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Full Length Research Paper

Land use determination of arid regions using geographical information system

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Soil serves as one of the most important components of natural resource. The vast areas in the arid region with low rainfall in the world were affected by land degradation due to natural factors, anthropological activities (agricultural) and ultra-utilization of land, and they became vain and desert land. Meanwhile, the importance and vitality of land use is more than that of other factors due to the effective role played by humans. The study area is located at the North and Northwestern region of the Semirom County. Based on the studies and operations that were carried out, almost 30 to 35% of the basin's total lands are in the mountain area with high outcrops and slopes. In addition, there are series of limitations in the soil of the observed land which include: Topographical factors, water erosion, soil appropriate physical condition, soil type, lack of nutrient (micro and macro), flooding of the flat plain and calcification of the area by which each of these limitations were identified and measured and the correspondent maps were prepared using software ArcGis9.2. Some of the aforementioned limitations are amenable and some of them are not. Limitations such as: Slope and soil depth gravel are those that their modification is impossible or not cost-effective, while limitations such as: Water erosion, inappropriate physical properties, relief, surface gravel, salinity and alkalinity are modifiable limitations that can be possibly dealt with by investment. This process showed that the area has a potential to irrigational forming application, dry forming, range management, forest and other applications.

Key words: Semirom, land use, land degradation, geographical information system.

INTRODUCTION

Population enhancement, industrial activities development and limited natural resources have severe effects on the environment, whereas degradation and pollution of land, air and water resources are the consequences of such effects. Ecosystem instability and environmental degradation are related to diverse factors and it has specific limitations including climatic factors such as: slope altitude and soil type, and anthropogenic factors such as: inappropriate management and landuse selection. A brief review of the records shows that the world population will reach 10 billion people in 2030 which will affect the biological factors. According to the latest information, about 20 million hectares of rainforest disappear each year (Gharagozlou, 2004). It is generally accepted that the world is facing serious environmental hazards which will considerably affect human activities. Xuejie et al. (2003) simulated the effect of land use change on climate in China using a regional model. Land use change, which is so called the alteration of soil surface cover, because of Albedo, surface roughness, thermal and hydrologic characteristics of soil, has an important effect on climate change. In order to sustainably manage the ecosystem, humans should measure its effects on the environment to distinguish between natural phenomena of the earth and anthropogenic activities (Pauleit et al., 2005). It is necessary to have quantitative assessment of the changes caused by human activities in the current land use of the earth. Industry and population explosion have resulted in high metropolitan land use changes in recent years (Ateraf, 2000). By increasing and improving these changes in the metropolitan area, a range of environment

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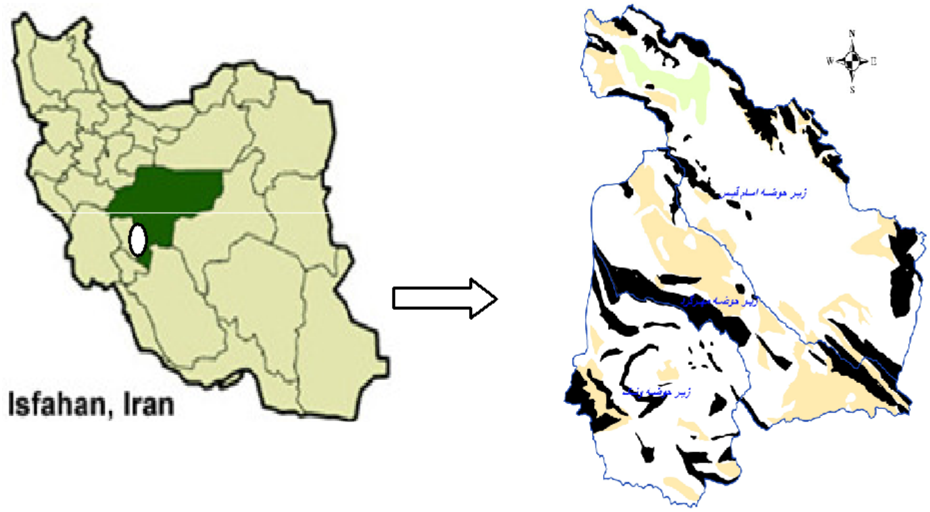

Figure 1. Geographical position of the studied area.

changes are appearing, which are more associated to cropping and land use shifting rather than the residential and industrial one.

Decline of the marginal and suburb land and the vegetation degradation in the metropolitan area are considered as negative outcomes of metropolitan extension, structuring, pavementation and other destructive activities within cities, as the environment in which the people are living in and the control of this trend is a vital issue in the metropolitan area. The most important role of vegetation in the metropolitan area is that it can control energy exchanges and environmental condition through solar radiation absorption and selective reflection (Goward et al., 1985), and it can be introduced as an effective factor in air pollution control and on human health (Wagrawski and Hites, 1997). The modern techniques that can be used to identify and control the metropolitan phenomena are the aerial satellite data and remote sensing technique. For this reason, based on the remote sensing technique and the study of normalized difference vegetation index (NDVI), most of the researchers emphasized on the greenness indices, or devoted their study to changes on the metropolitan areas and achieved acceptable results. Uchida (1997), using satellite information, analyzed the temporal change of agricultural land use in the arid semi-discrimination IRS region of India. They discriminated under-cropped lands from NDVI, changed land use by means of indices values and by studying the under-cropped area in a long term period of 8 years (1989 to 1996), they were able to identify arable lands for agricultural purposes. The principal goal for carrying out this investigation is to identity the studied basin's limitations, considering the basin's condition and the economical, social and biological effect it has on the different approaches applied, and finally, to identify the best land used for basin lands.

