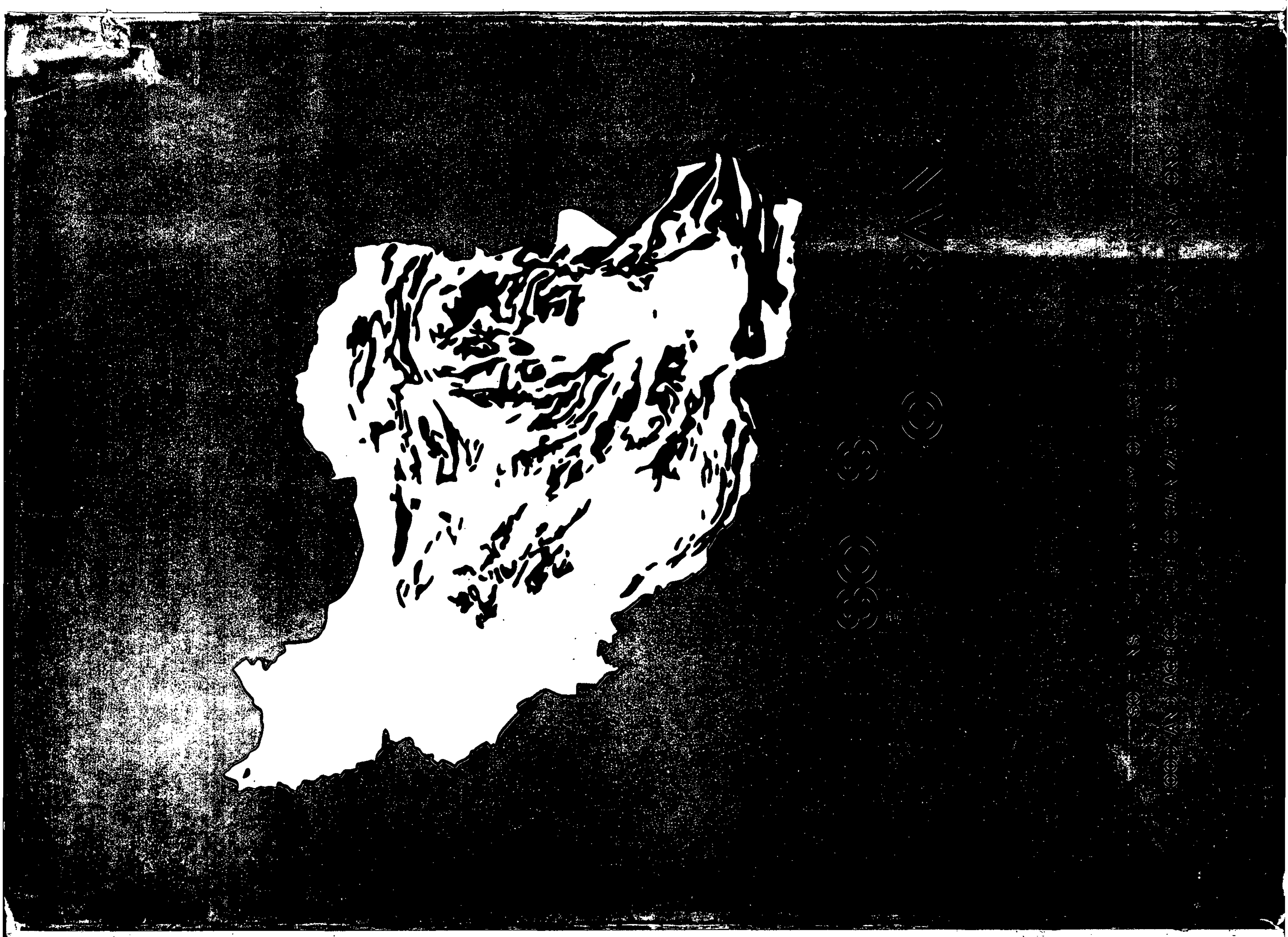

# THE SOILS OF IRAN

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BY

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# SUMMARY

Iran has a total area of about 1,650,000 square kilometers. It lies between 25 and 40 degrees north latitude and 44 and 64 degrees east longitude.

Iranian territory is composed to a large extent of mountains surrounding the saline, sandy, and rocky deserts of the central plateau and forming a closed basin containing many kinds of accumulations.

There are four main physiographic areas in Iran, each with a distinctive character:

1. The Zagros and Elburz range of mountains in the form of a great V.
2. The area within the V, which begins as a high plateau with its own secondary ranges and gradually descends into deserts.
3. The region of Khuzistan, a low-lying plain and a continuation of the Mesopotamian plain.
4. The Caspian Sea coast which is below sea level and forms a separate climatic zone.

Over 50 percent of the total land surface of Iran is mountainous and rough, and includes areas mapped as soils of dissected slopes and mountains.

The factors determining the formation of the different climatic regions are the strongly marked orography and the geographical position of the Caspian Sea, the Caucasus ranges of the northern border, the Persian Gulf and the Sea of Oman at the southern borders. The major part of the country is arid or semiarid. Except on the northern flanks of the Elburz Mountains where it varies from 1,000 to 2,000 mm annually the little rainfall is restricted to winter months. On the plateau the average annual rainfall of over 200 mm in the north decreases to less than 120 mm in the south and southeast. At the head of the Persian Gulf the amount is somewhat greater. Snow is common in the high areas above 1,300 meters. The precipitation map (B5) gives an idea of the rainfall pattern.

Vegetation varies according to climate. The original vegetation consisted (and still consists to a considerable extent) of oak and beech in the more humid sections of the north, and a thin cover of grasses and/or scattered shrubs in the semiarid and arid interior. Many variations between these two extremes, consisting of tree-grass, grass-shrub, or tree-grass-shrub combinations, often occur within a short distance of one another throughout the country. Because of its destruction by man,

the vegetation of many areas, especially the arid and semiarid ones, now bears little resemblance to the original cover.

Iran can be divided into the following main geological units, from south to north:

1. *Khuzistan plain.* It is covered mainly by the flood plains and deltas of the Karun and Karkheh rivers in southwest Iran.
2. *Folded zone.* Stratigraphic sequence in this zone starts in the Upper Paleozoic and ends with the Miocene. The desolate character of the southern half of Iran is due to Mio-Pliocene sequence composed of Asmari limestone over which lie the thick Fars Series of gypsum, anhydrite, salt, marl, silt and sandstone, etc. Above the Fars Series are the Bakhtiari Series made up mainly of conglomerates.
3. *Iranides.* A structural complex formed by three units:
   (*a*) the Radiolarite and Ophiolite zone, made up of red and green cherts, siliceous shales and green eruptive ultrabasic rocks (serpentines).
   (*b*) The Bisitun limestone zone, made up of thick massive limestones of Cretaceous age.
   (*c*) The Hamadan zone, formed of dark shales and sandstones, dark phyllites and chlorite schists of Mesozoic age.
4. *Central plateau.* Characterized by the gypsiferous and saline series of Eocene to Miocene age. The washing out of gypsum beds has led to the formation of salt lakes (kavirs).
5. *Elburz mountains.* This range is made up of a thick stratigraphic sequence composed of limestones, shales, sandstones, tuffs, etc. Gypsiferous and saline series are absent. The age of these formations ranges from Cambrian to Tertiary.
6. *The Turkeman-Khurasan mountains* to the east are composed mainly of limestones and marls.
7. *Caspian littoral.* Alluvial material as well as younger Tertiary sediments and some loess deposits are found here.

Iran has a great variety of soils formed by factors such as climate, vegetation, topography, parent rock, and time. To these must be added the factor of man, who, in a country with a long history such as Iran, has effected considerable changes in soils by plowing, irrigation, harvesting, and other work. The effect of these genetic factors is discussed later.

A systematic map of the soil cover of Iran was prepared by Dr. Kovda in 1944 on a 1:6,000,000 scale but the soil map included in this volume is the first based on direct field observations for the country as a whole and indicating its different soils. Field soil survey work was done on the basis of aerial photographs and photo indexes, and field sheets at scales of 1:250,000 and 1:500,000. These were reduced to a 1:1,000,000 scale, 11 sheets of which have been reduced to the 1:2,500,000 scale for publication purposes. Reconnaissance, semidetailed, and detailed soil maps prepared for special projects were also used.

For a map at the scale of 1:2,500,000, the most adequate mapping unit appears to be the soil association. This is a grouping of soil units geographically associated in the landscape and selected in order to correspond to broad climatic and physiographic units which, in addition, have a certain land use pattern in common. Mapping units in the legend have been conveniently grouped under four physiographic units. This subdivision, however, is not exclusive since units mentioned under one group may also occur to a minor extent under the others. Names of the associations are given in terms of the dominant soil groups, while the inclusions are mentioned in the text. No attempt was made to indicate in this map soils below the level of great soil groups, although phases of most of these soils were identified and indicated on the field map, and a few on the generalized soil map.

Inclusion of the names "Lithosols," "Rendzinas," or "Regosols" in the associations occupying dissected slopes and mountainous areas may not always be justified on the basis of their distribution areawise; their inclusion in the association name indicates mainly the shallow development of most of the soils under these units.

The areas of each of the soil associations mapped is given below:

| *Soil Assoc. No.* | I. *Soils of the plains and valleys* | *Area in 1,000 ha* |
|---|---|---|
| 1 | Fine-textured Alluvial soils | 4,750 |
| 2a | Coarse-textured Alluvial and Colluvial soils and Regosols | 4,500 |
| 2b | Sand Dunes (including Coastal Sands) | 2,500 |
| 3 | Low Humic-Gley, Humic-Gley and Half Bog soils | 750 |
| 4 | Solonchak and Solonetz soils (including Gypsum soils) | 6,000 |
| 1-4 | Saline-Alluvial soils | 5,000 |
| 3-4 | Salt-Marsh soils | 7,000 |
| | Total soils of the plains and valleys | 30,500 |
| | II. *Soils of the plateau* | |
| 5 | Grey and Red Desert soils | 2,000 |
| 6 | Sierozem soils | 8,000 |
| 7 | Brown soils | 6,000 |
| 8 | Chestnut soils | 1,000 |

| | | |
|---|---|---|
| 5-2a | Desert soils - Regosols | 8,000 |
| 5-2b | Desert soils - Sand Dunes | 8,000 |
| 5-4 | Desert soils - Sierozem soils - Solonchak soils | 3,000 |
| 6-2 | Sierozem soils - Regosols (with inclusions of Sand Dunes) | 9,000 |
| 7-15 | Brown soils - Lithosols | 2,000 |
| | Total soils of the plateau | 47,000 |
| | III. *Soils of the Caspian Piedmont* | |
| 9 | Red and Brown Mediterranean soils | 20 |
| 10 | Red-Yellow Podzolic soils | 30 |
| 11 | Brown Forest soils (including Grey-Brown Podzolic soils) | 300 |
| | Total soils of the Caspian Piedmont | 350 |
| | IV. *Soils of the dissected slopes and mountains* | |
| 12 | Brown Soils - Rendzinas | 400 |
| 13 | Calcareous Lithosols - Desert and Sierozem soils | 35,000 |
| 14 | Calcareous Lithosols (from saliferous and gypsiferous marls) - Desert and Sierozem soils (including Salt Plugs) | 12,000 |
| 15 | Calcareous Lithosols - Brown soils and Chestnut soils | 24,000 |
| 16 | Lithosols (from igneous rocks) - Brown soils and Sierozem soils | 12,000 |
| 17 | Lithosols - Brown Forest soils and Rendzinas | 2,500 |
| 18 | Regosols (mainly from sandstones) - Red-Yellow Podzolic soils | 100 |
| 19 | Lithosols (mainly from igneous rocks) - Brown Forest and Podzolic soils | 150 |
| | Total soils of the dissected slopes and mountains | 86,150 |
| | Lakes | 1,000 |
| | Total area of Iran | 165,000 |

## Description of mapping units

### SOILS OF THE PLAINS AND VALLEYS

Soils of the plains and valleys are formed by soil material which is not residual but is brought by the usual agencies of water and wind.

*Alluvial soils* are composed of young water-deposited sediments of the flat or gently sloping flood plains. They do not show a prominent horizon differentiation other than the formation of an organic matter layer ($A_1$) at the surface. The alluvial soils separated in the mapping unit are generally medium- to fine-textured and mostly calcareous.

*Coarse-textured Alluvial and Colluvial soils and Regosols* include soils of coalescing alluvial fans (also called diluvial soils by Soviet soil scientists). They have been and in most cases are still being built up by material carried by flood waters from the mountains to relatively narrow valleys.

Some profile development is observed in the soils. Lime accumulation is found in concretions and pockets, as powder or deposited on gravels. Gravels are usually cemented with finer material by means of lime which has moved; the degree of cementation varies with the region, rainfall, and other factors affecting lime movement in the soil profile.

*Sand Dunes* are common in most of the arid regions of Iran. They consist of deposits of loose sand, occurring within or near the margins of deserts and coasts and are composed largely of quartz or of fragments of many different minerals. Sand dunes may be moving or may be fixed by vegetation. High wind velocities prevailing in some of the regions are an important factor influencing moving sand dunes.

*Hydromorphic soils including Low Humic-Gley, Humic-Gley, and Half Bog Soils.* The major hydromorphic soils found in Iran are Low Humic and Humic-Gley soils, Pseudo-Gley or Grey Hydromorphic soils, and a small area of Half Bog soils near Pahlavi, all in the north.

Low Humic and Humic-Gley soils, also called Wiesenboden or Swamp Meadow soils, are dark brown or black soils, high in humus, grading into a greyish and rust mottled color. They are mostly slightly acid to slightly alkaline and gleization and calcification are the main processes of soil development.

Grey Hydromorphic or Pseudo-Gley soils are typical of the paddy lands in the Gilan-Mazanderan area of the Caspian littoral. These soils have brown mottles with black iron and manganese concretions, normally at a depth of 10 to 40 cm. Surface structure is usually fine granular. The groundwater table is usually very deep, but in winter and fall there is a superficial or perched water table. These Pseudo-Gley soils are actual degradations of forest soils. There is no running groundwater below the surface, but there is a stagnation of surface water, hence the hydromorphic nature of the soils.

*Solonchak and Solonetz soils* are the saline and alkali soils of the arid, semiarid, and dry subhumid regions of Iran. They are either poorly drained, or have been developed under poor drainage conditions and where the sediment has come from gypsiferous and saliferous marls.[1] Solonchak soils contain large quantities of soluble salts, mainly sulfates but also chlorides of calcium, magnesium, and sodium. Commonly light colored, Solonchak soils are poor in organic matter and have a lightly crusted friable granular structure. Solonetz soils are the products of the partial leaching and alkalization of Solonchak soils, such as happens by irrigation without proper drainage and water management, and they often occur as spots scattered throughout the latter. Solonetz soils have a surface layer of light-colored leached material over a darker colored subsoil layer of tough heavy material of columnar structure.

*Saline-Alluvial soils* consist of poorly drained areas of alluvial soils, moderately to severely affected by soil salinity.

*Salt-Marsh soils* are usually wet for all or most of the year and occur in more or less seasonal types of marshes in the glens of valleys and in great parts of Dasht-i-Kavir, usually the low-lying areas which are flooded annually by rivers form these Salt-Marsh soils. These soils combine the characteristics of salty soils such as Solonchaks and marshy soils. Salinity (and alkalinity) as well as gleying or gleization are the main processes of soil development; mottling up to the surface is their most characteristic feature.

## Soils of the plateau

A great part of Iran is a plateau of about 1,000 meters or more above mean sea level. As indicated earlier the arid or semiarid climate is prevalent in a great portion of this plateau. The soils of the plateau are summarily described below.

*Grey and Red Desert soils.* Desert soils are formed through severe moisture deficiency. One of the differentiating characteristics or common occurrences in these soils is a thin surface crust of slightly cemented to severely compacted materials, usually referred to as the desert pavement.

Horizon differentiation is barely visible in some cases, and in most instances is nonexistent. The soils are very deficient in humus, usually containing about 0.1 to 0.2 percent in the surface horizon. The soil is calcareous throughout and usually has a calcium carbonate zone close to the surface. The soil reaction is always alkaline with numerous instances indicating an accumulation of soluble salts in the profile, presumably as a result of capillary upward movements of moisture.

*Sierozem soils.* Sierozem refers to the light grey-colored AC soil, extremely calcareous with little leaching and deficient in humus, usually containing only about

[1] Mapping unit or Soil Association No. 14. See Map B1.

0.5 percent in the surface layer; it has sparse open xerophytic plant cover, and a scanty soil life. It occurs primarily as a climax formation in desert steppes.

Common to all varieties of Sierozem is a shallow humus horizon of 5 to 10 cm depth, contrasting little with the subsoil, followed usually by a Ca horizon which gradually passes into the generally looser C horizon. On the surface, a lighter colored bright grey $A_1$ horizon is seen which is either powdery or dusty or in many-loamy forms has a dense, partly leafy structure. Its formation is due to a large supply of wind-borne calcareous sediments which either remain loose, or become puddled by rain water. Under the $A_1$ horizon is the slightly brownish-colored $A_2$ horizon usually somewhat darker and rich in humus, which again is followed by a light grey A/Ca horizon. On highly calcareous parent material the Ca horizon often differs very little from the C horizon.

*Brown soils.* The Brown steppe soils are probably the predominant soils in Iran. These are brown to light brown, alkaline soils usually overlying calcareous horizons. They have a very weak, often thick, $A_1$ horizon with an organic matter content of about 1 percent or more. Usually illuviation and eluviation are slightly active although some of the Brown soils show zones of accumulation of clay usually in the form of clay skins.

Brown soils have greyish brown granular surface soils, brown or yellowish-brown granular crumbly, weak but often thick subsoils which grade at 15 to 30 cm into a pale brown or greyish highly calcareous clay. The depth of the solum varies according to the slope of the area. Well-developed soil profiles with distinct texture, structure, color, and reaction are rare and occur only on gentle slopes. These soils are developed in semiarid climate under grass vegetation and suffer moisture deficiency during summer months and they have recently been called Yellow soils (temporary designation)[2] to distinguish them from the Brown soils which receive rainfall in summer.

*Chestnut soils* occur in certain parts of Iran and are described as dark brown (chestnut-colored) soil over light-colored material overlying a calcareous horizon. The depth of the humus horizon varies from about 30 to 60 cm, and is usually 40 to 50 cm. The typical Chestnut soil profile described consists of a lighter greyish-colored loose $A_1$ horizon, occasionally showing slight leafy separation in the upper part underlain by a chestnut brown horizon normally rich in cavities and of a spongy character. This changes gradually to a light brownish-grey transition A/Ca horizon, then with a whitish more or less crusted Ca horizon, and finally into the loose parent material.

The Chestnut soils are usually neutral at the surface and effervesce only at a depth

[2] See List of Soil Science Terms and Definitions.

of about 30 to 40 cm, except when they occur on highly calcareous parent materials. Humus content in the surface soil usually averages about 3 to 4 percent.

Soil associations such as Desert soils–Sand Dunes, etc. are shown on Map B1. These are complexes where one predominant soil group and other soils occurring together with it are indicated as associations.

## SOILS OF THE CASPIAN PIEDMONT

Slight to moderately sloping foothills in the northern areas of the Elburz Mountains bordering the southern coast of the Caspian Sea are characterized by a humid and subhumid subtropical climate, and are referred to as the Caspian Piedmont, which includes the Caspian provinces of Gilan, Mazanderan, and Gorgan. These regions have climatic conditions different from the other parts of Iran and have certain similarities to the Mediterranean climate, humid in the west and subhumid, semi-arid in the eastern part.

Abundance of vegetation and intensity of chemical weathering on Jurassic, Cretaceous, and Tertiary limestones and conglomerates, sandstones, etc., on the northern slopes of Elburz, are responsible for the formation of this cover of Brown Forest, Red-Yellow Podzolic, and in some cases Grey-Brown Podzolic soils. In some transitional areas a few profiles of Red-Brown Mediterranean soils have been mapped. These soils occupy only 0.2 percent of the country and are described in some detail in the main body of the text.

## SOILS OF THE DISSECTED SLOPES AND MOUNTAINS

Soils of the dissected slopes and mountains are, in general, stony soils, shallow over bedrock, without a definite profile development. These soils consist largely of unweathered rock fragments, and though they may have some initiation of weathering, and accumulation of organic matter, yet little or no profile development has taken place. Such conditions may be due to recent exposure of the parent material to the action of soil-forming processes or, more commonly, to forces of natural erosion sufficient to remove the finer texture soil material as fast as it is formed. These soils are called Lithosols and are found in all climates, although more commonly associated with arid and semiarid areas.

The complex soils of mountains and dissected slopes occupy a large part of Iran. The separations under this classification are mapping units which contain areas unsuited as a whole for crop use. However, many of these contain small areas of alluvial and colluvial soils, or soils from residuum that could be cropland or improved pastures. Nomadic grazing in Iran depends to a considerable extent on such areas of better soils, which, however, comprise only a small percentage of the total area in which they are found. In a general study of this kind, it is impractical to show them on the map. Their existence is recognized, however, and an attempt was made to estimate the proportion of these soils in each miscellaneous soil group.

Each of the above soils mapped is described in Chapter 3 with typical profile or profiles, range in characteristics, relief, drainage, vegetation, parent material, land use, and distribution. Aerial and other photographs depicting such soils, and analytical data on soil samples of the typical profiles are provided.

## Present and potential land use

Regarding present land use in Iran no statistics exist, but an estimate has been made. Of the 165 million hectares, 19 million are under agriculture, including fallow and orchards, 10 million under pasture, 19 million under forest and woodland, and the rest wastelands, desert area, or mountains (as much as 33 million ha are unused but potentially productive). Of the 19 million ha under agriculture only 6.6 million are under crops in any one year, and only 3 million are under irrigation. Seven hundred thousand hectares are under vineyards and orchards and 2.3 million under irrigation crops such as rice, cotton, sugar beet, oil seeds, and in some cases wheat.

An attempt has also been made to group the soils into a soil potentiality map (B2). Five broad groupings have been made and a total of 10 classes indicates the limitations of soils for agricultural productivity as follows:

1. Soils with no limitations or slight limitations.
   No important problem except locally.
2. Soils with slight to moderate limitations.
   (*a*) Moderate deficit of water and slight to moderate undulations.
   (*b*) Limitation due to poor or moderate drainage.
3. Soils with moderate to severe limitations.
   (*a*) Moderate to strong deficit of water, limitation due to gravel, undulation, or depth.
   (*b*) Limitation due to slope or depth.
   (*c*) Slope, depth, and water are predominant limitations.
4. Soils with severe to very severe limitations.
   (*a*) Slope, depth, and water are main limitations.
   (*b*) Salinity, gravel, depth, and strong deficit of water.

5. Soils with almost no potentiality.
   (*a*) Sand Dunes.
   (*b*) Solonchak, Salt-Marsh, saliferous and gypsiferous marls.

Problems to be solved if the soils of Iran are to be used productively are salinity and alkalinity of soils, water and wind erosion, inadequacy or lack of organic matter, and lack of plant nutrients. To work out these practical problems, several projects for agricultural development have been started in Iran.

The soil survey, land classification, and other soil research and investigation made during the last 12 years by the Government of Iran is being continued on the same lines with the help of FAO and other agencies.

There are several problems in soil classification which must be more fully understood. Notable among them are those related to the soils of mountains and dissected slopes, the saline and alkali soils, and the soils of irrigated areas. A beginning has been made in the preparation of maps of large areas of the country on 1:50,000 scale. In short, all soil survey, research, and investigation work is aimed at the following objectives:

1. That each hectare of land be used according to its capability;
2. That any increase in the agricultural area of Iran should be on those soils which have great potentiality;
3. That each hectare under agriculture or other land use should give improved yields.

To this end several irrigation, drainage, and reclamation projects have been started in the last decade and a great deal of work is going on in investigation for improved yields through efficient use of fertilizers.

# 1. INTRODUCTION AND ACKNOWLEDGMENT

Soils are the most valuable natural resources of Iran. In 1958-59 the country derived \$1,100 million income from agricultural production as against \$257 million from oil. Furthermore, soils are to some extent renewable natural resources, whereas oil is not. Although considerable information already exists on the oil resources of Iran, as yet there is only scanty information on soils.

The present study of the soils of Iran, together with the soil map of Iran, prepared at the scale 1:1 million and printed at 1:2.5 million, is the first systematic attempt to classify and define the broad groups of soils, and to explain some of the relationships between soils, climate, vegetation, parent material, and relief.

This first systematic study of the soils of Iran has been possible because of team work. FAO soil scientists (20,47) and Iranian soil surveyors and laboratory chemists worked together, with funds provided by the Plan Organization and the Irrigation Bongah of the Ministry of Agriculture.

All the soil maps prepared by various groups in Iran, including the consulting engineers (such as the Khuzistan Development Service, Sir Alexander Gibb and partners, and Cotha Sogreah), have been used in presenting this general study compiling present soil knowledge.

It is hoped that this work, essentially a preliminary one, will be utilized in all agricultural planning in Iran. The central theme of any sound agricultural planning must be a more efficient land use with higher sustained yields and this is also the first objective of any soil research and investigation program. This aim cannot be achieved unless the characteristics of the soil have been carefully studied and understood. Soil survey and classification are essential for such an understanding, and for an accurate appraisal of the potentiality of these soils.

It is also hoped that this study will form the basis for the improved use, management, and conservation of Iranian soils, and that it will stimulate further work on these problems.

It is essential that increased yields of diversified crops be obtained and a larger area of suitable soil brought under permanent agriculture, both under irrigation and dry farming, in order to satisfy the growing needs of an expanding population in Iran.

It should not be assumed that this first study will supply *specific* answers to all of the many questions concerning use, management, and classification of the soils of Iran. Concrete problems can be solved only through detailed soil surveys and through research both in field and laboratory. Perhaps one of the important uses of this study will be to emphasize the need for more detailed soil survey and a research program to ensure a more efficient use of the land.

Although the authors take complete responsibility for this volume, they wish to acknowledge the soil scientists who participated fully in the work and prepared several parts of the map – M. Vakilian, M. Farmanara, R. Mahjouri, N. Pirooz, and M. Samadi of the Ministry of Agriculture, and P. Verot of the consulting engineering firm of Cotha Sogreah, who contributed with the approval of the Plan Organization; FAO soil scientists, especially Dr. Veenenbos and Mr. Subramanian, who worked in Iran, have also directly contributed to the material and ideas. The laboratory analyses were done by G. Sharifi, L. Ahrunian, and others under the general guidance of the late Dr. Gracie and Mr. J. Dewis.

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Suggestions for improvements from Dr. Bramão, Dr. Dudal, and Mr. Reese of Headquarters, FAO, Rome, were gratefully received.

# 2. GENERAL DESCRIPTION

Iran stretches from 25° to 40° north latitude and from 44° to 64° east longitude. It is surrounded by the Caspian Sea, the steppes of southern Turkistan, and the Caucasus ranges at the northern border; U.S.S.R. (Turkemenia), Afghanistan, and Pakistan on its eastern border; the Gulf of Oman and the Persian Gulf at the southern border; the Republic of Iraq and the Republic of Turkey on its western borders.

The total land surface is about 165 million hectares (1,650,000 sq km) of which about 1 million hectares are inland lakes and water bodies. Iran is widest at 36° N latitude, a distance of about 1,400 km. When measured along a parallel it is narrowest at 26° N latitude, with a width of 350 km. When measured along a meridian it is longest at 58° E longitude (about 1,340 km) and shortest at 50° E longitude (about 800 km). The vastness of Iran can be realized if one travels in a straight line from the northwest corner of Iran (Azerbaijan) to its furthest southeast corner (Baluchistan), separated by a total of 2,300 km. The distance from the Shatt-al-Arab to Khurasan (SW-NE) is 1,350 km. The two narrow parts are between Bandar Shahpoor and Nowshahr (720 km) and between Bandar Abbas and Hormuk (Seistan) (500 km).

## 2.1 Physiographic provinces and geomorphology (Refs. 6, 7, 8, 9)

A great portion of Iranian territory is occupied by mountains which surround the saline, sandy, and rocky deserts of the central Iranian plateau, thus making it a closed basin containing many kinds of accumulation. The four main distinct physiographic provinces in Iran are:

The *Zagros and Elburz mountain ranges* and their northwest and southeast extensions. These ranges enclose the large triangular area of central and east Iran, in the form of a V.

The area within the range of mountains in the form of a V, i.e., the *central plateau* of Iran with its own secondary ranges, gradually sloping down to become deserts, which continue into southern Afghanistan and Pakistan.

The *region of Khuzistan and the other low-lying southern plains* on the coast of the Persian Gulf and the Gulf of Oman; a continuation of the Mesopotamian plain.

*The Caspian Sea coastal area* which is below sea level and forms a separate climatic zone.

The physiographic divisions are:

### Mountains

There are two major mountain systems in Iran each of a different character. These are the Elburz, running almost from west to east, and the Zagros, extending from northwest to southeast. The two systems, with other Asiatic mountain ranges, meet at the great mountain junction of Armenia in southern Russia. The Elburz and its associate ranges form a continuous wall along northern Iran from Ararat in the northwest corner to Sarakhs in the northeast corner of Iran. This system (Elburz) consists of parallel ranges, increasing in elevation from north and from south. In the middle ranges of the Elburz is the famous Mount Demavend, the highest peak in Iran with an elevation of 5,766 meters.

The Zagros Mountains begin with the Turkish frontier ranges, and consist of a number of ranges from northwest to southeast, almost parallel to one another. They form an unbroken wall of mountains, about 1,000 km in length and often more than 200 km wide. They attain heights of more than 4,500 m and hence play an important part in the climatology and soil formation of the country. The Zagros system takes a southeasterly direction before reaching Khuzistan and runs through the provinces of Fars and Kerman for over 800 km. South of Kerman, the Zagros splits into two branches which enclose the large Jaz Murian Basin. The north branch culminates in the Kuh-i-Taftan volcanoes, where it joins the north-south ranges east of Iranshahr. The south branch runs parallel to the coast line of the Gulf of Oman and continues into Pakistan.

### Plateau

The area within the V of the mountain ranges is a high plateau with its own secondary ranges, and gradually slopes down to become desert which continues into southern Afghanistan and Pakistan.

This plateau is dissected and includes mountains and foothills, other hills, lake basins, and several alluvial plains. Elevations range from about 500 to 2,500 m. The triangle of central and east Iran can be subdivided into four major geomorphological units:

(*a*) The high plateau of northwest-central Iran, including the Urmia basin, 1,200 to 2,500 m above mean sea level.

(*b*) The Isfahan-Saidabad basin, at 1,000-1,200 m elevation.

(*c*) The salt desert basin (Masileh-Kavir), elevation about 600-1,000 m.

(*d*) The Lut desert basin at 500-600 m elevation.

The basins are surrounded and partly subdivided by mountain ranges along which extend large outwash fans and alluvial plains grading into the lake and playa deposits.

### Region of Khuzistan and low-lying southern coastal plains

This includes the vast low-lying Khuzistan plain in southwestern Iran, which is a continuation of the Mesopotamian plain, and other low-lying plains on the coast of the Persian Gulf and the Gulf of Oman. These coastal areas vary from a very narrow strip bordered abruptly by steeply sloping hills or mountains to wide deltaic or alluvial plains. The Khuzistan plain is a vast area of 30,000 sq km built up from the flood plains and deltas of the rivers draining into the head of the Persian Gulf.

In addition, there is a narrow belt of low-lying plains in western Iran, on the eastern border of Iraq draining into the Tigris River, which, together with the Euphrates, reaches the gulf by way of the Shatt-al-Arab.

Large rivers in the southern coastal plains from west to east are the Shahpur River, which has built the Bushire and Borozjan Plains, the Mand River which is building a large plain in Fars; and the Minab river near Bandar Abbas which is building large plains of only minor agricultural importance because of the salinity of groundwater and the soil.

### Caspian Sea coastal area

The Caspian littoral is a narrow coastal plain with an average width of about 50 km, produced by a "general retreat" of the sea, which at one time probably extended as far as the foot of the Elburz Mountains. Numerous rivers originate in the northern foothills of the Elburz, but they are all short and cover small distances before they reach the sea. There are, however, four rivers of importance that have their sources in the distant regions and empty their water in the Caspian after covering considerable distances. They are, in order of importance and from west to east: Aras (Araxes), Sefid Rud, Gorgan, and Atrek. These rivers have respectively built the Moghan Plain, the Sefid Rud Delta (Rasht Plain), the Gorgan and Atrek Plains. In addition, a group of rivers – Talvar, Haraz, Babol, and Tejan – have built up the Mazanderan Plain.

Iran is a mountainous country and predominantly a high plateau. A rough approximation of its relief is shown below as calculated by planimetric measurement from the 1:2,500,000 outline map.

| Description | Area in sq km | % of total area of Iran |
|---|---|---|
| 1. Land over 2,000 m elevation above mean sea level | 260,000 | 15.7 |
| 2. Land between 1,000-2,000 m elevation | 879,000 | 53.3 |
| 3. Land between 500-1,000 m elevation | 154,000 | 9.3 |
| 4. Land between 0-500 m elevation | 332,000 | 20.1 |
| 5. Land below mean sea level Caspian coastal area (0-28 m below mean sea level) | 11,000 | 0.7 |
| 6. Inland lakes and water bodies | 14,000 | 0.9 |
| Total area of Iran | 1,650,000 | 100.0 |

The relief picture illustrates a few points more clearly:

1. A majority of the land surface of Iran (53.3 percent) is in the 1,000-2,000 m zone, and only a small area (9.3 percent) in the 500-1,000 m zone. This latter indicates steeper slopes.
2. Where the erosion base is at sea level, and higher precipitations are recorded, there is a great deal of present and potential danger of soil erosion, especially as the natural vegetation is progressively cleared.
3. There is a large hydroelectric potential in Iran.

## 2.2 Geology and lithology (Refs. 24, 25, 27)

Iran is situated between the Eurosiberian platform in the north and a deltaic platform in the south. Iran participates of both, with the Caspian littoral and the Khuzistan Plain, respectively. Between the Elburz and the Zagros ranges there is a wide and high central plateau. From southwest to northeast Iran can be divided into seven main structural units:

(*a*) Khuzistan Plain

(*b*) Autochthonous Folded zone of the Zagros system

(*c*) Thrust-folded zone of the Zagros system (Iranides)

(*d*) Central Plateau

(*e*) Elburz range

(*f*) The Kopet-Dagh or Turkeman-Khurasan range, northeast of the Elburz

(*g*) Caspian littoral

The above units are shown in the joint tectonic map which is simplified from the tectonic map of Iran (Appendix B6). An outline of Iranian geology is clear from the above units.

### Khuzistan Plain

This is covered by the deltas of the Karun, Dez, and Karkheh rivers and consists of:

1. alluvial deposits which are coarser toward the mountains and very fine toward the plains;
2. silt and clay in large quantities deposited by the Karun and Karkheh (to the southwest of Ahwaz).

### Folded zone

The stratigraphic sequence in this zone starts with Cretaceous limestones and ends with the Miocene. The structures are a succession of regular features forming anticlines and synclines exposing middle Cretaceous beds in the cores. A green and purple group some 400 m thick may be present near the base of the Eocene. At the top of the Eocene-Oligocene sequence, gypsum is often found.

The desolate character of the southern fringe of Iran is due to Mio-Pliocene sequence. This sequence is composed at the base of Asmari limestone, which constitutes a hard layer nearly 300 m thick. Above the Asmari limestone are the thick Fars series of gypsum, anhydrite, salt, marl, silt, and sandstone which are usually brick red in color and form typical "badlands." They are several thousand m thick, and show great lateral variations due to the original conditions of deposition and to tectonic factors.

Above the Fars Series, the Bakhtiari Series, several hundred m thick, is composed of conglomerates, with pockets of clays, mudstones, and sandstones. The Bakhtiari conglomerates are usually found on the outer edge of the Folded zone. The Folded zone sediments in some parts are cut through by Cambrian salt domes.

### Iranides

The Iranides are a structural complex formed by three units:

1. The Radiolarite and Ophiolite zone, made up of red and green cherts, siliceous shales, and green eruptive ultrabasic rocks (serpentines).
2. The Bisitun limestone zone, made up of thick massive limestone of Cretaceous age. The Bisitun limestone zone wedges out between the Radiolarite-Ophiolite and the Hamadan zones west of Hamadan.

3. The Hamadan zone, formed of dark shales and sandstones, dark phyllites and chlorite schists of Mesozoic age. In the Alvand range, southwest of Hamadan, biotitegranites have been intruded into the phyllites. This zone is very broad (about 140 km) and extends from Azerbaijan to the province of Kerman, whereas the Radiolarites and Bisitun zones do not have the same extension everywhere and in some cases may almost disappear. The southwest limit of the Hamadan zone coincides everywhere with an important geomorphological and climatic divide. Southwest of this line, the original drainage is toward the Persian Gulf, the erosion is youthful, the mountain area has more precipitation, and the predominant limestone formations are good aquifers with numerous springs near the valley bottoms. Northwest of this line, the original drainage is toward central Iran, the topography is mature, with wide, high plateaus and plains, little erosion, less rainfall than toward the southwest, a generally impervious bedrock, and a steppelike vegetation.

### Central Plateau

A great tectonic line separates the zone of central Iran from Iranides. In the Upper Cretaceous and Tertiary, eruptive rocks such as andesite were formed in different places on this tectonic line. Along this line there are many springs which have caused deposition of travertine. In central Iran, sediments of Paleozoic, Mesozoic, and Tertiary are seen.

The gypsiferous and saline series of Eocene to Miocene age characterize this unit and are made up of salt, gypsum, clays, mudstones, siltstones, and sandstones.

The washing out of gypsum beds has led to the formation of salt lakes (kavir). Marine Oligo-Miocene deposits cover a great part of central Iran and the oil possibilities are perhaps only related to these sediments (Qom area). The volcanic activity in Central Iran which started in the upper Cretaceous develops fully in the Eocene and forms eruptive material made up of tuffs and basaltic rocks. In the Oligo-Miocene volcanic activity decreased considerably as compared to the Eocene, and more acid rocks (andesite, diorite, etc.), usually with tuff, were formed. Pre-Cambrian metamorphic and volcanic rocks have been recognized in central Iran west of Kavir (130 km north of Tabas) and in southeast Ravar (Kerman).

### Elburz

The Elburz Mountains are formed of a thick stratigraphic sequence of limestone, shales, sandstones, and tuffs. The gypsiferous and saline series are absent. The age of formations ranges from Cambrian to Tertiary. In Elburz the Paleozoic formation covers a relatively large area. In the Mesozoic the Jurassic has a great relative extension and because of the presence of coal has a great economic value.

Along the south slope of the Elburz, the Eocene and probably the lower Oligocene consist of 3,000 m of tuff beds with volcanic and intrusive rocks.

Metamorphic and eruptive rocks of pre-Devonian are more widespread in Elburz, e.g.:

In the Rasht area phyllites, quartzites, gneiss, biotite-granite; in the Alam Kuh (central Elburz) schists, marbles, amphybolite, and granitic rocks; and in the Gorgan area, phyllite, green schists and eruptive basic rocks are found.

### The Turkeman–Khurasan mountains

These are also called Kopet-Dagh mountains in the northeast of Elburz and are mainly composed of Cretaceous limestones and marls.

### Caspian littoral

In the Gorgan, Mazanderan, and Rasht Plains in the north, alluvial materials, as well as younger Tertiary sediments of Caspian type, are found, and also some loess deposits, especially in the Atrek area.

## 2.3 Climate (Refs. 1, 9, 22, 23)

The climate is an extremely important soil-forming factor. Although Iran is predominantly an arid and semiarid country there are considerable variations in climate from one part of the country to another. These variations, influenced by orography and physiography, are reflected in the climatic provinces of Iran. These provinces are based on Koeppen's system as adapted by Dr. Ganji in his publication, "The Climates of Iran."

### Types of climate

#### *B Climates*

*B climates* are dry climates in which evaporation exceeds precipitation. The rainfall, evaporation, and drainage patterns indicate that the B climates form the dominant types (2/3) on the climatic map of Iran. There are two kinds of B climates in Iran.

*BW climate:* The BW or desert type of climate is found in two distinct sections of Iran, namely, along the coasts of the southern seas, and in the interior. Along the southern coastal areas, aridity is combined with high temperature and often very high humidity. Precipitation is very meager in amount and extremely variable in occurrence. Whatever rainfall there is comes in the cooler winter months.

The greatest extent of desert, and the BW type of climate that is associated with it, is found in the interior of the country. There is a wide range in both the daily and annual temperatures. Rainfall is very scanty, even less than in the coastal areas. Of the stations included in this section, Yazd has rainfall of about 67 mm and Nehbandan about 98 mm.

*BS climate:* The BS or semiarid steppe climate is often a transition between the arid deserts on one hand and the more humid climates on the other.

The BS type of climate, covering about half a million square kilometers of Iranian territory, occupies in most cases the foothills of higher mountains. It is found generally between the 1,000 and 1,500 m contours, except for the foothills of the Khuzistan plains which are much lower in elevation. Precipitation is on the whole meager and variable. Of the stations included in this section, Dezful has the highest rainfall, about 300 mm, and Isfahan the lowest, about 140 mm. There is a coincidence of rainy season with the period of low sun and low temperature, so that the precipitation effectiveness becomes much greater. The winter rains, except when they are intense and produce considerable erosion, find their way underground where they add to the storage which can be utilized in the drier months of the year. Thus the presence of springs and ghanats[1] as sources of this underground water form a very important feature in the agricultural life of Iran in the BS climate.

*C Climates*

One quarter, about 400,000 km of the total land surface of Iran is dominated by the C or mesothermal group of climates. The most populous section of Iran is located in this climatic zone. As a group, C climates occupy all the higher levels of the Zagros, a major part of Azerbaijan, and the coastal plains of the Caspian Sea.

In the C climates, distinction can be made between the "Highland" type (Cs) which dominates most of the higher lands of Iran, and the "Caspian" type (Cc) which is limited to the coastal plains of the Caspian Sea and the mountains lying immediately behind them.

*Cs Climate (Highland type).* The Cs climate is usually regarded as a Mediterranean climate. However, the typical Mediterranean climate is characterized by (i) a concentration of precipitation in the winter season, summers being nearly completely dry; (ii) warm to hot summers and mild winters, and (iii) a high percentage of possible sunshine in the year, especially in summer. One characteristic of the typical Mediterranean climate, namely the warm winter, is not found in the Iranian highlands which are very cold, especially in Azerbaijan and Khurasan. These two areas are more exposed to the effects of cold waves from the U.S.S.R., and the protection of the mountains is much less than that provided by the Alps to most of the Mediterranean lands. However, the Cs climate in the Fars area has greater similarity

[1] Ghanat is an underground gallery which brings water by gravity to the surface of the soil lower down the slope in the foothills and other areas.

to the typical Mediterranean climate because Fars has greater protection from the cold winds.

*Cc Climate* (*Caspian type*). The coastal plain of the Caspian Sea, and the northern slopes of the mountains that overlook this sea, are climatically very different from the rest of the country. This Caspian type of climate is best characterized by moderate temperatures, small annual and diurnal ranges, very high humidity, strong land and sea breezes and local winds, and very high precipitation (varying normally between 1,000 and 2,000 mm) spread over the different seasons. The combined result of the above-mentioned conditions can be seen in the luxuriant subtropical forests which cover the northern slopes of the Elburz to a height of about 2,500 m.

*D and E climates*

Of the total land surface of Iran, probably about 40,000 sq km have a D type of climate in which the coldest months are below 3°C, the warmest above 10°C. This climate normally occurs over higher lands, although it cannot be fitted into definite ranges of altitude.

The E type of climate, where the warmest months are below 10°C as average temperatures, occurs where the mountains are permanently covered with snow on their higher slopes. The volcanic peaks of Demavend and Sabalan, and a certain area around Sahand, on the plateau of Azerbaijan, are classified as having an E type climate.

## Rainfall

A map of average annual precipitation in Iran was issued in 1959. This was composed of 9 subdivisions, 5 of 0 to 500 mm in steps of 100 mm, and 4 of 500 to over 2,000 mm in steps of 500 mm (500-1,000 mm, 1,000-1,500 mm, 1,500-2,000 mm, and over 2,000 mm).[2] For the purposes of this study these have been simplified to the following five soil moisture regions with some description given below:

*Average annual precipitations*

| *Arid* | *Semiarid* | *Dry subhumid* | *Moist subhumid* | *Humid* |
|---|---|---|---|---|
| less than 100 mm | 100-250 mm | 250-500 mm | 500-1,000 mm | 1,000-2,000 mm |

*Arid regions:* Influenced by geographic position as well as by elevation. The two areas in Iran which are in this region form part of the Kavir region including Dasht-i-Kavir, Dasht-i-Lut, both in the 500-1,000 m elevation zone; they occupy 221,000 sq km or about 13 percent of the total surface of Iran.

*Semiarid regions:* Normally between 100 and 250 mm average annual precipitation;

[2] Koeppen symbols: A = coldest month above 18°C. B = dry climates. W = desert. S = steppe. C = coldest month between 18° and 30°C. D = coldest month below —30°C, warmest above 10°C. E = warmest month below 10°C.

includes a good portion of the coastal area of the Persian Gulf and the Gulf of Oman as well as Khurasan and Azerbaijan and central Iran. Most of this region is in the 1,000-2,000 m elevation zone and occupies 1,005,000 sq km or about 61 percent of the land surface of Iran.

*Dry subhumid regions:* Normally with 250-500 mm average annual precipitation; this region includes large mountainous areas of the Elburz and Zagros systems, mostly over 2,000 m or at least over 1,500 m. It occupies 280,000 sq km or about 17 percent of the land surface of Iran.

*Moist subhumid regions:* Consist of the higher peaks of the Zagros and Elburz ranges and part of the eastern coastal area of the Caspian Sea in the north; average annual precipitation is between 500 and 1,000 mm. It occupies 134,000 sq km or about 8 percent of the land surface of Iran.

*Humid regions:* Consist of the southern Caspian coastal area (normally below main sea level), Pahlavi, Ramsar, and other areas, having average annual rainfall of 1,000-2,000 mm. It occupies 14,000 sq km or about 1 percent of the land surface of Iran.

## 2.4 Phytogeographical and ecological regions[8]

Of all the countries in the Near and Middle East characterized by the lack of rainfall during the hot season, Iran has by far the greatest variety of regional climates, and consequently of soil and vegetation types (Refs. 8, 33, 38, 39). It has wet forests like those in central Europe, central Asian-like steppes, deserts of the Sahara-Sind type, and subtropical mangroves.

All these regional differences are determined mainly by the climate, that is, by the temperature and rainfall pattern.

The essential distinguishing factors are:

1. The abundant rainfall and the relative humidity of the summer season in the Caspian region, while the rest of the country suffers from prolonged summer drought.
2. The high winter temperatures of the regions bordering the Indian Ocean and the Persian Gulf, while in the interior of the country the winters are always fairly cold.
3. Between these two regions which differ radically in climate, the mainland of Iran can be divided into large ecological zones primarily according to annual precip-

[8] This section was written by H. Pabot, FAO ecologist to whom grateful acknowledgment is made. The author wishes his observations and remarks to be considered preliminary and subject to amendment as more field work is done.

itation, namely, the subdesert, steppe, substeppe, and xerophilous forest zones. These zones may be subdivided by winter temperature (the coldest lie in Azerbaijan province and the warmest in the south and southeast).

4. Lastly, as snow lies on the high mountains for several months in the year, a particular vegetation has developed which should be considered as a special substeppe type of vegetation.

The following provisional phytogeographical classification is suggested for Iran.

CASPIAN ZONE (partly similar to Caucasian and central European regions)

Minimum rainfall in June, but no actual drought; atmosphere humid. Difference between July and January mean temperatures about 20°C. Annual precipitation over 600 mm and generally much more. Mean temperature for January below 8°C. Corresponding to Caspian climate C under Koeppen symbols and humid and moist subhumid regions in Map B5.

The Caspian flora shows very little similarity to the Mediterranean flora (very few evergreen species) but it greatly resembles that of the southern Caucasus and comprises a large number of central European species. It is essentially a forest flora, mostly hardwood trees, and spreads over the northern slope of the Elburz Mountains. Owing to the wide differences in altitude, several vegetation belts can be differentiated; going from west to east their approximate limits appear to rise with altitude, partly owing to less precipitation, but mainly to the higher temperatures.

In general, four broad belts can be distinguished:

*Lower forest belt* (up to about 800 m altitude). The main tree species (when not destroyed) is *Quercus castanaefolia* and the undergrowth is often dominated by *Buxus sempervirens*. *Carpinus betulus*, *Zelkowa crenata*, and *Parrotia persica* generally are numerous. In the lower part of this zone, very frequently and even in abundance, there are *Punica granatum*, *Albizzia julibrissin*, *Gleditschia caspica;* and in the moister soils *Alnus glutinosa*, *Pterocarya fraxinifolia*, *Ulmus campestris*, *Fraxinus excelsior*. At higher altitudes the oak and hornbeam stands also include *Tilia rubra*, *Acer loetum*, *Diospyros lotus*, *Celtis australis*, *Alnus subcordata*, *Acer insigne*, *Sorbus torminalis*, etc.

*Middle forest belt* (from 800 to approximately 1,800 m altitude). This is the zone of the beech *Fagus orientalis*. It certainly corresponds to the zone of maximum precipitation. The principal species growing in association with the beech are *Carpinus betulus*, *Acer insigne*, *Tilia rubra*, and in some places, *Taxus baccata*.

*Upper forest belt* (from 1,800 to about 2,500 m altitude). Here the primeval forests have largely been destroyed. Apparently they consisted mainly of one oak

FIGURE 1. A river in spate breaks down the protective wall on the bank. Well-drained Alluvial soils, mixed forest.

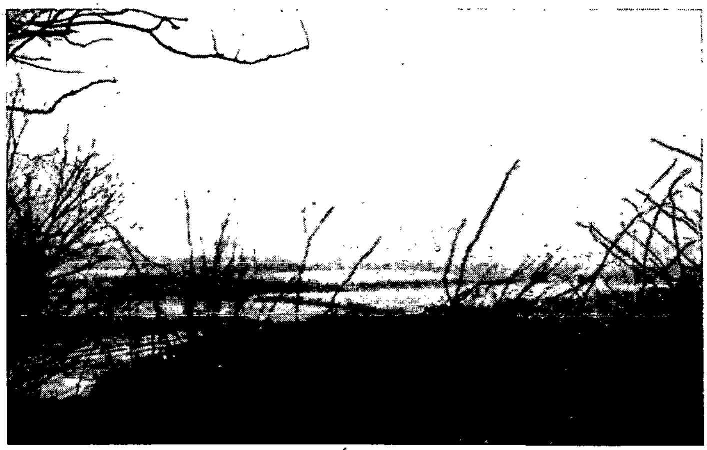

FIGURE 2. Winter in the Rasht area, with paddy fields and snow-capped peaks behind. Mixed forest.

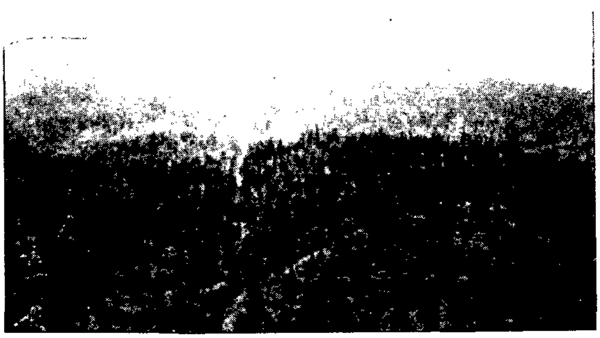

FIGURE 3. Soils formed in igneous rocks in humid regions, under beech and mixed forest.

species, *Quercus macranthera*, in association with *Sorbus umbellata, Acer platanoides, Betula verrucosa, Viburnum lantana, Juniperus communis, Malus pumila.*

This zone is now covered with more or less degraded pastures.

*High mountain pasture belt* (above 2,500 m altitude). There are alpine-type pastures which have not yet been studied much, with many grass species, which come into contact with the xerophilous "tragacanth" vegetation (*Acantholimon, Astragalus*, etc.) of high mountain steppes.

BALUCHI ZONE (affinities with Sahara-Sind and subtropical regions)

Annual precipitation under 300 mm, but some atmospheric humidity due to the proximity of the ocean; long summer drought. Mean temperature for January above 15°C. Differences between July and January mean temperatures between 14° (coast) and 20°C. Corresponds to BW type of climate under Koeppen's symbols and under arid and semiarid type of climate (this climate may be classed as "subtropical-arid").

Although most of this zone has an extremely arid and sometimes desertlike appearance, a fairly large number of tree and shrub species has been reported in Persian Baluchistan.[4] Practically none of these species is found in the rest of Iran; like most of the herbaceous species, they belong to the Sahara-Sind flora which extend from the Sahara to Arabia and to the south of Pakistan. Some species on moist sites are even definitely tropical; for example, certain *Ficus* with persistent leaves, *Avicennia officinalis and Rhizophora mucronata* which form mangrove swamps along the coast. Some families and a large number of genera are represented in Iran only in the Baluchi zone, e.g., this is the only place where the banana and mango has been profitably cultivated. The palm family is represented by the date palm, undoubtedly indigenous, and *Chamaerops ritchieana*. The *Ziziphus* occur very frequently as apparently do various *Acacia*.

Among the trees or shrubs peculiar to this region are *Prosopis spicigera, Dalbergia sissoo, Diospyros tomentosa, Tamarindus indica*, etc. (about 40 peculiar species).

The Leguminosae are mainly represented by special, often subtropical genera: *Indigofera, Tephrosia, Caragana, Crotolaria, Rhynchosia, Cajanus, Cassia, Towerniera*, etc.

The Graminae are nearly all hot region species, among which are various *Pennisetum, Cenchrus, Panicum, Sporobolus, Eragrostis*, etc.

The northern boundary of this Baluchi zone cannot yet be defined; it probably lies to the north of the Bampur depression, but the high mountains in this "province"

[4] Also the name of the ostan (province) in southeastern Kerman.

seem to have an Irano-Turanian flora. To the west, the Baluchi zone certainly extends beyond Bandar Abbas, and some plants of this flora may go as far as Bushire; but Khuzistan, despite its high summer temperatures, has mainly an Irano-Turanian flora and can in no way be linked to the Balûchi zone.

IRANO-TURANIAN ZONE

(Term adopted by botanists and climatologists for the large eastern zone which has a very dry summer and a temperate continental climate; it extends from Syria and Anatolia to Turkestan and the Pamirs.) Precipitation variable (usually less than 500 mm), with drought for at least three summer months. Atmosphere dry or very dry. Temperatures vary greatly, but the winter is usually decidedly cold. Differences between the July and January mean temperatures between 20° and 29°C (usually over 24°). The large Irano-Turanian zone (covering nearly 90 percent of surface area of Iran) can be subdivided into five zones:

*Subdesert zone* (driest part of the Iranian central plateau). Annual precipitation under 100 mm approximately. January mean temperature between 2° and 6°C; July mean temperature between 28° and 33°.

*Steppe zone* (encircles the subdesert zone, but also occurs to the east of Khurasan, on the Khuzistan plain and to the north of the Baluchi zone). Annual precipitation between 100 mm and 200-250 mm (colder winters). Wide differences in temperature (especially in winter) from one region to another at different latitudes and altitudes.

*Substeppe zone* (forms a strip in places very narrow around the Zagros and Elburz Mountains, broader in the Azerbaijan and Khurasan provinces, and probably in patches in the southeastern mountains). Annual precipitation between 200-250 mm (according to region) and 400-450 mm. Wide temperature differences depending on region (as in the steppe zone).

*Xerophilous forest zone* (located mainly in the Zagros Mountains, in Azerbaijan – now deforested – and to the east of the Elburz Mountains). Annual precipitation over 400-500 mm. Altitude varies from 1,000 m to about 2,600 m. Temperatures vary greatly according to region and altitude.

*Dry Alpine zone* (comprises all the mountainous regions rising to heights of between approximately 2,600 m and 4,300 m). Annual precipitation probably less than 600 mm in general. Accumulated snowfall lasts several months. January mean temperature below —2°C; July mean temperature below 20°C.

*Irano-Turanian flora*

This is the true Iranian flora. It is distinctly characterized by the frequency and wealth of species of certain genera, and especially of the *Astragalus* (at least 600 species). Mention should also be made of the genera *Cousinia* (over 200 species), *Silene* (nearly 100 species), *Allium* (about 90 species), *Nepeta* (about 80 species), *Euphorbia* (about 80 species), *Acantholimon* (over 70 species), *Salvia* (about 70 species), *Onobrychis* (nearly 60 species), and *Centaurea* (60 species).

Among the genera with fewer species, but largely represented in the Irano-Turanian zone, are *Acanthophyllum*, *Artemisia*, *Stipa*, *Aristida*, *Salsola*, *Phlomis*, *Stachys*, *Achillea*, *Bromus*, *Poa*, *Agropyrum*, *Hordeum*, *Scrophularia*, *Eremurus*, *Echinops*, and *Ephedra*.

The arborescent vegetation includes a fair number of *Amygdalus*, *Prunus*, *Crataegus*, *Pirus*, *Rhamnus*, and *Ficus*. The principal trees are *Quercus persica*, *Pistacia atlantica*, *Juniperus excelsa*, various *Tamarix*, *Populus euphratica*.

In nearly all the Irano-Turanian zone, the deterioration of the original pastures has fostered the spread of *Poa bulbosa* (several subspecies and varieties), and more recently of *Carex stenophylla* and a related species in the highlands. In cultivated areas large stretches of land are often overgrown with perennial weeds: *Alhagi maurorum*, *A. camelorum*, *Glycyrrhiza glandulifera*, *G. glabra*, *Prosopis stephaniana* (low altitudes), *Hulthemia persica* (tableland), *Goebelia alopecuroides* (irrigated zones and mountains).

Two spiny species, *Noaea mucronata* and *Lactuca orientalis*, are usually extremely widespread in grassland and wasteland areas which receive over 150 mm of rain.

*Subdesertic flora*. In the central "deserts" of Iran a sparse amount of vegetation is usually possible.

Many of the species of this zone are inevitably halophilous Chenopodiaceae: various *Salsola*, *Seidlitzia rosmarinus*, *Halocnemum strobilaceum*, *Salicornia herbacea*, etc. Other Chenopodiaceae may be abundant outside the saline zones, especially on the sands and rocky slopes that get water from the rains. The only possible perennial Gramineae would be the *Aeluropus* in the moderately saline depressions and the *Aristida* on the sands and dunes. No doubt some *Astragalus* and *Cousinia* became adapted to this very arid climate. *Peganum harmala* may be plentiful around the few villages or camping sites.

The only arborescent vegetation possible at certain favored sites will be limited to a few species of *Tamarix*, including *T. macrocarpa* on saline soils, and *Haloxylon ammodendron* on sands, where it is accompanied by *Calligonum* bushes.

*Steppe flora*. The steppe zone has been defined by the pluviometric factor only; this implies that it would be necessary to distinguish types of steppe vegetation by temperatures. For example:

steppe with cold winters (mean for January, below $+5^{o}C$), center and east of Iran;

steppe with mild winters (mean for January, above +9°C), Khuzistan and Fars.

*Artemisia herba-alba* is still fairly typical of the steppe zone with cold winters, where it is often accompanied by nonhalophilous Chenopodiaceae; these woody species do not occur on the steppe with mild winters. *Noaea mucronata* is to be seen almost everywhere. On noneroded soils *Poa bulbosa* is abundant, *Carex stenophylla* is often observed and patches of lichens and bryophytes are often found (trampled soils). *Aristida plumosa* is normally the dominant grass on sandy soils or soils with a granular surface. The *Stipa* (*S. barbata* and related forms), the usual steppe grasses, have frequently disappeared from large areas. The woody and spiny species of the *Astragalus*, *Acantholimon*, and *Acanthophyllum* genera are generally quite common, at least above 1,000 m. Elsewhere the Chenopodiaceae are the most abundant, especially if the soils are slightly saline (*Anabasis*, *Haloxylon*, *Salsola*, *Seidlitzia*, etc.).

There are few legumes, although occasionally *Onobrychis* and even a perennial *Trigonella* can still be seen. The herbaceous *Astragalus* and the *Cousinia* are fairly common.

In spring, the annual species are often abundant, but they are stunted and dry up very quickly. A large number of bulbous species are to be found during the same season, *Gagea*, *Allium*, etc.

The sand dunes have their own special vegetation, which nearly always includes *Aristida* and *Calligonum* species, *Pennisetum dichotomum*, *Cyperus conglomeratus*.

The saline, silty depressions have practically the same flora as the subdesertic zone, although *Aeluropus* pastures are much more frequent.

Lastly, a point to be noted is that trees and shrubs are not completely absent from the steppe zone. *Pistacia atlantica* can still be found in some places, mainly on rocky slopes, and *Amygdalus scoparia* or other bushy almond shrubs occur still more often; *Pteropyrum*, *Ephedra*, and *Lycium* shrubs are sometimes frequent.

*Tamarix stricta* and *Haloxylon ammodendron* still grow as trees on sand dunes. Other species of *Tamarix* are still plentiful, generally reduced to shrub form in the moister depressions, on salty land and sometimes on very arid soils. *Populus euphratica* can be found in valley bottoms, whatever the temperature. *Ziziphus spina-christi* may penetrate into the southern steppes.

*Substeppe flora.* In this zone, as in the xerophilous forest cultivated land is often overgrown with *Prosopis stephaniana* (low altitudes), *Hulthemia persica*, *Alhagi camelorum* (or *A. maurorum*), *Peganum harmala*.

The climax vegetation of this zone is the more or less dense forest of *Pistacia* (*P. atlantica* and *P. khinjuk*) with various species of *Amygdalus* (mainly *A. scoparia*), *Celtis*, *Ficus*, *Rhamnus*, *Pirus*, *Crataegus* (especially *C. azarolus*), and at higher alti-

FIGURE 4. A view of the hillsides indicating the oak bush in Kermanshah. If these are properly protected and utilized, the slopes can support good forest stands.

FIGURE 5. Nomads and their livestock near Doroodzan, Fars.

FIGURE 6. Soil surveyors, drivers, and laborers working in the soil survey camp.

tudes *Juniperus excelsa.* Actually such forests have been completely destroyed and only traces are left, specimens usually being localized on some rocky slopes. In the south *Ziziphus spina-christi* is not unusual. Various *Tamarix* and *Populus euphratica* may be found in abundance in certain valleys or depressions. The herbaceous flora is more abundant than in the steppe zone; the following families are particularly well represented: Compositae, Labiatae, Umbelliferae, Papilionaceae Caryophyllaceae, Borraginaceae, Cruciferae, Gramineae. The *Astragalus* and *Cousinia* are very numerous. Spiny cushions of *Acantholimon* are frequent at higher altitudes.

Among the perennial Gramineae, in addition to the *Poa*, *Stipa*, and *Aristida* of the steppe zone are: *Hyparrhenia hirta* (southwest), *Cymbopogon laniger*, *Pappophorum persicum*, *Pennisetum orientale*, *Hordeum bulbosum*, *Tricholaena teneriffae* (southwest), *Cenchrus ciliaris* (south), and at higher altitudes (from 1,500 m up), *Bromus tomentellus* and various *Agropyrum*, and *Festuca*.

Degraded pastures on compacted soil are often overgrown with *Carex stenophylla* and covered with patches of lichens and mosses.

On dry fields, besides the weeds of the steppe zone, the following species are usually abundant: *Glycyrrhiza glandulifera*, *Phlomis persica*, *Salvia syriaca*, *Achillea santolina*, and various *Centaurea*.

*Xerophilous forest flora.* This type of vegetation is chiefly important in the Zagros Mountains, but it is also climatically possible in part of the Khurasan Mountains and in some parts of Azerbaijan where the ancient forests have been completely destroyed.

In all these regions where the precipitation exceeds 400 mm, the natural climax is the dense, xerophilous forest (long summer drought) where, until they were destroyed, deciduous oaks dominated: *Quercus persica*, still very abundant in the Zagros Mountains and Fars; *Q. infectoria*, *Q. libani*, and perhaps some related species of *Q. sessiliflora* in the northwest.

The following forest species are usually associated with oaks: *Acer cinerascens*, *Pistacia atlantica*, *Fraxinus syriaca*, *Pirus syriaca*, *Crataegus azarolus*, *Celtis spp.*, *Amygdalus spp.*, *Prunus spp.*

Above 1,500 m the Zagros oak forests include a certain number of tree or shrub species: *Amygdalus eleagnifolia*, *Cotoneaster nummularia*, *Lonicera nummularifolia*, *Prunus mahaleb*, *Daphne angustifolia*, *Colutea persica*, and some large spiny *Astragalus*. *Juglans regia* appears to grow wild in some parts. *Juniperus excelsa* may also be found in these forests.

In the more humid valleys are: *Salix*, *Platanus orientalis*, *Eleagnus angustifolia*, and even some *Tamarix* and *Populus euphratica*, which may occasionally occur at an altitude of 1,900 m.

The herbaceous flora is rather poor up to 1,500 m, consisting mainly of annual species (an abundance of *Aegilops*); a few worthwhile forage species, *Poa bulbosa* and *Hordeum bulbosum*, appear to be the only truly common grasses; *Stipa* or *Agropyrum* can be seen occasionally; there are very few leguminous forage species.

At altitudes higher than about 1,500 m, the perennial species are widespread such as *Bromus tomentellus*, *Festuca valesiaca* (or other species), *Stipa spp.*, *Oryzopsis holciformis*, *Dactylis glomerata*, *Agropyrum spp.*; the best leguminous species are: various *Onobrychis*, certain *Astragalus*, *Trigonella elliptica*, indigenous *Medicago sativa*; there are also some *Poterium*. The Labiatae and Compositae very often form the greater part of the vegetation; too often overgrazing has eliminated the forage species, leaving the unpalatable or spiny species; *Phlomis*, *Euphorbia*, large Umbelliferae, *Eryngium*, *Cousinia*, *Astragalus*, *Acantholimon*, *Acanthophyllum*. These last three genera become more and more common at higher altitudes and are remarkable for their hemispherical cushion shape; they are succeeded by arid, high mountain flora.

The dominant weeds in crop fields are: *Glycyrrhiza glandulifera*, *Goebelia alopecuroides*, *Phlomis persica*, *Salvia syriaca*.

*Dry alpine flora.* Above 2,600 m the only tree that can grow is *Juniperus excelsa;* it can grow at an altitude of about 3,400 m, though it is not likely to form forests above 3,000 m. Some *Amygdalus*, *Prunus*, *Daphne*, and *Lonicera* bushes can be found as high as 3,000 m, at least in the Zagros.

The vegetation in these high-lying regions, where the growing season is limited to a few months, consists mainly of perennial plants, and is characterized by an abundance of spiny, cushionlike species ("tragacanth" vegetation) such as *Acantholimon*, *Astragalus*, *Acanthophyllum*, *Onobrychis cornuta*; these species are now disappearing as they are used for fuel.

Several forage grasses can be found at altitudes as high as 3,700 m, in particular, *Oryzopsis molinioides*, one *Festuca*, and various *Poa*. *Bromus tomentellus* goes up to 3,200 m and possibly higher. There are very few leguminous fodder species. The *Phlomis*, *Eryngium*, *Cousinia*, and *Euphorbia* only too often form the bulk of the vegetation when the useful species have been eliminated through overgrazing and the uprooting of the woody plants for fuel.

In a few granite mountains some humid slopes or depressions, with possibly acid soil, are covered with a dense turf very similar to certain alpine greenswards in

Europe. In fact, a certain number of species peculiar to the Alps or the Caucasus can be found: *Polygonum bistorta*, *Primula auricula*, and *Pedicularis comosa*. This specific vegetation is doubtless a relic of the glacial period.

## 2.5 Agriculture

### 2.51 Land use

Some form of agriculture has been practiced in Iran for many centuries and even thousands of years. There has been an historical transition from man as a food collector to man as a food producer. Early efforts, of course, were concentrated on livestock raising and probably only small plots were used for growing subsistence crops. Evidence is accumulating that at least part of this transition took place during the early Persian civilization, and in the "fertile crescent" of the Middle East, about 6,000 to 8,000 years ago (Refs. 11, 12, 13).

Some of the earliest food-producing activities were probably closely connected with the utilization of the rivers and springs. Some of the springs in the Kermanshah region probably irrigated large areas. Ghanats or underground channels or galleries as a source of irrigation have apparently been used for a long time. It seems that, in general, climate, topography, and the fact that wheat and barley are an essential major part of the diet of the peasant, have greatly influenced agricultural practices. Most of the earlier attempts at cultivation were made on foothills and the less sloping parts of the uplands where wheat or barley was the surest crop. Many of the stream valleys probably were not inhabited during ancient times because of malaria and other diseases. Some of the valleys have been farmed under irrigation, mainly for growing vegetables and fruits.

No exact statistics exist on present land use in Iran, but an estimate has been made below. Of the 165 million ha, 19 million ha or about 11.5 percent are under agriculture, including food, fiber, and fodder crops. This area includes fallow. Apart from this 10 million ha are classed as under pasture, 19 million ha under forest and woodlands, and the rest are wastelands. These wastelands include mountainous and desert areas where there is a possibility of increasing agriculture. It is estimated that an additional 31 million ha can be cultivated or reclaimed, whereas about 86 million ha will always remain as wastelands from the agricultural viewpoint. More of these data are given under soil management groups in Chapter 4. Table 1 gives the estimated land use in Iran.

TABLE 1. — ESTIMATED LAND USE IN IRAN

| Land use | Million hectares | Percentage of total |
|---|---|---|
| 1. Arable land including fallow and orchards | 19 | 11.5 |
| A. Area under crops | 6.6 | 4.0 |
| (i) Area under irrigated crops | 3.0 | 1.8 |
| (*a*) Area under orchards and gardens | 0.7 | 0.4 |
| (*b*) Area under other irrigated crops | 2.3 | 1.4 |
| (ii) Dry farming | 3.6 | 2.2 |
| B. Temporary fallow | 12.4 | 7.5 |
| 2. Permanent meadow and pastures | 10 | 6.1 |
| 3. Forests and woodlands | 19 | 11.5 |
| 4. Unused but potentially productive areas | 31 | 18.8 |
| 5. Wastelands, desert areas, mountains | 86 | 52.1 |
| | 165 | 100.0 |

2.52 CROPS

Wheat is the staple crop in Iran except in the Caspian area, where rice is the predominant crop. The arable land occupies about 12 percent of the total land surface. Out of this about 35 percent is under crops in any one year, and about 65 percent under temporary fallow still. A very wide variety of field crops, fruit, and vegetables is grown in the small portion of arable land.

Wheat, however, is the chief crop in Iran. It is one of the vital and major parts of the Iranian peasant's diet and is also one of the surest crops that can be grown under the dry climate, characteristic of the country. Normally, wheat is grown in rotation with fallow. Under irrigated agriculture, however, wheat may be grown year after year in a few areas. Depending on the availability of water, wheat may be rotated with other crops such as oil seeds, or even leguminous crops, but more often it is rotated with fallow. In the case of areas where land is more plentiful than corresponding water for irrigation, it is a common practice to have irrigated wheat once in every two or more (reported up to seven) years.

Out of an approximate 4.7 million ha under wheat and barley, 3.2 million ha are under dry farming and 1.5 million ha, predominantly wheat, are under irrigation.

As against 3.2 million ha under dry farming, and a total of 1.5 million ha under irrigation, there are over 12 million ha each year that are kept fallow. There is, therefore, a large fallow cropland ratio.

Depending upon the climate, most of the dry-farmed wheat is planted in the fall as soon as there is sufficient moisture for plowing and seeding. On the larger farms, tractors and grain drills are used, but the greater portion is still sown by hand or by animal-drawn seeders. A comparatively small proportion of the total cropland is plowed by tractor; the wooden plow is still the principal tool of the small farmer. Much of the wheat is harvested by hand or by animal-drawn reapers, but the use of combines is increasing. The greater portion is threshed by animal-drawn sleds and winnowed by hand. It is marketed as a cash crop through the " Idareh Ghaleh " or silo office in the province. A relatively large part is kept on the small farms for food or seed and for local barter.

Barley is the second most important crop planted. Methods of seeding and harvesting are about the same as for wheat. The grain is largely kept on the farm and used for food or seed, although a considerable part may be sold as a cash crop or bartered.

Rice, the country's third most important cereal, produced in surplus, is grown wherever there is adequate water, but mainly along the Caspian Sea, and to a large degree in the south, southwest, and central part of Iran. The Caspian area produces some of the best table varieties of rice.

Cotton is grown in most sections of Iran but mainly in Mazanderan along the Caspian Sea and in Khurasan in the northeast. The cotton of the central plateau is of very short staple and low quality. In Khuzistan a renewed attempt is being made to bring back into production long staple varieties.

Sugar beet is one of the important crops. Sugarcane was once grown in larger quantities, and is being revived in Khuzistan through the Plan Organization's project. However, most of the sugar now produced in Iran comes from sugar beet, grown mainly in the plateau region and concentrated in certain irrigation belts.

Tobacco, one of the leading cash crops, is fairly important in the northwest and the quality is good. Its manufacture and distribution is a government monopoly.

Larger areas of tea are grown in the foothills of the northern slopes of the Elburz Mountains facing the Caspian Sea. Improved facilities, practices, and fertilization are helping to increase the yield, and better curing and processing are also helping to improve the quality. The country's needs in tea are still not met by internal production.

Fruit and nuts are important products in most sections of Iran: fruit such as dates, apricots, grapes, and nuts such as almonds and pistachios. The dates come mainly from the Persian Gulf area. Nuts are produced in most parts of the plateau. Most of the vegetables are grown in Iran – all for domestic consumption. Melons and watermelons are also grown in large quantities for local consumption. A great effort is being made to improve the processing and grading of fruit, nuts, and vegetables. Many more plants for processing these have been or are being erected.

The area under each of these crops is known through agricultural statistics compiled in Iran in 1960-61. Agricultural statistics showing the areas in crops, average yields per hectare, and the total production are given in Table 2.

2.53 LIVESTOCK AND LIVESTOCK PRODUCTION

Livestock has been an important enterprise in Iran for centuries. Out of a human population of about 20 million, tribes such as Shah Savan, Lur, Turkman, Bakhtiari, Qashquai, Kurd, Arab, and Baluchi, etc., comprise between 2 and 3 million, and depend almost wholly on the livestock industry for their livelihood. About 12 to 13 million peasants owning sheep, goats, horses, cows, buffaloes, donkeys, etc., supplement their meager farming income by livestock products, as well as using these animals for their farming operations. Over 4 to 5 million of the urban population consumes, or uses in business, livestock products (e.g., meat, milk and milk products, leather, hides and skins, wool and carpet industry, etc.).

Yearly gross agricultural incomes from plants and animal products are roughly 60 and 40 percent respectively.

The estimate of livestock numbers given in Table 3 indicates that there were about 28 million head of sheep and goats in 1958 and only about 5 million cattle. This is an important aspect of land use in Iran. A majority of these sheep and goats are owned by nomadic tribes who, in search of grazing, annually migrate from the plains to the mountains and back again.

## 2.6 Soil-forming factors

Soil is the natural medium of land plant growth. In this sense, soil covers lands as a continuum, except on rocky slopes or where the cover of soil has disappeared.

Wind, sun, rain, and changes in temperature break down the rocks, slowly crumbling them to dust. Seeds of grass and hardy plants spring up and spread their roots. Bacteria convert compounds in the rocks and the surrounding air into available forms of plant nutrients. The whole process results in what we call soil. It may take hundreds of years to build a centimeter of this soil.

A hole dug in the ground exposing the surface of a well or a ghanat, a gully, or even a stream or roadside cut, shows a series of horizontal soil layers of varying thickness which may differ from one another more or less in such properties as color, texture,

Table 2. — Annual and fodder crops in Iran (agricultural statistics 1339) *

| Crop | | Quantity of seeds (100 kilos) | Area cropped (ha) | Area harvested (ha) | Yield in tons | Number of farmers reporting |
|---|---|---|---|---|---|---|
| Total wheat | | 4,092,600 | 3,663,200 | 3,317,700 | 2,589,830 | — |
| Wheat irrigated | Fall | 1,804,860 | 1,120,100 | 1,101,300 | 1,371,240 | 863,900 |
| | Spring | 87,500 | 63,000 | 57,900 | 54,710 | 41,190 |
| Wheat nonirrigated | Fall | 1,889,600 | 2,009,800 | 1,732,700 | 1,010,420 | 760,150 |
| | Spring | 274,600 | 470,400 | 425,800 | 153,470 | 269,270 |
| Total barley | | 1,071,200 | 1,058,200 | 906,700 | 683,740 | — |
| Barley irrigated | Fall | 332,200 | 217,800 | 213,100 | 269,600 | 321,660 |
| | Spring | 66,400 | 62,300 | 40,900 | 47,600 | 75,530 |
| Barley nonirrigated | Fall | 443,900 | 447,900 | 339,600 | 258,400 | 339,800 |
| | Spring | 228,700 | 350,100 | 313,100 | 108,140 | 320,090 |
| Rice | | 329,000 | 313,000 | 292,800 | 651,080 | 256,870 |
| Total area, other crops | | — | 408,900 | 859,599 | — | — |
| Millet irrigated | | 4,700 | 12,100 | 11,900 | 12,880 | 39,150 |
| Millet nonirrigated | | 1,470 | 9,570 | 4,670 | 3,550 | 5,760 |
| Corn irrigated | | 1,750 | 9,080 | 9,080 | 7,080 | 18,750 |
| Corn nonirrigated | | 400 | 2,310 | 1,750 | 3,130 | 900 |
| Other cereals irrigated | | 3,900 | 5,200 | 4,920 | 7,730 | 16,250 |
| Other cereals nonirrigated | | 1,670 | 6,420 | 5,840 | 2,370 | 9,220 |
| Pulses irrigated | | 41,240 | 67,770 | 63,070 | 39,390 | 123,040 |
| Pulses nonirrigated | | 31,270 | 55,080 | 50,970 | 24,230 | 119,010 |
| Potatoes irrigated | | 105,030 | 15,880 | 15,280 | 88,660 | 97 |
| Potatoes nonirrigated | | 4 | 1 | 1 | 2 | 3 |
| Cotton irrigated | | 110,940 | 146,720 | 136,590 | 135,380 | 133,830 |
| Cotton nonirrigated | | 65,660 | 137,020 | 128,050 | 101,160 | 67,840 |
| Hemp | | 1,900 | 6,630 | 6,070 | 5,640 | 16,440 |
| Other fiber crops irrigated | | — | 790 | 790 | 60 | 450 |
| Other fiber crops nonirrigated | | — | 3 | 3 | 1 | 150 |
| Sugar beets irrigated | | 7,870 | 33,530 | 32,010 | 648,480 | 40,600 |

TABLE 2. (*Concluded*)

| Crop | Quantity of seeds (100 kilos) | Area cropped (ha) | Area harvested (ha) | Yield in tons | Number of farmers reporting |
|---|---|---|---|---|---|
| Beets for seeds irrigated | — | 1,600 | 1,600 | 1,000 | 52 |
| Sugarcane nonirrigated | — | 125 | 71 | 41 | 1,150 |
| Tobacco irrigated | — | 20,560 | 20,170 | 7,560 | 38,930 |
| Tobacco nonirrigated | — | 7,380 | 7,380 | 4,560 | 12,310 |
| Oil seed irrigated | 4,580 | 22,670 | 22,590 | 6,160 | 35,650 |
| Oil seed nonirrigated | 1,040 | 23,470 | 22,330 | 1,210 | 18,820 |
| Vegetables irrigated | — | 22,370 | 21,650 | 194,530 | 121,270 |
| Vegetables nonirrigated | — | 5,970 | 5,940 | 14,830 | 37,510 |
| Melons, watermelons irrigated | — | 37,300 | 35,640 | 236,720 | 93,100 |
| Melons, watermelons nonirrigated | — | 55,940 | 53,310 | 115,200 | 50,470 |
| Saffron irrigated | — | 1,000 | 1,000 | 5 | 12,260 |
| Other crops—spices, aromatics irrigated | — | 48,010 | 47,650 | 16,470 | 24,390 |
| Other crops—spices, aromatics nonirrigated | — | 6,000 | 5,810 | 530 | 2,560 |
| Alfalfa legume crops irrigated | — | 83,160 | 81,340 | 208,180 | 234,200 |
| " " " nonirrigated | — | 2,600 | 2,600 | 1,160 | 4,050 |
| Other field crops irrigated | — | 39,130 | 37,360 | 80,820 | 119,140 |
| Other field crops nonirrigated | — | 23,210 | 21,670 | 28,840 | 60,330 |

* Iranian year (1960 to 1961).

structure, and other physical and chemical characteristics. In general, three stages may be differentiated:

1. a layer of top soil called the A horizon;
2. below it, the subsoil which is intermediate between the parent material and the top soil, called the B horizon;
3. below that, the parent material or C horizon from which the A and B layer have been derived.

Alternatively, however, there may be undifferentiated layers of the soil material, composed of soils which have developed from recently deposited alluvium with little or no modification. Iran's agriculture is largely dependent on alluvial soils that have been laid down by rivers and streams over the course of thousands of years.

A good soil for agricultural use must be deep, friable, and crumbly in structure, so that roots may spread freely, and through its capillary pores water may rise for use by the plants in dry weather, and drain out freely during rains or under irrigation. In addition, the soil must be well supplied with plant nutrients and the micro-organisms which make most of them available. It must, when replenished with plant nutrients, produce good crops.

Iran has a great variety of soils. The variation is due to differences in factors of soil formation, namely (1) parent rock, (2) vegetation, (3) climate, (4) topography or slope, and (5) age. To these different factors must be added the work of man – by his plowing, harvesting, irrigation, and other efforts, man may leave soils better or worse than he finds them.

A brief discussion of the genetic factors working together to produce soils is appropriate here.

