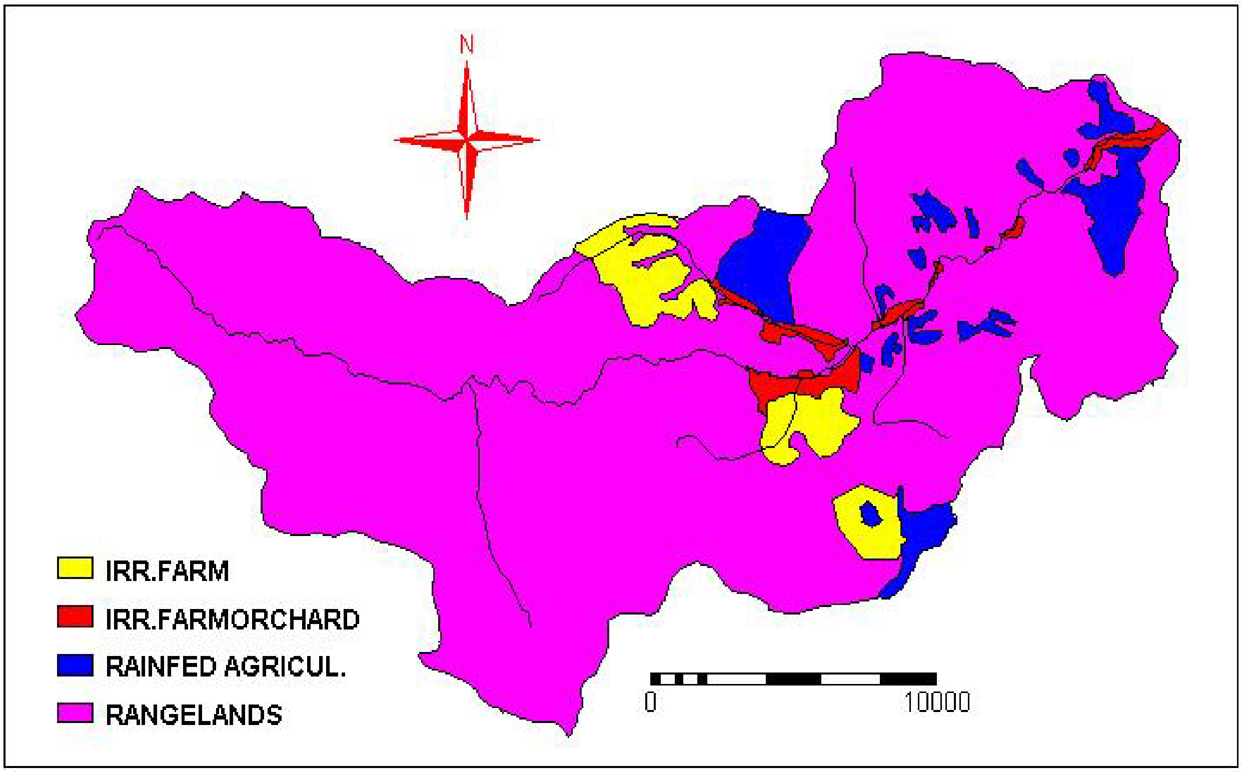


Figure4.19: past land cover map (aerial photo 1956)