MATERIALS AND METHODS

Study area location

The study area is located in the South West of Isfahan province in Semirom city. Its total area is 168548 ha and it includes: The hydrologic sub-basin of Imam Gheis and Mehrgard at Vardasht, whose area is 80976 and 43917 ha, respectively and the Vanak sub-basin in Vanak, whose area is 43655 ha. Figure 1 shows the position of the studied area in Isfahan province and Semirom city.

Investigation of land resources evaluation is usually conducted by land capability and or land suitability methods. The first method common in our country and is conducted in terms of investigation of land resources evaluation. In conducting this investigation, data from soil and water researches institution (Climate and weather data, 2007) were used.

Effective factors in land capability determination such as: level of present limitations and level of modification operations were studied and classified qualitatively, before land capability class was finally determined (Geological reports, 2007). The Food and Agriculture Organization (FAO) in Bolton, according to the terms of number 32, has proposed a framework for land evaluation in order for the calibrations of land evaluation methods to be prepared and published in different countries. However, only the applied terms in land suitability have suggested this framework to avoid suitability terms.

Outline of map signs

The digits and numbers used in land resources map at the basin of Imam Gheis, Mehrgard and Vanak indicate land type, land unit and land component, respectively from the left direction, and can be shown as in Figure 9.

RESULTS AND DISCUSSION

Based on the field studies that were carried out, about 30 to 35% of the total lands were occupied by basin Vardasht, while basin Vanak formed the mountain area with high outcrop and slope. In addition, there are series of limitations in the soil of this land and they are as follows:

1. Topographical factor, which includes acuteness and direction of slope and relief.
2. Water erosion and surface soil appropriate physical condition.
3. Soil type factor, which includes soil depth, surface and depth gravel, and depth and surface soil texture.
4. Exposition and erodibility degree of flooding of the flat plain.
5. Land calcification (Bai, 1989).

Topographical factor (slope acuteness and direction)

Regarding the mountain features of the large part of the basin, the weight average slope is more than 35%, while the least slope is 2 to 5% in the section of the streams and waterways which crosses through the mountain, and it has no appropriate slope until it arrives at plain areas. However, the maximum total slope in mountain areas is 40 to 100% and the side slope (lateral slope) is between 40 and 70% slope acuteness. Also, lack of soil and plant cover result in loss of water retention strength in this part. Finally, slope acuteness is considered as one of the erosion acceleration factors in the area. On the other hand, slope direction also has high importance in the area.

The slopes that are exposed to sunlight have more evaporation from their surface and due to the lack of enough moisture, the activities of microorganism in them will decline and eventually, selective vegetation will not appear. In contrast, if slopes are not exposed to sunlight, they will have more appropriate soil and vegetation. Thus, it finally creates the occasion for soil evolution and formation to have a better condition.

Topographical factor (relief)

This factor is one of the most important effective factors on plant and soil caver and is even effective in farming. In particular, this factor is more outstanding in hill and plateau basins, such as Vardasht and Vanuk. It appears in land components in the following form: 4/5.1.1, 6.1, 3.1.1, 3.1.1, 8.1.1, 3.2.2, 3.3.2, 3.2.1, 3.4.2 and 3.4.1.

Water erosion

Field measurement indicated that the main parts of the land in basins Vardasht and Vanuk have sheet erosion (surface) and because of its act in the whole surface, it could not be appreciated as seen thus:

1. White spots due to sheet erosion are observed in land component 3.2.1, 3.4.1, 3.3.2 and 3.2.2.
2. Accumulation of soft soil in the basin of bushes.
3. Lack of uniformity in vegetation or the plant cropped from the vegetation.

Surface soil appropriate physical condition

This limitation is seen in many parts of the study area, but its severity is different in various units due to climate factors and lack of enough moisture that eventually prevent vital activities of microorganisms and interrupt soil evolution. As such, combination of these factors resulted in both structure-less and sort-less soils. However, the sort-less soil has no resistance against rain, whereas raindrop diffused them and led to turbulent streams.

Outcrops

This limitation is seen especially in mountains and hills. The active physical destruction in the area and the climate result from the fragmented rocks carried by stream current and finally deposited in moderate and low slopes (Ghafary, 1998). The land with these characteristics has no plant soil cover, but has a surface cover; although the un-amenable and un-arable part of this area is 18.5 ha of the whole area. Table 1 shows the rack unit area in each of the sub-basin (Figure 4), where land with outcrop from 70 to 80% include land component 1.2.1, 2.1.1 and 1.1.1, and land with outcrop from 40 to 60% include land component 3.3.1, 1.3.1 and 2.2.

Soil depth limitation

Soil depth is one of the important and effective factors used for a successful agricultural design and it is specially important for orchards. The effective factors in soil depth are the presence of soil erosion and the removal of surface horizons (Jalalian and Mohammedi, 1987). The soil depth is seen in most part of the studied area in which their soil layers consisted of rock layers or petrocalcic layers seen in land component 2.1.1, 1.2.1, 1.3.1, 1.6.1 and 1.1.1 and partly in 2.2.1, 2.3.1, or pseudorack gravel (more than 75%) or lime (more than 50%) observed in basins Vardasht and Vanak in land component 8.1.1. In classifying soil depth based on Magazine 205 Guidance of Soil and Water Researches Institution, the following are considered (Figure 3):

1. The land without soil cover or with very low depth of soil cover has a depth of less than 25 cm and is considered in mountainous and hilly areas in land component 1.1.1 and 1.3.1, and in part in 1.6.1, 1.2.1 and 2.3.1.
2. Low depth soil has soil depth of 25 to 50 cm and is

considered in part in land component 1.2.3, 1.2.2, 1.6.1, 2.3.1 and 3.4.1.

