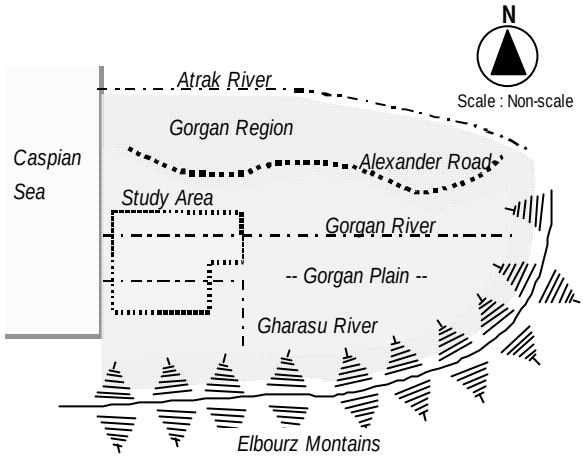
Annex 3 Geomorphology and Soils

ANNEX 3

GEOMORPHOLOGY AND SOILS

A3.1 Topography

The Study Area is located at the downstream part of the Gorgan Plain, which is formed by alluvium deposits of Gorgan river, Gharasu river and their tributaries, which are originated from the valleys of southern side slopes of Elbourz Mountains. Gorgan Region, which includes the Gorgan Plain, is defined as the area bounded by Elbourz Mountains in the south and east, Alexander road in the north and Caspian Sea in the west, with an area of about 14,000km^2.



Location of the Study Area in Gorgan Region

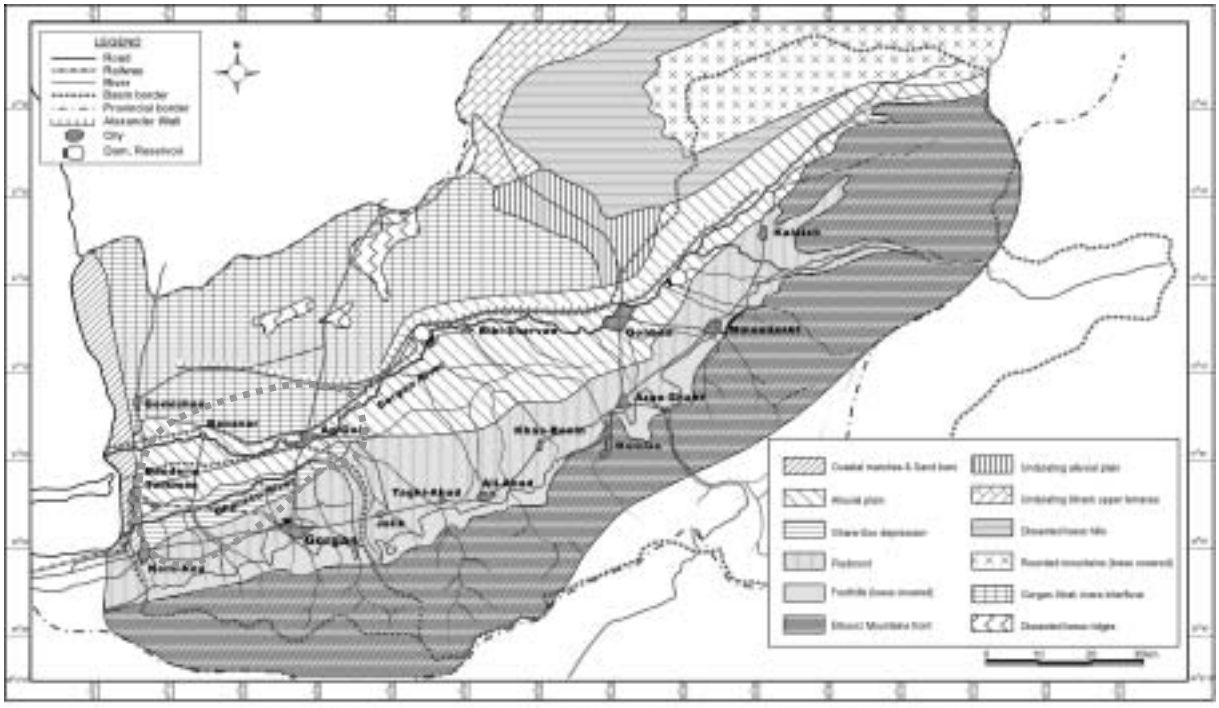
Gorgan Plain lies at the downstream areas of mainly the Gorgan River and Gharasu River watersheds. Gorgan River starts from peaks of Baba-Shamal Mountains and Narji mountains, and runs from east to west, gathering many tributaries originated from valleys of Elbourz Mountains and finally flows into Caspian Sea. The total area of the watershed is 11,480 km^2, while Gharasu river watershed occupies 1,720 km^2 at the southern part of the plain between Kordkuy and Taghi-Abad, about 40km along the foothills. Elbourz Mountains lies in the Northeast – Southwest direction, while guiding the river streams and defining the southern boundary of the watershed. At the far-eastern part of the watershed, Kopek Mountain divides Gorgan river from Atrak river, whose watershed covers the northern boundary of Gorgan river watershed. Gharasu river watershed, which is isolated from Gorgan river, forms an independent watershed at the Southwest part of the Gorgan plain. The total area of Gorgan Plain is about 5,330 km^2.