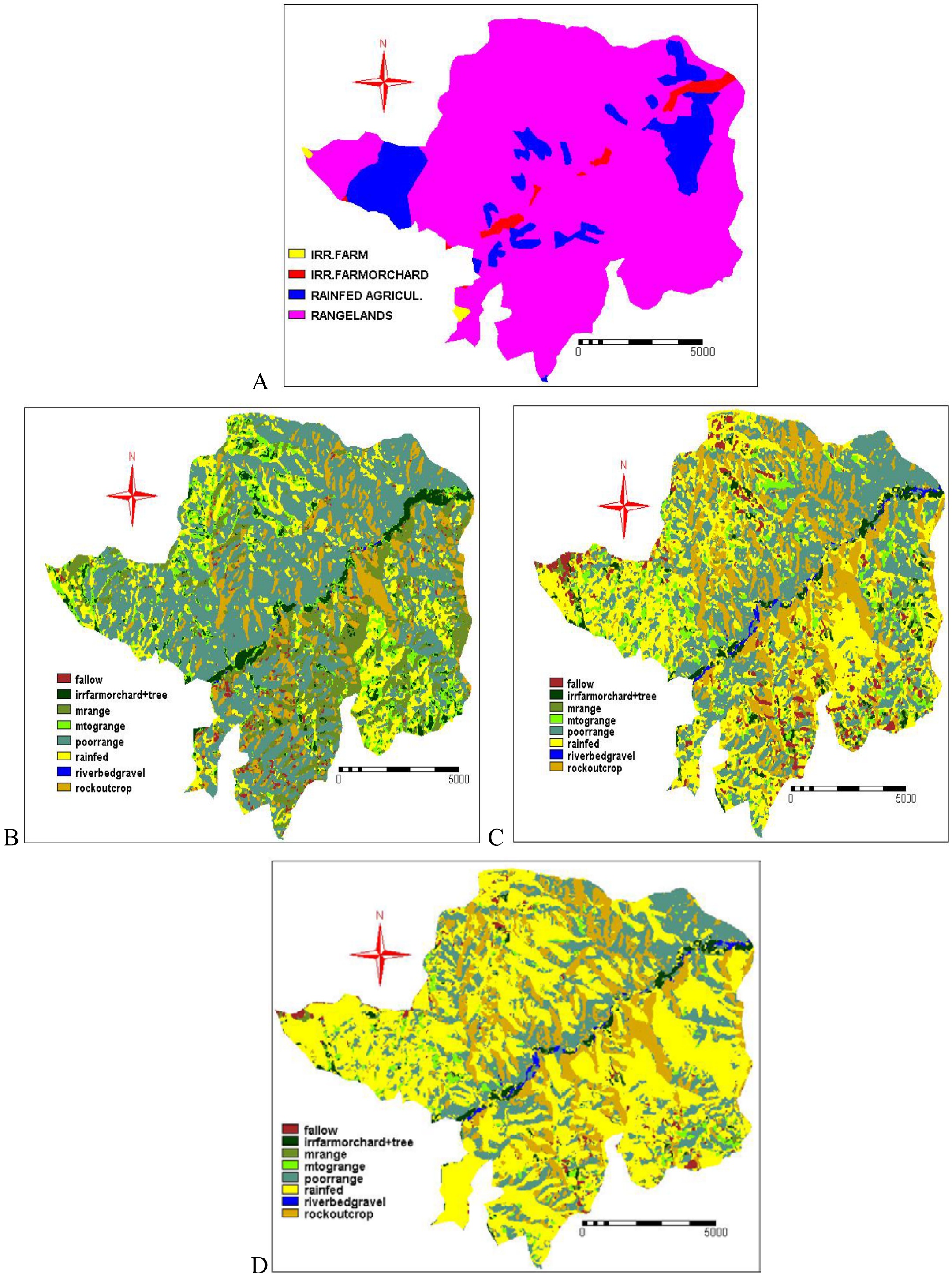
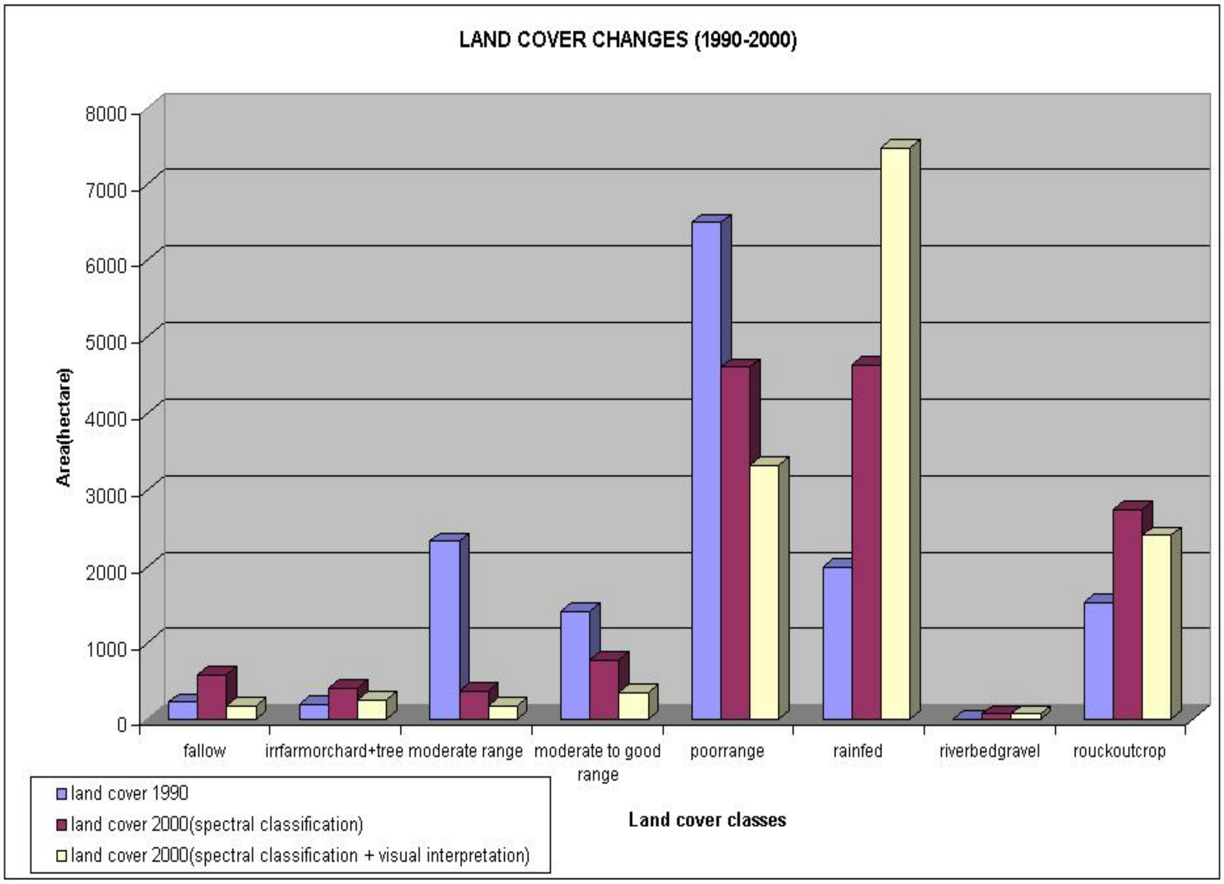
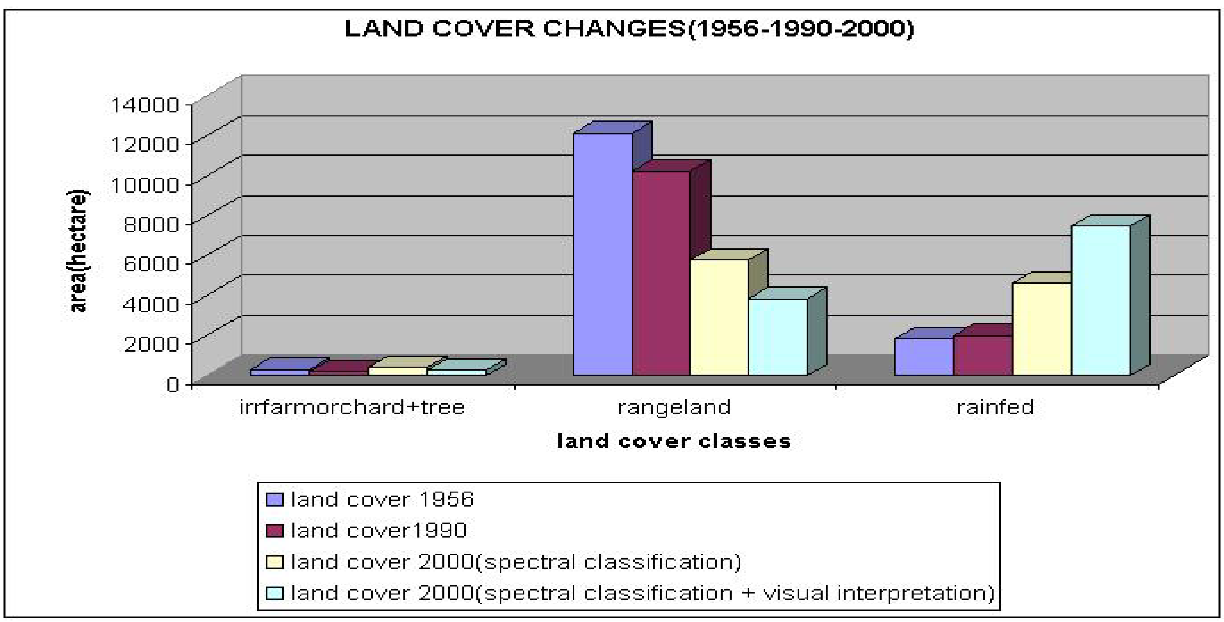


Figure4.20: land cover map 1956 from aerial photographs (A), 1990 from spectral classification TM Landsat (B), 2000 spectral classification from ETM Landsat (C) and 2000 data with visually interpreted (ASTER 2000) class “rainfed” added (D).