3. Semi-depth soils with soil depth of 50 to 80 cm are included in land component 8.1.2 and 2.1.1.

4. Very deep soil with soil depth of 80 to 120 cm is included in land component 3.4.2, 2.3.2, 2.1.2, 2.1, 2.2.1 and 3.3.1.

5. Very deep soil with soil depth more than 120 cm is included in land component 1.4, 3.3, 1.1.5, 2.3.3, 1.1.6 and 1.1.3.

Depth and surface gravel limitation

This limitation is characterized in most parts of the land component and is considered in all types, especially in talus and plateau fluvial and in upper terrace.

In classifying the depth and surface gravel in basins Vardasht and Vanak based on Guidance 205 Soil and Water Researches Institution, the following are considered:

1. Lands with very low surface gravel (less than 3%) in the basin are considered in land component 4.1.1 and in part in land component 3.4.2, 1.3.2, 1.2.2, 2.2.3 and 2.3.3.

2. Lands with low surface gravel (3 to 15%) in the basin are considered in land component 1.3.2, 1.1.2 and 1.2.2.

3. Lands with medium surface gravel (15 to 30%) are considered in land component 1.4.3, 2.4.3, 1.4, 1.5, 1.3.3 and 1.6.2.

4. Lands with very high surface gravel (35 to 75%) are considered in land component 2.2.2, 1.2.1 and 1.1.1 and in part in land component 8.1.1.

5. Lands with excessively high surface gravel (more than 75%) are considered in land component 8.1.1 (Figure 5).

Soil texture limitation

With regards to the origin of the study area's soil, lands in this basin have heavy and very heavy texture. Hence, it can be concluded that these lands have water and nutrient strength necessary for plant; as such, a suitable structure is created in them and as a whole. Thus, these lands have good evaluation. On the other hand, the presence of soil with heavy texture and a lot of clay has led to this situation during the long term period, especially when this layer was created in depth. After soil saturation, the layer resulted to run off and the outcome is erosion (Mahmoudzadeh, 1994). In particular, this phenomenon is seen in parts where humans have no control over it. However, low water infiltration represents stagnant water in a long period (Figure 6).

Flooding and land exposition to flooding

Due to the mountain feature of the area, especially in Vardasht sub-basin, acute slope and first and second degree water course in dendrite form are factors of rain and thawed water from snow movement, and because of the annual average rain fall (about 38 mm) and water that rapidly drains out from the area, the land eventually floods to a low slope area in the middle of the basin land in the margin of dry rivers.

Land calcareous

The presence of lime formation is also observed in the geological structure of the area in soil layers, where lime is present in various forms such as, powder, spot and petrocalcic, and is sometimes invisible in soils (Figure 2).

Most part of the study area soils have two kinds of lime: visible and invisible lime, in which its level at the horizon is about 10 to 40% and by increasing the depth to more than 70%, it is seen as a limiting layer for plant growth in soil; however, it is seen as white powder in mountain areas. Due to low solubility, these materials have no adverse effect on plants, but in case they accumulate too much or appeared in the horizon, they might have adverse effects. This is another limitation associated to soil type in the study area and its level include land component 3.1.1, 2.4.3, 3.2.1, 1.2.2, 1.3.2, 5.1.1, 2.4.1, 1.2.1, 3.4.1, 3.4.1, 3.3.2, 2.3.1 and 1.1.1, which is very high and land component 1.6.1, 2.2.2, 3.1.2, 3.2.2, 2.3.2, 2.3.2, 2.2.1, 1.6.2, 2.1.2, 1.1.2, 1.3.3, 1.3.1 and 2.3.1 which is medium, and in another part of the area, it comprises land component 6.1.1 and 8.1.1 which is very high (Figure 7).

Land capability at present

Land capability of each land unit component for various applications was determined by the studies carried out on each of the land components.

Irrigation forming

As a whole, 15307 ha in the studied area have the capability to form irrigation and it includes land component 3.1.1, 3.3.2 and 5.1.1.

Land capability for dry forming

The effective factors in cereal dry-forming include:

1. Rainfall level which must be more than 350; was used for the study area.

2. Slope less than 8%; otherwise, erosion starts and the soil becomes degraded.

3. Gravel and pebble at depth and surface soil, in part, are not responsible for the lack of using forming machines, but result to rapid infiltration in soils.

Figure 2. View of the very calcareous soil in root zone soil.

