

A Qualitative Land Suitability Assessment in Gypsiferous Soils of Kerman Province, Iran

¹Hassan Etesami, ²Leila Halajian and ³Mozhdeh Jamei

¹Department of Soil Science, Faculty of Agricultural Engineering and Technology, University of Tehran, Karaj, Iran.

²M.A. Environmental Management, Science & Research Branch-Khuzestan, Islamic Azad University, Iran.

³M.s.c Agro Meteorology, Khuzestan Water and Power Authority, Iran.

Abstract: The suitability is the aptitude of a given type of land to support a defined use. The process of land suitability classification is the appraisal and grouping of specific areas of land in terms of their suitability for a defined use. This research was performed to study of properties of gypsiferous soils and land suitability evaluation for agronomic productions in the study area. At first, the land maps were studied, then 35 farmlands were chosen, they had gypsic horizon and were scattered in the total plain. Then one profile in each farm was described and catch the samples from all horizons. The total gypsum characteristics, using agricultural instruments and applying of different inputs were studied. Land characteristics for example: salinity, acidity, Sodium Absorption Ratio (SAR), Cation Exchange Capacity (CEC), gypsum content, calcium carbonate content, texture and climate were used to classification of land suitability and land utilization types such as wheat, barely, alfalfa, maize, sugarbeet and potato were studied. meanwhile, plant and climate tables were gathered by sys and givi. The results show that the maximum and average of soil gypsum was 31% and 12% respectively. it is one of the most limitation for crop production. According to key to soil taxonomy(2006), the gypsic and cambic horizons were classified in aridisols and entisols. Parent materials, climate, microrelief (topography), physiography and pendant shapes effect the gypsum formation in the studied area. Investigation and qualitative reviewing of lands show that land suitability have a range of changes in classes from S2 to S3 for wheat with the limitations of gypsum in soils and texture, from S2 to S3 for barley with the limitations of gypsum in soils and texture, from S2 to N2 and S3 to N2 for potato with the limitations of soil acidity and gypsum, and S2 to N1 with the limitation of soil's texture for sugarbeet, from S2 to N2 and S3 to N2 for alfalfa with the limitations of soil's acidity and gypsum and topography and from S2 to N2 for onion with the limitations of soil's gypsum and acidity, respectively. researches show that the average of yield in different production in gypsic and non- gypsiferous soils are different.

Key words: Land suitability; Land utilization types; Gypsiferous soils; Kerman

INTRODUCTION

Decisions on land use have always been part of the evolution of human society. In the past, land use changes often came about by gradual evolution, as the result of many separate decisions taken by individuals. In the more crowded and complex world of the present they are frequently brought about by the process of land use planning. Such planning takes place in all parts of the world, including both developing and developed countries. It may be concerned with putting environmental resources to new kinds of productive use. The need for land use planning is frequently brought about, however, by changing needs and pressures, involving competing uses for the same land.

The function of land use planning is to guide decisions on land use in such a way that the resources of the environment are put to the most beneficial use for man, while at the same time conserving those resources for the future. This planning must be based on an understanding both of the natural environment and of the kinds of land use envisaged. There have been many examples of damage to natural resources and of unsuccessful land use enterprises through failure to take account of the mutual relationships between land and the uses to which it is put. It is a function of land evaluation to bring about such understanding and to present planners with comparisons of the most promising kinds of land use.

Land evaluation is concerned with the assessment of land performance when used for specified purposes. It involves the execution and interpretation of basic surveys of climate, soils, vegetation and other aspects of land in terms of the requirements of alternative forms of land use. To be of value in planning, the range of land uses considered has to be limited to those which are relevant within the physical, economic and social context of the area considered, and the comparisons must incorporate economic considerations.

Corresponding Author: Hassan Etesami, Department of Soil Science, Faculty of Agricultural Engineering and Technology, University of Tehran, Karaj, Iran.
E-mail: hassanetesami@ut.ac.ir

Land evaluation is concerned with the assessment of land performance for specific land utilization purposes and provides a rational basis for taking land use decisions based on analysis of relations between the land use and land, giving estimates of required inputs and predicted outputs. (FAO, 1985; Sys et al, 1991).