Figuer4.21: land cover changes during 1956-1990-2000 years

According to the figure 4.21 the sequence of land cover changes including:

- Decreasing moderate to good and moderate rangelands.
- Increasing poor rangelands. It is possible that increase of poor rangelands is due to farmers converted rangelands to rainfed area and they left these area because the soil of these area were unsuitable for cultivating.
- Increasing rainfed crops about 39 % from 1956 to 2000 year, rock out crop and riverbed gravel in present land cover.
- Increasing irrigated farm and orchard in the study area. Irrigated farm area decrease on the 1990 year it can be due to the decrease of water resource.
- The percentage area of rainfed crops with visual interpretation (52%) is more than spectral classification (33%), so this result shows that the spectral properties from rangelands and rainfed crops are mixed especially poor rangelands class.

Table 4.2: land cover changes during 1999 and 2000 years

landcover classes	area(hc)1990	percentage	area(hc)2000(spectral clasification)	percentage	area(hc)2000 (spectral clasification. + visual interpretation)	percentage
fallow	228	1.6	583	4	184	1
irrfarmorchard+tree	200	1.4	415	3	255	2
moderate range	2332	16.4	380	3	177	1
moderate to good range	1411	9.9	780	5	348	2
poorrange	6499	45.7	4608	32	3319	23
rainfed	1999	14.1	4631	33	7468	52
riverbedgravel	8	0.1	75	1	72	1
rouckoutcrop	1535	10.8	2743	19	2406	17

Table 4.3: land cover changes during 1959 and 2000 years

land cover classes	past land cover	%past land cover	area(hc)1990	area(hc)2000
irrfarmorchard+tree	293	2	200	255
rangeland	12123	85	10241	3844
rainfed	1822	13	1999	7468

Table 4.4: land cover changes during 1990 and 2000 years (percentage)

landcover classes	percentage 1990 year	percentage 2000 year	change percent
fallow	1.6	1	0.3
irrfarmorchard+tree	1.4	2	-0.4
moderate range	16.4	1	15.2
moderate to good range	9.9	2	7.5
poorrange	45.7	23	22.4
rainfed	14.1	52	-38.4
riverbedgravel	0.1	1	-0.5
rouckoutcrop	10.8	17	-6.1

Table 4.5: land cover (1990) vs. slope

land cover classes/ Slope classes	0-2	2-5	5-8	8-15	15-30	30-60	>60
Fallow	9	10	17	64	109	13	0
%	4	5	8	29	49	6	0
Irrigated farm orchard + tree	125	79	63	154	165	23	1
%	21	13	10	25	27	4	0
Moderate rangelands	55	95	114	504	1121	328	0
%	2	4	5	23	51	15	0
Moderate to good rangelands	50	64	75	309	474	66	0
%	5	6	7	30	46	6	0
Poor rangelands	166	327	452	2037	3008	437	2
%	3	5	7	32	47	7	0
Rainfed crop	54	108	161	612	908	120	0.9
%	3	5	8	31	46	6	0
Riverbed gravel	0.4	1.1	1.9	0.7	3.2	0.5	7.7
%	5	14	24	9	41	7	0
Rock out crop	25	46	59	345	818	226	0
%	2	3	4	23	54	15	0

Table4.6: present land cover (2000) vs. slope

land cover classes/ slope classes	0-2	2-5	5-8	8-15	15-30	30-60	>60
Fallow	3	16	16	52	71	8	0
%	2	10	10	31	43	5	0
Irrigated farm orchard + tree	75	46	30	51	46	6	0
%	29	18	12	20	18	2	0
Moderate rangelands	21	21	16	44	65	8	0
%	12	12	9	25	37	5	0
Moderate to good rangelands	11	21	35	123	143	10	1
%	3	6	10	36	42	3	0
Poor rangelands	110	171	209	924	1584	275	1
%	3	5	6	28	48	8	0
Rainfed crop	191.9	377	544	2323	3408	511	0
%	3	5	7	32	46	7	0
Riverbed gravel	0.4	1.1	1.9	0.7	3.2	0.5	0
%	5	14	24	9	41	7	0
Rock out crop	44	71	89	503	1278	393	0
%	2	3	4	21	54	17	0

According to tables 4.2, 4.3, 4.4, 4.5, 4.6:

I: converting sloping areas for agricultural purposes increasing specially rainfed crops.
II: increasing rainfed crops that are located in hilly area that it has the low resistance lithology to erosion.
III: there is 6664 hectares of the present land cover known as rainfed agriculture that was rangelands in past land cover from aerial photo.
IIV: 52% of rangelands area from 1956 to 2000 year was converted to rainfed area.

4.7. Discussion of result:

To determine present land cover unsupervised, supervised classification (using original bands of ETM Landsat and transformed bands) and visual interpretation of ASTER image were tried.
The result of unsupervised classification bands of ETM Landsat was unsatisfactory because equal spectral can be seen in different places of hill area and mountain area but on the field observation these classes have no meaning.

Results of Supervised classification using transformed bands included:

- Maximum likelihood classification of principal component (PC1, PC2, PC3) gave unsatisfactory results because moderate rangelands was wrongly classified in many cases e.g. near the main valley. Also the overall accuracy of this classify was 73.49%.