*Parent material or parent rock.* Parent material is formed largely through rock weathering. Rocks are broken down by changes in temperature, especially freezing, by water as a scouring and solvent agent, by wind, and by ice. After weathering begins, the material may be transported by water, wind, or ice and deposited; or it may remain in place for further weathering and decomposition. Further chemical action, including solution by water as well as translocation and deposition, hastens decomposition of the parent material. Thus, rocks and minerals are broken down into small particles of sand, silt, and clay.

*Vegetation.* This starts the actual process of soil formation and development. Roots penetrate the loose material gathered in cracks and crevices, and remove both the water and plant nutrients. The roots exert both physical and chemical action on the parent materials and aid the passage of air and water into them. When the plant dies or sheds leaves, the remains are returned to the soil. Here they are acted upon by micro-organisms and small animal forms. At the same time, chemical decomposition occurs on both the parent material and the organic matter; this releases minerals or plant nutrients for succeeding plants and thus ensures a continuation of the process of biological activity.

*Climate.* This is an active factor in soil formation which is influenced largely

by the amount and distribution of moisture. The amount of water that actually penetrates the soil and percolates through it largely determines the rate at which some materials are dissolved and leached and deposited. The temperature and the soil moisture influence the growth of both micro-organisms and vegetation. It should be realized, however, that all official rainfall and temperature records in Iran, as anywhere else, deal with the macroclimate, and that small areas have microclimates that may differ considerably from the macroclimate.

*Relief.* Relief or slope of land influences surface runoff, natural erosion, and vegetation. It also determines the amount of effective rainfall that enters the soil; thus indirectly it affects the internal drainage by regulating to some extent the amount of water remaining on the surface long enough to enter the soil.

The important effects of relief are obvious in many places. For example, slowly permeable soils on nearly level or gently sloping areas are usually much deeper than on steeply sloping areas. On steep slopes, the soils may be very thin, due to rapid surface runoff and erosion under natural conditions. The direction of slopes may affect soil genesis. For example, the slopes facing south in Iran warm up earlier in the spring and have a longer growing season. Again with higher elevations, there is more snow; the higher snow: rain ratio and vertical zonality[1] caused by the improved moisture regime has been observed in many of the mountainous soils of Iran.

*Time.* In soil-forming processes, time is necessary for the combined action of all factors to become effective. However, the amount of time required for soil development varies with changes in conditions of relief, drainage, parent material, vegetation, and climate.

Each soil has a life history somewhat comparable with the different periods of human life, but on a much longer scale; the change from youth to maturity and then to old age takes place progressively. In short, soil is living and dynamic and is said to become mature when it comes into equilibrium with its environment. After this point is reached, there is little or no change in the soil if the environment is unchanged.

*Man.* As mentioned earlier, man has been an important factor in the modification of the soils in Iran. By his plowing, irrigation, management, and harvesting, man has made considerable changes in soils during the last 7,000 to 8,000 years.

[1] For details of vertical zonality see Appendix A3.

A few examples will illustrate the point. First is the irrigation layer of silt and other sediment in irrigation water that was deposited in Khuzistan and other irrigated regions. The presence of bones, pottery, and other evidence of human habitation at depths of as much as 1, 2, or more meters below the present plowed layer indicates the amount and rate of silt being deposited by canals in these areas. Second, for special crops, such as melons, cucumbers, etc., a great movement of sand from river beds on to the soil was made in some places (e.g., Esfahan) (17). This has been going on for decades and in many cases has significantly modified the soil texture, at least of the surface horizon. Third, the use of organic matter and other management practices have a significant effect on crop production on agricultural soils. The use of pigeon guano (16, 18), long practiced in regions such as Isfahan, has improved crop production and caused consequent changes in the soils.

In some areas centuries of plowing on slopes has left them completely bare or with only very thin soil covering.

Salinization and even waterlogging of soils as a result of neglected irrigation systems has put once very productive areas out of cultivation. In some cases permanent harm has been done to these soils.

Deforestation of other areas and/or overgrazing (under nomadic systems) to fulfill man's immediate needs of food, feed, and fuel, has resulted in the loss to large areas of surface and subsoils; in some cases permanent changes have taken place.

These are some examples of the influence of man as a factor in soil formation – he may leave the soils better or worse than he finds them.

### **2.7 Soil classification** (Ref. 3)

Since soils are variable, they must be classified in order to be understandable. The purpose of classification is to place objects in suitable categories in order to study and learn their characteristics and to interpret their interrelationships. For centuries, people have been using soils and ascertaining what uses are best for them. What is a good use for one may be a very poor use for another, e.g., rice may grow very well on a field where wheat would not, and vice versa. Terraces may reduce the amount of soil loss from sloping fields where the soil is permeable and yet may cause even more loss on others where the soil has a hard dense layer underneath, reasonably close to the surface.

Not only are there varying degrees of difference between soils, but also varying kinds of differences. First, there are those differences due to local variations in parent rock, slope, or age. For example, one garden may be sandy loam, the neighboring one clay; one may be nearly level and the other hilly; in one there may be several different layers while in the other the soil may be about the same from the top to a meter or more beneath; or one may be wet while the other may be well-drained. Second, there are differences due to climate and vegetation. Then, it should be added, there are some soils so young that no features have developed, such as the fresh material deposited by a stream during a recent flood, or the practically bare slopes of mountains, or the dry sands along the beach.

In order to classify soils, several systems of soil classification have been used, which are described below.

### 2.71 Evolution of soil classification systems

Records indicate that a classification of soils, largely based on color and structure, was developed in China by the engineer Yu during the reign of Emperor Yao, about 4,000 years ago. Since then soil classification has undergone a long evolution. All the systems developed have been influenced by the concept of soil held by their originators.

The recognition of soil differences was made on the basis of local observations and served limited, mostly utilitarian, purposes. Many observations were based on single features of the soil, such as texture, pH, color, potassium or phosphorus content, etc. Although these differentiations were incomplete, they were scientifically valid since they dealt with true soil differences. The "single value" units made by Arrhenius for sugarcane production in Indonesia are an example of this kind of classification.

The rise of geology as a distinct science with its own field methods, and the recognition of the close relationship between soil and its parent material led to a classification based on the composition of the underlying formations. These were reflected in the nomenclature, e.g., in limestone soils, basaltic soils, alluvial soils, sandstone soils, etc. The early classification set up by Mohr for the soils of Java is an example of such an approach. At a later stage, physiographic characteristics of the landscape were also considered and units of this system were called after geomorphological terms, e.g., terrace soils, mountain soils, hilly soils, bottom-land soils, etc. It is a fact that the relation between soils, parent material, and landscape are significant within a defined area; however, a classification based on local observations can hardly be applied on a large scale. After 1870, when the new school of Dokuchaiev was founded in Russia, special emphasis was given to soil genesis and more particularly to climate as the dominant soil-forming factor. Soils were classified after the climate belts in which they occurred. The subdivision proposed in the higher category into normal, transitional, and abnormal soils was later changed by Sirbitsev into *zonal*, *intrazonal*, and *azonal* soils. The zonal soils were those great groups having well-developed soil characteristics that reflect the influence of the active factors of soil formation, mainly climate and living organisms. The intrazonal soils reflect the dominating influence of certain factors other than climate and vegetation, e.g., topography or parent material. Azonal soils do not have well-developed profiles because of their youth or because of very steep topography. The zonality idea has been used until recently, but is now being progressively dropped on the grounds that climate is not always the dominant soil-forming factor and that serious overlaps occur between the different zones. The work of the Russian school became known mainly through the work of Glinka (1914).

In the United States, Marbut (Table 6) subdivided the highest soil category into *Pedalfers* and *Pedocals;* the former showing accumulations of aluminum and iron while the latter showed accumulations of calcium. *Pedalfers* occur in localities where rainfall dominates evaporation causing a downward water movement; with *Pedocals*, evaporation dominates and an upward movement in the soil tends to increase base saturation and induces redistribution and accumulation of calcium. It later appeared that there was an overlap of these two major subdivisions and they were gradually abandoned. Marbut further strongly emphasized that soil classification should be based on soil morphology because of previous errors made by acceptance of the balance-sheet theory and of the geological concept, by which soils without having been examined had been assumed to have certain characteristics. Marbut made the point abundantly clear that examinations of the actual soils were essential for developing a system of soil classification. In some circles this still needs emphasis today. The characteristics suggested by Marbut to be used are the following ones: color, texture, structure, consistence, thickness, and arrangement of horizons, drainage status of the soil, nature of parent material, kind of organic matter, and occurrence of lime or soluble salts. As these characteristics are interrelated, soils are defined by a set of characteristics which generally change according as soil formation varies. Therefore, besides accurate morphology, a knowledge of genesis is needed to guide the work and to test the results; the setup is a *morphogenetic classification* system. The classification of Marbut has been revised and completed by Baldwin, Kellogg, Smith, and Thorp. Whereas Russian and German investigations were chiefly concerned with the determination of general characteristics and the recognition of soil units that could be given broad geographic expression, the system introduced by Marbut subdivides soils according to their observable characteristics. Soil genesis, if unknown or little known, can subsequently be studied to group the soils into higher categories. This is especially useful in new areas. Classification goes from bottom to top, while in the so-called genetic system, it starts at the top; genesis must be known first.

Other disadvantages of purely genetic classifications are that a soil can reach its maturity in different ways, that soils are often polygenetic, that for very many soils basic facts to support theories of their genesis are deficient or even entirely lacking. Some major defects of previous soil classification systems were (1) that the definitions of the classes were vague and (2) that the classification was based primarily on genesis or on the properties of virgin soils in a virgin landscape. Cultivated soils were ignored or were classified on the basis of the properties that they were presumed to have had when virgin. It is obvious that the general classification system must be applicable to all soils, including and indeed particularly those under cultivation or affected in any other way by man's activities.

Recent developments of soil classification in Australia, France, Germany, Russia, and the United States show that there is a growing tendency among soil scientists all over the world to reach a uniform and general system of classification. A major attempt is now being made by the United States Department of Agriculture, Soil Conservation Service. Between 1955 and 1960 seven approximations have been circulated reflecting the views and suggestions of very many scientists of different countries. The seventh approximation was presented at the International Congress of Soil Science in 1960. The Food and Agriculture Organization (Land and Water Development Division) has soils specialists working also in many tropical and subtropical countries and is contributing to this international correlation especially through the World Soil Resources Office and the special FAO/Unesco joint project on the soil map of the world.

Below are given the schemes for systems of soil classification:

1. Classification of soils by V.V. Dokuchaiev

   Table 4 (1886)
   Table 5 (1900)

2. Soil categories by Marbut
   Table 6

3. Soil classification in the higher categories (United States) after J. Thorp and G. D. Smith (1949)
   Table 7

In addition the following tables are also reproduced:

Table 8: Present soil orders and approximate equivalents in revised classification of Baldwin *et al.*

Table 9: Formative elements in names of soil orders

Table 10: Formative elements in names of suborders

Table 11: Formative elements in names of great groups

Table 12: Names of orders, suborders, and great groups

The principal soils of Iran have been classified and mapped. The classification and legend used are given on Map B1 as well as in Chapter 3.

TABLE 4.* — 1886 CLASSIFICATION OF SOILS BY V.V. DOKUCHAIEV

| According to position (to presence of primary genetical features) | According to origin | According to climatic regions (and to humus content) | According to zeolite clay (each soil) |
|---|---|---|---|
| A. Normal | I. cl. Dry land vegetative soils | 1. Light grey northern soils | sandy |
| | | 2. Grey transitional soils | sandy-loamy |
| | | 3. Chernozem soils | loamy |
| | | 4. Chestnut transitional soils | clayey |
| | | 5. Southern brown alkaline soils: primary, secondary, periodical, eroded, burrowed | |
| | II. cl. Dry land moor soils | 6. Soils of swamped forests | |
| | | 7. Meadow soils | |
| | III. cl. Moor (bog) soils (soils in potentia) | 8. Tundra soils | |
| | | 9. Peats | |
| | | 10. Waterlogged flood plains, etc. | |
| B. Transitional | IV. cl. Washed soils | | |
| | V. cl. Dry land sedimentary soils | | |
| C. Abnormal | VI. cl. Sedimentary soils | | |

* Tables 4–12 reproduced from *Soil classification, a comprehensive system*, 7th approximation, U.S. Dept. of Agriculture, 1960.

TABLE 5. — FINAL (1900) CLASSIFICATION OF SOILS BY V. V. DOKUCHAIEV

*Class A.* Normal, otherwise dry land vegetative or zonal soils

| *Zones* | I. Boreal | II. Taiga | III. Forest-steppe | IV. Steppe | V. Desert-steppe | VI. Aerial or desert zone | VII. Sub-tropical and zone of tropical forests |
|---|---|---|---|---|---|---|---|
| *Soil types* | Tundra (dark brown) soils | Light grey podzolized soils | Grey and dark grey soils | Chernozem | Chestnut and brown soils | Aerial soils yellow soils white soils | Laterite or red soils |

*Class B.* Transitional soils

| | | |
|---|---|---|
| VIII. Dry land moor soils moor-meadow soils | IX. Carbonate containing soils (Rendzina) | X. Secondary alkali-soils |

*Class C.* Abnormal soils

| | | |
|---|---|---|
| X. Moor soils | XI. Alluvial soils | XIV. Aeolian soils |

TABLE 6. — SOIL CATEGORIES BY MARBUT

| | | |
|---|---|---|
| Category VI | Pedalfers (VI-1) | Pedocals (VI-2) |
| Category V | Soils from mechanically transported materials<br>Soils from siallitic decomposition products | Soils from mechanically transported materials |
| | Tundra<br>Podzolic<br>Grey-Brown Podzolic soils | Chernozems<br>Dark-Brown soils |
| Category IV | Red soils<br>Yellow soils<br>Prairie soils<br>Lateritic soils<br>Laterite soils | Brown soil<br>Grey soils<br>Pedocalic soils of arctic and tropical regions |
| | Groups of mature but related soil series | Groups of mature but related soil series |
| | Swamp soils<br>Gley soils<br>Rendzinas | Swamp soils<br>Gley soils<br>Rendzinas |
| Category III | Alluvial soils<br>Immature soils on slopes<br>Salty soils<br>Alkali soils<br>Peat soils | Alluvial soils<br>Immature soils on slopes<br>Salty soils<br>Alkali soils<br>Peat soils |
| Category II | Soil series | Soil series |
| Category I | Soil units or types | Soil units or types |

TABLE 7. — CLASSIFICATION IN THE HIGHER CATEGORIES (UNITED STATES) AFTER J. THORP AND G.D. SMITH (1949) (44, 46)

| Order | Suborder | Great soils groups |
|---|---|---|
| Zonal soils | 1. Soils of the cold zone | Tundra soils |
| | 2. Light-colored soils of arid regions | Desert soils<br>Red Desert soils<br>Sierozem<br>Brown soils<br>Reddish-Brown soils |
| | 3. Dark-colored soils of semiarid, subhumid, and humid grasslands | Chestnut soils<br>Reddish-Chestnut soils<br>Chernozem soils<br>Prairie soils<br>Reddish-Prairie soils |
| | 4. Soils of the forest-grassland transition | Degraded Chernozem<br>Noncalcic Brown or Shantung Brown soils |
| | 5. Light-colored podzolized soils of the timbered regions | Podzol soils<br>Grey-wooded, or Grey Podzolic soils [1]<br>Brown Podzolic soils<br>Grey-Brown Podzolic soils [1]<br>Red-Yellow Podzolic soils |
| | 6. Lateritic soils of forested warm-temperate and tropical regions | Reddish-Brown Lateritic soils [1]<br>Yellow-Brown Lateritic soils<br>Laterite soils [1] |
| Intrazonal soils | 1. Halomorphic (saline and alkali) soils of imperfectly drained arid regions and littoral deposits | Solonchak, or Saline soils<br>Solonetz soils<br>Soloth soils |
| | 2. Hydromorphic soils of marshes, swamps, seep areas, and flats | Humic-Gley soils [1] (includes Wiesenboden)<br>Alpine Meadow soils<br>Bog soils<br>Half-Bog soils<br>Low Humic-Gley soils [1]<br>Planosols<br>Groundwater Podzol soils<br>Groundwater Laterite soils |
| | 3. Calcimorphic soils | Brown Forest soils (Braunerde)<br>Rendzina soils |
| Azonal soils | ................................ | Lithosols<br>Regosols (includes Dry Sands)<br>Alluvial soils |

[1] New or recently modified great soil groups.

TABLE 8. — PRESENT SOIL ORDERS AND APPROXIMATE EQUIVALENTS IN REVISED CLASSIFICATION OF BALDWIN ET AL.

| Present order | Approximate equivalents |
|---|---|
| 1. Entisols | Azonal soils, and some Low Humic-Gley soils |
| 2. Vertisols | Grumusols |
| 3. Inceptisols | Ando, Sol Brun Acide, some Brown Forest, Low Humic-Gley, and Humic-Gley soils |
| 4. Aridisols | Desert, Reddish-Desert, Sierozem, Solonchak, some Brown and Reddish-Brown soils, and associated Solonetz |
| 5. Mollisols | Chestnut, Chernozem, Brunizem (Prairie), Rendzinas, some Brown, Brown Forest, and associated Solonetz and Humic-Gley soils |
| 6. Spodosols | Podzols, Brown Podzolic soils, and Groundwater Podzols |
| 7. Alfisols | Grey-Brown Podzolic, Grey-Wooded soils, Noncalcic Brown soils, Degraded Chernozem, and associated Planosols and some Half Bog soils |
| 8. Ultisols | Red-Yellow Podzolic soils, Reddish-Brown Lateritic soils of the U. S., and associated Planosols and Half Bog soils |
| 9. Oxisols | Laterite soils, Latosols |
| 10. Histosols | Bog soils |

TABLE 9. — FORMATIVE ELEMENTS IN NAMES OF SOIL ORDERS

| Number of order[1] | Name of order | Formative element in name of order | Derivation of formative element | Mnemonicon and pronunciation of formative elements |
|---|---|---|---|---|
| 1 | Entisol | ent | Nonsense syllable | recent |
| 2 | Vertisol | ert | L. *verto*, turn. | invert |
| 3 | Inceptisol | ept | L. *inceptum*. beginning | inception |
| 4 | Aridisol | id | L. *aridus*, dry | arid |
| 5 | Mollisol | oll | L. *mollis*, soft | mollify |
| 6 | Spodosol | od | Gk. *spods*, wood ash | Podzol; odd |
| 7 | Alfisol | alf | Nonsense syllable | Pedalfer |
| 8 | Ultisol | ult | L. *ultimus*, last | ultimate |
| 9 | Oxisol | ox | F. *oxide*. oxide | oxide |
| 10 | Histosol | ist | Gk. *histos*, tissue | histology |

[1] Numbers of the orders are listed here for the convenience of those who became familiar with them during development of the system of classification.

TABLE 10. — FORMATIVE ELEMENTS IN NAMES OF SUBORDERS

| Formative element | Derivation of formative element | Mnemonicon | Connotation of formative element |
|---|---|---|---|
| acr | Gk. *akros* highest | acrobat | Most strongly weathered |
| alb | L. *albus*, white | albino | Presence of albic horizon (a bleached eluvial horizon) |
| alt | L. *altus*, high | altitude | Cool, high altitudes or latitudes |
| and | Modified from *Ando* | Ando | Ando-like |
| aqu | L. *aqua*, water | aquarium | Characteristics associated with wetness |
| arg | Modified from argillic horizon; L *argilla*, white clay | argillite | Presence of argillic horizon (a horizon with illuvial clay) |
| ferr | L. *ferrum*, iron | ferruginous | Presence of iron |
| hum | L. *humus*, earth | humus | Presence of organic matter |
| ochr | Gk. base of *ochros*, pale | ocher | Presence of ochric epipedon (a light-colored surface) |
| orth | Gk. *orthos*, true | orthophonic | The common ones |
| psamm | Gk. *psammos*, sand | psammite | Sand textures |
| rend | Modified from Rendzina | Rendzina | Rendzina-like |
| ud | L. *ūdus*, humid | udometer | Of humid climates |
| umbr | L. *umbra*, shade | umbrella | Presence of umbric, epipedon (a dark-colored surface) |
| ust | L. *ustus*, burnt | combustion | Of dry climates, usually hot in summer) |

TABLE 11. — FORMATIVE ELEMENTS FOR NAMES OF GREAT GROUPS
(Formative element is added to suborder name to obtain name of great group)

| Formative element | Derivation of formative element | Mnemonicon | Connotation of formative element |
|---|---|---|---|
| agr | L. *ager*, field | agriculture | An agric horizon |
| alb | L. *albus*, white | albino | An albic horizon |
| anthr | Gk. *anthropos*, man | anthropology | An anthropic epipedon |
| arg | Modified from argillic horizon; L. *argilla*, white clay | argillite | An argillic horizon |
| brun[1] | L.L. *brunus*, brown | brunet | Dark-brown colors |
| calc | Modified from *calcium* | calcium | A calcic horizon |
| camb | L.L. *cambiare*, to exchange | change | A cambic horizon |
| crust | L. *crusta*, crust | crust | Crusting |
| cry | Gk. *kryos*, coldness | crystal | Cold |
| crypt[1] | Gk. *kryptos*, hidden | cryptogram | With a deep horizon |
| dur | L. *durus*, hard | durable | A duripan |
| dystr | Modified from *dystrophic*, infertile | dystrophic | Low base saturation |
| eutr | Modified from *eutrophic*, fertile | eutrophic | High base saturation |
| ferr | L. *ferrum*, iron | ferric | Presence of iron |
| frag | Modified from L. *fragilis*, brittle | fragile | Presence of fragipan |
| frag-loss | Compound of *fra(g)* and *gloss* | | See the formative elements *frag* and *gloss* |
| gloss | Gk. *glossa*, tongue | glossary | Tongued |
| grum | L. *grumus*, crumb | grumusol | Granular structure |
| hal | Gk. *hals*, salt | halophyte | Salty |
| hapl | Gk. *haplous*, simple | haploid | Minimum horizon |
| hum | L. *humus*, earth | | Presence of humus |
| hydr | Gk. *hydôr*, water | hydrophobia | Presence of water |

TABLE 11. (*Concluded*)

| Formative element | Derivation of formative element | Mnemonicon | Connotation of formative element |
|---|---|---|---|
| maz | Gk. *maza*, flat cake, from *massô*, knead | | Massive |
| nadur | Compound of *na*(*tr*), below, and *dur*, above | | |
| natr | Modified from *natrium*, sodium | | Presence of natric horizon |
| ochr | Gk. base of *ôchros*, pale | ocher | Presence of ochric epipedon (a light-colored surface) |
| orth | Gk. *orthos*, true | orthophonic | |
| phan[1] | Modified from *allophane* | | Presence of allophane |
| plac | Gk. base of *plax*, flat stone | | Presence of a thin pan |
| plag | Modified from Ger. *plaggen*, sod | | Presence of plaggen horizon |
| plint | Modified from Gk. *plinthos*, brick | | Presence of plinthite |
| psamm | Gk. base of *psammos*, sand | psammite | Sand texture |
| quarz | Ger. *quarz*, quartz | quartz | High quartz content |
| rhod | Gk base of *rhodon*, rose | rhododendron | Dark-red colors |
| sal | L. base of *sāl*, salt | saline | Presence of salic horizon |
| therm | Gk. base of *thermos*, hot | thermal | Warm |
| typ | Modified from *type*, typical | | Typical |
| ult | Modified from *ultimus*, last | ultimate | Strongly weathered |
| umbr | L. base of *umbra*, shade | umbrella | Presence of umbric epipedon |
| ust | L. base of *ustus*, burnt | combustion | Dry climate, usually hot in summer |
| verm | L. base of *vermes*, worm | vermiform | Wormy, or mixed by animals |

[1] Very tentatively proposed for great groups of the Oxisol order.

TABLE 12. — NAMES OF ORDERS, SUBORDERS, AND GREAT GROUPS

| Order | Suborder | Great group |
|---|---|---|
| 1. Entisol | 1.1 Aquent | 1.11 Cryaquent |
| | | 1.12 Psammaquent[1] |
| | | 1.13 Hydraquent |
| | | 1.14 Haplaquent |
| | 1.2 Psamment | 1.21 Quarzopsamment |
| | | 1.22 Orthopsamment[1] |
| | 1.3 Ustent | 1.31 Psammustent[1] |
| | | 1.32 Orthustent[1] |
| | 1.4 Udent | 1.41 Cryudent |
| | | 1.42 Agrudent |
| | | 1.43 Hapludent |
| | | 1.44 Plaggudent |
| 2. Vertisol | 2.1 Aquert | 2.11 Grumaquert |
| | | 2.12 Mazaquert |
| | 2.2 Ustert | 2.21 Grumustert |
| | | 2.22 Mazustert |
| 3. Inceptisol | 3.1 Aquept | 3.11 Halaquept |
| | | 3.12 Umbraquept[1] |
| | | 3.13 Fragaquept |
| | | 3.14 Cryaquept |
| | | 3.15 Ochraquept[1] |
| | 3.2 Andept | 3.21 Cryandept |
| | | 3.22 Durandept |
| | | 3.23 Ochrandept[1] |
| | | 3.24 Umbrandept[1] |
| | | 3.25 Hydrandept |
| | 3.3 Umbrept | 3.31 Cryumbrept |
| | | 3.33 Haplumbrept |
| | | 3.34 Anthrumbrept |
| | 3.4 Ochrept | 3.41 Cryochrept |
| | | 3.43 Eutrochrept |
| | | 3.44 Dystrochrept |
| | | 3.45 Ustochrept |
| | | 3.45 Fragochrept |
| 4. Aridisol | 4.1 Orthid | 4.11 Camborthid |
| | | 4.12 Durorthid |
| | | 4.13 Calcorthid |
| | | 4.14 Salorthid |
| | 4.2 Argid | 4.21 Haplargid |
| | | 4.22 Durargid |
| | | 4.23 Natrargid |
| | | 4.24 Nadurargid |

TABLE 12. (*Continued*)

| Order | Suborder | Great group |
|---|---|---|
| 5. Mollisol | 5.1 Rendoll | 5.11 Rendoll |
| | 5.2 Alboll | 5.21 Argalboll |
| | | 5.22 Natralboll |
| | 5.3 Aquoll | 5.31 Haplaquoll |
| | | 5.32 Argaquoll |
| | | 5.33 Calcaquoll |
| | | 5.34 Duraquoll |
| | | 5.35 Natraquoll |
| | 5.4 Altoll | 5.41 Vermaltoll |
| | | 5.42 Haplaltoll |
| | | 5.43 Argaltoll |
| | | 5.44 Calcaltoll |
| | | 5.45 Natraltoll |
| | 5.5 Udoll | 5.51 Vermudoll |
| | | 5.52 Hapludoll |
| | | 5.53 Argudoll |
| | 5.6 Ustoll | 5.61 Vermustoll |
| | | 5.62 Haplustoll |
| | | 5.63 Argustoll |
| | | 5.64 Durustoll |
| | | 5.65 Calcustoll |
| | | 5.66 Natrustoll |
| 6. Spodosol | 6.1 Aquod | 6.11 Cryaquod |
| | | 6.12 Humaquod[1] |
| | | 6.13 Ferraquod |
| | | 6.14 Placaquod |
| | | 6.15 Thermaquod |
| | | 6.16 Duraquod |
| | 6.2 Humod | 6.21 Orthumod |
| | | 6.22 Thermhumod |
| | 6.3 Orthod | 6.31 Cryorthod |
| | | 6.32 Placorthod |
| | | 6.33 Typorthod |
| | 6.4 Ferrod | |
| 7. Alfisol | 7.1 Aqualf | 7.11 Albaqualf |
| | | 7.12 Glossaqualf |
| | | 7.13 Ochraqualf |
| | | 7.14 Umbraqualf |
| | | 7.15 Fragaqualf |
| | 7.2 Altalf | 7.16 Natraqualf |
| | | 7.21 Cryaltalf |
| | | 7.22 Typalfalf |
| | | 7.23 Natralfalf |

TABLE 12. (*Concluded*)

| Order | Suborder | Great group |
|---|---|---|
| | | 7.24 Fragaltfalf |
| | 7.3 Udalf | 7.31 Agrudalf<br>7.32 Typudalf<br>7.33 Fragudalf<br>7.34 Glossudalf<br>7.35 Fraglossudalf |
| | 7.4 Ustalf | 7.41 Durustalf<br>7.42 Natrustalf<br>7.43 Rhodustalf<br>7.44 Ultustalf [1]<br>7.45 Typustalf |
| 8. Ultisol | 8.1 Aquult | 8.11 Plintaquult<br>8.12 Ochraquult [1]<br>8.13 Umbraquult [1]<br>8.14 Fragaquult |
| | 8.2 Ochrult | 8.21 Plintochrult<br>8.22 Rhodochrult<br>8.23 Typochrult<br>8.24 Fragochrult |
| | 8.3 Umbrult | 8.31 Plintumbrult<br>8.32 Typumbrult |
| 9. Oxisol | | |
| 10. Histosol | | |

[1] Used temporarily for want of a better name. The prior formative element is duplicated in such a way that two different subgroups may have identical names.

## 2.8 Methods and procedures used in this study

### 2.81 FIELD STUDIES

The methods and procedures used in the preparation of the Soil Map of Iran consist of three steps:

(*i*) Field studies including aerial photo analysis, profile and other descriptions, and determination of slope classes.

(*ii*) Laboratory studies, including physical and chemical analysis of soil samples.

(*iii*) Preparation of mapping legend.

1. Detailed, semidetailed, or reconnaissance soil surveys of several project areas which have been made between 1953-60.

   *a.* Soil maps made with the use of aerial photographs:

   (*i*) Project areas in Khuzistan plains and headwaters made with the co-operation of the Food and Agriculture Organization of the United Nations, Khuzistan Development Service and Soils Department, e. g., Dezful, Karkheh West, Aqili, Ramhormoz, etc.

   (*ii*) Mazandéran plain, by Sir Alexander Gibb and partners

   (*iii*) Sefid Rud area by Cotha Sogreah. Both (*ii*) and (*iii*) were done by consulting engineers on behalf of the Plan Organization of the Government of Iran.

   (*iv*) Garmsar project, by the Soils Department of the Ministry of Agriculture.

   *b.* Soil and land classification maps prepared without the assistance of aerial photographs. Examples of such maps are those prepared for Moghan, Zarrineh Rud Project, areas in Azerbaijan, and Doroodzan in Fars.

   Appendix A1 indicates all the project areas which have been studied, together with details of the types and scales of maps prepared. Information obtained through these maps and reports is summarized herein.

2. Information gained mainly through field studies carried out in nonproject areas in 1955-56. Soil identifications were made in the field and indicated on topographic maps of 1:253,440 scale (quarter inch to a mile), Survey of India sheets, and U.S. Aeronautical charts on 1:250,000 scale. The short time available for field work and the distance between roads traversable by automobile necessarily limited the detail of study, the scope of observation, and choice of sites representative of the soil units mapped. This study was initially done in the Kerman, Baluchistan, Seistan, and Khurasan areas.

3. Soil mapping. The soil mapping of the majority of areas was done by using the aerial photo index mosaics of about 1:500,000 scale. Photo interpretation techniques were used in classifying the soils. Several test checks were made by a stereoscopic analysis of aerial photos on about 1:50,000-1:60,000 scale which are available for almost the whole of Iran. The photo indexes on which tentative soil boundaries were marked were then taken to the field for checking and amendment where necessary.

Descriptions of typical profiles in the field were made for each soil group. Soil samples were brought to the laboratory for analysis. These analyses helped in reinforcing the field description and identification of each soil unit. In most cases,

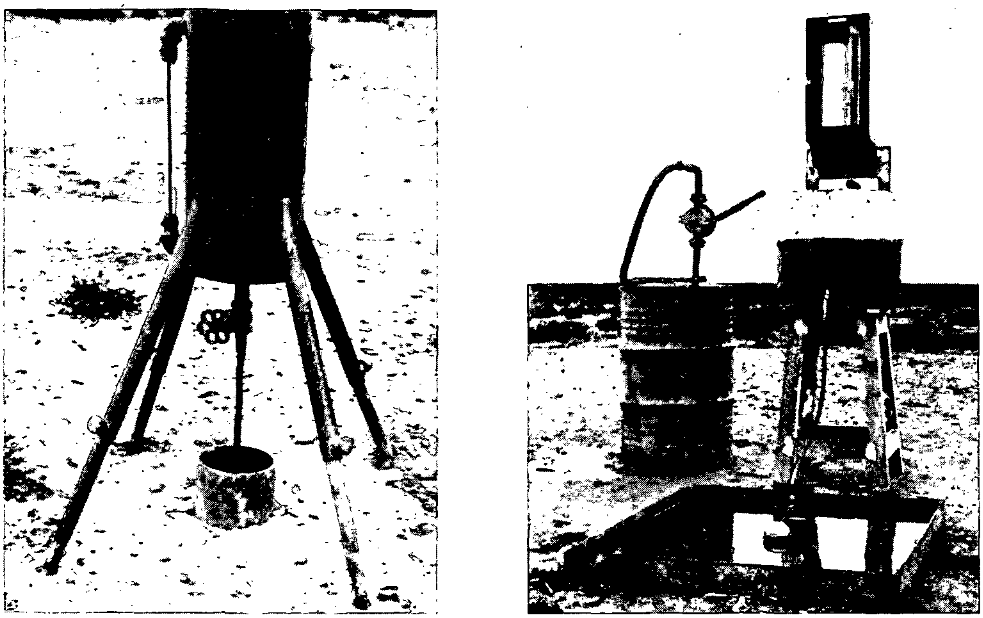

FIGURE 7. Permeability apparatus at work on the soils to be irrigated in the Moghan Plain.

large numbers of profile samples of each important soil group from widely separated sites were collected.

Vegetation, land use, and productivity as indicated by crops, topography or slope of land, and other features were observed and recorded in field notes. The description of soil profiles sampled for laboratory examination are based on the original notes. The variation or range in characteristics is based on these as well as on a large number of additional soil descriptions made during field work. These are reproduced for the soils mapped, and are described in Chapter 3.

*Slope classes*

Relief, or slope, influences soil formation and often indicates differences in soils which are significant for land use and management. Soil slope classes or slope phases of soils were used in the 1:500,000 scale and reduced to 1:1,000,000 field maps to indicate morphological and genetic differences of soils as well as those significantly related to the use-capability of the soil. Six slope classes were used. They are defined below:

*A Class:* Level or nearly level, 0 to 1 percent. This class includes level or nearly level areas on which runoff is slow or very slow. Soil areas within this slope class are well suited for irrigation, although some leveling may be required.

FIGURE 8. Crossing one of the streams during a soil survey in Seistan.

*B Class:* Gently sloping, 1 to 3 percent. This class consists of gently sloping or gently undulating soil areas in which runoff is slow to medium. Most areas will require some levelling or land preparation for gravity irrigation, and careful management of irrigation water. Similar measures for reducing water runoff and erosion may be necessary in some areas.

*C Class:* Moderately sloping, 3 to 8 percent. This class includes gently rolling, rolling, or moderately sloping soil areas on which runoff is moderate to rapid. Soils with *C* slopes are moderately erodible under cultivation. They are best suited for close-growing crops such as small grains but can be safely used for row crops if carefully managed. They are mostly unsuited for gravity irrigation.

*D Class:* Strongly sloping, 8 to 15 percent. In this class the areas are strongly sloping or hilly and on most soils runoff is rapid or very rapid . Most of these areas are too shallow or strongly sloping for good cropland. Grazing is the best use of soils of *D* class but some areas can be cropped or planted in vine or fruit trees if carefully managed.

*E Class:* Rough broken land, 15 to 40 percent . This class comprises steeply sloping, very hilly or rough broken areas. The soils are mainly lithosolic and most areas are miscellaneous land types rather than true soils. Runoff is very rapid and usually erosion is active, both normal or geologic erosion, as well as accelerated erosion due to overgrazing or other misuse. Soils of this slope class are unsuited for ordinary crop use and most areas are of low value for grazing.

FIGURE 9. Transport of soil survey tools on donkeyback on Aqili Plain, inaccessible to the motor vehicle.

*F Class:* Rough mountainous land, 40 percent and above. This class is used for very steep or mountainous areas with little soil development. The areas are mostly unsuited for grazing, or are of very low value. Their best use is for growing trees where climatically possible.

In mapping, there is much overlapping as well as inclusion of other slope classes in any delineation. The slope class symbols indicate that the greater portion of the areas concerned have the slope range of the class indicated. The delineations on the map seldom consist entirely of slopes within the indicated class. The greater portion is within the class shown, but there are inclusions of other slope classes which cannot be separated in a generalized type of survey. Still, if there is approximately an even distribution between two slope classes in a particular area, then both classes are put on the map. For example, 7AB is the unit indicated representing

Brown soils, level phase, as well as
Brown soils gently to moderately sloping phase.

In the map on the 1:2,500,000 scale which forms an appendix to this book, the slope classes are not indicated. However, the 1:1,000,000 series and the field sheets on 1:500,000 scales indicate slope classes according to the above nomenclature. One map on the 1:1,000,000 scale is also appended (Appendix B3) and indicates the slope classes mapped along with soil groups.

## 2.82 LABORATORY STUDIES

The methods used for chemical analysis of the soil samples were based mainly on those recommended in Handbook 60 of the United States Department of Agriculture (45), *Diagnosis and improvement of saline and alkali soils* (February, 1954). Relevant details are given below where reference is made to the method of Chapter 6 of the handbook.

1. *Saturation percentage, total soluble salts and pH of a soil paste.* A soil paste, made as described in Method 2, was transferred to a Bureau of Soils cup, filled the cup completely, and was leveled off at the top. From the weight of this known volume of soil paste, the saturation percentage was calculated (Method 27c) by the following formula:

$$SP = \frac{100 \ (2.65V\text{-}W)}{2.65 \ (W\text{-}V)}$$

where SP = Saturation percentage
V = Volume of saturated paste in $cm^3$ = constant
W = Net weight of $cm^3$ of saturated soil paste, g.

The resistance of the same amount of paste was measured on an Industrial Instruments conductivity bridge type RC and the percentage of total soluble salts estimated as in Method 5 by use of Table 17 (page 93 of the handbook). Finally the pH of the paste was measured on a Beckmann Model G pH meter, using a glass electrode and saturated calomel electrode.

2. *pH of 1:5 soil water suspension.* Twenty g of soil were stirred at intervals with 100 ml of distilled water for about 30 minutes and the pH of the suspension was read on a Beckmann pH meter.

3. *Total neutralizing value.* A known weight of soil (usually 5 g) was boiled gently for 5 minutes with excess standard hydrochloric acid and the amount of excess acid determined by titration with standard sodium hydroxide (Method 23c).

4. *Organic carbon.* One g of finely ground soil was heated very gently on an electric hot plate with a known quantity (usually 10 ml) of N potassium dichromate and an equal volume of concentrated sulfuric acid for 20 minutes. The excess dichromate was determined by titration with ferrous sulfate solution (Method 24).

5. *Available phosphorus.* Five g of soil were shaken for 30 minutes with 100 ml 0.5 M sodium bicarbonate solution, adjusted to pH 8.5 with sodium hydroxide, a little activated carbon having been added to absorb soluble organic matter. The mixture was filtered on aliquot (usually 20 ml) neutralized with N sulfuric acid and phosphate determined by developing molybdenum blue color with ammonium molybdate and

stannous chloride at 0.4 N sulfuric acid (Method of Olsen et al., Circular 939, U.S. Department of Agriculture).

6. *Soluble and exchangeable sodium and potassium* (including available potassium). Ten g of soil were treated with about 100 ml neutral N ammonium acetate solution and, after standing overnight, the supernatant liquid was decanted on to a filter and the filtrate collected in 250 ml graduated flask. The residual soil was treated with about 30-35 ml ammonium acetate solution and after settling for 30 minutes, the supernatant liquid was also decanted on to the filter. This procedure was repeated twice and finally the soil was all transferred to the filter and leached with ammonium acetate to give 250 ml of extract (Method 18). Sodium and potassium were measured in this extract by means of a Kipp Flame Photometer. Potassium results were considered to be a measure of available potassium.

7. *Water soluble sodium and potassium.* 100 g of soil were stirred with 100 ml of distilled water (or, for some heavy or organic soils, 200 ml) for about 30 minutes and filtered. Sodium and potassium were determined in the extract by flame photometry (as above).

8. *Cation-exchange capacity.* The exchange complex was saturated with sodium ions by repeated treatment with N sodium acetate and the excess was washed out with 95 percent ethanol. Finally the sodium ions were removed with N ammonium acetate and determined by flame photometry (Method 19).

9. *Exchangeable calcium and magnesium* (acid soils only). An aliquot of the N ammonium acetate extract or one made for sodium and potassium determinations was evaporated to dryness and heated gently with a little aqua regia to remove ammonium acetate and organic matter. The residue was taken up in water and titrated with EDTA to measure Ca + Mg.

10. *Mechanical analysis.* Mechanical analysis of some selected samples was carried out. A known weight of soil with a dispersing agent consisting of sodium metaphosphate and sodium carbonate was used. Where organic carbon was greater than about 1 percent, a pretreatment with hydrogen peroxide was carried out. The clay and clay and silt determinations were done with a Bouyoucos hydrometer (see Methods 41 and 42 b). The results are expressed as a percentage of sand (> 20 percent), silt (2 — 20 percent) and clay (< 2 percent).

*Comments on analytical data reproduced with a description of the principal soils of Iran*

All results are expressed in terms of the air-dry conditions of Tehran, where the Soil Laboratory is located; these figures are not very different from those expressed on oven-dry soil.

The meanings of the analytical figures are as follows:

1. *Saturation percentage* (S.P.). Weight of water (to nearest whole number of g) needed to saturate 100 g of oven-dry soil.

2. *Total soluble salts* (T.S.S.). Number of g of "soluble" salts in 100 g of air-dry soil, assessed from the electrical resistance of soil paste. It is not possible to record figures accurately above 2 percent.

3. pH. pH value of soil paste or a suspension containing 1 part of soil in 5 parts of distilled water by weight.

4. *Total neutralizing value* (T.N.V.). Number of g (nearest whole number) of calcium carbonate equivalent to the acid neutralizing power of 100 g of air-dry soil.

5. *Organic carbon.* Number of g (nearest 0.1 g) of easily oxidizable carbon in 100 g of air-dry soil. The method used probably oxidizes an average 85-90 percent of the total carbon and the figures may be converted approximately to "organic matter" by multiplying by 2.

6. *Available phosphorus* (parts per million, ppm). Phosphorus (P) extractable from 1,000 g of air-dry soil. The figures are recorded to the nearest 0.5 ppm up to 9.5 ppm P and to the nearest whole number from 10 ppm P upwards. A tentative classification used at the moment for fertility purposes is:

| | | | |
|---|---|---|---|
| up to 4.0 | ppm P | — | very low |
| 4.5 to 8.0 | " | — | low |
| 8.5 to 20 | " | — | moderate |
| 21 to 50 | " | — | high |
| above 50 | " | — | very high |

7. *Available potassium.* mg potassium (K) extractable from 100 g air-dry soil. The figures are recorded to the nearest 5 ppm to 145 ppm K and to the nearest 10 ppm from 150 ppm K upward. A tentative classification used at the moment for fertility purposes is:

| | | | |
|---|---|---|---|
| up to 75 | ppm K | — | very low |
| 80 to 150 | " | — | low |
| 160 - 250 | " | — | moderate |
| 260 - 400 | " | — | high |
| above 400 | " | — | very high |

8. *Cation-exchange capacity.* Number of mg equivalent of cations capable of exchange in 100 g of air-dry soil.

9. *Exchangeable sodium.* Number of mg equivalents of sodium ions in the exchange complex of 100 g of air-dry soil, assessed from the difference between

the total sodium ions in an ammonium acetate extract and the soluble sodium ions in a water extract. Where the total soluble salts are more than 3 g per 100 g no figure is given for exchangeable sodium since it is considered to be unreliable. It can be reckoned, however, from analytical work done, that if the soil contains these high amounts of soluble salts - mostly sodium chloride - more than 50 percent of the exchange complex is occupied by sodium ions.

10. *Exchangeable potassium.* Number of mg equivalents of potassium ions in the exchange complex of 100 g of air-dry soil, assessed as in the case of exchangeable sodium. *Note:* Where the sodium content of the ammonium acetate extract was low (i.e., less than 1 mg equivalent per 100 g )no water extract was made and the figures for exchangeable sodium and potassium may include traces (less than 0.2 g equivalent per 100 g) of soluble sodium and potassium.

11. *Exchangeable calcium and magnesium.* Number of mg equivalents of calcium and magnesium (combined) in the exchange complex of 100 g of air-dry soil. Only determined in the case of acid soils, in order to assess the probable percentage of the exchange complex occupied by hydrogen.

### 2.83 PREPARATION OF MAPPING LEGEND

For a map at the scale of 1:2,500,000, the soil assocation appears to be the most adequate mapping unit. It is a grouping of soil units geographically associated in the landscape and selected in order to correspond to broad climatic and physiographic units which, in addition, have a certain land-use pattern in common.

The mapping units in the legend have been conveniently grouped under four physiographic units. This subdivision, however, is not exclusive since units mentioned under one group may also occur to a minor extent under the other. This grouping is mainly for convenience in reading and to give some idea of the overall structure of the country.

The names of the associations are given in terms of the dominant soil groups, while the inclusions are mentioned in the text. The inclusion of the names " Lithosols," "Rendzinas," or " Regosols " in the association occupying dissected slopes and mountainous areas may not always be justified on the basis of the distribution and development of most of the soils under these units. In addition the soil association of Salt Marsh is listed as salty or marshy or salt-marsh, even though in the mapping unit there may be some scattered small areas without any of these characteristics. The scale of the soil map shown (1:2,500,000) does not allow for separation of these from one another, and because of the lack of detail some of the soils mapped are simplified.

2.84 DESCRIPTION OF MAPPING UNITS

The description of the mapping units included hereafter is of a general nature. The rather great range of variability of the soils throughout the country necessitates more than one soil description. The nomenclature, classification, and description follows mainly that used in *Soils and men, U.S.Department of Agriculture Yearbook 1938*, and *Soil survey manual*, U.S. Department of Agriculture Handbook No. 18, 1951. It is in general accord with the soil names used in other countries of the region and by FAO and other specialists, national and international.

The soils mapped are described in the following chapter.

# 3. SOILS OF IRAN

## 3.1 Soils of the plains and valleys

The soils of the plains and valleys are formed by soil material which is not residual but is brought by the usual agencies of water and wind. Predominant among these are alluvial soils which are composed of young water-deposited sediments of the flat or gently sloping flood plains. The alluvial soils separated in the mapping unit are generally medium to heavy textured and they are mostly calcareous.

### 3.11 FINE-TEXTURED ALLUVIAL SOILS

Young alluvial soils normally do not show prominent horizon differentiation, other than an occasional formation of an organic matter layer ($A_1$) at the surface. A great many of these soils are constantly subjected to floods, and the new sediments mask whatever embryonic slight profile development might have taken place between flood periods. The sedimentation normally produces a stratified effect.

In this unit are also included old alluvial formations, such as the terraces of river valleys, lake terraces, and marine terraces. When uplifted these deposits are not subject to the effects of floods and wave action. The result is that the soil-forming processes begin their work and bring about horizon differentiation and creation of a soil profile.

Although the fine-textured alluvial soils show considerable variations in the profile with depth, especially in texture and character of apparent horizons, they have no true pedologic horizons. The sedimentary layers deposited in these soils can vary in a number of characteristics, including those of texture, stoniness, depth, color, and lime content, but they are generally fairly clearly defined at their point of contact with each other and not infrequently some layers show evidence of current bedding. In general, differences between pedologic horizons and sedimentary layers are not difficult to detect. Frequently some of the layers in the profile show evidence in their content of organic matter of having been former surface soils buried under later deposits. Sometimes the buried, or fossil soils show pedologic horizons.

There are certain principles which determine the types, character, and distribution of modern valley sediments which form the fine-textured alluvial soils and which are agriculturally so important that they deserve detailed description. The deposits occur in three distinct associations: *alluvial fan; flood plain; delta.*

FIGURE 10. Fine-textured Alluvial soils in the north where the climate is humid and the land normally under maize or other upland crops.

The recognition of various types of sediments makes possible the interpretation of horizontal and vertical varieties in the distribution and texture of sediments. The texture of the sediments is usually heterogeneous. However, it is still possible to distinguish some regularity of sequence in the sediments when they are interpreted in the light of sedimentation processes.

*Alluvial fans.* As rivers emerge fully loaded from eroded valleys into wide depressions where the slope is gentle, they deposit part of their load in such a way as to build alluvial fans. The surface of a fan resembles a portion of low cone with its apex in the mouth of the valley from which the fan-building stream emerges.

The front of the fan is roughly semicircular but varies in outline according to any irregularities of the surface on which it is built, and also owing to the influence of adjacent fans on one another at their confluent margins.

Over a growing fan a stream flows, taking new courses from time to time, flowing in turn down every radius of the fan. Thus the alluvium is distributed evenly and the fan grows symmetrically. Fans are generally abundant in mountainous regions where a normal cycle of erosion is still in its early stages.

Examples of alluvial fans are spread throughout the country - Hableh-Rud at Garmsar, the river Jaje Rud, some of the rivers of Mazanderan in northern Iran, such as Talvar, Tejan, Haraz, and many others.

These areas are normally mapped as 1B[3] or 1AB[3] in the present generalized soil mapping on 1:1,000,000 scale (Appendix B3 shows a sheet on 1:1,000,000) but are shown as fine-textured alluvials (1) on the map at 1:2,500,000 scale.

*Flood plains.* A valley plain or a flood plain is the nearly flat surface of an accumulation of alluvium. The alluvium is of variable thickness which gives the flood plain a considerably braided relief, greatest in the case of the largest rivers. This results from channels shifting their courses and cutting off meanders and the upbuilding during floods of strips bordering the river. These latter tend to confine the river to its channel during all but high floods, acting in the same way as the artificially built confining ridges termed "stop banks" or "levees." They are therefore called natural levees. These valley floor relief features on the alluvium are superimposed on a broad side convexity developed on the valley floods by grading rivers, as if the floors were radial strips of low angle cones.

In the aggraded valley plains the deposit of alluvium forming the valley floor is thicker than the depth of the stream channel, the thickness being 10 or even 100 m. A cause which may lead to aggradation in a stream is that it is required to steepen slopes initially too gently to give the streams sufficient velocities to transport their loads. Furthermore, aggrading streams are not confined to well-defined channels, for deposition occurs in the channels, filling them up. Where a channel is thus filled, the stream in it flows at a higher level than neighboring parts of its valley plain on the strip of alluvium which it has just deposited. Such a course is obviously unstable and the stream will sooner or later overflow at some point, scour out a passage through its low bank and take an entirely new course over the valley plain. Aggrading streams repeatedly divide and subdivide thus forming braided courses.

*Delta.* Where the sediment is deposited at the mouth of a river in a body of standing water, either on ocean or lake, the shoreline is generally built forward, some new land being formed. Where such natural "reclamation" takes place, the deposit at the river mouth is termed a delta. A delta is built only when more sediment is supplied than is disposed of by wave action and tidal and other currents.

Deltas along the coast at the mouth of streams in the north (Caspian) and in the south (Persian Gulf and the Gulf of Oman) are very common features for several rivers. The alluvium laid down by flood waters in these deltas varies in age from very recent - some as recent as the last overflow - to several hundreds or even thousands of years.

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[3] Fine-textured alluvial soils on nearly level and slightly sloping land.

FIGURE 11. Terraced paddy fields, on the way from Tehran to Chalus.

Alluvial soils are as variable as the parent rocks forming the source of transported material. As they have not been in place sufficiently long to acquire characteristics due to the environment, they are closely related and often resemble the material from which they are derived. For example, alluvial soils in flood plains of streams which drain areas of brown calcareous clay or clay loam soils are brown, clayey and usually calcareous, whereas those deposited by streams which drain dark-colored acid soils from the north are dark colored and acid. This similarity is usually pronounced in small narrow flood plains as the central Caspian littoral area, where the material has not been sorted over long distances. This alluvium is mostly of local origin and may differ distinctly from that in large flood plains and deltas of streams which drain a great variety of soils in different environments. Many of the young alluvial soils are still receiving additions of soil material, or sediments, to their surfaces during flooding. Many transitions also occur between fresh alluvium which does not support vegetation and older alluvium which has been in place for a relatively long period and supports a thick vegetative cover. Transitional soils with weakly developed profiles from alluvium also exist, especially in the Sefid

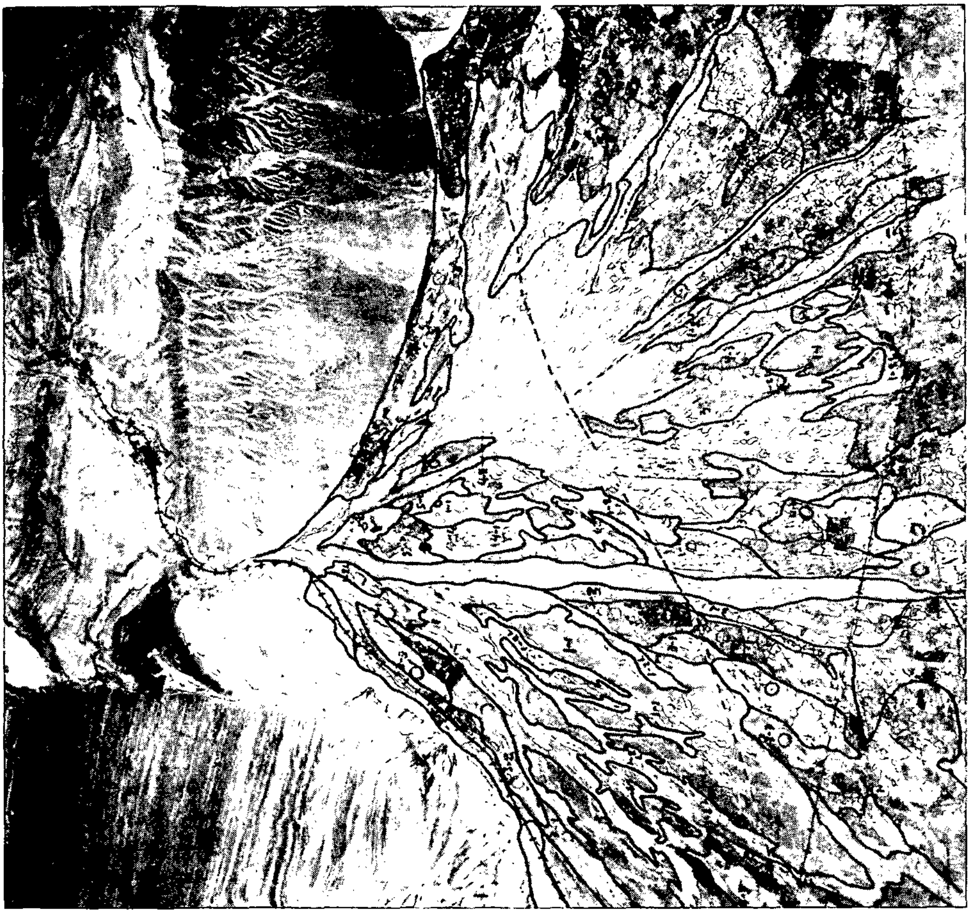


FIGURE 12. Taken in the Garmsar area, east of Tehran, the photograph shows how Alluvial soils are formed. The river Hableh-Rud comes out of the steeply sloping, hilly and mountainous area. As the stream loses velocity it deposits alluvium in the shape of a fan. Coarse-textured material is deposited close to the gorge and fine-textured materials at the point where the river comes out of the hills. The use of aerial photographs assists both in delineation of soil units and in more accurate demarcation of their boundaries. North of the fan, the Lithosols (13 and 14) are predominant soils. The fan consists of predominantly Saline Alluvial (1-4) and some coarse Alluvial and colluvial soils (2a).

Rud area in the Rasht Plain. In the present study many of these transitional soils on deltas and in high, well-drained valleys or nearly level or very gently sloping surfaces have been included with the alluvial soils.

Four typical soil profiles of fine-textured alluvial soils are described below.

1A. Kaal loam, level or nearly level (0-1 percent).

*Profile No. 266, located in Dezful Valley in Khuzistan.*

| | |
|---|---|
| 0-15 cm | Ap horizon, pale brown (10 YR 6/3 d) loam, structureless breaking to fine granular, friable, few wormcasts. |
| 15-40 cm | Dark yellowish - brown (10 YR 4/4 m) sandy loam, structureless breaking to granular. friable, few wormcasts. Slight concentration of gypsum. |
| 40-75 cm | Brown (10 YR 5/3 m) very fine sandy loam, slightly platy, breaking to soft medium angular blocky and then to granular. Few root hairs and wormcasts. Slight gypsum content. |
| 75-120 cm | Dark yellowish-brown (10 YR 4/4 m) sandy loam, structureless breaking to granular, some root hairs and wormcasts from 90-120 cm. |
| 120-165 cm | Dark brown (10 YR 4/3 m) very fine sandy loam, massive near sticky, medium visible lime and gypsum concentration. |
| 165-200 cm | Dark brown (10 YR 4/3 m) very fine sandy loam, massive sticky clearly visible lime and gypsum concentration, slight to moderate salinity. |

1A. Jagoto fine sandy loam, level or nearly level (0-1 percent).

*Profile No. 1004, Zarrineh Rud project area, near the village of Ebrahimabad, Mian doab, Azerbaijan.*

| | |
|---|---|
| 0-1 cm | Pale brown to brown (10 YR 6/3d, 5/3 m) weak platy, silt to fine sandy loam. |
| 1-5 cm | Grey brown (2.5 Y 5/2 m) loose when moist, soft when dry, weak thin platy sandy loam to loamy sand. |
| 5-30 cm | Grey brown (2.5 Y 5/2 m) weak blocky loamy fine sand, very friable when moist. |
| 30-100 cm | Dark grey brown (2.5 Y 4/2 m) silt loam to fine sandy loam, hard, medium blocky. |
| 100-200 cm | Brown (10 YR 4/3 m) silt loam, medium platy, friable consistence. |

1A. Babolsar silty clay loam, level or nearly level (0-1 percent).

*Profile No. 43, located about 20 km south of Babolsar in an upland cotton field, Mazanderan.*

| | |
|---|---|
| 0-5 cm | Light brownish-grey (2.5 Y 6/2 d, 4/2 m) silty clay loam, of blocky structure and consisting of big peds, which are hard when dry and friable when moist. High in shells and effervesces violently, pH about 7.5. |

| | | |
|---|---|---|
| 5-20 | cm | Dark grey-brown (2.5 Y 4/2 m) silt loam, moist friable, weak medium blocky, pH about 7. |
| 20-40 | cm | Dark grey-brown (2.5 Y 4/2 m) fine sandy loam, weak fine granular, friable. pH about 7. |
| 40-60 | cm | Dark grey-brown (2.5 Y 4/2 m) silty clay loam, with common mottling (dark brown 10 YR 3/2), weak blocky structure and friable consistence. |
| 60-100 | cm | Grey-brown (2.5 Y 5/2 m) clay loam to silty clay loam, friable, weak blocky, with common yellowish-brown mottling. |
| 100-120 | cm | Olive-colored (5 Y 4/3 m) silt loam, with weak blocky structure and friable consistence, and common mottling. |
| 120-140 | cm | Dark grey-brown (2.5 Y 4/2 m) silt loam, weak blocky and friable, with common mottling, pH between 7 and 8. |

All horizons have common or abundant sea shells and effervesce violently when reacted with diluted Hcl.

1A. Siasia silty clay, level or nearly level (0-1 percent).

*Profile No. 63, Kermanshah Province.*

| | | |
|---|---|---|
| 0-25 | cm | Light brown (7.5 YR 6/3 d, 4/3 m) silty clay, big cloddy, mixed with some crumbs and single grains; clods extremely hard, crumbs soft to slightly hard, medium abundant roots. |
| 25-50 | cm | Brown (7.5 YR 5/3 d, 4/3 m) silty clay, well-developed coarse and some very coarse blocks; also some medium coarse blocks, slight horizontal lamination, very hard, many roots. |
| 50-80 | cm | Brown (7.5 YR 5/3 d, 4/3 m) silty clay, fine and medium and some coarse blocks, very hard, medium abundant lime spots, few roots. |
| 80-120 | cm | Brown (7.5 YR 5/3 d, 4/3 m) silty clay, medium-developed prisms and medium cubic blocks, prisms breaking into medium cubic blocks, very hard, few lime spots. |
| 120-160 | cm | Brown (7.5 YR 5/3 d 4/3 m) silty clay loam, medium to well-developed medium blocks partly breaking into fine, less sharp-angled than above, very hard, some lime spots. |

*Range in characteristics.* Fine-textured alluvial soils vary from silt loam to silty clay loam, clay loam and even clay in the surface. The subsoil consists of layers of varying textures and thicknesses. Normally these layers are silt loam, silty clay loam or clay loam, but they may be friable clay with poor to good permeability. The surface color varies from pale brown to brown and even dark grey brown and is normally variable. Structure varies from platy to blocky and may be granular depending upon vegetation, etc. These layers are normally free from salt and also

FIGURE 13. Irrigated Alluvial soils, Miandoab-Zarrineh Rud, Azerbaijan. Poplars are very much grown under irrigation in Iran.

mottling but they may have slight mottling or slight salinity in certain cases. All of these soils have low to moderate amounts of organic matter and all are low in available phosphate. The calcium carbonate is high to very high except in a few areas in the north. In these soils calcium and magnesium are the predominant exchangeable cations and nearly all of them are medium to high in exchangeable potassium. Table 13 shows the variation in analyses of the soil profiles.

*Relief.* Level or nearly level when in flood plains or deltas, very gently sloping with some slight undulations for those of alluvial fans.

*Drainage.* Usually medium to good.

*Vegetation.* When not under crops, the rainfall and the moisture status of the soil (depending on the region) supports some natural vegetation such as leguminous, *Glycyrrhiza glabra* (shirin bian), and some grasses.

*Parent material.* Variable, depending on the geology of the catchment from whence the sediment is carried.

*Land use.* These soils are suitable for irrigated agriculture and almost any crop thrives well on them. Cotton, sugar beets, vegetable crops, fruit and other trees, and sometimes wheat and other cereals. Dry farming in certain areas is also well suited to the soil.

FIGURE 14. Chem-Chamal area, above Bisitun, Kermanshah. Engr. Gholizadeh of Irrigation Bongah examines a shirin bian (*Glycyrrhiza glabra*), a leguminous plant which is an indicator of good soils.

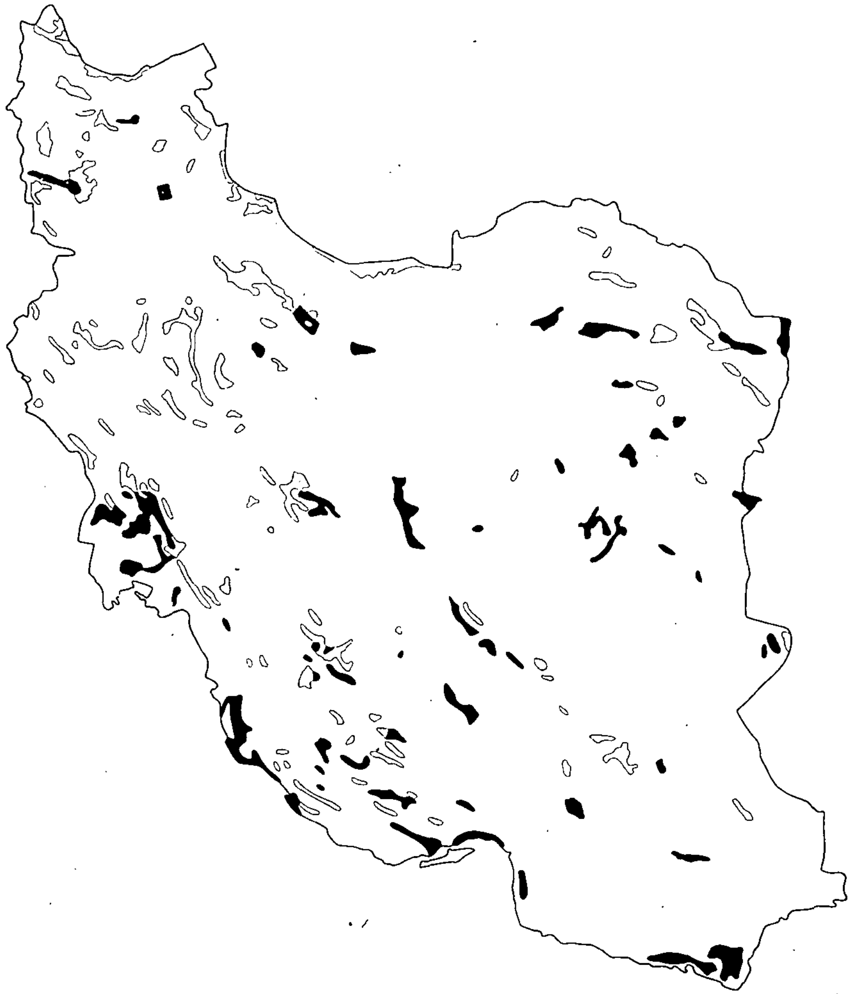
FIGURE 15. Zarrineh Rud. A peasant who has permanent tenure exhibits excellent production of grapes in the village of Tagi-Abad near Miandoab on fine-textured Alluvial soils.

FIGURE 17. Fine-textured Alluvial soils and Brown soils on old alluvium. Crop of dry-farmed wheat near Gutwand, Khuzistan. Late Engr. Sulemainpour indicates the growth of the crop.

FIGURE 16. Citrus grown on Alluvial soils in Babolsar, Mazanderan, northern Iran. *Photo, O. T. Osgood.*

TABLE 13. — LABORATORY ANALYSIS OF TYPICAL ALLUVIAL SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S. P. | % T.S.S. | pH | | % T.N.V. | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | $E_{Ca}$ | Mechanical analysis | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Paste | 1:5 | | | | | | | | | Sand >20μ | Silt 2-20 | Clay <2μ |
| 266 | 0-15 | | Dezful | Kall loam | 49 | — | | 8.2 | — | 1.4 | | | | | | | 43.6 | 38 | 18.4 |
| | 15-45 | | | | 40 | — | | 8.7 | — | .6 | | | | | | | 50.0 | 31.6 | 18.4 |
| | 45-90 | | | | — | | | 8.7 | | .5 | | | | | | | 50.8 | 26.8 | 22.4 |
| | 90-120 | | | | — | — | | 8.8 | | .4 | | | | | | | 75.2 | 11.4 | 13.4 |
| | | | | | | | | | | | | | | | | | flaculated | | |
| | 120-165 | | | | 47 | .21 | | 8.4 | | .3 | | | | | | | | | |
| 1004 | 0-1 | | Zarrineh Rud | Jagato fine sandy loam | 41 | .04 | 8.3 | 8.9 | 16 | | | | | | | | 70.8 | 20.8 | 8.4 |
| | 1-5 | | | | 30 | .05 | 7.9 | 8.7 | 13 | | | | | | | | 73.6 | 18.4 | 8.0 |
| | 5-30 | | | | 32 | .03 | 7.9 | 8.8 | 9 | | | | | | | | 79.8 | 14.0 | 6.2 |
| | 30-100 | | | | 36 | .37 | 8.2 | 8.8 | 14 | | | | | | | | 75.0 | 14.8 | 10.2 |
| 43 | 0-20 | 1631 | Babolsar | Babolsar silty clay loam | 53 | .08 | 7.4 | 8.3 | 17 | 1.8 | 16.0 | 480 | 40.0 | .2 | .1 | | | | |
| | 60-100 | 1632 | | | 55 | .07 | 7.6 | 8.6 | 22 | 0.4 | 3.0 | 390 | 65.2 | .2 | .2 | | | | |
| | 120-140 | 1633 | | | 41 | .06 | 7.6 | 8.7 | 25 | 0.1 | 2.5 | 80 | 18.7 | .1 | .7 | | | | |
| 63 | 0-25 | 5609 | Kermanshah (Shahabad) | Siasia silty clay | 55 | .08 | 7.6 | 8.8 | | 1.1 | 3.0 | 420 | — | | | | | | |
| | 25-50 | 5610 | | | 51 | .08 | 7.8 | 9.0 | | .6 | .5 | 220 | — | | | | | | |
| | 50-80 | 5611 | | | 50 | .07 | 7.8 | 9.0 | | .5 | — | 184 | — | | | | | | |
| | 80-120 | 5612 | | | 52 | .08 | 7.9 | 9.2 | | .4 | .0 | 198 | — | | | | | | |
| | 120-160 | 5613 | | | 53 | .07 | 8.0 | 9.2 | | .4 | 1.0 | 204 | — | | | | | | |



| | | |
|---|---|---|
| (white box) | 1 | Fine-textured Alluvial soils |
| (black box) | 1-4 | Saline Alluvial soils |

MAP D1. Distribution of soils in Iran.

*Distribution.* The fine-textured alluvial soils are located throughout Iran, totaling approximately 6.1 million ha or 3.7 percent of the land surface of Iran. Their distribution is given in Table 14 and Map D1.

*Aerial and other photographs.* Figures 10, 18, 19, and 20 show some of the fine-textured alluvial soils.

*Analytical data.* Table 13 shows analytical data for Profiles 266, 1004, 43, and 63 described above.

TABLE 14. — DISTRIBUTION OF ALLUVIAL AND SALINE-ALLUVIAL SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Fine-textured Alluvial 1 | | Saline-Alluvial 1-4 | | Total | |
|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | 236 | 6.21 | 40 | 1.05 | 276 | 7.26 |
| 2. Mazanderan | 14 000 | 380 | 2.71 | 120 | .86 | 500 | 3.57 |
| 3. Azerbaijan | 10 500 | 1 200 | 11.48 | 240 | 2.20 | 1 440 | 13.68 |
| 4. Kurdistan | 3 122 | 80 | 2.56 | — | — | 80 | 2.56 |
| 5. Kermanshah | 6 212 | 711 | 11.45 | — | — | 711 | 11.45 |
| 6. Khuzistan | 13 466 | 969 | 7.31 | 920 | 5.85 | 1 889 | 13.16 |
| 7. Fars | 17 420 | 600 | 3.42 | 600 | 3.42 | 1 200 | 6.84 |
| 8. Kerman | 23 280 | 320 | 1.37 | 800 | 3.44 | 1 120 | 4.81 |
| 9. Khurasan | 30 900 | 960 | 3.11 | 1 080 | 3.50 | 2 040 | 6.61 |
| 10. Isfahan | 17 600 | 200 | 1.14 | 440 | 2.50 | 640 | 3.64 |
| 11. Baluchistan | 18 500 | 80 | .43 | 760 | 4.11 | 840 | 4.54 |
| 12. Tehran | 6 200 | 400 | 6.45 | 120 | 1.93 | 520 | 8.38 |
| Total for the country | 165 000 | 6 136 | 3.71 | 5 120 | 3.11 | 11 256 | 6.82 |

## 3.12 COARSE-TEXTURED ALLUVIAL AND COLLUVIAL SOILS AND REGOSOLS INCLUDING SAND DUNES

These are colluvial soils and soils of coalescing alluvial fans which are also called deluvial soils by Soviet soil scientists. They have been, and in most cases are still

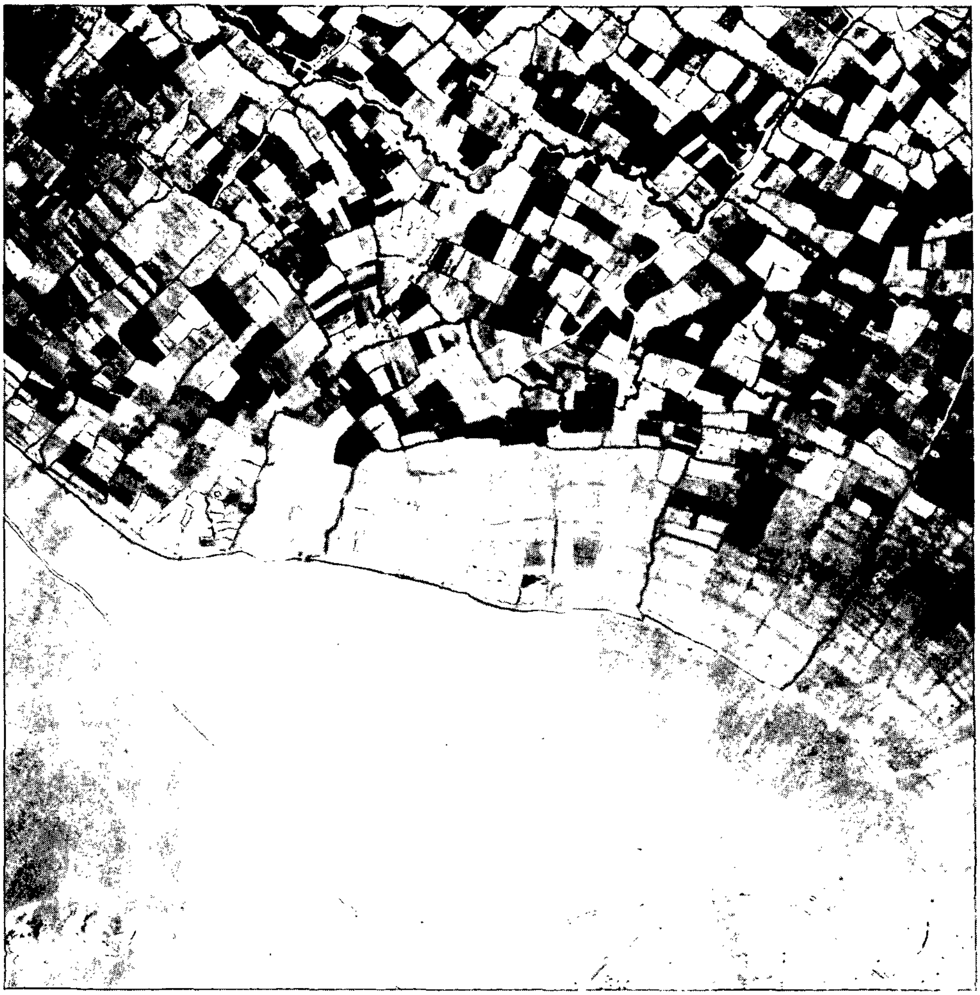


FIGURE 18. Canal-irrigated soils in Golpaygan, west central Iran, are fine-textured Alluvial soils (1) where highly developed agriculture has been practiced for centuries, or even thousands of years. These soils are well drained non-saline, and have good quality irrigation water. Farmers use crop rotation with leguminous crops such as alfalfa. The nonirrigated area is colluvial with some coarse Alluvial (2a), and the moisture-holding capacity is low. Furthermore, as they are high lying, gravity canals cannot irrigate these soils.

being built up by material carried by flood waters from the mountains to relatively narrow valleys.

Some profile development is observed in the soils. Lime accumulation is found in concretions and pockets as powder, or deposited on gravels. Gravels are usually

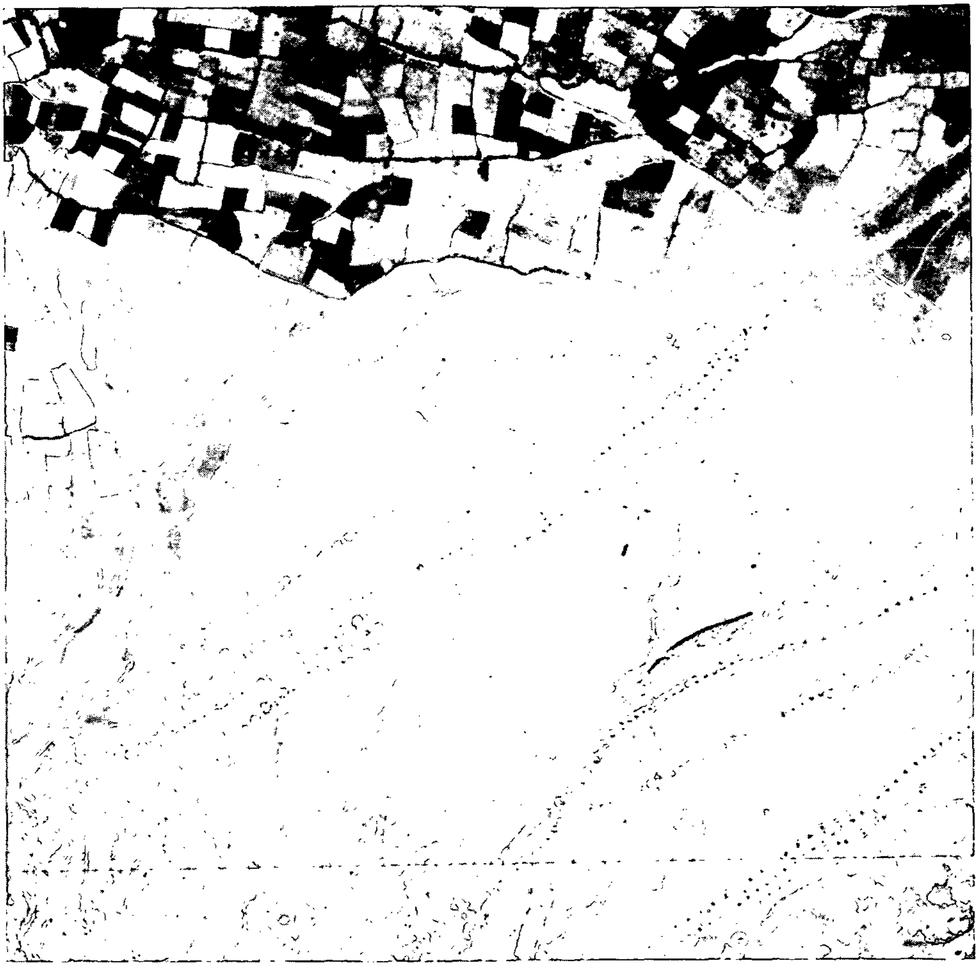


FIGURE 19. A series of ghanats is shown in the Golpaygan area in west central Iran. The northern third of the photograph is covered by fine-textured Alluvial soils, the lower two thirds by Sierozems partly irrigated by ghanats. Over 2,500 years ago a special system for the utilization of groundwater resources was developed in Iran. By the construction of underground galleries, called ghanats (or kariz), the groundwater table is tapped and the water is brought to the surface, thus forming a sort of artificial spring. A great number of wells have to be dug in order to connect the gallery with the surface. The excavated earth is lifted in leather buckets through these wells and heaped around the opening, protecting it against the entrance of surface water. These lines of " mole hills " are a remarkable feature of the Iranian plateau, especially when seen from the air.

cemented with finer material by means of lime which has moved, the degree of cementation varying with the region, rainfall, and other factors which affect the lime movement in the soil profile.

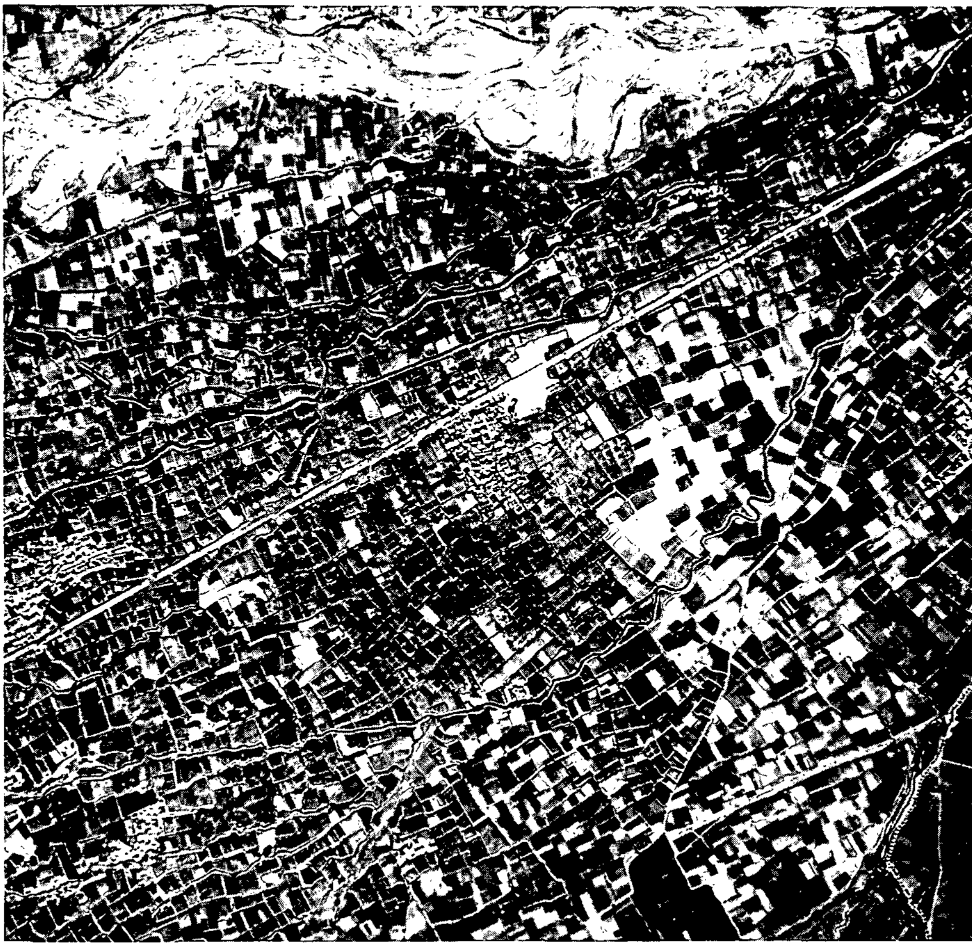


FIGURE 20. Alluvial soils are the most important soils for agriculture in Iran. Those in arid or semiarid zones must be irrigated for crop growing. Shown above is Esfahan, located on the old and young alluvia of Zayandeh Rud River, where there is intensive crop production on heavy old Alluvial soils. Land surfaces are mostly level with gentle slopes. Wheat, barley, alfalfa, cotton, tobacco, and melon are the main crops. Apple, pear, and peach orchards are the most important ones in the area.

