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The Correlation Between Lithology, Physiography and the Vegetation Cover in Iran

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Keywords: Vegetation; lithology; cartography; geomorphology; Iran. FDK 11 : 18 : 58 : (55)

Abstract: The correlation between the vegetation cover, lithology and some physiographic factors in Iran was investigated. A region of 132 500 hectares was chosen and maps were prepared. The results obtained show that by interfacing the lithologic map with the physiographic maps, a map with a high-level correlation with the vegetation-cover map can be obtained.

Abstract: Untersucht werden die Wechselbeziehungen zwischen der Vegetationsdecke, der Lithologie und einigen physiographischen Faktoren im Iran. Dazu wurden eine Region von 132 500 Hektaren ausgewählt und Karten erstellt. Die Resultate zeigen klar, dass durch das Überschneiden der lithologischen Karte mit den physiographischen Karten eine Karte mit hohen Wechselbeziehungen zur Vegetationsschichtkarte erstellt werden kann.

1. Introduction

Today, it is proved that suitable vegetation in each area is the most important factor in the preservation of soil and the regulation of the water regime. One of the main factors accelerating soil erosion and increasing the amount of sediment production causing damaging flood in many parts of the world is the degradation of vegetation resulting in bare soil damaged by rainfall impact. For these reasons, it is necessary to recognize the correlation between the present vegetation and other physical factors. One of the important (perhaps the most important) factors in natural resources studies is the lithology of the area having direct or indirect effect on all other natural factors (such as geomorphology, physiography, erosion and sedimentation). Understanding the correlation between the vegetation cover and lithology can improve the recognition of the correlation between the vegetation and its surrounding environment and also the planning of better presentation and reclamation of vegetation in each area.

2. The studied area

Iran is a vast country and has very different climatic and ecological conditions, which have caused variation in vegetation. The climatic and ecological conditions can be classified as humid, temperate (Hirano region), desert (Dasht-E-Kavir and Dasht-E-Lut) and semi-tropical (southern coasts) regions. In spite of outstanding differences between humidity and physiography, there is a significant correlation between geological boundaries and vegetation boundaries. For instance, the region of Main Zagros Thrust, which extends from the northwest to the southeast in the west of Iran. This thrust, and a few minor thrusts around it, are geological boundaries and at the same time vegetation boundaries. Of course, other factors also play role. For the investigation of the correlation between the vegetation cover and lithology, a more limited and specified area should then be chosen, thus, differing from smaller vegetation types and comparing them with lithologic units, a reasonable and statistical conception can be reached. At the same time, the area should not be too small and limited from the viewpoint of vegetation and lithology. After preliminary investigation, the Taleghan-Rood drainage basin in the central part of the Alborz Prealps in the northern part of Iran was chosen.

3. Characteristics of the Taleghan Rood River drainage basin

The Taleghan Rood River drainage basin is one of the important branches of the Sefid-Rood River in Iran. The Taleghan Rood River originates from the Alborz Prealps and is situated about 90 km northwest of Teheran in approximate latitude of 36.05 to 36.23 north and longitude of 50.20 to 51.01 east. The area of the drainage basin consists of about 132 500 hectares.

The main precipitation is influenced by the Mediterranean with a maximum precipitation at the end of the winter period and the beginning of spring and one maximum in autumn and a long and dry season in the summer. The mean precipitation of the Taleghan drainage basin is about 600 millimeters.

It is a mountainous area and its general slope is high. More than about half of the area has slopes of more than 40 percent, however, there are also areas with slopes between 0–5 percent.

The variation in altitude is significant; it varies from about 1740 meters to about 3100 meters above sea-level.