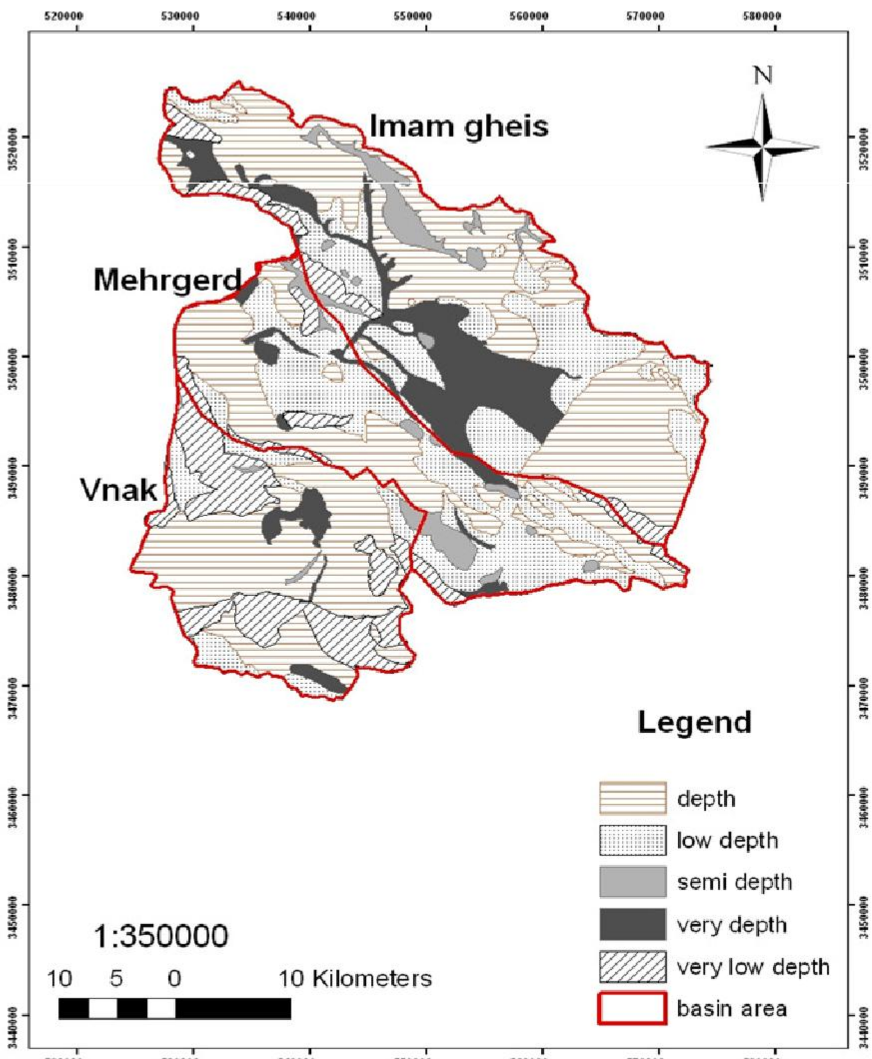

Figure 3. Classes depth soil study area.

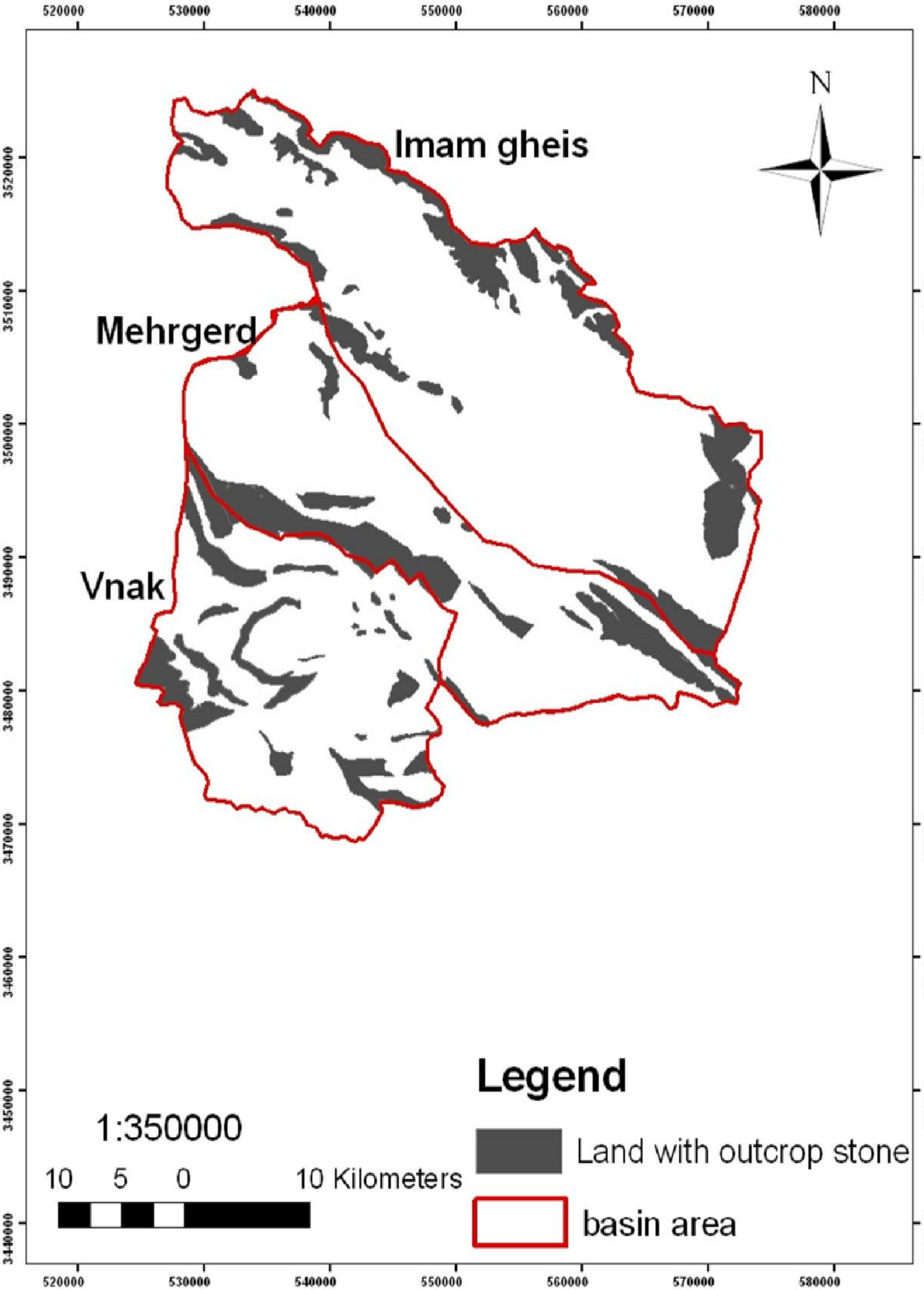

Figure 4. Land with outcrop stone in the study area.