A typical profile of such a coalescing alluvial fan is described below.

2a: Coarse-textured colluvial soil: Slope C (3 to 8 percent).

*Profile No. 5, located in Shahreza-Abadeh section, Esfahan Province.*

0-12 cm Brown (7.5 YR 5/4 m) clay loam, calcareous, medium weak blocky breaking into medium granular structure, contains about 10 percent of sharp-edged angular gravel.

12-25 cm Reddish-brown (5 YR 5/4 d, 4/4 m) gravelly clay loam (sharp-edged gravel about 20 percent of the soil mass), medium blocky breaking to medium granular structure. Some lime mycelia and concretions present.

25-48 cm Reddish-brown (5 YR 5/4 m) very gravelly clay loam (with sharp-edged gravel about 60 percent of the volume of the soil mass). Some lime pockets exist, usually accumulated underneath the gravel.

48-75 cm Almost all gravel cemented with some soil material with the eluviated lime.

*Range in characteristics.* These soils are usually developed on coarse to medium-textured material but have a small to large percentage of sharp-edged gravel. They are normally not saline except when the sediments are from calcareous marls, saliferous and gypsiferous (Fars and Upper Red Series). See Map B4.

*Relief.* Usually occurring on slopes of 2 to 5 percent, but also on steeper or more gentle slopes. Gullies are commonly found in these soils, partly because of the slope and partly due to the loose nature of the material.

*Drainage.* Good to excessive surface and internal drainage.

*Vegetation.* Very scarce and scattered, as is normal in arid and semiarid regions. Since these soils usually occur in the zone of Brown soils, Sierozems, and Desert soils they therefore contain the natural vegetation typical of the latter.

*Parent material.* Varies depending on the geology of the catchment area from which the sediments are brought. The sediment is carried by small rills which form coalescing alluvial fans.

*Land use.* Coarse-textured Alluvial and Colluvial soils are not of great use for agricultural development because they have too much gravel, are low in moisture-holding capacity, and are usually unfertile. When these Colluvial and coarse Alluvial soils are in the Brown soils zone, dry farming gives fairly low yields of wheat or

TABLE 15. — LABORATORY ANALYSES OF TYPICAL COARSE-TEXTURED ALLUVIAL SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH 1:5 | T.N.V. % | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 0–25 | 7458 | | | 23 | 0.12 | 7.7 | 69 | 0.1 | 0.5 | 134 | 5.39 | 0.44 | 0.33 |
| | 25–60 | 7459 | Fars | 2a | 23 | 0.11 | 7.8 | 69 | 0.0 | 0.5 | 100 | 4.34 | 0.24 | 0.24 |

barley and occasionally complete crop failures may occur because of the low water-holding capacity of these soils.

*Distribution.* In foothill areas throughout the arid and semiarid parts of the country. Table 16 shows that there are about 6 million hectares of these soils in various parts of Iran. Map No. D2 gives the distribution together with the sand dune areas.

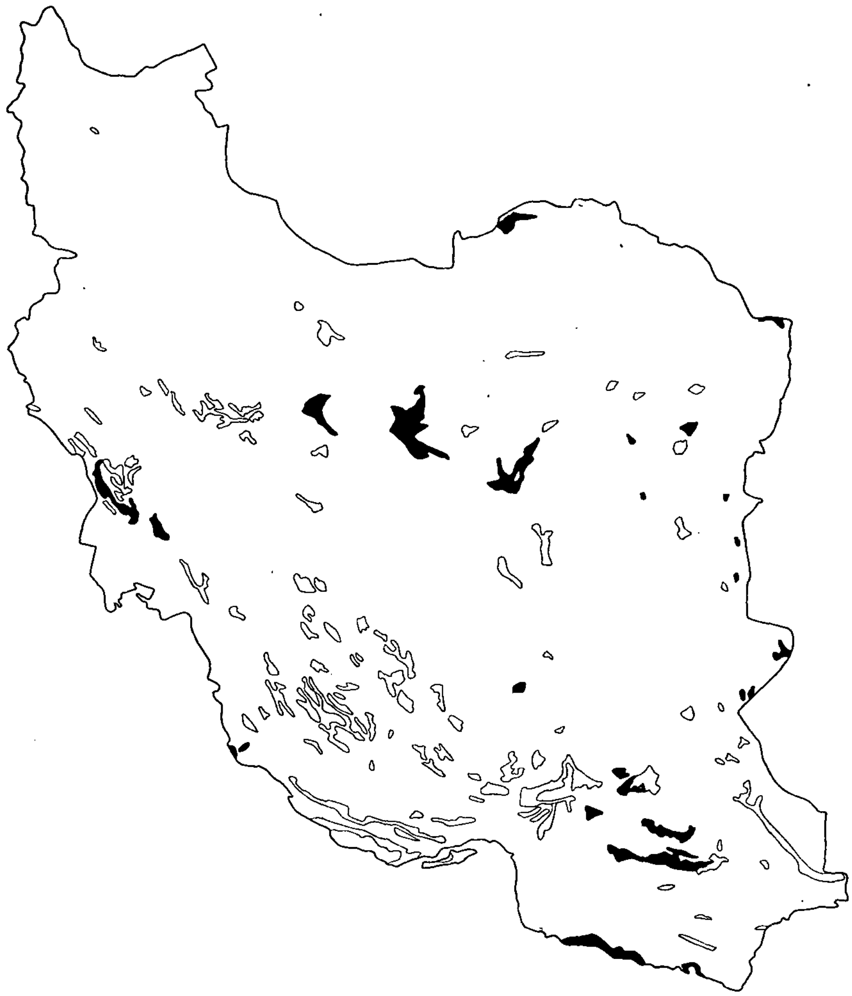
*Analytical data.* See Table 15.

TABLE 16. — DISTRIBUTION OF COARSE-TEXTURED ALLUVIAL AND COLLUVIAL SOILS AND SAND DUNES IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | 2a Coarse-textured Alluvial and Colluvial soil | | 2b Sand Dunes and coastal sands | | Total | |
|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | — | | — | | — | — |
| 2. Mazanderan | 14 000 | 80 | .57 | 360 | 2.57 | 440 | 3.14 |
| 3. Azerbaijan | 10 500 | 40 | .38 | — | | 40 | .38 |
| 4. Kurdistan | 3 122 | — | | — | | — | |
| 5. Kermanshah | 6 212 | 80 | 1.29 | — | | 80 | 1.29 |
| 6. Khuzistan | 13 466 | 760 | 5.74 | 240 | 1.82 | 1 000 | 7.56 |
| 7. Fars | 17 420 | 1 800 | 10.30 | 40 | .22 | 1 840 | 10.52 |
| 8. Kerman | 23 280 | 1 480 | 6.36 | 440 | 1.89 | 1 920 | 8.25 |
| 9. Khurasan | 30 900 | 360 | 1.17 | 400 | 1.29 | 760 | 2.46 |
| 10. Esfahan | 17 600 | 440 | 2.50 | 640 | 3.64 | 1 080 | 6.14 |
| 11. Baluchistan | 18 500 | 680 | 3.68 | 920 | 4.97 | 1 600 | 8.65 |
| 12. Tehran | 6 200 | 200 | 3.22 | — | — | 200 | 3.22 |
| Total for the country | 165 000 | 5 920 | 3.60 | 3 040 | 1.84 | 8 960 | 5.44 |

*Sand dunes (including coastal sands)*

Sand dunes are common in most of the arid regions of Iran. They consist of deposits of loose sand, occurring within or near the margins of deserts and coasts and are composed largely of quartz or of fragments of many different minerals.





MAP D2. Distribution of soils in Iran.

The sand dunes may be moving or fixed by vegetation. The high wind velocities prevailing in some regions are an important factor for the movement of these sand dunes.

Where there is some grass vegetation, especially in the moist regions, a slight profile development may occur. In a few cases a very thin and weakly developed $A_1$ horizon with some organic matter has been observed up to even 1 percent in the surface 2-5 cm, which helps to stabilize these dunes. Fine and medium sands throughout the profile have usually been observed as well as some visible lime in the form of nodules in the subsoil. Soil formation processes are, however, very weak.

Evidence has been obtained in some areas indicating that the present sands have been deposited on former agricultural land. For example, a clay loam layer below about 1 meter of sand was found in the Karkheh West area in the Khuzistan Plains.

Moving coastal sands and sand beaches have been grouped together with sand dunes in the map appended (B1); although on field scale, these were mapped separately.

Found chiefly on low lying land which has been recently built up by the sea, these coastal sands may ascend cliffs, travel inland, and spread over the country so as to bury a former relief. In the arid areas, there is little or almost no profile development. Hovewer, there is some profile development in the Caspian area as indicated by the description of the following profile of coastal sand dunes.

2b: Caspian coarse sand, level or nearly level (0-1 percent).

*Profile No. 48, located about 16 km east of Nowshahr in the littoral of the Caspian Sea, Mazanderan Province.*

| | |
|---|---|
| 0-2 cm | Mull layer with considerable fungal growth, pH 6.5. No effervescence. |
| 2-25 cm | Very dark brown (10 YR 2/2m) coarse sand, weak granular, slightly sticky, high in roots and organic matter, pH 6.5-7. No effervescence. |
| 25-60⁻ cm | Dark grey (10 YR 4/2 m) coarse sand, weak blocky, slightly sticky, slight to strong effervescence. |
| 60-100 cm | Very dark greyish-brown (10 YR 3/2 m) coarse sand, weak blocky, slightly sticky, slight to strong effervescence. |

This profile indicates some tendency of podzolization and is underlaid by beach sand which has some shells.

*Range in characteristics.* Sand dunes may be mobile or fixed. Mobile sand dunes may migrate over the land, destroying crops, agricultural areas, villages, etc. Many of the villages, for example in the Kerman and Seistan areas, are buried, or at least partially subject to the moving sands.

FIGURE 21. Coarse Alluvial and Colluvial soils in the Saveh area, southwest of Tehran.

FIGURE 22. Brown soil on a colluvial slope with abundant "Kangar" vegetation. Korbal district in the Doroodzan Project, Fars.

Profile development may vary from nil in the case of mobile sand dunes, to the fixed variety where there may be weak to even moderate profile development.

*Relief.* Usually nearly level to undulating. Mobile sand dunes may have moderate slopes to large undulations.

FIGURE 23. Unconsolidated colluvial materials without definite genetic horizons can be found in mountain areas all over the country. These consist of only slightly altered local soil materials washed from surrounding moderately sloping hills, usually containing a high quantity of gravels. These soils exist mainly in the arid area. The above photograph shows the Regosols between Shahreza and Abadeh, central Iran (2a).

*Drainage.* Excessive internal drainage and normally good to excessive external drainage.

*Vegetation.* Mobile sand dunes are normally devoid of any vegetation. Stable or fixed dunes usually have short growth of grass or scattered shrubs in arid and

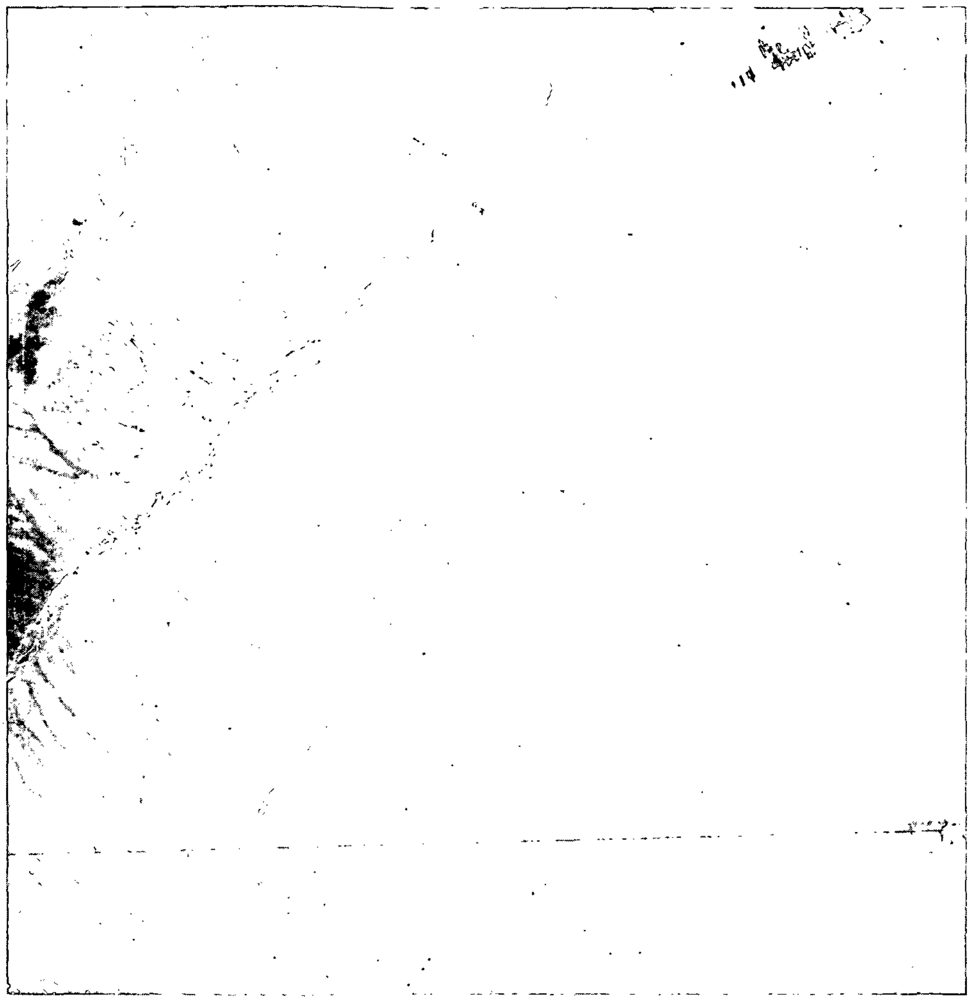


FIGURE 24. The colluvial, coarse Alluvial, and Regosols (2a) also occur in the form of coalescing alluvial fans which have been and are still being built up by material carried with flood waters from the mountains to relatively narrow valleys. They are developed on coarse to medium and even heavy-textured soils with small sharp-edged gravel material and are found in the dry regions of Iran. The photograph indicates coalescing alluvial fan around Abadeh, in the south and central parts of the country where rainfall is very low, surface runoff is very rapid, and erosion is very severe, in some cases giving rise to gully erosion. These soils, usually used for poor range and pasture, have low moisture-holding capacity.

semiarid regions. In coastal sands in the humid and subhumid areas, mixed and other forest species are also found to occur. The plant species found on these soils are usually as follows: in central parts of Iran, *Zygophyylum atriplicoides, Zygo-*

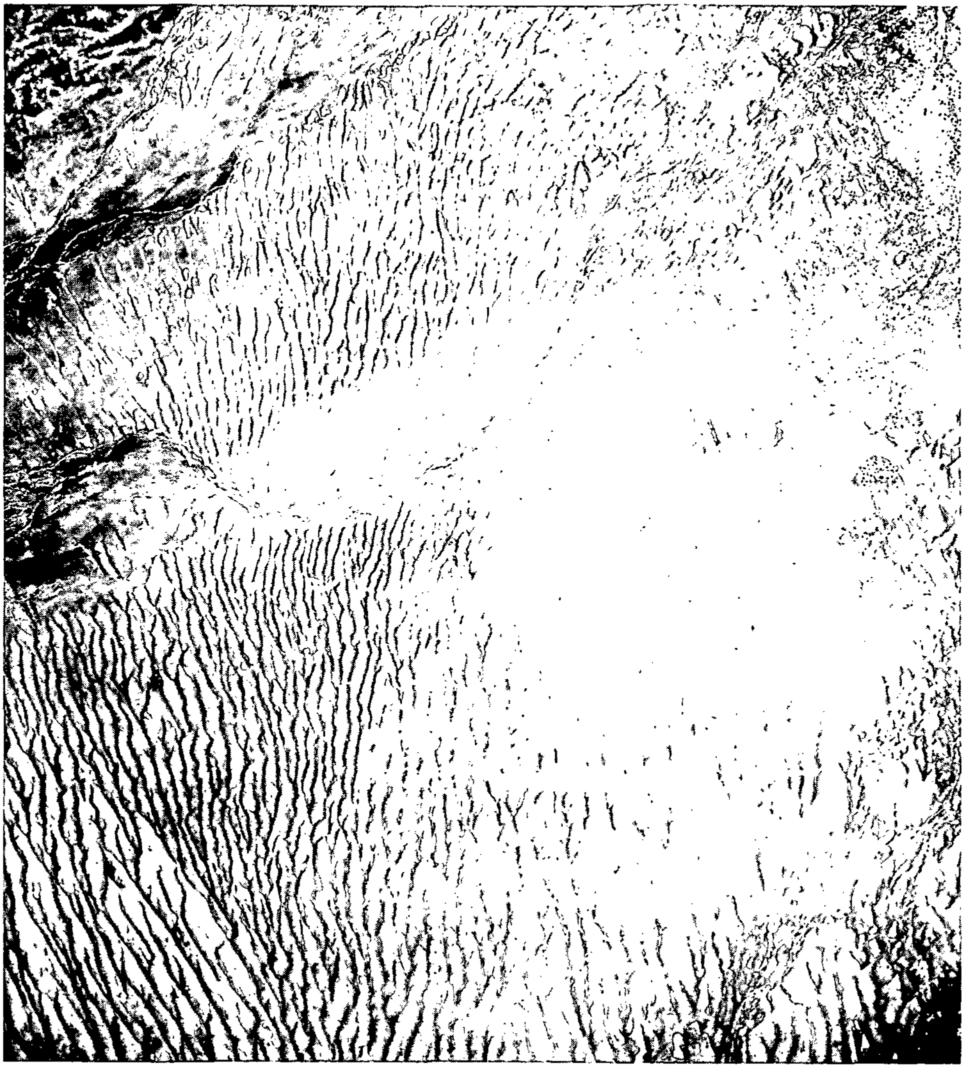


FIGURE 25. Sand Dunes occur in large parts of Iran, especially in the center and south. They may be stabilized or moving; the latter can do considerable harm to agricultural lands in the neighborhood. There are two streams passing through the photographed area of sand dunes (in central Iran) where " waves " can be observed.

*phylum eurypterum, Zygophylum dumosum, Tribulus terrestris, Cornulaca leucacantha, Calligonum comosum, Calligonum persicum, Aristida pennata, Haloxylon ammodendrom;* on the shores of Caspian Sea, *Willmetic tuberosa, Tournefortia arguzia, Crepis foetida, Daucus littoralis, Plantago arenaria, Convolvulus persicus, Sedum pallidum,*

FIGURE 26. Seistan has a special wind condition. Monsoon winds blow back the sand around the lake and rivers to the south central part of the area in dry seasons. The above photograph shows the moving sand dunes along the agricultural area (1-4 and 2b). The black parts in the sand dunes are the wheat fields in places where the soil is slightly wet and not covered by sand.

*Maresia sp., Psamites candolei;* in the southern parts of Iran on coastal sands, *Euphorbia tirucalli.*

*Parent material.* Sand dunes may be composed largely of quartz or of fragments of many different minerals, depending on the geological composition of the varying sources of these dunes.

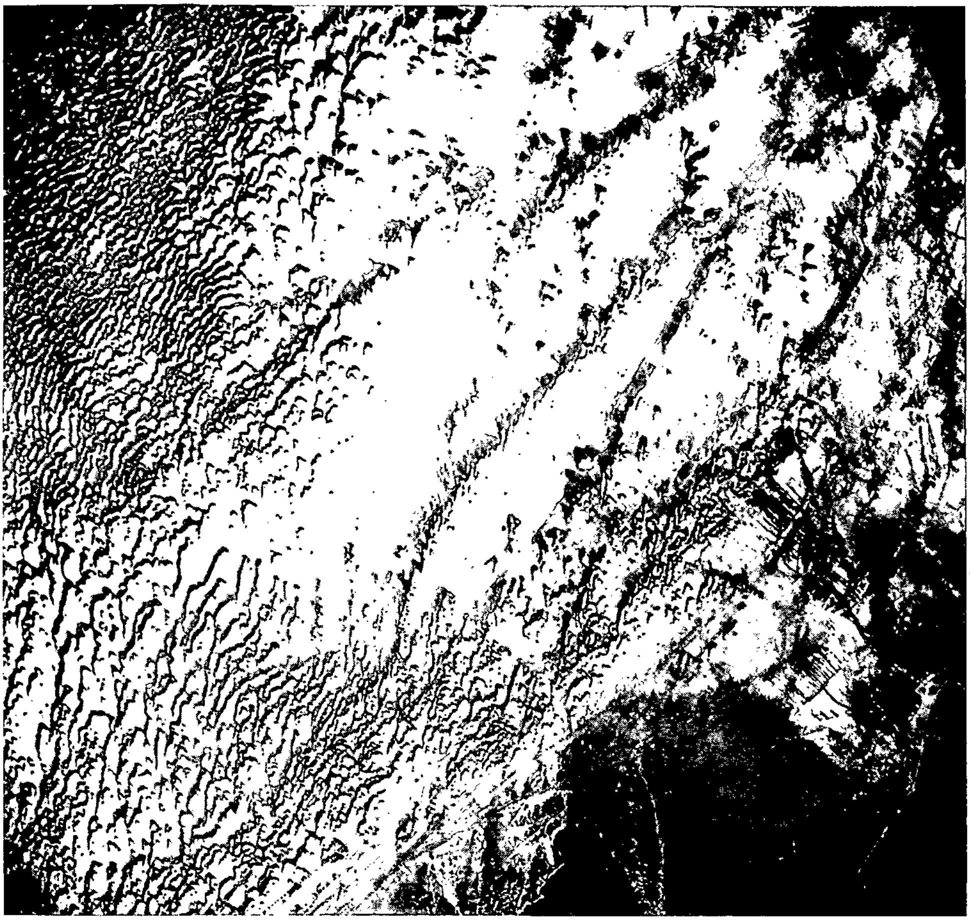


FIGURE 27. A village near Kerman where sand dunes (2b) are rushing toward the village and surrounding lands. They are not only a danger to the land but also to roads and ghanats (source of irrigation water from underground). The photograph shows also the range of sand dunes along the ghanat heaps.

*Land use.* Sand dunes are generally wastelands. In some cases where these are fixed or stable they may be used for pastures although their carrying capacity is small. In many parts of the world efforts have been, and are being made to stabilize the moving sand dunes in the arid areas. This is also needed for the protection of other agricultural land which could be damaged or destroyed by these sands if they were to migrate. A poor to moderate pasturage or even some woody species could be grown in order to make use of these areas. In Karakum desert in the Turkmen Republic of the U.S.S.R., in Israel, and in the Rajasthan desert of India, vegetation has been promoted in order to stabilize the sand dunes. It subsists on moisture, such as dew, absorbed by the sand from the atmosphere, in addition to the scanty rainfall which occurs in such arid areas.

*Distribution.* Sand dunes cover a large part of the country in the central, southern, and southeastern parts of Iran, notably Kerman, Baluchistan, Seistan, and Khuzistan. In most of these places sands migrate over the land destroying crops, agricultural areas, villages, etc.

Moving coastal sands and sand beaches occur in the three main coastal areas, namely the Caspian, Persian Gulf, and Gulf of Oman. There is practically no evidence of present coastal sands on Lake Urmia in Azerbaijan although some old coastal sand dunes have been observed during the semidetailed soil survey of the Zarrineh Rud area.

The distribution of sand dunes, including coastal sands, is given in Table 15. Map No. D2 also shows their distribution in various parts of Iran. About 3 million hectares or about 1.8 percent of land surface of Iran is under these sand dunes.

## 3.13 Hydromorphic soils

These soils are the continually or intermittently moist soils. They usually have a dark surface horizon, and occupy low lying and flat areas.

The major hydromorphic soils found in Iran are Low Humic and Humic-Gley soils, calcareous wet Alluvials, Pseudo-Gley or Grey Hydromorphic soils, and a small area of Half Bog soils near Pahlavi, all in the north.

### 3.131 Low Humic and Humic-Gley soils

Also called Wiesenboden or Swamp Meadow Soils, these are dark brown or black soils, high in humus, grading into a greyish and rust mottled color. Mostly slightly acid to slightly alkaline. Gleization and calcification are the main processes of soil development. These soils are influenced by the substances brought in by groundwaters, and consequently may be rich in plant nutrients. The morphological characteristics can be described as follows:

A: Black or greyish-black, without any well-expressed structure, frequently impregnated with dark brown veins of iron oxide, somewhat compact, almost always wet, at a depth varying from 10 to 30 cm.

BG: Light, pale yellowish-brown, spotted and mottled, sometimes grey, structureless, with rusty spots along the cracks and root paths.

C: Parent material showing effects of waterlogging.

Representative profiles are described below.

3. Rasht clay, level or nearly level (0-1 percent).

*Profile No. 78, located in a fallow paddy field, 15 km north of Rasht toward Pahlavi, Gilan Province.*

0-20 cm Very dark grey to dark brown (7.5 YR 3/2 -3/1 m) clay with common mottling reddish-brown (5 YR 3/3 m), very plastic, abundant roots, strong effervescence, pH 8.

20-40 cm Very dark greyish-brown (10 YR 3/2 m) fine-textured clay which is wet and very plastic and has common mottling, reddish-brown (5 YR 3/3 m) strong effervescence, pH 7.8.

40-60 cm Very dark greyish-brown (10 YR 3/2 m), very fine-textured clay, very plastic, saturated, and having abundant mottling, reddish-brown (5 YR 3/3 m), slight effervescence, pH 7.8.

60-80 cm Same as above, but *no* effervescence, pH 7.

The water table came up to 40 cm below the surface after half an hour.

*Profile No. 47, located in a paddy field, between Suledeh and Nowshahr, near the Caspian shore.*

0-15 cm Very dark greyish-brown (10 YR 3/2m) fine-textured clay, strongly blocky, hard when dry, plastic when wet, containing a lot of roots, and with abundant mottling, dark reddish-brown (5 YR 3/4 m).

15-60 cm Dark greyish-brown (10 YR 4/2 m) fine-textured clay, strong blocky structure, less roots, plastic when wet, abundant mottling, dark reddish-brown (5 YR 3/4 m).

60-80 cm Dark greyish-brown (10 YR 4/2 m) saturated sandy clay, with abundance of shells, plastic, gritty, common dark reddish-brown mottling.

100-140 cm Dark greyish-brown (10 YR 4/2 m) clay, saturated, plastic and with common mottling.

The water table was at 70 cm.

*Profile No. 79, located in a melon field near Taleabad, about 6 km east of Pahlavi and about 1.5 km south of the Caspian Sea.*

0-5 cm Dark greyish-brown (10 YR 4/2 m) loam, moderately granular, hard when dry, with white (10 YR 7/1 m) shells scattered over the surface, pH 5.5.

5-20 cm Very dark grey (10 YR 3/1 m) fine-textured loam with brown to reddish-brown mottling, sticky, common roots, pH 6.5.

20-40 cm Very dark grey to very dark greyish-brown (10 YR 3/1-3/2 m), clay plastic, saturated, no effervescence with soil, but strong when HCl gets in contact with shell material.

40-60 cm Black (10 YR 2/1 m) saturated loam with brown and reddish-brown mottling common with white shells, soil proper without shells has slight effervescence.

60-80 cm Black (10 YR 2/1 m) medium sand, saturated, with brown and reddish-brown spots due to decomposition of roots, etc.
Soil proper has.slight effervescence, pH 8.

The variation of soils described above occur in what may be called marine Alluvial or coastal marsh soils. They are shallow sediments of the Caspian Sea and are converted into land because of the recession of the sea, which leaves a more or less Anmoor-like gley soil. These soils contain the remains of mussel shells. With the lowering of the groundwater and the washing of the salts, the marsh soils become very fertile. At the same time, the chalk whose presence is due to the remains of sea shells begins to be dissolved and is washed down into the deeper soil layers. With increasing removal of the chalk there always follows a precipitation of ferrous hydroxide in the form of brown and grey mottles.

*Range in characteristics.* Frequently the A horizons are missing because of cultivation and/or sheet erosion. In autumn and winter, the surface horizon of medium texture is mixed with B horizon by plowing. Lime concretions are frequently observed at depths of about 1-2 m owing to past leaching and groundwater movement.

*Relief.* Level, nearly level, and usually slightly depressional areas.

*Drainage.* Slow to very slow internal drainage and poor natural drainage.

*Vegetation.* Usually covered with meadow grasses, sedges, and bushes. A few common species found on these soils are: in Rasht area, *Alnus glutinosa, Coix lacrymajobi, Panicum eruciforius, Pterocarya fraxinifolia, Salix alba, Samolus valerandi;* in Khoy area, *Tamarix rosa, Tamarix sowitziana.*

*Parent material.* Variable, depending on the catchment area, as the sediments are usually brought by the agency of water.

*Land use.* Mainly under paddy fields in general, some under pasture and forest. Some coastal marsh soils, large areas of which were under " Murdab " (coastal marshes) until about 20 years ago, are the center of horticultural crops such as melons and vegetables for Pahlavi and Rasht markets. (Produce is transported to Tehran).

Another variation of Low Humic-Gley soils occurs in what are called calcareous wet Alluvial soils. These soils have a high water table near the surface for part of the year. Surface runoff is low or lacking and some areas remain under water for days or weeks during floods or during the wet period. These poorly drained soils commonly occur in slightly depressed portions of wide flood plains.

*Analytical data.* See Table 17.

3.132 PSEUDO-GLEY SOILS

These are the typical soils of the paddy lands in the Gilan-Mazanderan areas of the Caspian littoral. These soils have brown mottles with black iron concretions, normally at a depth of 10 to 40 cm. The surface structure is usually fine granular. The groundwater table is usually deep, normally below 2 m but in winter and fall there is a superficial or perched water table. These Pseudo-Gley soils are actual degradations of forest soils. There is no running groundwater below the surface, but there is a stagnation of surface water, hence their hydromorphic nature.

Under this superficial waterlogging, iron moves along preferential drainage channels. Frequently two horizons can be distinguished in the top soil; the A horizon as weak grey (7.5 YR 5/1 m) with yellow mottling and round black iron concretions at the base, and B horizon, medium- to heavy-textured brown color with grey clay along old root channels.

These soils are very often the hydromorphic (groundwater) phases of the Grey Brown Podzolic soils, where the B horizon is under hydromorphic conditions. A few typical profiles are given below.

*Profile No.* $X_1$, *Pseudo-Gley soil from Rasht Plain, level or nearly level (0 to 1 percent).*

0-5 cm A — Dark brown, loam, root system very dense, crumb structure.

5-80 cm B/g — Clay to clay loam, grey with numerous ochre spots, very humid, massive with a tendency to fine subangular blocky structure, noncalcareous.

80-180 cm C/g — Clay, grey with numerous ochre spots and black ferruginous concretions. Noncalcareous.

180-250 cm G — Loam, bluish-grey, gleyed, noncalcareous.

*Profile No.* $X_2$, *Pseudo-Gley from Mazanderan, level or nearly level (0 to 1 percent).*

0-10 cm — Very dark brown (10 YR 2/2 m) silty clay, strong coarse crumbly, friable, organic matter layer with much raw humus. Very well rooted, porous, shell (snail) fragments, well drained.

10-50 cm — Grey with olive brown mottling (5 YR 5 /1m with 2.5 Y 4/4 mottling), silty clay. Medium moderate subangular blocky, slightly plastic when moist, compact layer (hard to dig) imperfectly drained, mottled, shell (snail) fragments, thick roots, merges gradually into

50-85 cm — Olive brown with grey mottling (2.5 Y 4/4 m with 5 Y 5/3 mottling), silty clay loam. Very strong, fine crumby, very friable, more aerated,

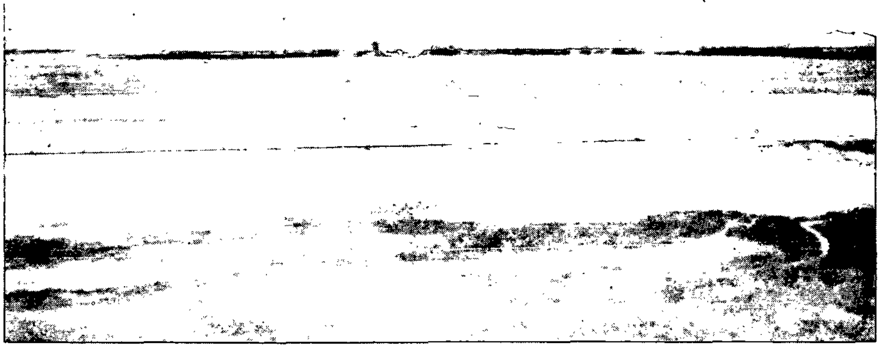
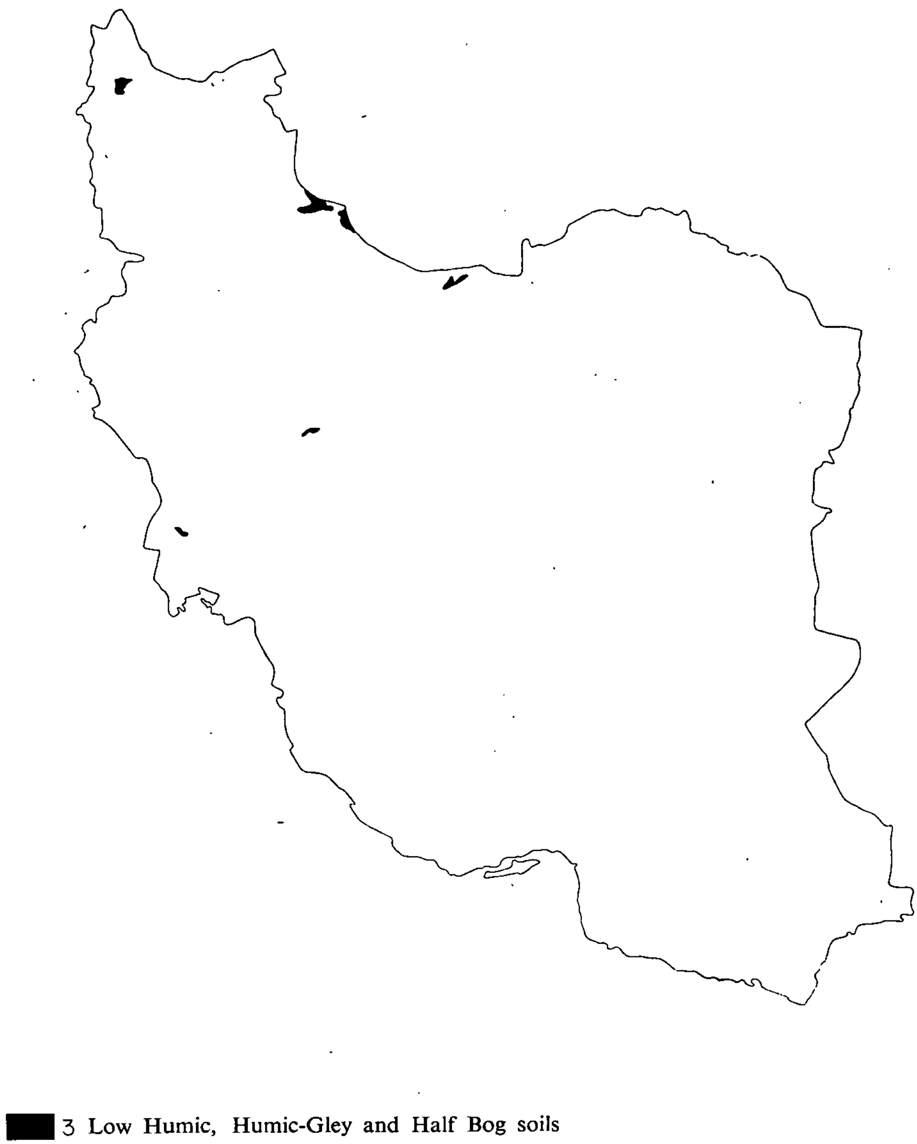


FIGURE 28*a* and *b*. Hydromorphic soils, Low-Humic Gley (3a), Doroodzan, Fars.

few roots, moderately well-drained, shells (snail) abundant, merges gradually into

85-130 cm Dark grey (5 Y 4/1m) (gley horizon) silty clay loam. Medium subangular blocky to weak coarse crumby when moist, plastic and slightly sticky when wet, when dry very hard; angular blocky. Ground water at 105 cm. Below this level more rusted and $CaCO_3$ concretions.




MAP D3. Distribution of soils in Iran.

*Profile No. $X_3$, depressional area, Pseudo-Gley soils of Mazanderan.*

| | |
|---|---|
| 0-20 cm | Dark grey-brown (2.5 Y 4/2 m) silty loam. Very plastic when wet, well rooted, staining along roots of Mn/Fe, coating of Mn/Fe on surface of clods. |
| 20-50 cm | Dark grey-brown with olive grey mottling (2.5 Y 4/2 m with 5 Y 5/2 mottling), sandy loam. Heavily rusted, well rooted. Fe and Mn concretions, groundwater at 30 cm. Transition not visible (under water). |
| 50 cm + | Olive grey (5 Y 5/2 m), sandy loam, with gley horizon. |

*Range in characteristics.* Pseudo-Gley soils are usually medium to fine-textured on the surface with textures in the B and C horizons depending on the texture of the parent alluvium deposited. B horizon usually varies in structure from slightly polyhedral to prismatic.

*Relief.* Normally low lying with very little or no slope.

*Drainage.* Internal and external drainage are slow. The water table is usually high and sometimes on or very near the surface, depending on the time of year. Permeability is usually slow to moderately slow.

*Vegetation.* Cover is variable and is partially the same as given under Humic and Low Humic-Gley soils.

*Parent material.* Variable depending on the catchment area as the sediments are usually brought by agency of water.

*Land use.* These soils are normally used for paddy which under good management give good yields.

*Distribution.* Hydromorphic soils including Low Humic and Humic-Gley soils and Half Bog soils occur mainly in humid and sub-humid areas of northern Iran. Their distribution is given in Table 18 and also on Map D3—about 356,000 ha or about 0.21 percent of the land surface of Iran.

*Analytical data.* See Table 17.

### 3.14 Halomorphic soils (Solonchak and Solonetz)

Solonchak and Solonetz soils are the saline and alkali soils of the arid, semiarid, and dry subhumid regions of Iran. They are either poorly drained, or have been developed under poor drainage conditions. Solonchak soils contain large quantities of soluble salts, are commonly light colored, are poor in organic matter, and have a lightly crusted friable granular structure. Solonetz soils are the product of the partial leaching and alkalization of Solonchak soils, such as is possible by irriga-

TABLE 17. — LABORATORY ANALYSES OF TYPICAL HYDROMORPHIC SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH | | T.N.V. % | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | $E_{Ca}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Paste | 1 : 5 | | | | | | | | |
| 78 | 0–20 | 1720 | N of Rasht | 3 (Low Humic-Gley) | 86 | .19 | 7.2 | 8.4 | 7 | 1.7 | 6.0 | 290 | 43.8 | 0.9 | .7 | |
| | 20–60 | 1721 | | | 92 | .18 | 7.0 | 8.2 | 2 | 1.5 | 5.5 | 230 | 43.4 | 1.0 | .6 | |
| | 60–80 | 1722 | | | 76 | .14 | 7.0 | 7.9 | 1 | 1.2 | 5.0 | 220 | 40.0 | 0.9 | .6 | |
| 47 | 0–15 | 1644 | Suledeh-Nowshahr | 3 (Humic-Gley) | 72 | .12 | 7.1 | 8.0 | 1 | 2.0 | 14.0 | 210 | 29.2 | | .2 | 0.5 |
| | 15–60 | 1645 | | | 63 | .06 | 7.5 | 8.4 | 2 | 0.8 | 4.5 | 130 | 20.1 | | .1 | 0.2 |
| | 60–100 | 1646 | | | 43 | .04 | 7.4 | 8.6 | 9 | 0.6 | 2.5 | 80 | 11.5 | | .1 | 0.2 |
| 79 | 0–20 | 1723 | Pahlavi | 3 (Humic-Gley) | high | .12 | 6.2 | 6.8 | — | 5.9 | 17.0 | 380 | 61.0 | | .5 | 1.0 |
| | 20–40 | 1724 | | | high | .15 | 6.2 | 7.8 | — | 6.2 | 9.0 | 340 | 52.0 | | .8 | 0.9 |
| | 60–80 | 1725 | | | 44 | .12 | 5.5 | 6.6 | — | 0.8 | 5.0 | 100 | 7.6 | | .2 | 0.3 |
| $X_1$ | 5–20 | | 5 km north of Rasht | 3 (Pseudo-Gley) | — | — | 6.1 | — | — | 8.0 | | | | | | 0.4 |
| | 80–100 | | | | — | — | 6.7 | — | — | 0.85 | | | | | | 0.4 |
| | 180–200 | | | | — | — | 6.5 | — | — | 0.68 | | | | | | |

tion, especially without proper drainage and management, and often occur as spots scattered throughout the latter. They have a surface layer of light-colored leached material over a darker colored subsoil layer of tough heavy material of columnar structure.

TABLE 18. — DISTRIBUTION OF LOW HUMIC-GLEY, HUMIC-GLEY, AND HALF BOG SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Soil association | |
|---|---|---|---|
| | | 1 000 ha | % |
| 1. Gilan | 3 800 | 236. | 6.21 |
| 2. Mazanderan | 14 000 | 40. | .29 |
| 3. Azerbajian | 10 500 | 80. | .76 |
| 4. Kurdistan | 3 122 | — | |
| 5. Kermanshah | 6 212 | — | |
| 6. Khuzistan | 13 466 | | |
| 7. Fars | 17 420 | | |
| 8. Kerman | 23 280 | | |
| 9. Khurasan | 30 900 | | |
| 10. Esfahan | 17 600 | | |
| 11. Baluchistan | 18 500 | | |
| 12. Tehran | 6 200 | | |
| Total for the country | 165 000 | 356 | .21 |

A few typical profiles of Solonchak soils, including one for the Khuzistan region in the southwest, one for the Miandoab region in Azerbaijan in the northwest, and one in the Doroodzan area in Fars are described below, giving considerable geographical distribution.

Urmia clay loam, level or nearly level (0-1 percent).

*Profile No. 602A, located near Tape Rash, Miandoab, Azerbaijan Province.*

0-1 cm White crust, light grey (10 YR 7/2 m) clay loam, slightly hard, weak thin platy, pH 6.9.

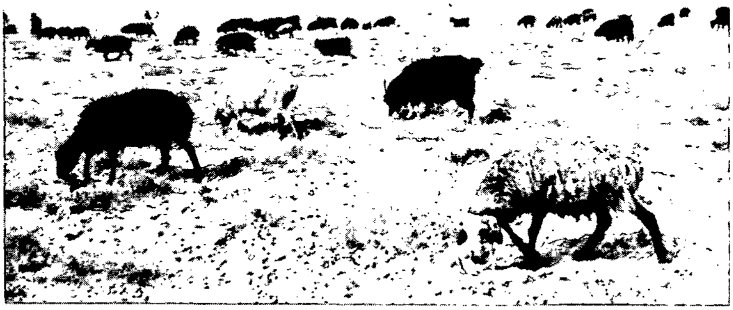


FIGURE 29. Solonchak soils used for grazing, near Lake Urmia (Rezayeh), Azerbaijan.

FIGURE 30. Digging ghanats at Chabankareh, South Fars. The dug-out material is put around the "well" and appears as a ring on the aerial photograph (see Fig. 19).

FIGURE 31. Digging to investigate the nature of deep strata, as part of drainage studies in the Ḳarkheh area, Khuzistan.

| | | |
|---|---|---|
| 1-6 | cm | Grey-brown, very dark grey-brown (10 YR 5/2 d, 3/2 m) puffy very saline clay loam, pH 6.9, weak thin platy, soft, abruptly changing into the next layer which is |
| 6-15 | cm | Grey-brown (2.5 YR 5/2 m) soft clay loam, weak very fine prismatic and with abundant gypsum, pH 7.6. |
| 15-30 | cm | Dark grey-brown (10 YR 4/2 m) friable clay, fine moderately prismatic, pH 7.5, with some gypsum grading into |
| 30-56 | cm | Brown (10 YR 4/3 m) friable, silty clay loam, abundant gypsum moderately fine prismatic, pH 7.7, grading into |
| 56-70 | cm | Brown (10 YR 4/3 m) friable silty clay loam, moderately fine prismatic structure, with abundant gypsum, pH 7.6. |
| 120-150 | cm | Brown (10 YR 4/3 m) sandy clay loam, weak prismatic, sticky when wet, common mottling, pH 7.5. |
| 150-200 | cm | Very sticky plastic clay, saturated, water table at about 150 cm. Very saline groundwater; almost all horizons very saline; roots quite common up to 70 cm depth. |

Tagly series, nearly level (0-1 percent).

*Profile No. 50, from Ramhormoz, Khuzistan.*

| | | |
|---|---|---|
| 0-2 | cm | A compact grey surface over a puffy layer. |
| 2-25 | cm | Dark grey-brown (10 YR 4/2 moist) loamy sand, structureless white patches of gypsum at 10 cm depth (gypsum sand). |
| 25-60 | cm | Yellowish-brown (10 YR 6/4-5/4 moist) sandy loam structureless, no roots, loose with white gypsum crystals. |
| 60-100 | cm | Brown (10 YR 5/3 wet) sandy clay, mixed with gypsum, mottled and with salt crystals |

*Profile No. E 21, Great Salt Desert.*

| | | |
|---|---|---|
| 0-5 | cm | White puffed layer, full of salt. |
| 5-40 | cm | Brown to dark brown (7.5 YR 4/4 m) sandy clay loam, weak blocky to platy, hard when dry, sticky when wet, no mottling, some roots, very severe salinity, no effervescence, pH about 10. |
| 40-60 | cm | Brown to dark (7.5 YR 4/4 m) sandy loam abundant in gypsum crystals, loose when dry, with no mottling, no roots, severe salinity, no effervescence, pH about 10. |
| 60-90 | cm | Brown to dark brown (7.5 YR 4/4 m) heavy sandy clay loam, massive in structure, no effervescence, severe salinity, pH about 10. |
| 90-160 | cm | Dark reddish-brown (5 YR 3/3 m) silty clay to silty clay loam, massive structure, very sticky when wet, no mottling, moderate old roots, severe salinity, strong effervescence, pH about 9. |

FIGURE 32. Poorly drained Alluvial soils in the Sumar area, Kermanshah Province, are used for rice production.

FIGURE 33. Wet paddy fields on Pseudo-Gley soils in Gilan Province

| | |
|---|---|
| 160-180 cm | Dark grey-brown (10 YR 4/2 m) sand, structureless, loose when dry, no mottling, no roots, moderate salinity, violent effervescence, pH about 8-9. |
| 180-210 cm | Dark grey-brown (10 YR 4/2 m) silty clay loam structureless, violent effervescence, pH about 8-9. |
| 210-260 cm | Dark grey-brown (10 YR 4/2 m) sandy loam, structureless, slightly hard when dry, slightly sticky when wet, no mottling, no roots, moderate salinity, violent effervescence, pH about 8-9. |

*Profile No. KK24, nearly level, Karkheh right bank, Khuzistan.*

| | |
|---|---|
| 0-20 cm | Very dark grey-brown (10 YR 3/m), high in organic matter, clay loam with a white thin crust on the surface. |

FIGURE 34. Low Humic-Gley, Humic-Gley, and Half Bog soils are found in several parts of the Caspian coastal area, especially in Murdab Anzali which is mostly the area around Pahlavi. In certain parts there is paddy cultivation and fine-textured Alluvial soils formed by alluvia brought by small and medium streams. This is the area of about 1,000 mm or more rainfall and, where there is no paddy cultivation or severe marshy conditions; forest vegetation is prevalent.

| | |
|---|---|
| 20-60 cm | Yellowish-brown (10 YR 5/4 m) sandy clay loam, saline. |
| 60-140 cm | Very pale brown (10 YR 7/4 m), some gypsum crystals present, very highly saline, prismatic structure. |

*Profile No. G 10, Great Salt Desert.*

| | |
|---|---|
| 0-2 cm | All salt crystals, puffed white layer. |
| 2-20 cm | Brown (10 YR 5/3 m) silt loam, slightly sticky when wet, no mottling, abundant roots, very severe salinity, organic matter high, strong effervescence, pH about 9-10. |
| 20-70 cm | Brown (7.5 YR 5/3 m) silty clay loam, structureless, slightly sticky when wet, moderate mottling, slight roots, severe salinity, many gypsum crystals, strong effervescence, pH about 9-10. |
| 70-120 cm | Light brownish-grey (2.5 Y 6/2 m) sandy clay loam, massive structure, sticky when wet, abundant mottling, no roots, many gypsum crystals and lime concretions, strong effervescence, pH about 8-9. |
| 120-200 cm | Dark grey-brown (2.5 Y 4/2 m) silty clay loam, massive structure, sticky when wet, abundant mottling, strong effervescence, pH about 8. |
| 200-240 cm | Dark grey-brown (2.5 Y 4/2 m) clay, massive structure, plastic when wet, abundant mottling with some old marshy vegetation roots, and abundant lime concretions, strong effervescence, pH about 8. |

240-300 cm Dark grey (5 Y 4/1 m) silty clay loam, massive structure, slightly plastic when wet, with very abundant olive-colored mottling and many old roots, big lime concretions, strong effervescence, pH about 7.5-8.

Beiza clay, nearly level and in depressional areas (0-1 percent).

*Profile No. D 5, located between Zargham and Bapuni on the way to Beiza district in Marve Dasht Plain, Fars Province.*

0-1 cm Grey-brown (2.5 Y 5/2 m) very plastic clay, with crumb structure, covered by grass.

1-10 cm Dark grey (10 YR 4/1 m) very plastic clay, with crumb structure, moderate mottling.

10-30 cm Grey-brown (2.5 Y 5/2 m) to olive grey (5 Y 5/2 m) very plastic fine-textured clay, with abundant mottling.

30-50 cm Grey (2.5 Y 5/1 m) very plastic fine-textured clay, with crumb structure and abundant mottling of light olive-brown color (2.5 Y 5/4 m).

50-70 cm Light brownish-grey (2.5 Y 6/2 m), very wet, very plastic clay.

Roots are abundant all through the profile.

Water table was reached at 70 cm, but soon rose to about 50 cm, with very saline and bitter groundwater.

Shurzar Clay, level or depressional area (0-1 percent).

*Profile No. KA1, located in Abadan Island, Khuzistan.*

0-2 cm Grey (10 YR 6/1 m) thin salty crust on the surface.

2-5 cm Light brownish-grey (10 YR 6/2 m) fine granular clay, calcareous.

5-60 cm Brown to dark brown (10 YR 5/3 d, 4/3 m) clay, with strong prismatic structure, highly salty with many identifiable individual salt crystals, calcareous.

60-120 cm Dark brown (10 YR 4/3 m) clay with prismatic structure, highly salty and gradually becoming saturated with moisture at a lower depth, calcareous.

120-150 cm Water table, salt content of water 3 percent or above.

*Range in characteristics.* The surface texture may vary from a silt loam to clay loam or clay, though usually it is clay underlain by very medium- to fine-textured material, sometimes ranging to plastic clay. There is usually a typical salt crust on the surface and a granular layer just below the surface. One or more layers are normally abundant in gypsum. Total soluble salts in most cases is over 3 percent and consisting of chlorides and sulfates of sodium, calcium, and magnesium.

All the horizons are calcareous and pH varies from 8 to 8.5. More particulars of the analytical data are given in Tables 19 and 20.

The water table is often close to the surface, fluctuating normally between 1-3 m below the surface and the water is usually very saline.

*Relief.* Solonchak soils occur in lands which are apparently quite flat, level or nearly level, and in some cases in depressional areas. These soils are seldom found on land with an obvious slope of more than 1 percent. These soils may also exist on steeper slopes when parent material is from gypsiferous and saliferous marls.

*Drainage.* Solonchak soils are characterized by very poor drainage. They have today, or in some cases had in the past, a high groundwater table, normally very salty.

*Vegetation.* The vegetation found on Solonchak soils is of a halophytic, salt-loving species such as the following:

(*a*) *Salsola*

(*b*) *Suaeda*, such as *Suaeda salsa, suaeda maritima*

(*c*) *Plantago*, such as *Plantago lagopus, Plantago albicans, Plantago coronopifoliis*

(*d*) *Atriplex*, such as *Atriplex dimorphostegia, Atriplex trifolium*

(*e*) *Halocnemum.*

In addition, other species of plants have also been observed on Solonchak and Solonetz soils: Plants related to these soils are *Calotropis procera, Cassia obovata, Lycium ruthenicum, Lycium turcomanicum, Periploca aphylla, Seidlitzia rosmarinus, Ziziphus spina-christi.*

Vast tracts of Solonchak soils, however, too salty to permit plant growth, support no vegetation of any kind.

*Parent material.* Solonchak soils are formed usually on alluvial sediments brought by water. In many cases these soils had initial uniform salting, having been part of the lake or sea at one time; and often having had high groundwater table.

*Land use.* Solonchak soils are, in general, unsuitable for agricultural use. Certain special measures may, however, be employed for their reclamation, though often at high cost, and constant vigilance is required for upkeep.

Such land is used principally, if not entirely, as range for livestock. The interesting observation has been made in Solonchak soil areas around Lake Urmia, that sheep and goats, grazed mostly on soils of less salty areas, are brought to graze on this salty vegetation about once a week. It may be that to ensure a balanced diet (micronutrients) for their sheep and goats, the local shepherds feel that some dose of the saltier vegetation is essential.

FIGURE 35. 4 Solonchaks in Ummaidieh, Khuzistan.

FIGURE 36. Wheat being grown on severely saline area, Ummaidieh.

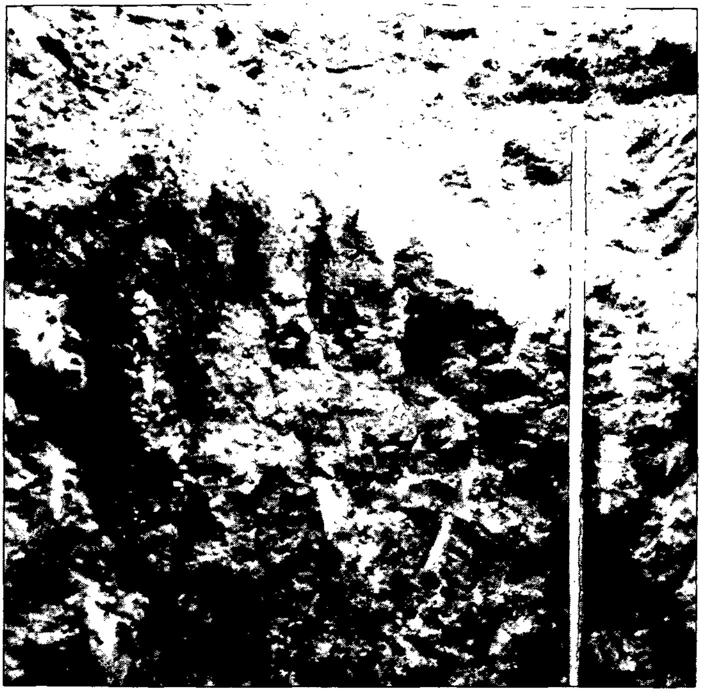


FIGURE 37. Typical columnar structure in Solonetz soils, Moghan, northwestern Iran.

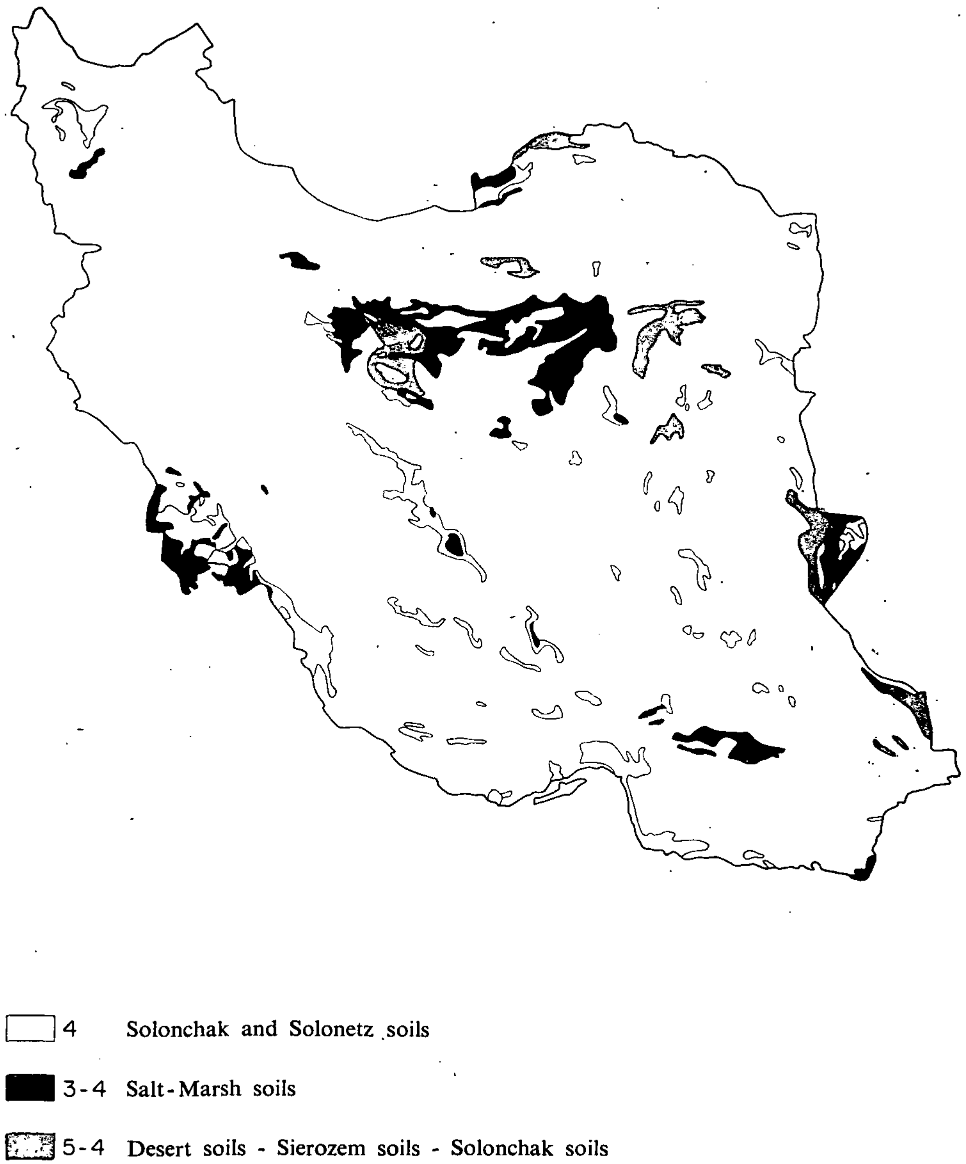
*Distribution.* Solonchak soils, called "Shurzar" in certain parts of Iran, are found in several parts of southern Khuzistan, on the shores of Lake Urmia, especially where these seem to be part of the Pleistocene extension of the lake, and also in several parts of the Doroodzan area in Fars, and in many other places in central and southern Iran as shown in Map No. D4. There are about 6 million hectares of Solonchak and Solonetz soils, as given by province in Table 21.

*Analytical data.* See Table 20.

*Solonetz or Alkali soils* which are not predominantly saline have typical strong columnar structure and high clay content in almost all the horizons, and moderate to high salt content especially in the layers below the columns. A typical profile of Solonetz soil is given by the Parsabad Series as follows.

*Profile No. M9, located in Parsabad area, Moghan, in Azerbaijan Province, northwestern Iran, on the border of the Soviet Union.*

| | | |
|---|---|---|
| 0-1 | cm | Brown (10 YR 5/3 d) clay with definite platy structure. |
| 1-3 | cm | Dark brown (10 YR 4/3 d) clay with fine granular structure. |
| 3-20 | cm | Dark grey-brown (10 YR 4/2 m) clay with granular structure changing to weak blocky structure after the first few centimeters, friable, with abundant roots and with slight salinity, pH 9.6. |




MAP D4. Distribution of soils in Iran.

| | |
|---|---|
| 20-65 cm | Dark grey-brown (10 YR 4/2 m) heavy clay, with very prominent coarse columnar structure, each column of about 30 cm × 30 cm, extremely hard, with slight roots, slight lime present and also gypsum passing down through the cracks, which are abundant; very little or no salinity in the columns, but high alkalinity, pH 9.2. |
| 65-105 cm | Dark grey-brown (10 YR 4/2 m) heavy clay, medium columnar (not elongated ones, but wide ones) and not so prominent as the above layer. Very hard still with slight roots and cracks, and moderate to severe degree of salinity and alkalinity. pH about 8.3. Some lime present, more than in the layer above but still not the zone of lime concentration. |
| 105-150 cm | Pale brown to brown (10 YR 6/3 d, 5/3 m) silty clay loam, hard with weak prismatic structure breaking to blocky, zone of lime concentration ($CaCO_3$, 14 percent) as well as that of salt (T.S.S., 1.5 percent); pH about 8.0. |

*Range in characteristics.* The usual texture of the surface layer as well as of the columnar layers is heavy clay, normally between 40-60 percent. The percentage of silt is about the same in all the layers, 25-35 percent, and there is little sand in all layers except the one below the columns which is the zone of lime concentration. Organic matter content in the first 20 cm and in the columnar layer is about the same, i.e., about 1 percent $CaCO_3$ increasing to reach a maximum in the layer below the columnar one.

FIGURE 38. Solonchak soils. In the foreground scrapings from the soils are being concentrated; they contain high amounts of sodium nitrate. Saveh area, southwest of Tehran.

*Relief.* Level, or nearly level, normally in slight depression where the possibility of water standing is more than in other areas.

*Vegetation.* Depending on the region, poor stands of *Artemisia*, very little Grammineae, and almost no Leguminosae. If also saline, some species listed under Solonchak soils are found.

*Parent material.* Same as of Solonchak soils.

*Land use.* Some wasteland, some under pasturage, and some areas under dry farming, which may give poor and patchy growths of wheat and barley. Even under irrigation farming, these soils would in due course be nonproductive enough to be abandoned, unless they had an adequate quantity of gypsum in the profile. Cost of reclamation is justified only in areas where the soils are permeable enough and the quality of water for reclamation is good and has a favorable Ca/Na ratio.

In general, if the soils have a large clay content, it is preferable to keep them under natural vegetation or dry farming, as reclamation costs may be prohibitive.

*Distribution.* Solonetz soils were not mapped separately, nor could they be separated from Solonchak soils. Map No. D4 and Table 21 give their distribution.

*Analytical data.* See Table 19.

3.15 Saline Alluvial soils

This unit (shown as 1-4 on Map A1) consists of poorly drained areas of Alluvial soils, moderately to severely affected by soil salinity.

This soil association has been mapped in various parts of Iran. Three of the typical profiles are reproduced here.

1S Mianab silty clay level or nearly level (0-1 percent).

*Profile No. 164, located near Mianab, southeast of Dezful in Khuzistan Province.*

| | |
|---|---|
| 0-20 cm | Ap horizon, dark brown (10 YR 4/3 m) silty clay, medium angular blocky, hard when dry and sticky when moist. Few rootlets. |
| 20-60 cm | Dark brown (7.5 YR 4/4 m) silty clay, coarse angular blocky, hard when dry and sticky when moist. Slight gypsum, few roots. |
| 60-100 cm | Dark brown (7.5 YR 4/4 m) silty clay, coarse angular blocky, hard when dry and sticky when moist. Medium gypsum, no roots. |
| 110-180 cm | Dark brown (7.5 YR 4/4 m) clay, massive, sticky when moist. Slight mottling, no roots. Medium gypsum. |

1S Marve Dasht clay, level or nearly level (0 - 1 percent).

*Profile No. D 10, located in Marve Dasht district of the Doroodzan Plain, Fars Province.*

| | |
|---|---|
| 0-20 cm | Brown (10 YR 5/3 m) friable, slightly sticky silty clay with crumb structure. |

TABLE 19. — LABORATORY ANALYSES OF TYPICAL SOLONETZ OR ALKALI SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | $EC \times 10^3$ | % T.S.S. | pH | | % T.N.V. | % Org. C | Av. P | Ca | Mg | $E_{Na}$ | $E_K$ | $E_{Ca}$ | Mechanical analysis % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Paste | 1:5 | | | | | | | | | Sand | Silt | Clay |
| M9 | 0– 20 | 4216 | Parsabad -Moghan | 4 | 48 | 2.30 | .10 | 7.8 | 8.6 | 11 | .61 | | .12 | .53 | — | — | .07 | 33.2 | 26.6 | 40.2 |
| | 20– 65 | 4217 | | | 62 | .99 | .05 | 8.2 | 9.2 | 6 | .48 | | — | .31 | — | — | .11 | 11.6 | 34.8 | 53.6 |
| | 65–105 | 4218 | | | 60 | 14.40 | .60 | 8.0 | 8.3 | 9 | — | | .82 | .43 | 5 | — | .60 | 11.2 | 29.8 | 59.0 |
| | 105–150 | 4219 | | | 39 | 20.60 | .50 | 7.7 | 8.0 | 10 | — | | 1.74 | .91 | 4 | — | .04 | 10.2 | 29.8 | 60.0 |

20-40 cm Brown (10 YR 5/3 m), friable, sticky clay with blocky structure.

40-80 cm Brown friable, sticky clay.

80-120 cm Brown (10 YR 5/3 m) clay with medium moderate blocky structure, hard when dry, firm when moist, very plastic when wet.

120-170 cm Brown (10 YR 5/3 m) silty clay loam to silty clay with medium moderate blocky structure, friable when moist, sticky when wet.

170-200 cm Brown clay with slight yellowish-brown (10 YR 5/6 m) mottling.

200-220 cm Brown (10 YR 5/3 m) clay with slight to moderate mottling, friable when moist, sticky when wet, blocky structure.

Jamshed clay, level or nearly level (0-1 percent).

*Profile No. 1011, located near the village of Jamshedabad, Miandoab, Azerbaijan*

0-1 cm Light grey (2.5 Y 7/2 d) to grey-brown (10 YR 5/2 m) silty clay with strong thin platy structure, moderate effervescence, pH about 8.

1-15 cm Light grey to dark grey-brown (10 YR 7/2 d-4/2 m) silty clay, strong medium blocky with some roots, very hard when dry, very firm when moist and plastic when wet, medium effervescence.

15-45 cm Light brownish-grey to brown (10 YR 6/2 d-4/3 m) clay strong medium prismatic, very hard when dry, very firm when moist and very sticky when wet; some gypsum crystals and threads are found, moderate effervescence.

45-70 cm Very dark grey-brown (10 YR 3/2 m) clay, moderate medium to coarse prismatic, firm when moist and sticky when wet, abundant gypsum and salt found in crystals and threads. The horizon is significantly darker than that above or below and appears to have been an A horizon in the past over which more recent alluvial deposits are laid; medium to strong effervescence.

70-90 cm Brown (10 YR 4/3 m) friable silty clay, medium moderate blocky, some gypsum and salt, medium effervescence.

90-130 cm Dark grey-brown (10 YR 4/2 m) silty clay, medium coarse blocky with gypsum and salt in abundance; reddish and blue mottling with grey-blue more prominent in the roots, moderate effervescence, saturated.

130-150 cm Brown (10 YR 4/3) silty clay saturated and under groundwater, very sticky, gypsum and salt abundant.
Water table at about 140 cm.
The profile shows several cracks even as great as 15-20 cm deep, 15-25 cm long, and 2-5 cm wide.

FIGURE 39. Salinity and alkalinity, of soils are a major problem in Iran as in almost any other arid/semiarid country. A great portion of Iranian territory is covered by Solonchak soils, formed because of the high evaporation and low precipitation of the desert areas. Here, especially in very level plains, and also in the closed basins into which the salt river flows, the water table is near the surface. The Kavir (salt plain) of Garmsar is a closed basin with high water table in which join many small, salty rivers. Evaporation is very high and salty and gypsiferous layers induced by the evaporation processes can very often be found in the soil profile. The area has neither agricultural nor pasture value as only a few species of halophytic vegetation, such as *Salicornia*, exist, and hydromorphic plants such as *Juncus* and reeds which grow in very low and convex areas. The photo shows typical examples of Solonchak soils (4).

TABLE 20. — LABORATORY ANALYSES OF TYPICAL SOLONCHAK SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH | | % T.N.V. | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | $E_{Ca}$ | Gypsum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Paste | 1:5 | | | | | | | | | |
| 50 | 0–20 | | Ramhormoz | | 48 | 3.0+ | 7.8 | 7.9 | 11.9 | .4 | | | 8.3 | | | | 60%+ |
| | 20–100 | | | 4 | 48 | 3.0+ | 7.8 | 7.9 | 15.0 | .3 | | | 12.0 | | | | — |
| | 100–160 | | | | 51 | 3.0+ | 8.0 | 8.1 | 26.3 | .2 | | | 10.4 | | | | — |
| 602A | 0–1 | | Near Lake Urmia | | 30 | 3.0+ | 6.9 | 8.2 | | | | | | | | | |
| | 1–6 | | | | 34 | 3.0+ | 6.9 | 8.1 | | | | | | | | | |
| | 6–15 | | | | 40 | 3.0+ | 7.6 | 8.2 | | | | | | | | | |
| | 15–30 | | | 4 | 45 | 3.0+ | 7.5 | 8.4 | | | | | | | | | |
| | 30–56 | | | | 41 | 3.0+ | 7.7 | 8.4 | | | | | | | | | |
| | 56–70 | | | | 35 | 2.8+ | 7.7 | 8.4 | | | | | | | | | |
| | 70–90 | | | | 40 | 3.0+ | 7.6 | 8.4 | | | | | | | | | |
| | 90–120 | | | | 36 | 3.0+ | 7.6 | 8.4 | | | | | | | | | |
| | 120–150 | | | | 32 | 3.0+ | 7.5 | 8.4 | | | | | | | | | |
| KK24 | 0–5 | 141 | Karkheh right bank | 4 | 54 | 6.6* | 8.5 | | | | | | 18.6 | 5.7 | 1.44 | | |
| | 5–20 | 142 | | | 48 | 43.5* | 8.3 | | | | | | 12.1 | 5.6 | 0.30 | | |
| | 100–140 | 143 | | | 40 | 5.7* | 7.7 | | | | | | 4.6 | 0.67 | 0.30 | | |
| KO11 | 0–20 | 120 | Omidieh near Aghajari | | 52 | 44.6* | 7.7 | | | | | | 13.4 | 5.92 | 0.92 | | |
| | 60–100 | 121 | | 4 | 59 | 50.5* | 8.4 | | | | | | 12.6 | 3.51 | 0.80 | | |
| | 160–200 | 122 | | | 43 | 61.6* | 8.2 | | | | | | 5.9 | 2.57 | 0.44 | | |

* Figures for EC$\times 10^8$ @ 25°C. For details of analysis see Table 49.

TABLE 21. — DISTRIBUTION OF SOLONCHAK AND SALT-MARSH SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Solonchak | | Salt-Marsh | | Total | |
|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | — | | — | | — | |
| 2. Mazanderan | 14 000 | 400 | 2.86 | 1 600 | 11.40 | 2 000 | 14.26 |
| 3. Azerbaijan | 10 500 | 360 | 3.48 | 120 | 1.14 | 480 | 4.62 |
| 4. Kurdistan | 3 122 | — | | — | | — | |
| 5. Kermanshah | 6 212 | — | | — | | — | |
| 6. Khuzistan | 13 466 | 1 000 | 7.54 | 1 260 | 9.47 | 2 260 | 17.01 |
| 7. Fars | 17 420 | 1 640 | 9.40 | 120 | .67 | 1 760 | 10.07 |
| 8. Kerman | 23 280 | 1 740 | 7.56 | 400 | 1.72 | 2 140 | 9.28 |
| 9. Khurasan | 30 900 | 800 | 2.59 | 1 600 | 5.18 | 2 400 | 7.77 |
| 10. Esfahan | 17 600 | 760 | 4.32 | 920 | 5.23 | 1 680 | 9.55 |
| 11. Baluchistan | 18 500 | 520 | 2.81 | 1 240 | 6.70 | 1 760 | 8.51 |
| 12. Tehran | 6 200 | 80 | 1.29 | 920 | 14.86 | 1 000 | 16.15 |
| Total for the country | 165 000 | 7 320 | 4.45 | 8 180 | 4.97 | 15 500 | 9.42 |

*Range in characteristics.* The surface soil normally varies from medium texture of silt, silt loam to clay loam and silty clay or clay. The subsoil usually has a layer of clay sometimes very fine. There may be slight to moderate, or even severe, salinity in some part of these saline alluvial soils.

*Relief.* The areas are all level or nearly level, and in some cases depressional.

*Drainage.* Natural drainage is imperfect to poor. Internal drainage and the permeability of the profile is slow to very slow. Groundwater table is usually at low depth (3 m or below) where soil is not irrigated, and close to the surface (1 m or so) where soil is irrigated. When the groundwater table is not saline it can be used for irrigation.

*Vegetation.* Varies with the areas of the country. However, in some parts

FIGURE 40. Moderately drained Alluvial and Saline Alluvial soils in the Doroodzan area, Fars. Sugar beets being harvested.

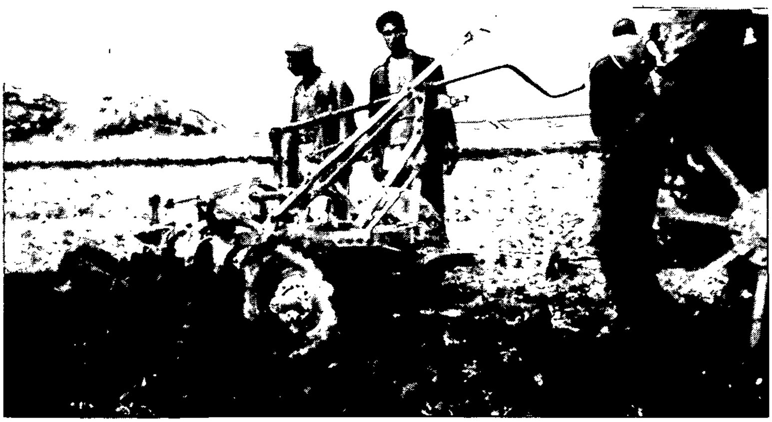


FIGURE 41. Plowing the Alluvial and Saline Alluvial soils of the Korbal district, Doroodzan, Fars.

such as Doroodzan, the following natural vegetation was observed on Saline Alluvial soils: seasonal plants such as *Ranunculus asiaticus, Plantago* sp.; perennial vegetation such as *Agropyron repens, Atriplex* spp., etc.

*Parent material.* These are alluvial sediments brought by the rivers and streams draining the area, and hence are variable depending on the local geology and lithology.

*Land use.* These soils when cropped normally produce wheat and barley. In some cases, sugar beet and cotton are also grown when adequate quantities of good to medium quality irrigation water are available. Utilization of groundwater, if not saline, even by pumping, seems to be an effective way of drainage and reclamation. In case of saline groundwater, however, artificial drainage might lower a high water table. Part of the Saline Alluvial soils may be under fallow and pasture.

*Distribution.* Saline Alluvial soils occupy about 5 million hectares or about

3.04 percent of the land surface of Iran. They are distributed throughout Iran, but especially on the plateau and in the plains and valleys such as Khuzistan, Seistan, etc. Their distribution is given in Map D1 and Table 14.

*Analytical data.* See Table 22.

TABLE 22. — LABORATORY ANALYSES OF TYPICAL SALINE ALLUVIAL SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH | | % T.N.V. | Mechanical analysis % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Paste | 1:5 | | Sand | Silt | Clay |
| 164 | 0–20 | | Mianab (Dezful) | 1–4 | 38 | .12 | | 8.2 | 73 | 35.6 | 31.6 | 32.8 |
| | 20–60 | | | | 46 | .11 | | 8.6 | 40 | 23.4 | 37.6 | 39.0 |
| | 60–110 | | | | 54 | .28 | | 8.9 | 41 | 23.8 | 38. | 38.2 |
| | 110–180 | | | | 75 | .70 | | 8.7 | 36 | 5.6 | 35.8 | 58.6 |
| 1011 | 0–1 | 1928 | Zarrineh Rud area | 1–4 | 66 | .15 | 9.5 | 8.1 | | | | |
| | 1–15 | 1929 | | | 77 | .21 | 9.5 | 8.1 | | | | |
| | 15–45 | 1930 | | | 81 | .59 | 9.2 | 8.1 | | | | |
| | 45–70 | 1931 | | | 74 | 1.25 | 8.8 | 7.8 | | | | |
| | 70–90 | 1932 | | | 65 | 1.90 | 8.7 | 7.9 | | | | |
| | 90–130 | 1933 | | | 69 | 2.75 | 8.9 | 7.9 | | | | |
| | 130–150 | 1934 | | | 50 | 2.60 | 8.8 | 7.8 | | | | |

## 3.16 SALT-MARSH SOILS

These soils (shown as 3-4 on Map B1) are usually wet for all or most of the year. They occur in more or less seasonal types of marshes in the glens of the valleys and in great parts of Dasht-i-Kavir, and also include the low lying areas which are annually flooded by rivers from these salt-marsh soils. Soil association of salty or marshy or salt-marsh is included. These soils combine the characteristics of salty soils such as Solonchak and the marshy soils. Salinity (and alkalinity) as well as gleying or gleization are the main processes of soil development and mottling their most characteristic feature.

Two typical profiles are described.

FIGURE 42. Saline Alluvial soils (1-4) occupy large parts of Iran and have been used to grow crops of low to medium yields. Wheat or barley is rotated with fallow. The area often becomes more salinized and needs to be leached during the first irrigation. Note that the fields are long and narrow. The photo shows the Seistan area (1:12,500 scale) where irrigation can be practiced because of the dams recently built by the government (note the canal layout).

3-4 Gramsar silty clay loam, level or nearly level (0-1 percent).

*Profile No C.17, located in Garmsar area of Dasht-i-Kavir.*

0-20 cm Very dark grey-brown (10 YR 3/2 m) heavy silty clay loam, with friable consistence and granular structure, high in organic matter, abundant mottling, abundant roots, and severe salinity.

20-60 cm Very dark grey to very dark grey-brown (10 YR 3/1.5 m) clay loam, massive structure, sticky when wet, abundant mottling, and high in roots, medium salinity.

60-100 cm Dark olive-grey (5 Y 3/2 m) clay, massive structure, very sticky when wet, abundant mottling, and some roots, medium salinity.

FIGURE 43. In the level alluvial plains of the arid and semiarid regions of Iran the salinity problem arises if the water table is high. Evaporation is much more active than precipitation and causes the salt accumulation on surface soil. In Khuzistan (*above*) the land is smooth and the gradient is about 0.5 to 1 percent. Soil texture is very fine and capillary movement very high. Cultivation areas are located only near the river, where the natural drainage is usually better than in the other parts. Here are shown the Saline Alluvial soils (1-4) so widely found in several parts of the country.

100-200 cm Dark grey-brown (2.5 Y 4/2 m) heavy clay, plastic when wet. abundant mottling, some roots, medium salinity.

200-300 cm Dark olive-grey (5 Y 3/2 m) clay, plastic when wet, abundant mottling, some roots, medium salinity.

Shadgan clay, level or nearly level (0-1 percent).

FIGURE 44. Salt-Marsh soils in Shadgan, Khuzistan. Typical marshy vegetation, *Juncus*

TABLE 23. — LABORATORY ANALYSES OF TYPICAL SALT-MARSH SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | $E.C.x10^3$ | pH Paste | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C17 | 0–20 | | | | 49 | .90 | | | | | |
| | 20–60 | | | | 56 | .38 | | | | | |
| | 60–100 | | Garmsar | 3–4 | 42 | .52 | | | | | |
| | 100–200 | | | | 43 | .36 | | | | | |
| | 200–300 | | | | 46 | .32 | | | | | |
| KS16 | 0–5 | 130 | Shadgan | 3–4 | 50 | | 26.9 | 7.5 | 12.8 | 2.16 | 0.95 |
| | 5–20 | 131 | | | 53 | | 15.0 | 7.5 | 13.7 | 1.83 | 1.21 |
| | 100–140 | 132 | | | 61 | | 11.4 | 7.2 | 11.2 | 1.53 | 0.77 |

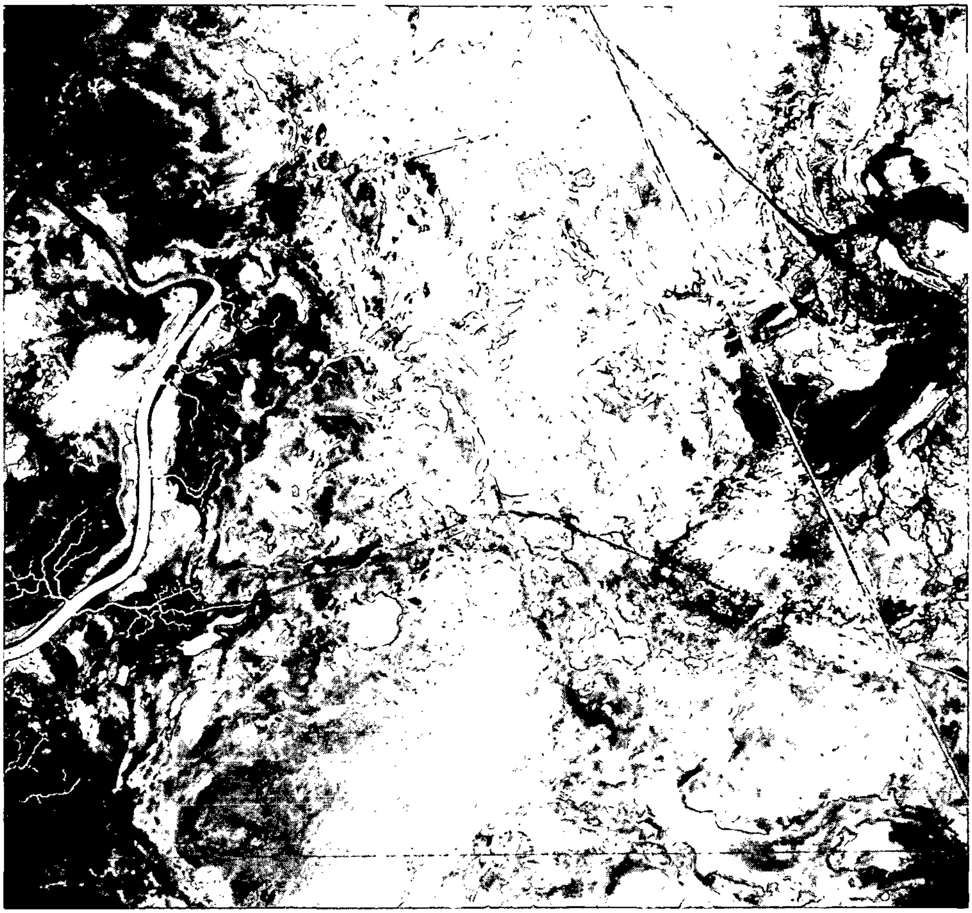


FIGURE 45. Lack of natural drainage, high evaporation, and tidal effects are the main factors of Salt-Marsh formation in Iran. This group of soils occurs in closed basins of central and southern Iran, as well as on the shore of the Persian Gulf, the Oman Sea in the south, and Lake Urmia (Rezayeh) and the Caspian Sea in the north. They are seldom used for grazing, because of very poor vegetation. The photographs (above and on page 127) indicate Salt-Marsh areas (3-4) in Abadan Island near the Persian Gulf.