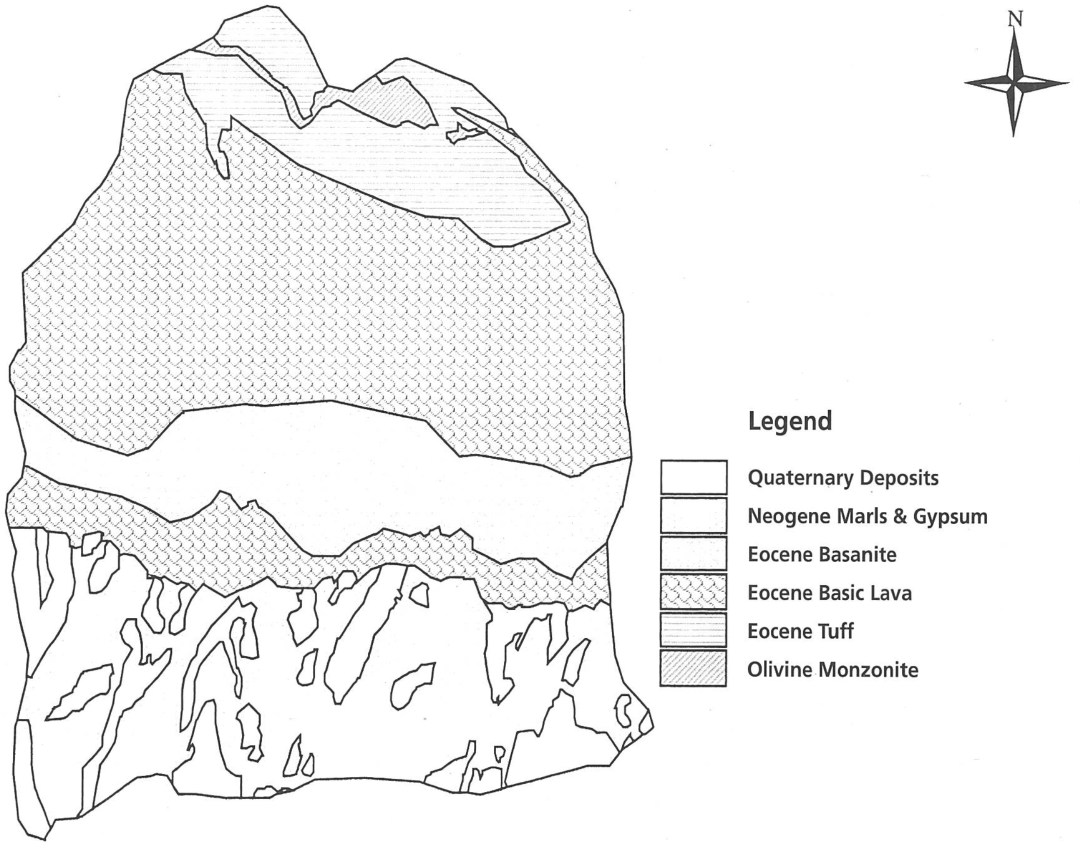
4. Materials and methods

In order to investigate the amount of correlation between some physical factors, we need to have a correlation index, so that the amount of correlation between those factors can be compared and analyzed. Therefore, a suitable index should first be introduced.

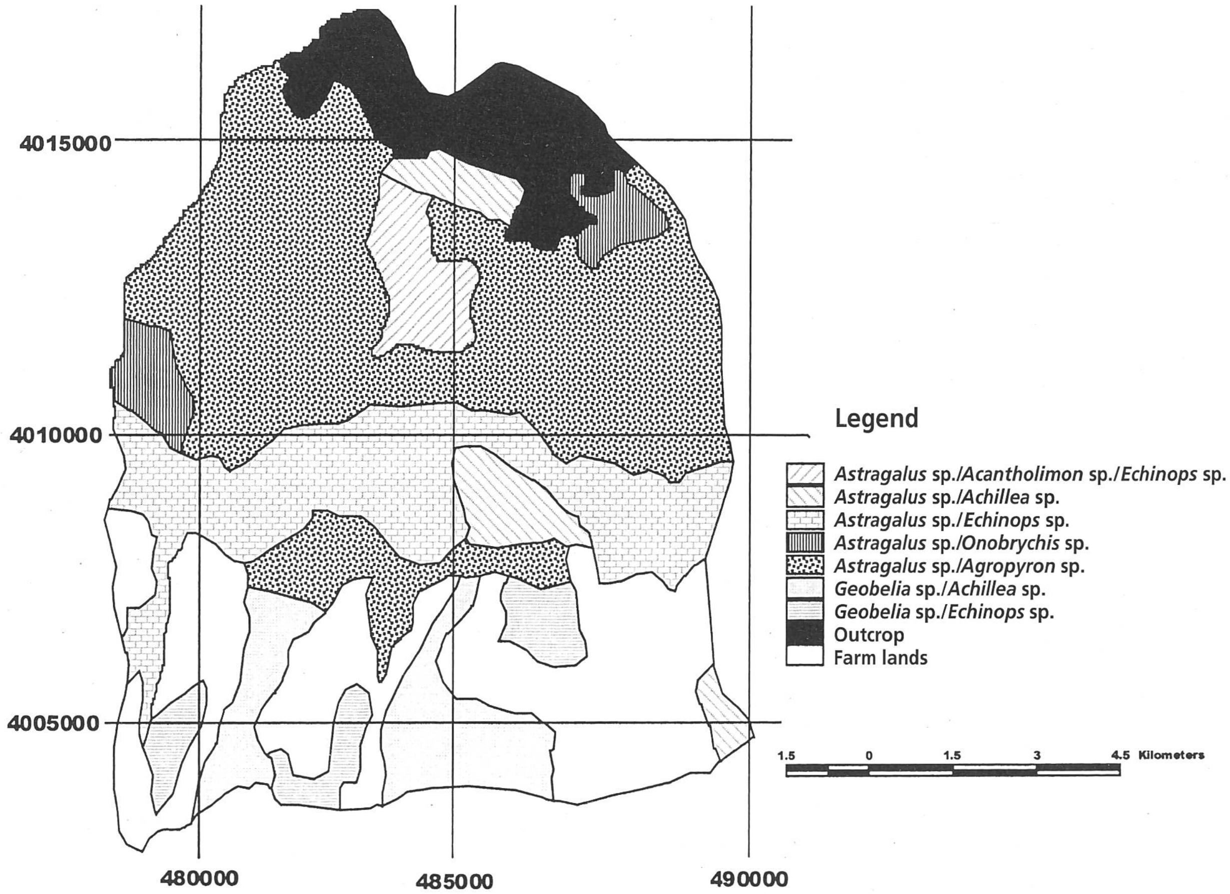
4.1 Correlation index (CI)