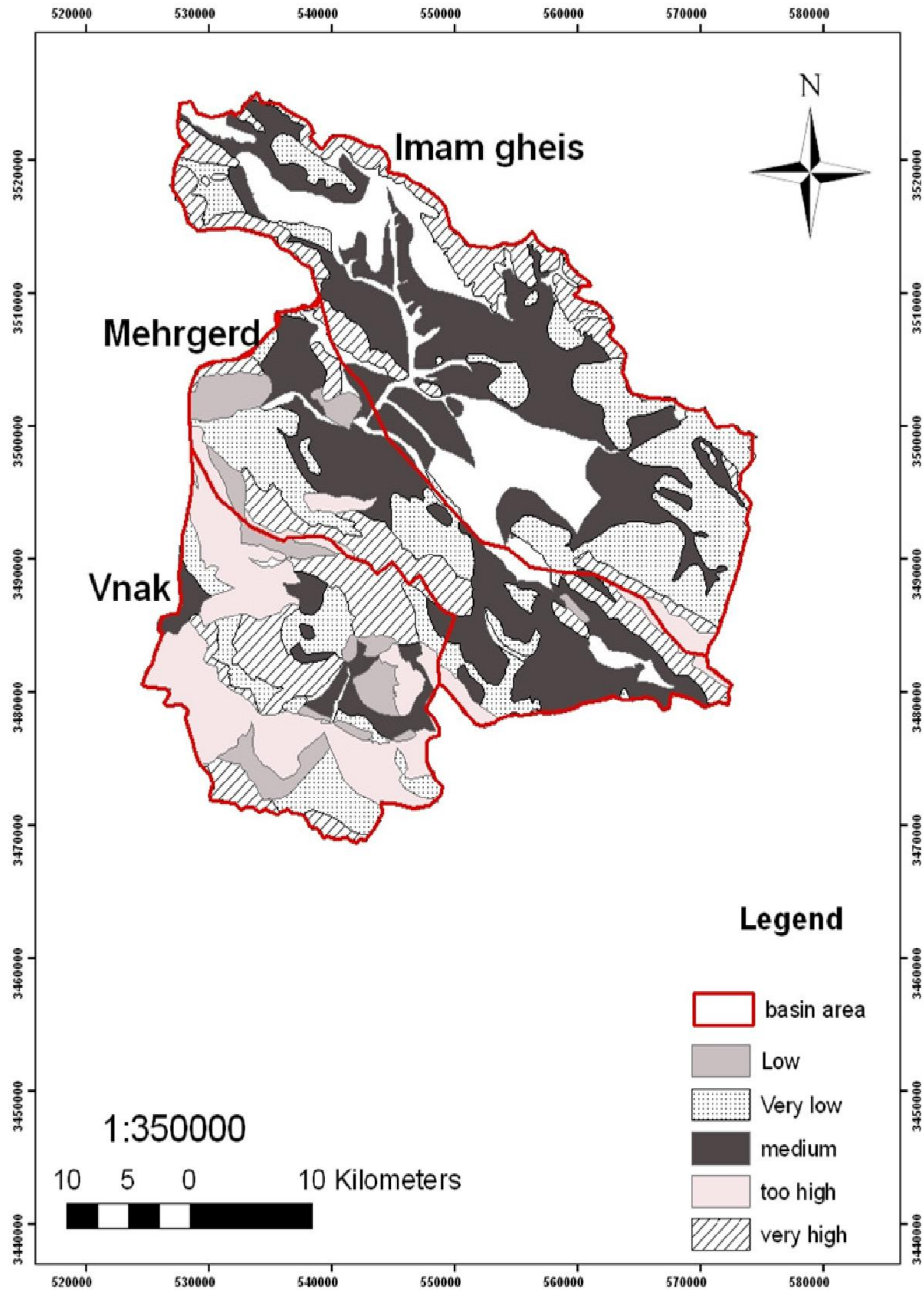

Figure 5. Classification of gravel in the soil profiles.