- Maximum likelihood classification of NDVI using bands 2 and 3 ETM Landsat showed that this technique gives a good result for determining of rangelands area but still seems that it cannot be used well for rainfed area and other clusters. Also the overall accuracy of this classify was 76.31%.

- Hue, Saturation, Intensity classification (maximum likelihood) gave unsatisfactory results because the area of moderate to good rangeland is overestimated. On the basis of field observation the area of this class is not much. Also the overall accuracy of this classify was 72.42%.

Hence the classification of original bands of ETM land sat (4,3,2) using maximum likelihood method gave satisfactory result. However there were some problems for distinguishing rainfed crop area because the month of image is not appropriate for delineation of rainfed crop areas. The spectral properties from rangelands and rainfed crops are mixed in this month. For solving this problem on screen of fields from the ASTER image was done using pattern to determine rainfed crop area, because of high resolution. The resulting map was reasonably representing dry land farm areas.

So a comparison between the results of spectral classification of ETM Landsat image and visual interpretation of ASTER image shows that visual interpretation is better than spectral classification for delineation of rainfed crops.

Anyhow in Shar-chi catchment land use types can be grouped to irrigation (farm, orchard), rainfed crops and rangelands.
On the basis of field observation Irrigated agriculture concentrated in the alluvial area and along the valley also there are some orchards that are mostly apple trees and also walnut with intercrop also there are puplus and Salix trees.
Considering the aim of this study land use type of hilly area is very important because most of rainfed crops (7468 hectares) are located in this area and type of geology is low to medium resistance to erosion so it has more erosion and production of sediment yield.

About the mountain area, not much can be said. Because of high steep slopes, higher elevation, lack of roads for car and near to the boundary with Turkey it was very difficult to access this part but by considering the vegetation types map (figure 3.5) a large area of this part is covered by natural vegetation cover.

Chapter5: Analysis of the sediment yield:

Introduction:

The sediment yield as determined at the outlet of a catchment is the expression of the erosion and deposition in a catchment. There is overwhelming evidence that cultivation increases erosion, Therefore, it is relevant to study the trend in sediment yield of the Shar-chi catchment in the light of the increased cultivated acreages in the downstream part of the catchment, the "Hills". As described earlier in this thesis expansion of cultivation on the sloping lands of the Hills has led to increased erosion on the fields as was observed by Rashidi (1997) and has led to abandoning of some fields, because no more topsoil was left.

There are two gauging stations in the catchment where sediment sampling was done in the period 1974 to 1999 The upstream one is at Mirabad, where the catchment consists of the mountain unit. The downstream one is at Band, where the river leaves the hills to enter into the alluvial plain.

In the mountains, no conversion to arable land has taken place. Although the Erosional conditions in the mountains are different from those in the hills, the sediment yield from the mountain can serve as control data on the sediment yield of the Band station, which contain the effects of conversion from rangeland to cultivated land. In the Mountain and the Hill units the drainage networks are incisive and little sediment is deposited. These units have sediment delivery ratios close to unity. In the alluvial zone between Mirabad and Band stations, some of the bed load can be deposited, but nearly all of the suspended load is kept in transport.

Only suspended part of the total load is evaluated and bed load is not include, but in most catchments the dominant parts of the eroded material consist of suspended load (Lal, 1994).

For the analysis of the data care must be taken, because there are some sources of errors that initiate from problems in measurements and also the way analysis is done on available data (Walling, 1994). Continuous records of stream discharge are readily available at most measuring stations, but an equivalent record of sediment concentration may be difficult to obtain by a program of manual sampling (Walling and Webb, 1982).

Estimation of suspended sediment load produced using these indirect load calculation procedures may involve considerable errors and the resultant data must be treated with caution.

In a study that have been carried out by W. T. Dickson it has been suggested that the moving rating curve method is the most accurate and precise method for all but the lowest sampling frequency (Dickinson, 1981).

5.1. Sediment rating curve:

For the analysis of the sediment yield 26 years of records of the upstream Mirabad station (n=495 see appendix 5) were plotted against the discharges at the time of the sampling. The resulting rating curve is shown figure 5.1 and for the downstream Band station (n=336 see appendix 6) in figure 5.2.

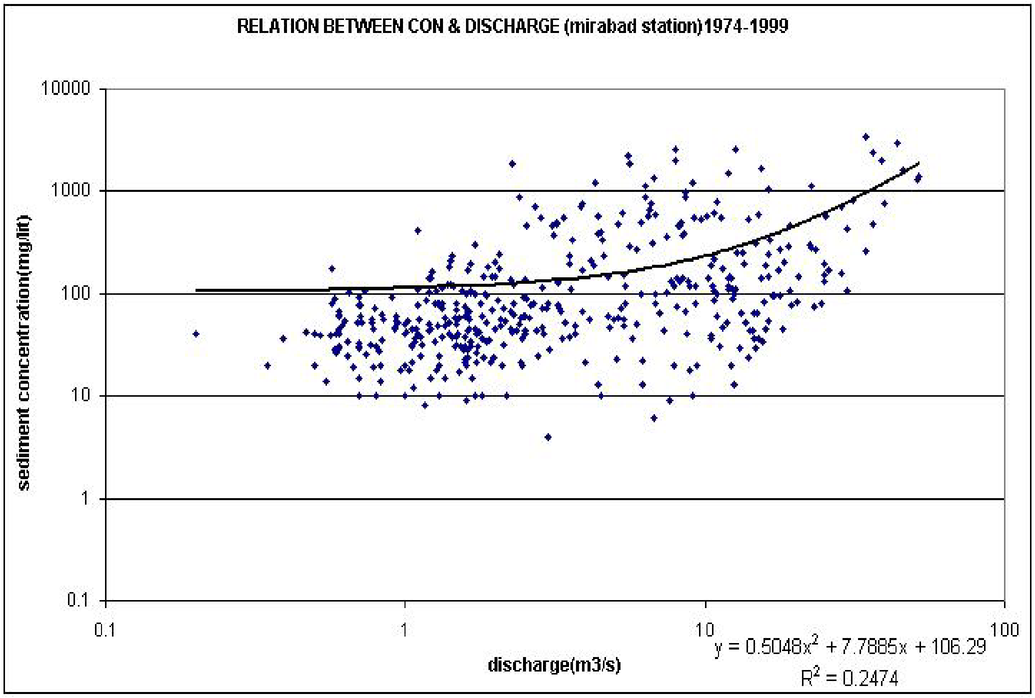


Figure5.1: Relationship between discharge and sediment concentration in Mirabad station