*Profile No. KS 16, located in Shadgan area, Khuzistan Province.*

| | |
|---|---|
| 0-10 cm | Grey brown (10 YR 5/2 d) or dark grey (10 YR 4/1 m) moist clay, calcareous. |
| 10-50 cm | Dark grey (10 YR 4/1 m) mottled clay, with considerable blue streaks, calcareous. |
| 50 cm + | Water table appears. |

*Range in characteristics.* Water may be on the surface, or as much as 50 cm

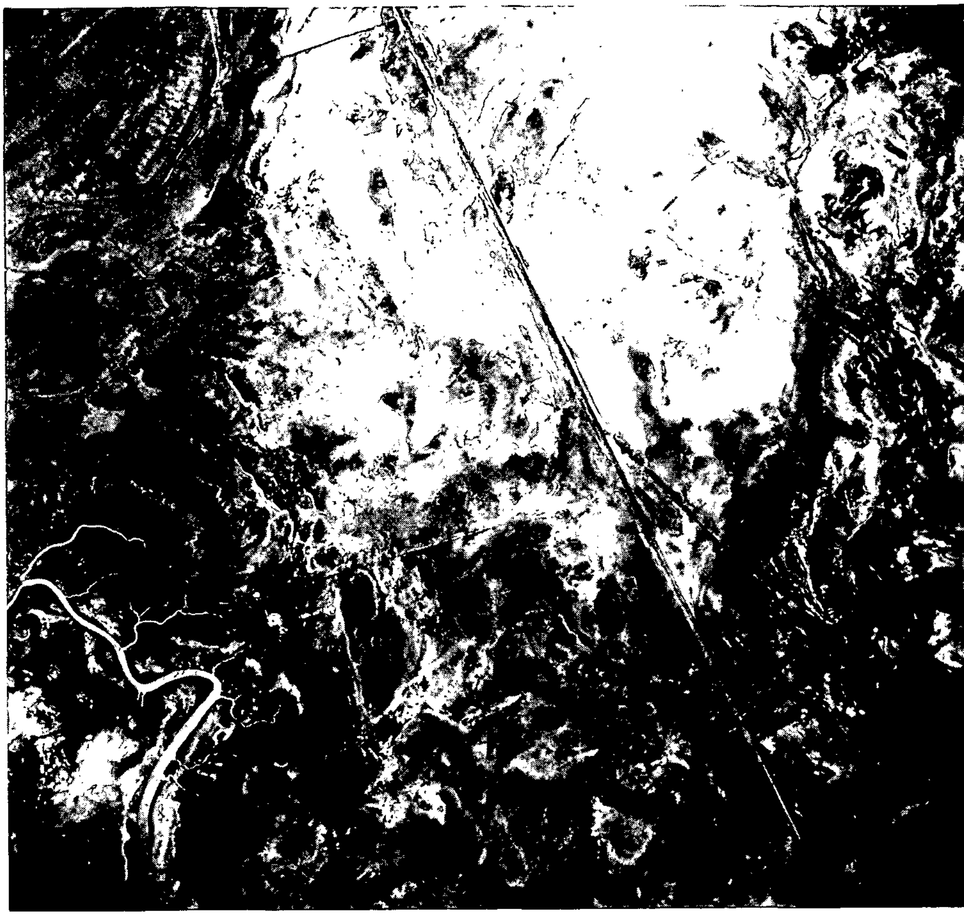


FIGURE 45 A. Salt-Marsh area in Abadan Island.

below the surface in such soils, depending on what time of the year the profile is dug and samples taken. Color of the surface soil would also vary accordingly from grey brown to dark grey, depending on the moisture status of the soil. Normally, clay is found throughout the profile, but a layer of clay loam may be observed in between clay layers. Mottling is observed all through the profile.

*Relief.* These soils occupy low lying or level areas, which usually are floors of valleys.

*Drainage.* Very poor.

*Vegetation.* The natural vegetation is sedges, reeds, and grasses. Some of the plants which are commonly found to occur on these soils are: in the Gorgan area,

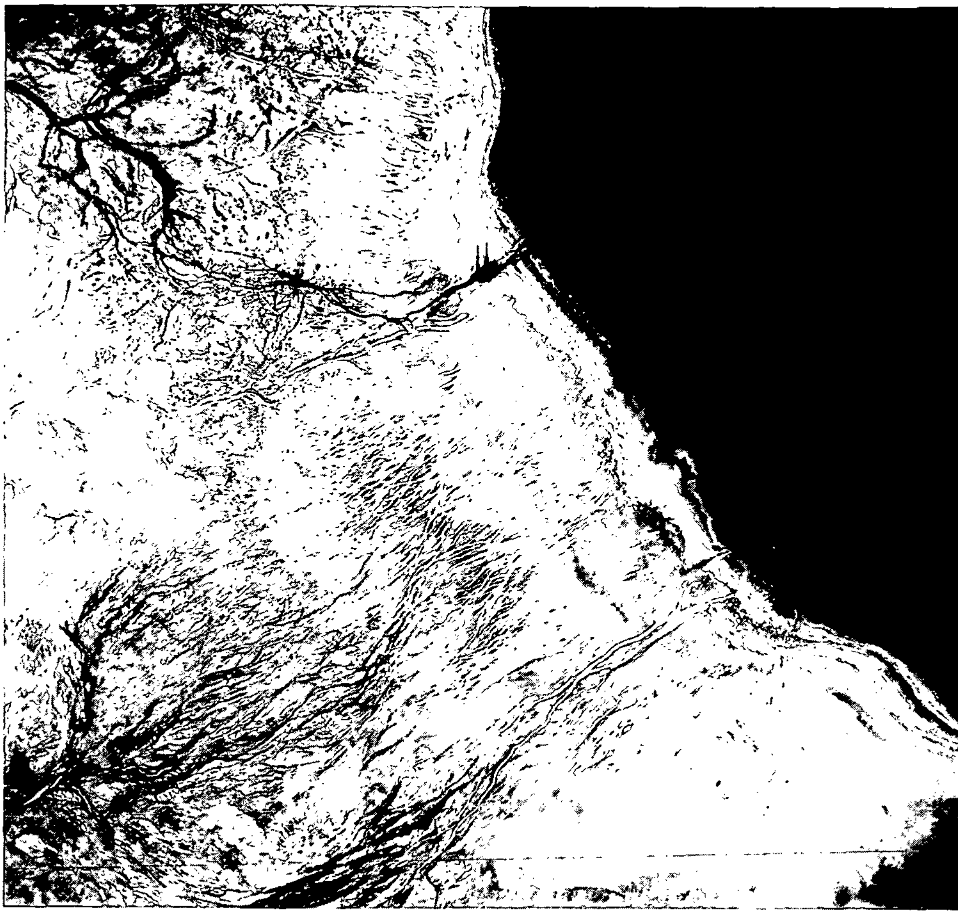


FIGURE 46. A Salt-Marsh area near Lake Urmia (Rezayeh). Note the erosion close to the lake shore. Salinity is residual and there is a high water table in the areas which are not submerged under the severely saline waters (salinity as high as 17 percent) of the lake.

*Typha angustifolia, Phragmites, Tamarix, Carex, Myricaria germanica*;on the shores of Gulf of Oman, *Avicennia officinalis, Rhizophora mucronata;* in other parts of Iran, *Typha angustifolia, Phragmites, Sphenopus, Glyceria, Carex, Lusula, Acirpus, Salicornia,* and *Juncus.*

*Parent material.* Variable, depending on the geology and lithology of the catchment from whence the sediment is carried.

*Land use.* Normally marshy and wastelands. In some cases, the natural vegetation of reeds and sedges is used by the local population as building material for the roofs of houses and for certain reed products. Parts of these areas are suitable for rice production of poor to moderate varieties.

*Analytical data.* See Table 23.

### 3.2 Soils of the plateau

A great part of Iran is a plateau of about 1,000 meters or more above mean sea level. As indicated earlier, the arid or semiarid climate is prevalent over a great portion of this plateau. In general, the soils of the plateau include the following associations:

Desert soils—both Grey and Red Desert soils
Sierozem soils
Brown soils
Chestnut soils
Desert soils—Regosols
Desert soils—Sand Dunes
Desert soils—Sierozem soils—Solonchak soils
Sierozem soils—Regosols
Brown soils—Lithosols

#### 3.21 Desert and Red Desert soils

Desert soils are formed through severe moisture deficiency. One of the differentiating characteristics or common occurrences in these soils is a thin surface crust of slightly cemented to severely compacted materials, usually referred to as the desert pavement. Horizon differentiation is barely visible in some cases, and in most instances is nonexistent. Small accumulations of organic matter may occur. The soil is calcareous throughout and usually has a calcium carbonate zone close to the surface. The soil reaction is always alkaline with numerous instances indicating an accumulation of soluble salts in the profile, presumably a result of upward capillary movement of moisture. Desert soils usually have small angular gravel on the surface called desert pavement.

There should be some differentiation made between desert crust and desert pavement. Desert crust is defined as a thin crust occurring rather frequently on desert soils, and is the protective crust which appears as a film, hardly more than 1 mm in thickness, rather dark brown in color. It also forms a somewhat shiny coating on the rocks and gravels exposed to the influence of sunshine and desert heat. It consists largely of oxides of iron and manganese, though a slight amount of organic matter is sometimes present.

Desert pavement, on the other hand, consists of a layer of gravel and small stones, lying practically bare and kept bare of fine material by the wind. The gravels of the pavement are embedded in a grey, almost white, fine-grained material which is usually extremely porous or vesicular. (See Table 24.)

The nature of desert pavement in certain parts of the Near East and some parts of Iran has been studied by Dapples (Ref. 14). According to him the superficial sediments from Syria, Jordan, and western Iran may be classified into residual deposits transported by running water and wind, evaporite deposits, playa lake deposits, and aeolian deposits. Residual deposits are dominant and stream deposits are absent. Except for the aeolian deposits, the sediments are a coarse material of granule and pebble size consisting of fresh rock; but debris of sand grain size and smaller usually consists of clay minerals and quartz. Such fine-grained residuum has been cemented by calcite into aggregates. The aggregates disintegrate in water or when moved by the wind; this suggests that the present desert surface generally is stable. The presence of a film of calcite coating all grains and rock fragments suggests that chemical disintegration of rocks is not at present an active process over large parts of the desert surface. The large quantities of fine-grained material representing the decomposed residues appear to have been developed during a period of greater humidity than the present one.

Two typical profiles of Desert-Red Desert soils are described below; they are nearly level (0-1 percent).

5: Desert and Red Desert soil, nearly level (0-1 percent).

*Profile No. 3 between Isfahan and Nain 20 km east of Nain-Yazd road.*

| | |
|---|---|
| 0- 1 cm | Desert pavement all limestone, some ferruginous, some calcitic, rather well rounded. |
| 1- 5 cm | Pinkish-grey (75 YR 6/2 d, m) clay loam, very porous platy structure. |
| 5-20 cm | Reddish-brown (5 YR 4/3 m) sandy loam, blocky structure. |
| 20 cm + | Coarse to medium angular gravel. |

5: Desert and Red Desert soil nearly level (0-1 percent).

*Profile No. 29, between Sefid Aveh and Birjand, 36 km from Sefid Aveh.*

| | |
|---|---|
| 0- 1 cm | Desert pavement of angular limestone, and siliceous limestone and shales. |
| 1- 5 cm | Pinkish-grey (5 YR 6/2 m) loamy sand. |
| 5-10 cm | Loamy sand to sandy loam. |
| 10 cm + | Coarse to medium angular gravel. |

*Range in characteristics.* Desert soils may have coarse to medium surface texture with coarse to heavy subsurface. Depth may vary from a few centimeters to a meter or more. Normally the desert pavement is 1-2 cm thick but may be thicker.

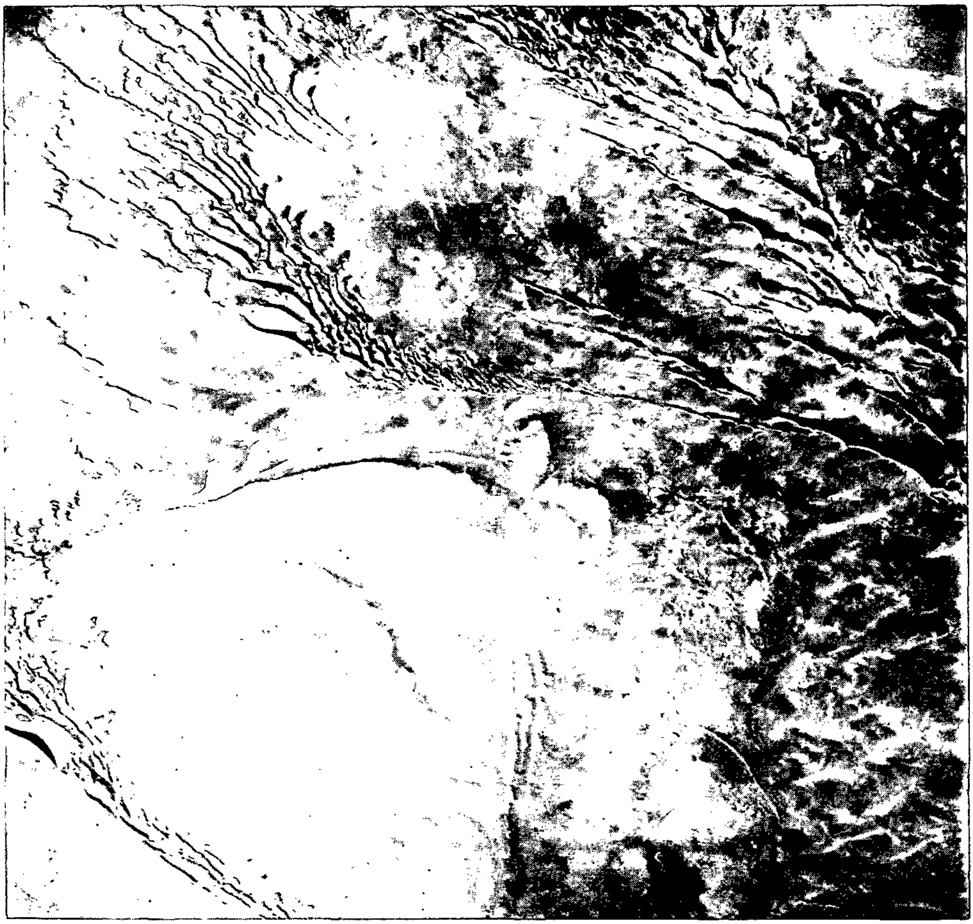


FIGURE 47. From a desertic area between Zahedan and Bam, in the southeast central part of the country, a large portion of which is mapped as Grey and Red Desert soils area (5). Precipitation is negligible, with little or no vegetation. The climate is very cold in winter and very hot in summer. Much soil erosion results from wind action. There is no cultivation or, when a small source of water is available, very limited cultivation.

*Relief.* Normally level, or nearly level, or undulating slopes up to 3-5 percent.

*Drainage.* Normally well drained.

*Vegetation.* Typical Desert soils do not contain any humus. Only a relatively small number of specifically adapted species of plants survive in the deserts of Iran; they do not form a sod, and they produce a comparatively small amount of green matter. Desert vegetation is composed of the short-lived spring annuals as well

TABLE 24. — SAMPLES OF DESERT PAVEMENT[1]

| Profile no. | Sample no. | Locality | Type of deposit |
|---|---|---|---|
| 2 | 1455 | 31 km from Esfahan (88 km from Nain on road to Isfahan) | Grey and greenish volcanic rocks, intermediary porphyrites and andesites, fairly angular |
| 3 | 1578 | 20 km east of Nain on Nain-Yazd road | All limestone, some ferruginous, some calcitic. rather well rounded |
| 6 | 1467 | 70 km from Yazd, between Kerman-Anar in the desert | Mostly calcareous, limestone, angular with solution pattern |
| 10 | 1478 | Jasr Naderi, between Kerman-Anar in the desert | Granite and diorite and acid igneous rock, porphyrites, transported by river, rounded |
| 11 | 1481 | Post Kausak, in the middle of Shurgaz, between Bam and Zahedan | Siliceous limestone quartz and limestone with some metamorphic and igneous, all angular |
| 12 | 1484 | 55 km before Zahedan between Nusratabad and Zahedan | Angular quartzite, some diorite igneous fragments and chert, some volcanic rocks and schists |
| 12b | 1488 | Between Zahedan and Lutak on way to Zabol | Angular quartz fragments, chlorite schists and carbonate schists, limestone and some chert |
| 13 | 1491 | In the Seistan area, near Lutek, Zabol area | Quartz, chert with carbonate and some dark radiolarite, somewhat rounded |
| 13 | 1473 | In the Seistan area, near Lutek, Zabol area | Angular limestone, dolomites and calcareous sandstones |
| 28 | 1541 | In the Seistan area, near Lutek, Zabol area | Mainly limestone (angular solution pattern) strongly ferruginous porphyrite and oxolitic limestone |
| 29 | 1546 | Between Sefid Aveh-Birjand, 36 km from Sefid Aveh | Angular limestone and siliceous limestone and shales |
| 31 | 1553 | Near Gonabad, close to Mashhad | Slightly rounded volcanic rocks, siliceous shales and quartz |
| 35 | 1570 | 20 km west of Abbasabad, between Abbasabad and Shahabȃd. On road from Mashhad to Tehran, at 3,700 ft above mean sea level | Limestone, siliceous green cherts, sandstone partly tufaceous and angular, also volcanics, prophyrite and plagioclase phenocrysts |
| 36 | 1574 | Near the crossroad of Gorgan-Mashhad-Tehran Road at 4,100 ft elevation | Limestone, dolomite and ferruginous, partly siliceous, subrounded |

TABLE 24. (*Concluded*)

| Profile no. | Sample no. | Locality | Type of deposit |
|---|---|---|---|
| 127 | 1805 | East of Tehran | Young volcanic ash layers of igneous and volcanics (mostly porphyrites) |
| 130 | 1814 | East of Tehran | Red siliceous shales and grey cherts, most pebbles coated with calcite, no varnish, subrounded |
| 35 | | Desert floor 80 miles northwest of Esfahan | Residual limestone |
| 36 | | Salt marsh near Qom southwest of Tehran | Playa lake |
| 37 | | Salt marsh near Qom | Residual crystalline |
| 44 | | Desert floor near Qom 80 miles southwest of Tehran | Residual limestone water transported |
| 45 | | Desert floor near Sivand, southwest Iran | Residual limestone |
| 49 | | Desert floor at Dehbid, south Iran | Residual limestone |
| 50 | | Salt marsh near Qom, southwest of Tehran | Residual crystalline water transported |
| 70 | | Salt marsh near Qom, southwest of Tehran | Evaporite |

[1] First 15 samples were collected and identified by the author and M. Vakilian; 8 samples were collected and identified by Dr. Henry Field. Acknowledgment is also made to Dr. Huber of the National Iranian Oil Company for assistance in identifying the samples.

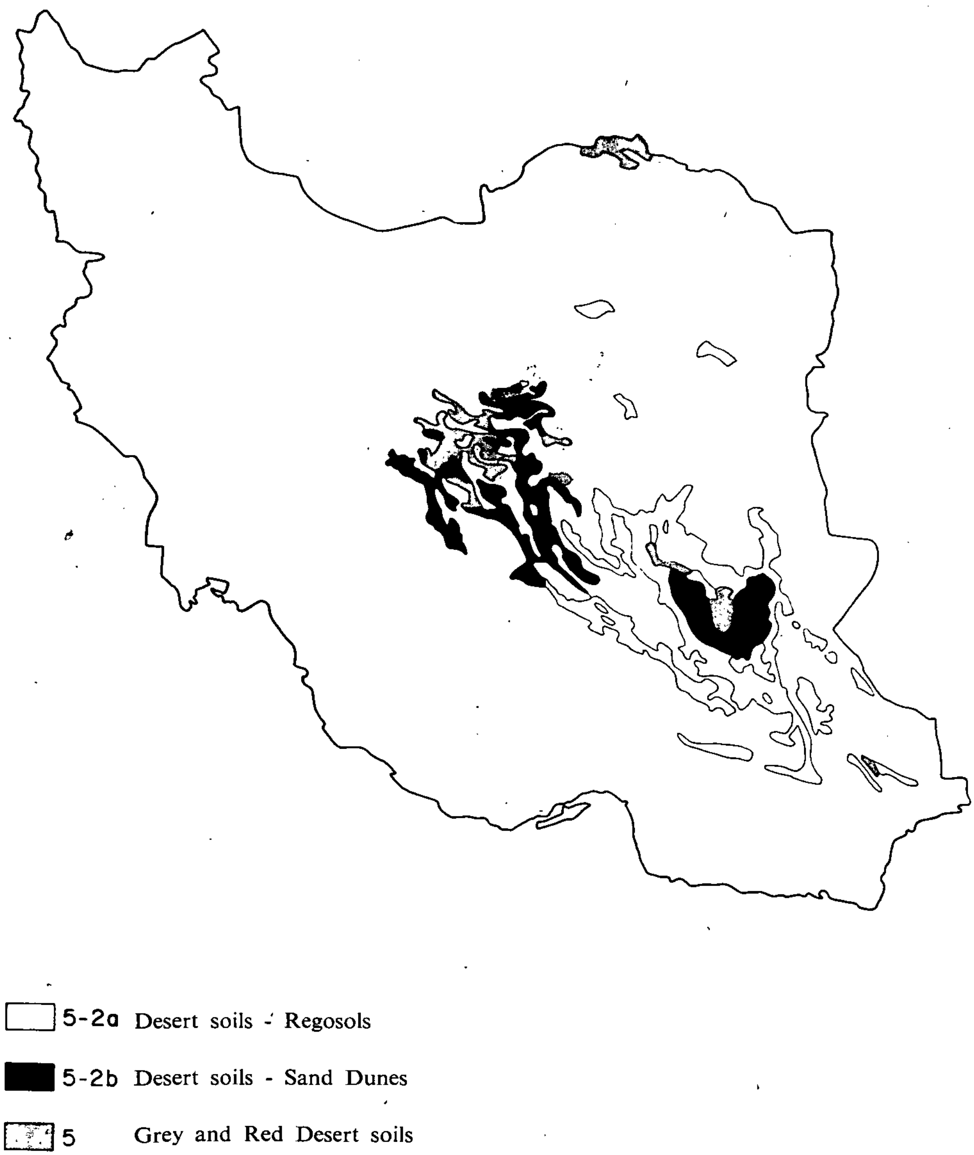
as a group of perennial plants, the latter represented mainly by desert shrubbery, *Alhagi camelorum* (the camelthorn).

*Parent material.* The parent materials of Desert soil in Iran vary considerably. They are formed on a strata of unconsolidated drifts and various other loose deposits, as well as in the region of shallow soils underlain by solid rocks, which may be sedimentary, metamorphic, or igneous.

*Land use.* Desert soils are unable to produce satisfactorily under dry farming, and in their natural condition have a low potentiality for forage. However, they can be made highly productive with irrigation. There are large areas of Desert soils under ghanat irrigation and they can be highly productive if the quality of irrigation

Table 25 — Laboratory analyses of typical desertic soils

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH Paste | pH 1:5 | % T.N.V. | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | $E_{Ca}$ | $S_{Na}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1–5 | 1459 | Nain Yazd | 5 | 22 | .12 | 8.0 | | 23 | .2 | 7.0 | 320 | 7.5 | 1.5 | .7 | | 1.0 |
| | 5–20 | 1460 | | | 25 | .04 | 9.0 | | 22 | .2 | 5.5 | 240 | 6.6 | 1.1 | .5 | | .5 |
| 29 | 1–5 | 1547 | Sefid Aveh - Mashhad | | 23 | .14 | 7.8 | | 16 | .2 | 6.0 | 340 | 10.9 | .8 | .8 | | .8 |
| | 5–10 | 1548 | | 5 | 25 | .04 | 7.8 | | 16 | .1 | 4.5 | 270 | 11.1 | .4 | .7 | | |
| 10 | 1–5 | 1479 | Bam-Zahedan (Jasr Naderi) | 5–2a | 28 | .03 | 8.7 | | 9 | .01 | 3.0 | 200 | 3.6 | 1.3 | .5 | 0.5 | |
| | 5–20 | 1480 | | | 22 | .14 | 7.8 | | 9 | .02 | 2.5 | 660 | 8.4 | 4.5 | 1.5 | 1.3 | |
| 11 | 1–10 | 1482 | Bam-Zahedan | 5–4 | 22 | 3.0+ | 7.8 | | 10 | .2 | 16.0 | 400 | 11.1 | — | .8 | 31.0 | |
| | 10–20 | 1483 | (Shurgaz) | | 22 | 1.60 | 7.8 | | 8 | .01 | 5.0 | 170 | 7.0 | 8.2 | .3 | 14.0 | |
| 13 | 1–5 | 1492 | Seistan Lutak | 5–4 | 20 | 3.0+ | 8.1 | 9.2 | 15 | .5 | 6.5 | 260 | | 4.5 | — | | .4 |
| | 5–18 | 1493 | | | 25 | 3.0+ | 8.1 | 9.0 | 19 | .3 | 5.0 | 300 | | 5.9 | — | | .6 |




MAP D5. Distribution of soils in Iran.

water is suitable. Since there is essentially no leaching, the soils do not lose their chemical elements, and thus are well supplied with plant nutrients. The exception, of course, is the severe lack of nitrogen resulting from sparse vegetation.

*Distribution.* Large areas of Desert and Red Desert soils occur in Iran. Roughly, the total area covered is 9 million hectares, distributed as shown in Table 30 and in Map D5.

*Analytical data.* See Table 25.

### 3.22 Sierozem soils

Sierozem is the light grey-colored, very humus-deficient, but extremely calcareous AC soil with very little leaching, shallow humus horizon, with sparse, open xerophytic plant cover and scanty soil life, which occurs primarily as climax formation in the desert steppe.

Common to all varieties of Sierozem is a shallow humus horizon of 5 to 10 cm depth, contrasting little with the subsoil, followed by a usually compacted Ca horizon which gradually passes into the generally looser C horizon. On the surface, a lighter-colored bright grey $A_1$ horizon is seen which is either powdery or dusty or in many loamy forms has a dense, partly leafy structure. Its formation occurs from a large supply of wind-borne calcareous sediments which either remain loose, or become puddled by rain water. Under the $A_1$ horizon is usually seen a somewhat darker and rich humus, the slightly brownish-colored $A_2$ horizon, followed by a light grey A/Ca horizon. On highly calcareous parent material the Ca horizon often differs very little from the C horizon. With stronger colorization by soil animals, the humus and lime-enriched horizons have more or less distinctly spongy structure.

Zhakorov's description of a typical Sierozem profile (Ref. 40) follows.

| | |
|---|---|
| 0-10 cm | Characteristic straw-colored grey with various shades of yellow, brown, red, pink; scaly, laminated structure, fairly open constitution. |
| 10-30 cm | A transition horizon, lighter in color than $A_1$, at times having a brown shade, of a spongy constitution, honeycombed with tracks of burrowing animals. |
| 30-80 cm | Illuviate, lighter in color, usually straw-colored, at times grey because of the numerous lime veins, more compact with a fine porosity. White spots known as white eye spots are frequently encountered. |
| 80 cm | The parent material, at the surface of which sulfates and chlorides are frequently found alongside the lime carbonate. |

Sierozem soils occur extensively in arid and semiarid parts of Iran. A few typical profiles are described in this section.

6AB: Sierozem on nearly level or gently sloping area (1-3 percent).

*Profile No. 2, 31 km from Esfahan-Nain Road, 88 km from Nain.*

| | | |
|---|---|---|
| 0-1 | cm | Desert pavement. Grey and greenish, volcanic rocks, intermediary porphyrites and andesites, fairly angular. |
| 1-5 | cm | Light brownish-grey (10 YR 6/2 m) coarse sandy loam to loamy sand, loose. |
| 5-40 | cm | Brown (10 YR 4/3 moist) loamy coarse sand with abundant angular gravels. |
| 40-100 | cm | Brown (10 YR 4/3-5/3 m) loamy coarse sand with abundant gypsum crystal and some angular gravel. |

6A: Sierozem soil on level or nearly level area (0-1 percent).

*Profile No. 31, west of Gonabad, in eastern Iran.*

| | | |
|---|---|---|
| 0-1 | cm | Desert pavement, slightly grounded volcanics, siliceous shales and quartz, gravel on the surface. |
| 1-20 | cm | Brown (10 YR 4/3 m) fine gravelly silt loam, friable, weak blocky structure. |
| 20-35 | cm | Brown (10 YR 4/3 m) fine gravelly loam, friable consistence, weak to medium blocky structure. |
| 35-60 | cm | Gravelly loamy sand to coarse loam, friable to loose. |
| 60-80 | cm | Brown gravelly sand, loose, very weak blocky. |

*Range in characteristics.* In several areas, Sierozem soils occurring in association with Desert soils form an intricate pattern with them. They vary from deep to shallow, and coarse- to fine-textured soils. Lime accumulation is normally close to the surface, though the whole profile is calcareous and pH varies around 8. The organic matter usually does not accumulate and is almost always below 0.5 percent. Sierozem soils are saturated with bases and the total cation exchange capacity is usually low; some analytical data is reproduced (Table 27).

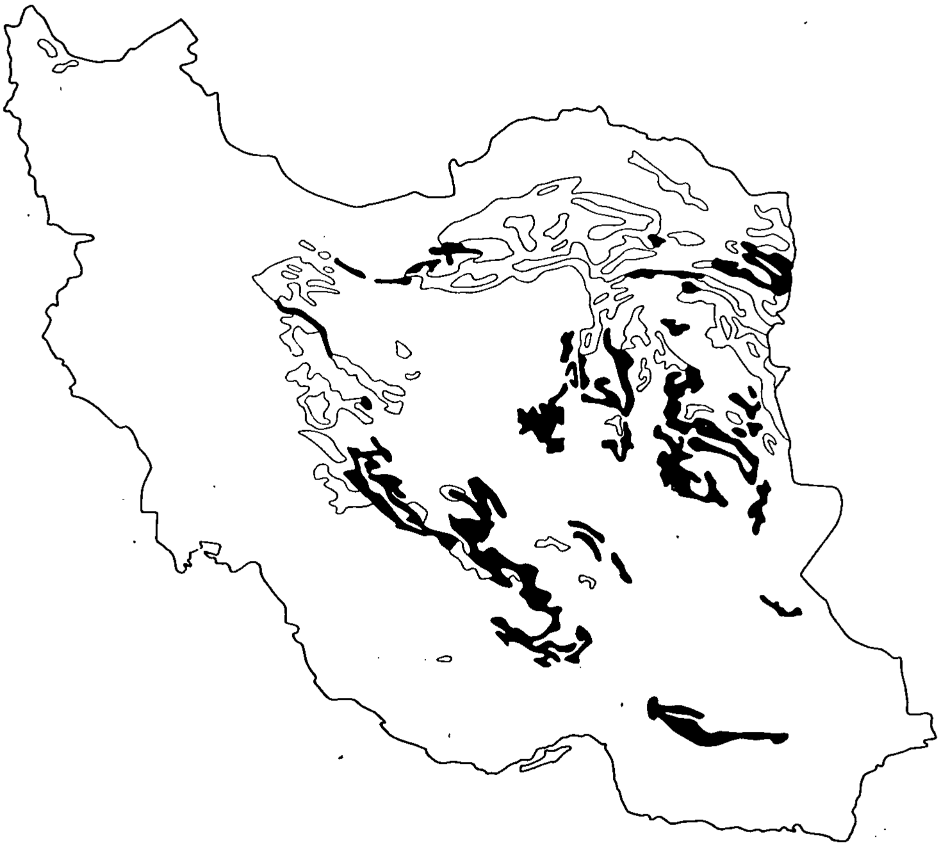
*Relief.* Sierozem soils occur on very level or nearly level to all kinds of steep and rough slopes. Those mapped in Iran (excluding soils of dissected slopes and mountains in association with Sierozem soils) are nearly level to moderately sloping.

*Drainage.* Slow from the surface, moderate internally; substratum permanently dry.

*Vegetation.* Thin grass and desert-type shrub cover; much of the surface bare of vegetation. *Alhagi camelorum* is the predominant vegetation. Obviously a

FIGURE 48. Sierozem soils are located in dry regions where rainfall is low and insufficient for crop production unless there is a natural source of water for irrigation, such as groundwater. Some small patches of agricultural fields can be seen very close to the stream, which passes in the middle of an area in central Iran.

small number of specifically adopted species of plants survive in the Sierozem soils. The vegetation consists both of short-lived spring annuals and a group of perennials, including *Artemisia* plants which are found on higher elevations. Other specific vegetation of these soils is *Andrachne fruticulosa, Echinops sp., Hulthemia persica, Prosopis stephaniana, Reseda, Bungei, Zelikoferia sp.*



6 Sierozem soils

6-2 Sierozem soils - Regosols (with inclusions of Sand Dunes)

MAP D6. Distribution of soils in Iran.

*Parent material.* All kinds, including sedimentary, metamorphic, or igneous, also old alluvial material, sand and regosolic material, etc.

*Land use.* The agricultural value of these soils depends upon the availability of suitable water for irrigation. Excellent yields of a variety of crops can be expected with an application of water, provided that the profile has sufficient depth, that texture is not too coarse, that topography is favorable, and that there is not more than a slight accumulation of salts in the subsoil. With irrigation, application of nitrogen and phosphorus is usually needed for optimum yields. In their natural condition, the potentiality of the Sierozem soils is fair for range, and gives low to very low returns (frequent failures) in dry-farming systems for barley and wheat.

TABLE 26. — DISTRIBUTION OF SIEROZEM AND SIEROZEM-REGOSOL SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area 1 000 ha | Sierozem 6 | | Sierozem-Regosol 6-2 | | Total | |
|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | — | — | | | — | — |
| 2. Mazanderan | 14 000 | 3 000 | 21.40 | 260 | 1.86 | 3 260 | 23.26 |
| 3. Azerbaijan | 10 500 | 160 | 1.52 | — | | 160 | 1.52 |
| 4. Kurdistan | 3 122 | — | | — | | — | — |
| 5. Kermanshah | 6 212 | — | | — | | — | — |
| 6. Khuzistan | 13 466 | 80 | .59 | — | | 80 | .59 |
| 7. Fars | 17 420 | 320 | 1.80 | 640 | 3.65 | 960 | 5.45 |
| 8. Kerman | 23 280 | 120 | .51 | 1 680 | 7.22 | 1 800 | 7.73 |
| 9. Khurasan | 30 900 | 4 900 | 15.59 | 4 500 | 14.56 | 9 400 | 30.15 |
| 10. Esfahan | 17 600 | 1 120 | 6.36 | 1 600 | 9.09 | 2 720 | 15.45 |
| 11. Baluchistan | 18 500 | 20 | .11 | 520 | 2.81 | 540 | 2.92 |
| 12. Tehran | 6 200 | 720 | 11.61 | 80 | 1.29 | 800 | 1.290 |
| Total for the country | 165 000 | 10 440 | 6.33 | 9 280 | 5.62 | 19 720 | 11.95 |

*Distribution.* About 10.4 million hectares of Sierozem soils occur in Iran. Their distribution by provinces is given in Table 26 and Map D6.

*Analytical data.* See Table 27.

3. 23 BROWN SOILS

The Brown Steppe soils are probably the predominant soils in Iran. These are brown to light brown nearly neutral soils usually overlying calcareous horizons.

TABLE 27. — LABORATORY ANALYSES OF TYPICAL SIEROZEM SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH Paste | % T.N.V. | % Org. C | Av. P ppm | Av. K ppm | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | $E_{Ca}$ | $S_{Na}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1–5 | 1456 | Near Esfahan | 6 | 23 | .09 | 8.9 | 25 | .2 | 9.0 | 210 | 4.7 | .1 | .4 | | .3 |
| | 5–40 | 1467 | | | 39 | .14 | 7.6 | 24 | .3 | 7.5 | 280 | 5.2 | .2 | .5 | | .8 |
| | 40–100 | 1458 | | | 36 | .45 | 8.4 | 14 | .7 | 6.0 | 300 | 9.7 | 5.2 | .7 | | 4.8 |
| 31 | 1–20 | 1554 | Gonabad (Khurasan) | 6 | 30 | .02 | 7.6 | 14 | .1 | 6.0 | 240 | 6.4 | .3 | .6 | .2 | |
| | 60–80 | 1555 | | | 24 | .18 | 7.4 | 8 | .1 | 4.0 | 50 | 5.2 | .5 | .1 | 1.3 | |
| 36 | 1–5 | 1575 | Shah-Rud Damghan (Khurasan) | 6–2 | 37 | .04 | 8.0 | 28 | .2 | 12 | 280 | 8.3 | .4 | .7 | — | .2 |
| | 5–12 | 1576 | | | 33 | .07 | 7.9 | 23 | .2 | 6.5 | 490 | 11.8 | .4 | .7 | — | .2 |

They have a verv weak, often thick, $A_1$ horizon with an organic matter content of about 2 percent. Usually illuviation and eluviation are slightly active although some of the brown soils show zones of accumulation of clay in the form of clay skins and bridged between aggregates.

Brown soils have greyish-brown granular surface soils, with organic lighter brown or yellowish-brown granular crumbly, weak but often thick subsoils which grade at 15 to 30 cm into a pale brown or greyish highly calcareous clay, with limestone and shale interbedded. The depth of the solum varies according to the slope of the area. Well-developed soil profiles with distinct texture, structure, color, and reaction are rare and occur only on gentle slopes.

These soils are developed in semiarid climates under grass vegetation and suffer moisture deficiency during summer months. The vegetation is medium and short grasses, but all areas not used for cropland are severely overgrazed, and now have a very thin cover of annual grasses that probably bear little resemblance to the original native cover. The total precipitation that occurs in the Brown soil zone is normally between 250-400 mm mostly in the winter months and is quite often sufficient for small grains, but not for summer crops. Part of this precipitation is in the form of snow.

As indicated above, Brown Steppe soil is calcareous AC soil of the desert steppe with light brown-colored top soil. Due to the low humus content and to its occurrence under an open xerophytic plant cover and because of humus content, humus depth, and intensity of soil life this soil is superior to the Sierozem but inferior to the Chestnut soil.

That the soil is quite variable is strongly reflected in the profile. All varieties have in common a humus horizon from 20 to 50 cm in depth which is divided into a light, more grey-colored, nearly always loose $A_2$ horizon and a very much lighter A/Ca horizon of a brownish light grey color. The formation of the loose $A_1$ horizon is strongly influenced by the supply of wind-borne sediments. Joined to the humus layer is a more or less cemented Ca horizon, which gradually passes into the usually calcareous parent rock.

Zhakarov gives a morphological description of a typical Brown soil profile.

The soil is alkaline in reaction, effervesces at depth and at times even slightly at the surface.

| | | |
|---|---|---|
| $A_1$ | 0-15 cm | Humus horizon, straw-colored grey with a brown or chestnut brown shade, laminated structure, friable with a finely porous constitution. |
| $A_2$ | 15-26 cm | Slightly compacted, a brighter chestnut brown shade, columnar like, partly crumbly structure. |

$A_3$ 26-45 cm Lighter straw-colored, with brown streaks and tonguelike projections, crumbly, nutty structure, more friable constitution, with many worm tracks.

A/Ca 45-75 cm Illuvial horizon, straw-colored with white spots and veins of calcium carbonate, slightly prismatic, porous, and feebly cracked.

C 75+ cm Loesslike, or some other parent material which sometimes contains soluble salts.

The Brown soils differ from the Chestnut soils by their lighter grey color. Because of this grey shade which is characteristic for all the soils of the steppe, the humus horizon of the Brown soil cannot be differentiated at times from the underlying horizon. The greyish-brown predominates over the dark-colored humus which is not too abundant in Brown soils. On the average, Brown soils contain 2 to 3 percent organic matter in the surface 10 cm.

Some of the typical Brown soil profiles examined during field studies are described below.

7A: Amle clay loam, level or nearly level (0-1 percent).

*Profile No. $B_1$, located near the village of Amle in the Kermanshah Plain.*

0-20 cm Ap horizon, brown (10 YR 5/3d, 4/3 m) clay loam, subangular blocky, plenty of roots and rootlets present, friable when moist, but hard when dry, and holes and small particles of lime present, slightly sticky when moist, effervescence with acid.

20-40 cm Yellowish-brown (10 YR 5/4 d, 7.5 YR 5/4 m) brownish clay, cloddy when dry but friable when moist. Rootlets present, hardens on drying and sticky when moist, mixed with small limestone particles and concretions, effervescence with acid.

40-80 cm Yellowish-brown (10 YR 5/4 d, 7.5 YR 5/4 m) clay, cloddy and hard dry, more compact than previous layer and with powdery pockets and concretions of lime, sticky when moist.

80-150 cm Brown (10 YR 4/3 m) clay, cloddy, same as previous layer with less lime particles, no mottling, hard when dry and sticky when moist, few rootlets present, effervescence with acid.

7A: Qazvin silty clay loam, level, or nearly level (0-1 percent).

*Profile No. O.M. II, located 5 km northwest of Qazvin.*

0-15 cm Brown (7.5 YR 4/3 m) silty clay loam, massive structure, moist friable, with moderate roots, no salinity, almost no effervescence with acid.

15-45 cm Brown (7.5 YR 4/3 m) sandy clay loam, weak medium blocky, friable when moist, slight roots, slight effervescence, moderate lime mycellia, about the limit of moisture penetration.

45-65 cm Brown (7.5 YR 5/4 m) clay loam with abundant lime mycellia, moderate medium blocky, hard when dry, violent effervescence.

65-110 cm Brown (7.5 YR 5/4 m) gravelly coarse sandy clay loam, moderate medium prismatic structure breaking to moderate medium blocky, hard when dry, few perennial roots, violent effervescence definitely small (3-5 mm) lime concretions and abundant gravel.

110-125 cm Brown (10 YR 5/4 d) gravelly loamy sand, structureless, lime deposited on gravel.

This profile is considered to be Brown soil on old alluvium.

7A: Shush clay loam, level or nearly level (0-1 percent).

*Profile No. $B_2$, located in Shush area in the Khuzistan Plain.*

0-20 cm Ap horizon; light brownish-grey (10 Yr 6/2 d); dark greyish-brown (10 Yr 4/2 m) silty clay loam, coarse angular blocky, very hard, some roothairs, no visible lime or gypsum.

20-40 cm Brown (7.5 YR 5/4 d, 4/4 m) heavy silty clay loam, medium angular blocky, very hard, horizontal lamination, some root hairs, no visible lime, no gypsum.

40-60 cm Brown (7.5 YR 5/4 d, 4/4 m) clay, weakly prismatic to medium-fine angular blocky, hard, horizontal lamination, some root channels, medium visible lime (nodules).

60-125 cm Brown (10 YR 4/3 d, 4/3 m) clay structureless breaking to medium-fine, angular blocky, hard. Few root channels. Medium visible lime nodules.

125-170 cm Brown (7.5 YR 4/4 d, 4/4 m) clay, structureless breaking to medium-fine angular blocky, hard. Few lime nodules.

7AB: Bonab sandy clay loam, nearly level (1-2 percent).

*Profile No. 1002, located in an irrigated wheat field near the village of Gol, in Zarrineh Rud area, Miandoab, Azerbaijan.*

0-20 cm Brown (10 YR 4/3 m) friable sandy clay loam, with moderately coarse granular structure, soft, abundant roots, pH 7.9, lime content about 13 percent.

20-28 cm Brown (10 YR 4/3 m) medium blocky clay loam, abundant roots, slightly hard when dry, sticky when wet, pH about 8.0, lime content about 13 percent.

28-80 cm Brown (10 YR 4/3 m) fine gravelly clay, medium moderate prismatic, abundant white "eyes" indicating calcium carbonate

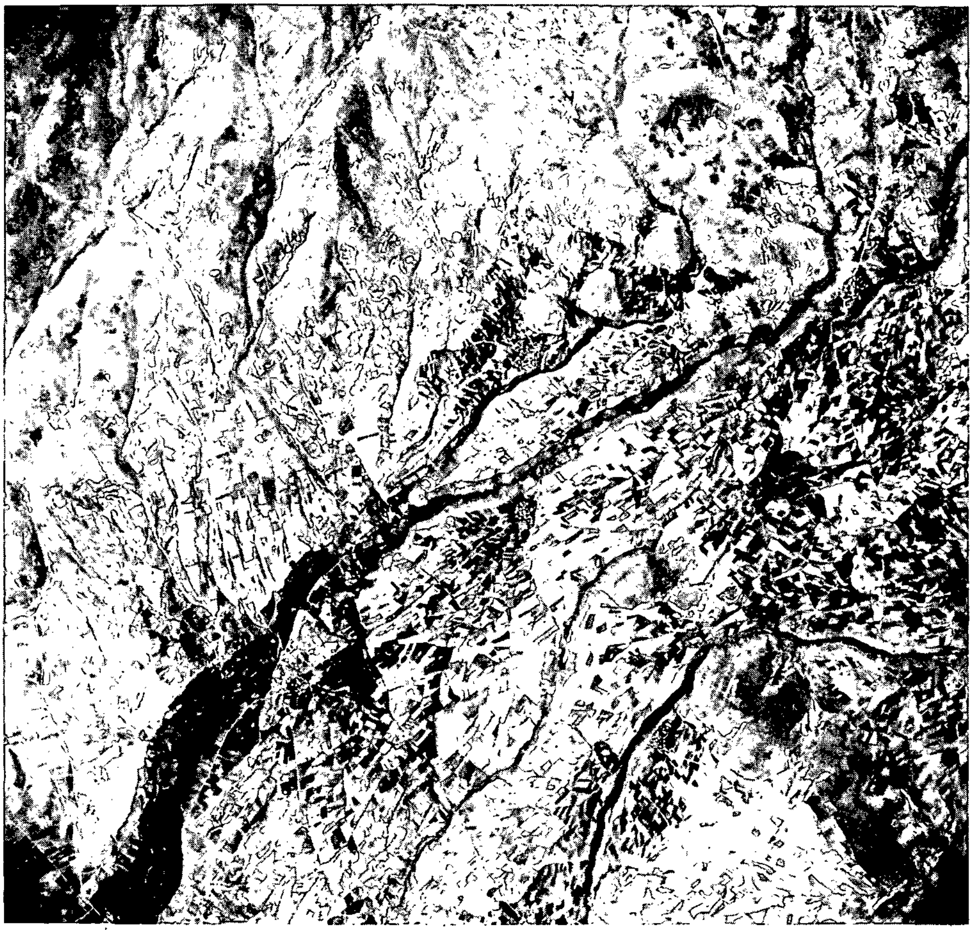


FIGURE 49. A Brown soils area between Sarab and Tabriz (Azerbaijan in northeastern Iran). A wide area of Iran is occupied by Brown soils or, at least, belongs to the Brown soils zone. Precipitation ranges between 300 to 400 mm per year. The rainy seasons are winter and spring. Both dry-farming wheat and barley are very usual on these soils, but their yields are relatively low. Irrigation raises the yield of these potentially very productive soils.

| | |
|---|---|
| | in movement, friable when moist, slightly hard when dry, very little roots, pH 7.7, lime content about 25 percent. |
| 80- 95 cm | Brown (10 YR 5/3 m) coarse gravelly clay, moderately coarse prismatic, mixed with some colluvium, slightly hard, pH 7.9, lime content 26 percent. |
| 95-120 cm | Dark yellowish-brown (10 YR 4/4 m) coarse gravelly sand (coarse |

alluvium, could be old riverbed), loose and structureless, pH 7.8, lime content 25 percent.

7A: Kushk-Hazar clay, level or nearly level but on an old river terrace.

*Profile No. D7, located near the village of Kushk-Hazar in the Doroodzan Plain.*

| | |
|---|---|
| 0-15 cm | Brown (10 YR 5/3 m) plastic clay, fine platy structure, wet and very sticky. |
| 15-70 cm | Brown (10 YR 5/3 m) silty clay, with prismatic structure, friable when moist, slight gravel and a few lime concretions. |
| 70-150 cm | Pale brown (10 YR 6/3 m) to brown (10 YR 5/3) silty clay to clay with more gravel and more lime concretions than above horizon. |
| 150-170 cm | Very pale brown to pale brown (10 YR 7/3 m to 6/3 m) clay with blocky structure, very concretionary, tending to a hard lime pan. |

7B: Ultan clay, nearly level or gently sloping (1-3 percent).

*Profile No. M3, located in the Ultan area of the Moghan Plain, Azerbaijan.*

| | |
|---|---|
| 0-12 cm | Brown to dark grey-brown (10 YR 5/3 d, 4/2 m) clay, cloddy, friable, with crop residue on the surface. |
| 12-55 cm | Brown (10 YR 4/3 d, m) clay with fine blocky structure, firm consistence, with white eyes of lime (10 YR 8/2), very few roots and salinity changing to |
| 55-100 cm | Yellowish-brown to brown (10 YR 5/4 slightly m, 5/3 m) clay, medium blocky to prismatic, very firm, with abundance of lime " eyes " and zone of lime concentration. |
| 100-125 cm | Yellowish-brown to brown, very gravelly clay loam, medium granular, very firm with abundance of round gravel which has been laid down by water. |
| 125-165 cm | Grey-brown (10 YR 5/2 m) gravelly sand, very weak granular and loose in consistence. |

*Range in characteristics.* The Brown soil here is usually medium to fine texture though all variations in texture are found. In general, the subsurface horizons are of finer texture than surface, but here too there is variability depending on the parent material. Permeability is often medium to low. Organic matter in the surface 10 to 20 cm varies from 1 to 2 percent. The depth of zone of lime concentration which varies considerably depending on the region and the texture of the layers, may be between 30 cm to 1 m depth. Analysis of the zone of lime concentration definitely shows increased percentage of $CaCO_3$.

The pH is always alkaline; the surface may often be neutral but may vary from about 7.4 to 8.4 with sometimes an indication of some slight degree of alkalinity.

*Relief.* Slopes vary considerably from the level or nearly level Brown Steppe soils occurring on old alluvium to even sloping and rough. The soils described here are normally level, nearly level, or gently sloping.

*Drainage.* These soils usually have medium to good natural drainage.

*Vegetation.* Normally short and medium grasses, also perennial shrubs like *Artemisia*, the most prevalent natural vegetation in Brown Steppe soils which have not been put under crops. *Glycyrrhiza glabra* (shirin bian) and *Alhagi camelorum* (camelthorn) are also found on these soils.

*Parent material.* Usually on old alluvium, but sometimes on parent rock calcareous and rich in lime.

*Land use.* On nearly level and on sloping lands the Brown Steppe soils are often under pasture. However, on level or nearly level lands and even on sloping areas the soils are dry farmed for wheat and barley and usually give moderate to good yields in an average year. Under irrigation, when level or nearly level, these soils do well. Fruits, vegetables, cotton, sugar beet, and wheat are grown under irrigation extensively. If the soil is properly irrigated and fertilized and if other soil management practices are employed, yields of these crops may be high to very high.

*Distribution.* Map D7 gives an indication of the distribution of Brown soils in Iran. Table 32 shows this distribution provincewise.

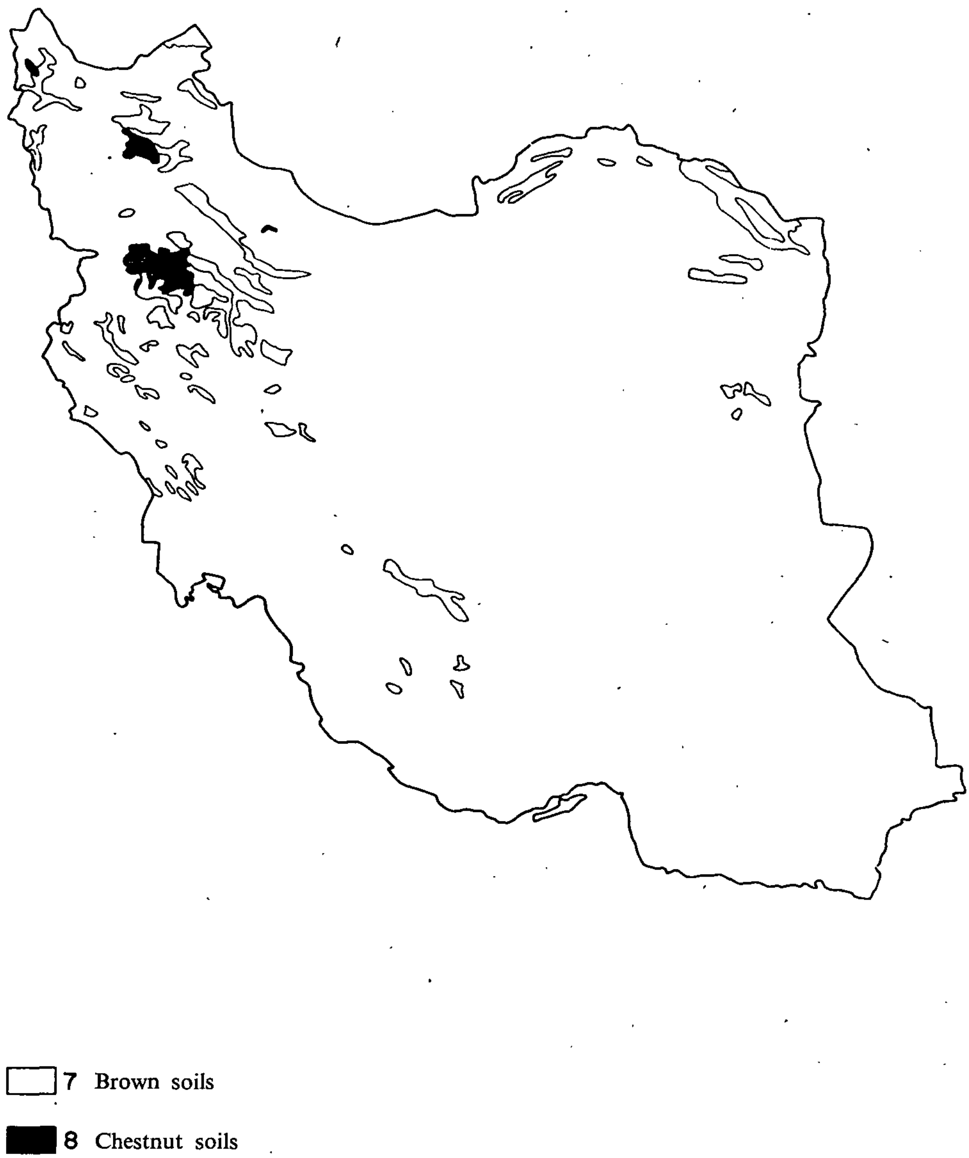
*Analytical data.* See Table 28.

### 3.24 Chestnut soils

Chestnut soils occur in certain semiarid and subhumid parts of Iran and are in short described as friable and platy dark brown (chestnut-colored) soil over light-colored material overlying a calcareous horizon which is usually at a depth of 50 to 150 cm. The depth of the humus horizon varies from about 30 to 60 cm, and is usually 40-50 cm. These soils most often occur under a mixed tall and short grass native vegetation.

The typical Chestnut soil profile consists of a lighter greyish-colored loose $A_1$ horizon occasionally showing slight leafy separation in the upper part underlain by a chestnut brown horizon which is normally rich in cavities and has a spongy fabric. This changes gradually to a light brownish-grey transition A/Ca horizon, then to a whitish more or less crusted Ca horizon, and finally into the loose present material.

Chestnut soils are usually neutral at the surface; they effervesce only at a depth of about 30 to 40 cm except when they occur on highly calcareous parent materials. Humus content in the surface soil usually averages about 3 to 4 percent.




MAP D7. Distribution of soils in Iran.

TABLE 28. — LABORATORY ANALYSES OF TYPICAL BROWN SOILS

| Profile no. | Depth (cm) | Location | Soil symbol | S.P. | % T.S.S. | pH | | % T.N.V. | % Org. C | $E_{Ca}$ | Mechanical analysis % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Paste | 1:5 | | | | Sand | Silt | Clay |
| $B_1$ | 0–20 | Amle, Kermanshah | 7 | | .05 | — | 8.6 | 13 | 2.4 | | 26.4 | 41.6 | 32.0 |
| | 20–40 | | | | .04 | — | 8.7 | 16 | 1.8 | | 23.2 | 49.8 | 27.0 |
| | 40–80 | | | | .04 | — | 8.7 | 20 | 1.3 | | 28.4 | 36.6 | 35.0 |
| | 80–150 | | | | .05 | — | 8.8 | 20 | .1 | | 16.4 | 36.6 | 47.0 |
| $B_2$ | 0–20 | Shush, Khuzistan | 7 | | .07 | — | 8.4 | 12 | 1.5 | 32.2 | | 22.0 | 45.8 |
| | 20–60 | | | | .07 | — | 8.5 | 23 | .9 | 22.2 | | 27.0 | 50.8 |
| | 60–100 | | | | .07 | — | 8.6 | 12 | .5 | 26.2 | | 28.0 | 45.9 |
| 250 | 0–20 | Shush | 7 | | | — | 8.8 | 42 | 1.0 | | 30.4 | 36.8 | 32.8 |
| | 20–60 | | | | | — | 9.0 | 44 | 0.6 | | 23.2 | 35.8 | 41.0 |
| | 60–100 | | | | | — | 8.6 | 41 | 0.5 | | 20.4 | 33.4 | 46.2 |
| | 100–160 | | | | | — | 8.6 | 40 | 0.4 | | 23.0 | 30.4 | 46.6 |
| 101 | 0–20 | Shush | 7 | | .06 | — | 8.6 | 40 | | | 24.4 | 36.8 | 38.8 |
| | 20–40 | | | | .08 | — | 8.8 | 40 | | | 19.4 | 36.8 | 43.8 |
| | 40–80 | | | | .13 | — | 9.1 | 34 | | | 18.4 | 34.4 | 47.2 |
| | 80–120 | | | | .19 | — | 8.6 | 42 | | | 16.4 | 35.8 | 47.8 |
| M3 | 0–12 | Ultan, Moghan | 7 | | .91 | 7.7 | 8.4 | | | | 54 | 23.4 | 22.6 |
| | 12–55 | | | | .97 | 7.7 | 8.6 | | | | 18 | 35.2 | 46.8 |
| | 55–100 | | | | 1.03 | 7.4 | 8.7 | | | | 18.6 | 28.4 | 53.0 |
| | 100–125 | | | | 1.44 | 7.7 | — | | | | 26.8 | 27.2 | 46.0 |
| 1002 | 0–20 | Bonab (Zarrineh Rud, Azerbaijan) | 7AB | 38 | .08 | 7.9 | 8.8 | 12 | | | 55.4 | 21.4 | 23.2 |
| | 20–28 | | | 38 | .06 | 8.0 | 8.9 | 13 | | | 43.2 | 31.0 | 25.8 |
| | 28–80 | | | 48 | .09 | 7.7 | 8.9 | 25 | | | 39.6 | 24.2 | 36.2 |
| | 80–95 | | | 39 | .06 | 7.9 | 9.1 | 26 | | | 57.6 | 22.4 | 20.0 |
| | 95–120 | | | 27 | .06 | 7.8 | 9.1 | 25 | | | 72.8 | 17.4 | 9.8 |

Two typical profiles of Chestnut soil are described below.

8A: Chestnut soil on level land (0-1 percent).

*Profile No. Caspian 28, located near Haji Kalat about 50 km east-northeast of Gorgan.*

| | |
|---|---|
| 0-15 cm | Very dark grey (10 YR 3/1 m) silty clay loam with strong fine granular or crumb structure, hard when dry, abundant roots, with some snails and shells, pH about 7, organic matter about 5 percent or more, no effervescence. |
| 15-40 cm | Very dark greyish-brown (10 YR 3/2 m) heavy clay loam, very weak, structure granular, friable when moist, moderate effervescence. |
| 40-100 cm | Dark greyish-brown (10 YR 4/2 m) heavy clay loam or silty clay with weak platy structure, strong effervescence, zone of lime concretions and powdery pockets. |
| 100-130 cm | Yellowish-brown (10 YR 5/4 m) fine sandy loam to silt loam, platy structure, strong effervescence, no lime pockets. |

8C: Chestnut soils on moderately sloping land (3-8 percent).

*Profile No. 128, about 12 km from Bostanabad toward Tehran at about 6,000 ft (1,800 m) elevation above mean sea level, Azerbaijan.*

| | |
|---|---|
| 0-15 cm | Dark greyish-brown to very dark greyish-brown (10 YR 4/2 d, 3/2 m) fine-textured clay, granular and no effervescence. |
| 15-140 cm | Dark brown (10 YR 3/3 m) clay, strong blocky structure, some white powdery pockets, none or very weak effervescence. |
| 140-150 cm | Very pale brown (10 YR 7/3 m) concentration of lime concretions. |
| 150 cm + | Gravels and stones, coated with lime. |

*Range in characteristics.* Chestnut soils are usually medium- to heavy-textured on the surface as well as in the subsoil. The surface layer of 10 to 15 cm has high organic matter, while at depths of about 30 to 60 cm there is adequate organic matter, usually 3 to 4 percent. The reaction in the topsoil is neutral to slightly alkaline.

Lime accumulates at a depth of between 50 to 150 cm and may vary considerably in percentage.

*Relief.* Chestnut soils normally occur in Iran on steep slopes or in rolling hilly or mountainous areas. However, in the eastern part of the Caspian area, some Chestnut soils on gentle slopes, or even on level or nearly level lands have been mapped.

*Drainage.* Moderate to good.

*Vegetation.* Originally grass and bush vegetation. Normally a mixture of short and tall grasses. However, in the valleys and stream bottoms, there is a growth of trees, ash, oak, etc.

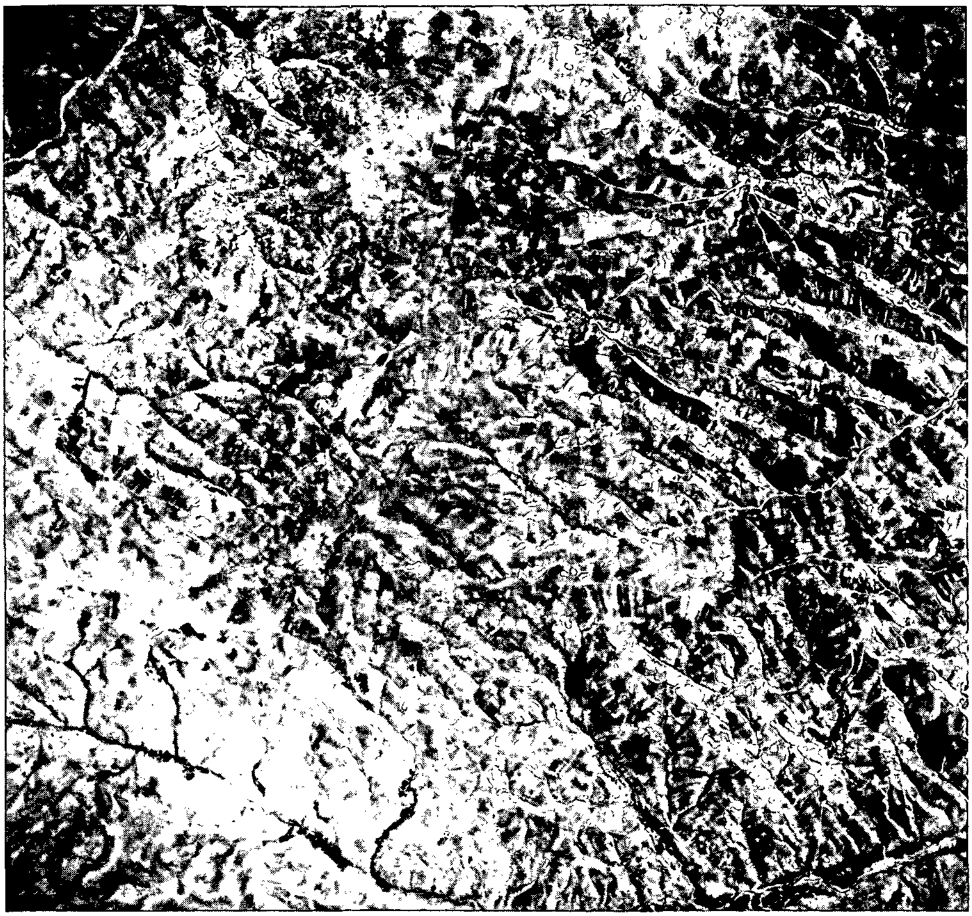


FIGURE 50. A part of Azerbaijan, between Mianeh and Maragheh. The pattern indicates very intensive dry farming, with wheat as the main crop. Most other crops can be cultivated if water is available for irrigation. In semiarid, subhumid regions of moderate elevation, where the soil moisture is adequate to grow more natural vegetation, such as in Azerbaijan, Chestnut soils are formed.

*Parent material.* Normally alluvial, deluvial, and colluvial deposits from limestone and shales and sandstone material.

*Land use.* Cereal grains, normally wheat dry farmed; cotton by supplemental irrigation.

*Distribution.* Chestnut soils occur to a limited extent on the eastern border of the Caspian in the Gorgan Plain but are found mainly in higher lying areas in Azerbaijan. About one million hectares have been mapped mainly in the Azerbaijan, Kurdistan, and Kermanshah areas. Map D7 and Table 32 indicate this distribution. It may be noted here that Chernozem soils have also been observed in limited areas, in association with Chestnut soils, in northeastern Iran, especially in the Gorgan Plain. The Chernozem soils are defined as dark, well-drained grassland soils granular in structure, rich in humus, with or without concentration of clay in the B horizon, and calcareous below. These soils observed are usually dark (10 YR 2/1 m) in the $A_1$ horizon, with deep surface horizon, resting on a transitional friable lighter colored layer which quite often grades into a zone of clay accumulation. As these soils were observed in limited areas or in association with Chestnut soils, they were not mapped as separate soil association.

*Analytical data.* See Table 29.

### 3.25 Desert soils - Regosols

Desert soils often occur in association with Regosols forming an intricate pattern with them. They normally are shallow to very shallow, light- to coarse-textured; lime accumulation is normally close to the surface. The whole profile is usually calcareous and pH varies around 8. There is hardly any organic matter, as it has little possibility to accumulate. Gravel and coarse sand is very predominant in the profile. Angular gravel forms a large percentage of the layer below 10-20 cm. A typical profile is described below.

5-2a: Desert soils – Regosols association

*Profile No. 10, Jasr Naderi between Bam amd Zahedan in the Seistan area in southeastern Iran.*

| | |
|---|---|
| 0- 1 cm | Desert pavement consisting of granite, diorite, and acid igneous rock, as well as porphyries transported by river, rounded. |
| 1- 5 cm | Coarse sand. |
| 5-10 cm | Pinkish-grey (7.5 YR 6/2 m) loamy sand. |
| 10-20 cm | Coarse gravelly sand. |
| 20 cm + | Coarse to medium angular gravel. |

*Relief.* This soil association occurs on level to steep or rough slopes.

*Drainage.* Good to excessive.

*Vegetation.* Hardly any vegetation, except some bush such as *Alhagi camelorum*, *Peganum harmala*, and *Citrullus colocynthus.*

*Parent material.* All kinds, including sedimentary, metamorphic or igneous, also old alluvial material, sand and regosolic material.

*Land use.* This soil is poorly cultivated at present. Agricultural value depends on the availability of suitable water for irrigation which, when available through ghanats, permits the growth of some good horticultural crops. The type of crop will depend on the climate, especially maximum and minimum temperature.

Table 29. — Laboratory analyses of typical Chestnut soils

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH | | % T.N.V. | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Paste | 1:5 | | | | | | | |
| 28 | 0–15 | 7154 | Haji Kalat (SE of Gorgan) | 8 A | 59 | | 7.2 | | 5 | 3.4 | 8.0 | | 40.1 | .2 | 2.6 |
| | 15–40 | 7155 | | | 56 | | 7.6 | | 13 | .7 | 1.5 | | 20.8 | .2 | 1.5 |
| | 40–100 | 7156 | | | 51 | | 7.7 | | 24 | .4 | 1.5 | | 20.0 | .4 | .5 |
| | 100–130 | 7157 | | | 49 | | 8.0 | | 32 | .2 | — | | 16.7 | .7 | .3 |
| 128 | 0–15 | 1807 | Near Bostanabad | 8 B | 58 | .09 | 7.3 | 8.2 | 1 | .7 | 9 | 400 | 30.6 | .2 | 1 |
| | 60–80 | 1808 | | | 63 | .20 | 7.2 | 8.5 | 2 | .4 | 3 | 280 | 33.7 | 1.6 | .7 |
| | 140–150 | 1809 | | | 70 | .08 | 7.2 | 8.8 | 25 | .3 | 4 | 190 | 29.5 | .2 | .5 |

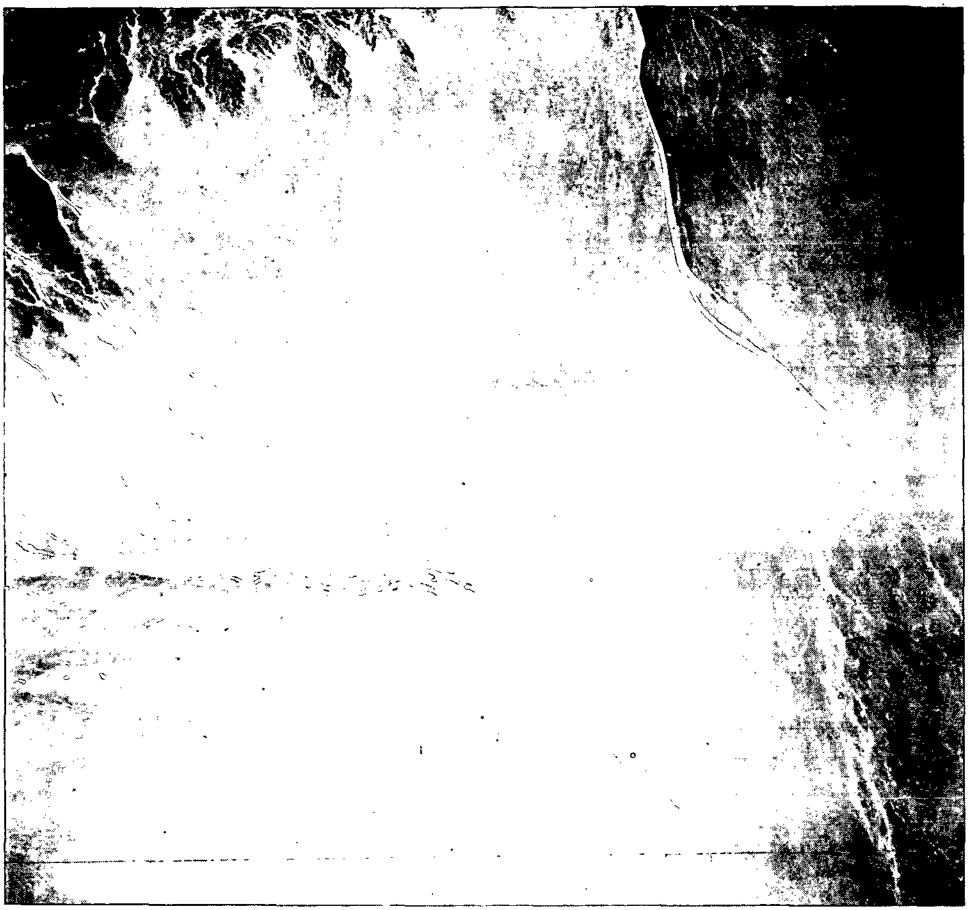


FIGURE 51. In the desert areas of eastern and southeastern Iran there is a commonly occurring soil association, Desert soils-Regosols (5-2a). These occupy areas (photo shows Baluchistan, northwest of Iranshar) with annual rainfalls of less than 150 mm. Vegetation is poor and such areas are classified as poor range and wastelands.

*Distribution.* Large areas of Desert soils – Regosols occur especially in Dasht-i-Lut, Kerman, Baluchistan, and Seistan. An approximate calculation from the areas mapped indicates the area covered by these soils – a total of about 7.6 million hectares (see Table 30), comprising:

| | | |
|---|---|---|
| Kerman | 4,050,000 | ha |
| Khurasan | 1,400,000 | „ |
| Baluchistan | 2,200,000 | „ |

*Analytical data.* See Table 25.

### 3.26 Desert soils – Sand Dunes

In the plateau of Iran, large areas of Sand Dunes occurring in association with Desert soils have been mapped in the Dasht-i-Lut, for example, and also in Kerman-Esfahan.

The aerial photo (Fig. 27) from the Kerman area shows the pattern of soil. Sand dunes are of the moving type and gradually spread over the other part of the desert soils, sometimes over small tracts of irrigated areas. Though no typical profiles were described, these consist mainly of Sand Dunes and/or the Desert soils described earlier.

*Relief.* Usually undulating relief typical of Sand Dunes.

*Drainage.* Rapid to moderately rapid internal drainage, moderate externally.

*Vegetation.* Hardly any. Sometimes bush or short grass vegetation may grow in moist spots. *Populus euphratica*, *Cressa cretica*, and *Tragus racemosus* are also found to occur on this soil association.

*Parent material.* All kinds including sedimentary, metamorphic or igneous; also old alluvial material, sand and regosolic material.

*Land use.* Normally wasteland, but sometimes used as very poor range.

*Distribution.* The distribution of these soils is indicated in Map D5 and Table 30.

A total of about 5.6 million hectares is mapped in this soil association, and in the following areas:

| | | |
|---|---|---|
| Kerman | 1,560,000 | ha |
| Esfahan | 3,370,000 | ,, |
| Baluchistan | 640,000 | ,, |

### 3.27 Desert soils – Sierozem soils – Solonchak soils

In certain parts of Iran especially in the Great Salt Desert (Dasht-i-Kavir) or the Seistan Plain in southeastern Iran, large areas of this soil association are found. Apart from the characteristics of Desert and Sierozem soils, wherein desert pavement, some lime movement, etc., are the differentiating factors, extreme salinity of the surface or subsoil or both also occurs. This salinity may be due to saline waters passing over the desert soils. The source of saline water could be one of the saliferous and gypsiferous formations.

Two profiles are described below representing this soil association.

5-4: Desert soils-Solonchak soils level or nearly level (0-1 percent).

FIGURE 52. Near Shurgaz, between Kerman and Zahedan in southeastern Iran. Completely desert though a *Salicornia* plant is visible in some places.

FIGURE 53. Relics of severe wind erosion in the Shurgaz desert, Bam-Zahedan.

FIGURE 54. Desert pavement, Kerman-Zahedan.

*Profile No. 11, located off Post Kausak, 30 km from Shurgaz between Bam and Zahedan, southeastern Iran.*

| | |
|---|---|
| 0-1 cm | Desert pavement of siliceous limestone, quartz and limestone, with some metamorphic and igneous, all angular. |
| 1-10 cm | Pinkish-grey (5 YR 6/2 m) coarse loamy sand, severely saline. |
| 10-20 cm | Coarse gravelly sand, saline. |
| 20 cm + | Medium to coarse gravel, angular. |

5-4: Desert soil - Solonchak soils, level or nearly level (0-1 percent).

*Profile No. 13, located on an upper terrace near Lutak in Seistan, southeastern Iran.*

| | |
|---|---|
| 0-1 cm | White crust (7.5 YR 8/1 m) gravelly sand. |
| 1-5 cm | Pale brown (7.5 YR 6/3 m) loamy sand. |
| 5-18 cm | Brown (7.5 YR 4/3 m) granular sandy loam. |
| 18 cm + | Gypsum layer. |

*Range in characteristics.* The soils in this association vary from shallow to deep; from light or coarse textured to heavy textured, and from white puffed layer of severely saline surface layer to severe salinity in the subsurface layers.

TABLE 30. — DISTRIBUTION OF DESERT, D-REGOSOL, D-SAND DUNE, D-SOLONCHAK SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Desert 5 | | D-Regosol 5-2a | | D-Sand-Dune 5-2b | | D-Solonchak 5-4 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (1 000 ha) | % | (1 000 ha) | % | (1 000 ha) | % | (1 000 ha) | % | (1 000 ha) | % |
| 1. Gilan | 3 800 | — | | — | | — | | — | | — | |
| 2. Mazanderan | 14 000 | 40 | .28 | — | | — | | — | | 40 | .28 |
| 3. Azerbaijan | 10 500 | — | | — | | — | | — | | — | |
| 4. Kurdistan | 3 122 | — | | — | | — | | — | | — | |
| 5. Kermanshah | 6 212 | — | | — | | — | | — | | — | |
| 6. Khuzistan | 13 466 | — | | — | | — | | — | | — | |
| 7. Fars | 17 420 | — | | — | | — | | — | — | | |
| 8. Kerman | 23 280 | 480 | 2.06 | 4 050 | 17.40 | 1 560 | 6.70 | — | | 6 090 | 26.16 |
| 9. Khurasan | 30 900 | 400 | 1.29 | 1 400 | 4.53 | — | | 1 400 | 4.53 | 3 200 | 10.35 |
| 10. Esfahan | 17 600 | 1 120 | 6.36 | — | | 3 370 | 19.15 | 320 | 1.82 | 4 810 | 29.33 |
| 11. Baluchistan | 18 500 | 40 | .22 | 2 200 | 11.88 | 640 | 3.96 | 760 | 4.11 | 3 640 | 20.17 |
| 12. Tehran | 6 200 | — | | — | | — | | 120 | 1.93 | 120 | 1.93 |
| Total for the country | 165 000 | 2 080 | 1.26 | 7 650 | 4.65 | 5 570 | 3.38 | 3 460 | 2.10 | 18 760 | 11.39 |

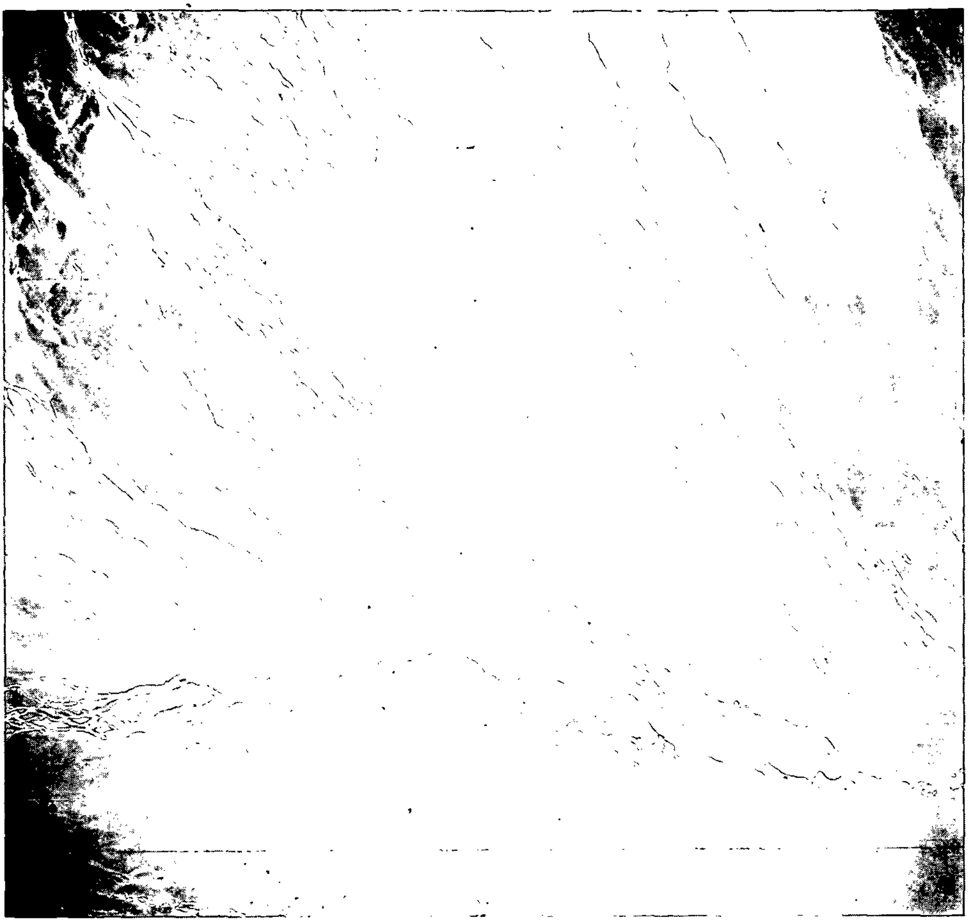


FIGURE 55. The area bordering Pakistan in southeastern Iran. Desert soils—Sierozem soils—Solonchak soils occupy certain parts of Iran, especially near the Dasht-i-Kavir and in Seistan and Baluchistan. Here are salty streams, sometimes originating from areas of dissected slopes with calcareous Lithosols from saliferous and gypsiferous marls, including salt plugs (14). These soils can hardly be used even for poor grazing, and are grouped into wasteland.