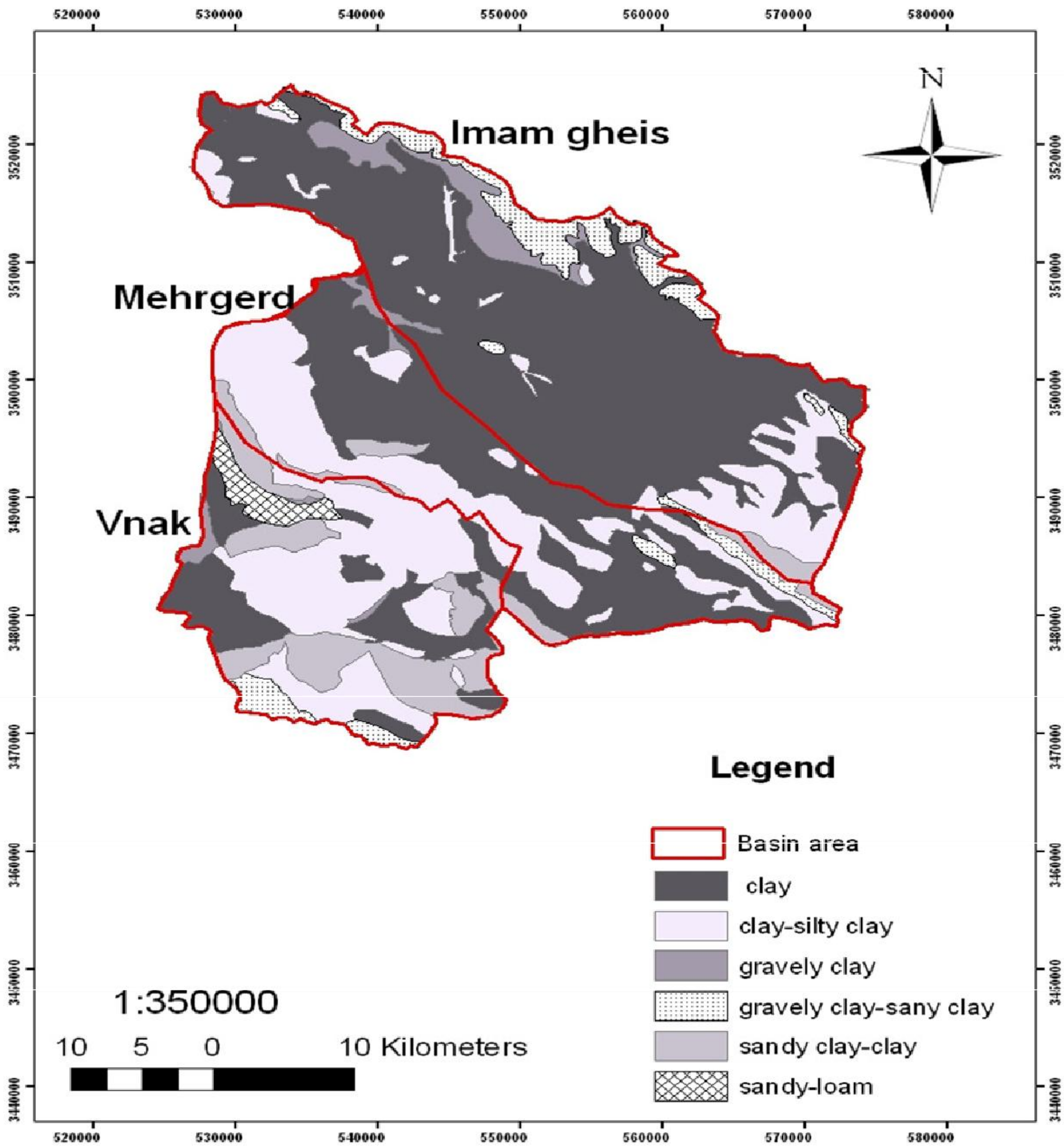

Figure 6. Classes soil texture in the study area.

Absolutely, in the studied area, 11069 ha can be used for cereal dry forming with land component 3.2.2, 3.3.1, 1.1.3, 3.2.2, 3.3.1, 1/5.1.1, 3.2.1, 3.2.2, 3.4.2, 1.6.2, 2.3.2 and 8.1.1.

Land capability for range management

Capability for range management is determined based on soil type, slope, erosion, physiographic moisture and temperature condition, climate and land unit hydrological characteristic. In the studied area, 82791 ha of lands have range capability and it includes land component 1.1.2, 1.2.2, 1.3.2, 1.3.3, 1.6.2, 2.1.1, 2.1.2, 2.2.1, 2.3.2, 2.4.1, 2.4.3, 3.2.1, 3.4.1, 3.4.2 and 8.1.1.