Gypsiferous soils are soils that contain sufficient quantities of gypsum (calcium sulphate) to interfere with plant growth. Soils with gypsum of pedogenic origin are found in regions with ustic, xeric and arid moisture regimes (Nettleton *et al.*, 1982). They are well represented in dry areas where sources for the calcium sulphate exist. They do not usually occur under wet climates. In most cases the gypsum is associated with other salts of calcium and salts of sodium and magnesium.

Gypsiferous soils are very variable and there are many factors that affect their properties in relation to plant growth. Gypsiferous soils can be productive and managed profitably if they are first studied properly. The effect of the chemical properties of gypsiferous and calcareous soils on the growth of plants, both natural vegetation and crops, and their mineral contents have been investigated by numerous authors. In the first American system of soil classification gypsiferous soils are not separated from other soils. The soils of the dry areas are classified as Red Desert Soils equivalent to Argids, Calciorthids and Camborthids of the modern American system. The first system was elaborated from the classification of (Marbut, 1967) after some redefinition. It was revised several times subsequently.

The performance of plants grown on shallow soils depends to a large extent on their root system, the gypsum content, the fertility level of the topsoil, and the water availability during the growing season. In particular the presence of a hard impervious gypsic layer has a strong effect on crop production under irrigation. Percolating water dissolves gypsum and salts and stagnates at the top of the gypsic layer creating a perched water-table, often resulting in an accumulation of gypsum and salts. The resulting high water-table may rise to the soil surface leaving salts and gypsum. Under these conditions, the performance of crops will be affected by both gypsum and salinity. Gypsiferous soils have been cultivated under dry farming systems for centuries mainly with cereal crops and small-grain legumes. Because of population pressure and recent technological developments in the use of underground waters some gypsiferous soils are now irrigated. Under irrigation, new problems have arisen through the introduction of high-yielding crops especially those least tolerant of gypsum. The intensive leaching of nutrients, calcium solubilization from gypsum, and the removal of exchangeable potassium and magnesium affect the productivity of gypsiferous soils. The influence of the gypsum concentration in soils is comparable to that of calcium carbonate, except gypsum is more soluble and may cause dissolution pockets and successive development of a characteristic microrelief if the soils are irrigated. The general indices in Table 1 are suggested where soils and crops information are very limited.

Table 1: Rating index on the basis of average gypsum content on the upper 100 cm of the soil or to a limiting layer (Sys and Verheyne 1972, Barzanji 1973).

Gypsum content(%)	Gypsum indices
Up to 0.3	0.9
0.3-10	1.0
10-25	0.85
25-50	0.60

Smith and Robertson (1962) observe that yields of annual and perennial crops are depressed when grown on soils where the gypsum content of the root zone is higher than 25 percent. Thus, Barzanji (1973) suggested the following parameters for annual crops where the indices were calculated according to the weighted average of the gypsum content of the upper 40 cm of the soil profile (Table 2). For perennial crops the weighted average of the gypsum content was calculated for the upper 100 cm of the soil, if no gypsic layer is present. If there is a gypsic layer the weighted average is calculated for soil above the gypsic layer only .

Table 2: Gypsum indices for annual crops with shallow root system according to their gypsum tolerance (Barzanji, 1973).

	I	II	III
Gypsum(%)	Crops that tolerate a high level of CaSO ₄	Crops that tolerate some CaSO ₄	Crops sensitive to CaSO ₄
up to 0.3	1	1	1
0.3-10	1.1	1	0.75
10-25	0.8	0.7	0.5
>25	0.5	0.4	0.3

The above classification adopted by Barzanji was based on limited data, field observations, and information given by Smith and Robertson (1962). In more recent studies, many annual and perennial crops are found to perform well in highly gypsiferous soils; and the depth of the gypsic layer and the degree of its cementation determine to a large extent the irrigability of that type of soil.