*Relief.* Normally level or nearly level.

*Drainage.* Moderate to slow internal drainage, moderate external drainage.

*Vegetation.* Either without any vegetation, or salt-loving halophytic species such as *Aellenia, Aeluropus littoralis, Anabasis aphylla, Atriplex, Halimocnemis, Halocnemum strobilaceum, Salicornia fruticosa, Haloxylon ammodendron, Salsola, Seidlitzia rosmarinus.*

*Parent material.* Normally old alluvial material, sands and regosolic material; also gypsum and marls, saliferous and gypsiferous.

*Land use.* Wastelands, with some poor range. In a few cases where irrigation water of suitable quality is available, some subsistence or marginal agriculture may be possible.

*Distribution.* A total of 3.5 million hectares has been mapped as this soil association, in the region indicated in Table 30 and in Map D5.

*Analytical data.* See Table 25.

### 3.28 Sierozem soils – Regosols (with inclusions of Sand Dunes)

The description of this soil association is only slightly different from that of a combination of 5-2a and 5-2b (Table 30). They differ only to the extent that Sierozem soils have slightly better moisture status than Desert soils. This soil association occurs fairly extensively in several desertic parts of the plateau of Iran.

One profile observed in the area mapped as this soil association is described below.
6-2 Sierozem-Regosols soil, on nearly level land (1-3 percent).

*Profile No. 36, located between Semnan and Damghan, in Khurasan near the cross-roads of Gorgan-Mashhad-Tehran at about 1,300 m elevation.*

| | |
|---|---|
| 0-1 cm | Desert pavement, limestone, dolomite, plus ferroginous lime, partly siliceous, subrounded. |
| 1-5 cm | Pale brown (10 YR 6/3 m) gravelly light sandy loam, porous friable but gritty. |
| 5-12 cm | Brown to dark brown (10 YR 4/3 m) sandy clay loam, granular gravel. |
| 12 cm | Gravel. |

*Range in characteristics.* This soil association includes soils that are shallow to deep with varying degrees of colluvium or sandy wind-borne material on the surface. The textures of surface or subsurface vary from coarse to medium fine. Normally very calcareous, pH of surface and subsurface, 8. Salinity slight.

*Relief.* Usually nearly level, or gently to moderately sloping and undulating.

*Drainage.* Good to excessive.

*Vegetation.* Some bush vegetation typical of arid areas mainly *Alhagi camelorum*.

*Parent material.* Variable, normally all types, sedimentary, metamorphic or igneous, often old alluvial or colluvial, with sand and regosolic material.

*Land use.* Wastelands, or poor grazing. Where irrigation water is available, orchards or horticultural crops such as grapes, plums, apples, etc., may be grown.

*Analytical data.* See Table 27.

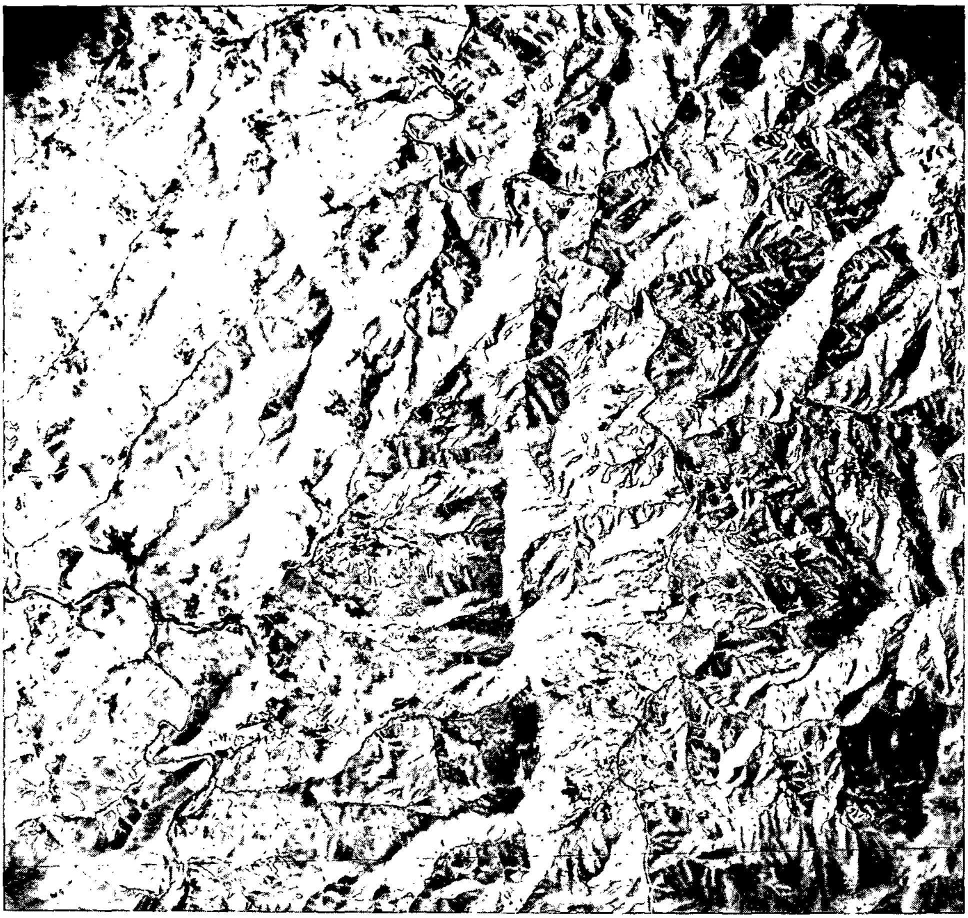


FIGURE 56. An area of soil association, Brown soils-Lithosols (7-15), northwest of Mahabad, south of Urmia (Rezayeh) City, on the southwest bank of Lake Urmia (Rezayeh). Large areas in Iran are intergrade between soils of the plateau and soils of the dissected slopes and mountains. Much of this land, usually of moderate to gentle slopes is under dry-farming wheat, whereas the steeper slopes are kept for grazing and wastelands. On gentle slopes there is considerable moisture retention; on steep slopes surface runoff is very rapid and gully erosion common.

### 3.29 BROWN SOILS - LITHOSOLS

This soil association is used as if it were an intergrade between the Brown Steppe soils on normally level or abruptly sloping land, and the soils of the dissected slopes and mountains in the Brown soil zone.

The Brown soils therefore describe this soil association fairly accurately, with the exception of difference in slope.

A profile description of Brown soil as a part of the above soil association is given below.

7-15 Brown soil on undulating and steeply sloping land (8-15 percent).

*Profile No. 89, located near Ardebil in Azerbaijan, about 8 km on road to Tabriz, in a field plowed for dry-farming wheat.*

0-15 cm Brown, dark greyish-brown (10 YR 5/3 d, 4/2 m) fine-textured clay loam or clay, mixed with some lime concretions (from subsoil), friable consistence, some roots of short grasses, violent effervescence, pH 8.

15-90 cm Brown (10 YR 5/3 m) friable heavy clay loam, or light clay, violent effervescence, pH 8.

90-130 cm Grey-brown (10 YR 5/2 m) silt loam with abundant lime concretions, violent effervescence, pH 8.

*Range in characteristics.* Soil may vary from very shallow to moderately deep.

*Relief.* Slope may vary from undulating to strongly sloping.

*Drainage.* Good to excessive.

*Vegetation.* Same as Brown soil.

*Parent material.* Apart from alluvium, all sedimentary, igneous or metamorphic rocks, especially those which are rich in calcium.

*Land use.* These soils are normally suited for poor to moderate range. In the parts with favorable relief, irrigation is practiced if good quality water is available (from ghanats or springs, from diversion or storage projects) and such parts are normally well suited for irrigation of crops such as wheat, and for orchards, vineyards, etc.

*Distribution.* Map D7 shows the distribution of this soil association and Table 32 gives the distribution by province.

TABLE 31. — LABORATORY ANALYSES OF TYPICAL LITHOSOLS BROWN SOILS

| Profile no. | Depth cm | Location | Soil symbol | S. P. | % T. S. S. | pH | | % T. N. V. | % Org. C | Av. P | ppm K | C. E. C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Paste | 1:5 | | | | | | | |
| 94 | 0–4 | Ardebil | 7–15 | 75 | .08 | 7.4 | 8.3 | 16 | 2.8 | 17 | 680 | 25.6 | .2 | 1.7 |
| | 4–60 | | | 63 | .07 | 7.5 | 8.4 | 17 | 2.7 | 4.5 | 460 | 26.0 | .2 | 1.2 |
| | 60–120 | | | 47 | .05 | 7.4 | 8.8 | 33 | 0.5 | 3.0 | 130 | 15.6 | .2 | 0.3 |

TABLE 32. — DISTRIBUTION OF BROWN, BROWN LITHOSOL, AND CHESTNUT SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Brown 7 | | Chestnut 8 | | Brown-Lithosol 7-15 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | 512 | 13.47 | 20 | .53 | 320 | 8.42 | 852 | 22.42 |
| 2. Mazanderan | 14 000 | 320 | 2.28 | — | | — | | 320 | 2.28 |
| 3. Azerbaijan | 10 500 | 1 420 | 13.58 | 240 | 2.29 | 800 | 7.62 | 2 460 | 23.49 |
| 4. Kurdistan | 3 122 | 240 | 7.69 | 608 | 19.47 | 301 | 9.64 | 1 149 | 36.80 |
| 5. Kermanshah | 6 212 | 920 | 14.81 | 152 | 2.45 | 645 | 10.38 | 1 717 | 27.64 |
| 6. Khuzistan | 13 466 | 680 | 5.10 | — | | 454 | 30.50 | 1 134 | 35.60 |
| 7. Fars | 17 420 | 720 | 4.10 | — | | — | | 720 | 4.10 |
| 8. Kerman | 23 280 | — | | — | | — | | — | |
| 9. Khurasan | 30 900 | 1 600 | 5.18 | — | | 80 | .26 | 1 680 | 5.44 |
| 10. Esfahan | 17 600 | 140 | .79 | — | | — | | 140 | .79 |
| 11. Baluchistan | 18 500 | — | | — | | — | | — | |
| 12. Tehran | 6 200 | 400 | 6.45 | 20 | .32 | 40 | .65 | 460 | 7.42 |
| Total for the country | 165 000 | 6 952 | 4.21 | 1 040 | .63 | 2 640 | 1.60 | 10 632 | 6.44 |

## 3.3 Soils of the Caspian Piedmont

The northern foothills and the slight to moderately sloping foothill areas of the Elburz mountains bordering the southern coast of the Caspian Sea are characterized by a humid and subhumid subtropical climate, and are referred to as the Caspian Piedmont. These areas include the Caspian provinces of Gilan, Mazanderan, and Gorgan. Climatic conditions in these regions differ from those of other parts of Iran and have certain similarities to the Mediterranean climate; it is humid in the western part and subhumid, semiarid in the eastern part.

The abundance of vegetation and the intensity of chemical weathering on Jurassic, Cretaceous, and Tertiary limestone and conglomerates, sandstones, etc., on the northern slopes of Elburz are responsible for the formation of thin cover of Brown Forest, Red-Yellow Podzolic, and in some cases Grey-Brown Podzolic soils. In some transitional areas a few profiles of Red and Brown Mediterranean soils have been mapped.

Below, the soils of the Caspian Piedmont are described in the following order:

1. Red and Brown Mediterranean soils
2. Red-Yellow Podzolic soils
3. Brown Forest soils (including Grey-Brown Podzolic soils)

### 3.31 Red and Brown Mediterranean soils

Red and Brown Mediterranean soils have been observed in several places, especially in the transition zones between the Iranian Plateau and Caspian areas. When crossing the Elburz from the plateau toward the Caspian Sea by any of five routes (Mashhad-Kuchan-Gorgan; Tehran-Firuzkuh-Sāri; Tehran-Karaj-Chalus; Kazvin-Manjil-Rasht; Ardebil-Astara) one comes across some areas of soil which can be characterized as Red and Brown Mediterranean soils. These soils have a very high base saturation of the clay complex, and usually have some free calcium carbonate throughout the profile. They are found on weathered limestones, sandstones, and also on weathered basalts. Generally the original A horizon seems to be entirely or partly eroded. In almost all cases, even under forest vegetation, the A horizon shows a low organic matter and a color which hardly, if at all, differs from that of the underlying horizon. However, in areas where rainfall is higher than 600 mm, or in the weakly calcareous Red Mediterranean soils, there may be some color differences between A and B horizons of 1.5 to 2 value units. In general the Red and Brown Mediterranean soils occur in the subhumid and semiarid areas where the rainfall is about 400 to 800 mm and where there is a distinct dry season.

The A horizon usually has a crumb or granular structure and in a climatic zone with less than 600 mm rainfall (dry subhumid) is always calcareous; here too, most of the profiles contain free lime throughout. The following profile gives a description of the Red Mediterranean soil.

Red Mediterranean soil, on moderately sloping land (3-8 percent).

*Profile No. 38, located between Firuzkuh and Pul Sefid at an elevation of about 6,300 ft (1,900 m) and near the forest-grassland transition line (oak forest predominating).*

| | |
|---|---|
| 0-5 cm | Weak red (10 R 4/3 m) gravelly clay loam, granular structure, friable, considerably violent effervescence. |
| 5-20 cm | Same as above, except color (10 R 4/4 m). |
| 20-60 cm | Weak red (10 R 4/4 m) gravelly clay, granular structure, friable consistence, less roots, violent effervescence. |
| 60 cm + | Ferruginous limestone. |

*Range in characteristics.* The A horizon is either the same color or slightly darker by one or two values. The typical color for the B horizon is reddish-brown (5 YR 4/4 m). In the high rainfall zones the hue may be 2.5 YR, whereas in the transition zone to the Brown Mediterranean soils the color shifts to a hue of 7.5 YR.

The color of the A horizon shifts accordingly. The B horizon almost always shows a distinct blocky structure. The structural units are composed of subangular to angular blocky peds.

A Cca horizon is normally present in the deep phases of the Red Mediterranean soils. The Cca horizons occur at depths varying between 50 to 100 cm. Lime nodules are very distinct and may cover up to 30 to 50 percent of the exposed profile surface.

*Relief.* In the areas observed, the relief varies from rolling to hilly.

*Drainage.* Good to excessive.

*Vegetation.* Normally forest-grassland transition; oak forests are quite common.

*Parent material.* Most Red Mediterranean soils are formed in limestone areas; also on some calcium rich basalts, or even sandstone.

*Land use.* Partly in forest and in grassland, some on gentler slopes in wheat, also citrus and other horticultural crops, when irrigated.

*Distribution.* These soils occur in spots rather than in large areas. In general they seem to be transitional in mountainous areas crossing from the plateau to Elburz and to the Caspian areas. They are not yet mapped as continuous areas and their exact extent and distribution are unknown. In Map D8 a few spots have been marked where such soils have been found to occur. See also Table 36.

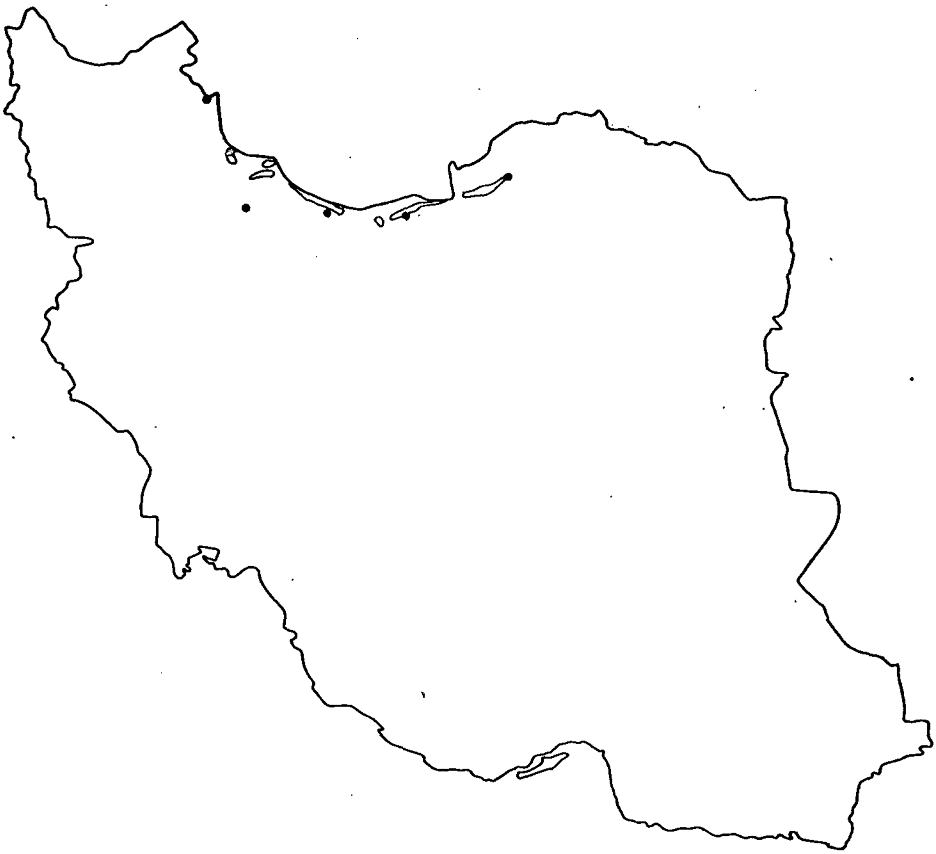
*Analytical results.* See Table 33.

TABLE 33. — LABORATORY ANALYSES OF RED MEDITERRANEAN SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH Paste | pH 1:5 | % T.N.V. | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | 0–5 | 1618 | Firuzkuh Pul Sefid | 9 | 54 | .08 | 7.4 | 8.6 | 12 | 1.6 | 20 | 360 | 30.6 | .1 | .9 |
| | 10–20 | 1619 | | | 44 | .06 | 7.5 | 8.6 | 14 | 1.5 | 18 | 190 | 26.0 | .2 | .5 |
| | 30–60 | 1620 | | | 51 | .06 | 7.9 | 8.6 | 8 | 1.3 | 9 | 160 | 29.5 | .2 | .2 |

## 3.32 RED-YELLOW PODZOLIC SOILS

Red Podzolic soil is defined as soil with a thin organic layer AC and $A_1$ over yellowish-brown to nearly white leached $A_2$ and red B horizon. The parent material, frequently mottled with red, yellow, and grey, is about 25 cm to 2½ m beneath the surface and is medium to strongly acid. The native vegetation varies from



11 Brown Forest soils (including Grey-Brown Podzolic soils)

9 Red and Brown Mediterranean soils

10 Red-Yellow Podzolic soils

MAP D8. Distribution of soils in Iran.

usually deciduous forest with some conifers, to long and short grass savanna woodland. Podzolization and laterization are the processes of soil development.

These soils form on all but the most siliceous and least ferruginous rocks in areas where the rainfall is adequate to leach the profile during at least part of the year. Their formation is not favored by locally overmoist sites where they tend to be replaced normally by Yellow Podzolic soils, which are defined as a group of well-developed acid soils having a thin $A_0$ and organic-mineral horizon over a light-colored bleached $A_2$ horizon, over a red, yellowish-red, or yellow and more clayey B horizon. Coarse streaks or mottles of red, yellow, and brown and light grey characterize deep horizons where the siliceous parent materials are thick.

In the Caspian area, Red Podzolic and Yellow Podzolic soils have been mapped as one association but, depending on the aridity or humidity of the spots, one or the other prevails.

A typical profile of Red-Yellow Podzolic soils is described below.

Red-Yellow Podzolic soil, moderately undulating (3-8 percent).

*Profile, about 11 km south of Rasht on the first slopes of hills, adjacent to the plains, under degraded forest.*

| | |
|---|---|
| 0-½ cm | Black (10 YR 2/1 m) with organic debris, acid type of humus |
| ½-5 cm | Very dark greyish-brown (10 YR 3/2.5 m) loam to fine sandy loam, coarse weak granular structure. |
| 5-30 cm | Dark yellowish-brown (10 YR 3/4 m) silty clay with coarse granular to subangular blocky structure. |
| 30-40 cm | Strong brown (7.5 YR 4/5 m) silty clay, strong subangular, blocky structure. |
| 40-60 cm | Yellowish-red (5 YR 5/6 m) silty clay, with subangular blocky structure. |
| 60-115 cm | Yellowish-brown (10 YR 5/6 m) silty clay, with fragments of shale and sandstone. |
| 115-200 cm | Yellowish-brown (10 YR 5/4 m) silty clay with numerous fragments of clayey shale, iron mottling yellow and black, grey clay in root channels. |

*Range in characteristics.* The color of the soil is controlled by the nature of the rock. On shales, the soil is usually yellowish; over sandstone, conglomerates, and granites, the red color is more marked. On weathered shales, the horizon in the subsoil is common, whereas on sandstone, the subsoil has little mottling.

*Relief.* These soils usually occur on medium to heavy slopes in the foothill section of the Caspian area.

FIGURE 57. Tea growing on Red-Yellow Podzolic and Grey-Brown Podzolic soils on steep slopes in the north.

FIGURE 58. Tea estate in the Mazanderan-Gilan area. Centered around Ramsar, Soil Association 18 or 19.

*Drainage.* Generally medium to good for the top horizon. However, in cases where the soil is developed on shaly parent materials, drainage is poor.

*Vegetation.* Usually forest such as *Quercus castanaefolia*, *Carpinus betulus*, some *Ulnus sp.*, and *Fagus orientalis*. These forests are often degraded by overgrazing; long grasses are mixed with woodlands.

*Parent material.* Parent rocks for the Red-Yellow Podzolic soils are variable and range from sandstone, shales to schists, as well as volcanic rocks. Limestones are rare. River-deposited gravels also have been observed as parent material of these soils.

*Land use.* On the medium to steep slopes, the best use is forest. However, the greater part of these soils is used for pasture. On medium and moderately steep slopes tea cultivation is desirable with measures for erosion control such as contour planting, etc. In general, such soils when cultivated are subject to severe erosion. On medium slopes the hill people utilize the soils for wheat, etc. However. the creeping of the surface horizon over the lower heavy Pseudo-Gley horizon is not uncommon if the original forest vegetation is removed.

*Distribution.* These soils occupy some forest slopes in Gilan Province, and occur over sandstone, granites, quartzite, and shale. About 10,000 ha of such soils have been mapped in the Caspian west (Gilan) in the piedmont areas (Table 36 and Map D8).

### 3.33 Brown Forest soils

Defined as soils with a forest humus layer of mixed organic and mineral matter and having no accumulation horizon of clay and sesquioxides, these soils have developed under a temperate to warm, temperate, moist, subhumid to humid climate, with average rainfall ranging from about 600 to 1,500 mm.

In general, the surface horizon of Brown Forest soils is composed of leaf litter from deciduous trees, underlain by a very thin layer of nearly black leaf mold. The upper mineral A horizon is dark greyish-brown and greyish-yellow below. The texture is usually silty; structure is single grain or in the upper portion weak granular. Reaction is generally acid, with acidity increasing downward in the A horizon. The thickness of the A horizon varies depending on the composition of parent material. The B horizon is brown or yellowish-brown in color, higher in clay content than the A horizon; the structure is fairly strong, the mass breaking readily into angular peds; reaction is generally acid; thickness ranges from 30 to 60 cm. The $B_3$ and $C_1$ horizons have a high lime content, and the pH ranges from 7 to 8.

A few typical profiles of Brown Forest soils from various parts of the Caspian area are described below.

Brown Forest soils, gently to moderately sloping area (3-8 percent).

*Profile No. 18, located between Sari and Behshahr. Foothill soil.*

0-20 cm Very dark brown (10 YR 2/2 m) silty clay loam, moderate medium granular, dry hard, no mottling, abundant roots, no effervescence, some cracks on the surface.

20-50 cm Grey-brown (10 YR 3/2 m) clay, structureless, moist firm, nil to slight mottling, few roots, no effervescence, some angular gravel.

50-60 cm Dark brown (10 YR 4/3 m) clay, structureless, moist firm, moderate mottling, slight roots, abundant lime concretions.

60-80 cm Dark brown and light greyish-brown (10 YR 4/3 m and 10 YR 6/2 m)

FIGURE 59. Oak forests on Brown Forest soils near Kermanshah.

sandy clay loam, structureless, moist firm, slight mottling, slight roots, strong effervescence.

80-100 cm Yellowish-brown and light brownish-grey (10 YR 5/6 m and 10 YR 6/2 m) sandy clay loam, structureless, moist firm, moderate to abundant mottling, strong effervescence.

*Profile No. 30, near Masumabad village, southeast of Gorgan, 3-8 percent slope.*

0-10 cm Very dark brown (10 YR 2/2 m) silty clay, moderately medium granular, friable when moist, no mottling, abundant roots, slight effervescence.

10-50 cm Dark brown (10 YR 3/3 m) silty clay loam, weak medium blocky to prismatic, very firm when moist, no mottling, moderate roots, strong effervescence.

50-100 cm Dark brown (7.5 YR 4/2 m) silty clay, weak prismatic to moderately medium blocky, moist friable, no mottling, slight roots, lime concretions, strong effervescence.

*Profile No. 51, south of Chalus near the Chalus-Karaj road, about 200 m above mean sea level, in the Caspian Piedmont, 8-15 percent slope.*

0-1 cm Fungi-covered undecomposed organic matter, no effervescence.

1-5 cm Dark reddish-brown (5 YR 2/2 m) loam, weakly granular, very mellow, a mixture of humus and mineral matter, no effervescence, pH between 6.5-7.

5-15 cm Dark brown (10 YR 3/3 m) clay with abundant mottling, abundant roots, weak blocky. No effervescence; slightly acid to neutral in reaction.

15-50 cm Dark brown (10 YR 3/3 m) clay with abundant reddish-brown mottling. No effervescence, pH between 6-6.5.

50-55 cm Light grey (2.5 YR 7/2 m) clay, calcareous with violent effervescence.

55 cm + Limestone, partially decomposed; violent effervescence.

*Profile No. 25, 24 km east of Gorgan in mixed forest, 1-3 percent slope.*

0-10 cm Very dark greyish brown (10 YR 3/2 m) silty clay, fine granular structure, very friable, no mottling, abundant roots, no effervescence.

10-40 cm Brown to dark brown (10 YR 4/3 m) silty clay loam, moderate medium blocky, moist firm, no mottling, moderate roots, some small gravel, no effervescence.

40 cm + Brown to dark brown (10 YR 4/3 m) silty clay loam, moderate medium blocky, moist firm, no mottling, moderate roots, no effervescence,

TABLE 34. — LABORATORY ANALYSES OF BROWN FOREST SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH paste | % T.N.V. | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 0–20 | 7139 | Sari-Behshahr | 11 C | 58 | | 7.2 | 3 | 2.1 | 24.0 | 27.1 | .2 | 1.5 | |
| | 20–40 | 7140 | | | 78 | | 7.2 | 3 | 0.6 | 4.0 | 38.7 | .3 | .9 | |
| | 40–50 | 7141 | | | 52 | | 7.4 | 16 | .5 | — | 33.4 | .3 | .7 | |
| | 50–60 | 7142 | | | 46 | | 7.7 | 50 | .4 | 1.0 | 17.2 | .3 | .3 | |
| | 60–80 | 7143 | | | 37 | | 7.7 | 50 | — | 1.0 | 14.4 | .7 | .4 | |
| 30 | 0–10 | 7161 | Chalus | 11 C | 51 | | 7.7 | 14 | 1.8 | 9.0 | | 27.8 | 0.3 | 1.4 |
| | 10–50 | 7162 | | | 48 | | 7.7 | 21 | 0.6 | 2.5 | | 18.2 | 0.2 | 0.2 |
| | 50–100 | 7163 | | | 48 | | 7.9 | 21 | 0.6 | 1.0 | | 21.5 | 0.3 | 0.4 |
| 25 | 0–10 | 7149 | Gorgan | 11 C | 71 | | 7.1 | 3 | 4.4 | 4.0 | | 15.1 | .2 | .8 |
| | 10–40 | 7150 | | | 46 | | 6.5 | 2 | 0.1 | 3.0 | | 23.1 | .1 | .6 |

very gravelly with some deposit of lime on gravel (igneous gravel, not limestone, not calcareous).

*Range in characteristics.* The thickness of solum in the areas mapped varies from 10-15 cm. Organic matter in the first 10-20 cm may vary from 2-4 percent. The calcium carbonate layer may have as much as 15-50 percent, depending on the parent material.

*Relief.* The Brown Forest soils normally occur on steep slopes and in association with rough broken land. In some cases, they have been observed and mapped on nearly level or gently sloping lands.

*Drainage.* Normally medium to good external drainage, medium to poor internal drainage.

*Vegetation.* Native vegetation on Brown Forest soil is deciduous forest, mainly beech, hornbeam, some oak, and, in places, scattered conifer. Details are given in Chapter 2.

*Parent material.* Usually lime-rich shales, rocks with limestone, basic schists or gneiss.

*Land use.* Brown Forest soils are in general unsuited for cultivation except for small, less sloping areas which may have fruit trees or thick growing crops, the best use for these soils. The most common present soil use is under forest.

*Analytical data.* See Table 34.

### 3.34 Grey-Brown and Brown Podzolic soils

These soils have been found to occur in association with Brown Forest soils and hence have been mapped under the same association.

Soils of this group have been formed in a humid to subhumid cool climate under the influence of forest vegetation, and from a number of parent materials, usually poor in bases. They also occur on alluvial deposits, over ancient terraces and alluvial cones of the coastal rivers. These soils are always slightly to moderately acid with a low base saturation of less than 25 percent.

A thin layer of raw organic debris rests on the $A_1$ horizon which is thin and moderately low in organic matter content. It overlies a bright-colored B horizon which may have secondary concretions cemented by oxidized iron and aluminum oxides. These soils are of variable texture, usually friable, permeable, and with moderate to high water-holding capacity.

Typical Podzols have not been observed in Iran. However, Podzolic soils, such as those described below, have been mapped. The degradation leads to the formation of Grey-Brown Podzolic soils.

Grey-Brown Podzolic soils, undulating to moderately sloping (3-8 percent).

*Profile No. Caspian 1, observed on ancient terrace of Sia Mazgui River in the region of Foumen, south of Chaft village, under forest vegetation.*

| | | |
|---|---|---|
| 0-5 | cm | Black (10 YR 2/1 m) organic debris or decayed leaves, in the surface moss abruptly changing to lower horizon, pH about 6.3. |
| 5-10 | cm | Light brownish-grey to dark greyish-brown (2.5 Y 6/2 d, 10 YR 4/2 m) loam to sandy loam, subangular blocky structure weakly developed, abundant roots, pH about 6.5. |
| 10-18 | cm | Light grey to brown (2.5 Y 6/2 d, 7.5 YR 5/4 m) sandy loam, with some yellow iron spots and small iron concretions. Weakly developed structure, pH about 5.6. |
| 18-32 | cm | Light brownish-grey to brown (2.5 Y 6/2 d, 7.5 YR 5/4 m) silty clay loam to silt loam, some iron concretions, plastic, very few roots, pH about 5.2. |
| 32-65 | cm | Dark brown (10 YR 4/3.5 m) to yellowish-brown (10 YR 5/4 m) silty clay loam with grey clay along the roots, fine columnar structure, slightly developed with vertical cracks, very plastic, pH about 5.6. |
| 65-90 | cm | Grey silty clay loam with blackish ferruginous spots, grey clay along the roots, rock fragments, some roots, pH about 6.1. |

Grey-Brown Podzolic soil, moderately sloping (3-8 percent).

*Profile No. 60, in the north near the Ramsar-Rudsar road about 17 km west of Ramsar in a mixed forest, near Caspian Sea level.*

| | | |
|---|---|---|
| 0-5 | cm | Dark brown (10 YR 3/3 m) loam, granular structure, friable, full of tree roots, pH 6. |
| 5-25 | cm | Dark yellowish-brown (10 YR 3/4 m) clay, granular structure, hard, has less roots but still abundant, pH 6. |
| 25-100 | cm | Dark yellowish-brown (10 YR 3/4 m) gravelly clay, hard, prismatic structure, few mottling, pH 6. |
| 100 | cm + | Angular gravel, colluvium, outwash from granitic and other rocks from the nearby mountain. |

*Range in characteristics.* The principal variation seems to be due to the type of the parent material and the importance of leaching which can change the soil to strongly acidic, amounting to a weak process of podzolization.

*Relief.* These soils are generally situated on gentle slopes.

*Drainage.* In general, medium to poor.

*Vegetation.* Deciduous or mixed deciduous and coniferous forests. Predominant species are given in Chapter 2.

*Parent material.* These soils occur normally on igneous, volcanic, and metamorphic rocks: occasionally on sedimentary rocks (or outwash from these rocks) which are not rich in calcium.

*Land use.* Normally forest; some selected slopes are under tea gardens, or are planted in fruit trees or other horticultural crops.

*Distribution.* Map D8 shows the spots of Red-Yellow Mediterranean and of Red-Yellow Podzolic soils, as well as Brown Forest soils and Grey-Brown and Brown Podzolic soils. The latter soils have been shown as included with the mapping unit (11) and their distribution is given in Table 36. Of course, more detailed soil surveys may indicate the areas occupied by these soils.

*Analytical data.* See Table 35.

TABLE 35. — LABORATORY ANALYSES OF GREY-BROWN PODZOLIC SOILS

| Profile no. | Depth (cm) | Lab. no. | Soil symbol | S.P. | % T.S.S. | pH paste | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | Ca+Mg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Caspian I | 0–1 | 6633 | | V. high | .06 | 6.3 | 7.9 | 24 | 420 | 37.5 | 0.2 | 1.1 | 24.4 |
| | 1–10 | 6634 | 11C | 84 | .25 | 6.5 | 2.4 | 6.5 | 140 | 19.4 | 0.3 | .4 | 11.6 |
| | 10–18 | 6635 | | 54 | .13 | 5.6 | 0.7 | 3. | 100 | 14.6 | .6 | .3 | 28.2 |
| | 18–32 | 6636 | | 53 | .02 | 5.2 | 0.5 | 11.5 | 105 | 19.4 | .2 | .7 | 19.2 |
| | 32–65 | 6637 | | 75 | .05 | 5.6 | 0.3 | 9. | 260 | 34.7 | .4 | .6 | 30.0 |
| | 65–90 | 6638 | | 66 | .08 | 6.4 | 0.2 | 17.5 | 230 | 30.6 | .4 | .6 | 41.6 |

## 3.4 Soils of the dissected slopes and mountains

Soils of the dissected slopes and mountains are, in general, stony soils, shallow over bedrock, without a definite profile development. These soils consist of a great proportion of unweathered rock fragments, but may show some initiation of weathering and accumulation of organic matter: yet little or no profile development has taken place. These conditions may be due to recent exposure of the parent material to the action of the soil-forming processes, or more commonly to the forces

Table 36. — Distribution of Red and Brown Mediterranean, Red-Yellow Podzolic, Brown Forest soils (including Grey-Brown Podzolic soils) in various parts of Iran

| | | 9 | | 10 | | 11 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Province or part of Iran | Total area (1 000 ha) | Red and Brown Mediterranean | | Red-Yellow Podzolic | | Brown Forest | | Total | |
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | — | | 20 | .53 | 80 | 2.11 | 100 | 2.64 |
| 2. Mazanderan | 14 000 | 40 | .28 | — | | 280 | 2.00 | 320 | 2.28 |
| 3. Azerbaijan | 10 000 | 20 | .19 | — | | — | | 20 | .19 |
| 4. Kurdistan | 3 122 | — | | — | | — | | | |
| 5. Kermanshah | 6 212 | — | | — | | — | | | |
| 6. Khuzistan | 13 466 | — | | — | | — | | | |
| 7. Fars | 17 420 | — | | — | | — | | | |
| 8. Kerman | 23 280 | — | | — | | — | | | |
| 9. Khurasan | 30 900 | — | | — | | — | | | |
| 10. Esfahan | 17 600 | — | | — | | — | | | |
| 11. Baluchistan | 18 500 | — | | — | | — | | | |
| 12. Tehran | 6 200 | 20 | .32 | — | | — | | 20 | .32 |
| Total for the country | 165 000 | 80 | .05 | 20 | .01 | 360 | .22 | 460 | .28 |

of natural erosion being sufficient to remove the topsoil. The subsoils remain, and sometimes an A horizon appears on top.

These soils may be called Lithosols and are found in all climates though they are more commonly associated with arid and semiarid areas.

Soils of the dissected slopes and mountains in Iran form the following soil associations:

1. Brown soils—Rendzinas
2. Calcareous Lithosols—Desert and Sierozem soils
3. Calcareous Lithosols (from saliferous and gypsiferous marls—Desert and Sierozem soils (including salt plugs).
4. Calcareous Lithosols—Brown soils and Chestnut soils
5. Lithosols (from igneous rocks)—Brown soils and Sierozem soils
6. Lithosols—Brown Forest soils and Rendzinas
7. Regosols (mainly from sandstones)—Red-Yellow Podzolic soils
8. Lithosols (mainly from igneous rocks)—Brown Forest and Podzolic soils.

The complex soils of mountains and mountain valleys occupy a large part of Iran.

FIGURE 60. Profile of Rendzina soils in Azerbaijan. Dark surface soil over very light subsoil.

FIGURE 61. 12C, Brown soil, Rendzina profile. Ardebil, Tabriz.

Large areas of these soils which are rough broken or rough mountainous lands are unsuited as a whole for crop use. However, many of them contain small areas of alluvial and colluvial soils, or soils from residuum, that are suitable for cropland or improved pastures. The nomadic system of grazing depends to a considerable extent on such areas of better soils. These, however, comprise only a small percentage of the total area in which they exist. In a generalized study of this kind, it is impractical to show them on the map. Their existence is recognized, however, and an attempt was made to estimate the proportion of each miscellaneous soil group composed of these soils. Detailed surveys of sample areas to test the accuracy of the estimates of arable land for each unit have not been made. This will be done if detailed studies are needed of some selected areas for more intensive land use or management.

In the following pages, most of the soil associations mapped in the mountains and mountain valleys are described.

3.41 BROWN SOILS-RENDZINAS

This association contains Brown Steppe soil together with Rendzina soils, which are also called humus-carbonate soils. The latter are defined as dark calcareous, usually shallow soil, formed on soft calcareous parent materials. These shallow soils contain, in most places, a considerable amount of fragments or particles of undecomposed limestone. The climate is temperate to warm temperate, moist, subhumid with rainfall ranging from 500 to 750 mm.

The Rendzina soils are granular and friable and high in organic matter where not eroded. A high content of lime and organic matter makes these soils easily tillable, in spite of their apparent high clay content.

A few typical profiles of Rendzina soils are given below.

*Profile No. 88, about 30 km southwest of Astara (between Astara and Ardebil) in an area of forest-grassland transition (about 550 m above mean sea level).*

0-25 cm Very dark greyish-brown (10 YR 3/2 m) granular, gravelly clay, some roots, violent effervescence, pH about 8.

25-70 cm White (10 YR 8/2 d, m) gravelly loam, typical chalky blocky structure, violent effervescence, pH 8.

70 cm + Limestone, undecomposed, or only partially decomposed.

*Profile No. 23, North Fars, about 20 km on the main road from Firuzabad to Shiraz in the mountain area.*

0-13 cm Dark greyish-brown (10 YR 4/2 d, 3/2 m) heavy loam, weak medium granular to platy structure, dry slightly hard, no mottling, moderate roots, moderate gravel, and some lime, humus layer.

13-26 cm Dark brown (10 YR 4.5/3 d, 3.5/3 m) clay loam, with moderate to weak blocky structure, dry hard, no mottling, slight roots, moderate gravel, slight to moderate lime concretion.

26-43 cm Brown (7.5 YR 5/4 d) loam, weak medium, blocky, dry very hard, no mottling, some roots, moderate to light lime, not in pockets, concretions and nodules.

43-110 cm White (2.5 Y 8/1 d) all chalk lime, in weathering stage, some tree roots.

*Range in characteristics.* The $A_1$ horizon usually varies from 10 to 25 cm in depth and contains 1 to 2 percent organic matter. With a transitional zone, there is always a chalky marly layer at depths usually varying between 15 and 20 m. The lime content of this layer may be as high as 52 percent. Table 37 gives the analytical data for the few typical profiles described.

*Relief.* Rendzina soils have developed mainly on moderately to strongly sloping surfaces. These soils usually occur in association with strongly sloping

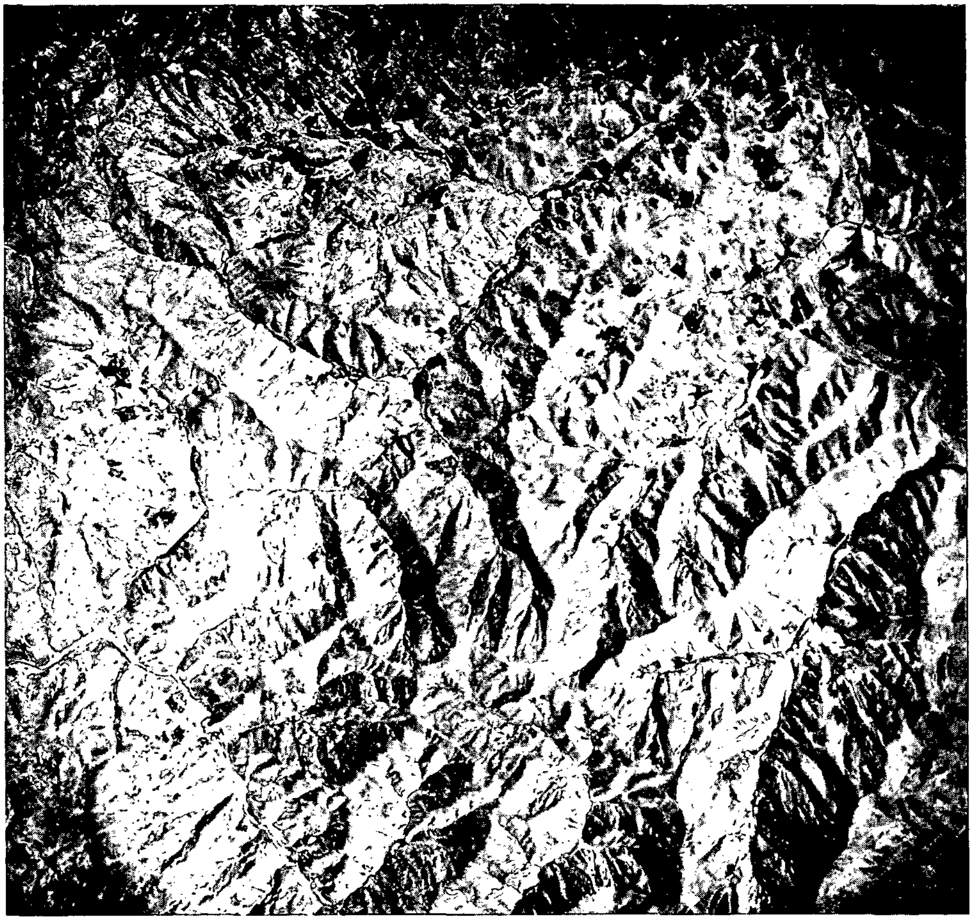


FIGURE 62. Bookan area (1: 60,000 scale), Azerbaijan, where the Brown soils-Rendzina (12) association is predominant. Soft limy and chalky parent materials predominate and Rendzinas occur in association with Brown Steppe soils (7 and 7-15). These soils, when not on very steep slopes, can be cultivated under crops. The area shows about 15 percent under cultivation, mainly dry-farming wheat and barley. The winter snow provides a moisture reserve on these soils.

Lithosol soils, but large areas of moderately sloping soils, with small areas of gently sloping surfaces also occur.

*Drainage.* External, good; internal, poor to medium.

*Vegetation.* Natural vegetation on these soils is grass cover and shrubs, or open scrubby oak woodland with wild pistachio and almond and with a moderately thick ground cover of grass and shrubs.

*Parent materials.* These consist of soft chalky marls, or marls with interbedded limestones.

*Land use.* The Rendzina soils are best adapted to spring and early maturing summer crops because of their limited capacity for storing moisture. These are not highly productive soils, mainly because of their shallow sola. When not too sloping, they can be used for crops adaptable to the region. The only safe use for such areas is grazing.

*Distribution.* Some areas of Rendzina soils have been observed in the forest-grassland transition area between Astara and Ardebil, some areas in Azerbaijan, especially in Mahabad, and other areas near Lake Urmia. A total of about 465,000 ha has been mapped in various parts of Azerbaijan, normally in areas of dissected slopes and mountains. Also some areas of Rendzina soils (about 90,000 ha in extent) have been mapped in Fars. Map D11 and Table 38 show the distribution of these soils.

*Analytical data.* See Table 37.

TABLE 37. — LABORATORY ANALYSES OF TYPICAL RENDZINA SOILS

| Profile no. | Depth (cm) | Location | Soil symbol | SP | % T.S.S. | pH | | T.N.V. % | % Org. C | Av. P | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Paste | 1:5 | | | | | | | |
| 88 | 0–25 | Astara-Ardebil | 12C | 59 | 0.12 | 7.3 | 7.9 | 30 | 1.2 | 35 | 320 | 45.8 | 0.1 | 0.8 |
| | 25–70 | | | 50 | 0.06 | 7.5 | 8.6 | 50 | 0.4 | 11 | 85 | 31.2 | 0.2 | 0.2 |
| 23 | 0–13 | Between Firuzabad and Shiraz | 12C | 61 | 0.06 | 7.5 | — | 44 | 2.5 | 30 | 380 | 26.0 | 0.1 | 1.0 |
| | 13–26 | | | 70 | 0.05 | 7.6 | — | 51 | 1.6 | 12 | 240 | 25.2 | 0.2 | 0.6 |
| | 26–43 | | | 59 | 0.02 | 7.6 | — | 70 | — | 14 | 95 | 13.8 | 0.1 | 0.2 |
| | 43–110 | | | 56 | 0.02 | 9.2 | — | 70 | 0.3 | 11 | 35 | 6.2 | 0.1 | 0.1 |

### 3.42 CALCAREOUS LITHOSOLS–DESERT AND SIEROZEM SOILS (Soil Association 13)

This is a complex association consisting of steep, dissected, rough or broken nonarable areas in the Desert and Sierozem soil zone. There is little or no soil development, as most of the soil is removed by natural erosion. Unweathered or only slightly weathered parent material is exposed over much of the area, with practically no soil covering except in small patches. Narrow V-shaped valleys, steep-sided valley walls with no soil covering, and narrow steep divides are common. Water runoff is very rapid and little penetrates into the parent material. Geologic erosion is severe to very severe, except in local areas.

There is hardly any profile development where there is a soil cover. The thin soil consists of a 2 to 10 cm layer of pale brown strongly calcareous clay loam or clay soil as is indicated by the profile description of this soil association.

13 EF: Calcareous Lithosols—Desert and Sierozem Soils on a steep slope in a hilly to mountainous area (15 percent +).

*Profile No. 8, located near Mahan between Kerman and Bam, Kerman Province*

| | |
|---|---|
| 0-1 cm | Desert pavement. |
| 1-5 cm | Pinkish-grey (7.5 YR 6/2 d, 4/2 m) sandy clay loam, very porous, friable, weak platy. |
| 5-10 cm | Reddish-brown (5 YR 4/3 d, m) heavy clay loam or light clay, platy. |
| 10-15 cm+ | Limestone. |

*Range in characteristics.* There are doubtless small areas of other soil materials and other kinds of parent rocks included in this unit. There may be spots in these areas of deeper soil than that described above, but in general the soil depth is usually very little or almost nil.

*Relief.* Mountainous and hilly areas, strongly sloping, severe to very severe erosion.

*Drainage.* Excessive external drainage; internal drainage, variable.

*Vegetation.* The vegetative stand on these soils is normally poor. Some species of *Artemisia* and other plants occur. In the southern part of Iran, for example, species such as *Capparis decidua, Dodonaea viscosa, Nerium odorum, Rhazya stricta,* and *Nannorrhops ritchieana* are found; in the central parts *Artemisia* sp., *Ephedra sp., Lycium turcomanicum, Prosopis stephaniana,* and *Nitraria schoberi.*

*Parent material.* Mainly calcareous clays and shaly limestones; or clay and limestone interbedded.

*Land use.* The land is unsuited for cropland except in some small patches but is used for poor grazing by sheep and cattle. It has a very low carrying capacity. It is estimated that about 2 percent of the area shown as 13 E, 13 EF, and 13 F in the 1:1,000,000 scale maps is suited for cropland. This may be in narrow valleys of alluvial soils and gently sloping areas of soil well suited for irrigation cropping. The unit includes areas where grazing is the present or potential major land use.

The use of moisture conservation measures to retain all or most of the runoff would aid considerably in improving the grazing land. In addition, some runoff might be diverted into small lower-lying arable areas, thus greatly increasing the amount of moisture for crops.

All of these rough broken or rough mountainous lands are severely overgrazed. Under better range management, after a natural cover has been allowed to become re-established, overgrazing must be avoided, and grasses given a chance to develop root reserves.

*Distribution.* The total area of this soil unit is 27,840,000 ha, as shown in Table 38. Map D 9 shows the distribution.

*Analytical data.* See Table 39.

TABLE 38. — DISTRIBUTION OF BROWN SOILS-RENDZINAS, CALCAREOUS LITHOSOLS, DESERT AND SIEROZEM SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | 12 Brown soils-Rendzinas | | 13 Calcareous Lithosols, Desert and Sierozem | |
|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | — | | — | |
| 2. Mazanderan | 14 000 | — | | 1 900 | 13.50 |
| 3. Azerbaijan | 10 500 | 400 | 3.81 | 40 | .38 |
| 4. Kurdistan | 3 122 | 120 | 3.84 | — | |
| 5. Kermanshah | 6 212 | — | | — | |
| 6. Khuzistan | 13 466 | — | | 600 | 4.55 |
| 7. Fars | 17 420 | 200 | 1.45 | 2 440 | 14.00 |
| 8. Kerman | 23 280 | — | | 5 090 | 21.86 |
| 9. Khurasan | 30 900 | — | | 6 820 | 22.07 |
| 10. Esfahan | 17 600 | — | | 3 770 | 21.42 |
| 11. Baluchistan | 18 500 | — | | 6 380 | 34.49 |
| 12. Tehran | 6 200 | — | | 800 | 12.90 |
| Total for the country | 165 000 | 720 | .44 | 27 840 | 16.80 |

█ 13 Calcareous Lithosols - Desert and Sierozem soils

MAP D9. Distribution of soils in Iran.

TABLE 39. — LABORATORY ANALYSES OF LITHOSOLS, DESERT, AND SIEROZEM SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S. P. | % T.S.S. | pH paste | % T.N.V. | % Org. C | Av. P | Av. K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | $S_{Na}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 1-5 | 1474 | Mahan-Kerman | 13 EF | 28 | .03 | 7.8 | 26 | .3 | 14 | 230 | 7.5 | .1 | .6 | .1 |
| | 5-10 | 1475 | | | 33 | .05 | 7.8 | 22 | .3 | 14 | 340 | 9.7 | .1 | .9 | .1 |

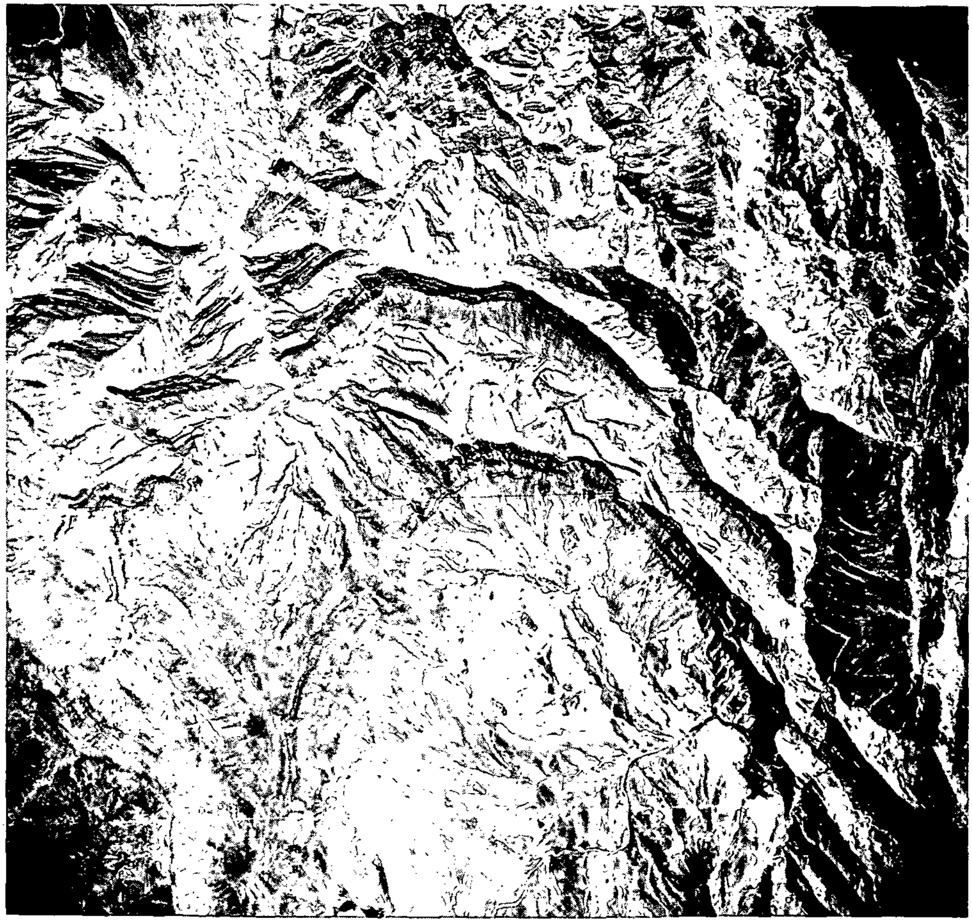


FIGURE 63. The area north of Bandar Abbas and southwest of Jiroft. Calcareous Lithosols associated with Desert soils and Sierozems cover a large part of central, east, southeast, and even northeast Iran, and form part of the soils of dissected slopes and mountains.

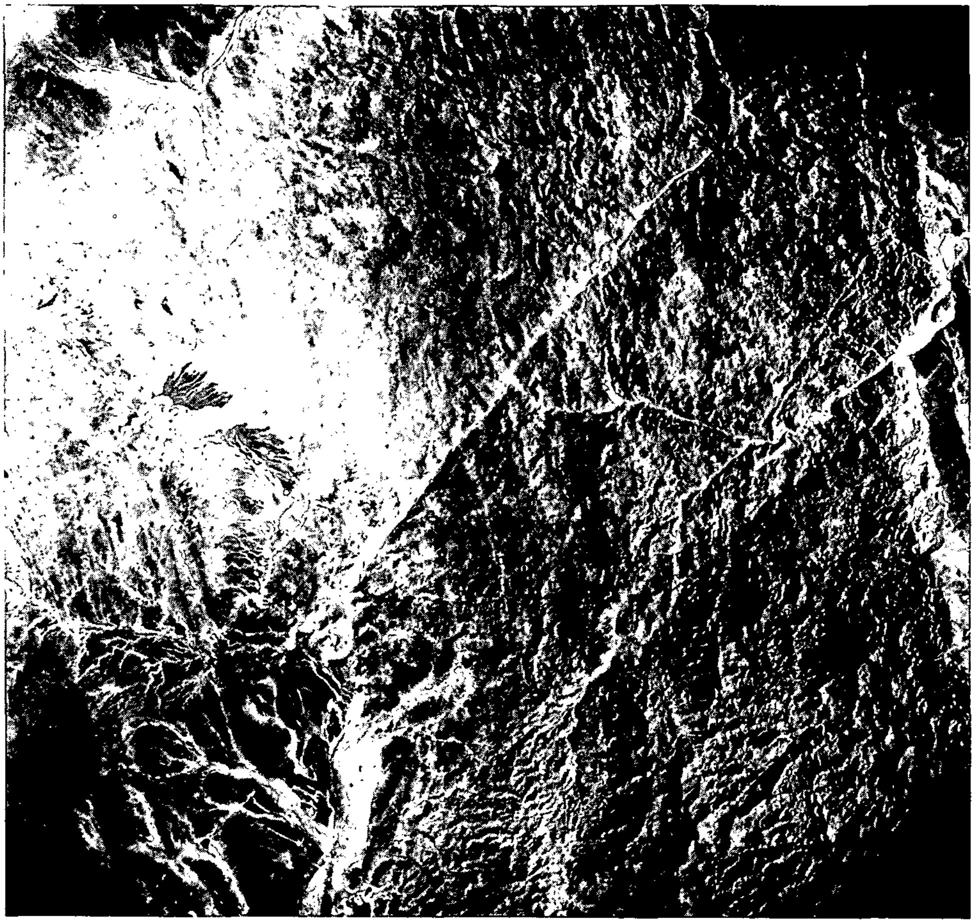


FIGURE 64. A part of Baluchistan, southeastern Iran, close to the border of Pakistan, showing rough dissected areas with high runoff and severe erosion. There is hardly any area suitable for agriculture and grazing is also very poor. Large areas of Calcareous Lithosols in association with Desert and Sierozem soils (13) occur in eastern, southeastern, and other parts of Iran. Soils of the dissected slopes and mountains comprise an important part of this association.

### 3.43 CALCAREOUS LITHOSOLS (from saliferous and gypsiferous marls) - DESERT AND SIEROZEM SOILS (including salt plugs). (Soil Association 14)

This association occurs in rough broken and rough mountainous land, over gypsiferous and saliferous marls, including salt plugs.

Soils from salty and gypsiferous marls and sandstones are the most unfavorable in Iran. They are partially responsible for the large salt deserts in the central part and in the southeast coastal areas.

This association consists of a dome-shaped formation with red, reddish-brown, and white layers. No typical profile could suitably describe these complex areas.

TABLE 40. — DISTRIBUTION OF CALCAREOUS LITHOSOLS FROM GYPSIFEROUS-SALIFEROUS MARLS AND SALT PLUGS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | 14 | | Salt plug | | 14 + Salt plug | |
|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | — | | — | | — | |
| 2. Mazanderan | 14 000 | 580 | | 60 | | 640 | 4.50 |
| 3. Azerbaijan | 10 500 | 880 | | — | | 880 | 8.41 |
| 4. Kurdistan | 3 122 | — | | — | | — | |
| 5. Kermanshah | 6 212 | 1 120 | | — | | 1 120 | 18.03 |
| 6. Khuzistan | 13 466 | 1 840 | | — | | 1 840 | 13.78 |
| 7. Fars | 17 420 | 4 450 | | 80 | | 4 530 | 26.00 |
| 8. Kerman | 23 280 | 1 320 | | 40 | | 1 360 | 5.84 |
| 9. Khurasan | 30 900 | 1 360 | | 40 | | 1 400 | 4.53 |
| 10. Esfahan | 17 600 | 1 280 | | — | | 1 280 | 7.27 |
| 11. Baluchistan | 18 500 | 1 520 | | — | | 1 520 | 8.21 |
| 12. Tehran | 6 200 | 200 | | 40 | | 240 | 3.38 |
| Total for the country | 165 000 | 14 550 | | 260 | | 14 810 | 8.98 |

*Range in characteristics.* In this association, also called Fars Series by geologists, variations are distinguished as:

(*a*) Lower Red Formation: These contain rich amounts of salt and gypsum and have formed as diapric uplifts in highly tectonic areas. The sediments consist of red siltstone and marlstone and are mixed with volcanics of gabbro-diorite composition. Gypsum layers and salt, concentrated in lenses, are frequent, particularly in the lower part.

(*b*) Upper Red Formation: In this formation the soils are sediments formed under brackish conditions alternating with terrestrial fills. The color of the sedi-

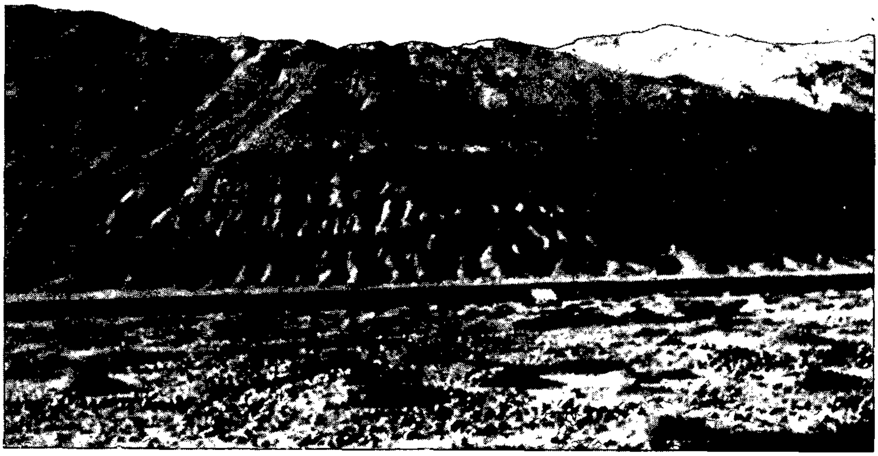


FIGURE 65. Typical badlands from Soil Association 14. In Garmsar area, southeast of Tehran.

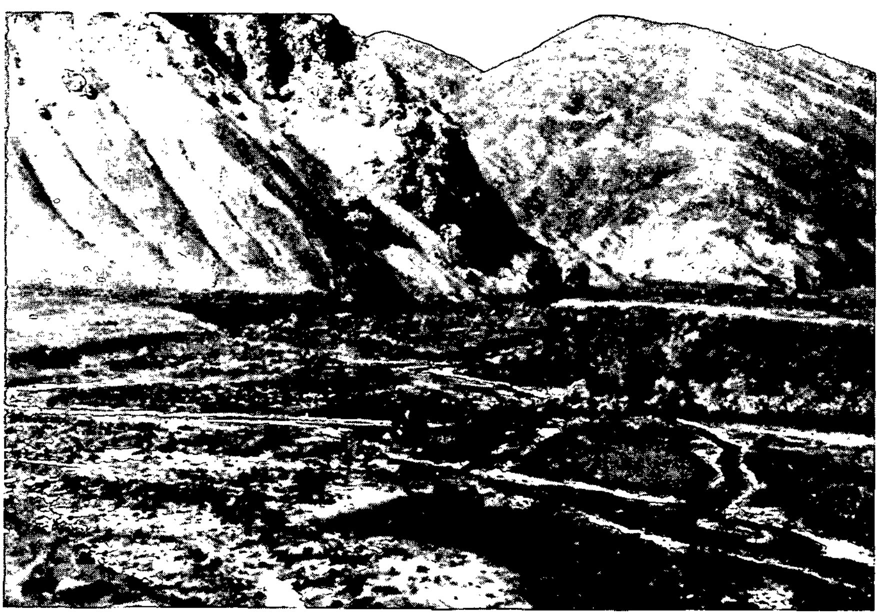


FIGURE 66. In the Red Formation (Soil Association 14) on the lower Hableh Rud above the Garmsar plain, salts come into the water from springs in the bottoms of natural drains. *Photo, O. T. Osgood.*

14 Calcareous Lithosols (from saliferous and gypsiferous marls) - Desert and Sierozem soils (including Salt Plugs)

MAP D10. Distribution of soils in Iran.

ment is red, since the base is Miocene. Gypsum, or more specifically anhydrite, is frequent in outcrops in which the salt layers are mostly washed out, except if concentrated in lenses. The evaporites are followed by very uniform red-brown silty marlstones with thin sandy intercalcations, and covered by two thin green fossiliferous marl bands, representing an important brackish water. Above the green marls are again the red marlstones, grading into more sandy deposits which in turn are covered by more or less sandy marls, the color of which is now predominantly grey-greenish to light creamy. In some cases, these deposits are very saline, and rich in gypsum seams along the bedding and cleavage planes.

(*c*) Salt Plugs: These are generated by sources *a* and *b* described above. The Salt Plugs thought to be of Cambrian age are numerous.

*Relief.* Hilly, normally low to medium hills; the rate of erosion is very rapid and gives rise to typical badland topography.

*Drainage.* External drainage, excessive; internal drainage, poor.

*Vegetation.* Normally no vegetation, as these hills are bare. In some cases, halophytic vegetation such as *Salicornia*, *Salsola*, etc., have been observed.

*Parent material.* This, together with the geology, is described under the range of characteristics. In short, stratigraphically speaking, this association is composed of:

(i) Lower Red Formations, which are Oligocene and Lower Miocene, and may vary from 300 to 1,000 m thickness.

(ii) Upper Red Formation which may be Miocene-Pliocene age.

(iii) The above two formations give rise to salt plugs.

*Land use.* Wastelands, not suitable for grazing.

*Distribution.* As shown in Map D10, this unit (14) occupies over 14.8 million ha or about 9 percent of the total land surface of Iran. Table 40 gives this distribution in various areas.

### 3.44 Calcareous Lithosols–Brown soils and Chestnut soils (Soil Association 15)

This is an association of soils occurring on steep, dissected, rough or broken hilly areas in the Brown and Chestnut soil zones. There is only slight soil development as most of the soil is removed by natural erosion. Where the soils exist, subsoils remain and sometimes a Ca horizon appears on the top when A is eroded. Unweathered, or only slightly weathered parent material, normally limestone, is exposed over much of the area.

This soil association has small inclusions (estimated at 5 percent) of shallow

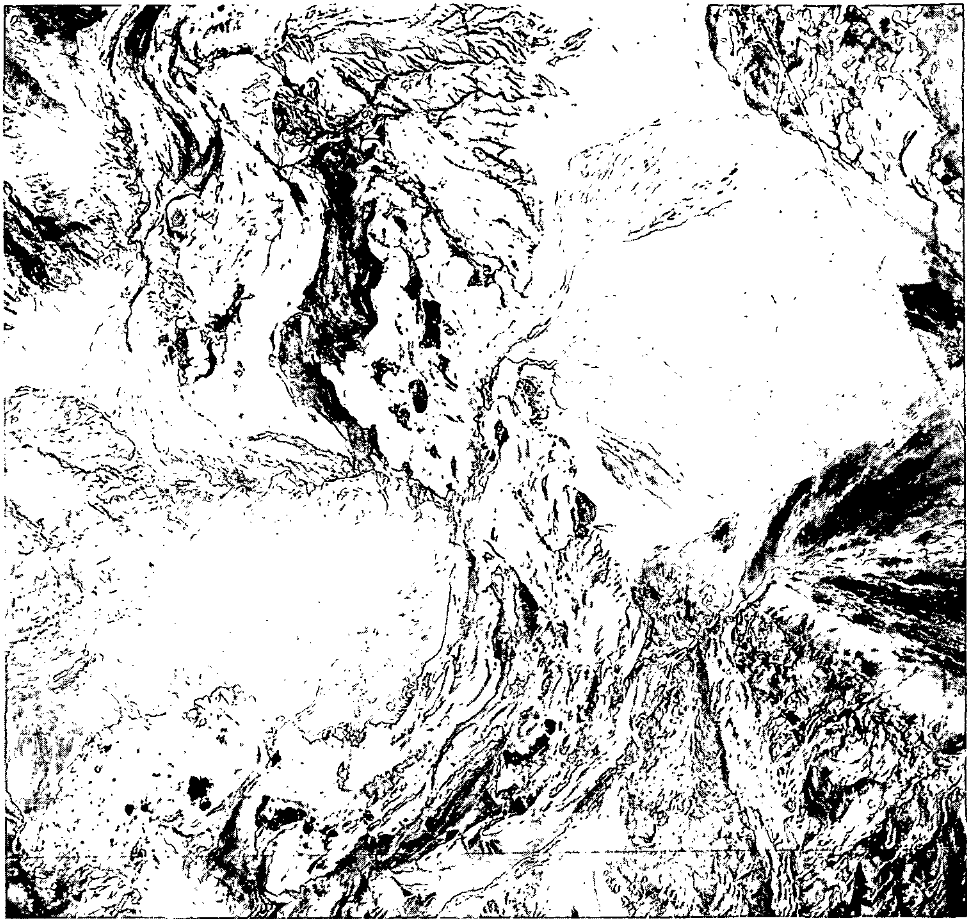


FIGURE 67. Garmsar area (1:60,000 scale) near the Great Salt Desert (Dasht-i-Kavir) east of Tehran. The photo shows a salt plug (14) called the Upper Red Formation of the Fars Series which consists of saliferous and gypsiferous marls as well as salt lenses. The area covered by salt plugs in Iran may be even less than 1 percent, but as much as 11 to 12 million hectares or about 7 percent of land surface is affected by this formation and is therefore unfit for any present or potential agriculture. These plugs are responsible for salt desert formation, salinization of bodies of water, streams, etc., and are a source of salinity in many parts of the country. In some places the plugs are mined for salt for human and animal consumption.

and medium depth soils which are used for dry farming. There are many small arable or potentially arable areas of Brown soils at the foot of slopes, and some narrow strips of alluvial soil in the flood plains of streams which drain the areas. Other cases include stony areas and areas with frequent outcrops of bed rock.

These include narrow V-shaped valleys, steep-sided valleys, valleys with no soil

FIGURE 68. The salt plug photographed is responsible for the Solonchak soils of the Garmsar, Kavir, and Darab area. Rainwater washes away a great portion of the salt domes and carries salt to the Garmsar Plain. In very good permeable soils, only moderate salinity results and moderate crop yields can be obtained under proper soil management. However, salty deserts often result in slow permeable soils of flat areas and closed basins.

covering, and narrow steep divides. Water runoff is normally rapid but there are large karstic areas in the rocks along the outcrops of calcareous formations, like Eocene, Upper Cretaceous and Upper Jurassic, which take in the water and are characterized by many strong streams. However, snow stays on the ground for some time in a part of the area, especially on the western slopes.

Some areas of badland topography are included in this unit. The badland consists of steep and very steep gullied and dissected barren or nearly barren land.

Essentially, badland is topographically similar to rough broken land, but differs in having no vegetation cover.

In this association where there is a soil covering, the thin Lithosol associated with Brown and/or Chestnut soils consists of a layer or layers as described in the following profiles.

15 E: Lithosols-Brown soils, rough hilly land (15-40 percent).

*Profile No. 113, in Doroodzan area.*

| | |
|---|---|
| 0-15 cm | Brown (10 YR 5/3 m) loam, slightly gravelly, granular, strong effervescence. |
| 15-40 cm | Very pale brown (10 YR 7/3 m) loam, prismatic structure, violent effervescence. |
| 40 cm + | Calcareous conglomerate rock. |

15 EF: Lithosols, Brown soils, rough hilly and mountainous land (40 percent +)

*Profile No. 94, between Tabriz and Ahar in Azerbaijan, at an elevation of about 7,000 ft above mean sea level.*

| | |
|---|---|
| 0-4 cm | Dark grey-brown (10 YR 4/2 d, 3/2 m) clay loam, granular, friable, with abundant roots, strong effervescence. |
| 4-60 cm | Dark grey-brown (10 YR 4/2 d, 3/2 m) clay, strong granular structure, some lime concretions, strong effervescence. |
| 60-120 cm | Light brownish-grey (2.5 Y 6/2 d) friable, plastic clay with considerable lime concretions, violent effervescence. |
| 120 cm + | Limestone with a light brown (10 YR 4/3 m) clay deposited in the crevices, violent effervescence. |

*Range in characteristics.* Normally only 15 to 20 cm layers of a thin soil, greyish-brown to brown, of strongly calcareous clay or clay loam, are found. This thin soil is quite similar to the surface layer of brown soil and, under more favorable relief, normal soils of this group could be expected. The two profiles described are from areas with greater depth than the normal layers.

*Relief.* Included in this unit are rough mountainous lands, and a combination of rough broken and rough mountainous lands. These comprise areas which are dominantly mountainous, with local relief in hundreds and thousands of meters and slopes more than 40 percent.

Local relief ranges considerably: slopes between 15 and 40 percent, but much steeper as well as less sloping areas are included. This unit is intended to include nonarable land slopes ranging up to about the upper limit suitable for grazing.

*Drainage.* Excessive external drainage and partly moderate to good internal drainage.

*Vegetation.* Normally a thin cover of short and medium grasses, similar to that of Brown soils (strongly sloping) though much thinner. The plants that have been observed in the Zagros region are *Acer cinerascens, Daphne angustifolia, D. causa sica, Fraxinus oxycarpa, Tuniperus polycarpus, Lonicera arborea, Pistacia khinjuk, P. mutica, Prunus mahaleb, Pirus syriaca, Quercus persica, Ulnus procera;* in the Khurasan region, species such as *Juniperus polycarpus, Lonicera arborea, Pistacia khinjuk, P. mutica, P. vera,* and *Sorbus persica.*

*Parent material.* Usually limestones, or calcareous rocks such as calcareous conglomerate.

*Land use.* The greatest part is unsuited for cropland, but is used for grazing sheep and cattle, the present or potential major land use. However, the land has a very low carrying capacity and almost all areas are severely overgrazed.

Calcareous Lithosols associated with Brown and Chestnut soils have been mapped in the field as three partly merging subunits:

| | | *Usual slope* % | *Usual inclusions of possible area to be cropped* % |
|---|---|---|---|
| 15 E | Rough broken land | 15-40 | 10-20 |
| 15 EF | Rough broken and mountainous land | Combination of slopes of 15 E and 15 F | 5-10 |
| 15 F | Rough mountainous land | 40 + | 2-5 |

Large areas of this type occur in hilly and mountainous country, both in the Elburz and Zagros ranges: some are intermixed with stretches of arable soil, others occupy continuous areas of several hundred square kilometers. As a whole, the unit comprises nonarable lands but includes many small patches of soils which are suitable as cropland. There are large inclusions of moderately and strongly sloping areas of low value for cropland, as well as narrow valleys of alluvial soil and gently sloping soil well suited for cropland. In general, about 10 to 15 percent of these soils are suitable for dry farming.

*Distribution.* These three subunits are distributed in all parts of Iran (Table 40). They occupy over 21 million ha or about 13 percent of land surface of Iran as shown on Map D11.

*Analytical data.* See Table 31.

FIGURE 69. Calcareous Lithosols (Soil Association 15). A hillside near Shahabad West in the Kermanshah Ostan. There are still oak trees where the exploitation is limited. Nearby are bushes.

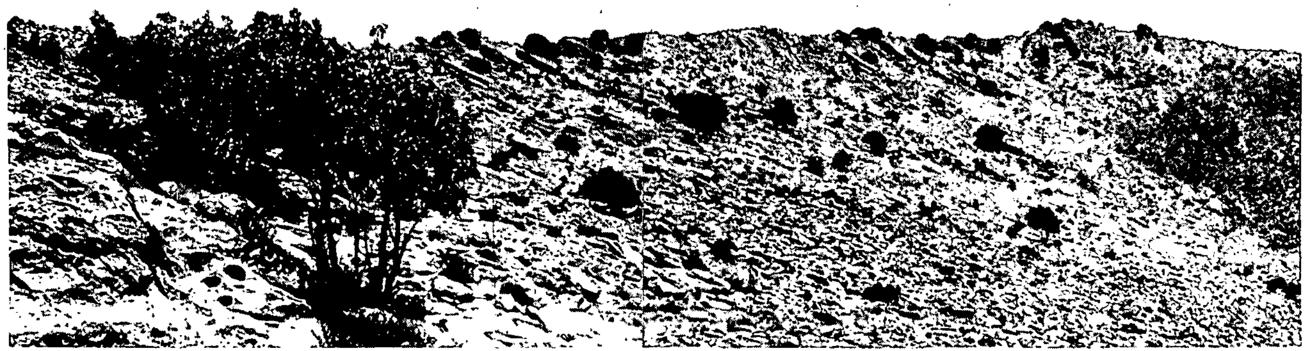
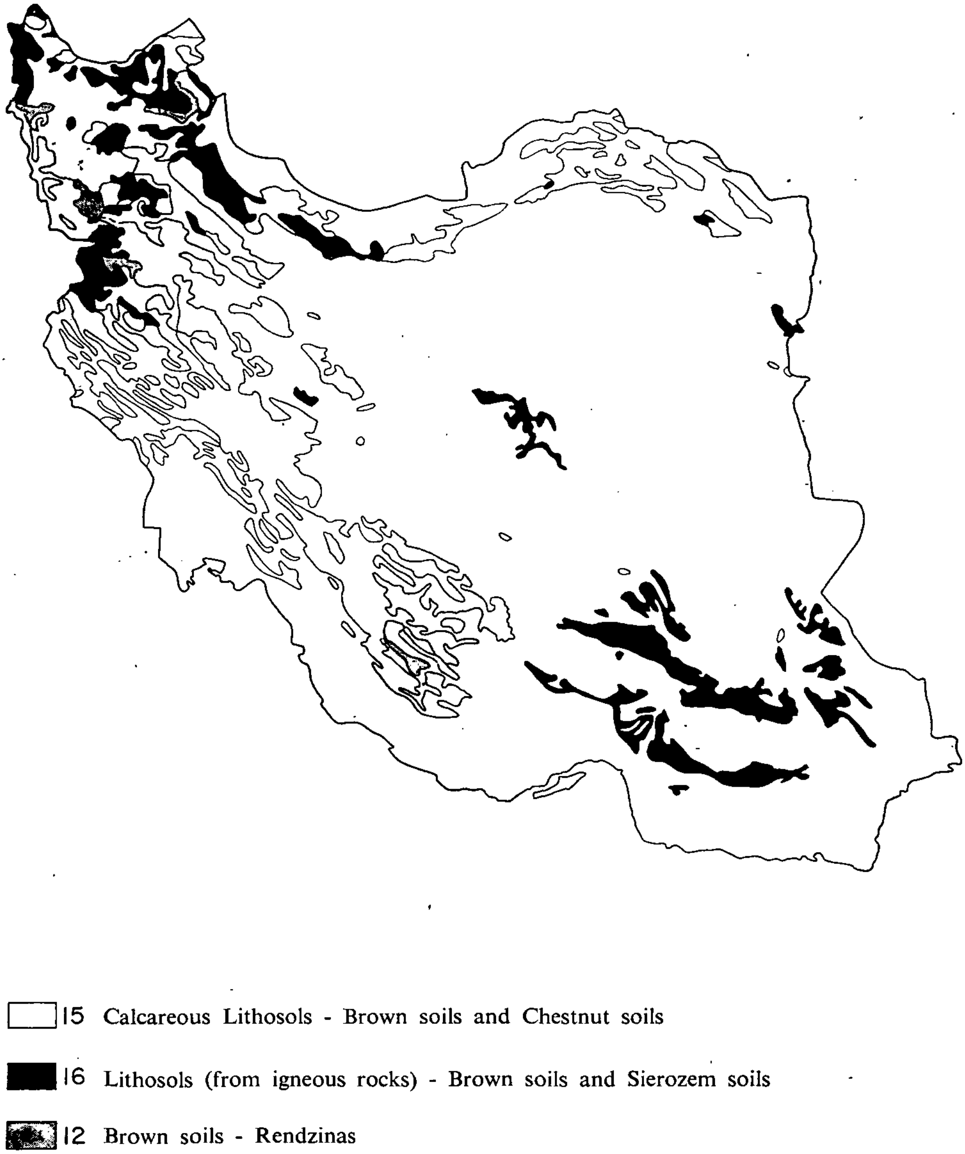


FIGURE 70. Lithosols-Brown soils, east of Tehran, plowed for dry farming.




MAP D11. Distribution of soils in Iran.

3.45 LITHOSOLS (from igneous rocks)—BROWN SOILS AND SIEROZEM SOILS

These lithosols have a great similarity to Unit 15 (Calcareous Lithosols - Brown and Chestnut soils) both in profile and in associated land features, but with the following differences:

1. Lithosols are usually not calcareous or only slightly so.
2. They are developed from igneous rocks.
3. They have usually steeper slopes and thus smaller percentages of inclusions which have dry-farming possibilities.

The soils can be divided in two subgroups: (*a*) Soils in the northwest with moderate precipitation as well as more vegetation; soil development is more and soil erosion, less. (*b*) Soils in southeastern and central Iran show less soil development, much less vegetation, and more severe erosion.

Some typical profile descriptions of Lithosols (from igneous rocks) associated with Brown and Sierozem soils are given below.

Brown soils on rough, broken land (8-15 percent).

*Profile No. 30, village of Pivak, about 6,000 ft elevation, 15 km north of Birjand.*

| | |
|---|---|
| 0-2 cm | Pinkish-grey (5 YR 6/2 m) fine gravelly clay loam. |
| 2-4 cm | Dark reddish-brown (5 YR 3/3 m) gravelly clay loam, granular structure. |
| 4-20 cm | Dark reddish-brown (5 YR 3/ 3 m) clay without gypsum and with lime. |
| 20-40 cm | Dark reddish-brown (5 YR 3/3 m) clay with gypsum and lime with blocky structure. |
| 40-55 cm | Basic igneous rock, partly decomposed. |
| 55 cm | Basic igneous rock, hard and not decomposed. |

*Profile No. 34, west of Mashhad.*

| | |
|---|---|
| 0-5 cm | Reddish-brown (2.5 YR 5/3 m) sandy clay loam. |
| 5-20 cm | Dark reddish-brown (2.5 YR 3/3 m) clay loam, friable, blocky. |
| 20 cm + | Reddish igneous rock as parent material. |

*Range in characteristics.* Surface textures vary from loamy sand to clay loam, but being on steep slopes are gravelly to very gravelly. The colors of surface and subsoils are reddish or have a reddish tinge. The profiles described above are not indicative of the area as a whole but of "spots." Lime content is usually small but differs from place to place and relates to the parent rock, seldom more than 15 percent, as against similar Lithosols in association with Brown and Chestnut soils where the subsoil may have as much as 50 to 70 percent $CaCO_3$. Organic matter content in the surface is very small, usually less than 0.5 percent.