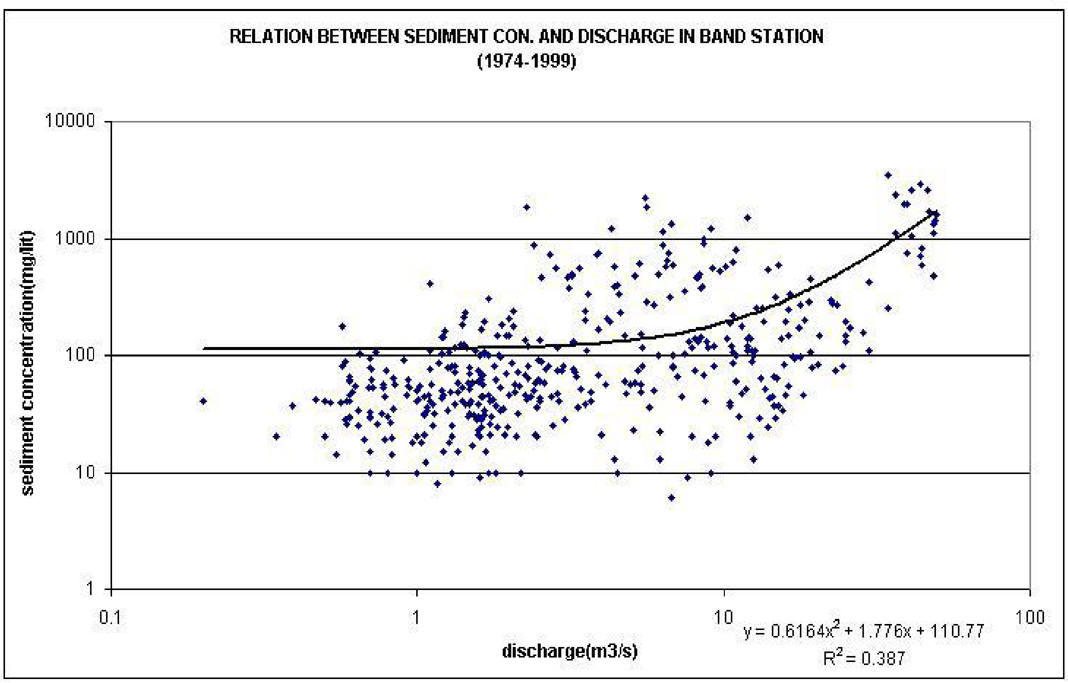


Figure 5.2:Relationship between discharge and sediment concentration in Band station

As can be seen, there is much scatter on both graphs, and the poor correlation coefficients require analysis of segmented data.

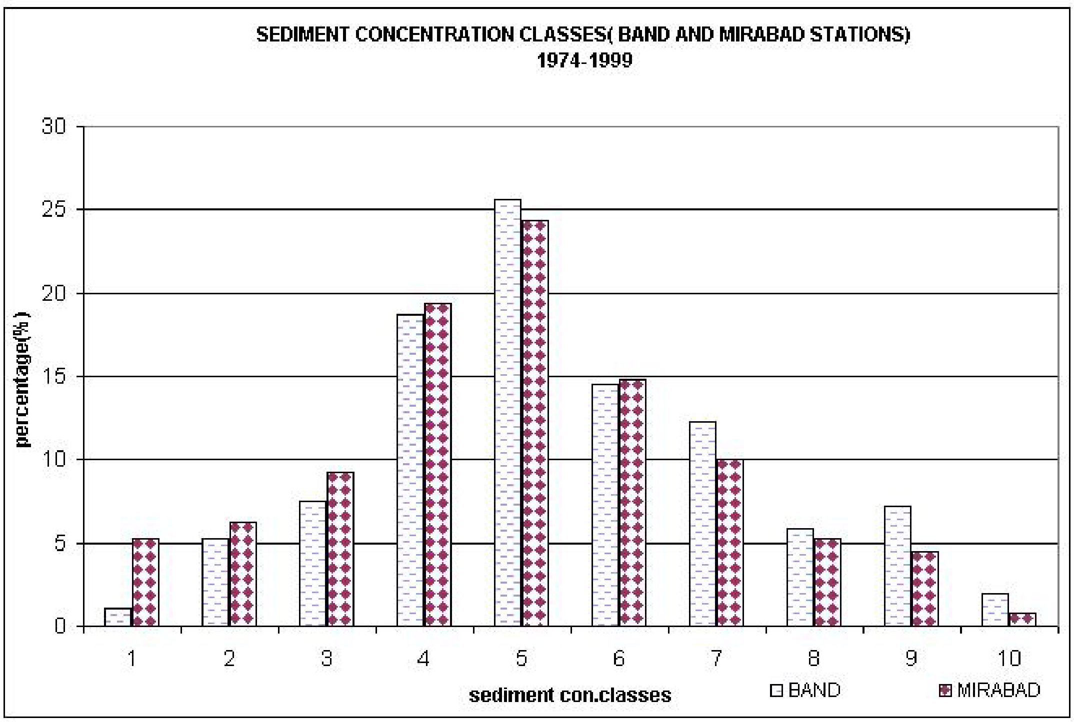
The scatter for the mountain catchment can be partly explained by the effect of snowmelt, which causes discharges in the medium range (say, up to some 15 m^3 /sec.), but with low sediment concentrations. The same discharges, if caused by rainfall during summer or in spring at lower altitudes, will have high sediment concentrations.

The scatter for the data of the Band station can be explained mainly by the variable extension and erosivity of the rainfall, although snowmelt runoff during early spring also occurs. Widespread depressional rainfall with low intensities may cause appreciable discharges but low to moderate sediment concentrations. High intensity storms with limited size cause high sediment concentrations, but only moderately discharges.

5.2:Frequency analysis of sediment data:

For the frequency analysis of sediment data, the have been divided into ten classes histogram of sediment concentration as can be seen on figure 5.3.