The most important condition of each correlation index is that it should have a logical and reasonable relation with the amount of correlation between two or more factors. Because the vegetation types and the kinds of lithologies are obtained by qualitative measures, the index of weighted average of interfacing of all units (vegetation types) relative to other units (lithology) in each area was selected as correlation index. In other words, by overlaying the vegetation and geology maps of each area, we can find the amount of interface of each vegetation type with its equivalent geological formation (which are turned into percentages). Thus, the weighted average of percentages of different interfaces is obtained, which is used as correlation index. These tasks have been effected by means of Geographic Information Systems (GIS).

Geology Map of the Shaharak Region (Taleghan Watershed)



Vegetation Cover Map of the Shaharak Region (Taleghan Watershed)



Comparison of geology and vegetation cover maps in the Shaharak Region of Taleghan watershed.

It is evident that as soon as the amount of interfacing and correlation of lithology and vegetation maps is more significant, the correlation index will be higher, too.

For example, in *figure 1*, it can be seen that by crossing the vegetation cover map of one region with supposed vegetation types A and B, with the lithologic map of that region with supposed lithologic types M and N, a new map is generated that has the following units: MA, MB, NA and NB. Now, the amount of interface of type A with its analogous type M, amounting to about 80% is obtained (it should be mentioned that if this unit and type is present in other parts of the map, the amount of their interface is also calculated and then the average amount is obtained). The amount of interface of type B with its analogous type N is also calculated and amounts to about 85%. If type B covers about 40% and type A about 60% of the vegetation cover map, the correlation index for the region is the weighted average of the amount of interface of analogous units of each type, which is calculated as follows:

$CI = (60*80+80*40) / 100 = \%82$

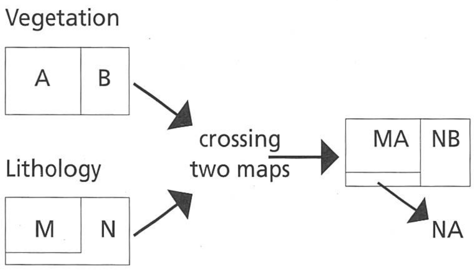


***Figure 1*: Crossing the two maps.**

4.2 Preparation of the lithology map

For the preparation of a lithology map of the area, the present geology maps with a scale of 1:100 000 and 1:250 000, effected by the Geological Survey of Iran (Geologic map of Qazvin-Rasht quadrangle; geologic map of Shakran-sheet), and other maps with larger scales were used. A lithology map of the area with a scale of 1:50 000 was prepared for this research.

From a geological point of view, the study area is made of the following formations from the oldest to the youngest ones:

Pre-Cambrian:
Kahar formation: sandstone, siltstone and mudstone.
Soltanieh formation: dolomite.
Zaigun and Barut formations: sandstone, siltstone and mudstone.

Paleozoic:
Lalun formation: sandstone, with subordinate mudstone and siltstone.
Mila formation: limestone, dolomite, sandstone and shale with dolomite unit, basic lava, sandstone, quartzite and shale.
Mobarak formation: limestone in part shale and limestone.
Dorud formation: sandstone and quartzite.
Ruteh formation: limestone and locally dolomite.