Land capability for forest

As a whole, there are two states in the present condition

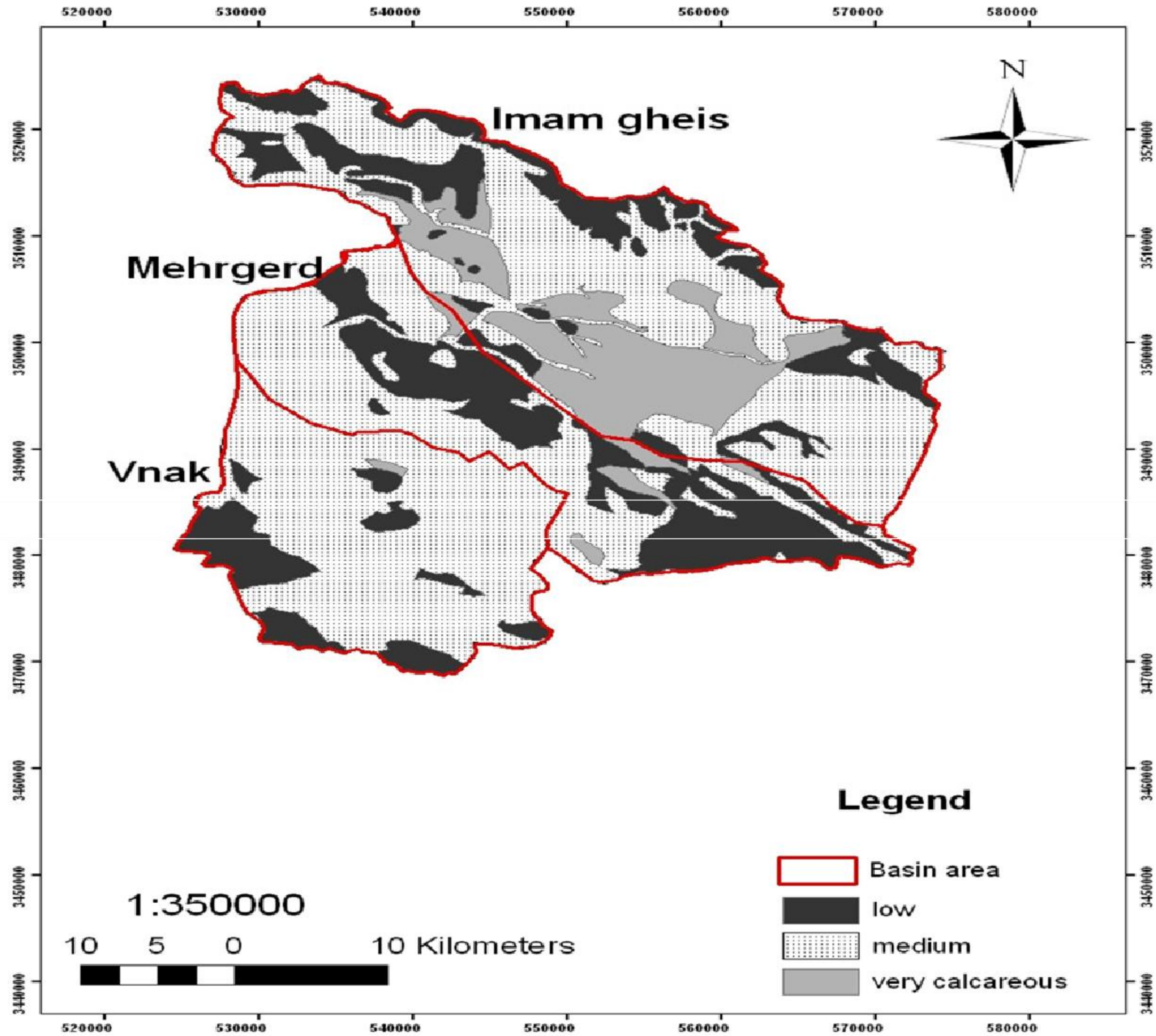

Figure 7. Distribution of lime in the root zone (horizon subterraneous).

in classification of a forest:

Presence of natural forest

In peaks of elevated mountains, land component 1.2.1. 1.2.2, 1.3.2, 1.1.2, 1.6.1, 1.6.2, 1.6.2 and 3.1.1 and forest cover is low and very low, and they include trees such as, common juniper tree and Amygdalus.

Lack of natural forest cover

With regards to the growth of forest plants in elevations and among outcrops, we can conclude that the area has forestation capability, especially in elevations that are more than 2500 m, such as peaks and mountains Behruz Bolghal, Kaman, Sormand and Chirgire.

Land capability for other applications

Urban and village improvement possibility

In an area where the soil surface thickness is 10 cm, there is improvement in the urban and village setting, and this state can be seen from talus 8.1.1., etc.

Basin protection

As a whole, major component 1.3.2, 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.4.1, 2.4.3, 3.4.1 and 8.1.1, where there is a very low capability for the range, controlled grazing is very

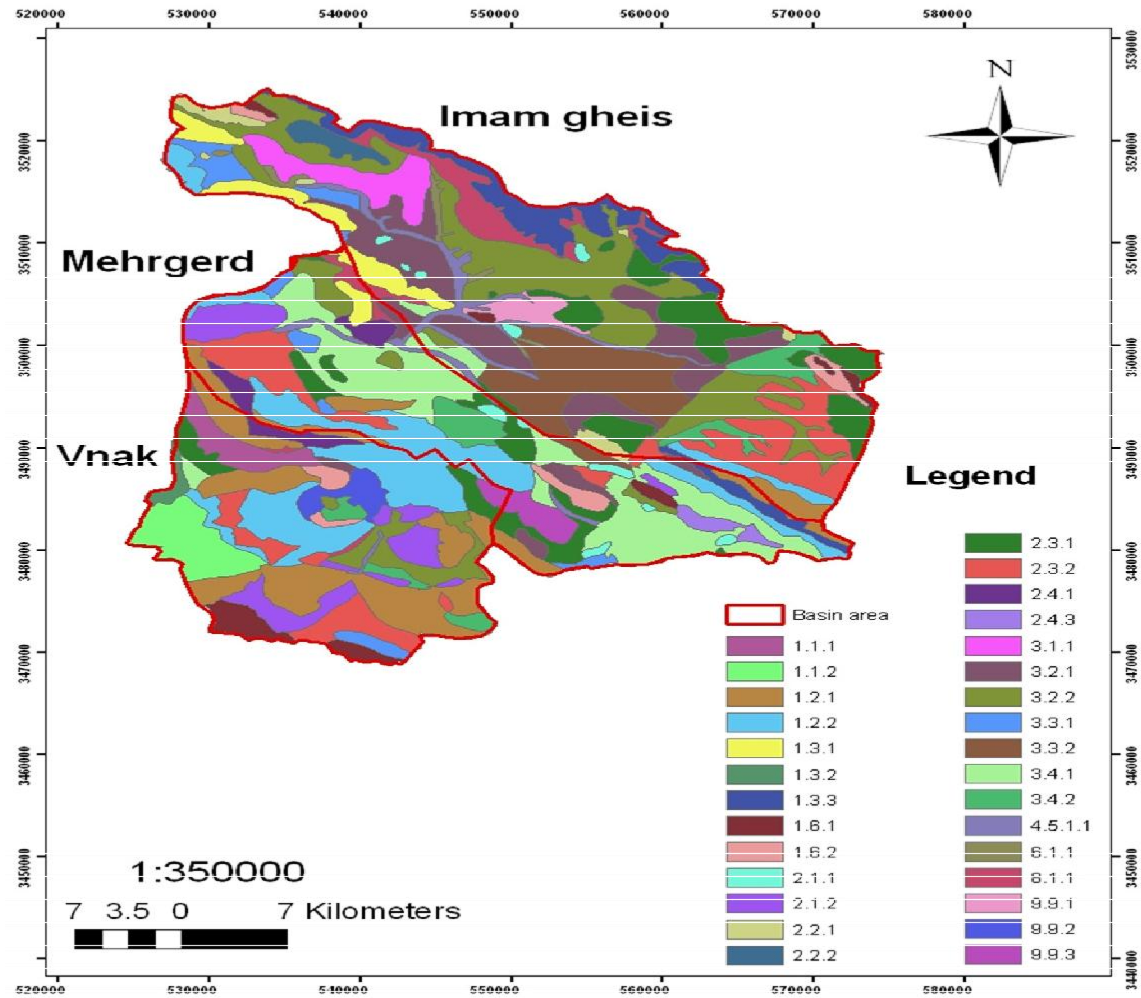

Figure 8. Components of land units in the study.