For the low concentrations, up to 50 mg/l, the mountain Mirabad station has somewhat higher concentrations that the downstream Band station, but for the higher concentrations the reverse is true. This confirms the more erosive nature of the soils and the poor vegetal protection in the Hills, compared to the Mountain unit.



class	sediment concentratio(mg/lit)
1	0-10
2	10--20
3	20-30
4	30-50
5	50-100
6	100-200
7	200-500
8	500-1000
9	1000-5000
10	>5000

Figure5.3: percentage of sediment concentration classes in Band and Mirabad stations

5.3. Suspended load data analysis:

For finding a more accurate way to obtain the sediment yield than by using the general rating curves, the monthly data and seasonal data were analysed, and results are given in table 5.1. In the appendix 1,2,3 the graphs are shown.

These plots are included:

- Sample of each month (see appendix 7)
- Sample of spring and autumn seasons (see appendix 8)

Table 5.1 shows the result of regression between sediment concentration and discharge for the different plots that it mentioned above.

BAND STATION	PREDICTED VARIABLE	REGRESSION	R squre
JAN.	Y=1.2516e^-0.0016x	plonominal	0.11
FEB	Y=39.049e^0.1987x	exponential	0.02
MARCH	Y=11.414x^2-23.707x-6.8284	plonominal	0.11
APR.	Y=104.67e^0.0924x	exponential	0.56
MAY	Y=1.1442x^2-19.207*-x+364.3	plonominal	0.78
JUNE	Y=57.326*e^0.0613x	exponential	0.17
JULY	Y=57.326e^0.0613x	exponential	0.17
AUG	Y=48.323e^0.1281x	exponential	0.01
SEPT	Y=-18.779x^2+64.323x+26.495	plonominal	0.1
OCT	Y=16.824x^2-39.601x+127.38	plonominal	0.84
NOV	Y=44.196x^0.7839	power	0.29
DEC	Y=0.5944x^2+58.626-6.1933	plonominal	0.62
SPRING	Y=83.607e^0.0711x	exponential	0.32
AUTUMN	Y=42.496e^0.2233x	exponential	0.25
TOTALL(TON/DAY)	Y=3.8112x^1.5174	power	0.76
MIRABAD STATION			
JAN.	Y=9.4659e^0.9668x	exponential	0.53
FEB	Y=22.745e^0.4386x	exponential	0.08
MARCH	Y=56.539e^0.0607x	exponential	0.05
APR.	Y=95.082e^0.053x	exponential	0.15
MAY	Y=198.34*e^0.0109x	exponential	0.0032
JUNE	Y=45.922*e^0.0488x	exponential	0.09
JULY	Y=31.51x^0.3079	power	0.09
AUG	Y=63.494e^0.0472x	exponential	0.0014
SEPT	36.452e^0.3371x	exponential	0.24
OCT	Y=0.7701e^0.0021x	exponential	0.25
NOV	Y=0.9914e^0.0054x	exponential	0.09
DEC	Y=1.0933e^0.0025x	exponential	0.11
SPRING	Y=50.3344e^0.0631x	exponential	0.24
AUTUMN	Y=30.669e^1756x	exponential	0.27
TOTALL(TON/DAY)	Y=3.6961*X^1.5668	power	0.72

Table5.1: result of regression between sediment concentration and discharge

As can be seen from table5.1. For the Band station the best correlations were obtained for the months of May and October, when rainfall occurs. This is also the case for the most of the spring data and for the autumn data, but correlations were poor. The different nature of erosive processes in the mountain catchment is apparent from table5. 1, no strong correlations were found.
It is difficult to provide further details because erosive processes were not studied in the field at different times of the year.

5.4:Annual sediment yield:

Segmentation by months or seasons will not improve a more accurate estimate of the sediment yield, Therefore the suspended load data was expressed in tons/day, that following formula was used:
Suspended load (ton/day)= 0.0864*sediment concentration (mg/lit)*discharge at the same time (m3/s) and was plotted against discharge, see figures 5.4 and 5.5.
The data sets were split up in a part with low discharges (Band: 0.1-19 m^3.sec., Mirabad 0.1 –17 m^3.sec) and a part with high discharges (Band > 19 m^3.sec ,Mirabad > 17 m^3.sec.)_as indicated in the figures, to which an exponential function was fitted. The correlation coefficient for Band station was r =0.88 and for Mirabad station r =0.85, for the fit of the exponential function.
Band station:

19< Q<70 m3/s: **Y=68.25*2.74 *e^0.1096X**

Mirabad station:

17< Q < m3/s: **Y=23.008 *e^0.1192X**

Where the Y is sediment load in ton/day and X is discharge in m3/s. the result of estimating sediment yield for each year is in the table see appendix 9.
For the conversion of suspended load to sediment transport using daily discharges, the arithmetic average of the low ranges were taken and for the higher ranges the exponential equations.
Summing up the daily values and dividing the totals by catchment area derived the annual sediment yield.

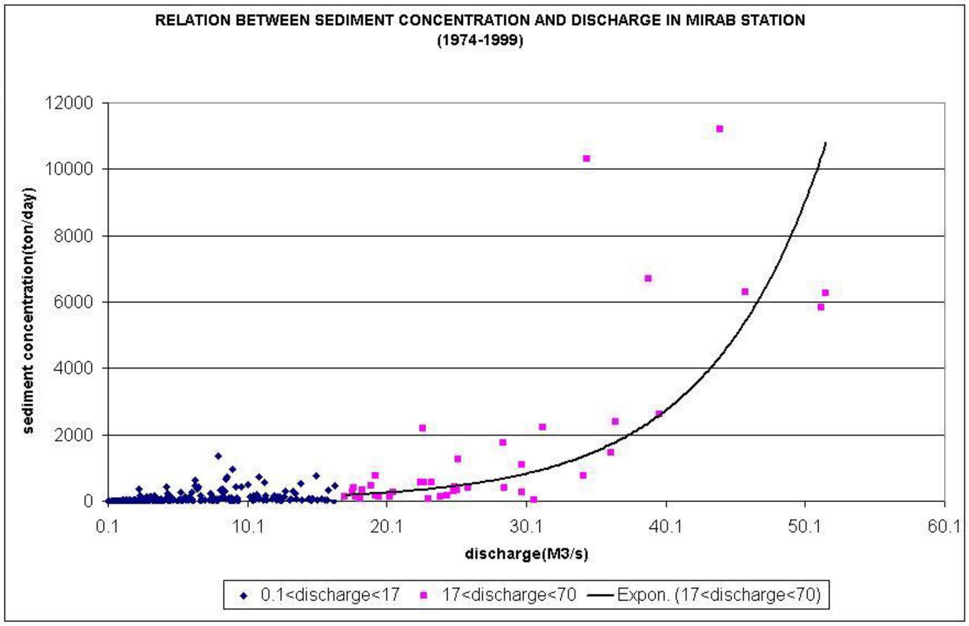


Figure 5.4: the relationship between sediment load (ton/day) and discharge in Mirabad station