Mesozoic:
Elika formation: dolomite.
Shemshak formation: mudstone, conglomerate and basic lava.
Tizkuh formation: limestone, basic lava with intercalation of limestone.

Cenozoic (Tertiary):
Karaj formation: acid tuff, tuffaceous mudstone, basic agglomerate, acid agglomerate, andesite lava, andesite-dacite sheets, conglomerate, limestone, gypsum, basic lava, basanite, basic tuff and acid tuff.
Upper Red formation: mudstone, siltstone, conglomerate and breccia, intercalations of gypsiferous mudstone and siltstone.

Cenozoic (Quaternary):
Trachytic lava, older landslide deposits, older gravel deposits, older alluvial deposits, younger landslide deposits, moraine, scree and talus, younger alluvial and floodplain deposits.

It should be mentioned that the map used in this part was a lithologic map of the region that was prepared by using a geologic map of the area (Geologic map of Qazvin-Rasht quadrangle) and effecting some photogeologic tasks and field surveys.

4.3 Preparation of the vegetation map

Plant species of the studied area are very diverse and mostly belong to the rangeland types (Bachelor projects, 1983–1998; Study of vegetation of the Taleghan Rood drainage basin, 1994). Each rangeland type is part of a rangeland which is different from other types with regard to the composition of plants and predominant species. Each type is named according to one, two or at most three species which are predominant in it and are of most significance in the composition of the vegetation cover. For the determination of the rangeland types and differentiation of their limits, a field survey was carried out and aerial photo interpretation and topographic maps with a scale of 1:50 000 were used. The method of preparing a vegetation cover map of the area is as follows:

First, by using aerial photos, the primary vegetation units were separated (in other words, the primary boundaries of vegetation types were separated by different tones in aerial photos). Then, by doing intense fieldwork and using measuring plots (standard plots) of type and percentage of vegetation, the types and percentage of species of each primary unit were determined. After determining the species of each unit, the map of the vegetation cover of the area was prepared.

Due to the fact that the time of blossoming in different plants is different, the surveys were done in different seasons so that the prepared map is as accurate as possible. In general, about thirty-one vegetation types were identified in the area, which are listed below;

1: *Astragalus* sp. / *Agropyron* sp.
2: *Geobelia* sp. / *Echinops* sp.
3: *Prangos* sp. / *Astragalus* sp.
4: Perennial Grasses / *Thymus* sp. / *Prangos* sp.
5: *Geobelia* sp. / *Achillea* sp.
6: *Astragalus* sp. / Perennial Grasses
7: *Astragalus* sp. / *Onobrychis* sp.
8: *Astragalus* sp. / Perennial Forbes
9: *Astragalus* sp. / *Acantholimon* sp. / *Echinops* sp.
10: *Astragalus* sp. / *Acantholimon* sp.
11: *Astragalus* sp. / *Euphorbia* sp. / *Thymus* sp.
12: *Astragalus* sp. / *Thymus* sp.
13: *Astragalus* sp. / *Diplotaenia* sp.
14: *Astragalus* sp. / *Achillea* sp.
15: *Astragalus* sp. / *Thymus* sp. / *Bromus* sp.
16: *Astragalus* sp. / *Thymus* sp. / Perennial Grasses
17: *Acanthophyllum* sp. / *Acantholimon* sp. / *Astragalus* sp.
18: *Astragalus* sp. / *Echinops* sp.
19: *Astragalus* sp. / *Ferula* sp.

20: *Achillea* sp. / *Thymus* sp.
21: *Agropyron* sp. / *Thymus* sp.
22: *Agropyron* sp. / *Astragalus* sp.
23: *Astragalus* sp.
24: *Agropyron* sp. / *Thymus* sp.
25: *Gundelia* sp. / *Agropyron* sp.
26: *Astragalus* sp. / *Agropyron* sp. / *Thymus* sp.
27: *Artemisia* sp. / *Astragalus* sp. / *Thymus* sp.
28: *Acantholimon* sp. / *Gundelia* sp.
29: *Astragalus* sp. / *Gundelia* sp.
30: *Thymus* sp. / *Urtica* sp.
31: *Astragalus* sp. / *Stachys* sp.

5. Investigation of the correlation index

At this stage, by laying the lithology map onto the vegetation map (*Figure 2*) and calculating the amount of the interface of all the units, the correlation index for units was obtained and then the general correlation (average) for the Taleghan Rood drainage basin was calculated.