Studies on gypsiferous soils don't have long antiquity and their background is returned to the second half of the twentieth century. These soils are considered among the unsuitable or with acute proportion soils agriculturally. A large amount of gypsum in soils have considerable extent in arid and semi-arid regions of the

world. gypsiferous soils extent has been estimated about 85 million hectares in the world and these lands extent has been reported about 73 million hectares in the Middle East which 9.8 million hectares of that has been reported in Islamic Republic of Iran that about 124500 hectares of these lands are placed in Kerman. According to the features of these soils, their potentials are different for different applications. Such soils identify, is not only valuable from the viewpoint of soil resources evaluation, but also awareness of their formation mechanism and evolution procedure can be effective in application programmings, environment protect, and soil preservation and etc. Basically, when the gypsum amount in soil is poor, its existence is proper for plants growth, but the yield of crop production is decreased by increasing gypsum percent because of imbalance in nutrient elements absorption by plants roots. One of the product increase methods in surface unit and/ or in the other words optimum use of lands is identifying production capacity of each land and choosing proper application with that's production capacity. Identifying the lands proportion evaluation is a proper solution for acquiring this goal. Nowadays, the formation of gypsiferous soils, evaluation of these lands and presenting special management and proper agricultural garden shift for these lands are among considerable subjects. These soils formation and extent part of under farm lands of Bardsir area that in some points have had many destructive effects on soil's function and features.

MATERIALS AND METHODS

The Study Area:

The land investigated in research located in Bardsir (kerman province) and has the area of 3000 hectares between latitudes of 47°29'30" and 52°29'30" N and between longitudes of 56°45'00" and 56°52'30" E at west south of Kerman city. The average heights are 1980 meters from sea level. (fig.1).

Sampling:

Based on Soil Taxonomy (2006), this region has soils in Aridisols and Entisols orders. Using GPS device and base map, profiles location defined and profiles excavated and described using presented methods in "Field Book Describing and Sampling Soils"(1998). To perform experimental studies, 59 bulk soil samples prepared and air dried and after being ground passed through standard sieve size of 2mm. The soil texture was defined via hydrometric method and after calibration in saturated paste the pH and Electrical Conductivity (EC) were measured, calcium carbonate content measured via Calcimetry methods, gypsum measured via Acetone, cation exchange capacity measured via Bower method.

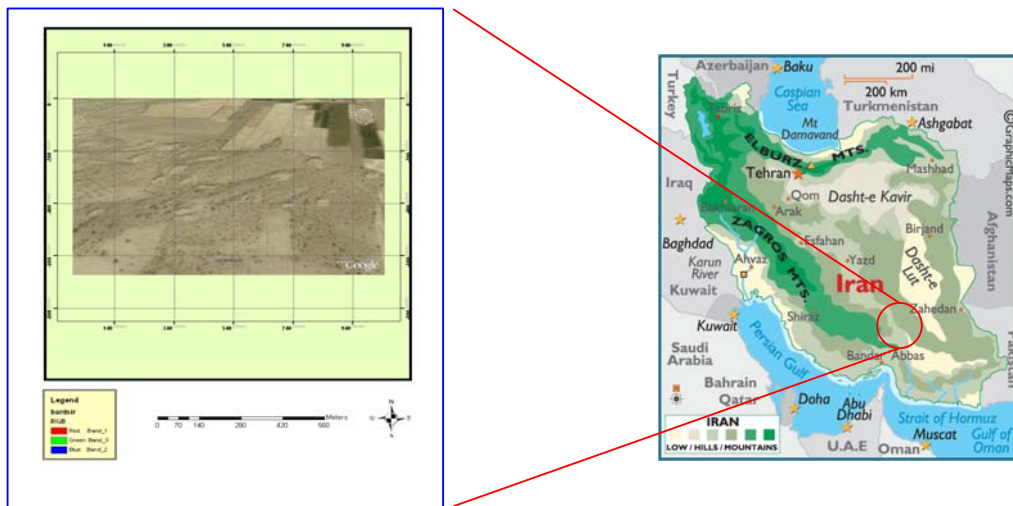


Fig.1: Location of the study area.

In this study, 59 points (35 profiles and 24 drills) were studied in the kind of profile and drill (alternatively). Profiles were sampled and described according to key to soil taxonomy (2006) guide upto family level. Land suitability evaluation were performed according to the land quality for special agricultural plants(FAO, 1990). Land suitability classes were calculated by parametric method and herbaceous needs were extracted from tables which were collected by sys using harmony and correction with area conditions(Sys et al., 1991).

RESULTS AND DISCUSSION

On the basis of performed pedology studies in selected lands, diagnostic horizons of Gypsic and Cambic were segregated and categorized according to key to soil taxonomy in *aridisols* and *entisols* orders and *Xeric Haplogypsid*s and *Xeric Haplocambid*s and *Xeric torrifluvent*s great groups and totally 19 different soil units were segregated. Climatic suitability categorizing in study area was performed on the basis of parametric method and according to ranges of limitations.