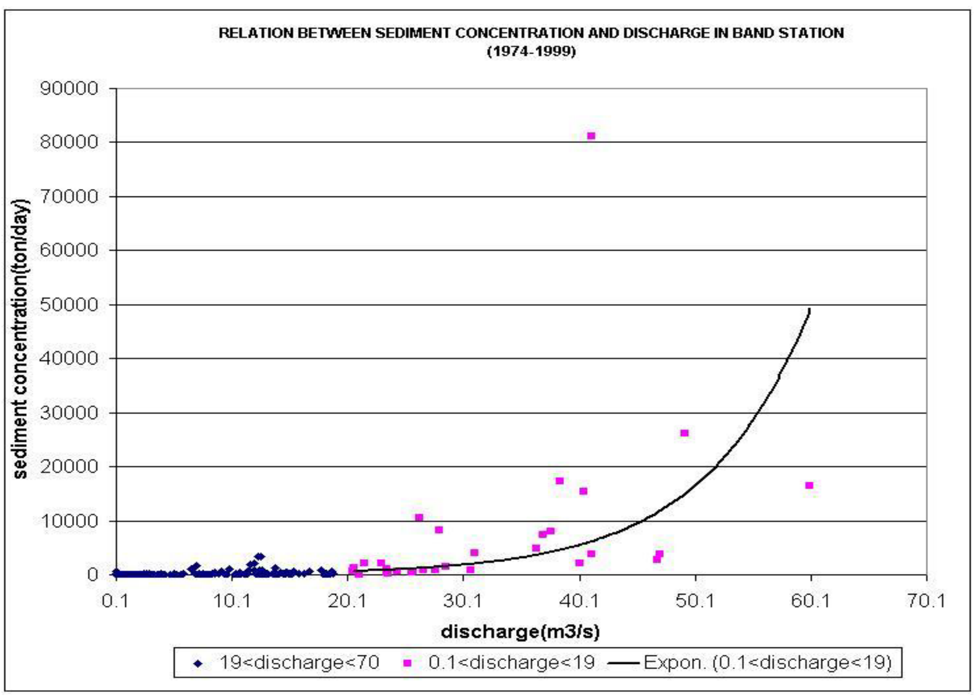


Figure 5.5: the relationship between sediment load (ton/day) and discharge in Band station

The total and average annual sediment yield for two stations from 1974 to 1999 are as follows:

Band station: 20172 (ton/km2/year) Average: 776 (ton/km2/year)

Mirabad station: 10829 (ton/km2/year) Average: 417 (ton/km2/year)

These values are only for sediment wash load and the bed load and deposited material are not considered, but they are limited to a few percent of the total load probably. Despite the fact that the slope steepness in the Hills is generally less than that in the mountains, the sediment yield is nearly double.

5.5:Trend analyses:

The objective of the sediment yield analysis was to study whether increased cultivation in the hills has led to an increased sediment yield and this was done by calculating 5-year moving averages of the annual sediment yields of Mirabad and Band stations, shown in figure 5.6. To obtain an estimate of the sediment yields from the Hills the Mirabad sediment yield was subtracted from the Band sediment yield (43021 ton/km2/year 1994-1999) and the 5-year moving average is shown in the same figure and a linear trend line was fitted.

5.6:Discussion of results:

The linear trend line, suggesting a long term increase in sediment yield contributed by the Hill unit is strongly based on the high sediment yields in the period 1989 – 1996, which was a wet period. There is no such trend in the Mirabad data, and that data can be regarded as a control set, because no conversion of rangeland to rainfed cultivation took place in that part of the catchment. The data shown in figure 5.6 are not conclusive, because if a long dry period would follow after 1996, the trend might not be obvious, or from 1993 onwards, a negative trend would occur. It can also be observed that for the last 5 years of the period of record, the 5-years average was at the same low level as in the early 1980's.
However, 1991 and 1992 were wet years (no suspended load data were available for this study) and it is likely that the 5 year moving average curve for the difference in sediment yields Band -Mirabad stations would rise again, possibly confirming the trend.
However, the positive trend is no surprise and is in line with what was expected because cultivation causes increase in erosion, as was explained in an earlier section. It may be remembered that conversion of rangelands in the Hills started some time after the Revolution in 1979 and progressed after the arrivals of powerful tractors capable of ploughing up and down slope of steeply sloping fields.
The analysis also shows that the Hills contribute much more to the sediment yield than the Mountains, because of their erodible nature in terms of rocks and soils. It stands to reason that disturbances of the rangeland cover in such terrain will contribute more to the sediment yield than a similar disturbance in units that are more resistant to erosion, as much of the Mountain terrain.
The true trend in sediment yield can only be properly assessed if the period of observation is extended by another 10 to 20 years.