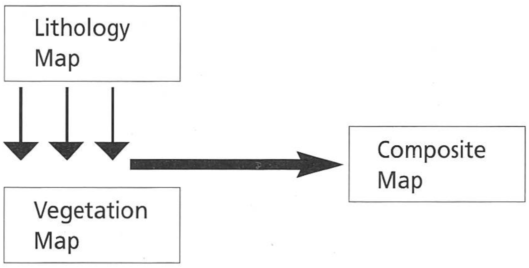


Figure 2: **Overlaying lithology and vegetation cover maps.**

The correlation index for units is very variable and ranges between 0–100% (*Figure 1*), in other words; the boundaries of some lithologic units and vegetation types were exactly conform and some were not. By using this method, the average correlation index for the Taleghan Rood drainage basin was 19.5%.

At a later stage, by considering the similarities between lithologic units, some of them were combined. The bases for combining lithologic units were mineralogy and the texture of the rock. Because in the case of similar climatic conditions, these factors highly affect the type of produced soil. Therefore, the rocks which had similar mineralogical and textural characteristics were combined. All of the basic volcanic units were considered one unit. Thus, the average correlation index for the basin has increased to 35.3%. If similar vegetation types are combined, the average correlation index of the basin is increased to 44.4%, which represents a relatively good correlation between the vegetation and the lithology. In some cases, the correlation of boundaries of some lithologic units with vegetation types is outstanding, for example the species *Geobelia* is mainly found on calcareous units such as limestone and calcareous marls.

6. The effects of physiographic factors

It is known that physiographic factors are important in the micro- and macroclimate of the area. For example, in the studied area, northern slopes which absorb less solar energy than southern slopes have more humidity and higher elevations. They receive more atmospheric precipitation, and the climate, therefore, is colder. For this reason, *Astragalus* can be found in higher elevations within the studied area. So, in addition to lithology, physiographic factors also play an important role in the differentiation of the vegetation types in the area. The maps of physiographic factors (slope, elevation...) were prepared and overlaid to the lithology map and thus a new map was created, called map of homogeneous units. The amount of the correlation index in different cases showed that among different factors, the effect of elevation is more important and the amount of slope and direction of slope factors are less important. The amount of the correlation index (as far as maps of elevation classes, lithology and vegetation are considered) amounts to 70.3%, which shows a very high correlation between these factors *(Table 1)*. It should be mentioned that an increasing CI at these stages has nothing to do with an increasing correlation between lithology and vegetation but is due to the effect of a second factor.

Table 1: **The amount of weighted average of the correlation index (in percent) for 18 chosen sub-catchments of the Taleghan drainage basin at different stages.**

No	Stage1	Stage 2	Stage 3	Stage 4
1	15.3	30.6	35.6	65.4
2	19.2	39.3	45.3	63.7
3	21.1	42.8	35.4	82.6
4	4.2	19.7	30.2	56.4
5	12.3	28.1	42.7	60.8
6	17	35.4	35.4	59.7
7	42.3	41.3	68.3	78.9
8	12.1	19.5	26.5	58.7
9	19.4	47.3	49	78.1
10	25	59.2	62.5	93.8
11	29.2	37	46.1	75.3
12	16.9	46.5	56.7	68.7
13	28.2	47.2	56.2	76.3
14	37	56.2	65	80.2
15	11.3	20.6	24.2	64.3
16	16.4	28.7	28.7	58.1
17	13.8	18.9	51.6	85.4
18	6.5	16.4	39.8	59.8
Mean	19.5	35.3	44.4	70.3

Stage 1. CI due to crossing lithologic and vegetation maps.
Stage 2. CI due to crossing the vegetation map and the lithology map (prepared by combining similar units).
Stage 3. CI due to crossing of a map prepared by combining similar lithologic units and a map prepared by combining similar vegetation types.
Stage 4. CI due to crossing of the vegetation map prepared by combining similar types and a map prepared by overlaying the lithology map (combining similar lithologic units) with the hypsometric (elevation) map.