Results show that, climate for wheat, barley, potato and onion productions is in S1 class. the climate has no limitation for wheat, barley, potato and onion. But climate was categorized for sugarbeet production in S2 class and with the limitation of temprature the coldest month of growth season and alfalfa production is in S2 class and with the limitation of temprature during the growth season. According to the results of Climatic suitability categorizing, area climate is proper for wheat, barley , potato and onion plants productions and qualitative reviewing of lands show that range of changes in classes is from S2 to S3 for wheat with the limitations of gypsum in soils and texture, from S2 to S3 for barley with the limitations of gypsum in soils and texture, from S2 to N2 and S3 to N2 for potato with the limitations of soil acidity and gypsum, and S2 to N1 with the limitation of soil's texture for sugarbeet, from S2 to N2 and S3 to N2 for alfalfa with the limitations of soil's acidity and gypsum and topography and from S2 to N2 for onion with the limitations of soil's gypsum and acidity, respectively. Soil texture is majorly light in surface and bottom levels of gypsiferous soils and water transformation is performed rapidly in these soils, but absorption and maintenance capacity of water and nutrients is very low and these soils have problem in the view of providing nutrients which need soil texture reform and increasing of organic matter in surface soil. Meanwhile surface and subsoil texture is majorly weighty in not gypsiferous soils and water transformation is done slowly and don't have many problems in nutrients and water absorption and maintenance and also have more organic matter in their surface soil (Tomanian, 1998).

Reviewing of nutrients condition of gypsi- and not gypsiferous soil's in different levels show that according to the soil physical conditions especially soil texture, gypsiferous soils are less fertiliezer than non- gypsiferous soils in the view of nutrients, that existence of surface level with specified thickness which majorly doesn't have any gypsum but there are specified amounts of gypsum from the second depth to lower depths, makes the necessity of lands reformation more serious. So, the usage management of agricultural qualities especially different chemical fertilizers must be used with attention and especial conditions(Syedjalali, 2000; Mahmodi, 1998).

Reviewing of products function in gypsi- and non- gypsiferous soils show that gypsiferous soils weight in average are at least one ton in hectare lower than non- gypsiferous soils, which is considerable in the level of 5000 hectares of gypsiferous soils in Bardsir area(Barzanji and Salien, 1980; Hess, 1976).

According to the performed studies about optimum use of these resources, the following cases are suggested:

- 1- Choosing proper production according to the physical and chemical conditions of area's soils and climate.
- 2- It is better to evaluate all the features of gypsiferous soils and different respects of these soils in order to optimum use of production resources.
- 3- Gypsiferous soils have limitations in the view of nutrients, so, performing correct fertilization can be effective.
- 4- Farmer's education and their awareness of gypsiferous soil's features can be effective in the improvement of production condition.

Conclusion:

Gypsiferous soils have been cultivated for centuries under traditional rotational rainfed farming systems in which wheat or barley is followed by leguminous grain crops or by fallow. Under rainfed farming conditions, yields depend mainly on rainfall and are usually low to moderate. Soil chemical properties are in a dynamic equilibrium. Gypsum and other salts are leached in the rainy season to deeper horizons and returned to the surface horizons during summer by capillary rise. When gypsiferous soils are irrigated changes in their chemical properties take place involving further movement of gypsum salts and nutrients.

The improvement in the productivity of gypsiferous soils under rainfed conditions is currently approached by several methods depending upon the soil properties.

Soil terracing has been practised for many centuries on the deep hilly soils of the Murcia area of Spain to prevent erosion. Fruit orchards have been planted including peaches, pears, olives and other crops. Supplementary irrigation has been used to increase productivity where water resources are available.

Harrowing the land after harvesting and before the rainy season is a common practice to improve the infiltration of water and conserve soil moisture.

The organic matter of soils can be increased by replacing fallow by small-grain leguminous crops in the wheat-fallow rotations. This was practised in Syria and Iraq, especially in areas where the annual precipitation

ranges between 250 to 450 mm. Akramov (1981) discusses the positive effect of manure on converting unproductive gypsiferous soils into productive ones.