*Relief.* Hilly or mountainous. Local relief varies considerably. Gradients

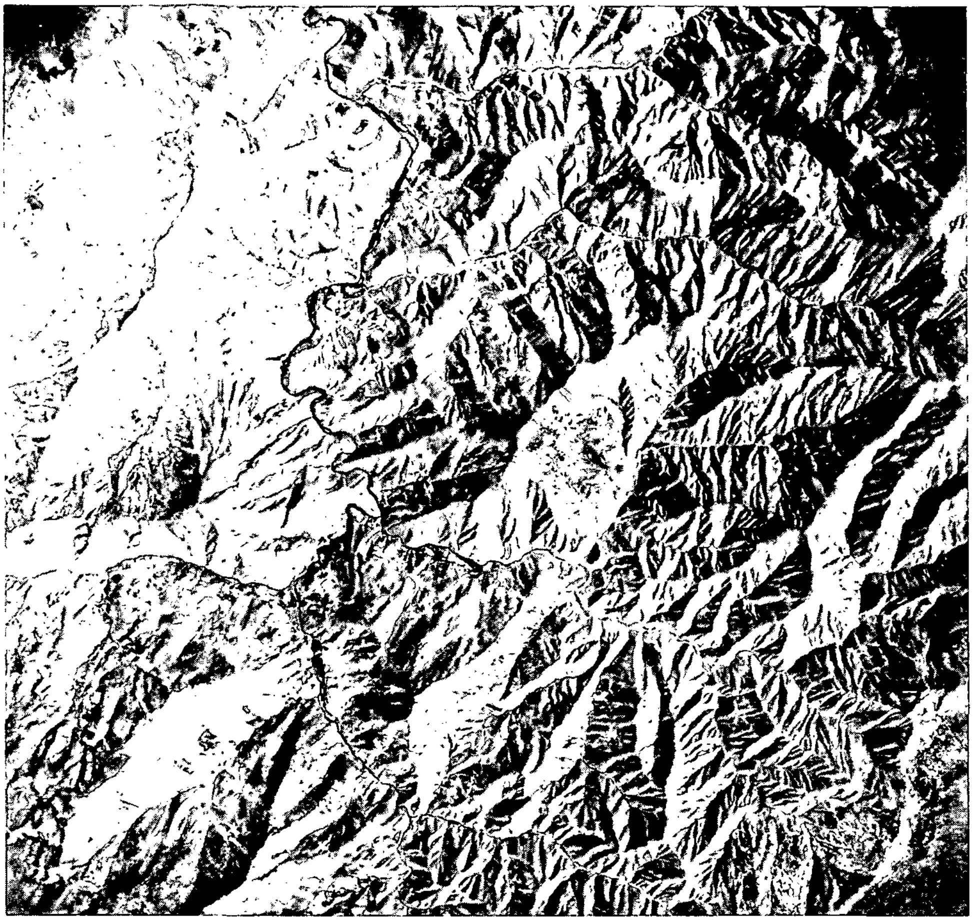


FIGURE 71. Soils of the dissected slopes and mountains in Calcareous Lithosols-Brown soils (15), northwest of Mahabad. Though dissected slopes are very prominent there are large patches where dry farming is practiced. In the area are small streams and the layout shows greater amount of rainfall. On steep slopes, surface runoff is rapid and erosion severe.

range from 15 to 60 percent, though much steeper as well as some slightly less sloping areas are included.

*Drainage.* Normally excessive external drainage.

*Vegetation.* This differs to some extent in the northern and northwestern parts of Iran. Plant species include *Acer campestris, Asynema pulchellum, Berberis integerrima, V. vulgaris, Carpinus orientalis, Helianthemum* sp., *Juniperus* sp., and *Overcus* sp.

Normally a thin cover of short grasses, *Artemisia* species, and in the case of drier areas, even *Alhagi camelorum* is observed.

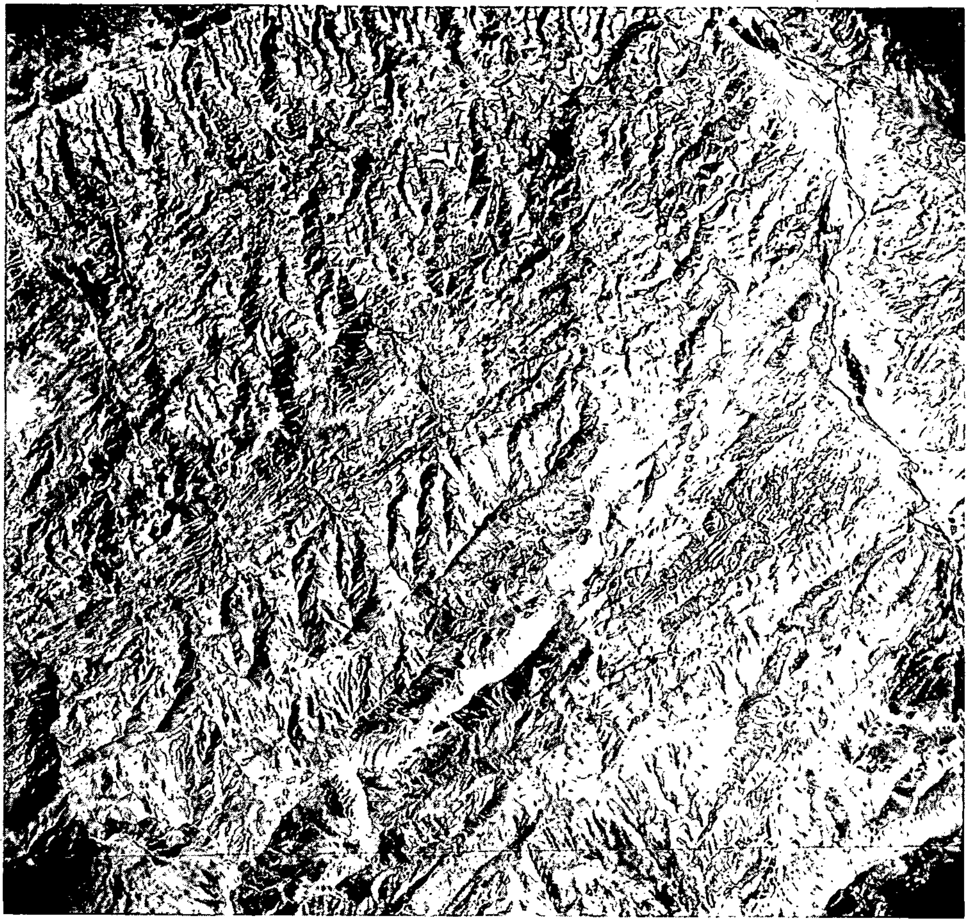


FIGURE 72. An area between Qasr-e-Shirin and Ilam in western Iran. All slopes are very much dissected, surface runoff is very rapid, and erosion very severe. Some bush vegetation grows in high inaccessible areas. There is grazing in accessible areas but hardly any cultivation, except on some gentle to moderate slopes near the river bank on the northeast corner. Calcareous Lithosols associated with Brown soils (15) occur in large areas in the north, northwest, west, and southwest mountainous areas of Iran. They are developed on limestones and other calcareous material.

*Parent material.* Parent material is very variable, but mostly of igneous and metamorphic rocks of different periods from Pre-Cambrian to Recent.

Igneous rocks of different types can be present such as acid (granite, granadiorite, quartz prophyries), intermediate (diorite, andesite, prophyrites), basic (basalts, diabases, gabbros), or ultrabasic (olivine basalt, periodite, serpentine).

Metamorphic rocks have occurred in various regions of Iran and during different periods. Some of these rocks are Pre-Cambrian metamorphic from central Elburz and Pre-Devonian from Gorgan and from northwestern Iran. In southwestern Iran metamorphic schists are overlaid by basic limestone. Mesozoic schists and marbles are found in central and northwest central Iran. Post-Eocene metamorphic rocks occur around Zahedan.

*Land use.* The greater part is unsuited for cropland, but is used for grazing sheep and cattle. It has a very low carrying capacity and almost all areas are severely overgrazed. Some pockets suitable for cultivation also occur in this association. Below is listed the percentage of areas which are, or can be brought under, cultivation.

Unit 16 was mapped in three distinct subunits in the field, on the 1:1,000,000 scale:

| | | *Slope %* | *Area which can be brought under cultivation %* |
|---|---|---|---|
| 16 E | Rough broken land | 15-40 | 10 |
| 16 EF | Complex of rough broken and rough mountainous lands | 15 + | 5 |
| 16 F | Rough mountainous land | 40 + | 2 |

*Distribution.* The areas of this soil association occupy about 10.6 million ha or about 6.4 percent of land surface of Iran. This association occurs in each part of Iran as shown in Table 42 and on Map D11.

*Analytical data.* See Table 41.

TABLE 41. — LABORATORY ANALYSES OF TYPICAL LITHOSOLS (FROM IGNEOUS ROCKS) — BROWN SOILS AND SIEROZEM SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | Soil symbol | S.P. | % T.S.S. | pH paste | T.N.V. % | % Org. C | Av. P | Av. K | C.E.C. Me/100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | 0–4 | 1549 | Near Pivak-Birjand | | 28 | 0.05 | 7.6 | 7 | 0.2 | 10 | 300 | 14.4 |
| | 4–20 | 1550 | | | 36 | 0.07 | 7.4 | 7 | 0.1 | 9 | 360 | 19.1 |
| | 20–40 | 1551 | | 16 | 45 | 0.11 | 7.2 | 10 | 0.2 | 4 | 240 | 23.4 |
| | 40–55 | 1552 | | | 42 | 0.09 | 7.3 | 6 | 0.1 | 5 | 170 | 22.6 |
| 34 | 0–5 | 1567 | West of Mashhad | | 31 | 0.03 | 7.7 | 13 | 0.3 | 18 | 200 | |
| | 5–20 | 1568 | | 16 | 37 | 0.04 | 7.9 | 15 | 0.3 | 6 | 180 | |

TABLE 42. — DISTRIBUTION OF CALCAREOUS LITHOSOLS-BROWN AND CHESTNUT AND BROWN SIEROZEM SOILS FROM IGNEOUS ROCKS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Brown and Chestnut soils 15 | | Brown Sierozem from igneous rocks 16 | | Total | |
|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | 1 040 | 27.37 | 600 | 15.79 | 1 640 | 43.16 |
| 2. Mazanderan | 14 000 | 1 560 | 11.42 | 180 | 1.28 | 1 740 | 12.70 |
| 3. Azerbaijan | 10 500 | 2 240 | 21.33 | 1 620 | 15.34 | 3 860 | 36.67 |
| 4. Kurdistan | 3 122 | 987 | 31.62 | 786 | 25.18 | 1 773 | 56.80 |
| 5. Kermanshah | 6 212 | 2 170 | 34.93 | 374 | 6.02 | 2 544 | 40.95 |
| 6. Khuzistan | 13 466 | 4 623 | 34.44 | — | — | 4 623 | 34.44 |
| 7. Fars | 17 420 | 3 650 | 20.90 | — | — | 3 650 | 20.90 |
| 8. Kerman | 23 280 | 160 | .69 | 3 480 | 14.95 | 3 540 | 15.64 |
| 9. Khurasan | 30 900 | 2 800 | 9.60 | 200 | .65 | 3 000 | 10.25 |
| 10. Esfahan | 17 600 | 920 | 5.23 | 480 | 2.73 | 1 400 | 7.96 |
| 11. Baluchistan | 18 500 | 20 | .11 | 2 160 | 11.68 | 2 180 | 11.79 |
| 12. Tehran | 6 200 | 1 200 | 19.36 | 720 | 11.61 | 1 920 | 30.97 |
| Total for the country | 165 000 | 21 370 | 12.96 | 10 600 | 6.43 | 31 970 | 19.39 |

3.46 LITHOSOLS-BROWN FOREST SOILS AND RENDZINAS (Soil Association No. 17)

This association consists of lithosolic Brown Forest soils and of Rendzinas which are mostly unsuited for cultivation. The terrain is steep, irregular, and rough. The area consists of weathered or partially weathered geologic materials, but there is a thin to medium soil cover in places.

The soil consists of a 5 or 10 cm layer of very dark brown organic material on the surface. Typical profiles in this hilly area are given below.

*Profile 49, located 5 km south of Chalus, vegetation, mixed forest, elevation 15 m above mean sea level or about 43 m above Caspian level.*

0-5 cm Very dark brown (10 YR 2/2 m) clay loam, moderately granular structure, high biological activity, abundant roots and earthworms, high

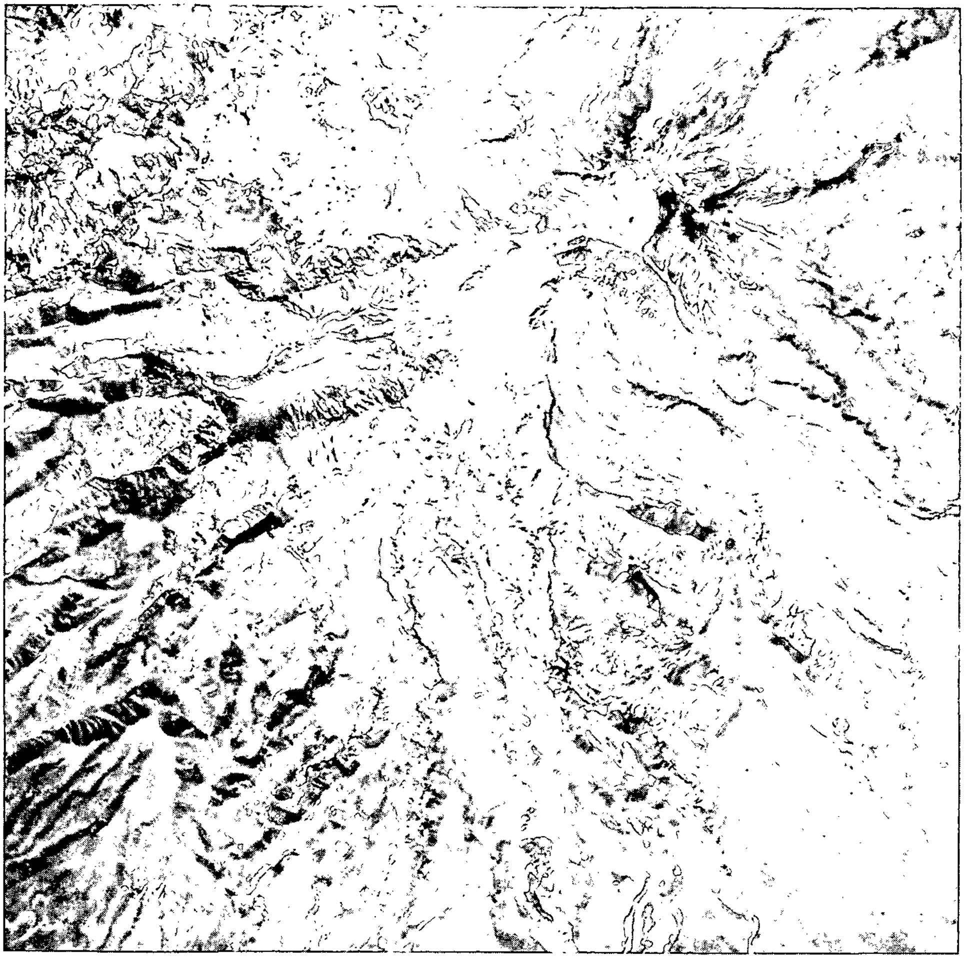


FIGURE 73. The Khash area in Baluchistan where igneous rocks are the underlying parent material. The predominant soil association here is Lithosols-Sierozem soils. In the northeast quarter of the photo the volcanic origin of the area is depicted. Lithosols (from igneous rocks) associated with Sierozem and Brown soils occur in northern, northwestern, and southeastern parts of Iran. The underlying rocks may be igneous, may have volcanic origin, and may be metamorphic or semimetamorphic.

in organic matter (mull type); some sea shells; slight effervescence, pH about 7.

5-20 cm Dark brown (10 YR 7/3 m) silty clay loam, moderately granular, less roots, no mottling, moderate effervescence due to presence of some shells and some calcareous gravel particles, pH about 6.5.

20-60 cm Dark greyish-brown to dark brown (10 YR 4/2 - 4/3 m), moderately granular. Sandy clay loam, slightly sticky, little mottling, some gravel which gives rise to violent effervescence, pH of soil mass about 6.5.

60 cm + Calcareous conglomerate, violent effervescence.

*Profile No. 74, about 42 km south of Rasht in a predominantly oak forest area; in rough hilly and mountainous area (slope 40% +).*

0-5 cm Dark grey-brown to dark brown (10 YR 4/2 d, 3/2 m) silt loam, granular, friable, with considerable organic matter, slight effervescence, pH about 7.5.

5-20 cm Dark grey-brown to dark brown (10 YR 4/2 d, 3/3 m) loam, granular, friable, slight to strong effervescence, pH about 7.5.

20-80 cm Dark grey-brown to dark brown (10 YR 4/2 d, 3/3 m) loam, granular, friable, violent effervescence, pH about 8.

80-140 cm Brown to dark brown (10 YR 4/3 m) gravelly clay loam, friable, blocky structure, and some lime accumulation, violent effervescence, pH about 8.

140 cm + Limestone, partially decomposed.

*Profile No. 15, near Narjakban in the Caspian foothills.*

0-10 cm Very dark brown (10 YR 2/2 m) clay loam, strong fine granular, moist friable, no mottling, abundant roots, no effervescence.

10-40 cm Grey to very dark grey (10 YR 5/1 d, 3/1 m) clay, moderate fine to medium blocky to strong fine granular, hard when dry, no mottling, moderate roots, slight effervescence.

40-80 cm Very dark greyish-brown and light grey (10 YR 3/2 m, 10 YR 7/2 m,) clay, dry hard, no mottling, slight roots, slight effervescence, moderate to abundant lime concretions.

80 cm + Calcareous gravel.

*Caspian profile No. 25, 24 km east of Gorgan in mixed forest.*

0-10 cm Very dark greyish-brown (10 YR 3/2 m) silty clay, fine granular structure, very friable, no mottling, abundant roots, no effervescence.

10-40 cm Brown to dark brown (10 YR 4/3 m) silty clay loam, moderate medium blocky, moist firm, no mottling, moderate roots, some small gravel, no effervescence.

40 cm + Brown to dark brown (10 YR 4/3 m) silty clay loam, moderate medium blocky, moist firm, no mottling, moderate roots, no effervescence, very gravelly with some deposit of lime on gravel (igneous gravel, not limestone, not calcareous).

*Range in characteristics.* The rough mountainous land in the Brown Forest soil zone contains no soil covering or a thin one, varying with slope and character of rock. Nearly vertical rocky slopes without soil or vegetative covering occur, intermixed with small patches of partly weathered rock and soil material where trees and shrubs form a thin to thick cover. In places shallow and medium depth soils have developed on colluvium.

*Relief.* The terrain is usually steep, rough, and irregular.

*Drainage.* Excessive external drainage; moderate to slow internal drainage.

*Vegetation.* Vegetation ranges from a thin brush-grass cover to a thick stand of deciduous trees, mainly beech, hornbeam and elm, with pine and fir in places. Where bare, the absence of trees is due to destructive cutting and burning (for charcoal, etc.). Erosion has removed the original soil covering from some steep rocky slopes and hard rock is now exposed in several of these areas. The plants normally found on this soil association are *Acer insigne*, *Alaetum*, *Alnus subcordata*, *Artemisia obsinthium*, as well as species such as *Fraxinus*, *Hypercum*, and *Jasminum*.

*Parent material.* Parent rock ranges from limestone, conglomerates, and shales, to schists, gneiss, and volcanic rocks.

*Land use.* Under prevailing management, these rough broken lands produce only a fraction of the potential forest products. Few areas have a good stand of trees, and none was observed under good forest management practice. Under improved management, these areas could become a valuable resource for fruit and agricultural production; with destructive use, they become wasteland. An estimate is given below of the percentage areas that are or could be brought under cultivation in this soil association.

| | | *Slope %* | *Area which can be brought under cultivation %* |
|---|---|---|---|
| 17 E | Rough broken land | 15-40 | 15 |
| 17 EF | Rough broken and mountainous land | 15-40 | 10 |
| 17 F | Rough mountainous land | 40 + | 5 |

*Distribution.* This soil association occupies about 2.3 million ha or 1.4 percent of the land surface of Iran. Though small in extent, it is important and occupies the areas shown on Map D12.

*Analytical data.* See Table 43.

TABLE 43. — LABORATORY ANALYSES OF LITHOSOL—BROWN FOREST AND RENDZINA SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | S.P. | % T.S.S. | pH | | % T.N.V. | % Org. C | Av. P | Av. K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Paste | 1:5 | | | | | | | |
| 49 | 0–5 | 1650 | 5 km south of Chalus | 134 | 0.14 | 7.1 | 7.9 | 2 | 5.1 | 15. | 270 | 43.8 | .1 | .7 |
| | 5–20 | 1651 | | 101 | 0.09 | 6.8 | 8.1 | 33 | 2.9 | 6.5 | 190 | 36.4 | .1 | .5 |
| | 20–60 | 1652 | | 51 | 0.06 | 7.3 | 8.4 | 37 | .8 | 6.5 | 110 | 17.4 | .1 | .3 |

3.47 REGOSOLS (mainly from sandstones) - RED-YELLOW PODZOLIC SOILS (Soil Association No. 18)

*Profile No. 53, situated about 8 km south of Shahsavar in the mountains. Tea garden area on about 50 percent slope where a horizon was apparently washed completely away, about 100 m above mean sea level.*

0-5 cm Light brownish-grey (10 YR 6/2 m) gravelly clay, blocky structure, hard when dry, plastic when wet, no effervescence with Hcl, pH 6.

5-20 cm Dark greyish-brown (10 YR 4/2 m) moist gravelly clay, strong blocky, plastic when wet, no effervescence, pH 6.

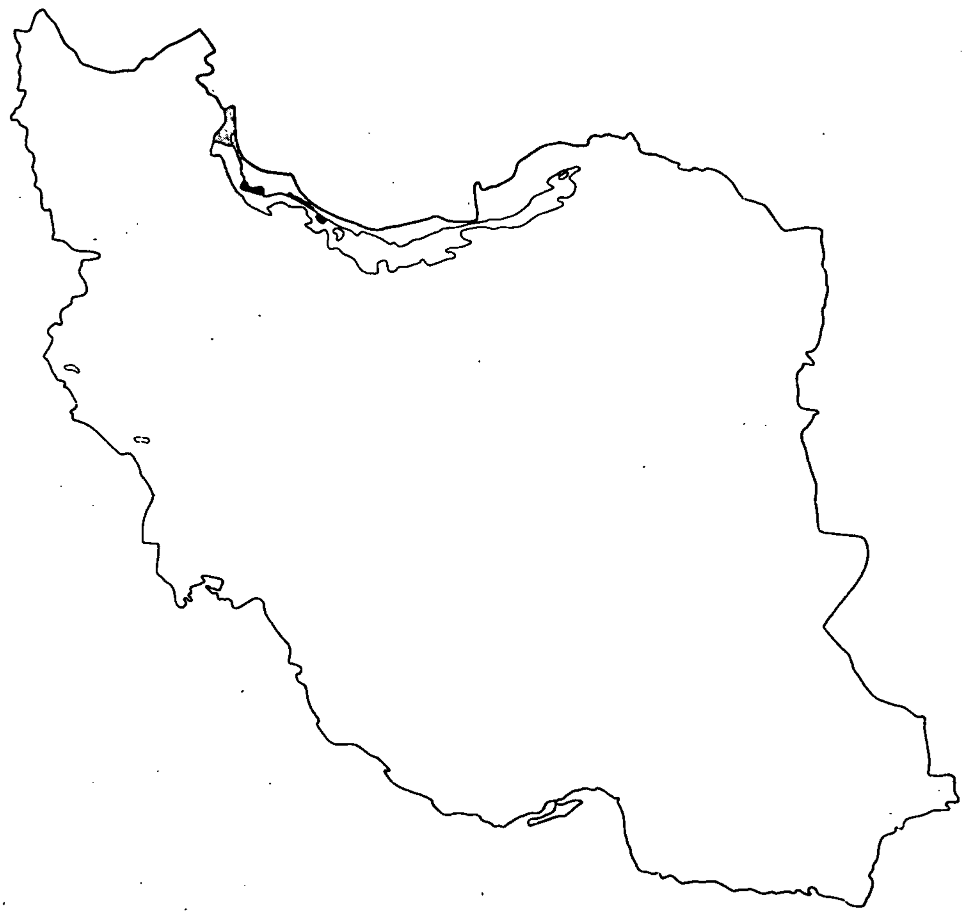
20-30 cm Dark brown (7.5 YR 4/3 m) gravelly clay, moist, plastic, gritty, pH 6.

30-40 cm Rock.

*Range in characteristics.* Red-Yellow Podzolic soils, associated with sandstones and other parent rocks, are found to occur in certain parts of the northern slopes of the Elburz. They usually occupy hilly and mountainous parts and are all forested. Where the forest is cut and where slope is steep, there is severe erosion. The color of the surface horizons varies from deep red to yellow, depending on the parent material.

*Relief.* Hilly and mountainous.

*Drainage.* Excessive external drainage; moderate internal drainage.



17 Lithosols - Brown Forest soils and Rendzinas

18 Regosols (mainly from sandstones) - Red-Yellow Podzolic soils

19 Lithosols (mainly from igneous rocks) - Brown Forest and Podzolic soils

MAP D12. Distribution of soils in Iran.

*Vegetation.* Some areas support a fair to good growth of pine, fir, and in places spruce and some deciduous trees. Others are essentially bare due to the complete destruction of original forest.

*Parent material.* Normally sandstones, sometimes shales and conglomerates.

*Land use.* Essentially for forest, although some selected areas have been used for specialized crops such as tea.

*Distribution.* As shown in Map D12, the area of Regosols associated with Red-Yellow Podzolic soils is 170,000 ha mainly in the western part of the Caspian area.

*Analytical data.* See Table 44.

3.48 LITHOSOLS (mainly from igneous rocks) - BROWN FOREST AND PODZOLIC SOILS (Soil Association No. 19)

This is a complex of rough broken land and rough mountainous areas wherein the normal soil formation processes would lead to the development of Grey-Brown or Brown Podzolic soils. Relief is the dominant factor, and natural erosion has kept pace with soil development.

Some of the profiles studied in the areas mapped in this association are described below. It shoud be clear, however, that the profiles described are not representative of these lithosolic soils. They merely illustrate the type of profile that develops in this climate on more favorable relief. Soils as described exist only in small areas and cannot be delineated specifically even in large-scale maps.

Three profiles are described below of areas which have similarities to Brown and Grey-Brown Podzolic soils. All are on steep to very steep slopes.

*Profile No. 64, in a tea garden south of Divishal village on a hilltop, about 150 m above mean sea level.*

| | |
|---|---|
| 0-20 cm | Dark grey-brown (10 YR 4/2 d, 3/2 m) gravelly silt loam, granular structure, moist and friable in consistence, some roots. |
| 20-40 cm | Very dark grey-brown (10 YR 3/2 m) gravelly clay loam, blocky structure, friable consistence and sticky when wet. |
| 40-100 cm | Very dark grey-brown (10 YR 3/2 m) slightly gravelly clay loam, weak blocky, no mottling. |
| 100-140 cm | Very dark grey-brown (10 YR 3/2 m) clay loam, with some tinge of reddish-yellow obtained from the color of the parent material. |
| 140 cm + | Basic igneous (granite) rock, partially decomposed. |

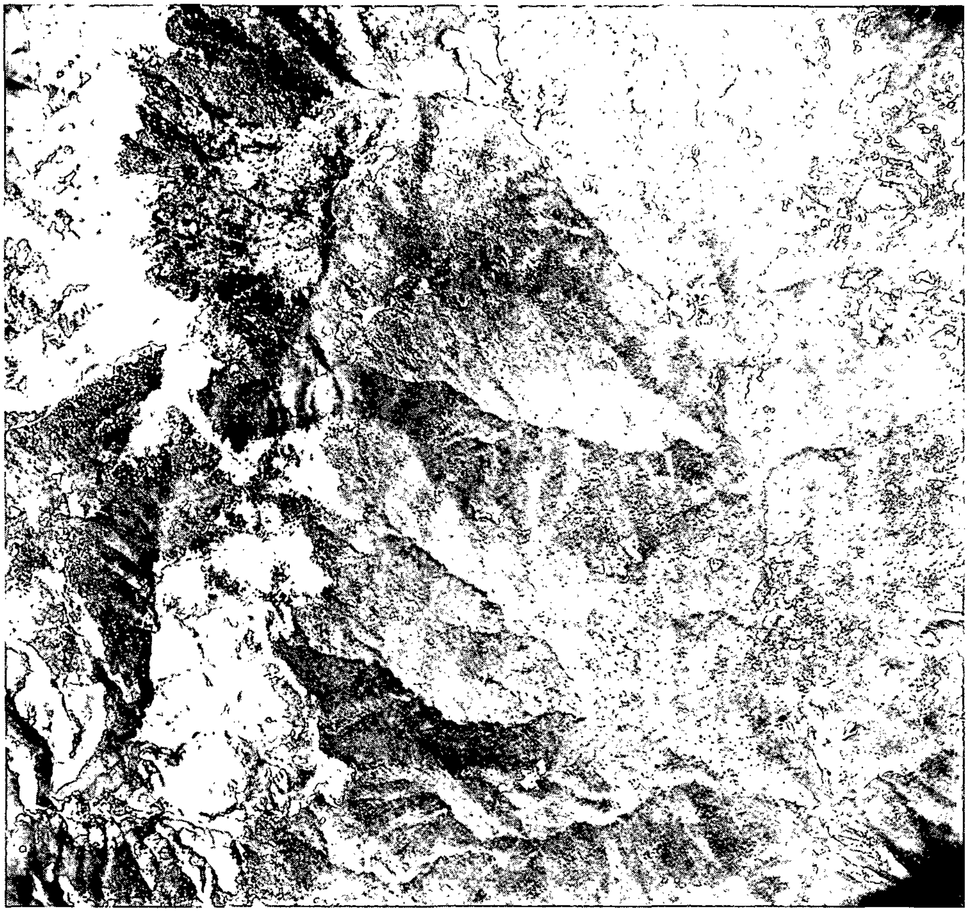


FIGURE 74. Brown Forest soil (11 and 17) near the Rasht district, part of which has been cleared of trees; here erosion is very active. Brown Forest soils exist in the semihumid regions of the Caspian shore, where the parent material is highly calcareous. Areas of this group of soils are moderately sloping with shallow and medium-depth soils in mountainous parts. They are mostly suited for growing certain useful types of trees. Some areas were originally forested but as a result of irrational cutting, a large portion of the forests was destroyed. The soil is eroded due to lack of cover and steepness of slope.

*Profile No. 57, situated 12 km south of Ramsar in the mountains at an elevation of 350 m above mean sea level; under an oak walnut type of mixed vegetation.*

$A_1$ 0-5 cm Dark brown (10 YR 3/3 m) sandy clay loam, mull type, organic layer; fungi growing on the surface, granular structure, friable

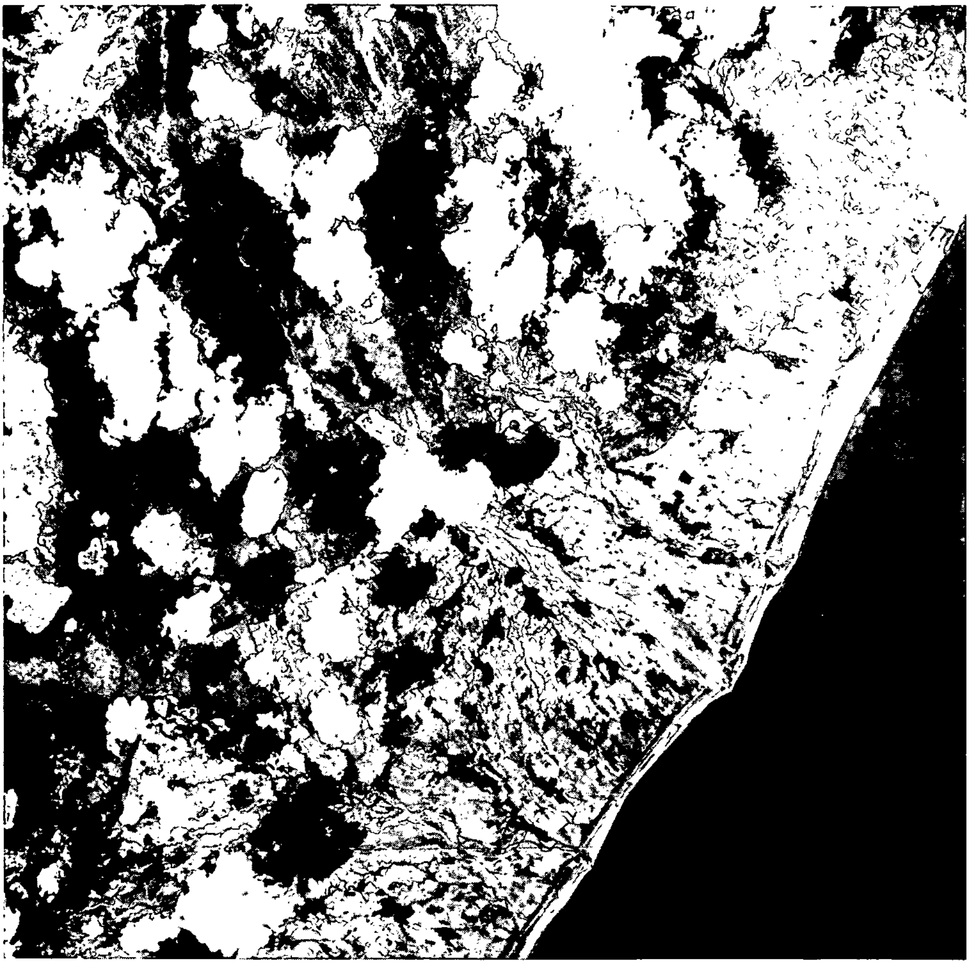


FIGURE 75. Ramsar Forest area comprises Brown Forest soils including Grey-Brown Podzolic in the piedmont areas and Lithosols (mainly from igneous rocks) in association with Brown Forest and Podzolic soils in the dissected slopes and mountains (19). Near the sea Low Humic-Gley and Humic-Gley soils (3) are observed, mainly under paddy culture. Some Alluvial soils are under citrus and other orchards. The photograph shows some clouds as the area is one of high rainfall (above 1,000 mm).

| | | |
|---|---|---|
| | | consistence, considerable roots. |
| $A_2$ | 5-15 cm | Dark brown (10 YR 4/3 m) loamy coarse sand, with some gravel. |
| $B_1$ | 15-40 cm | Dark brown (7.5 YR 3/2 m) gravelly loamy coarse sand, friable. |
| C | 40 cm + | Ferruginous shale. |

*Profile No. 66, near Dehlimi village, about 10 km east of Lahijan in a tea garden area.*

A 0-5 cm Grey-brown (10 YR 5/2 m) gravelly clay loam, dry and cloddy, pH about 6.

B 5-25 cm Very dark greyish-brown (10 YR 3/2 m) gravelly clay loam, blocky structure, pH about 6.

C 25 cm + Granite.

*Relief.* Mountainous and hilly. Changes in slope, elevation, and location in relation to mountain barriers and rainfall exert marked changes in the character of local areas.

*Drainage.* Moderate to excessive.

*Vegetation.* Vegetation is equally variable. Some areas support a fair to good forest growth of pine, fir, and in spots, spruce and some deciduous trees. Other areas are essentially bare, due to complete destruction of the original forest.

*Parent material.* Parent material is mainly of extrusive, intermediate igneous rocks such as diorite, andesite, and prophyrites.

*Land use.* Lithosols associated with Grey-Brown Podzolic soils (usually from igneous rocks) are very shallow, situated on steep slopes, they are usually left under original oak forest where soils are too shallow even for tea. Otherwise some areas are being cleared for tea cultivation.

*Distribution.* A total of about 200,000 ha of this association is mapped, mainly in western Caspian area (Table 45).

*Analytical data.* See Table 44.

TABLE 44. — LABORATORY ANALYSES OF LITHOSOL, BROWN FOREST, AND PODZOLIC SOILS

| Profile no. | Depth (cm) | Lab. no. | Location | S.P. | % T.S.S. | pH Paste | pH 1 : 5 | % T.N.V. | % Org.C | Av. P. | ppm K | C.E.C. Me/100 | $E_{Na}$ | $E_K$ | Ca+Mg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | 0– 5 | 1655 | 8 km | 67 | .03 | 6.3 | 6.9 | 0 | 1.5 | 12 | 120 | 29.9 | .1 | .3 | 18.3 |
| | 5– 20 | 1656 | south of Shahsavar | 60 | .04 | 6.1 | 6.8 | 0 | 1.2 | 9.5 | 120 | 27.8 | .1 | .3 | 17.5 |
| | 20– 30 | 1657 | | 64 | .05 | 6.2 | 6.9 | 1 | .6 | 14 | 120 | 32.7 | .2 | .3 | 24.5 |
| 64 | 0– 20 | | Divishal | 55 | .03 | 6. | 6.2 | 0 | 1.9 | 10 | 160 | 16.7 | .1 | .4 | 11.5 |
| | 60– 80 | | | 50 | .07 | 6. | 6.2 | 2 | .9 | 9 | 120 | 16.7 | .2 | .3 | 12.6 |
| | 100–120 | | | 49 | .06 | 6.1 | 6.2 | 0 | .7 | 13 | 80 | 13.2 | .2 | .2 | 12.7 |

TABLE 45. — DISTRIBUTION OF LITHOSOL—BROWN FOREST AND RENDZINA—REGOSOLS, RED-YELLOW PODZOLIC AND LITHOSOL BROWN FOREST AND PODZOLIC SOILS IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | 17 Lithosol-Brown Forest + Rendzina | | 18 Regosols-Red-Yellow Podzolic | | 19 Lithosol-Brown Forest + Podzolic | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % | 1 000 ha | % |
| 1. Gilan | 3 800 | 480 | 12.63 | 56 | 1.47 | 160 | 4.21 | 696 | 18.31 |
| 2. Mazanderan | 14 000 | 1 680 | 12.00 | 20 | .14 | — | | 1 700 | 12.14 |
| 3. Azerbaijan | 10 500 | 40 | .38 | — | | 40 | .38 | 80 | .76 |
| 4. Kurdistan | 3 122 | — | | — | | — | | — | |
| 5. Kermanshah | 6 212 | 40 | .64 | — | | — | | 40 | .64 |
| 6. Khuzistan | 13 466 | — | | — | | — | | | |
| 7. Fars | 17 420 | — | | — | | — | | | |
| 8. Kerman | 23 280 | — | | — | | — | | | |
| 9. Khurasan | 30 900 | — | | — | | — | | | |
| 10. Esfahan | 17 600 | — | | — | | — | | | |
| 11. Baluchistan | 18 500 | — | | — | | — | | | |
| 12. Tehran | 6 200 | 80 | 1.29 | — | | — | | 80 | 1.29 |
| Total for the country | 165 000 | 2 320 | 1.41 | 76 | .05 | 200 | .12 | 2 596 | 1.58 |

About one percent of the land surface of Iran consists of lakes (Table 46), most of them salty.

TABLE 46. — DISTRIBUTION OF LAKES IN VARIOUS PARTS OF IRAN

| Province or part of Iran | Total area (1 000 ha) | Lakes | |
|---|---|---|---|
| | | 1 000 ha | % |
| 1. Gilan | 3 800 | — | |
| 2. Mazanderan | 14 000 | 240 | 1.70 |
| 3. Azerbaijan | 10 500 | 560 | 5.33 |
| 4. Kurdistan | 3 122 | 40 | 1.3 |
| 5. Kermanshah | 6 212 | — | |
| 6. Khuzistan | 13 466 | — | |
| 7. Fars | 17 420 | 120 | .67 |
| 8. Kerman | 23 280 | 100 | .43 |
| 9. Khurasan | 30 900 | 200 | .64 |
| 10. Esfahan | 17 600 | 80 | .45 |
| 11. Baluchistan | 18 500 | 40 | .22 |
| 12. Tehran | 6 200 | 40 | .64 |
| Total for the country | 165 000 | 1 420 | .86 |

TABLE 47. — SUMMARY OF CHARACTERISTICS OF THE PRINCIPAL SOILS OF IRAN

| Group | Definition | Profile | Native vegetation | Climate | Use |
|---|---|---|---|---|---|
| 1. Alluvial | Deposited from flowing or still water | Little profile development. Some organic matter accumulated, stratified | Depends on climate | All climates | Practically all crops |
| 2. Regosols | Soil without definite genetic horizons developing from deep unconsolidated rock or soft mineral deposits | Essentially no profile. Either loose or consolidated sand or loose unconsolidated colluvial debris etc. | Scanty grass or scrubby forest; much of land has no vegetation | Humid to arid, temperate to hot | Very seldom used except for grazing |
| 3. Hydromorphic soils, including Low Humic-Gley, Pseudo-Gley | Continually or intermittently moist with or without a peaty covering, but having prominent dark A horizon and a gleyed horizon | Dark brown to black, grading at a depth of 25-50 cm into greyish and rust mottled gley horizon. Normally high water-table | Grasses and sedges | Cool to warm humid - sub-humid even arid or semi-arid but with micro-humidity | Grazing, reeds; in some nonsaline areas paddy can be grown |
| 4. Halomorphic soils, including Solonchak and Solonetz soils | Saline soils (whose properties have been determined by the presence of salts) Solonchak - saline soil without structure Solonetz - Formerly saline soil from which the salts have been leached, with cloddy prismatic or columnar B horizon | Grey thin salty crust on surface, fine granular mulch, just below, with greyish friable salty soil below this; salts may be concentrated on the surface where they occur as a puff layer, or in the subsoil | Sparse growth of halophytic vegetation, grasses and short shrubs like *salsola*, *salicornia*, and *sueda* species | Usually dry sub-humid to arid. Hot or cold | Some grazing; much wasteland |
| 5. Grey and Red Desert soils | Soil of arid regions low in organic matter, usually having calcareous subsoil or lime pan | Light-grey or light brownish-grey, low in organic matter, closely underlain by calcareous material | Scattered shrubby desert plants | Temperate to cool arid | Poor grazing. Intensively cultivated under irrigation where good quality water for irrigation available |

TABLE 47. (*Continued*)

| Group | Definition | Profile | Native vegetation | Climate | Use |
|---|---|---|---|---|---|
| 6. Sierozem | Brownish-grey soil overlying a calcareous horizon | Pale greyish soil grading into calcareous material at a depth of 30-60 cm or less | Desert plants, *Alhagi camelorum*, scattered short grasses and brush | Temperate to cool arid | Poor to moderate grazing. Intensively farmed in small units where irrigated |
| 7. Brown Steppe | Brown to light brown alkaline soil, usually overlying a calcareous horizon | Brown soil grading into a whitish calcareous horizon with lime concretions at 30-100 cm from surface | Short grass, bunch grass, *Artemisia* and mixed grass-bush | Temperate cool, semiarid | Large areas of small grains; if unirrigated moderate to good grazing |
| 8. Chestnut (and Chernozemic) | Dark brown over lighter-colored soil, overlying a calcareous horizon | Dark brown friable and platy soil over brown soil, prismatic, with lime accumulation at 40-50 cm depth | Mixed tall, short grasses | Temperate to cool, semiarid to dry-subhumid | Cereal grains, also very good grazing |
| 9. Red-Brown Mediterranean | Soils of subhumid and semiarid areas with a distinct dry season | Thin organic layer and granular A horizon, calcareous with a reddish-brown B horizon, followed by a Cca horizon | Forest-grassland, transition oak forest | Subhumid, semiarid, temperate with rainfall about 400-800 mm with distinct dry season | Wheat, citrus, other horticultural crops, respond to irrigation |
| 10. Red-Yellow Podzolic | Soil with thin $A_0$ and $A_1$, yellowish-brown to nearly white leached $A_2$ and red, yellowish-red or yellow more clayey B horizons | Thin organic layer over yellowish-brown or greyish-brown, leached surface soil over deep red, yellowish-red or yellow B horizon. Parent material frequently mottled red, yellow, and grey. Acid. pH of surface and subsoil normally between 5 and 6.5 | Deciduous forest with some conifers | Warm to temperate to subtropical. Humid. | Some small areas in cotton, tea, and other crops. Much forest land |

TABLE 47. (*Concluded*)

| Group | Definition | Profile | Native vegetation | Climate | Use |
|---|---|---|---|---|---|
| 11. Brown to Grey-Brown Podzolic | Acid soil developed under forest with little or no bleached A horizon and only a weak-textured profile. Organic matter sequioxide and clay decreasing gradually with depth. Forest soil with thin $A_0$ and $A_1$ over a greyish-brown leached $A_2$ and brown blocky B horizon | Thin leaf litter over mild humus; dark-colored surface soil 5 to 10 cm thick; a definite $A_2$ brown leached layer over brown heavy B horizon. Acid, normally pH varying between 5 and 6.5 | Mostly deciduous forest with mixture of conifers in places | Temperate humid | Some small areas in cotton, tea, and other crops. Much forest land |
| 12. Brown Forest | Soil with mull horizon and having no accumulation horizon of clay and sesquioxides | Very dark-brown, friable surface soil grading through lighter-colored soil to parent material. Little illuviation. High absorbed calcium | Forest, usually broad-leaved | Cool temperate to warm temperate and subtropical humid | Some crops on the slopes. Pastures and forests on steeper slopes |
| 13. Rendzina (Humus-Carbonate) | Dark calcareous, usually shallow soil, formed *on soft limestone* | Dark greyish-brown to black granular soil underlain by grey or yellowish, usually soft calcareous material | Usually grassy, some broadleaved forest | Cool to warm, humid to dry subhumid | Wheat and some other dry crops; also good pasture and forest |
| 14. Lithosols | Thin stony soil shallow over bedrock without a definite B horizon due to relative youth; or soil consisting of nearly unweathered rock fragments | Thin stony surface soils, little or no illuviation, stony parent material | Depends on climate and in what soil and climate zone these Lithosols occur | All climates | Forestry, grazing, barren and waste-land |

# 4. INTERPRETATION, USE, AND MANAGEMENT OF THE SOILS

## 4.1 General and interpretation

Soil studies, research, and investigation are all directed toward improved agricultural use and production including higher sustained yields of crops. The soil survey is a necessary step in a co-ordinated agricultural program. Soil classification is a means whereby the characteristics of soils are studied, defined, and arranged in a systematic order so that relationships between soils can be compared. The areas of different kinds of soils are plotted on a map to show their distribution in relation to other prominent natural or cultural features. These soil maps and accompanying information are utilized in the following way:

1. To delineate areas of soils which can be developed for specific purposes, such as irrigation and drainage, conservation, etc.
2. To apply the results of experimental work on plots and fields of known kinds of soils to similar soils in different locations.
3. To predict, when the response of one soil is known,
   (a) the response of similar soils to management practices;
   (b) their adaptability to certain crops;
   (c) the long-time effect of various use or management systems on productivity.

Thus the soil survey provides a means for extending new knowledge from experimental plots to widely separated areas of similar soils and eliminates or largely *reduces* the necessity for duplicate experimental work.

To make detailed predictions and recommendations detailed soil studies are necessary. Such detailed or semidetailed studies in over 40 different locations or projects of Iran have been completed, many with a specific objective. It should be realized that plants are very sensitive to slight differences in soil characteristics and hence modify management practices. Therefore, a narrow range in soil characteristics in detailed or semidetailed soil surveys is necessary, together with correlative soil research.

However, for some interpretations, such as suitability for crop use, erosion hazards, the need for drainage, etc., broad groupings of soils may be made. Such groupings are a great aid to agricultural development planners in delineating areas that merit further attention for intensive development and use. These groupings also show the location on the map of such areas.

The present generalized study helps to locate and outline on the map areas of soils suitable for specific uses. It is a first step in a comprehensive Research and Development program, to be followed by more detailed studies of selected areas. The classification units in the present generalized study show the major categories of soil groups and are not sufficiently homogeneous for making accurate predictions. The mapping units, although defined in terms of these great soil groups and their phases, are in many cases, associations of soils with varying and often unlike characteristics. In some cases of necessity, strongly contrasting soils are included in one delineation or association. The discussion of each mapping unit deals primarily with the dominant soil shown on the map.

### 4.2 Present and potential land use

For a discussion of this topic, see pages 17 and 18, and Map B2.

### 4.3 Soil management groups

The soils of Iran are divided into the following 10 soil management groups:

Group 1: Well-drained, fine-textured soils: Soils with no or slight limitation—no important problem except locally.
- 1A fine-textured alluvial soils, level or nearly level[1]
- 1B fine-textured alluvial soils, slightly sloping phase

Group 2: Soils with slight to moderate limitation. Limitation due to moderate deficit of water and undulating relief.

2A: Level to gently sloping Brown and Chestnut soils. Deep to moderately deep soils, of semiarid and dry subhumid regions.
- 7A Brown soils, level phase
- 7B Brown soils, gently sloping phase
- 8A Chestnut and Chernozem soils, nearly level phase
- 8B Chestnut and Chernozem soils. gently sloping phase

2B: Moderately to steeply sloping Brown, Chestnut, and Chernozem soils of semiarid and dry subhumid regions.
- 7 CD Brown soils, moderately to strongly sloping phase.
- 8 CD Chestnut and Chernozem soils, moderately to strongly sloping phase

[1] Description of soils under each group is given for the units which are mapped on 1:1,000,000 scale Map B3.

Group 3: Poorly drained Alluvial and Hydromorphic soils, with or without slight to moderate salinity. Limitation due to poor or moderate drainage.

1S Saline Alluvial soils
1h Hydromorphic Alluvial soils
1hs Saline Hydromorphic Alluvial soils
3a Low Humic-Gley soils
3b Humic-Gley, or Swamp Meadow soils
3c Pseudo-Gley soils

Group 4: Desert and Sierozem soils of arid and semiarid regions. Slightly to moderately sloping. (Soils with limitations due to moderate to strong deficit of water and of shallow depth.)

5A Desert soils, level phase
5B Desert soils, gently sloping phase
5C Desert soils, strongly sloping phase
6A Sierozem soils, level phase
6B Sierozem soils, gently sloping phase
6C Sierozem soils, strongly sloping phase

Group 5: Soils of Humid-Subhumid with undulating relief and/or strongly dissected topography. (Soils with limitations due to dissected relief and/or shallow depth.)

9: Red and Brown Mediterranean soils

| | |
|---|---|
| 10A, 10B, 10C | Red-Yellow Podzolic soils – level to strongly sloping |
| 11A, 11B, 11C | Brown Forest soils (including Grey-Brown Podzolic soils) – level to strongly sloping |
| 17E, 17EF, 17F | Rough broken and rough mountainous land (on Brown Forest soil material) |
| 18E, 18EF, 18F | Rough broken land and rough mountainous land (on Brown and Grey-Brown Podzolic soil material) |

Group 6: Strongly sloping shallow soils and rough broken and rough mountainous land in semiarid soils. Soils with limitation due to dissected relief, shallow depth, and moderate deficit of water.

7-15 Brown soils–Lithosols
12C Brown soils–Rendzinas

| | | |
|---|---|---|
| and | 15E<br>15EF<br>15E | Calcareous Lithosols – Brown soils and Chestnut soils |
| | 16E<br>16EF<br>16F | Lithosols, igneous rocks - Brown soils |

Group 7: Rough broken and rough mountainous land in arid regions. Soils with limitations due to dissected relief, shallow depth and moderate deficit of water.

| | |
|---|---|
| 13E<br>13EF<br>13F | Calcareous Lithosols - Desert and Sierozem soils |

Group 8: Salt Desert and higly saline desert.
Level areas or nearly level. Soils with severe to very severe limitations due to salinity, stoniness, shallow depth, and severe deficit of water.

5-4: Desert soils - Sierozem soils - Solonchak soils

Group 9: Sand Dunes, moving coastal sand and sand beaches complex. (Soils with almost no potentiality).

2b: Sand Dunes
5-2b: Desert soils - Sand Dunes
6-2: Sierozem soils - Regosols (with inclusion of Sand Dunes).

Group 10: Soil groups including Solonchaks, Salt-Marshes and rough broken and rough mountainous land on saliferous and gypsiferous material including salt plugs. (Soils with almost no potentiality.)

4: Solonchaks and Solonetz
3-4: Salt-Marshes

| | |
|---|---|
| 14E<br>14EF<br>14F | Calcareous Lithosols from saliferous and gypsiferous material including salt plugs |

SOIL MANAGEMENT GROUP 1: WELL-DRAINED, FINE-TEXTURED ALLUVIAL SOILS

The soils of Group 1 comprise the most important agricultural soils of Iran. They are composed of relatively recent sediments or alluvial materials and have little or no profile development. These young alluvial soils continue to receive deposits in some areas from overflow, either by streams or by local runoff from adjacent hillsides and rough broken areas. Thus, there is usually some renewal of fertility by this addition of fresh soil materials to the surface.

The capabilities of these soils for crop production range from low (because of frequency of flooding or due to low natural fertility) to very high. When sufficient moisture is available for crops, either naturally or by irrigation, these soils are moderately to highly productive. Certainly they are the most naturally fertile soils of the country under prevailing use and management and have greater potentiality than any other group of soils for increased production. Most of these soils are fine-textured clays, silty clays, clay loams or silty clay loams, and are slow in drying out after rains or overflows. They have slow to very slow internal drainage, and are rather difficult to work.

All or most of the soils are high in calcium and potassium but nearly all are low to very low in available phosphorus, in nitrogen and in organic matter. As most of them have been cropped for centuries, little has been returned in terms of plant food. Legumes are grown only in a few selected areas and the practice of adding N and P is still in the initial stages.

Irrigation is usually practiced on these soils. Soil management, adequate drainage, and more efficient use of water are needed. There is a great variety of winter and summer annual legumes, as well as perennial legumes, that are adaptable in Iran; they should be grown on these soils for food, seed, and soil improvement. Protection from overflow may be practical in several areas.

Some experiments in similar soils, especially in Khuzistan, indicate that yield can be doubled under efficient irrigation, good soil management, including crop rotation, fertilization, etc.

Out of the 6.1 million hectares mapped under 1A-1B (or 1AB), about 2 million ha or about 30 percent are under irrigation. In general, 70-75 percent of these lands are under cultivation. With improved management, water storage, etc., as much as 80-90 percent of these soils can be cultivated.

### SOIL MANAGEMENT GROUP 2A: LEVEL TO GENTLY SLOPING BROWN AND CHESTNUT SOILS, DEEP TO MODERATELY DEEP, OF SEMIARID AND DRY SUBHUMID REGIONS

This group includes nearly level to gently sloping soils of the foothills or intermountain valleys, mainly in the plateau but also in parts of Khuzistan and other plains close to the Persian Gulf, as well as in the eastern Caspian littoral area, east of Gorgan.

These soils are very important in the dry-farming belts of Iran and next to alluvial soils, are the most productive.

The soils are medium to very deep, moderately permeable to air, water, and plant roots. Their productivity is limited by the low rainfall (normally 300-500 mm per annum).

They are very low in available phosphorus and organic matter, but most are high in exchangeable potassium. All contain plentiful to excessive amounts of calcium (normally 30 to 50 percent as carbonates). In spite of low available nitrogen and phosphorus, moderate yields of small grains are produced when moisture is adequate.

Because of their gentle slope, very little runoff occurs except during unusually heavy rains. Some, however, receive runoff from higher lying or more sloping areas, and both soil and water are lost by runoff.

The small grain-fallow system is used almost entirely and wheat is the main crop. Small areas are planted to barley, or other crops like sorghum or millet, but these, except barley, are unimportant compared to wheat. The wheat stubble is usually left after summer and winter harvest and is grazed. On many fields, the stubble is almost entirely removed by grazing before the land for summer fallow is plowed. Crude wooden plows are mainly used though in recent years many more mechanical plows are being introduced. The sowing is done usually in early fall, depending on the location, elevation, and time of the first snow. Much response, both to nitrogen and phosphorus, has been observed in many of these dry-farming Brown soil zones.

The small grain-fallow system has been used on these soils for generations and seems to be the safest method known for utilizing them for crop production. Perhaps few other crops will produce as well for as long on these soils.

Better soil management practices are likely to give improved yields, and should be experimented with on these soils before large scale adoption in big areas. These practices include contour cultivation, stubble mulch, rough tillage, and strip cropping, level and close terraces, addition of nitrogen and phosphorus fertilizer, rotation of grains with certain native and other legumes. Irrigation is practical where water, at a reasonable cost, can be brought from springs or ghanats, diverted or pumped from streams, or pumped from wells.

In general Mapping Units 7A, 7B, 8A, and 8B are placed in Soil Management Group 2A; over 80 percent of these soils are under cultivation. With improved practices, it is possible to increase the areas under cropping to 90 percent.

## GROUP 2B: MODERATELY TO STEEPLY SLOPING BROWN, CHESTNUT AND CHERNOZEM SOILS OF SEMIARID AND (DRY) SUBHUMID REGIONS

This group includes moderately (3-8 percent) to steeply sloping (8-15 percent) medium to shallow depth soils, in Azerbaijan, and in certain highlands of Fars, Kurdistan, and Khurasan. They have characteristics somewhat similar to soils of Group 2A but are shallower, more sloping, and more droughty, and are also very low in avaliable phosphorus and organic matter.

The management requirements of these soils are similar to those of Group 2, but more intensive measures for reducing water runoff and erosion are needed. As a whole they have sufficient depth for deep-rooted crops, but water seldom, if ever, penetrates into the subsoil.

Part of these soils occur in hilly or mountainous areas in the valleys. Precipitation is in the form of rainfall and some snow. Runoff is moderate to high from the more sloping areas. Under the small grain-fallow systems of farming, much of this land is essentially bare of protective vegetation during the months of highest rainfall. Even in the early spring, land planted to small grains has little protective cover during most years. Runoff varies in proportion to the slope and intensity of rainfall. The loss of moisture on these soils may make the difference between a high yield or even a crop failure during some years.

If used for cropland, these moderately sloping soils require measures for reducing or preventing water runoff. If safe outlets can be prepared, this may be done by constructing terraces, contour plowing and alternating strips of small grains with fallow. Rough and stubble mulch are very effective practices which can be used on all croplands. A smaller number of hectares, when properly managed, can give as much total yield as double the area. The need for phosphate, especially together with nitrogen, seems very likely; some local and other legumes should also be planted in alternate strips on the contour using small grains and fallow. This practice may be effective enough to eliminate the need for terraces on all but the longer and steeper slopes.

The soils of this group, together with those of Group 2A, comprise the most extensive and important wheat soils of Iran. Every effort should be made to conserve moisture, increase the organic matter, and prevent erosion on these soils.

These soils, including soils of Group 2A, occupy about 8 million ha or 5 percent of the land surface of Iran. About 70-80 percent of the soils of Group 2B are cultivated (usually in rotation with fallow.)

GROUP 3: POORLY DRAINED ALLUVIAL AND HYDROMORPHIC SOILS WITH OR WITHOUT SLIGHT TO MODERATE SALINITY

These soils are normally fine-textured, with high groundwater table, and mottling predominant throughout the profile. In many cases associated with the soils, especially in semiarid areas, there is slight to moderate salinity. The topography is, in all cases, level or depressional and has a basin character.

Drainage is the most important prerequisite for safe crop production. The practices suggested for utilizing saline soils are dealt with in the chapter on salinity, alkalinity, and reclamation. The same is true for hydromorphic soils, except for Pseudo-Gley soils where paddy is the predominant crop, especially in the Caspian coastal area which has a subhumid or humid climate.

Poorly drained alluvial soils and some of the hydromorphic soils support barley and wheat as predominant crops. In the zone close to the Persian Gulf, the date palm is the predominant crop.

Pseudo-Gley soils in the Rasht Gilan and some parts of the Mazanderan Plain are the paddy areas where high to moderate yields of paddy are obtained.

These soils occupy 5.5 million ha or 3.2 percent of the land surface of Iran:

| | | |
|---|---|---|
| IS | 3.4 | million ha |
| 1h | 0.7 | million " |
| 1hs | 1.0 | million " |
| 3a, 3b, and 3c | 0.4 | million " |

About 50-60 percent of these soils are under crop production or fallow.

GROUP 4: RED AND GREY DESERT AND SIEROZEM SOILS, COARSE ALLUVIAL, COLLUVIAL SOILS AND REGOSOLS OF ARID AND SEMIARID REGIONS – SLIGHTLY TO MODERATELY SLOPING

The group comprises the Desert and Sierozem soils of dry regions where rainfall is insufficient for crop production. These are moderately permeable and inherently fertile soils, but without irrigation crops are usually not possible or at least not economical. This group also includes coarse alluvial, colluvial soils and Regosols.

The soils are very high in calcium and very low in organic matter. Most areas are suited to irrigation, if irrigation water of suitable quality is available. Organic matter and nitrogen could be increased by the use of legumes under irrigation and a wide variety of field and special crops could be grown. Soil management practices such as contour cultivation, strip cropping, addition of nitrogen and phosphorus fertilizers, rotation of grains with certain native and other legumes are likely to give increased yields.

In general a small percentage (5 percent) of these soils is under cultivation mainly by irrigation from springs and ghanats. Some colluvial soils are also irrigated. The total area under this management group in Iran is 26 million ha and includes the following areas of given soil associations.

| Soil associations | Area |
|---|---|
| 2a | 6 million ha |
| 5A, 5B, 5C, 5-2a | 10 million ha |
| 6A, 6B, 6C, 6-2 (50 %) | 10 million ha |

GROUP 5: SOILS OF HUMID-SUBHUMID WITH UNDULATING RELIEF AND/OR STRONGLY DISSECTED TOPOGRAPHY

This group comprises the rough broken and rough mountainous lands and Lithosols and geologic materials in a subhumid to humid climate. The parent rocks include a wide variety of sedimentary, metamorphic, and igneous rocks with or without a thin soil covering. The less sloping parts have a thin soil covering but steeper areas consist of outcrops of only slightly weathered geologic materials. Vegetation ranges from a thick stand of deciduous or even coniferous trees to a thin shrub-tree cover with some grass and brush in open areas.

Mapping units 9, 10, 11, 17E and 17EF, 18E, 18EF, 19E, and 19EF are included in this management group.

These areas are best suited for growing trees. Vast stretches were originally forested, but due to destructive cutting, burning, and grazing probably less than 50 percent of the area now has a tree cover.

The prevailing lack of proper management and over-cutting, burning, etc., causes a further decrease in the amount of forested land, as well as in the quality of the trees. These lands, although not suited for cultivation, comprise a valuable natural resource. Rainfall is adequate for growing some types of useful trees. Reforestation of many areas, and forest management for all, will be needed if they are to be properly and fully utilized. A beginning has been made both in the Mazanderan and Gilan areas in this direction, but much more intensive effort is needed.

FIGURE 76. Wheat and alfalfa growing on Soil Groups 3 to 7.

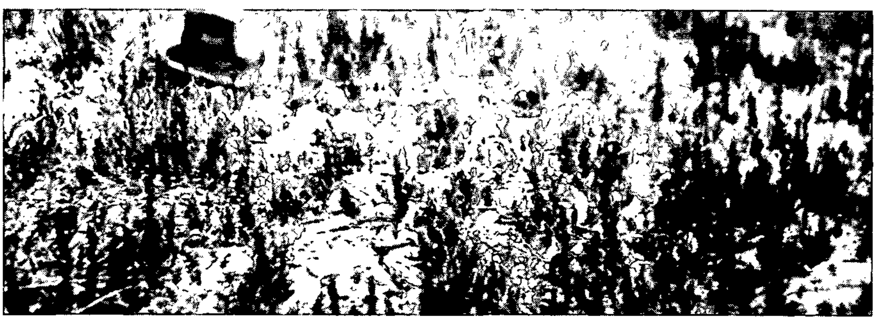


FIGURE 77. Near the better edge of the salt flats and adjoining the parts of these flats that are slightly higher, and where a little barley can be grown, are the *Sueda* and other plants reflecting the slightly lower concentration of salts.

FIGURE 78. On the better-drained parts of the salt lands where some of the salts have been washed away, two species or types of *Sueda* (*left* and *right*) are found.

FIGURE 79. The low, wet Group 2 soils over which flood waters pass each year provide good permanent pastures and hay from native grasses and clovers.

FIGURE 80. Where sands have been spread over some of the Group 3 soils by overflows from streams, water is sometimes lifted 2 or 3 meters for irrigating from 1/2 to 1 hectare of good melons and squashes.

FIGURE 81. The leguminous *Glycyrrhiza glabra* (shirin bian) is commonly found on the best Alluvial soils of the area, Group 4. It is valued as a good pasture plant.

Areas of this group also include some small and some relatively large bodies of gently sloping shallow and medium depth soils in foothills, and alluvial soils in narrow valleys. These are all suited for cropland, fruit trees, or pasture. If properly used, these areas can contribute much in subsistence crops to those in forestry activities. Thus the need for keeping animals in the forested areas would be reduced, and forestry management would be improved.

This group also includes mapping units 17F, 18F, and 19F which are rough mountainous lands in zones where normal soils, if developed, would be Brown Forest or Podzolic. These areas, however, consist mainly of rock outcrops with only a thin soil covering in places. Vegetation exists mainly in places of partly weathered rock and soil material between masses of broken rock, on small local footslopes, and on mountainsides where there is enough soil to support plant growth. These areas have forests as the natural vegetation, but all areas, except the highest and most inaccessible ones, are severely abused by destructive cutting, burning, and grazing. The production of charcoal is by far the greatest incentive for such destructive cutting.

Potentially these lands are capable of producing more forest products than at present. Better management is required and has been initiated in some areas. Afforestation, where some soil material exists for the plants to get a foothold, would also be desirable. Some field crops and special crops, such as tea, are grown on these soils.

Soil Management Group 5 comprises the following area:

| | | |
|---|---|---|
| 9 | 80,000 | ha |
| 10 | 20,000 | ” |
| 11 | 360,000 | ” |
| 17EF | 2,320,000 | ” |
| 18EF | 76,000 | ” |
| 19EF | 200,000 | ” |
| Total | 3,056,000 | |

About 15 percent of these soils are under cultivation, and the rest are suited for forest. Some of the best forest soils of Iran are included in this group.

## GROUP 6: ROUGH BROKEN AND ROUGH MOUNTAINOUS LAND IN SEMIARID REGIONS

Group 6 includes the rough broken and rough mountainous land over limestone, shales, marls, or volcanic and igneous rock material in the arid and semiarid regions of Iran. The mapping units 7-15, 12C, 15E, 16E, 15F, 16F, make up this group.

| | | |
|---|---|---|
| 7-15 (E+F) | 1,300,000 | ha |
| 12 (C) | 720,000 | " |
| 15 (E+F) | 21,370,000 | " |
| 16 (E+F) | 10,600,000 | " |
| | 33,990,000 | |

These comprise the most extensive areas of Iran, 34 million ha or about 21 percent of the land area of Iran; Lithosolic soils, and rock outcrops on steep rough broken and mountainous terrain are outstanding characteristics of this group. Vegetation ranges from none to a thin grass or grass-shrub cover. Geological erosion has always been active, and overgrazing has further intensified this condition.

These miscellaneous and complex areas are unsuited for xerophytic trees because of the dry climate in which they exist. They are poorly to moderately suited for grazing. The carrying capacity of the areas ranges from low to very low.

There is little possibility of improving the vegetative cover under the prevailing practice of overgrazing. Deferred grazing, which may necessitate at least partial exclusion from severely overgrazed areas of sheep, goats, and cattle for at least two years or more, will be necessary for vegetation to become established in several parts of the area. After vegetation becomes established, controlled grazing, with about one half of the present rate of stock, will be necessary to maintain a vegetative cover. The other half will need to be either dispersed to less accessible areas (or less overgrazed areas), or preferably settled to mixed farming areas.

In Group 6 deeper, less sloping soils, and narrow strips of alluvial soils suited for cultivation that comprise a small percentage of these rough broken and mountainous lands, occur in small areas, usually of only a few hectares each. These small arable areas within large grazing units, if properly managed, can contribute much more in subsistence crops. Many of the soils can be irrigated from local small streams and be made to produce high yields of food and feed crops. In many cases, small diversions are necessary and are often resorted to by the local farmers. In regard to storage, some technical aid is needed on how to store the winter flow or snow melt, and use it for spring or summer growth of feed crops. Quite often extra water storage makes a considerable difference. Many small and local irrigation projects in the valleys could contribute much to local development. About 5-10 percent of these areas is under cultivation, most in rotation with fallow periods.

GROUP 7: ROUGH BROKEN AND ROUGH MOUNTAINOUS LAND IN ARID REGIONS

Group 7 (units 13E, 13EF, and 13F) includes the rough broken and rough mountainous land on limestone shales, marls, or metamorphic and igneous rock materials in the arid region of Iran. It comprises the next most extensive area of Iran, nearly 22 million ha or about 14 percent of the land area. Lithosolic soils and rough outcrops on steep, rough broken and mountainous terrain are outstanding characteristics of this group. Vegetation ranges from none to a thin grass or grass-shrub cover. Soil erosion has always been active and overgrazing has further intensified the condition.

These last and complex areas are unsuited for growing trees because of the dry climate in which they exist. If handled properly they may be used for grazing but their carrying capacities vary from low to very low.

Under the prevailing practice of severe overgrazing, there is little possibility of improving the vegetative cover. Deferred grazing may necessitate at least partial exclusion of sheep, goats, and cattle from overgrazed areas. It would take at least two years or more for vegetation to become established in several parts of the area.

Included are areas of deeper, less sloping soils and narrow strips of alluvial soils suitable for cultivation under irrigation, which comprise a small percentage of these rough broken and mountainous soils. If properly managed, these small arable areas within large grazing units can contribute much to subsistence crops. When irrigated from local streams such small areas can be made to produce high yields of food and field crops.

Probably about 1 to 2 percent of the soils of this group are under cultivation, mainly under irrigation.

GROUP 8: SALT DESERTS - HIGHLY SALINE DESERT SOILS, SOLONCHAKS

These comprise large areas in central, eastern, and southeastern Iran. They are essentially wastelands, and are only very seldom used for grazing. In most cases these areas will remain wastelands, except in some localities where irrigation by moderately saline irrigation waters may produce low to medium yields of some crops such as barley, or fruit crops such as figs, and where drainage may prove to be possible and economically feasible. In most cases it would be hardly necessary, desirable, or economical to reclaim them for croplands. This group (5-4), and part of Soil Association 4 occupies about 4.8 million ha and possibly 1 to 2 percent are under cultivation, mainly by irrigation, and in some cases accompanied by drainage.

### GROUP 9: SAND DUNES, MOVING COASTAL SAND, AND SAND BEACHES

Group 9 includes units 2b, 5-2b, and part of 6-2, shown on the map. These comprise the coastal areas (Caspian, Persian Gulf, and Gulf of Oman) that have no agricultural value, except for the sparse grazing afforded by salt and other grasses and sedges. Also within the group are Desert soils—Sand Dunes association, and Sierozem soil, Regosols including Sand Dunes. There may be exceptions but generally speaking, the best use for such areas at present appears to be either for poor grazing or as wildlife reserves. The area occupied by this soil management group is about 13 million ha, or about 8 percent of the land surface of Iran.

| | | | |
|---|---|---|---|
| 2b | | — | 3,040,000 ha |
| 5-2b | | — | 5,570,000 " |
| 6-2 | (50%) | — | 4,640,000 " |
| | Total | | 13,250,000 |

### GROUP 10: SOIL GROUPS INCLUDING MOST OF SOLONCHAKS, SALT-MARSHES, AND ROUGH BROKEN AND ROUGH MOUNTAINOUS LAND ON SALIFEROUS AND GYPSIFEROUS MATERIAL INCLUDING SALT PLUGS

These soils comprise wasteland and soils which have practically no agricultural value. They occupy large areas in central Iran and many other parts of south and southeastern Iran, including many of the deltaic districts where rivers like the Karkheh or the Karun form marshes near the sea. They also include tidal marshes and inland marshy regions. The great salt desert and the severely saline soils occurring in several parts of Iran are included in this group.

They are only very seldom used for grazing. For example, in the case of the Solonchak soils on the banks of Lake Urmia, the graziers bring their sheep and cattle to these severely saline areas, say once a week, for grazing on the halophytic vegetation. The local people consider it necessary. Some research on this is needed, but it can be surmised that certain minor or micronutrient elements are probably supplied by the salty vegetation. Included also in these soils are Fars Series formations, saliferous and gypsiferous, containing salt plugs. Not only are these formations very salty but they are responsible for salinizing other large areas into which the waters of the saline areas drain.

In general, these areas will remain wastelands. Under present conditions, it would hardly be necessary, desirable, or economical to reclaim them for crop-lands. In some cases these are or could be used as hunting preserves.


| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Waste and poor pasture. Salty soils. Groundwater near surface | Good permanent pasture and hay. Low, wet soils | Barley, wheat, cotton, sugar beets. Poor to moderately drained alluvial soils | Vegetables, grapes, fruits, alfalfa, melons, wheat, tobacco, sugar beets. Deep, well-drained alluvial soils | Dry-farmed wheat. Higher, well-drained Brown soils | Dry-farmed wheat, fallow and range. Sloping, shallow Brown soils and Lithosols | Poor range and waste. Very shallow soils and rock outcrops |

FIGURE 82. Soils and land uses in the order in which they commonly occur in the Zarrineh Rud area.

This management group occupies 29.0 million ha

| | | | |
|---|---|---|---|
| Unit 4 | — | 6.0 | million ha |
| 3-4 | — | 8.2 | ,, ,, |
| 14 | — | 14.8 | ,, ,, |

Table 48 summarizes the characteristics of each soil management group described above.

### 4.4 Land use and production in relation to kinds of soil

In many areas and village communities throughout Iran, it has been observed that land use and yields are closely related to the kinds of soil. The established custom of assigning some of each of the different kinds of soil in a village to each of the peasants is evidence that this fact has been recognized by landowners, tenants, farmers, and others working on the land. The pattern that has developed in the use of different kinds of soil has evolved through trial over hundreds and possibly thousands of years. It is based on relative yields and general adaptability of the different land uses on the various kinds of soil.

The land-use pattern in some of these areas is clearly visible to all who recognize the order in which the various kinds of soils are generally located in relation to each other, and to the major natural features of the area.

In two of the areas specifically studied in Iran seven broad soil groups were identified. In general, the major parts of the land of the area may be considered as segments of a more or less continuous range: from the soils of low flat salty lands (Solonchak soils), the wet pasture and hay lands over which flood waters pass (Humic-Gley soils—usually saline but may have only slight salinity), the poorly drained and wet alluvial to better drained alluvial soils, the Brown soils on old alluvium as remnants of old terraces, the Brown soils formed on calcareous and other rocky materials, to the Lithosols and the rocks on the mountains.

Such a pattern of the occurrence of soils as well as their land use, recurs in several parts of Iran. One part differs from another simply in the extent of each of these segments, although their ratio and relationship may also vary somewhat. A chart showing the soils and land use in the order in which they commonly occur in relation to each other and to the major natural features of the area is reproduced, with Zarinneh Rud area as an example (Fig. 82).

TABLE 48. — CHARACTERISTICS OF SOIL MANAGEMENT GROUPS IN IRAN

| Soil management group | Soil association no. | Slope % | Soil depth | Drainage through soil | Erosion hazard under cultivation | Productivity under prevailing conditions | Suitable use in order named | Area for crops | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total area of group | Area under cultivation | Total area suitable to cultivation |
| | | | | | | | | (ha) | (ha) | (ha) |
| *Group 1:* | | | | | | | | | | |
| Well-drained, fine-textured soils | 1 | 0-1 | Very deep | Slow to moderate, favorable for crops | None | Moderate to high | Cropland irrigated or dry-farmed, horticultural crops, including fruits and vegetables, pastures | 6,100,000 | 4,600,000 | 5,500,000 |
| *Group 2A:* | | | | | | | | | | |
| Level to gently sloping Brown and Chestnut Soils. Deep to moderately deep soils | 7, 8 | 1-3 | Deep | Slow to moderate, favorable for crops | Slight | Moderate | Croplands, dry farming pastures | | | |
| *Group 2B:* | | | | | | | | 8,000,000 | 6,000,000 | 7,200,000 |
| Moderately to strongly sloping Brown, Chestnut, and Chernozem soils of semiarid and dry subhumid regions | 7, 8 | 3-8 | Medium | Slow to moderate, favorable for crops | Moderate | Moderate | Croplands, dry farming pastures | | | |
| *Group 3:* | | | | | | | | | | |
| Poorly drained alluvial and hydromorphic soils with or without slight to moderate salinity | 1-4 and 3 | 0-1 | Very deep | Very slow to slow | None to slight | Moderate to low | Paddy, barley | 5,500,000 | 2,800,000 | 4,400,000 |

TABLE 48. (*Continued*)

| Soil management group | Soil association no. | Slope % | Soil depth | Drainage through soil | Erosion hazard under cultivation | Productivity under prevailing conditions | Suitable use in order named | Area for crops | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total area of group | Area under cultivation | Total area suited to cultivation |
| | | | | | | | | (ha) | (ha) | (ha) |
| *Group 4:* | | | | | | | | | | |
| Desert and Sierozem soils of arid and semiarid regions, slightly to moderately sloping | 5, 5-2a, 6, 6-2 and 2a | 1-3 | Medium | Moderate | Moderate to high (wind) | Slow | Pasture, cropland, irrigated, dry farmed | 30,600,000 | 1,530,000 | 15,300,000* |
| *Group 5:* | | | | | | | | | | |
| Soils of humid, subhumid with undulating relief and/or strongly dissected topography | 9, 10, 11, 17, 18 and 19 | Normally 15 + | Very shallow to shallow | Moderate, runoff is high | Moderate to high | Moderate to low | Trees, specialized crops | 3,100,000 | 470,000 | 620,000 |
| *Group 6:* | | | | | | | | | | |
| Strongly sloping shallow soils and rough broken and rough mountainous land in semiarid soils | 7-15, 12, 15, 16 | 15 + | Shallow | Moderate | High | Low to moderate | Pasture, dry farmed | 35,300,000 | 3,530,000 | 5,300,000 |
| *Group 7:* | | | | | | | | | | |
| Rough broken and rough mountainous land in arid regions | 13 | 15 + | Very shallow | Slow | High | Very low | Grazing | 27,800,000 | 420,000 | 550,000 |

* Provided irrigation water of suitable quality is made available.

TABLE 48. (*Concluded*)

| Soil management group | Soil association no. | Slope % | Soil depth | Drainage through soil | Erosion hazard under cultivation | Productivity under prevailing conditions | Suitable use in order named | Area for crops | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total area of group | Area under cultivation | Total area suited to cultivation |
| | | | | | | | | (ha) | (ha) | (ha) |
| *Group 8:* | | | | | | | | | | |
| Salt desert and highly saline desert | 5-4 and 4 (part) | 0-1 | Deep | Very slow | Water low, wind high | Productivity very low | Poor grazing | 4,800,000 | 50,000 | 100,000 |
| *Group 9:* | | | | | | | | | | |
| Sand Dunes, moving coastal sand and sand beaches complex | 2b, 5-2b, 6-2 (part) | 1-3 variable | Shallow | Rapid to very rapid | Water slight, wind high | Very low to low | Pasture or wildlife | 13,300,000 | 0 | 0 |
| *Group 10:* | | | | | | | | | | |
| Soil groups including Solonchaks, Salt Marshes and rough broken and rough mountainous land on saliferous and gypsiferous material containing salt plug | 3-4, 14 and 4 (part) | Variable | Very shallow to deep | Slow | Typical badlands for unit 14 | Very low | Wasteland | 29,100,000 | 290,000 | 500,000 |
| *Total* | | | | | | | | 163,500,000 | 19,690,000 | 39,470,000 |

# 5. SOIL FACTORS LIMITING AGRICULTURAL PRODUCTION

Iran is essentially an agricultural country a great part of which is arid or semiarid. An extensive system of irrigation is a prerequisite to the optimum development of its land and water resources. Large numbers of irrigation projects have been built in the country (see Figures 83, 84), some in ancient times and more in recent years. The present chapter does not deal with irrigation but with relevant soil factors affecting agriculture.

The soil factors which limit agricultural production in Iran are several.

Soil salinity, alkalinity, and waterlogging affect large areas to the extent that they do not support any crops or other vegetation. Soil infertility and inadequate amounts of plant nutrients in the soils are other big limiting factors for increasing crop production. The absence of organic matter in the soils of some of the arid and semiarid areas is another deficiency responsible for low crop production. Large areas affected by water and wind erosion occur in Iran and a soil and water conservation program to control erosion is essential before such areas can be brought under efficient agriculture. In the following chapter the above important factors will be dealt with separately giving the extent of the problems, causes, and suggested cures.

## 5.1 Soil salinity, alkalinity, and waterlogging

In Iran over 15 percent of the land surface, or a total of about 25 million ha, suffers from a combination of salinity, alkalinity, and waterlogging.