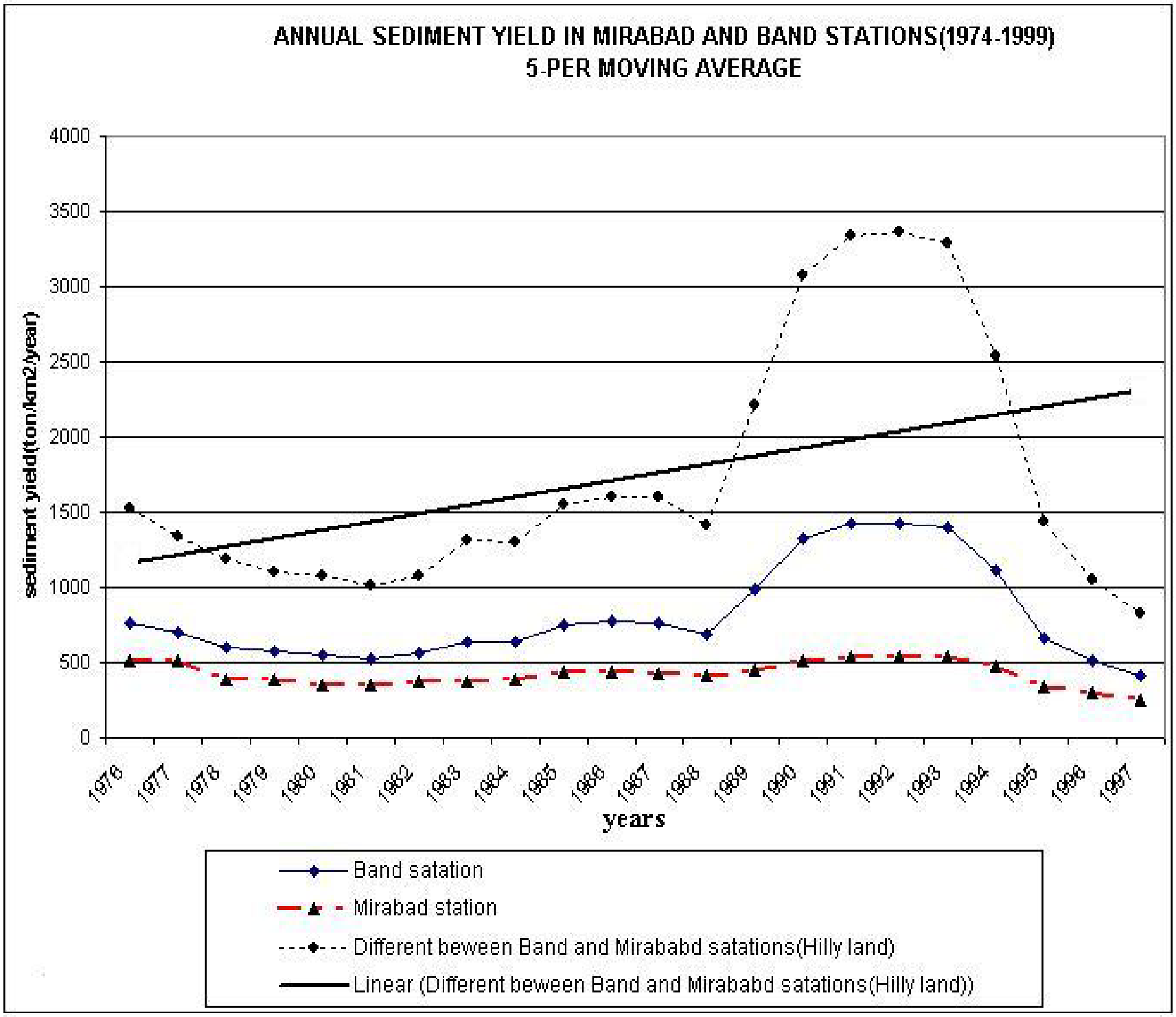


Figure 5.6: Annual sediment yields in Mirabad and Band stations and hilly area.

Chapter6: Conclusion and recommendation:

- The unsupervised classification was unsatisfactory because equal spectral classes can be seen in different places of Hill area and the Mountain area but on the basis of field observation these classes have no meaning.

- A comparison between classified images (Multi-spectral classification methods with original and transformed bands and visual interpretation) shows that Maximum likelihood classification based on the original bands (ETM 2000) visual interpretation of the ASTER image for determining the upland field boundaries gave the best results.

- Multispectral classification only has limitations because rainfed cultivation could not be separated from other classes. A large increase in rainfed-cultivated lands at the expense of rangelands was observed since the 1950 when the aerial photos were taken. The rainfed area was 1822 hectares. Most of the increase took place after the revolution in 1979 the statistics obtained all of approximate nature because no visual interpretation of the TM 1990 image could be done because of the 30 meter resolution, and a large difference was noted between the spectral classification of ETM 2000 and the visual interpretation of the ASTER 2000.

- The sediment yield cannot be assessed accurately because not many samples were taken during high discharges. Therefore the sediment yield estimates obtained are probably too low. Segmentation of the data set for establishing monthly or seasonal rating curves of suspended sediment concentrations and discharge did not gave meaningful results. A relationship between discharge and the sediment transport was finally used, and for the low discharge the arithmetic average of the sediment concentrations were used, but for the high discharges an exponential function.

- The land use change took place in the lower part of the catchment, termed the Hills, and the effect on the sediment yield could be analysed by subtracting the sediment yield from the upstream station (Mirabad) from the downstream station (Band). The estimated annual sediment yield of the Hills varied from 390 to 6529 ton/km^2/y. In the period 1989 to 1996 the yields varied from 1446 to 1298 ton/km^2/y, during the wet years from 1991 to 1992 a large increase was noted with a maximum of 6529 ton/km^2/y, but during the dry years of 1997 to 1999 the yields were 390 ton/km^2/y.

- A trend line fitted through the time series from 1974 to 1999 did show an increase in the sediment yield from the hills, but no such trend was found for the upper catchment. The sediment yields from the upper catchment can be considered as a control set because there no land use conversion took place.

The high sediment yield from the Hills not only proves the serious erosion problems, which has led to abandoning of some fields; it also affects the sedimentation in the newly created reservoir and in the Lake Uromieh wetland. Steps should be taken to implement soil conesrvation and restrict cultivation of the lands with steep slopes

- Visual interpretation from images with high resolution should be used for distinguishing of dry land farming from rangelands. Interpretation of aerial photographs (scale: 1/20000) would allow accurate to determination of cultivated lands.

- Using multi-temporal images (during crop growing) would have improved classification results.

- Relationship between incoming relative radiation and NDVI should be investigated for classification of land cover of mountain area.
- Interpretation of aerials photographs (scale: 1/20000) can be helping to determine the changes of land cover/use.
- The local people should be informed about the damages of dry land farm practices.
- Slope steeper than 12% in the Hills should not be cultivated, and soil conservation should be practiced (e.g. strip cropping on other sloping lands).
- Additional sediment trapping structures could be made in the fans for capturing the sediment produced in mountainous area, and in sub catchments that produce most of the sediment in the catchment.

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