Subsoiling can be undertaken to break the cemented gypsic subsoil. This improves root penetration and reduces susceptibility to drought, especially in the case of fruit and forest trees. It improves crop establishment and has been practised by many farmers in Algeria, Syria and other countries for planting pistachio, almond, etc., in soils with a hard calcareous crust. Caution should be exercised not to mix the topsoil and subsoil. The former usually contains less gypsum and has a higher organic matter than the latter.

Fertilization is very beneficial in increasing productivity. It has become a general practice under rainfed conditions to apply nitrogen and phosphorus to cereals. The rate of applied nitrogen fertilizers depends on the annual precipitation; N is generally applied where rainfall exceeds 260 mm annually. Phosphorus fertilizers are very effective in increasing the yield of cereals, especially under low rainfall.

Cereals are grown satisfactorily on soils with less than 30 cm depth and less than 25 percent gypsum content, especially if precipitation is adequate, ranging between 250 and 350 mm. Under higher rainfall these types of soils are satisfactory for many varieties of grape vines.

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REFERENCES

- Akramov, Y., 1981. Changes in organic matter in reclaimed solonchaks. *Soviet Soil Science*, 13(2): 99-105.
- Barzanji, A.F. and K.A. Salien, 1980. Effect of gypsum content and depth of gypic horizon on the growth and yield of some field crops in Iraq.
- Barzanji, A.F., 1973. Gypsiferous soils of Iraq. Ph.D. Thesis, University of Ghent, Belgium.
- FAO, 1985. Guidelines: Land evaluation for irrigated agriculture. *FAO Soils Bulletin* 55, Rome.
- FAO, 1990. Management of gypsiferous soils bulletin. 69. FAO, Rome, pp: 81.
- Hess, P.E., 1976. Shent communication . particle size distribution in gypsic soils plant and soil uu, 241-247.
- Mahmodi, Sh, 1998. Properties and management of gypsic soils. *Journal of water and soil*, 13: 224-230.
- Marbut, C.F., 1967. Soils of the United States. In: *Atlas of American Agriculture*. US Department of Agriculture, 1-98.
- Mashali, A.M., 1990. Management practices for gypsiferous soil under irrigated conditions. Technical officer. FAO., pp: 29.
- Naghavi, A., 1999. Study of properties of chemical and physical and quality of formation and evolution of soils of rafsanjan pistachiocultivation. Msc thesis, isfahan technology university.
- Nettleton, W.D., R.E. Nelson, B.R. Brasher and P.S. Derr, 1982. Gypsiferous soils in the Western United States. In: *Soil Science Society of America Special Publication*, 10: 147-168.
- Rossiter, D.G., 1994. Lecture Notes : "Land Evaluation". Cornell University. College of Agriculture & Life Sciences. ITC. Netherlands.
- Rossiter, David G., 1996. A theoretical framework for land evaluation. *Geoderma*, 72: 165-190.
- Smith, R. and V.S. Robertson, 1962. Soil irrigation classification of shallow soils overlying gypsum beds, northern Iraq. *Journal of Soil Science*, 13: 106-115.
- Syedjalali, A., 2000. Suitabilty evaluation of gypsic soils lands for water crops. *Journal of water and soil, iran*, 12: 234-240.
- Sys, C. and W. Verheye, 1972. Principles of land classification in arid and semi-arid regions. International Training Centre for Post-Graduate Soil Scientists, State University of Ghent, Belgium.
- Sys, C., E. Van Ranset and J. Debaveye, 1991. Land evaluation, part, I.II.III. General Administration for Development Agriculture publ. No. 7. Burssels, Belgium.
- Tomanian, N., 1998. Source of gypsic and circumstance of genesis and evolution of gypsic soils in northwest region of province of isfahan. Msc thesis , isfahan university of technology.
- USDA, 1998. Field book for describing and sampling soils, version 1.1, Lincoln, Nebraska. NRCS.
- USDA, NRCS, 2004. Soil survey laboratory methods manual. Soil survey investigations report, NO 42. version 4.0.
- USDA, Soil Survey Staff. 2006, keys to Soil Taxonomy. 10 th edition.
- Zeinadini, A. and A. Syedjalali, 2001. Estimation of potential and suitability evaluation of wheat land in orzoye plain in province kerman. Abstracts 1 th iranian soil sciences congress, 1: 125-128.
- Zeinadini, A. and M.H. Masihabadi, 2002. Suitability evaluation of wheat land in province of kerman. Papers 8 th iranian soil sciences congress, 1: 135-136.