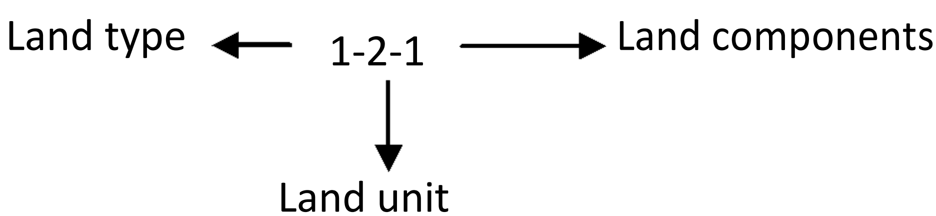

Figure 9. The digits and numbers used in land resources map at basin of Imam Gheis, Mehrgard and Vanak

Table 1. Area and percent of rock unit in the subbasin of the studied area.

Series	Subbasin	Subbasin area (ha)	Outcrop area (ha)	Percent from subbasin (%)
1	Imam ghis	80992	10520	33.7
2	Mehr gard	43901	13472	43.1
3	Vanak	43655	7262	23.2
Sum	-	168547	31254	100

Table 2. Various land capabilities for major application at present.

Series	Capability type Land	Unit component	Area (ha)
1	Irrigated feature	3.1.1, 3.3.2, 4/5.1.1	15307
2	dry forming capability	3.2.2, 3.3.1	11068
3	Range capabilities	1.1.2, 1.2.2, 1.3.2, 1.3.3, 1.6.2, 2.1.1, 2.1.1, 2.1.2, 2.2.2, 2.3.1, 2.4.1, 3.2.1, 3.4.1, 3.4.2, 8.1.1	79046
4	Ability to protect watershed	1.2.1, 1.6.1, 2.1.1, 2.4.1, 1.3.1, 1.1.2, 1.2.2, 1.3.3	39831
5	outcrops located in land having basin protection capability	1.1.1, 1.2.1, 1.6.1, 2.1.1, 2.4.1, 1.3.1, 1.1.2, 1.2.2, 1.3.3	23296
Sum	-	-	168548

important in the view point of erosion control and must be considered in terms of basin control (Table 2).

Conclusion

Land capability for each of the land unit components for various applications was determined by using studies conducted in each land component, and these capabilities include: irrigation forming, dry forming, range management, forest, urban and village improvement. These capabilities have declined all or parts of the major limitations by directly affecting land capability; as such, the types of application allotted to the coming condition should be characterized (Land use report, 2007). In land use researches, remote sensing (RS) and geographic information system (GIS) could provide useful information for land use planning and watershed management (Cropper et al., 1999; Tipaniat and Nitin, 2003; Mapedza et al., 2003; Rasul et al., 2004). Land use changes are equipped due to natural and human activities, and they can be observed using current methods archived through remotely sensed data (Cautam and Narayan, 1985; Verburg et al., 1999).

Ahmadi et al. (2006), in the area of Imam Khomeini airport region, Iran, reported that agricultural land in 1956 was 34.3%, while it reduced to 6410.24 ha (20.3%) because of land use changes in infrastructures and barelands. Rangelands include the areas with no cultivation, because of physical limitations and inadequate water resources. These areas are covered by annual and perennial plant species with about 1994.9 ha (63.3%) in 1956, while the current area of these lands increased to 20494.6 ha (1.5% more than that of the previous period). However, Dontree (2003), Verburg et al. (1999), Mapedza et al. (2003) and Islam and Weil (2000) obtained similar results in their studies.

Land capability for irrigation forming

In the case of solving the deficiency (high relief, plowing in a slope direction and gravel) in land component 3.2.3, 4.5.1, 3.2.2, 3.3.1 and 3.4.2, this land will have irrigational forming capability.

Land capability for dry forming

In the case of conducting modifying operations (counter plowing and pebble gravel collection) with land component 3.2.2, 3.3.1 and 3.4.2, this land can be used for dry forming.

Land capability for range in the future

In the case of conducting modifying operations (controlling grazing capability, preventing heavy grazing, closing, applying range management principles and erosion prevention) in land component 2.3.2, 3.2.2, 3.4.2, 1.2.2, 1.6.2, 2.1.2, 2.3.1, 3.2.1, 3.4.1, 8.1.1, 8.1.2, 1.2.2, 2.4.3,1.2.4 and 2.4.1, this land can be used as a range.

Land capability for forest in the future

By forest reclamation and by preventing the cutting of trees using area tribes, this capability can be created in parts of land component 1.2.1, 1.2.2, 1.2.3, 1.2.4 and 1.4.4 (Figure 8). However, the useful effects that resulted from forest protection include:

1. Soil establishment and formation, especially in acute slope area.
2. Creating recreation and changing the region's weather.
3. Wild life protection and helping the region economically.

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