Water, or the scarcity of it, is responsible for the greater part of the accumulation of salts in the soils of the arid and semiarid parts of Iran. Generally the parent material from which the soils are formed is high in salts. A good example of such salt-rich parent material is the marls-saliferous and gypsiferous of the Upper Red Formation (Fars Series). Because of the scarcity of rainfall, these salts have not been leached out of the soil mass, so most of the soils are inherently salty. In other cases the concentration of salts is not great enough to be harmful to crop growth at the time when irrigation is first introduced to an area. It is when irrigation water is applied that the trouble starts. All water, whether above or below the surface of the ground, contains salts. Surface water which flows over the land or which percolates through the soil picks up the salts. As a result,

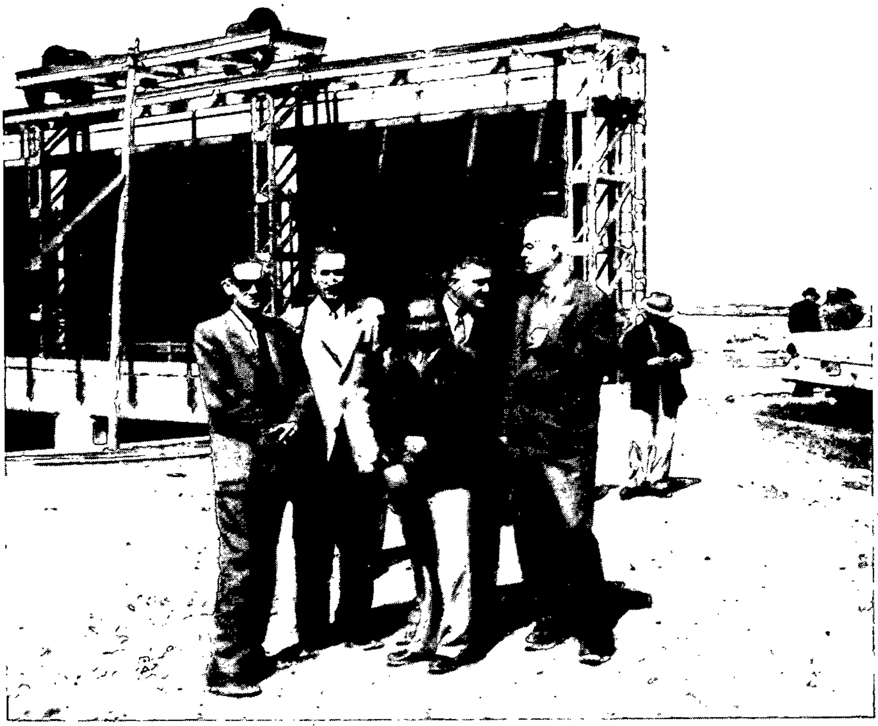


FIGURE 83. Some members of the FAO irrigation team standing near Karkheh Dam in Khuzistan.

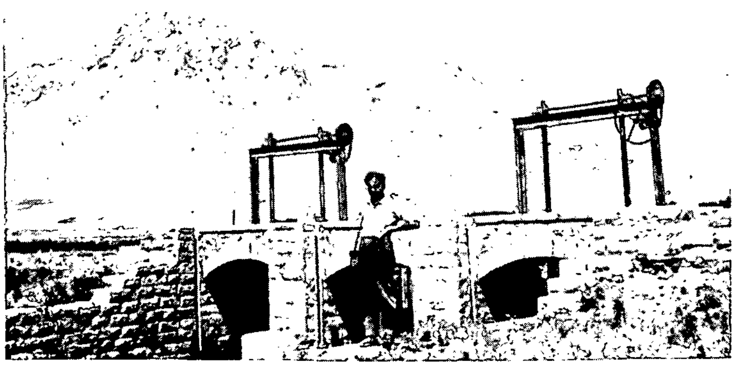


FIGURE 84. An FAO soil expert in front of the canal distribution system in Shahabad, Kermanshah.

surface water becomes increasingly more salty as it flows from its headwater source to the sea, or as it percolates through the soil to the groundwater reservoir.

There is ample evidence that a close correlation exists between a high water table and the tendency to accumulation of salts at or near the surface of the land. In fine-textured soils, which predominate in many of the irrigated projects, moisture will readily move upward by capillary movement from the water table to the surface, even where this distance is as much as 3 m. Under such conditions salts accumulate rapidly at the surface, unless irrigation water is applied regularly and in sufficient quantities to counteract the accumulation by leaching.

Another possible cause of the severe salinity in certain large sections of Iran (e.g., the lake shores of Urmia, the south Persian Gulf coast area, some parts of the edges of Dasht-e-Kavir Desert) is the initial uniform salting received by their having been, at one time, part of the lake or sea. Any salt remaining must be regarded as having persisted. The average rainfall in these areas could remove the salt where the soil is freely permeable, whereas salt would still be present where the soil is impermeable.

One of the principal causes of waterlogging and of high water tables, in general, is seepage from canals and other water courses. Another contributory cause is the inevitable deep percolation waste associated with the application of irrigation water to soils. Both of these wastes could probably be reduced, but neither can feasibly be eliminated.

In Iran, soil salinity, alkalinity, and waterlogging are doubtless the major causes of the deterioration of the irrigated lands and the resultant decreasing yields. Though it is true that large and expensive diversion or storage structures are adding to the total irrigated area of Iran, yet it is important here to explore the conditions responsible for the deterioration of irrigated lands.

Irrigation development in Iran is generally based on the principle of serving a maximum area of land with a limited supply of water, which does not permit adequate irrigation of the commanded area each season. As a result, potentially productive lands thus left fallow for one or more seasons often deteriorate within a few years, especially in the areas where the water table is relatively close to the surface. The capillary rise of saline groundwater affects the soils to the point where they no longer produce crops unless reclaimed. Since the additional water necessary for proper leaching of the saline soil is generally not available, increasingly large areas are going out of cultivation each year.

In the early stages of salinization of the soil, the salts which accumulate are neutral salts, predominantly chlorides or sulfates of sodium and magnesium. The term *soil salinity* in its strict sense applies to the presence of such neutral salts in or on the surface soil. The harmful effect of such salinity on crop production is essentially a result of the fact that crop plants cannot tolerate more than a certain concentration of salt in the water in contact with their roots; though some kinds of plants can tolerate much more salt than others. The deposit of salts on the surface of dry saline soils is *white* ("white alkali") and the reaction of these soils is usually only very slightly on the alkali side of neutrality, with a pH of between 7 and 8.5 or even in some cases as high as 9; here the soils could be described as *saline-alkaline*. Severely saline soils are also referred to as Solonchak, and saline-alkali as Solonetz-Solonchak.

*Soil alkalinity*, on the other hand, is a later and secondary stage in soil salinization. The salts in or on the surface soil are definitely alkaline, consisting of carbonate or bicarbonate of sodium, and such soils will have a pH of 8.5 to 9, or even as high as 10. Moreover, the dark-colored humic material resulting from the decomposition of plant residues is soluble in such alkaline solutions. The surface of the soil acquires a blackish color, hence the term "*black alkali*," also referred to as Solonetz soils. No crop plant can tolerate this degree of alkalinity, and such soils are therefore quite infertile. This infertility is much more deep-seated than that of saline soils. It is a result of a change in the chemical composition of the soil, so that the reclamation of such alkali soils requires more than just washing the salts out of the soil by a combination of adequate irrigation and drainage.

Closely associated with the salinity-alkalinity problem, though not necessarily coexistent, is the condition often referred to as waterlogging, or high water table. Waterlogging is considered to exist when the water table has risen to the surface of the ground, is so high that it interferes with plowing and planting operations, or, at least, is a limiting factor in the healthy growth of plant roots.

### 5.11 Essentials to solution of the problems

Although waterlogging is a problem of relatively limited extent, the areas affected nevertheless total many millions of hectares. Drainage is a first requisite to reclaiming these areas and bringing them back into full production. A question arises as to how deep the water table should be lowered to remove the danger of salinization. In some areas drains installed to depths of 1.2 to 2.5 m have been ineffective in preventing the rise of moisture and accumulation of salts in the soils whenever the land is left idle. In these same areas, however, virtually salt-free soils exist where the land is well irrigated and regularly cropped. Therefore, with abundant water for irrigation, it would seem that the depth of the drains need not be excessively great. In actual practice the depth required is to be determined by more detailed studies.

The prevention of soil salinity, and the reclamation of saline soils which have not developed a high degree of salinity, is thus entirely a question of preventing the accumulation of salts, or removing them from the soil by efficient irrigation combined with good drainage. The reclamation of more highly saline soils, however, and still more that of alkali soils, usually necessitates also the use of chemical soil amendments. The deep-seated changes in the chemical composition of alkali soils have already occurred before actual alkalinity develops. If, however, the amount of neutral salts in the soil is relatively high, the effects of these soil changes are masked so long as these neutral salts are still *in* the soil. But as soon as most of these neutral salts have been washed out, the changed chemical composition of the soil manifests itself by the development of alkalinity. The only way to remove this alkalinity, and to restore the fertility of the soil, is to reverse the changes and restore its original chemical composition. The commonest and cheapest amendment for this purpose is gypsum—calcium sulfate; though for soils already containing adequate amounts of calcium carbonate, other materials, such as sulfur, sulfates, or iron or alumina, or even sulfuric acid, may be equally or more effective, though usually too expensive. Sometimes, in such calcareous soils, alkalinity can be removed and fertility restored by the incorporation of bulky organic debris or compost, combined with skillful methods of mechanical cultivation.

The use of such means for reclaiming alkali soils is *a supplement to*, not a substitute for, irrigation and drainage. Regeneration of the normal chemical composition of the soil will persist only if the soluble salts resulting from the interaction of the alkali soil with the amendments used are removed by leaching and carried away in the drainage. The practical problems involved in reclamation of highly saline or alkali soils by the use of soil amendments are, however, not easy and need experimentation before they are adopted on a large scale.

Good drainage and effective irrigation practices are of prime importance to the maintenance and improvement of production on irrigated lands. However, optimum production will not be realized unless attention is given also to improved farming practices. Particular attention must be given to restoring and maintaining soil fertility by using both organic and inorganic fertilizers to a much greater extent than at present.

In the interest of good land use, as well as increased crop production, improvements must be made on cropping practices, including: the adoption of suitable crop rotations, better crop varieties and better seeds, improved practices in planting, cultivating, and irrigating and more effective control of insects and plant diseases. With these improvements, together with more adequate drainage and some additional irrigation water, it should be possible to more than double the production from the land in present irrigation projects.

The exact extent of salinity and alkalinity in the soils of Iran is not known. However, some approximate idea is given by the following data:

| *Soil association* | *Area in km²* | *Percent of land surface of Iran* |
|---|---|---|
| 1-4 | 51,000 | 3.1 |
| 4 | 73,200 | 4.5 |
| 3-4 | 89,800 | 5.0 |
| 5-4 | 34,600 | 2.1 |
| Total | 248,600 (or 24.86 million ha) | 14.7 |

Of these saline and alkali soils, Salt-Marsh soils and even a good part of the Solonchaks and Desert soils–Solonchaks are those which suffer from a high water table which is normally saline. In addition, 3,600 sq km in the north are hydromorphic soils which are not saline and which have a high groundwater table.

The chemical analyses of many of these saline, saline-alkali, and alkali soils of Khuzistan, Esfahan, and certain other parts are included, with their description, in Table 49. Some of the soil samples analyzed provide evidence of a strong tendency to alkalinity in saline soils, in many cases with depth. The analyses are often related to the chemical composition of the irrigation water. Some typical analyses of a few major rivers also appear in Table 50.

The main factor deciding the quality of an irrigation water is the total amount of soluble salts that it contains, i.e., its concentration. Complete analyses of the salts present enable expression to be given to the other factors that decide the quality of a water, the most important of which is the relative proportion of sodium to other cations, the percentage of sodium and especially the sodium adsorption ratio (SAR). The ratio measures the degree of danger, through using the water, of a soil becoming an alkali one, with its attendant adverse physical properties; that degree is at the same time dependent on the total amount of salt present, i.e., given a constant value for SAR, the more concentrated the water the more dangerous its use. Waters low in total soluble salts and having low value for the SAR are termed safe.

While a Class I (low salinity) water can be used on most soils with little danger of salt accumulating, on the other hand, to maintain the soil in a salt-free condition, larger quantities of Class III waters of high salinity must be used; this is only possible where permeability and drainage are adequate. Still larger amounts of the very high salinity Class IV waters must be applied if salt is not to accumulate. Correspondingly really free drainage is an absolute necessity. It is seldom that waters of this class can be used for irrigation.

Principles of drainage and reclamation must be applied to make effective use of saline soils.

The factors that affect drainage needs in any area of Iran, and that must be taken into consideration for a successful drainage project, are:

1. Rainfall intensity, depth, and disposal.
2. Canal lengths and water conveyance losses.
3. Salty soils require leaching.
4. Drainage is essential to the leaching of excess salts.
5. Temporary leaching is of little value.
6. Effective drainage requires early beginning.
7. Drainage should precede rural constructions.

In addition, arid region drainage principles are:

1. Irrigation and drainage are inseparable.
2. Careless irrigation is expensive, both to owners of lands and owners of irrigation and drainage systems.
3. Drainage alone is not enough to reclaim and make productive waterlogged saline and alkali soils; improved irrigation practices and good soil management are also indispensable.
4. Deep drains are considered much more necessary and more important.
5. Drainage system maintenance is urgent.

In most cases in Iran, detailed studies are necessary to indicate where drainage is likely to give economic benefits and where it is not. During the course of soil and land classification several such studies have been conducted and form parts of such reports.

### 5.2 Soil fertility and response of soils to fertilizers

Crop yields in Iran both on irrigated and nonirrigated land are very low. One of the major factors responsible for low yields is the deficiency of plant nutrients in the soil, which for centuries have not been applied to farmed land. The soils seem to be particularly deficient in nitrogen and phosphorus and may be lacking in other plant nutrients. Much of the farmyard manure is burnt because large numbers of the population cannot afford other fuel material.

The vicious circle of low yields responsible for the poverty of the farming population has to be broken, and one of the readiest means of accomplishing this is by the wide and efficient use of fertilizers.

The government, conscious of the problem, has initiated during recent years studies on the potential crop production of Iranian soils in conjunction with

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TABLE 50. — CHEMICAL CHARACTERISTICS OF SELECTED RIVER WATERS*

| Name of river | Location of sampling | Date of sampling | | Total soluble salts | | pH | Milligram equivalents per liter | | | | | | | Sod. % | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Iranian calendar | International calendar | ppm | EC x $10^6$ | | Ca | Mg | Na | K | $HCO_3$ | $SO_4$ | Cl | | |
| Karkheh | Near Karkheh dam | 26/9/31 | 18/12/52 | 780 | | 7.5 | 5.8 | 2.6 | 6.7 | 0.1 | 3.7 | 4.2 | 7.2 | 44.1 | 3.2 |
| Marun | Behbahan | 25/3/38 | 15/6/59 | 946 | 1489 | Nd | 4.55 | 1.15 | 7.22 | Nd | 2.70 | 3.50 | 8.40 | | |
| Marun | Behbahan | 7/1/38 | 28/3/59 | 1352 | 1926 | 7.9 | 4.85 | 0.05 | Nd | 0.25 | 2.55 | 6.27 | 13.10 | | |
| Ala | Ramhormoz | 12/9/35 | 5/12/58 | | 2254 | 7.5 | 9.8 | 7.2 | 8.7 | Nd | 2.0 | 11.8 | 11.0 | 33.9 | 3.0 |
| Zarrineh Rud | At bridge at Miandoab | 8/4/35 | 1/7/56 | 186 | 336 | 8.2 | 1.60 | 1.45 | 0.69 | 0.10 | 2.40 | 0.86 | 0.40 | 18.4 | 0.6 |
| Zarrineh Rud | Haji Hassan (lower down) | 30/7/35 | 23/10/56 | 416 | 662 | 7.9 | 3.50 | 2.00 | 1.68 | 0.25 | 3.95 | 1.54 | 1.20 | 23.4 | 1.0 |
| Simineh Rud | Dash Band (higher up) | 8/4/35 | 1/7/56 | 120 | 251 | 8.6 | 0.80 | 0.25 | 0.65 | 0.10 | 1.75 | 0.58 | 0.35 | 24.1 | 0.6 |
| Simineh Rud | At bridge near Miandoab | 10/4/35 | 3/7/56 | 492 | 788 | 8.1 | 2.50 | 2.85 | 3.30 | 0.25 | 3.00 | 2.95 | 2.20 | 38.2 | 1.0 |
| Karkheh | Near Hamidieh | 3/4/35 | 26/7/56 | 692 | | 7.4 | 4.65 | 1.85 | 3.40 | | 3.60 | 3.02 | 3.30 | 34.3 | |
| Zayandeh Rud | Pul Qaleh near Esfahan | 30/8/32 | 22/11/53 | 328 | | 8.4 | 2.9 | 1.00 | 1.34 | 0.04 | 2.76 | 1.41 | 0.80 | 25 | |
| Zayandeh Rud | Siose Pul at Esfahan town | 3/9/32 | 25/11/53 | 431 | | 8.3 | 2.78 | 1.57 | 2.50 | 0.04 | 2.65 | 1.67 | 2.00 | 36 | |
| Shapour | Near Chaban-kareh Dam, Fars | 22/9/31 | 14/12/52 | 2916 | | 7.7 | 8.5 | 4.7 | 32.7 | 0.2 | 3.3 | 11.2 | 35.6 | 71 | |
| Aras | Near Parsabad | 2/10/36 | 22/ 1/58 | 512 | 806 | 7.9 | 2.60 | 3.40 | 3.40 | — | 5.40 | 1.49 | 2.05 | 36.2 | 1.96 |

TABLE 50. — (*Concluded*)

| Name of river | Location of sampling | Date of sampling | | Total soluble salts | | pH | Milligram equivalents per liter | | | | | | | Sod. % | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Iranian calendar | International calendar | ppm | EC x $10^6$ | | Ca | Mg | Na | K | $HCO_3$ | $SO_4$ | Cl | | |
| Aras | Sarband | 2/10/36 | 22/ 1/58 | 532 | 779 | 8.1 | 2.25 | 3.30 | 3.45 | — | 5.05 | 1.56 | 2.10 | 38.3 | 2.07 |
| Aras | Near Parsabad | 10/11/36 | 30/ 1/58 | 412 | 896 | 8.2 | 2.05 | 3.30 | 3.53 | 0.95 | 4.60 | 1.47 | 2.75 | 39.0 | 2.1 |
| Hableh Rud | Near Zarin Desht | 24/1/37 | 15/4/58 | 254 | 461 | 7.1 | 2.15 | 1.30 | 1.43 | | 2.60 | 1.40 | 0.90 | 29.2 | 1.10 |
| Hableh Rud | Above salt spring | 24/1/37 | 15/4/58 | 880 | | 8.2 | 3.10 | 2.40 | 6.12 | | 1.00 | 4.02 | 6.30 | 56.2 | 3.7 |
| Hableh Rud | Near Bon -e-Kuh below salt spring | 24/1/37 | 15/4/58 | 1000 | 1861 | 7.6 | 3.85 | 1.85 | 11.22 | | 2.25 | 4.30 | 10.40 | 65.3 | 6.62 |
| Gorgan Rud | Gonbad Kavus | 2/2/42 | 23/4/63 | 324 | 705 | 8.6 | 0.90 | 3.00 | 3.35 | — | 2.30 | 2.05 | 2.45 | | 2.4 |
| Gorgan Rud | Pahlavi Dez | 7/2/42 | 28/4/63 | 716 | 1202 | 8.0 | 0.65 | 5.35 | 7.20 | — | 2.35 | 4.35 | 5.40 | | 4.1 |
| Hirmand | Near dam | 13/1/38 | 2/4/59 | 258 | 429 | 8.4 | 1.10 | 1.75 | 1.30 | — | 2.35 | 0.99 | 0.70 | | 1.1 |
| Hirmand | Near dam | 18/6/38 | 7/9/59 | 236 | 322 | 8.7 | 1.05 | 1.50 | 0.72 | — | 1.60 | 0.74 | 0.60 | | 0.6 |
| Karun | Bahmanshir | 30/5/42 | 20/8/63 | 684 | 900 | 8.5 | 0.80 | 3.30 | 4.40 | — | 1.40 | 2.80 | 4.15 | 52 | 3.1 |
| Karun | Solemanieh | 27/9/42 | 17/12/63 | 836 | 1393 | 8.1 | 3.25 | 1.85 | 7.25 | — | 1.15 | 4.05 | 8.10 | 59 | 4.5 |
| Dez | Dez West | 9/11/36 | 29/1/58 | 224 | 551 | 7.8 | 2.90 | 1.50 | 0.95 | — | 2.55 | 1.61 | 1.20 | 18 | 0.6 |
| Kor | Doroodzan | 17/3/43 | 8/6/64 | 349 | 582 | 9.8 | 0.80 | 1.30 | 2.30 | — | 1.40 | 0.75 | 0.75 | 52 | 2.2 |
| Kor | Doroodzan | 8/6/43 | 30/8/64 | 466 | 832 | 7.4 | 1.05 | 2.50 | 3.30 | — | 2.15 | 1.45 | 3.10 | 48 | 2.5 |

* Methods of analysis used are described in Chapter 8 of Agriculture Handbook No. 60 (U.S. Department of Agriculture), *Diagnosis and improvement of saline and alkali soils.*

FIGURE 85. Zarrineh Rud. Animal manures are made into patties, dried, and used for fuel.

FIGURE 86. Soil fertility workers in front of a fertilizer trials plot in Kermanshah.

fertilizers. Notable among these efforts are those in Khuzistan where during the years 1957 to 1962 special attention to the problem was given by the detailed soil fertility program of the Khuzistan Development Service.

The Soil Fertility Unit of the Ministry of Agriculture (with the assistance of United Nations Special Fund and government contributions) and other institutions, such as the Plant Science Department, Extension Service, Tobacco Monopoly, and Tea Organizations have carried out fertilizer experiments, the results of which are summarized below in four parts.

I. More than 54,000 test plots have been established and observed during four cropping years, in 407 villages in Khuzistan. Fertilizer tests were made on all the important local crops including wheat, barley, rice, sesame, cotton, sugar beets, alfalfa, sugarcane, and vegetable crops.

Chemical and physical analyses of more than 25,000 soil samples were made during the years 1958-62.

The summary and analysis of data from the test plots established that the proper use of fertilizer results in significant increase in yields of crops grown on the soils of Khuzistan. The results of this study in relation to various crops are listed below.

A. *Wheat and barley:* Analysis of the results of the data of 35,000 fertilizer plots offers the following conclusions:

1. Fertilizer applications to nonirrigated wheat or barley were generally unprofitable under normal rainfall conditions in the years 1957-61.
2. Fertilizer applications to irrigated wheat and barley generally resulted in profitable increases in grain yields.
3. On most soils a combination of nitrogen and phosphorus was necessary for highest yields.
4. Wheat and barley yields were not significantly or economically increased by use of potassium fertilizers.
5. Experiments conducted at 273 locations in Khuzistan indicated little difference between the yields obtained from the application of nitrogen at seeding time and nitrogen applied as a top dressing to growing wheat plants.
6. Investigations with various nitrogen carriers, i.e., ammonium nitrate, urea and ammonium sulfate revealed approximately equal benefits from these nitrogen sources applied to wheat and barley.
7. Phosphorus fertilizer carrier studies indicated that the more water-soluble forms of phosphorus fertilizer were the most desirable.
8. Although fertilizer response was obtained from the application of nitrogen and phosphorus on nearly all the soils of Khuzistan, the most economical level of applications could be ascertained best by soil testing.
9. The application of trace elements including boron, manganese, copper, zinc, magnesium, and molybdenum, resulted in no measurable increase in grain yields.
10. The application of nitrogen fertilizer without accompanying phosphorus fertilizer often resulted in monetary losses.
11. Fertilizer materials broadcast at seeding time and incorporated into the soil by shallow plowing were effective in producing increases in yields.
12. In general an application of 30 kg of nitrogen plus 30 kg of $P_2 0_5$ per ha on most soils resulted in the highest net return per hectare.

B. *Rice:* Over 7,000 trial plots were established on rice in farmers' fields.

Analysis of this data permits the following conclusions for fertilizer usage on Khuzistan rice:

1. The application of either nitrogen or phosphorus fertilizer to rice resulted in economical increases in yields, but combinations of nitrogen and phosphorus fertilizer were more effective in increasing yields than the use of either nitrogen or phosphorus fertilizer applied alone.
2. Certain soils of the Khuzistan Plain were found to require additions of potassium fertilizer for highest yields of rice.
3. Ammonium sulfate (20.5 percent nitrogen) proved to be a more effective nitrogen material for rice fertilization than urea or ammonium nitrate forms of nitrogen.
4. Fertilizer materials were successfully broadcast on transplanted rice, if irrigation waters were shut off for 24 hours after application.
5. In general the application of 30 kg of nitrogen plus 30 kg of $P_2 0_5$ per ha resulted in the highest return per unit of money invested.
6. In general the application of 60 kg of nitrogen plus 60 kg of $P_2 0_5$ per ha resulted in the highest return per hectare.
7. The application of trace elements including boron, manganese, copper, zinc, magnesium, and molybdenum did not result in significant increases in rice yields.
8. Best results from nitrogen fertilizer on rice were achieved when the fertilizer was applied at or near planting time, and incorporated into the soil at 5-10 cm depth.

C. *Sugar beets:* Altogether 5,800 fertilizer trial plots were established on sugar beets. Analysis of the data permits the following conclusions on use of fertilizer on sugar beets in the Khuzistan headwaters mainly in the Kermanshah area:

1. Nitrogen fertilizer alone was economic in increasing sugar-beet yields.
2. Phosphorus fertilizer alone applied at seeding time resulted in significant increases of yields.
3. The application of potassium often resulted in a small increase in yield, but the increase was not sufficient to be economically profitable.
4. Highest yields of sugar beets were generally obtained by applying a combination of nitrogen and phosphorus fertilizer.
5. The most economical level of fertilizer application on sugar beets can best be determined by soil tests. The wide variation in phosphorus and potassium content of the mountain valley soils makes a general recommendation often impractical.

6. In general an application of 60 kg of nitrogen plus 60 kg of $P_2O_5$ per ha resulted in the highest return per rial invested.
7. For highest return per hectare an application of 120 kg nitrogen plus 120 kg of $P_2O_5$ per ha was necessary.
8. Effective use under present farmers' conditions was obtained by broadcasting the fertilizers prior to planting and incorporating in the soil with the seed.

D. *Cotton:* Over 3,400 fertilizer judgment plots on cotton were established for a three-year period.

A review of this data offers the following conclusions on the fertilizing of cotton in the Khuzistan headwaters:

1. Nitrogen fertilizer applied alone or in combination with phosphorus fertilizer resulted in significant increases in seed-cotton yields.
2. The application of phosphorus alone did not result in measurable increases in yield in many localities.
3. Highest yields of seed-cotton were obtained from combinations of nitrogen and phosphorus fertilizer.
4. The different nitrogen carriers – urea, ammonium nitrate, or ammonium sulfate – resulted in similar increases in yields when applied at equivalent nitrogen rates.
5. Trace elements including manganese, copper, boron, magnesium, zinc, and molybdenum, resulted in no significant increase in seed-cotton yields.
6. Under present farm cultural practices an application of 60 kg of nitrogen plus 60 kg of $P_2O_5$ generally produced the greatest net return per hectare, as well as the highest return per rial invested.

E. *Truck crops:* Altogether over 1,400 fertilizer trial plots were established on truck crops (vegetables) during the three years 1959-1961.

Analysis of these data offers the following conclusions on the use of fertilizer on Khuzistan vegetables:

1. Nearly all truck crops were found to require both nitrogen and phosphorus fertilizer applications for highest yields.
2. Even under conditions where large quantities of animal manure were applied, the application of chemical fertilizer proved important.
3. For lettuce, highest yields were obtained when a combination of 60 kg of nitrogen, 60 kg of $P_2O_5$ and 30 kg of potassium was applied per ha.
4. For broad beans, phosphorus alone at the rate of 30 kg of $P_2O_5$ per ha produced the most significant increases.
5. For melons, an increase in size of fruit, as well as total yield per hectare was

obtained from nitrogen and phosphorus applications. An application of 90 kg of nitrogen plus 90 kg of $P_2O_5$ per ha resulted in highest yields.

6. Numerous trials on onions and garlic indicated excellent responses to nitrogen, phosphorus, and potassium fertilizer. Highest yields of onions were obtained from an application of 120 kg of nitrogen plus 120 kg of $P_2O_5$ and 60 kg of $K_2O$ per ha.

F. *Sugarcane:* An analysis of fertilizer testing data at the Haft Tapeh Sugarcane Plantation suggests the following conclusions:

1. Nitrogen and phosphorus fertilizer applications resulted in significant increases in tons of cane as well as tons of sugar produced.
2. Potassium fertilizer applications produced no significant increases in millable cane or in sugar content.
3. On ratoon cane fields (that is, crop produced by regrowth from previous year's crop roots), an application of 150 kg nitrogen per ha generally resulted in the most economical increase in sugar provided adequate phosphorus had already been applied.
4. 100 kg of nitrogen per ha resulted in the highest significant increase in sugar on new plantings of sugarcane.
5. Under conditions of low soil phosphorus an application equivalent to 200 kg of $P_2O_5$ per ha was needed on newly planted cane only.
6. Split applications of nitrogen proved superior to applying all the nitrogen early in the season.

II. The Soil Fertility Unit started its studies in January 1961 in the Caspian coastal areas and in the Province of Fars. The conclusions of its study during one season were:

A. Gilan

*Fertilizer experiments with rice.* The data of the few trials in Gilan show a definite superiority of the treatment 30-30-0,[2] which resulted for both Sari and Champa trials in an increase of the invested capital more than threefold. Also the treatments 60-30-0 and 60-30-0 were found to be justified economically, more so with Champa rice than with Sari rice.

A 60 kg $P_2O_5$ application per ha seems to be too high an compared to the other application rates and was shown to be uneconomical in these trials. Potassium applications did not show significant effects either.

[2] 30 kg N, 30 kg $P_2O_5$ and no $K_2O$ per ha.

Applications of one nutrient alone seems not to be recommendable as they would tend to deplete soil reserves of other nutrients.

B. Mazanderan

(i) *Fertilizer experiments with rice.* According to the experimental results in Mazanderan, similarities are found with the results obtained in Gilan insofar as the treatment 30-30-0 is generally favorable, resulting in yield increases which more than treble the capital invested in fertilizers. For Champa rice 60 kg N combined with 30 kg $P_2O_5$ was found to be especially favorable, increasing in these experiments the money invested more than fivefold (and in some cases resulting in a gross profit of more than 100,000 rials per ha, due solely to fertilizer application).

For Sari rice the treatment 60-30-0 is also suitable as it results in yield increases which more than double the invested capital.

The applications of 30 kg $P_2O_5$ per ha alone resulted for both types of rice in very high yield increases, which returned invested capital more than eightfold, because of the low price of the fertilizers needed. However, before a single phosphorus application can be recommended, the results obtained must be verified by more experiments. Since it is known from the data that nitrogen is also needed, an application of phosphorus alone might deplete the soil reserve of nitrogen quickly, resulting in a serious depression of yields in later seasons.

The higher phosphorus rate of 60 kg/ha $P_2O_5$ does not seem to have any advantage over the lower rate of 30 kg/ha, and is not economically justified.

Potassium does not seem to be needed at this stage, and application of it not economically justified.

(ii) *Fertilizer experiments with cotton.* The average responses give a general picture about the yield-increasing effect of each rate of nutrient separately. They are:

| | | |
|---|---|---|
| O | — $N_{45}$ | 63 kg/ha |
| $N_{45}$ | — $N_{90}$ | 142 " |
| O | — $P_{45}$ | 29 " |
| $P_{45}$ | — $P_{90}$ | 40 " |
| O | — $K_{45}$ | 55 " |

It is obvious that these effects are abnormally low. However, the low effect of nitrogen appears here again and is an indication that lack of sufficient water has hampered normal plant development.

From these data no conclusions can be drawn until more results of experiments in subsequent seasons are available.

C. Gorgan

During the 1961 season fertilizer experiments were carried out with the main summer crops, cotton and tobacco. Cotton is harvested in Gorgan many times. This limited the number of field trials which could be handled by the Soil Fertility Project's field staff. Tobacco experiments require special designs since the objective of fertilization of tobacco is mainly to improve the quality of leaves, which increases the crop value more than an increased quantity of leaves.

*Fertilizer experiments with tobacco* in Gorgan showed that all three plant nutrient elements, N, P, and K, were needed for increasing the leaf yields and the crop values. With the two best fertilizer treatments, 0-60-60 and 15-60-60, the total leaf yields were increased only about 10 percent. The well-balanced supply of plant nutrients brought about a shift of leaves from lower to higher quality classes. In this regard, the fertilizer treatment 15-60-60 was more effective than the other good treatment 0-60-60.

Among the well-balanced fertilizer applications, the total increase of the crop value was about 50 percent due to actual yield increase and the other 50 percent was due to improvement of the leaf quality.

The profit obtained by fertilizer application with the best treatment, 15-60-60, was found to be eight times more than the money invested, but the highest return was obtained with the treatment 15-30-30.

D. Shiraz

(i) *Fertilizer experiments with cotton.* The average yield as well as the yield increases were very low. None of the yield increases are statistically significant, except that of treatment 90-45-0.

(ii) *Fertilizer experiments with sugar beet* in Shiraz were carried out as top-dressing trials. Fields of very high original yield levels were partly included in these experiments, on which relatively low responses to fertilizers were observed. The group of trials conducted on normal yielding fields showed high yield responses to fertilizer applications, ranging between 5 and 12 tons of beets per ha, with an average of 8.5 tons per ha. The best nutrient relation in these trials was the treatment 90-45-45 with a yield increase of over 12 tons per ha of sugar beets.

The sugar contents of the beets were 19.65 percent. The above-mentioned fertilizer treatment 90-45-45 increased the sugar yield on medium yielding fields by more than 2 tons of sugar per ha.

The results show that, even with top-dressings applied six to eight weeks after seeding time, favorable and economic yield increases can be obtained.

E. Fassa

(i) *The cotton experiments* in Fassa showed very clearly that, under the experimental conditions of the 1961 season, the fertilizer treatment 45-45-0 is very promising in giving yield increases over 400 kg/ha of seed cotton, and resulted in high monetary profits and returns. Experiments during the coming seasons are needed to verify these results and to give more detailed information.

(ii) *Fertilizer experiments with sugar beet* in Fassa showed that fertilizer applications 90-45-0 and 90-90-0 are most suitable and economical under the present farming conditions. The first treatment 90-45-0 is safer in regard to economy and potassium content of the soil. Potassium fertilizers were found to be uneconomical. These results were obtained with top-dressing experiments only.

Fertilizer applications on fields with higher original yields pay higher monetary returns than those on "poor" fields.

F. Kazerun

(i) *Fertilizer treatment on rice* resulting in highest capital returns — more than four times the capital invested — was 30-30-0. The higher rate of 60-60-0 gave a gross profit of more than three times the invested capital. The 30-60-30 treatment also showed good results which, however, need confirmation by other treatments with similar combinations.

(ii) *Fertilizer experiments with cotton.* Cultivation practices of cotton in Kazerun seem to be less favorable than in other areas. Possibly water shortage has had a yield-decreasing influence during the 1961 season, lowering the yield ceiling to an unusually low level.

Under these conditions the fertilizer treatment 45-45-0 seems to be the most promising one. Higher application rates would not be advisable unless cultural and other soil management practices are improved.

III. Simple fertilizer trials on farmers' fields carried out by Extension Service supervised by the Plant Science Department. The results are as follows:

A. Azerbaijan

Fertilizer application increased the yields of the crops considerably. On irrigated wheat and rice the application of nitrogen alone (30 kg N for wheat and 50 kg for rice) had a good effect. On nonirrigated wheat, phosphorus is also needed, but it is not economical. Potassium application would be profitable to the farmers only in the case of potatoes (108 kg N, 92 kg $P_2O_5$, and 100 kg $K_2O$ per ha).

B. Gilan

Since the most important annual crop in Gilan is rice, fertilizer trials were carried out on this crop.

Nitrogen alone would increase the yield of rice and application of combined fertilizer, nitrogen, and phosphorus is also economical (51 kg N and 92 kg $P_2O_5$ per ha).

C. Mazanderan

Trials carried out for rice and cotton in Mazanderan proved that the yield will increase with nitrogen and phosphorus application (51 kg N and 92 kg $P_2O_5$ per ha).

D. Khurasan

The cotton trials indicated that highest returns from invested money would be obtained with an application of nitrogen alone. The next best treatment is 62-92-50. Statistically the latter treatment is much safer because the yield increase obtained is significantly higher than those of the two lower treatments.

The sugar-beet trials show also that the highest profits would be obtained with the application of nitrogen alone. The next best treatment in an economical sense is 62-92-0.

E. Tehran

From the cotton trials it would seem that the application of nitrogen would give the farmer a good monetary return. The application of 62-92-50 would be economically justified too, and resulted in these trials in a significant yield increase.

F. Esfahan

The cotton trials show that in the experimental soils the treatment 62-92-50 results in a significant yield increase which is profitable for the farmer. Also the highest application 92-92-50 is economically justified, but needs a higher money investment so that the farmer might be better off by fertilizing a bigger surface with the lower rate.

For potatoes the highest application rate of 108-92-100 would result in the highest monetary profit for the farmer.

G. Fars

The 12 cotton trials were established on 7 different fields. According to the results obtained, the combination of nitrogen with phosphorus is most suitable. It results in a highly significant yield increase and the farmer would make the highest profit with this treatment 62-92-0.

The effect of nitrogen alone is not significant, but the effects of the combinations (108 kg N, 92 kg $P_2O_5$ and 100 kg $K_20$ per ha) return good profit.

IV. Fertilizer experiments conducted by the Plant Science Department mainly on Experiment Stations:

(i) *The experiment with rice* in Rasht and Sari shows high responses to fertilizer applications. The combined application of nitrogen and phosphorus (130 kg N and 70 kg $P_2O_5$ per ha) results in the highest yield increase.

(ii) *Fertilizer experiment with cotton.* Application of 50-90-65 results in a highly significant yield increase over the unfertilized plots. Very often the rate of fertilizer applications was too high and the yield increases hardly repaid the money invested in fertilizer.

(iii) *Fertilizer trials on sugar beet.* Nitrogen increases the yield considerably and significantly in Karaj (120 kg N per ha will raise the average yield from 34.7 to 47.3 tons per ha). (In Mianeh from 40.5 to 46.3 tons per ha.)

The trials in Mashhad also show a high yield-increasing effect of nitrogen. The most economical application in Mashhad is the treatment 120-90-0.

Experiments with fertilizer and farmyard manure in Miandoab show yield increases. If 20 or 40 tons of manure per ha are used, it would pay to apply the lowest rate of fertilizer. If more fertilizer were applied with the manure the additional yield increase would not repay fertilizer costs. If 60 tons of manure are applied, no fertilizer application pays.

The sugar-beet trials conducted in the different areas of Iran in a very systematic way showed that, in general, nitrogen is the main plant food sugar beet requires under experimental conditions. Phosphorus has less effect and potassium might have a positive or negative effect, but always insignificant.

V. Fertilizer trials conducted by the Tobacco Monopoly.

Fertilizer trials on tobacco conducted at the Tirtash station show that nitrogen decreases the total yield insignificantly while phosphorus and potassium both increase the total yields.

The treatment of 40 kg $P_2O_5$ and 60 kg $K_2O$ results in the highest value of the crop per ha.

VI. Fertilizer trials on tea carried out by the Tea Organization.

The experiments in Gilan tea fields showed the highest yield increase, as well as the highest profit by the application of nitrogen alone (42 kg N per ha). Also the treatment 42-16-35 results in a good yield increase.

From an economical point of view the use of nitrogen alone does not result in the highest monetary profit. An additional application of 32 kg $P_2O_5$ increases the profit considerably. The combination of nitrogen plus potassium is also more profitable than nitrogen alone.

## 5.3 Soil organic matter for arid and semiarid areas

In general about 85 to 90 percent of the land surface of Iran including the cultivated areas contains inadequate organic matter. These areas belong essentially to the arid and semiarid regions of Iran – the exception being those areas under well-drained alluvial and other soils where good crop rotation and soil management practices have been adopted. In general the soils range from almost no organic matter to about 2 to 3 percent organic matter in some Brown and Chestnut soils or alluvial soils. The 10-15 percent of areas in the humid and subhumid regions of the north, however, usually contain an adequate amount of organic matter, normally between 3 to 5 percent or more.

Analytical data attached to the description of each soil association given in Chapter 3 gives the percentage organic matter in typical soils of Iran and Table 51 summarizes this data.

Studies have been conducted jointly by FAO, Unesco and the Arid Zone Center in Iran under a Unesco sponsored research project in Switzerland on the nature of organic matter present in the arid and semiarid soils. Some surface samples for this study were sent by the author (M. L. Dewan) to the E.T.H. Laboratory, Zurich. Here is the summary of these investigations and findings.

(*a*) The extraction of soil organic matter with ethanol benzene: In general about 50 percent of the organic matter (calculated on the basis of the nitrogen content) was extracted from the soil sample from Iran by repeated treatment with acid and alkali.

The extraction with ethanol-benzene was done in the experiments conducted. These extracts contained essentially fulvic and humic acids.

(*b*) Determination of nitrogen compounds showed that the nitrogen may be present as:

exchangeable ammonia
fixed ammonia
nitrates and nitrites

| | |
|---|---|
| amino acids and related compounds (14-65 percent of total nitrogen)<br>amino sugars (1-20 percent)<br>nucleic acids (traces)<br>humic acids (the type of bond has not been elucidated yet) | } organic nitrogen (about 98 percent of total soil nitrogen) |

(*c*) The amino acids in the Brown soils as detected by paper chromatography are:

TABLE 51. — ORGANIC MATTER CONTENT OF SOME SURFACE SOIL SAMPLES

| Serial no. | Profile no. | Location | Soil association no. | Predominant soil group | Depth of sampling (cm) | % Organic matter |
|---|---|---|---|---|---|---|
| I. Soils of plains and valleys: | | | | | | |
| 1 | 266 | Dezful | 1 | Fine-textured Alluvial | 0–15 | 1.4 |
| 2 | 43 | Babolsar | 1 | Typical fine-textured Alluvial | 0–20 | 1.8 |
| 3 | 257 | Dezful | 1 | Typical fine-textured Alluvial | 0–15 | 0.84 |
| 4 | 250 | Shush | 1 | Typical fine-textured Alluvial | 0–20 | 1.0 |
| 5 | 63 | Shahabad | 1 | Typical fine-textured Alluvial | 0–25 | 1.07 |
| 6 | 137 | Dezful | 1–4 | Saline Alluvial | 0–20 | 0.8 |
| 7 | 20 | Dezful | 1–4 | Saline Alluvial | 0–30 | 0.8 |
| 8 | 5 | Shahreza | 2a | Colluvial | 0–12 | 1.22 |
| 9 | 78 | Near Rasht | 3 | Low Humic-Gley | 0–20 | 1.7 |
| 10 | 47 | Nowshahr | 3 | Humic-Gley | 0–15 | 2.0 |
| 11 | 79 | Pahlavi | 3 | Humic-Gley | 0–20 | 5.9 |
| 12 | 79 | Pahlavi | 3 | Humic-Gley | 20–40 | 6.2 |
| 13 | 50 | Ramhormoz | 4 | Solonchak | 0–20 | 0.41 |
| 14 | 1 | Esfahan | 4 | Solonchak | 0–5<br>5–15 | 1.3<br>0.2 |
| 15 | M. 9 | Moghan | 4 | Solonetz | 0–20 | 0.61 |
| II. Soils of plateau and mountainous regions | | | | | | |
| (*a*) *Arid-semiarid* | | | | | | |
| 16 | 29 | | 5 | Desert | 1–5 | 0.2 |
| 17 | 3 | Nain | 5 | Desert | 1–5 | 0.7 |
| 18 | 10 | Bam-Zahedan | 5.2a | Desert - Regosols | 1–5 | 0.1 |
| 19 | 6 | Yazd | 5–4 | Desert - Solonchak | 1–5 | 0.2 |
| 20 | 12 B | Zahedan-Karman | 5–4 | Desert - Solonchak | 1–5 | 0.2 |

TABLE 51. (*Continued*)

| Serial no. | Profile no. | Location | Soil association no. | Predominant soil group | Depth of sampling (cm) | % Organic matter |
|---|---|---|---|---|---|---|
| 21 | 11 | Bam-Zahedan | 5–4 | Desert - Regosols | 1–10 | 0.2 |
| 22 | 13 | Seistan | 5–4 | Desert - Solonchak | 1–5 | 0.5 |
| 23 | 2 | Esfahan | 6 | Sierozem | 1–5 | 0.2 |
| 24 | 31 | Gonabad | 6 | Sierozem | 1–20 | 0.1 |
| 25 | 36 | Shahrud-Damghan | 6–2 | Sierozem Regosols | 1–5 | 0.2 |
| 26 | 9 | Fars north | 6–2 | Sierozem Regosols | 0–25 | 0.1 |
| 27 | 8 | Kerman-Bam | 13 | Lithosols | 0–5 | 0.3 |
| 28 | 30 | Birjand | 16 | Lithosols - Desert | 0–4 | 0.2 |
| 29 | 35 | Mashhad-Tehran | 16 | Lithosols - Desert | 1–5 | 0.1 |
| (*b*) *Dry subhumid* | | | | | | |
| 30 | B2 | Shush | 7 | Brown | 0–20 | 1.5 |
| 31 | 2 | Shush | 7 | Brown | 0–20 | 1.0 |
| 32 | 89 | Ardebil | 7–15 | Brown | 0–15 | |
| 33 | 28 | Haji Kalat - Gorgan | 8 | Chestnut | 0–15 | 3.4 |
| 34 | 128 | Near Bostanabad | 8 | Chestnut | 0–15 | 0.7 |
| 35 | | Ardebil-Sarab | 12 | Brown-Rendzinas | 0–25 | 3.2 |
| 36 | 20 | Fars north | 15 | Lithosols - Brown | 0–13 | 1.2 |
| III. Soils of the Caspian area: (moist - subhumid to humid) | | | | | | |
| 37 | 38 | Firuzkuh-Pul Sefid | 9 | Red Mediterranean | 0–5 | 1.6 |
| 38 | 18 | Sari-Behshahr | 11 | Brown Forest | 0–20 | 2.1 |
| 39 | 30 | North Gorgan | 11 | Brown Forest | 0–10 | 1.8 |
| 40 | 25 | East of Gorgan | 11 | Brown Forest | 0–10 | 4.4 |

TABLE 51. (*Concluded*)

| Serial no. | Profile no. | Location | Soil Association no. | Predominant soil group | Depth of sampling (cm) | % Organic carbon |
|---|---|---|---|---|---|---|
| 41 | Caspian I | Northwest of Rasht | 11 | Grey-Brown Podzolic | 0–1 | 7.9 |
| 42 | 49 | Near Chalus | 11 | Brown Forest | 0–5<br>5–20 | 5.1<br>2.9 |
| 43 | 49 | Chalus | 17 | Lithosols - Brown Forest - Podzolic | 0–5<br>5–20 | 1.5<br>1.2 |
| 44 | 55 | Ramsar | 18 | Lithosols - Red Podzolic | 0–5<br>5–25<br>25–50 | 2.9<br>1.4<br>0.2 |
| 45 | 63 | Langarud | 19 | Lithosols - Podzolic | 0–5<br>5–25 | 5.6<br>2.4 |
| 46 | 64 | Langarud | 19 | Lithosols - Podzolic | 0–20 | 1.9 |

glycine, alanine, valine, leucine, isoleucine, threonine, aspartic acid, lysine, arginine.

The causes of the low organic matter content in the soils of Iran are obviously the high temperatures and the lack of moisture, which result in a minimum of vegetation. Improper soil management and crop rotation are also important factors contributing to the low organic matter content of the soils.

Large areas of cultivated soils are bare for part of the year. In general there are winter rains in the arid and semiarid areas of Iran and that is when large areas are under crops. In summer when the temperatures are the highest there are no rains and very small areas under crops which are essentially under irrigation. High summer temperatures are also mainly responsible for the low organic matter status of the soils of Iran.

A proper crop rotation including mixed farming as far as possible for the cultivated areas, the introduction of certain soil cover, and the prevention of destruction of the soil where it exists, are some of the important methods of improving the organic matter status in the soils. Use of cattle, sheep, and even camel manure for the soil, as well as pigeon guano, has helped in some specific areas, and should have wider application where possible.

## 5.4 Soil conservation (including control of water and wind erosion)

SOIL EROSION

Looking into the past, one sees the continuous working of geologic erosion in all parts of Iran. Erosion has worn away and sculptured the surface of the earth since time immemorial and is a process of nature which has formed the landscape as we know it today. This process acts steadily but so slowly that ages are required for it to make any marked alterations in the major features of the earth's surface. During the ages there were doubtless changes in climatic conditions which affected rates of erosion. Natural or geologic erosion is a continuing and inevitable process regardless of what man may do.

On the other hand, the kind of soil erosion that is of serious concern is an abnormal and undesirable process resulting from man's activities and subject to his control. Soil erosion is one of the most pressing problems for Iran and, indeed, for the world. Already it has ruined millions of hectares of formerly cultivated land and reduced other millions to definitely submarginal conditions.

Under natural conditions, undisturbed by erosion, nature provides a certain type of "climax" vegetative cover for the earth, determined primarily by climate, soil, and topography. Climax vegetation for all areas has, however, a common characteristic: it is the dominant cover which protects and holds soil and water under the climatic conditions that prevail. With proper and reasonable use this vegetation can serve man and animals for food, fodder, fuel, and shelter and will maintain itself. However, if *overused or abused* by severe grazing, burning, cutting, or other means, the more desirable and palatable perennial plants will gradually be replaced by less desirable perennials and annuals. If the overuse continues long enough, only the most undesirable perennial species will remain and multiply and the cover will contain many undesirable and unpalatable annual species. When this condition occurs, the cover generally will not be sufficient to hold the soil in place.

Nature originally provided Iran with two types of vegetation. Under the humid maritime climate of the Caspian region, excellent forests were developed. Trees also grew in some of the mountain areas where snow provided sufficient moisture. Unplanned cutting and severe grazing has largely eliminated the trees from the mountainous area, and much of the Caspian forest has been severely damaged and depleted. The greater part of Iran, however, has an arid or semiarid climate under which a desert-type vegetation consisting of shrubs and grasses developed. That this latter area is important to Iran and has been important in the past is

FIGURE 87. Khuzistan. Gully erosion starts on slightly sloping area. *Below*, close-up.

FIGURE 88. Sumar area in Kermanshah Province. Engr. Rejali of the Division of Agriculture and Water Economy observes gully erosion from runoff water from irrigation. *Photo O. T. Osgood.*

proved by civilizations that developed at Hamadan, Esfahan, Shiraz, Shush, and other places.

Though certain changes are taking place, the economy of Iran, as it was in the past and is to a considerable extent even at present, is that of a pastoral nomadic people. The tribes and individual shepherds and herdsmen move their flocks about seeking the best pastures. Because of the orography and physiography of different climatic provinces of Iran, mountains and mountain valleys have a climate very different from that of the plains. A nomadic system therefore, enables the herdsman to get round-the-year pasturage for his flock. Though sometimes the distances traveled by these nomadic tribesmen may be great, usually they can be covered within a month. The tribesmen are intolerant of warm summers and thus inherently resistant to settled agriculture in the plains (which usually have high summer temperatures), and so they have played a great part in keeping alive the nomadic system.

Of the sparse vegetation a large part is utilized by cattle, some for fuel. As a result of thousands of years of such usage the original vegetation cover of these arid regions has almost completely disappeared. Perennial grasses are almost nonexistent, or grow only in some of the isolated far-off areas, difficult of access.

This change in vegetation in almost all of the area has had a marked effect on erosion and runoff. The present plants do not provide sufficient cover to protect the soil and hold it in place. The soil has become hard and packed and does not absorb water as readily as it should. During the periods of rain, or when the winter snows melt, both runoff and erosion are severe; so severe that in many places roads are covered by silt or washed out, villages and towns flooded and crops destroyed. Irrigation canals and ditches are often damaged. Ghanats, many of which have a value of the order of several millions of rials, are often destroyed.

In some places destruction of the protective vegetative cover has resulted in moving sand dunes, which often threaten to cover roads, villages, irrigation works, and other structures.

For agricultural lands, soil productivity is of basic importance. In order to keep the land productive a good conservation program is imperative. The basis of such a program is soil and water conservation; it also helps to improve land impoverished by erosion and overuse and to make it more productive. For effective conservation the various kinds of lands must be treated and *used according to their capability.*

On productive agricultural lands, soil conservation practices store more of the runoff from excess rainfall in the reservoir of soil for subsequent crop use, and this water is kept out of streams, thereby curbing floods.

The logical approach to agricultural development and sound soil and water conservation programs is to work on a "watershed basis." In this procedure an entire watershed is studied from the headwaters to the mouth. It can then be developed according to its capabilities for maximum production and permanent agriculture.

A large number of dams and reservoirs like Sefid Rud, Karaj, Doroodzan, Saveh, Zarríneh Rud, Dezful, and many others have been proposed, and some are under construction or are already built. No adequate watershed protection programs have been established, and in many cases excess runoff and silt will destroy the effectiveness of these structures. The data on silt in river waters indicate that lower Karaj has 302,000 $m^3$ per year of suspended load and would silt the reservoir under present conditions in a little over 100 years. In the case of Dez dam it appears that it will take 150 years or so to silt up. Such hydrometric studies should be made for other river systems where dams are being proposed.

The Latiyan reservoir on the Jaje Rud, according to the report of Sir Alexander Gibb and partners in 1958, would be reduced from 130,000 $m^3$ to 80,000 $m^3$ within 50 years. Water samples from the Jaje Rud at Lashkarek, a short distance above the proposed Latiyan dam, show a content of 4,220 ppm of suspended silt after two days of heavy rain (April 1959).

The need for soil and water conservation in Iran is urgent. The balance of nature which established climax vegetation is disturbed because of:

1. Overgrazing on large areas of all categories of land.
2. Intense concentration of population in certain cities.
3. Expanding communication such as new roads and railways.
4. Development and multiplication of new industries.

These changes have brought about:

1. Gathering of flocks on the outskirts of large cities to supply meat for the increasing populations.
2. Opening wide areas for new buildings.
3. Small farmers forced off lands now needed for grazing or industry, and plowing plots on steep slopes formerly used for occasional grazing.
4. New industrial centers (factories or kilns) accepting cheap fuel such as dry vegetation, thus encouraging despoilers of vegetation.
5. Depleting of forests to supply material for roads and railroads.
6. Leveling hills and interfering with the natural course of torrents.

FIGURE 89. Deep, well-drained Alluvial soils, near Babolsar in the north. River bank erosion is prominent and prevention measures are being taken.

The problem of soil and water conservation is no less important for cultivated areas where lack of soil-building rotation and of organic matter (due to burning of manure for fuel) accentuates the seriousness of the situation.

EXAMPLES OF DAMAGE DONE BY SOIL EROSION IN DIFFERENT REGIONS

To illustrate and emphasize the need for sound soil and water conservation, a review is being made of the damage done by soil erosion in different regions of Iran.

*a. Caspian region*

Though the climatic conditions (long period of growth and well-distributed high rainfall) are well suited to luxuriant growth and vegetation, and do give rise to dense forest, in recent decades many forests have been very heavily cut and destroyed. This, coupled with heavy grazing and fires, has left many hills barren. Quite a lot of deforestation has also been done for the cultivation of tea, cotton, wheat, and rice. Many of the hills have slopes of 40 to 50 percent or more. The remnants of forests are removed and these slopes plowed and cropped without even terracing them. Heavy sheet, rill, and gully erosion is in progress in most of such abused areas from Gorgan to Astara all along the Caspian littoral.

*b. Khuzistan Plain*

Erosion on the Khuzistan Plain is not so spectacular as is the soil salinity. However, conditions such as partial or complete loss of structure, due to insufficient protection of the soil surface by vegetation, too little organic matter in the soil, and rain showers of high intensity, promote accelerated erosion. The problem in this area may best be discussed under four separate headings:

1. *Water erosion on flat areas*: From their physical nature, fine texture, etc., the soils are not very permeable, so that during the rains, which have a relatively high intensity, water will tend to collect on the surface. Under these conditions it has been observed that wheel tracks, for example, can offer a point of attack, and be in effect the beginning of gully erosion; caving and cutting may follow.

2. *Water erosion on sloping areas*: In the foothills of the Bakhtiari mountains (Zagros range, northeast of Shushtar) as well as in the neighborhood of Behbahan and elsewhere, there are extensive areas under agriculture or poor pasture, which are on slight to moderate and occasionally even steep slopes. Although the annual winter rainfall amounts only to some 300 mm, it is often distributed in downpours of high intensity which cause increased runoff and accelerated erosion. This does not become spectacular until the stage of gully erosion is reached. The latter, however, is preceded by severe sheet erosion, which involves the partial or total loss of the topsoil. The restoration of fertility to a badly eroded soil is a slow and expensive operation.

Gully erosion by the action of rainwater has been observed on Ahwaz-Shushtar road, north of Weis and Band-i-Gir, as well as on the slopes of old terraces close to riverbanks.

3. *Riverbank erosion*: The rivers of Khuzistan, Karkheh, Dez, Karun, Jarrahi, and Hendijan pursue meandering courses through the plain and there is a continuing process of erosion of their banks at some points and deposition at others. This results not only in the destruction of what is generally good agricultural land, but there are often threats to, or interference with, communications; even villages on the banks of some of the rivers have sometimes to be abandoned. It may not be economically feasible to control all riverbank erosion, especially with very high floods, but it is frequently practicable and sometimes an absolute necessity.

4. *Wind erosion*: Westerly and northwesterly winds of high velocity are a feature of the open treeless plains of Khuzistan. Together with the drying-out and powdering of the surface soil in the high temperatures of spring and summer, they provide favorable conditions for wind erosion, so that it is not surprising that frequent dust storms occur.

Extensive sand dune formations are found on the right bank of the Karkheh River upstream of the dam, in the center of Parts I and II of the Karkheh project area, to the east as well as northeast of Ahwaz and in several other areas. Some of these dunes have been fixed, but others are still on the move. These shifting sand dunes are a menace to agriculture, and also to communications, as in the area about 15 km north of Ahwaz on Ahwaz-Andimeshk highwater. For example, the present rather extensive sand dune movement on Karkheh right bank is only arrested by the river itself.

The above four types of erosion are experienced in most parts of Iran, though each part may have much more of one type. These are described in areas below.

*c. Azerbaijan*

Some of the areas with intense erosion problems are listed below:

1. Brown soil zone between Mianeh and Bostanabad. This area is very hilly, has an elevation of about 6,000 ft (about 1,800 m) above mean sea level and is an area of heavy-textured soils with good water-holding capacity. The local farmers plow this area because of the relatively high total precipitation, partly in the form of snow, which is more slowly absorbed by the soil. More and more areas of this type are being plowed. The plowing, though quite often done on the contour, is not sufficient to stop the erosion on the steep slopes, even with showers of moderate intensity. Though soils are usually deep, yet more rock exposure indicates the great loss by water erosion.

2. Ardebil - Mishkinshehr - Moghan stretch: This area has complex Lithosols and shallow mountain soils. Most of these, being high lying or lying under the influence of Caspian climate, have greater precipitation than is normal for the area; hence a great deal of erosion is taking place. The amount of silts in the various streams during rainy seasons is evidence of a high rate of erosion.

3. Around Lake Rezayeh (Urmia): Miandoab - Mahabad - Rezayeh - Marand, etc. A substantial part of these soils are alluvial or soils formed on old terraces of Lake Rezayeh. Some of the slopes, for example, east of the village of Malek Kandi in the Miandoab Plain, are steep and have significant erosion.

4. In some of the drier areas like Marand-Julfa or the Marand-Maku stretch of Azerbaijan, there are large areas with high wind velocities and consequent high wind erosion. In several cases sand dunes and shifting sands were observed. Vegetative fuel gathered around kilns and brick factories near Tabriz is a common sight. The sad fact is that much of that vegetation comes from arid land where it is needed as an invaluable protection against erosion.

5. To the north of Tabriz there is a wide zone of the "Upper Red Formation." It is exposed in outcrops where marls alternate with sandstones or conglomerates, are generally saliferous and gypsiferous, have developed into badlands, and are

barren. Yet the relief here is moderate and limits their extension. Precipitation is sufficient to allow dry farming which is practiced sporadically. Among the plants adapted to such ground are capers, with their radiating creeping branches, and wild rhubarb with wide leaves up to one meter in diameter lying flat on the ground and doing their share in checking erosion.

6. To the south of Tabriz are old alluvial deposits brought down from the eruptive centers of the Sahand. The slopes are moderate, rising from 1,400 m in the neighborhood of the city to an altitude of 1,700 to 1,800 m within a distance of about 5 m. Their susceptibility to erosion is great, as the accumulated material is represented by layers of gravel or even boulders alternating with sand irregularly and, as a whole, poorly consolidated, and thinner beds of white clay and volcanic ashes.

*d. Tehran-Qazvin region*

The southern foothills of the central Elburz range, together with the piedmont and alluvial plain bordering them, afford the most notable illustrations and the most numerous examples of the threat of erosion, and the urgent need for adequate measures to check its too rapid development.

The extraordinary growth of the capital city, the accelerating rate of increase of its population and industrial development are raising numerous problems. Year after year unexpected new situations arise, the causes of which may at first be hard to understand or may often be misinterpreted.

Recently more and more rills and gullies are detected on the hillsides, and this invariably occurs where the thorny bushes have been harmed or have disappeared because of the increasing practice of gathering the "katireh" (gum tragacanth), or because of the extension of dry farming on slopes originally covered with that climax vegetation. These slopes were plowed so that the perennial dwarf grass such as *Poa bulbosa* disappeared for a number of years.

Until recent years whatever thin topsoil exists on the hillslopes to the northeast and east of the city has been kept in place by this climax vegetation, as long as those slopes are only pasture grounds. The case is now very different on the Jaje Rud watershed of the same Hezardareh hills. Here irreparable harm is being done where the steeper slopes are rapidly deteriorating into scoured badland surfaces.

In this eastern sector of the Hezardareh there is another problem to be faced; namely, the effect of dry farming recently introduced there.

Already gullies, at certain places, are beginning to appear as a result of the plowed surfaces. If such slopes have to be cultivated, in addition to contour plowing, instinctively practiced by the farmers, some terracing should be done. The lower margin of each plot should, at least, be protected by a ridge of clods with sod and small boulders, easily obtainable on the spot, sufficient to hold the incipent runoff and to facilitate infiltration.

The piedmont plain between Karaj and Qazvin consists of a succession of present-day, sub-Recent, or ancient alluvial fans overlapping one another. They are best seen near Kordan and Abeyek. They illustrate the very active erosive processes in the catchments of the respective rivers and their transporting power.

To the west of Qazvin the crest of the Elburz front range appears as a lower irregular ridge dwindling in altitude toward the north of Qazvin. To the west of that locality the whole ridge has actually disappeared, cut through by the retreating erosive activity of a left tributary of the Shahrud, transported as alluvium down toward the Caspian. But the old alluvial material that had gathered along its southern foot is still present and forms now the threshold between Quyin and Naki, a village 10 km to the south of the Quyin Pass. There the Iranian plateau, at an altitude slightly above that of the Qazvin alluvial plain, ends abruptly where we have now the divide between the Caspian and the inland watersheds. The whole district is very favorable for dry farming. The margin of the plateau seems to have long been regularly cultivated. Unhappily the tendency has recently been to extend the cultivation of wheat down along the steep slopes over the Caspian side of the divide. The effect of erosion by runoff is evidenced there on numerous spots between the Quyin Pass, Naki to the south, and the narrowing of the valley down at Ab-i-Torah on the road between Qazvin and Rasht.

In short, the whole region of Tehran-Qazvin and Tehran-Hezardareh, encompassing the Karaj and Jaje Rud catchments, is very severely menaced by erosion.

*e. Baluchistan and Kerman*

The project areas of Bampur in Baluchistan have been studied in detail, with respect to wind erosion. About 20 percent of the 10,000 ha has been affected by moderate wind erosion, even though there is some natural forest of *Tamarix* to protect the area.

There are important areas where sand dunes occur extensively and are moving, bringing further large areas under dunes. Such conditions are occurring also in other parts of Baluchistan and Kerman. A program of sand dune fixation by appropriate vegetative control measures will be needed there and in similar areas.

*f. Western Iran*

This area has many mountains and hills with steep slopes and a semiarid to subhumid climate.

On many of these lithosolic slopes and also on the alluvial slopes, large-scale dry farming is being done for wheat or barley. Average yearly yields are about 500-800 kg per ha. Farmers do not worry about these areas after the initial plowing and seeding. Normally these soils are dry farmed on a two-year rotation basis, one year fallow and the other year wheat. Farmers take a chance and try to plow, after the rain, as many of these mountainsides as they possibly can.

Figures 56, 71, and 72 illustrate the fact that soil erosion is rampant. Big areas are covered by rill and some by gully erosion. These are serious enough to lower the yields at present and in the future to take them out of dry farming, which would result in poor land even for pasture. However, much of this area can be used for pasture, natural where feasible, artificially seeded where necessary.

Most of the hillsides can be reforested with certain varieties of trees, especially *Quercus* which can be grown to stop erosion. It is important and urgent that a proper and improved land use be promoted for all these areas according to the land capability.

*g. Esfahan-Shiraz*

Areas included in the Zayandeh Rud project in Esfahan and the Kor project in Fars give some idea of the erosion problem of the agricultural areas of these two

FIGURE 90. The dam near Kuhrang tunnel, Esfahan. Silt deposit shows the extent of water erosion. The author (M. L. Dewan) discusses the subject with Engr. Moini Zand.

provinces. In general, the most common types of erosion are sheet, rill, and gully erosion in the sloping areas and erosion in the irrigated areas where irrigation channels have given rise to riverbank cutting and other forms of water erosion.

Wind erosion is prominent in certain areas of which no study has yet been made.

*h. Khurasan*

Some of the points made for Tehran are probably applicable to Khurasan Province. Some observations have been made in this province, especially for the Keshef Rud, Torug Rud, and Fariman projects. The rapid siltation of the Fariman Dam, rebuilt only 20 years ago, is an appalling sight. About one meter per year siltation is already causing a water scarcity in the area.

Water erosion and gullies in the foothill sections have been observed in several parts of Khurasan. Wind erosion is severe along the northeast border of Iran and the U.S.S.R., around Sarakhs. Large amounts of sand are deposited on the agricultural lands every year.

## Degree of erosion in several irrigation projects surveyed

As the observations above indicate, the extent and degree of soil erosion that has taken place in the various regions of Iran is not fully known. Some effort has, however, been made, while mapping soils of special irrigation and other projects, to note the erosion. This has been done for water erosion and for wind erosion, and is defined as follows:

- \+ Complex soil removal and deposition as in areas of flooding.
- 0 None to slight water erosion (less than 25 percent of topsoil removed).
- 1 Moderate water erosion (between 25-75 percent of topsoil removed).
- 2 Severe water erosion (more than 75 percent of topsoil removed).
- 3 Very severe water erosion (all topsoil plus a part of subsoil — normally gullies which cover more than 10 percent of the area).

Where wind erosion dominates, parentheses are used around the erosion symbol, thus (2) = severe wind erosion. For land completely destroyed by erosion for irrigation, the symbol "E" is used.

Although observations on the large number of irrigation projects have been made in defining the erosion status of the land, only the following are reported in the publication, *Soil and water conservation in Iran.*[8] A generalized soil conservation survey for the whole country is of prime importance. The Soil Survey

[8] M. L. Dewan and H. Rieben, FAO Mission in Iran, 1958.

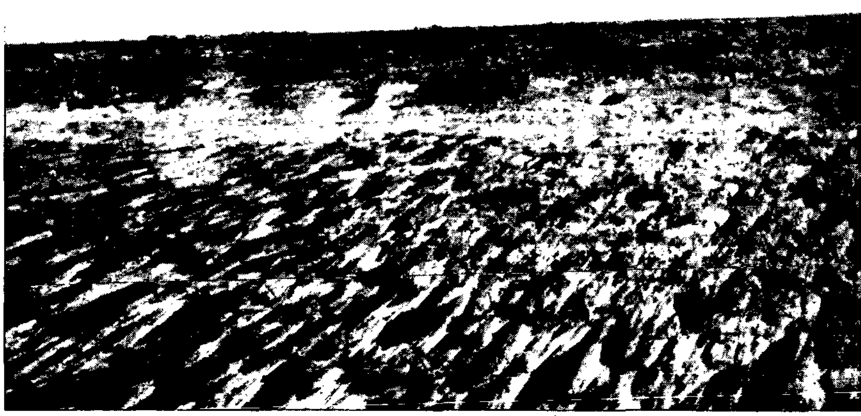

FIGURE 91 *a* and *b*. Soil erosion in Seistan.

and related studies that have been completed point out that several projects have major soil and water conservation problems. In certain big projects, like those at Seistan, Khuzistan, etc., the extent of damage done by erosion has been summarized in the "Soil Survey Reports" (Ref. 20) and assigned reference numbers in the Soils Department Library as follows:

12 Gorgan
199 Moghan

| | |
|---|---|
| 213-7 | Kunjam Cham Project—Kermanshah |
| 213-58 | Zohab Project, Kermanshah |
| 214-03 | Karkheh Project, Khuzistan |
| 214-06 | Ahu Dasht Project, Khuzistan |
| 215-18 | Gutwand Project, Khusiztan |
| 220 | Omidieh Project, Khuzistan |
| 234-9 | Chabankareh Project, Fars |
| 250 | Qeshm Project, Pai Pusht (Persian Gulf) |
| 263 | Gälegah Project, Fars |
| 412-1 | Golpaygan Project, Esfahan |
| 416 | Karaj Project, Ostan 1 |
| 419-8 | Garmsar Project, Ostan 1 |
| 419-9 | Saveh Project, Ostan 1 |
| 412 | Zayandeh Rud — Esfahan |
| 432 | Doroodzan Project, Fars |
| 441 | Bampoor Project, Baluchistan |

## SOIL AND WATER CONSERVATION: NEEDS AND APPROACH

Having established that there is a great problem of water and wind erosion in Iran, it is obvious that soil and water conservation are both important and urgent. Soil and water conservation in Iran or any part of Iran has two broad objectives, namely:

1. to slow down the runoff in the headwater catchment in order to reduce flood peaks and silt transport;
2. to improve agricultural conditions in the valley by the introduction of conservation methods of land use. Such measures will help to establish a balance between forest, pasture, and cultivated areas and through the improved productivity of the soil contribute to the betterment of the whole economic life of the area.

The first objective is especially urgent in view of the several irrigation and other projects being developed in Iran.

Specific advantages of soil and water conservation may be listed as follows:

1. Recharge of groundwater reservoirs.
2. Flood control on urban and rural agricultural lands.
3. Increase in life of reservoirs by decreasing siltation.

FIGURE 92. Fariman Dam, Khurasan. (*a*) Built originally during the Sassanian period, and rebuilt or repaired about 20 years ago. At present irrigates about 2,000 to 3,000 hectares. (*b*) Silting up of Fariman Dam in the last 20 years is gradually reducing the area under perennial irrigation. (*c*) Another view of the silt sediment in the Fariman Reservoir.

4. Improvement of irrigation systems, reduction of silt in lands, etc. (The best method of controlling damaging erosion and accompanying sediments is to prevent erosion in the watershed lands by installing adequate land treatment measures).

One of the first objectives of soil and water conservation, as stated above, is to slow the runoff in the headwater catchment. What is a catchment or a watershed? A very simple definition is that a watershed embraces all of the land and water areas which contribute runoff to a common point. The watershed above any point on a defined drainage channel is, therefore, all of the land and water areas which drain through that point.

What is "watershed management"? It is a term that implies the wide use of all soil and water resources so as to provide a clean, uniform water supply for beneficial use and for the control of damaging overflows. The term "watershed management" is very nearly synonymous with soil and water conservation with emphasis on water production and control rather than on maximum safe crop production.

A watershed program implies an operation developed and applied to all the land and water in a specific watershed, taking into consideration the physical conditions, needs and problems of the watershed, its relationship to the larger watershed, and the facilities available to accomplish the project.

Iran is divided as follows into watershed basins (2,26) (see Map B7):

1. River basins draining toward the Caspian Sea.
2. River basins draining to the Persian Gulf and Gulf of Oman.
3. The closed basin of Lake Rezayeh (Urmia).
4. The closed basins of central Iran.
5. The closed basins of central Afghanistan and east Iran.
6. River basins draining to the Karakum Desert in the U.S.S.R.

Of course, there are subdivisions of each of these watersheds and, as an illustration, the closed basins of central Iran are further divided* into:

41. Daryache Namak Basin
42. Esfahan Sirjan Basin
43. Shiraz Basin
44. Hamun-i-Jaz Murian Basin
45. Dasht-i-Lut Basin
46. Yazd-Ardestan Basin

Since no two watersheds are alike a general rule cannot be laid down to apply to all watersheds. Each must be studied in the light of its problems and individual characteristics before the most desirable corrective program can be developed and before it can be determined how the specific watershed will operate.

The overall objectives of all watershed management programs are:

1. To increase infiltration into the soil.
2. To control damaging excess runoff.
3. To manage and utilize runoff for useful purposes.

The principal factors which affect the operation of the individual watershed, and which must be studied before any management program can be developed, are:

1. Slopes and topography of land.
2. Soils.
3. Amount of precipitation and storm patterns.
4. Land use on the watershed lands.
5. Size and shape of watershed.

A brief comparison of the three watersheds in the neighborhood of Tehran, illustrating the effects of the above factors on the behavior of these watersheds, (Karaj, Jaje Rud, and Hableh Rud) indicates that in shape, topography and slope, soils, amount of precipitation and land use, the three vary. The watersheds of the Rivers Dez and Karkheh in Khuzistan also vary considerably in these factors.

Such variations must be known for each catchment before any soil and water conservation plans for improved land use in the catchments are instituted. In short, for soil and water conservation, the watershed management approach is essential — it must be a "co-ordinated approach."

Land and water are two of the most important elements in human environment. How they are used or worked affects not only contemporary Iran but future generations as well. Each generation is charged with the responsibility of using these natural resources so that maximum benefits derive without exploiting the heritage of the next generation.

Photographs in this chapter indicate beyond doubt that there is a significant deterioration in the land and water resources of Iran. To conserve them and to achieve optimum improved use of land as an overall benefit to the community, soil and water

* The numbers used are for reference in Hydrographic Service recordings (2,26).

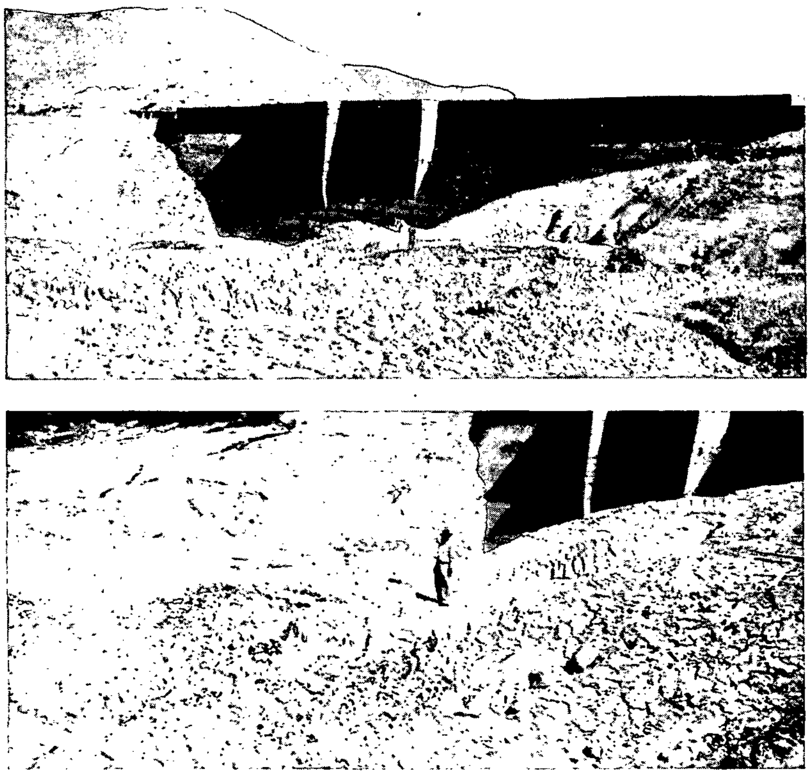

FIGURE 93. Golestan Dam, near Mashhad. (*a*) Silting up to an extent that permits only very limited use. (*b*) Another view of the silt. There is no water in the reservoir when it is needed most.

conservation measures should ultimately be spread by catchment to the whole of Iran. An organization for promoting soil conservation in Iran is indispensable.

Soil and water conservation is a complex task which needs the full co-operation of the agriculturist, the soil scientist, the forester, the agrostologist, the soil conservation engineer, the irrigation technician, the administrator, the public health worker, the educationist, and the social worker. Obviously, it will require harmonious teamwork. Good results can be achieved only if the efforts of all those engaged in this work are closely co-ordinated within an efficient team. This teamwork postulates that all the workers in the field are soil conservationists first, and specialists next. Good teamwork is more important for the achievement of success than the brilliancy of the individual scientist. One man, however able he may be, can never possess all the required knowledge of the various branches of soil and water conservation. The main point is to understand the importance of the work of each one of the persons and also to see in the right perspective the final objectives of soil and water conservation.

Success of conservation work presupposes a happy relation with the cultivators. A close study of the conditions under which an Iranian cultivator has to work, as well as his economic problems, will soon discover that his attitude toward new methods of production and to new crops is very often based on age-long experience. Though many of his methods can be improved he may very often be right in being cautious and conservative.

Soil conservation work in Iran is a necessity. It should encompass the following fields:

1. Soil conservation surveys, including soil surveys, land use and land capability surveys, vegetation surveys, etc.

2. Land use planning. As a result of the surveys conducted above, the best use of each parcel of land for crops and type of crop for continuous or rotation cropland, for pasture or grazing, for forests or for recreation is to be determined, specified, and action taken to promote such a land use.

3. Soil conservation research. Rates and extent of erosion under different conditions including research as to means and methods of soil and water conservation in different climatic ecological regions of Iran. Use and balance of various means of soil and water conservation.

4. Conservation agronomy. Type of cropping system, rotation, and their efficiency in conservation farming.

5. Pasture and range management. Types of grasses, legumes, and grass legume mixtures in different types of grazing and other rotations.

6. Forestry. Types of trees and their use in preventing erosion.

7. Soil conservation engineering. Types of terraces, check dams, and other engineering structures, small and big, for erosion control and improved land use.

8. Extension and demonstration. To promote the various means and methods of conservation among farmers and other users of land, including nomads, foresters, landlords, and even village and town dwellers. The success of any soil conservation work and development will depend mainly on the voluntary participation of the villagers. Extension work, in which improved conservation practices are demonstrated to farmers, therefore assumes very great importance. One of the best forms of extension work is demonstration.

SOIL CONSERVATION PRACTICES

It is not the purpose of this section to give all the soil conservation practices that are applicable in Iran. Soil conservation practices form a vast subject, and those to be followed in an area usually depend on the problem and its intensity. Soil conservation research would assist in defining the practices applicable to a particular problem area. Research on stations, but also as an integral part of the pilot projects, should embrace some or all of the following points, depending on the individual area:

1. contour cultivation
2. terracing
3. strip cropping
4. cover cropping
5. soil-depleting, soil-conserving, and soil-building crops
6. crop rotation
7. conservation irrigation
8. farm drainage
9. pasture improvement
10. rangeland improvement
11. conservation nurseries
12. woodlot improvement
13. forest management
14. prevention and control of gullies

The conservation measures could be divided into at least two types:

(*a*) those which are obvious and can be applied to the land without further study;

(*b*) those which need research and further study before recommendation on the conservation of the area can be given.

A research organization to study the important aspects of conservation measures is a prerequisite to any large-scale adoption of these measures. Of course, they should be tried in pilot project areas such as the following:

1. Upper Karaj Valley
2. Upper Golpaygan Valley
3. Jaje Rud Valley about Lashkarek
4. Sand dune fixation near Ahwaz, Khuzistan
5. Hezardareh Hills, near Tehran

6. Sepayeh Mountains, near Tehran
7. Hableh Rud Valley, above Garmsar
8. Seistan Project
9. Control of gully erosion in the Shushtar area, Khuzistan.

RECOMMENDATIONS

(i) The climax vegetation is important in order to stop or reduce erosion and facilitate infiltration. A dwarf grass, spared by sheep and goats and very efficient in aiding soil conservation and water infiltration is *Poa bulbosa*, the destruction of which should be stopped. Among the many other species of legumes, one of the common ones in the climax vegetation is a cushionlike dwarf bush, called *Giavan*, and it should be protected. Similarly the common legume *Alhagi camelorum* or camelthorn, which is used as fodder for camels, should not be allowed to be collected by villages and used for fuel.

An adequate distribution system for oil, to make it cheap and within easy reach of every villager, is an important and urgent step for saving the natural vegetation which is so often used for fuel.

(ii) A generalized soil conservation survey for all the regions in succession, and more detailed surveys for individual pilot areas should be conducted in order to select some pilot areas. Use of aerial photos for such surveys is extremely important. Some action programs should be started in these pilot areas.

(iii) A well-planned organization for soil conservation work in Iran is essential. Able, well-trained personnel should staff the service.

Soil conservation is a team enterprise; such a team should embrace all aspects of soil conservation, namely, surveys and planning, conservation research, conservation agronomy, range and pasture, forestry, soil conservation engineering, extension and demonstration, etc.