7. Conclusion

The results obtained from overlaying lithology and vegetation maps which is represented as average correlation index in the Taleghan Rood drainage basin show that there is a logical and reasonable relationship between bedrock geology and vegetation. Additionally, by using the map of homogeneous units (which is made by overlaying lithology and physiographic maps) and overlaying it with a vegetation-types map, we found that in addition to lithology, other physiographic factors have also important effects on the vegetation. Among different physiographic factors, the effects of elevation above sea-level is more important. In parts of the drainage basin in which differences in elevation is not significant, the effect of slope and its variation is better visible. So, in areas with little differences in elevation such as in pediments, instead of composing a lithology map and an elevation map, we can use the composition of the slope map and the lithology map. Our recent research in pediments confirms this conclusion, but further research is needed. It can be concluded that in each area, first a lithology map emphasizing on texture and mineralogy (factors with important effect on soil characteristics) should be prepared and then be generalized (similar units should be combined). By considering the physiographic conditions of the studied area, this lithology map should be combined with one or two physiographic factors and the map of homogeneous units should be prepared. This map is then often used for planning and studies of vegetation. The determination of a strong correlation between lithology and physiographic factors with vegetation types can be very helpful in many cases, especially in regions where studied areas are widespread and it is difficult to reach the area in order to determine the vegetation types. The results of Remote Sensing (RS) applied for the determination of the vegetation types can also be compared with the results of this method, that is, in RS, the primary boundaries are determined by different color composites, here by combining the lithology map with other physiographic factors (considering the characteristics of the region), a map is prepared that can be used as the basis map for the preparation of a vegetation map. The maps used in this method are usually accessible and can easily be combined with GIS.

The methodology of this paper can be used for the investigation of the amount of correlation between qualitative factors or quantitative and qualitative factors, which is very important in natural resources research. Furthermore, as the knowledge of controlling factors of vegetation types and the reasons for their diversity increases, the management of forests and rangelands will improve.

Summary

The purpose of this paper is to investigate the correlation between the vegetation cover, lithology and some physiographic factors in Iran. In order to achieve this purpose, small-scale lithologic, geomorphologic and vegetation maps of Iran were investigated, showing a general similarity and interrelation. To further investigate this interrelation, an area of about 132 500 hectares within an Iranian region situated in the southern Alborz-foothills was focused on. Lithologic, vegetation-cover and physiographic maps (such as hypsometric map, slope map, etc.) with a 1:50 000 scale were prepared. By defining an correlation index representative for the amount of correlation between the various factors, the correlation was investigated. The results obtained show that by interfacing the lithologic map with the physiographic maps, a map with a high-level correlation with the vegetation-cover map can be obtained.

Résumé

Relations mutuelles entre la lithologie, la physiographie et la couche végétale en Iran

Ce travail a pour but d'examiner les relations mutuelles entre la couche végétale, la lithologie et quelques facteurs physiographiques en Iran. Pour achever ce but, des cartes lithologiques, géomorphologique et de végétations en Iran ont été examinées mettant en évidence une similarité générale et des relations mutuelles. Pour examiner en détail ces interrelations, une région de 132 500 hectares dans les préalpes Alborz du Sud de l'Iran a été choisi et des cartes en grandeur 1:50 000 lithologiques, physiographiques (par exemple carte hypsométrique, pente etc.) et de la couche végétale ont été élaborées. En définant un index d'interrelation représentatif pour la quantité d'interrelation entre les facteurs différents, les relations mutuelles ont été examinées. Les résultats achevés montrent que le chevauchement de la carte lithologique avec les cartes physiographiques résulte dans une carte de haute interrelation avec la carte de la couche végétale.

Zusammenfassung

Die Wechselbeziehungen zwischen Lithologie, Physiographie und der Vegetationsschicht im Iran

Das Ziel dieser Studie besteht darin, die Wechselbeziehungen zwischen der Vegetationsdecke, der Lithologie und einigen physiographischen Faktoren im Iran zu untersuchen. Dazu wurden lithologische, geomorphologische sowie Vegetationskarten untersucht, die eine allgemeine Ähnlichkeit und auch Wechselbeziehungen aufwiesen. Um diese Wechselbeziehungen näher zu erforschen, wurde eine Region von 132 500 Hektaren im südlichen iranischen Alborz-Vorgebirge ausgewählt und lithologische, Vegetationsschicht- und physiographische (z. B. Hypsometrie, Neigung usw.) Karten im Massstab 1:50 000 erstellt. Die Wechselbeziehungen konnten dank der Definition eines Interrelationsindexes definiert werden, der die Interrelationsmenge zwischen verschiedenen Faktoren aufzeigte. Die erzeugten Resultate zeigen klar auf, dass durch das Überschneiden der lithologischen Karte mit den physiographischen Karten eine Karte mit hohen Wechselbeziehungen zur Vegetationsschichtkarte erstellt werden kann.

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