(iv) A Soil and Water Conservation Act should be instituted in due course, together with the means to enforce it. Such an act would be instrumental in preventing abusive practices and would encourage methods of improved land use.

(v) Certain pilot project areas should be selected where soil and water conservation practices would be instituted.

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## LIST OF SOIL SCIENCE TERMS AND DEFINITIONS

Alluvial soils . . . . . . Soils with very weak or no genetic horizons and consisting of recently deposited alluvium. (Milne included Tidal clays under Alluvial soils.)

alluvium . . . . . . . . A deposit of mineral or organic matter from flowing or still water. (Fresh alluvium, old alluvium.)

amendment (soil) . . . . Any material added to soil to improve or maintain production, excluding nitrogen, phosphorus and potassium carriers. (Lime and gypsum are soil amendments.)

arable (soil) . . . . . . Suitable for cultivation.

association (soil). . . . A group of defined and named taxonomic units regularly associated geographically in a defined proportional pattern on one relatively uniform parent material.

available . . . . . . . . Capable of being taken up by plants at a rate significant to crop production. (Available phosphate.)

azonal soil . . . . . . . A soil without distinct genetic horizons. (Alluvial soils are azonal.)

Brown Forest soils . . . Soils with mull horizon and having no accumulation horizon of clay and sesquioxides. (Brown Forest soils are well drained and are usually from materials rich in bases.)

Brown (steppe) soil . . . Brown to light brown nearly neutral soil usually overlying a calcareous horizon. (Brown soils are formed in temperate or cool semiarid climates.)

Brown Podzolic soil . . . Acid soil developed under forest with little or no bleached $A_2$ horizon and only a weak texture profile but with illuvial accumulation of sesquioxides. (Organic matter, sesquioxides and clay decrease gradually with depth in the Brown Podzolic soils.)

buried soil . . . . . . . Soil covered by a new deposit to a considerable depth usually greater than a soil profile thickness. (The buried soil is somewhat protected from further changes.)

Chernozem . . . . . . . Dark, well-drained grassland soil, granular and rich in humus to some depth, with or without concentration of clay in the B horizon, and calcareous below. (Typical Chernozems are predominant in the great plains in the U.S.S.R.)

clay . . . . . . . . . . . Particles of diameter less than 0.002 mm (international usage). (There are many different kinds of minerals which occur in the clay fraction.)

clay complex . . . . . . Clay mineral matter distinguished from humus. (The clay complex retains less bases per unit weight than the humus complex.)

clay fraction . . . . . . Clay distinguished from coarser soil particles. (In any soil, the clay fraction usually has a high cation exchange capacity.)

clay mineral . . . . . . Any crystalline substance occurring in the clay fraction, a crystalline hydrous layer silicate. (The study of clay minerals is extensively developed in recent years and is known as clay mineralogy.)

clay pan . . . . . . . . . Dense subsoil horizon high in clay content.

clod . . . . . . . . . . . A lump of soil material created by human disturbance. (Frost will break the clods.)

colluvium. . . . . . . . Detritus accumulated at the foot of steep slopes. (Wells are dug in the colluvium.)

concretion . . . . . . . Hard aggregate formed around a nucleus by successive precipitation of material. (Lime concretion, iron concretion.)

conductivity (electrical) . Reciprocal of electrical resistance. (Conductivity gives a rapid estimate of salt content.)

coniferous . . . . . . . Trees bearing cones and usually having needle-shaped leaves. (Podzols occur under coniferous forests in cold regions.)

consistence . . . . . . . The degree of cohesion of soil or of soil aggregates; resistance to deformation; feel to the fingers. (Friable, sticky, or plastic describe consistence.)

crumb . . . . . . . . . Rounded porous aggregate up to 10 mm in diameter.

crumb structure . . . . . Consisting of small, soft, porous aggregates of irregular shape.

deposit . . . . . . . . Material left in a new position by some transporting agent such as water, wind, or glacier. (An alluvial deposit, a $CaCO_3$ deposit.)

desert pavement . . . . Surface of stones and rocks remaining after finer material has been blown away.

desert soil . . . . . . . Soil of arid regions, low in organic matter, usually having calcareous subsoil or lime pan. (Desert soils are common in Iran.)

desert varnish . . . . . Glossy coating of stones, developed by wind action, in desert.

drainage . . . . . . . . 1. Degree of removal of water from soil.
2. Method of removal of water from soil.
3. Property of soil allowing removal of water.

drainage (soil) . . . . . The degree of removal of excess water from the soil profile through natural or artificial outlets.

drainage basin . . . . . Area or district drained by a river and its tributaries.

dry-land farming or dry farming . . . . . . . The practice of crop production, without irrigation, where rainfall is deficient.

eluvial horizon . . . . . Layer from which material had been removed in solution or in water suspension and in which silt- and sand-sized particles have become concentrated. (An eluvial horizon is usually an upper horizon.)

exchange capacity . . . . Milliequivalents of ions that can be absorbed by 100 g of soil material at a specific pH.

fallow . . . . . . . . . Condition of soil left without crop for a time.

family (soil) . . . . . . A taxonomic grouping of similar soils intermediate between series and great soil groups.

fine sand . . . . . . . . Particles of diameter between 0.2 and 0.02 mm (international usage). Particles of diameter between 0.25 and 0.10 mm (U.S.). (Fine sand usually contains no rock fragments.)

first bottom . . . . . . The normal flood plain of a stream. (The first bottom consists of recent alluvium.)

fixation. . . . . . . . . Conversion of a plant nutrient in the soil from a soluble or exchangeable form to less soluble or nonexchangeable form. (Nitrogen fixation.)

forest litter . . . . . . . Freshly fallen leaves and other forest debris which have not yet shown visual evidence of decomposition. (The forest litter is 2-5 cm thick.)

friable . . . . . . . . . . Easily crumbled with the fingers.

F layer. . . . . . . . . Layer of (usually forest) soil consisting of partly decomposed plant residues.

gley . . . . . . . . . . Mottling in the soil produced by partial oxidation and reduction of iron caused by intermittent waterlogging.

gley horizon . . . . . . A neutral, grey layer of intense reduction, characterized by the presence of ferrous iron that commonly changes to brown upon exposure to the air. (Swampy soils have a gley horizon.)

granular structure . . . Consisting of granules, friable rounded aggregates with irregular shapes and consisting of aggregates compounded of smaller aggregates. (The A horizon of Chernozem has a granular structure.)

gravel . . . . . . . . . . Stone particles between 20 and 2 mm in diameter. (The gravel consists of granite.)

Grey-Brown Podzolic soils . . . . . . . . . Forest soils with thin $A_0$ and $A_1$ over a greyish-brown leached $A_2$ and brown blocky B horizon of illuvial clay accumulations. (Grey-Brown Podzolic soils occur under deciduous forest chiefly in a temperate moist climate.)

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| great soil group . . . . . | A taxonomic group of soils similar in kind and arrangement of horizons. (Chernozems and Podzols are great soil groups.) |
| green manuring . . . . . | The turning under of a green crop for the enrichment of the soil. (The second crop of clover was used for green manuring; green manuring is advantageous in improving structure and fertility.) |
| groundwater . . . . . . | Water that fills all interstices below the water table. |
| guily . . . . . . . . . | Large channel cut by intermittently running water. (A gully may be too deep for agricultural implements to cross.) |
| halomorphic soils . . . . | Soils whose properties have been largely determined by the presence of halogen salts. |
| halophytic . . . . . . . | Able to grow in salty soil. (Halophytic vegetation includes *Sueda.*) |
| hard pan . . . . . . . . | Indurated or cemented layer of soil. |
| horizon . . . . . . . . | Soil layer with features produced by soil-forming processes. |
| A horizon . . . . . . . | The uppermost layers of a soil profile where accumulation of organic matter and eluviation commonly occur. |
| B horizon . . . . . . . | Part of a soil profile below the A horizon, usually illuvial. |
| C horizon . . . . . . . | Horizon of weathered rock material little affected by biological soil-forming processes. |
| D horizon . . . . . . . | Unweathered rock below the C horizon. |
| F horizon . . . . . . . | Layer of (usually forest) soil consisting of partly decomposed plant residues. |
| G horizon . . . . . . . | The horizon in which gley occurs. |
| H horizon . . . . . . . | Organic layer of (usually forest) soil with dark-colored structureless humus. |
| Humic-Gley soil. . . . . | Continually or intermittently moist soil with or without a peaty covering, but having a prominent dark $A_1$ horizon and a gleyed horizon. |

humus . . . . . . . . . The organic complex of the soil which is more or less resistant to microbial decomposition or the amorphous (colloidal) organic matter of soil.

hydromorphic . . . . . Soils developed in the presence of excess water all or part of the time. (Humic Gley soils are hydromorphic.)

infiltration . . . . . . . Movement of water into soil.

igneous rock . . . . . . Rock that has supposedly solidified from a molten state. (Granite is an igneous rock.)

illuvial horizon . . . . . Horizon that has received material in solution or suspension from the upper part of the soil. (The illuvial horizon is usually below the eluvial horizon.)

immature . . . . . . . Lacking a fully developed profile. (The soil is immature.)

impeded drainage . . . . Condition in which downward movement of gravitational water is hindered. (Roots are poor, owing to impeded drainage.)

impervious . . . . . . . Very resistant to penetration of water or roots. (An impervious hard pan occurs at 30 cm depth.)

indicator plants . . . . . Plants which commonly grow where particular soil conditions prevail. (*Sueda* and *Atriplex* are indicator plants for saline soils.)

intergrade . . . . . . . Soils intermediate in character between two different soils and genetically related to both.

intrazonal soils . . . . . Well-developed soil whose morphology reflects the influence of some local factor of relief, parent material, or age rather than of climate and vegetation. (Rendzina and Humic-Gley soils are intrazonal.)

lacustrine . . . . . . . Associated with a lake. (Lacustrine deposit.)

landscape . . . . . . . All the physical features that distinguish one geographical locality from another. (A glacial landscape, Chernozem landscape.)

leach . . . . . . . . . . Remove soluble material by passing a liquid through soil. (Heavy rain leaches the soil.)

leached saline soils . . . Soils showing effects of former presence of salts. (Many soils in Iran are leached saline soils.)

lithosol . . . . . . . . Thin stony soil, shallow over bedrock, without horizon development.

loam . . . . . . . . . . Soil material containing 7 to 27 percent clay, 28 to 50 percent silt and less than 52 percent sand. (Loam soils are often friable and permeable.)

loose . . . . . . . . . Readily dislodged by hand. (The horizon is loose.)

marl . . . . . . . . . . Clayey, $CaCO_3$ - rich sedimentary deposits. (Marl is soft.)

mature soil . . . . . . . A soil with clearly developed genetic horizon in equilibrium with the environment. (This soil is a mature Podzol.)

mechanical analysis . . . Particle size analysis - the determination of fractions by weight or mass, based on the separation of primary soil particles into groups according to "effective" diameters.

Mediterranean soils, Brown . . . . . . . . Mediterranean soils, Brown have an ABC horizon sequence with textural B horizon. The soils are of high to medium base saturation. They differ from the Red-Yellow Mediterranean soils in the color of the B horizon which in the chroma and value is lower than 4/6 when of 2.5 YR hue. The B horizon has a strong blocky or prismatic structure and may be underlain by an ironsilica pan. The solum of the soils is often noncalcareous, but there may be a Ca horizon in the B horizon.

Mediterranean soils, Red . . . . . . . . . Mediterranean soils, Red have an ABC horizon sequence. The profile has a textural B horizon of high chroma (i.e., red or yellow) of which the base saturation of the clay fraction is high (40 percent) or increases with depth. There are thick continuous clay coatings on ped surfaces in the B horizon which has a strong blocky or prismatic structure. The clay fraction of

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| | the B horizon consists mainly of clays of the 2:1 lattice type. The soils are formed on calcareous and noncalcareous parent materials. |
| microrelief . . . . . . . | Small-scale differences in relief, including mounds or pits that are a few decimeters across and have differences in elevation up to about one meter. |
| mottling . . . . . . . . | Patches of different colors. (Red and yellow mottling.) |
| monolith . . . . . . . . | Vertical section taken from soil. |
| morphology. . . . . . . | Pattern of horizons and their observable properties that make up the soil. (Morphology of Solonetz columns.) |
| mull . . . . . . . . . . . | Humus (most often forest-humus) layer of mixed organic and mineral matter with a gradual transition to the underlying mineral horizon. (In structure mull may be coarse grain, grain or compact.) |
| natural erosion . . . . . | The wearing away of land undisturbed by man. (Natural erosion is a geological process.) |
| neutral soil . . . . . . . | Soil of which the upper part is neither acid nor alkaline. (Phosphate remains readily available in neutral or nearly neutral soil.) |
| noncalcic Brown soils . . | Brown to reddish weakly leached soil with slightly acid light brown A horizon over darker B horizon. (Noncalcic Brown soils are formed under grass and bush vegetation.) |
| nutrient . . . . . . . . | Substance required for plant growth. (Phosphorus, and nitrogen are plant nutrients.) |
| organic matter content. . | The amount of organic material in a soil sample determined directly or estimated by multiplying the organic carbon content by 1.724. |
| outcrop (rock) . . . . . | Protrusion of a subterranean rock at the land surface. (An outcrop of sandstone.) |
| parent material . . . . | Unconsolidated material from which a soil is formed. (The parent material is alluvium from granite hills.) |

parent rock . . . . . . The rock from which parent material is formed. (Schist is the parent rock in this region).

particle size . . . . . . Effective diameter of a soil particle. (Particle size is sometimes estimated from settling velocity.)

pasture land . . . . . . Land used for grazing. (The valleys are good pasture land.)

pedogenesis . . . . . . The formation of soil from parent material.

pedology . . . . . . . . The science that treats of soils, including their nature, properties, formation, functioning, behavior, and response to use and management (also called soil science).

peneplain . . . . . . . An old land surface which has become nearly level. (The peneplain is dissected by shallow valleys.)

permeability . . . . . . Readiness with which air or water can pass through soil.

phase (soil) . . . . . . A subdivision of any class or any category in the natural system of soil classification, based on features important to soil use and management, but not significant in the natural landscape for native plants. (Stony phase, steep phase, eroded phase.)

physical properties . . . . States or qualities which are evaluated in standard physical units. (Permeability is a physical property of soil.)

physical weathering . . . The breakdown of rock into smaller fragments without chemical change. (Frost causes physical weathering.)

plant association . . . . A fundamental vegetational unit characterized by at least some homogeneity in floristic composition. (Plant association has been variously defined and restricted by different ecologists.)

plastic . . . . . . . . . Capable of undergoing deformation without rupture. (Some clays are plastic.)

Podzolic . . . . . . . . Soil with acid-humus surface horizon, bleached $A_2$, and illuvial B horizons with accumulations of iron-oxide or of iron-oxide and humus. (Podzolic soils occur largely in cool humid regions under forest or heath.)

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| pores . . . . . . . . . | Interstices between soil particles. (Legume roots leave large pores.) |
| pore space . . . . . . . | Fraction of the total soil volume not occupied by solid particles. (Pore space is reduced by excessive tillage.) |
| prairie soils . . . . . . | 1. Soils developed under grass in humid and sub-humid temperate regions, and resembling Chernozems, but dark brown on the surface, ordinarily with some textural profile, and without a prominent horizon of accumulated calcium carbonate.<br>2. A general term for all dark soils of the treeless plains. (Prairie soils should not be called leached Chernozems.) |
| productive (soil). . . . . | Having the capacity to produce a high yield of an adapted crop when well managed. (The alluvial soils are usually productive.) |
| profile . . . . . . . . . | Vertical section of soil showing sequence of horizons from surface to parent material. |
| pseudo mycelium . . . . | Threadlike mineral formation resembling fungus growth. (Calcium carbonate sometimes separates as pseudo mycelium.) |
| Pseudo-Gley soils . . . . | Pseudo-Gley soils have ABC horizon sequence with a compact textural B horizon. Both A and B horizons display strong mottling due to a temporary water table above the B horizon. The soils are acid and destruction of clay minerals occurs in the upper part of the B horizon into which the A horizon may penetrate in tongues. |
| reaction (soil) . . . . . | The degree of acidity or alkalinity of a soil, usually expressed in terms of pH value. (The soil has an acid reaction.) |
| Red Desert soils . . . . | Pinkish-grey to light reddish-brown soil over somewhat more clayey, yellowish-red, or red subsoil in desert and semidesert regions. (Red Desert soils occur in warm or hot arid climates.) |

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| reddish-brown (steppe) soils . . . . . . . . . | Reddish-brown soil grading into heavier soil overlying a calcareous horizon. (Reddish-brown soils are formed in warm or hot semiarid regions.) |
| reddish Chestnut soils . . | Dark reddish-brown soil grading into heavier soil overlying a calcareous horizon. (Reddish Chestnut soils are formed in warm subhumid to semiarid climates.) |
| reddish prairie soil . . . | Reddish-brown somewhat acid soil with rather clayey subsoil. (Reddish prairie soils are formed under tall grass in a warm humid climate.) |
| red Podzolic soil . . . . | Soil with thin $A_0$ and $A_1$, yellowish-brown to nearly white leached $A_2$ and red B horizons. (Red Podzolic soils are formed under forest in warm moist climates.) |
| Red-Yellow Mediterranean soils . . . . . . . . . | See Mediterranean soils. |
| Regosols . . . . . . . . | Soil without definite genetic horizons developing from deep unconsolidated rock or soft mineral deposits. (Recent sand dunes, volcanic ash, and loess deposits are included in Regosols.) |
| relief . . . . . . . . . . | Unevenness of the land surface considered collectively. (Mountainous reliefs; reduced relief, that is, nearly flat.) |
| Rendzina . . . . . . . | Dark calcareous, usually shallow soil formed on soft limestone; also soils with brown or black granular surface layer underlain by grey or yellow soft calcareous material. |
| rolling . . . . . . . . . | Having moderately steep slopes; intermediate between undulating and hilly. (Rolling topography.) |
| saline soil . . . . . . . | Soils containing enough salt to hinder crop growth. (Saline soils may contain sulfates or chlorides.) |
| sample . . . . . . . . . . | A small representative part taken from a large unit. (Soil sample, plant sample.) |
| second bottom . . . . . | The first terrace above the normal flood plain of a stream. (The second bottom is rarely or never flooded.) |

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| sediment . . . . . . . | Matter that settles to the bottom of a liquid. (The sediment from a river forms an alluvial deposit.) |
| sedimentary rock . . . . | More or less consolidated material deposited on land or under water. (Shale is a sedimentary rock.) |
| series (soil) . . . . . . . | A group of soils having horizons similar in distinguishing characteristics and arrangement in the soil profile, except for the texture of the surface soil, and formed from the same parent material. (This series includes two soil types.) |
| sheet erosion . . . . . | The gradual, uniform removal of surface soil by water. (Sheet erosion may take place unnoticed.) |
| Sierozem . . . . . . . . | Grey desert soil: brownish-grey soil overlying a calcareous horizon or lime pan. (Sierozems are formed in temperate to cool arid climates.) |
| silt. . . . . . . . . . | Particles with mean diameter of 0.02 to 0.002 mm (international usage). Particles with mean diameter of 0.05 to 0.002 mm (U.S. usage). (Soils containing much silt feel velvety.) |
| skeletal soil . . . . . . | Soil consisting of nearly unweathered rock fragments. (Skeletal soils generally occur on steep slopes.) |
| slope . . . . . . . . . . | Tangent of the angle of inclination from horizontal rise divided by the run. (A 10 percent slope.) |
| soft . . . . . . . . . . . | Relatively easily crushed or marked. (A soft porous crust.) |
| soil aggregate . . . . . | Compound particle of soil. (Soil aggregates differ in shape and size.) |
| soil formation . . . . . | The process of changing from parent material into soil. (Climate affects soil formation.) |
| soil genesis . . . . . . . | The formation of soil from parent material. (Climate plays a part in soil genesis.) |
| soil survey . . . . . . . | Classification, mapping, and interpretation of specific kinds of soils for applied objectives. (Soil survey utilizes air photos.) |
| Solonchak . . . . . . . | Saline soil, without structure. (Solonchak occurs in arid regions.) |

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| Solonetz | Formerly saline soil from which the salts have been leached, with cloddy prismatic or columnar B horizon. |
| solum | The part of the earth's crust influenced by climate and vegetation. The solum includes the A and B horizons or the upper part of the soil profile above the parent material. |
| stratified | Deposited in layers. (The alluvial material is stratified.) |
| strip cropping | Practice of growing different crops in alternate strips along contours or across prevailing direction of wind. |
| structure | Arrangement of primary soil particles in aggregates (of characteristic shape and size). (Blocky structure.) |
| subsoil | Part of a soil between the layer normally used in tillage and the depth to which most plant roots grow. (Sometimes applied to a B horizon if distinct.) (Salts are present in the subsoil.) |
| surface soil | The upper part of the soil ordinarily moved in tillage about 7 to 20 cm. (The surface soil is dark grey.) |
| terrace | 1. Approximately horizontal man-made channel or bank for controlling runoff water.<br>2. Alluvial deposit lying on bench above the flood plain of a stream. |
| texture | The composition of soil in respect of particle-size distribution. (Coarse texture, i.e., sandy.) |
| tilth | State of aggregation of soil after cultivation. (The soil is in good tilth.) |
| transitional soil | Soil intermediate in character between two different soils. (Degraded Chernozem soils are transitional between Chernozem and Podzol.) (Also called intergrade.) |
| type (soil) | A group of soils having horizons similar in distinguishing characteristics and arrangement, and developed from a particular kind of parent material. A soil type is the lowest unit in the U.S. system of soil |

classification. (Commonly the soil type name consists of the series name plus the textural class name of the surface soil.)

waterlogging . . . . . . State of water content being higher then field capacity. (Waterlogging causes reduction of nitrate.)

water table . . . . . . . The upper free surface of ground water; locus of points in soil water at which the hydraulic pressure is equal to atmospheric pressure. (Pumping lowers the water table.)

Wiesenboden . . . . . . Poorly drained soil with humus-rich $A_1$ horizon grading into grey mineral soil (now included in Humic-Gley soil.)

Yellow Podzolic soils . . A group of well-developed, well-drained acid soils having thin $A_0$ and organic-mineral $A_1$ horizons over a light-colored, bleached $A_2$ horizon over a red, yellowish-red or yellow and more clayey B horizon. Coarse streaks or mottles of red, yellow, brown, and light grey characterize deep horizons where the siliceous parent materials are thick.

zonal soil . . . . . . . Soil having a profile which shows a dominant influence of climate and vegetation on its development.

# APPENDIXES

## Appendix A1

# LIST OF SOILS REPORTS IN IRAN

*A. The following reports on soil survey and land classification of various project areas have been prepared by the Iranian engineers in the Soils Department of Irrigation Bongah with the assistance and guidance of soil experts of FAO.*

| Sl. no. | Project area | Ostan | Area surveyed (ha) | Nature of survey | Year and month of report | Kinds of maps made* | Scale of maps | Engineer party leader | FAO expert |
|---|---|---|---|---|---|---|---|---|---|
| 1. | Karkheh (Parts I and II) | Khuzistan | 57 000 | Semidetailed | May 53 | 1+ | 1 : 50,000 | — | M. L. Dewan, T. H. Day, and W. A. Sparwasser |
| 2. | Omidieh | Khuzistan | 45 000 | Reconnaissance | Aug. 53 | 1+ | 1 : 50,000 | — | T. H. Day |
| 3. | Zayandeh Rud | Esfahan | 200 000 | Semidetailed | Nov. 53 | 14+<br>3+ | 1 : 20,000<br>1 : 100,000 | —<br>— | M. L. Dewan<br>M. L. Dewan |
| 4. | Mohammadabad Agric. Farm | Esfahan | 250 | Detailed | Nov. 53 | 1+ | 1 : 5,000 | Famouri | M. L. Dewan and T. H. Day |
| 5. | Golpaygan (Part I) | Esfahan | 7 400 | Semidetailed | Nov. 53 | 1+ | 1 : 20,000 | Famouri | T. H. Day |
| 6. | Karkheh (Part III) | Khuzistan | 13 000 | Semidetailed | June 54 | 2+x | 1 : 50,000 | Famouri | T. H. Day |
| 7. | Chabankareh | Fars | 30 000 | Semidetailed | June 54 | 2+x | 1 : 20,000 | Zaringhalam | T. H. Day |
| 8. | Ahu Dasht | Khuzistan | 54 000 | Semidetailed | June 54 | 1+ | 1 : 50,000 | Farmanara | T. H. Day |
| 9. | Karaj | Ostan 1 | 55 000 | Reconnaissance | Aug. 54 | 1+ | 1 : 50,000 | Yousefi | M. L. Dewan |
| 10. | Saveh | Ostan 1 | 60 000 | Semidetailed | Nov. 54 | 3+xs | 1 : 50,000 | Haghiri | M. L. Dewan |
| 11. | Garden City Project Ahwaz | Khuzistan | 1 500 | Detailed | Apr. 55 | 3+xs | 1 : 10,000 | Mahoutchi | M. L. Dewan |
| 12. | Gutwand (Parts I and II) | Khuzistan | 126 000 | Semidetailed | June 55 | 5+xs | 1 : 10,000 | Farmanara | M. L. Dewan |
| 13. | Bajgah Expt. Station | Fars | 300 | Detailed | 55 | 1+ | 1 : 3,000 | Vakilian | M. L. Dewan |

* See key at end of list

**Appendix A1.** (*Continued*)

| Sl. no. | Project area | Ostan | Area surveyed (ha) | Nature of survey | Year and month of report | Kinds of maps made | Scale of maps | Engineer party leader | FAO expert |
|---|---|---|---|---|---|---|---|---|---|
| 14. | Doroodzan (Parts I and II) | Fars | 132 000 | Semidetailed | 1955-56 | 3+sw | 1 : 50,000 | Vakilian | M. L. Dewan |
| 15. | Land resources of Khuzistan | Khuzistan | 3 000 000 | Broad reconnaissance | Jan. 56 | 3+sw | 1:1,000,000 | — | M. L. Dewan |
| 16. | Gallegah | Fars | 55 000 | Semidetailed | Apr. 56 | 1+ | 1 : 20,000 | Vakilian | M. L. Dewan |
| 17. | Kunjam Cham | Kermanshah | 10 000 | Semidetailed | Apr. 56 | 1+ | 1 : 20,000 | Fahimi | M. L. Dewan |
| 18. | Dasht-i-Zohab | Kermanshah | 9 700 | Semidetailed | May 56 | 1+ | 1 : 20,000 | Ganjini | M. L. Dewan |
| 19. | Karkheh right bank (Part III A) | Khuzistan | 6 250 | Detailed | Aug. 56 | 4+<br>1+ | 1 : 5,000<br>1 : 20,000 | Yousefi | M. L. Dewan |
| 20. | Seistan | Baluchistan-Seistan | 290 000 | Reconnaissance | Oct. 56 | 4+<br>1+ | 1 : 20,000<br>1 : 100,000 | Famouri | — |
| 21. | Agriculture Bongah Miandoab | Azerbaijan | 150 | Detailed | Nov. 56 | 1+ | 1 : 5,000 | Samadi | M. L. Dewan |
| 22. | Gheshm Island Pai Posht | Kerman | 2 040 | Semidetailed | Apr. 57 | 1+ | 1 : 50,000 | Vakilian | M. L. Dewan |
| 23. | Doroodzan (Part III) | Fars | 5 400 | Semidetailed | Apr. 57 | 2+<br>2+ | 1 : 50,000<br>1 : 50,000 | Vakilian | M. L. Dewan |
| 24. | Zarrineh Rud (Parts I and II) | Azerbaijan | 114 000 | Semidetailed | 1955-56 | 5+oswf | 1 : 100,000 | Ganjini | M. L. Dewan |
| 25. | Golpaygan (Part II combined with Part I) | Tehran | 10 970 | Semidetailed | Dec. 57 | 1+ | 1 : 20,000 | Ganjini | M. L. Dewan |
| 26. | Bampour | Baluchistan | 9 960 | Semidetailed | Feb. 58 | 2+ | 1 : 50,000 | Samadi | M. L. Dewan |
| 27. | Moghan | Azerbaijan | 30 000 | Semidetailed | July 58 | 3+o<br>2 o+ | 1 : 50,000 }<br>1 : 20,000 } | Yousefi | M. L. Dewan |
| 28. | Garmsar Plain | Tehran | 54 000 | Reconnaissance | Aug. 58 | 10 | 1 : 60,000 | Famouri | M. L. Dewan |

**Appendix A1.** *(Continued)*

| Sl. no. | Project area | Ostan | Area surveyed (ha) | Nature of survey | Year and month of report | Kinds of maps made | Scale of maps | Engineer party leader | FAO expert |
|---|---|---|---|---|---|---|---|---|---|
| 29. | Garmsar-Nuraddin Dasht-i-Kavir lands | Tehran | 1 100 | Detailed | Aug. 58 | 2+o | 1 : 5,000 | Ganjini | M. L. Dewan |

*B. The following soil survey reports have been issued under Khuzistan Development Service (an agency of Plan Organization) funds in trust agreement with* FAO, *and together with the participation of the Soils Department of the Irrigation Bongah.*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 30. | Dezful I | Khuzistan | 54 000 | Semidetailed | Apr. 57 | 2+ | 1 : 50,000 | Famouri | J. P. Creswick |
| 31. | Dezful II | Khuzistan | 54 000 | Semidetailed | July 57 | 2+ou | 1 : 50,000 | Famouri | A. K. Ballantyne |
| 32. | Kermanshah Plain (Karkheh headwaters) | Kermanshah | 70 000 | Semidetailed | Jan 58 | 3+ou | 1 : 50,000 | Bordbar | V. S. Subramanian and A. K. Ballantyne |
| 33. | Northern headwaters area of the Dez | Kermanshah | 129 400 | Reconnaissance | Dec. 57 | 1+ | 1 : 250,000 | — | A. K. Ballantyne |
| 34. | Aqili plains | Khuzistan | 11 500 | Semidetailed | Feb. 58 | 3+ou | 1 : 25,000 | Bordbar | V. S. Subramanian |
| 35. | Dezful III | Khuzistan | 57 000 | Semidetailed | Aug. 58 | 3+ou | 1 : 50,000 | Bordbar | V. S. Subramanian and A. K. Ballantyne |
| 36. | Dezful peninsula | Khuzistan | 400 | Detailed | July 58 | 3+ou | 1 : 10,000 | Samai | J. S. Veenenbos |
| 37. | Karkheh headwater area (maps only) | Kermanshah | 450 000 | Reconnaissance | June 58 | 3+ou | 1 : 250,000 | Farmanara | J. S. Veenenbos |
| 38. | Bebahan | Khuzistan | 36 500 | Semidetailed | June 59 | 3+ou | 1 : 50,000 | Fakharzadeh | V. S. Subramanian |
| 39. | Dezful I, II, III, IV (Unified reports) | Khuzistan | 200 000 | Semidetailed | Nov. 58 | 12+ous | 1 : 50,000 | — | J. S. Veenenbos and V. S. Subramanian |
| 40. | Karkheh West | Khuzistan | 540 000 | Reconnaissance | Mar. 57 | 3+ou | 1 : 250,000 | Farmanara | J. S. Veenenbos |
| 41. | Shahabad | Kermanshah | 57 600 | Semidetailed | Oct. 58 | 3+ou | 1 ; 50,000 | Fakharzadeh | M. Van Oosten |
| 42. | Ramhormoz | Khuzistan | 56 000<br>94 500 | Semidetailed<br>Reconnaissance | Aug. 59 | 3+ou<br>3+ou | 1 : 50,000<br>1 : 50,000 | Bordbar | V. S. Subramanian<br>M. Van Oosten |

*C. In addition the following reports have been issued on soils and soil problems of Iran:*

43. Soil survey and land classification guide for Iran, by Soil Experts of FAO and ICA, August 1954.
44. Additional instructions for soil sampling, by M. L. Dewan, April 1957.
45. Report of observations on tea soils, by M. L. Dewan and W. A. Sparwasser, May 1953.
46. Chemical analyses of certain saline soils in Iran, by M. L. Dewan: FAO Irrigation and Drainage Practices Seminar, Tehran, November 1954.
47. Notes on soils of Moghan, by M. L. Dewan, 1955.
48. Preliminary report on reconnaissance survey of Gorgan area, by O. T. Osgood and M. L. Dewan, 1956.
49. Floods in Iran, their causes and cures, by M. L. Dewan; Journal "Ab," Tehran, 1956.
50. Land use and production in relation to kind of land in the Zarrineh Rud area of Azerbaijan in northwestern Iran, by O. T. Osgood and M. L. Dewan, April 1957.
51. Reclamation of saline soils by leaching, by M. L. Dewan and M. Bordbar, 1957.
52. Soil survey and classification in Iran. A course of lectures to postgraduate agricultural engineering students of the Karaj Agricultural Faculty, by M. L. Dewan, May 1957.
53. A comparison of soils, land use and estimated farm-production possibilities in two parts of the Golpayegan area from which selections are to be made for use of water from the Akhtakan reservoir, by O. T. Osgood and M. L. Dewan, Nov. 1957.
54. Land use and production in relation to kind of land in the Doroodzan Project area, Fars, by M. L. Dewan, May 1957.
55. A note on short soils reconnaissance of the Kazvin Plain, by M. L. Dewan, Jan. 1958.
56. Soil and water conservation in Iran, notes and recommendations, by M. L. Dewan and H. Rieben, FAO, September 1958.
57. Land use of Seistan Project, by J. Famouri, M. L. Dewan, and O. T. Osgood, 1958.

*D. The following reports have been published by FAO relating to or including soils and soil surveys:*

58. FAO Report No. 314. Report to the Government of Iran on soil conservation and land classification, by W. A. Sparwasser and T. H. Day, Sept. 1954.
59. FAO Report No. 553. Report to the Government of Iran on development of Khuzistan's land and water resources, by FAO Irrigation Team, 1956. Chapter V of this report is on land resources of the Khuzistan, by M. L. Dewan and D. S. Gracie. It includes:
    - 5.1. Geology as related to soils and water, by D. S. Gracie
    - 5.2. Soil surveys in Khuzistan: general results, by M. L. Dewan
    - 5.3. Soil surveys of special areas, by M. L. Dewan
    - 5.4. Observations on groundwater in the Khuzistan plains, by M. L. Dewan
    - 5.5. Salinity, alkalinity and drainage, by D. S. Gracie

**Appendix A1.** (*Concluded*)

5.6. Erosion in Khuzistan, by M. L. Dewan and J. G. Vermaat

5.7. Land resources of the Upper Karkheh basin, by M. L. Dewan

60. Report to the Government of Iran on development of Golpayegan's land and water resources by FAO Irrigation Team, 1957.

*E. In addition, a few papers have been published in some periodicals as follows:*

61. M. L. Dewan. Pigeon towers aid Iran's agricultural economy. *Middle East Reporter*, 6, No. 2, September 23, 1954.
62. M. L. Dewan. Modification of soil texture. *Journal of Soil and Water Conservation in India*, 3, No. 1, 37-38, 1954.
63. M. L. Dewan. Pigeon towers and pigeon guano in Iran. *World Crops*, 7, No. 3, March 1955.
64. M. L. Dewan. Soils of Iran. I. Soils of the Khuzistan Plains. *J. Ind. Soc.* Soil Sci., 7 (3): 127-134, 1959.

o Soil map
+ Land classification map
x Drainage investigation map
u Land use map
s Soil salinity map
w Wetness or groundwater map
f Flooding problem map

# Appendix A2

## Temperature and Precipitation at Selected Stations in Iran

### Table I. Arid Region

*Station:* Yazd
*Period of record:* 1953-59

*Elevation:* 1,233 m
*Location, lat.:* 31° 54' N
*long.:* 54° 24' E

| Month | Mean prec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 11.6 | 12.3 | 1.1 | 22.0 | − 6.0 | 6.7 |
| February | 3.7 | 15.6 | 3.0 | 25.6 | − 4.4 | 9.3 |
| March | 5.5 | 20.2 | 7.4 | 28.6 | − 3.0 | 13.8 |
| April | 9.0 | 26.7 | 12.6 | 36.6 | 1.0 | 19.5 |
| May | 2.7 | 31.0 | 17.2 | 40.0 | 11.0 | 24.1 |
| June | 1.2 | 35.7 | 21.6 | 44.6 | 12.4 | 28.6 |
| July | 1.5 | 38.8 | 24.3 | 45.0 | 18.0 | 31.5 |
| August | — | 37.4 | 22.0 | 44.2 | 15.0 | 29.7 |
| September | — | 33.4 | 17.4 | 41.0 | 10.0 | 25.4 |
| October | 1.3 | 26.0 | 11.2 | 33.4 | 4.0 | 18.6 |
| November | 21.3 | 17.1 | 5.7 | 26.0 | − 6.4 | 11.4 |
| December | 9.9 | 12.2 | 2.2 | 21.8 | − 7.2 | 7.2 |
| | 67.4 | | | | | |

*Station:* Nehbandan
*Period of record:* 1958-59

*Elevation:* 2,910 m
*Location, lat.:* 32° 20' N
*long.:* 57° 35' E

| Month | Mean prec. in mm | Mean max. | Mean min. | Abs. max. | Abs. min. | Mean monthly |
|---|---|---|---|---|---|---|
| January | 51.2 | 13.1 | 4.5 | 17.5 | −2.0 | 8.8 |
| February | 0.5 | 13.2 | 2.8 | 21.5 | −2.5 | 8.0 |
| March | 13.0 | 21.8 | 11.5 | 31.0 | 3.5 | 16.6 |
| April | 2.0 | 30.4 | 19.4 | 36.5 | 9.0 | 24.9 |
| May | 11.0 | 32.0 | 22.0 | 38.5 | 14.5 | 27.0 |
| June | 0.0 | 38.0 | 26.3 | 42.0 | 21.5 | 32.1 |
| July | 0.0 | 37.8 | 27.6 | 39.5 | 27.0 | 32.7 |
| August | 0.0 | 39.2 | 27.3 | 43.5 | 22.0 | 33.2 |
| September | 0.0 | 35.2 | 24.4 | 40.5 | 18.5 | 29.8 |
| October | 0.0 | 30.1 | 19.5 | 35.5 | 17.5 | 24.8 |
| November | 7.0 | 18.2 | 8.9 | 27.0 | 1.0 | 13.5 |
| December | 13.5 | 15.6 | 7.6 | 23.0 | 3.0 | 11.6 |
| | 98.2 | | | | | |

TABLE I. ARID REGION (*Continued*)

*Station:* Esfahan
*Period of record:* 1947-58

*Elevation:* 1,584 m
*Location, lat.:* 32° 37' N
*long.:* 51° 50' E

| Month | Mean prec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 21.8 | 10.7 | −2.8 | 18.0 | −13.9 | 4.0 |
| February | 14.4 | 14.3 | −1.0 | 23.3 | −13.3 | 6.7 |
| March | 20.4 | 18.9 | 3.2 | 26.7 | − 5.6 | 11.0 |
| April | 18.4 | 24.7 | 7.3 | 31.0 | − 4.6 | 16.0 |
| May | 11.8 | 30.9 | 11.6 | 35.6 | 4.4 | 21.3 |
| June | 0.9 | 37.7 | 15.5 | 40.6 | 7.8 | 26.6 |
| July | 3.8 | 40.5 | 17.9 | 41.4 | 11.1 | 29.2 |
| August | 0.7 | 38.9 | 15.9 | 41.7 | 10.6 | 27.4 |
| September | 0.2 | 35.7 | 12.0 | 38.0 | 5.7 | 23.9 |
| October | 2.9 | 28.0 | 6.1 | 32.8 | − 2.8 | 17.0 |
| November | 17.1 | 18.7 | 1.8 | 24.4 | − 7.5 | 10.3 |
| December | 23.0 | 11.7 | −1.3 | 20.0 | −10.0 | 5.2 |
| | 135.4 | | | | | |

TABLE II. SEMIARID REGIONS

*Station:* Kerman
*Period of record:* 1950-58

*Elevation:* 1,757 m
*Location, lat.:* 30° 17' N
*long.:* 57° 05' E

| Month | Mean prec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs min. | |
| January | 38.8 | 12.7 | − 1.3 | 20.6 | −17.8 | 5.7 |
| February | 23.2 | 15.3 | 0.6 | 25.0 | −15.0 | 7.9 |
| March | 43.8 | 19.3 | 5.2 | 26.1 | − 7.2 | 12.3 |
| April | 20.0 | 24.0 | 8.9 | 33.8 | − 5.0 | 16.5 |
| May | 17.6 | 29.5 | 12.4 | 36.7 | 4.0 | 20.9 |
| June | 2.6 | 33.8 | 17.0 | 42.8 | 10.0 | 25.4 |
| July | 6.1 | 35.9 | 10.4 | 41.1 | 9.0 | 23.1 |
| August | 0.4 | 34.4 | 15.6 | 41.1 | 6.0 | 30.0 |
| September | 0.8 | 31.7 | 12.4 | 38.0 | 4.4 | 22.0 |
| October | 3.4 | 26.5 | 6.4 | 33.3 | − 3.5 | 16.5 |
| November | 9.5 | 19.3 | 1.9 | 26.7 | −12.8 | 10.6 |
| December | 33.1 | 14.2 | 0.3 | 26.7 | −10.4 | 7.3 |
| | 199.4 | | | | | |

TABLE II. SEMIARID REGIONS (*Continued*)

*Station:* Ahwaz
*Period of record:* 1955-58

*Elevation:* 20 m
*Location, lat.:* 31° 19' N
*long.:* 48° 40' E

| Month | Mean prec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 36.0 | 16.4 | 6.8 | 22.2 | 0.6 | 11.6 |
| February | 34.5 | 20.2 | 7.2 | 27.3 | 0.6 | 13.7 |
| March | 15.0 | 26.9 | 12.7 | 34.0 | 6.4 | 19.8 |
| April | 28.1 | 32.1 | 17.0 | 41.7 | 10.2 | 24.5 |
| May | 2.5 | 38.5 | 21.8 | 47.8 | 14.5 | 30.1 |
| June | — | 44.6 | 24.1 | 49.1 | 19.6 | 34.3 |
| July | — | 46.9 | 26.7 | 50.0 | 19.8 | 36.5 |
| August | — | 47.3 | 26.1 | 50.3 | 22.4 | 36.7 |
| September | 0.1 | 42.5 | 22.5 | 47.3 | 18.2 | 32.5 |
| October | 20.5 | 36.7 | 19.1 | 42.9 | 13.8 | 27.7 |
| November | 33.4 | 25.7 | 13.2 | 34.8 | 2.6 | 19.5 |
| December | 46.0 | 18.0 | 13.4 | 21.4 | − 0.5 | 15.7 |
| | 216.1 | | | | | |

*Station:* Mashhad
*Period of record:* 1950-58

*Elevation:* 985 m
*Location, lat.:* 36° 16' N
*long.:* 59° E

| | | | | | | |
|---|---|---|---|---|---|---|
| January | 37.4 | 6.4 | − 5.0 | 18.9 | −24.4 | 0.7 |
| February | 27.7 | 8.8 | − 4.2 | 23.2 | −18.3 | 2.3 |
| March | 57.4 | 11.5 | 3.0 | 27.1 | − 7.2 | 7.3 |
| April | 44.4 | 18.9 | 7.0 | 31.4 | − 4.4 | 13.0 |
| May | 29.5 | 25.9 | 12.0 | 37.2 | 2.8 | 19.0 |
| June | 3.9 | 30.7 | 15.3 | 40.0 | 9.6 | 23.0 |
| July | 0.1 | 33.7 | 18.2 | 43.4 | 11.0 | 25.9 |
| August | 0.5 | 32.1 | 15.4 | 40.3 | 7.0 | 23.7 |
| September | 0.4 | 28.0 | 10.4 | 37.0 | 2.6 | 19.2 |
| October | 4.5 | 21.8 | 5.9 | 32.8 | − 3.9 | 13.9 |
| November | 11.2 | 13.6 | − 0.7 | 27.0 | −17.2 | 6.5 |
| December | 19.2 | 8.7 | − 3.5 | 20.8 | −14.4 | 2.6 |
| | 236.4 | | | | | |

TABLE II. SEMIARID REGIONS (*Continued*)

*Station:* Tabriz
*Period of record:* 1949-58

*Elevation:* 1,405 m
*Location, lat.:* 38° 05' N
*long.:* 46° 17' E

| Month | Mean prec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 18.5 | 2.5 | − 6.6 | 11.2 | −22.8 | − 2.0 |
| February | 35.5 | 4.3 | − 5.2 | 18.9 | −18.0 | − 0.4 |
| March | 46.6 | 9.6 | − 0.6 | 21.7 | −12.8 | 4.5 |
| April | 49.3 | 16.5 | 5.3 | 27.4 | − 8.7 | 10.9 |
| May | 42.0 | 22.3 | 9.3 | 31.6 | − 1.1 | 15.8 |
| June | 23.6 | 27.9 | 13.0 | 35.6 | 4.0 | 20.4 |
| July | 7.5 | 31.9 | 16.8 | 40.0 | 7.0 | 24.3 |
| August | 1.5 | 31.0 | 17.2 | 39.4 | 11.0 | 24.1 |
| September | 10.6 | 28.1 | 13.1 | 38.3 | 4.0 | 20.6 |
| October | 16.5 | 20.1 | 7.5 | 29.9 | − 2.0 | 13.8 |
| November | 27.3 | 11.3 | 1.1 | 21.7 | −17.2 | 6.2 |
| December | 18.7 | 4.3 | − 4.5 | 16.5 | −16.2 | − 0.1 |
| | 216.1 | | | | | |

*Station:* Tehran (Mehrabad)
*Period of record:* 1943-60

*Elevation:* 1,198 m
*Location, lat.:* 35° 41' N
*long.:* 51° 19' E

| | | | | | | |
|---|---|---|---|---|---|---|
| January | 37.3 | 14.0 | − 7.1 | 18.4 | −16.1 | 3.5 |
| February | 23.2 | 17.4 | − 7.1 | 23.0 | −13.4 | 5.2 |
| March | 36.3 | 21.9 | − 2.9 | 26.1 | − 8.0 | 10.2 |
| April | 30.9 | 27.8 | 2.0 | 32.0 | − 4.1 | 15.4 |
| May | 13.9 | 33.8 | 7.4 | 36.2 | 2.0 | 21.2 |
| June | 2.0 | 38.1 | 12.8 | 40.1 | 5.7 | 26.1 |
| July | 0.7 | 40.0 | 17.3 | 42.5 | 14.7 | 29.5 |
| August | 1.4 | 39.1 | 16.4 | 42.2 | 11.1 | 28.4 |
| September | 1.2 | 36.1 | 13.0 | 38.0 | 8.3 | 24.6 |
| October | 5.3 | 30.8 | 5.8 | 34.4 | 1.7 | 18.3 |
| November | 28.8 | 22.8 | − 0.6 | 25.0 | − 7.5 | 10.6 |
| December | 27.0 | 16.2 | − 5.6 | 19.4 | −15.0 | 4.9 |
| | 208.0 | | | | | |

TABLE III. DRY SUBHUMID REGIONS

*Station:* Kermanshah
*Period of record:* 1943-58

*Elevation:* 1,298 m
*Location, lat.:* 34° 19' N
*long.:* 47° 07' E

| Month | Meanprec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 56.0 | 7.1 | − 3.1 | 16.3 | −20.6 | 2.0 |
| February | 54.8 | 9.0 | − 2.7 | 21.0 | −23.9 | 3.1 |
| March | 87.6 | 13.4 | 1.1 | 23.4 | −11.7 | 7.3 |
| April | 55.8 | 19.2 | 5.1 | 31.2 | − 5.0 | 12.1 |
| May | 33.9 | 25.4 | 8.9 | 33.8 | 0.6 | 17.1 |
| June | 1.8 | 32.7 | 12.4 | 39.0 | 2.6 | 22.5 |
| July | tr. | 36.2 | 17.0 | 42.0 | 9.3 | 26.6 |
| August | 0.1 | 36.4 | 16.0 | 41.4 | 10.1 | 26.2 |
| September | 1.0 | 32.1 | 10.5 | 37.2 | 2.0 | 21.3 |
| October | 7.1 | 25.8 | 6.7 | 34.2 | − 3.2 | 16.3 |
| November | 56.4 | 16.6 | 9.6 | 26.1 | −11.6 | 13.1 |
| December | 59.1 | 9.4 | − 1.1 | 19.4 | −15.6 | 4.1 |
| | 413.6 | | | | | |

*Station:* Shiraz
*Period of record:* 1950-58

*Elevation:* 1,530 m
*Location, lat.:* 29° 36' N
*long.:* 52° 32' E

| Month | Meanprec. in mm | Mean max. | Mean min. | Abs. max. | Abs. min. | Mean monthly |
|---|---|---|---|---|---|---|
| January | 70.5 | 12.2 | 0.5 | 22.2 | −10.0 | 6.3 |
| February | 51.7 | 14.3 | 1.5 | 22.2 | − 8.3 | 7.9 |
| March | 68.4 | 18.5 | 5.3 | 25.6 | − 1.1 | 11.9 |
| April | 23.1 | 23.9 | 8.2 | 32.0 | − 2.5 | 16.0 |
| May | 17.2 | 29.8 | 13.1 | 37.0 | 5.5 | 21.4 |
| June | — | 34.8 | 16.8 | 38.9 | 6.7 | 25.8 |
| July | 1.3 | 36.9 | 20.3 | 41.0 | 15.5 | 28.6 |
| August | — | 35.6 | 18.8 | 40.6 | 13.0 | 27.2 |
| September | — | 33.1 | 15.3 | 37.2 | 9.0 | 24.2 |
| October | 0.1 | 27.7 | 9.6 | 33.3 | 3.5 | 18.6 |
| November | 79.3 | 19.8 | 4.5 | 26.7 | − 5.0 | 12.1 |
| December | 104.5 | 13.8 | 2.0 | 21.7 | − 5.5 | 7.9 |
| | 416.1 | | | | | |

TABLE IV. MOIST SUBHUMID REGIONS

*Station:* Gorgan
*Period of record:* 1953-58

*Elevation:* 120 m
*Location, lat.:* 36° 51' N
*long.:* 54° 28' E

| Month | TEMPERATURE °C | | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | Mean prec. in mm | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 29.5 | 12.8 | 4.9 | 26.2 | 0.0 | 8.9 |
| February | 38.3 | 14.6 | 4.2 | 27.7 | - 0.5 | 9.4 |
| March | 68.2 | 14.3 | 6.3 | 33.8 | 0.0 | 10.3 |
| April | 61.1 | 18.3 | 9.9 | 35.5 | 0.5 | 14.1 |
| May | 28.2 | 21.2 | 15.5 | 37.8 | 8.0 | 18.3 |
| June | 43.9 | 25.1 | 19.3 | 40.6 | 12.8 | 22.2 |
| July | 43.5 | 32.0 | 22.2 | 41.0 | 17.1 | 27.1 |
| August | 26.9 | 33.3 | 22.3 | 44.0 | 16.7 | 27.8 |
| September | 23.3 | 39.9 | 19.2 | 38.5 | 18.3 | 26.0 |
| October | 70.1 | 23.7 | 13.9 | 34.0 | 3.9 | 18.8 |
| November | 43.9 | 17.1 | 7.1 | 21.8 | - 0.8 | 12.1 |
| December | 44.3 | 13.4 | 4.7 | 29.0 | 0.0 | 9.0 |
| | 521.7 | | | | | |

*Station:* Babolsar
*Period of record:* 1950-58

*Elevation:* −21 m
*Location, lat.:* 36° 43' N
*long.:* 52° 39' E

| Month | Mean prec. in mm | Mean max. | Mean min. | Abs. max. | Abs. min. | Mean monthly |
|---|---|---|---|---|---|---|
| January | 60.8 | 11.2 | 3.1 | 22.8 | - 7.2 | 7.1 |
| February | 63.3 | 11.2 | 3.4 | 24.4 | - 5.6 | 7.3 |
| March | 62.0 | 12.8 | 6.5 | — | - 0.6 | 9.6 |
| April | 34.1 | 16.9 | 10.1 | 31.1 | 0.6 | 13.5 |
| May | 17.6 | 23.3 | 15.8 | 33.8 | 8.3 | 19.5 |
| June | 37.9 | 26.8 | 18.6 | 32.2 | 13.3 | 22.7 |
| July | 58.2 | 29.5 | 22.4 | 34.4 | 17.2 | 25.9 |
| August | 41.3 | 30.2 | 21.7 | 34.4 | 15.6 | 25.9 |
| September | 81.9 | 27.6 | 19.0 | 32.2 | 10.7 | 23.3 |
| October | 116.3 | 22.8 | 14.7 | 31.6 | 7.8 | 18.7 |
| November | 128.6 | 17.7 | 8.0 | 26.1 | - 7.8 | 12.8 |
| December | 91.3 | 13.2 | 5.1 | 27.2 | - 1.0 | 9.1 |
| | 793.3 | | | | | |

TABLE V. HUMID REGIONS

*Station:* Nowshahr
*Period of record:* 1957-59

*Elevation:* −5 m
*Location, lat.:* 36° 38' N
*long.:* 51° 30' E

| Month | TEMPERATURE °C | | | | | | Mean monthly |
|---|---|---|---|---|---|---|---|
| | Mean prec. in mm | Mean max. | Mean min. | Abs. max. | Abs. min. | | |
| January | 102.1 | 11.4 | 2.6 | 19.0 | − 1.0 | | 7.0 |
| February | 120.8 | 11.0 | 2.2 | 23.0 | − 3.5 | | 6.6 |
| March | 50.5 | 12.4 | 5.5 | 28.5 | − 1.0 | | 8.9 |
| April | 36.9 | 16.2 | 9.4 | 26.0 | 5.0 | | 12.7 |
| May | 30.6 | 22.8 | 14.8 | 29.0 | 8.5 | | 18.8 |
| June | 125.0 | 25.5 | 18.2 | 31.5 | 13.0 | | 21.9 |
| July | 75.4 | 28.4 | 20.5 | 32.5 | 16.0 | | 24.5 |
| August | 101.5 | 28.8 | 21.2 | 33.5 | 16.0 | | 25.0 |
| September | 169.1 | 25.0 | 18.4 | 31.0 | 14.0 | | 21.7 |
| October | 329.5 | 21.0 | 13.5 | 29.5 | 6.0 | | 17.2 |
| November | 233.9 | 15.2 | 6.5 | 21.5 | − 1.0 | | 10.8 |
| December | 114.8 | 14.6 | 3.9 | 20.0 | − 0.5 | | 9.2 |
| | 1 490.0 | | | | | | |

*Station:* Ramsar
*Period of record:* 1956-58

*Elevation:* 8 m
*Location, lat.:* 36° 53' N
*long.:* 50° 40' E

| | | | | | | |
|---|---|---|---|---|---|---|
| January | 32.5 | 16.7 | 5.2 | 19.0 | 1.0 | 11.0 |
| February | 58.3 | 11.2 | 4.9 | 25.5 | − 1.0 | 8.0 |
| March | 88.9 | 11.6 | 6.8 | x | − 0.5 | 9.2 |
| April | 53.2 | 16.5 | 9.3 | 28.6 | 0.0 | 12.9 |
| May | 51.3 | 19.0 | 14.4 | 30.0 | 6.0 | 16.7 |
| June | 108.1 | 25.8 | 18.1 | 31.5 | 11.5 | 22.0 |
| July | 42.7 | 28.6 | 20.1 | 32.1 | 16.5 | 24.3 |
| August | 80.6 | 29.0 | 21.2 | 35.0 | 16.0 | 25.1 |
| September | 193.7 | 26.1 | 19.2 | 33.4 | 11.8 | 22.6 |
| October | 255.8 | 21.4 | 14.4 | 30.0 | 6.5 | 17.9 |
| November | 179.6 | 16.1 | 8.6 | 26.1 | − 1.0 | 12.3 |
| December | 83.6 | 13.0 | 6.0 | 25.0 | 1.0 | 9.5 |
| | 1 188.3 | | | | | |

TABLE V. HUMID REGIONS (*Continued*)

*Station:* Rasht
*Period of record:* 1956-58

*Elevation:* 3 m
*Location, lat.:* 37° 17' N
*long.:* 49° 38' E

| Month | Mean prec. in mm | TEMPERATURE °C | | | | Mean monthly |
|---|---|---|---|---|---|---|
| | | Mean max. | Mean min. | Abs. max. | Abs. min. | |
| January | 89.3 | 12.0 | 2.8 | 23.3 | − 4.0 | 7.4 |
| February | 70.9 | 12.7 | 2.3 | 27.4 | − 4.6 | 7.5 |
| March | 149.5 | 13.3 | 4.9 | 28.8 | − 3.5 | 9.1 |
| April | 50.7 | 18.8 | 8.3 | 33.0 | − 1.7 | 13.5 |
| May | 52.9 | 25.4 | 12.4 | 32.2 | 5.6 | 18.9 |
| June | 55.7 | 27.7 | 15.5 | 35.4 | 10.0 | 21.6 |
| July | 45.1 | 29.4 | 17.8 | 35.0 | 11.2 | 23.6 |
| August | 65.6 | 30.4 | 18.2 | 35.6 | 12.8 | 24.3 |
| September | 208.0 | 26.7 | 16.2 | 33.3 | 7.4 | 21.5 |
| October | 277.7 | 22.1 | 12.5 | 32.0 | 4.0 | 17.3 |
| November | 194.1 | 16.5 | 5.6 | 28.3 | − 4.0 | 11.0 |
| December | 101.5 | 13.6 | 3.0 | 27.2 | − 4.0 | 8.3 |
| | 1 361.0 | | | | | |

*Station:* Pahlavi
*Period of record:* 1950-58

*Elevation:* −15 m
*Location, lat.:* 37° 28' N
*long.:* 49° 28' E

| Month | Mean prec. in mm | Mean max. | Mean min. | Abs. max. | Abs. min. | Mean monthly |
|---|---|---|---|---|---|---|
| January | 107.6 | 9.8 | 4.3 | 24.2 | − 8.9 | 7.0 |
| February | 101.7 | 9.7 | 4.1 | 28.0 | − 4.7 | 6.9 |
| March | 157.0 | 10.9 | 5.5 | 27.8 | − 0.8 | 8.2 |
| April | 59.0 | 15.4 | 9.6 | 27.8 | − 0.6 | 12.5 |
| May | 39.6 | 22.4 | 15.5 | 32.8 | 5.6 | 18.9 |
| June | 63.7 | 26.5 | 18.9 | 32.8 | 11.6 | 22.7 |
| July | 61.5 | 29.3 | 21.3 | 34.2 | 15.3 | 25.3 |
| August | 79.7 | 29.7 | 21.3 | 34.6 | 16.3 | 25.5 |
| September | 432.9 | 26.1 | 18.8 | 32.5 | 11.1 | 22.4 |
| October | 357.7 | 21.6 | 15.1 | 31.7 | 7.1 | 18.3 |
| November | 369.9 | 15.4 | 8.6 | 28.0 | − 0.8 | 12.0 |
| December | 175.1 | 11.9 | 5.6 | 27.4 | 0.3 | 8.7 |
| | 2 005.4 | | | | | |

## Appendix A3

### VERTICAL ZONALITY IN MOUNTAINOUS SOILS IN IRAN

As indicated in the general description, Iran is predominantly a mountainous country. The mountain formations surround the saline, sandy, and rocky deserts of the Central Iranian Plateau, thus making it a closed basin containing many kinds of sediments. In the course of soil mapping in these mountainous regions profile descriptions were made at intervals of specified heights. A special study was made of the Azerbaijan area. These observations are summarized in Table 1. Samples from these profiles were brought in and analyzed for organic matter, total neutralizing value, pH, cation exchange capacity, mechanical analysis, etc.

TABLE 1

| Location | Profile no. | Elevation | Soil color description | Munsell color notation (moist) | Identification of great soil group or soil association |
|---|---|---|---|---|---|
| (1) Ardebil-Tabriz | 92 | 6 000 | Brown | 10 YR 5/3 | Brown |
| " | 94 | 7 000 | Dark to very dark grey-brown | 10 YR 4/2-3/2 | Chestnut |
| (2) Northwest of Tabriz | 122 | 3 400 | Dark grey-brown to grey-brown | 10 YR 6/2-5/2 | Dark Sierozem |
| " | 113 | 4 600 | Brown | 10 YR 5/3 | Brown |
| " | 115 | 5 500 | Dark to very dark grey-brown | 10 YR 4/2-3/2 | Chestnut |

Field observations confirmed by laboratory analysis indicated that in the same general region there was a zonality of soils depending upon the altitude. For example, in the lower lying areas of Azerbaijan, Sierozem soils were observed grading into Brown soils which, with height, graded into Chestnut soils. Though generalized soil maps could not show such differences, occurring sometimes within a few kilometers, detailed soil maps would surely do so. In general, the following soil associations observed in mountainous regions from low to high elevations were: Lithosols — Desert soils (Soil Association 13); Lithosols — Sierozem soils (Soil Association 13); Lithosols — Brown soils (Soil Association 15); Lithosols — Chestnut soils (Soil Association 15). Intergrades between these soils were also observed. Similar observations were made in other mountainous parts of Iran, especially in

Khurasan and Fars. These observations support the view that there is a vertical zonality in the mountainous soils of Iran. The degree of change with height varies, of course, from one region to another depending on its climate, vegetation, and other environmental or physical factors.

The reasons for such a vertical zonality are not difficult to see. Factors responsible for the variability in soils change significantly with altitude. For example, there is a greater amount of total precipitation on higher lying areas, as well as an increased snow-rainfall ratio at these altitudes. Exposure and degree of slope determine the amount of time the snow lies on the ground and thus constitute important factors in soil formation. The difference in soils at varying altitudes is reflected in their use. It has been observed in most parts of the mountainous regions of Iran that, as one climbs, dry farming by the local farmers is more common. A higher percentage of the area is under dry farming even when the topography is rugged and rough. Because of greater moisture in the soils, it is possible to grow wheat and barley at higher altitudes whereas it is less certain in lower altitudes. However, such use of land is harmful in areas where the soils are exposed to erosion.

**Appendix A4**

## A NOTE ON SOIL CORRELATION WITH NEIGHBORING COUNTRIES

Five countries, Iraq, Turkey, U.S.S.R., Afghanistan and Pakistan, have common boundary with Iran. Some soil correlation work was done with these countries and the equivalents mapped are given below:

### IRAQ

| Soil map of Iran (Dewan, Famouri, 1961) | | Exploratory soil map of Iraq (Dr. Buringh, 1958) | |
|---|---|---|---|
| *Soil Association No.* | | *Soil Association No.* | |
| 1 | Fine-textured Alluvial soils | 29 | Fan soils |
| 1-4 | Saline Alluvial soils | 5 | River basin soils, salted, phase |
| 3-4 | Salt-Marsh soils | 10 | Marsh soils |

| | | | |
|---|---|---|---|
| 14 | Calcareous Lithosols (from saliferous and gypsiferous marls)-Desert and Sierozem soils (including salt plugs) | 29 | Bad Land |
| | | 27 | Reddish-Brown soils, medium and shallow phase, over gypsum, sand, and mud stone |
| 15 | Calcareous Lithosols — Brown soils and Chestnut soils | 38 | Rough, broken and stony land |
| | | 39 | Rough, mountainous land |
| 16 | Lithosols, from igneous rocks, Brown soils and Sierozem soils | 39 | Rough mountainous land |

## TURKEY

| Soil map of Iran | | General Soil map of Turkey (Ref. 36) (Harvey Oakes, 1958) | |
|---|---|---|---|
| *Soil No.* | *Association* | *Soil No.* | *Association* |
| 1 | Fine-textured Alluvial soils | 1B | Alluvial and youthful soil from alluvium gently sloping (1 to 3 percent) |
| 1-4 | Saline Alluvial soils | 2As | Hydromorphic Saline Alluvial soils |
| 15 | Calcareous Lithosols — Brown soils and Chestnut soils | 20F | Rough, broken land (Chestnut soil material) |
| 16 | Lithosols, from igneous rocks, Brown soils and Sierozem soils | 25E | Rough, mountainous land (over volcanic and igneous rocks) |

## U.S.S.R.

The correlation was made with Madame Labova, Dokuchaiv Institute of Soil Science, Moscow, during her visit to Rome in 1961. The soil map of Azerbaijan prepared in the U.S.S.R. was compared to the soil map of Iran on 1 : 1,000,0000 and the following equivalents were worked out:

| Soil map of Iran | | U.S.S.R. | |
|---|---|---|---|
| 1-4 | Saline Alluvial soils | 4 | Meadow soils on sierozemic alluvium with different salinity |
| 6 | Sierozem soils | | |
| 6-2 | Sierozem soils, Regosols | 5 | Sierozem primitive (CK) |
| 7 | Brown soils | 1 | Light Chestnut, Grey Cinnemonic, $K_2$ |
| 8 | Chestnut soils | 2 | Chestnut (Dark Chestnut) $K_1$ (Cinnemonic) |
| 11 | Brown Forest soils including Grey-Brown Podzolic soils | 3 | Brown Forest mountain soil (Galb) |
| 19 | Lithosols (mainly from igneous rocks) Brown Forest and Podzolic soils | | |

## AFGHANISTAN

There is no final soil map of Afghanistan prepared as yet. However, the provisional soil map of Afghanistan by Subramanian is the basis of comparison. In general the soil associations used in the soil map of Iran were used for the soil map of Afghanistan.

| Soil map of Iran | | Afghanistan General soil map of Afghanistan 1 : 2,000,000 (*V. S. Subramanian 1962, unpublished*) | |
|---|---|---|---|
| *Soil Association No.* | | *Soil Association No.* | |
| 4 | (Solonchak and Solonetz soils) | 8 | Saline — Alkali soils |
| 6 | (Sierozem soils) | 4 | Sierozem soils |
| 6-2 | Sierozem — Regosols | 5 | Sierozem — gravelly outwash — playas. |

## PAKISTAN

The soil map of West Pakistan is under preparation by the United Nations Special Fund team for Reconnaissance Soil Survey of Pakistan. It is expected that the following units occurring in Iran also occur in West Pakistan:

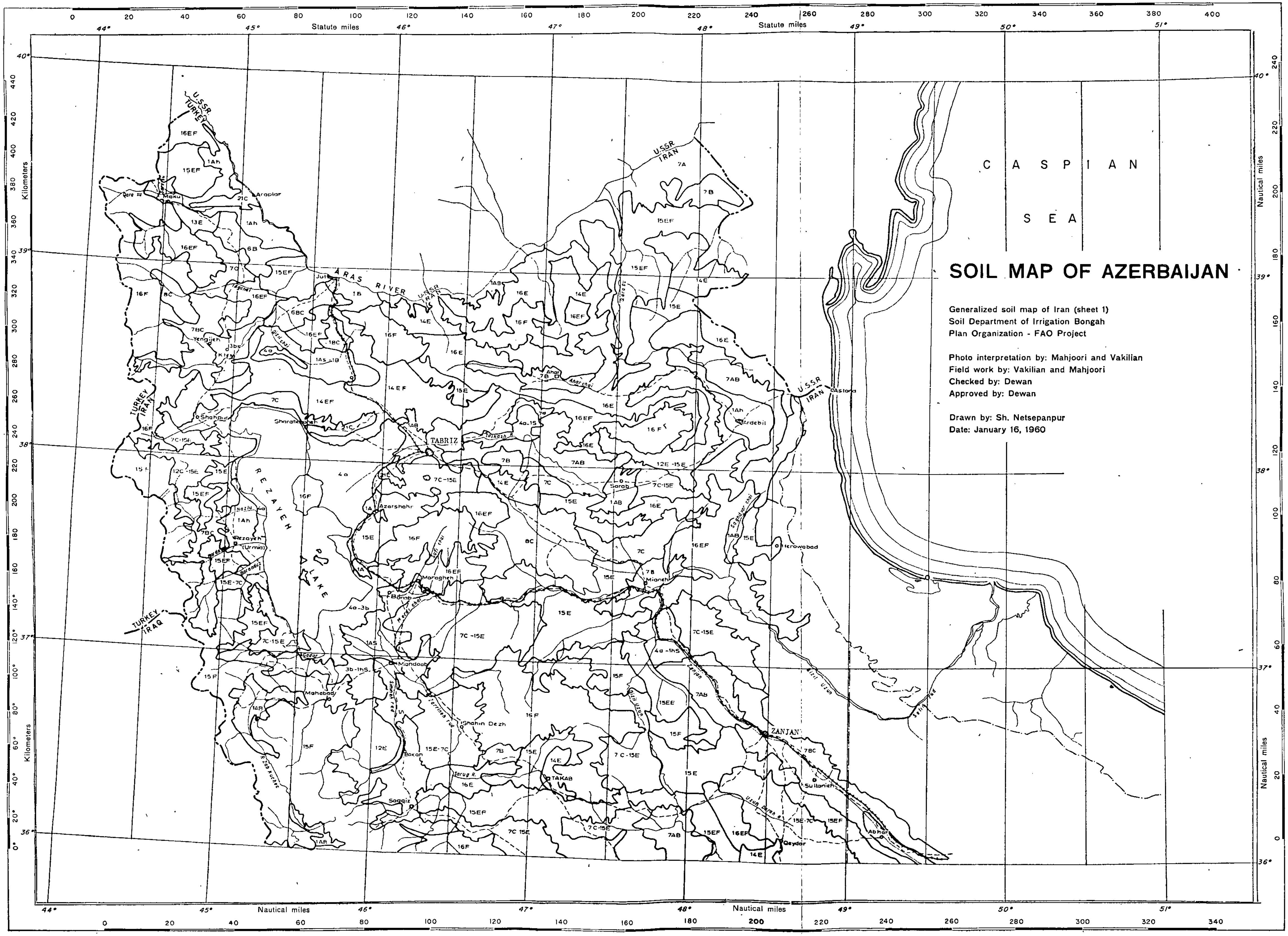
6 Sierozem soils

7 Brown soils

8 Chestnut soils

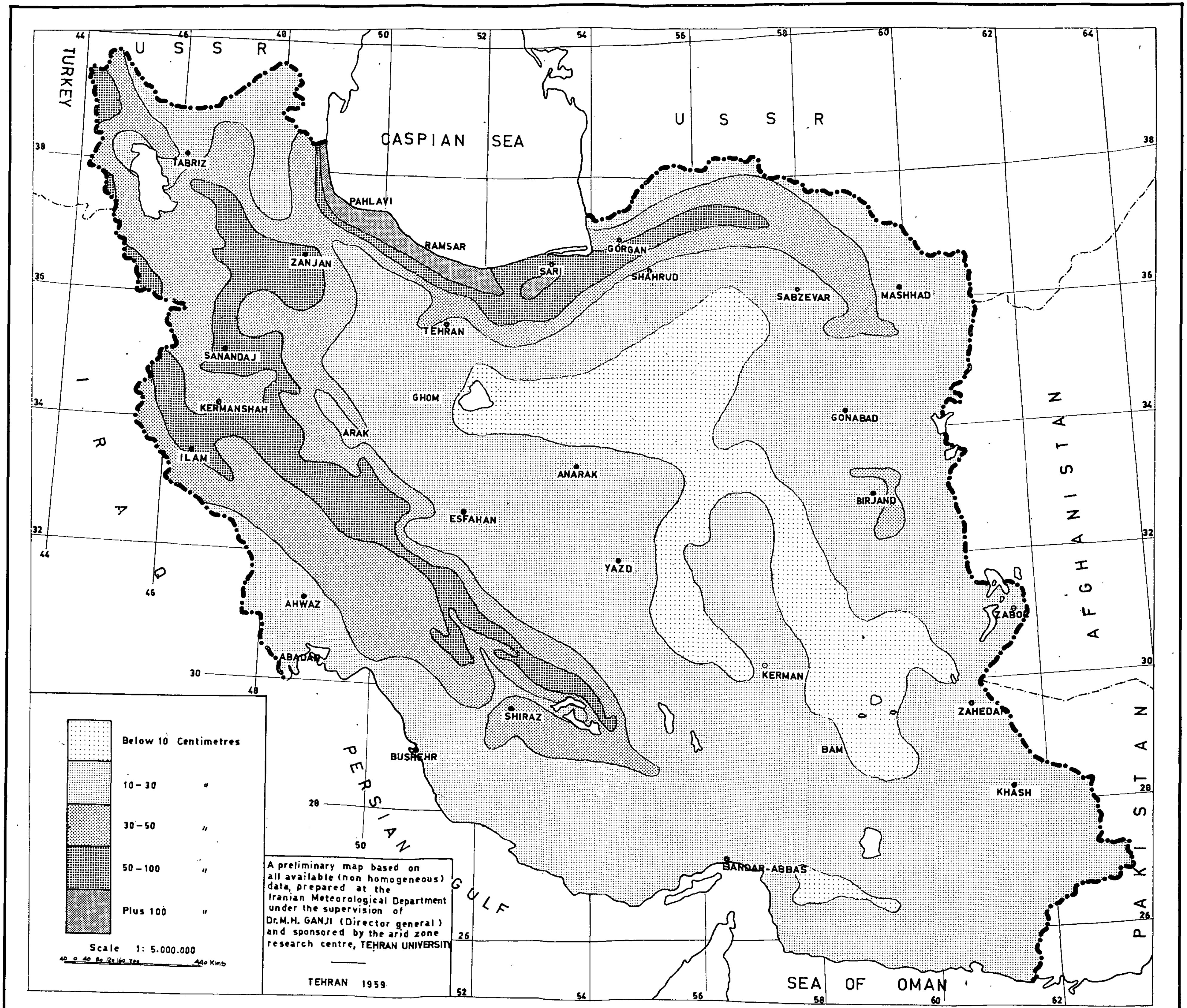
15 Calcareous Lithosols — Brown soils and Chestnut soils

16 Lithosols (from igneous rocks) — Brown soils and Sierozem soils


SOIL MAP OF AZERBAIJAN
Generalized soil map of Iran (sheet 1)
Soil Department of Irrigation Bongah
Plan Organization - FAO Project
Photo interpretation by: Mahjoori and Vakilian
Field work by: Vakilian and Mahjoori
Checked by: Dewan
Approved by: Dewan
Drawn by: Sh. Netsepanpur
Date: January 16, 1960
C A S P I A N
S E A
Statute miles
Nautical miles
Kilometers
U.S.S.R.
TURKEY
IRAN
IRAQ
ARAS RIVER
REZAYEH LAKE
TABRIZ
ZANJAN
TAKAB
Maku
Shahpur
Sharafkhaneh
Rezayeh (Urmia)
Azarshahr
Maragheh
Bonab
Miandoab
Mahabad
Shahin Dezh
Bokan
Saqqiz
Sarab
Mianeh
Ardebil
Astara
Herowabad
Ahar
Sultanieh
Abhar
Qeydar

# AVERAGE ANNUAL PRECIPITATION IN IRAN

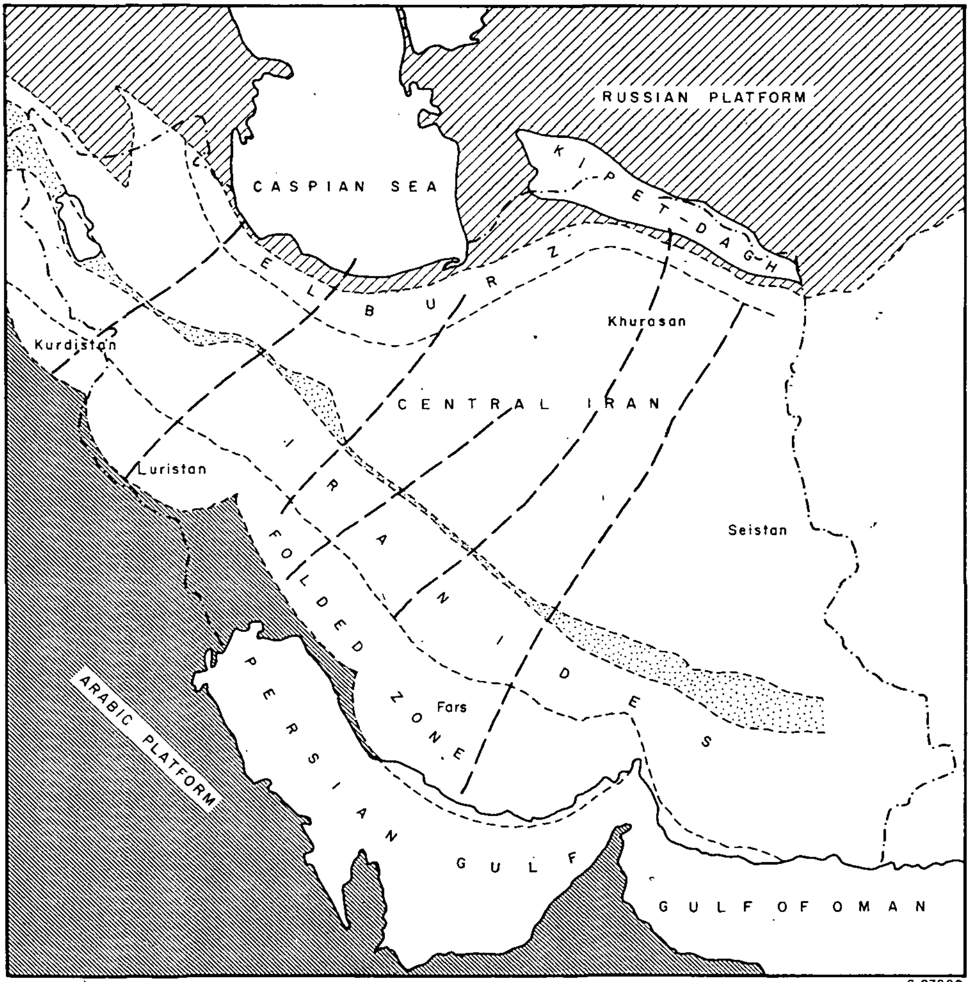





G.S. 1820

Appendix B6

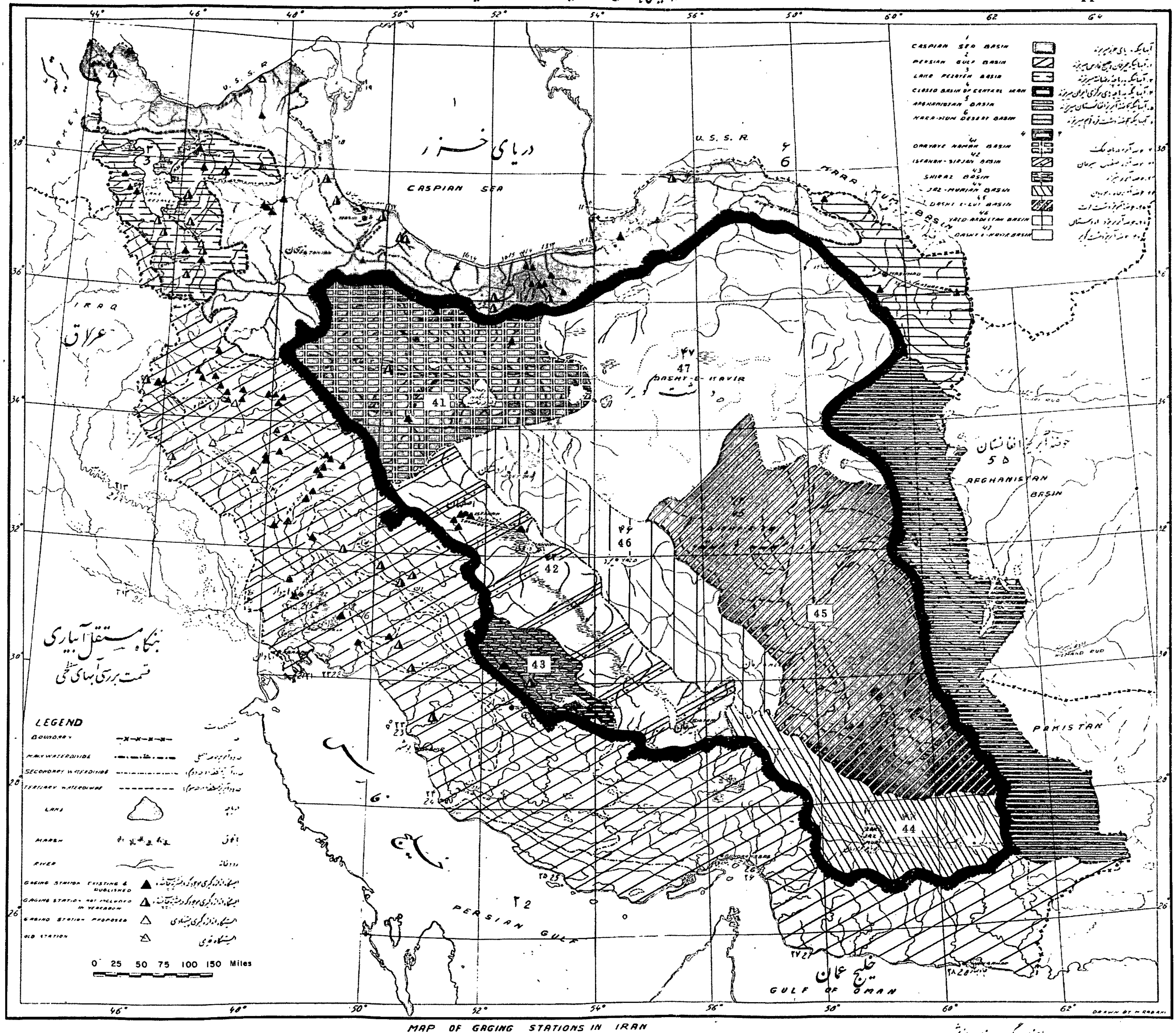
MAP OF PHISIOGRAPHIC PROVINCES OF IRAN




*Prepared by J. W. Schroeder*

نقشه ایستگاههای اندازه گیری رودخانه های ایران

**Appendix B7**




MAP OF GAGING STATIONS IN IRAN

چاپخانه و گراور سازی دانشگاه