The Study area extends from 54^{o}06’00” E to 54^{o}42’00” E (about 45km on East-West direction) and from lat. 36^{o}47’19” N to lat. 37^{o}06’08” N (about 35km extends on North-South direction). Southern boundary of the area is defined by the National Road of Kordkuy – Ali-Abad Route, which runs along foothill edge of Elbourz Mountains on East-West direction, while the north boundary is to be set as inscribed curve between Bandar-e-Torkman – Khajeh-Nafas Rout and Alexander Wall in Hemmad. The eastern boundary is defined by Ata-Abad, while the western boundary of the area is Kordkuy–Gomishan road which runs along the Caspian Sea coastal line. The figure of the Study area seems like a cocoon with an area of about 800 km^2.

The region consists of two distinct topographic features; 1) the Plain, a flat area with smooth topography and elevation ranging from -20 to 300m; 2) the Elbourz Mountain range which forms the south and east boundaries and ranges in elevation from 300 to 4,100 m. Alluvial fans which border the mountains on the north have initially steep slopes, interfingering into foothill zone within several kilometers, and connecting to the plain area. The plain has a gentle slope from south to north and east to west.

Slope from the high walls of Elbourz Mountains shows a steep decrease from 4,000 m to several hundred meters elevation within a few kilometers at first, and then enters into foothill ranges, which consisted of alluvium fans along the mountain west-east alignment. There are 12 major fans, which contributed for the historical agro-forestry productions from ancient days. At the edge of those fans Gorgan and Gharasu rivers run from east to west in the plain. Even though both the rivers formulate a concave corridor within 20 km width, it is hard to distinguish the undulation. There is a quite gentle slope of 0.15m per 1,000m, which runs to the north up to Atrak river watershed. On this south to north direction, the Study Area shares a faint concave provided by the two streams.

On the east to west direction, within a distance of 25 km from Kalaleh area near Gonbad, the slope is about 25m per 1,000m, with the elevation decreasing from 100m to 35m. For the next 30km westward, the elevation decreases to 17m, with an average slope of 0.7m per 1,000m, at the location of Voshmgir Dam site. The elevation of the plain decreases continuously with a gentle slope and reaches to 13m below sea level within the range from the Dam site to Aq Qala, which is located at 40km in the westward direction. The slope from Aq Qala to the Caspian Sea is about 0.4m per 1,000m in the 40km distance and the elevation decreases to 28m below sea level. The Gorgan river flows down in those slopes on east to west direction. The Study Area extends in the most downstream side roughly and the elevation is from 10m above sea level to 20m below sea level along the Gorgan river.



Major Physiographic Units of Gorgan Region (Mahler, 1971)

A3.2 Geology of the Study Area

The geological conditions of the Study area are described below based on the analysis of existing reports, mainly the Final Report of Complementary Investigations of Groundwater Development in the Gorgan and Plain Area. The entire region can be classified into three regions as 1) mountainous region, 2) foothill region and 3) plain area. Based on the geological conditions, the Study Area can be broadly classified into 3 classes as mentioned below;

a. Geological features of mountain areas.
b. Geological features of foothill areas.
c. Geological features of the plain

(1) Mountain regions

The mountain front forms the southern boundary of the Study area and hydrologic boundary varies between a constant flux recharge boundary (in the lime stone areas) to a zero flux and impervious boundary in the bedrock area.

1) Sedimentary rocks

It was analyzed with evidence that the Gorgan area was inundated for several times. Hence sedimentation plays a major role in the geologic events, which led up to the development of present day geologic features. Red colored sandstone noticed in Fazel-Abad and Ali-Abad canyons is said as the oldest rocks and are probably of Paleozoic age (600–250 million years ago).

A black limestone formation (with calcite intercalations) believed to be Devonian (400 – 350 million years ago) or Carboniferous age (350 – 280 million years ago) can be seen in the area. This formation covers a vast area extending from 10km southeast of Gorgan up to Azad-Shahr. Permian sediments in the region are also somewhat calcareous with outcrops located mainly in the southern parts of the mountains east of Gorgan.

During Mesozoic Era (230 – 6.5 million years ago), a large geosyncline covered most of Iran which ultimately resulted in forming the Elbourz and Zagros mountain ranges in early Tertiary period. The fact that no outcrops of tertiary sediments can be noticed in the highland areas of Gorgan supports this age of mountain forming. Jurassic sediments in the area are mainly calcareous, but some sandstones and schists can be found. Cretaceous deposits are also calcareous being generally dark, and interbedded with calcite.

No Tertiary (65.0 – 2.0 million years ago) sediments can be noticed in the mountainous or highland areas in the Gorgan region. Because the Elbourz Mountain range was formed in early Tertiary time as the results of orogenic uplifts. The topographic relief caused by the formation of the mountains forced the existing sea to regress towards the north and east.

These deposits are of a fluvial and Eolian origin consisting mainly of alluvial fans and wind-blown deposits.

2) Metamorphic rocks

Green-color rocks combining with schist is noticeable in places in the region, which is named as “Gorgan Schists”, comprising a major portion of the Elbourz Mountains and extend from the town of Ali-Abad. They are Metamorphic rocks and are believed to be pre-Cambrian in age.

3) Igneous Rocks

Red colored schists can be noticed in various locations of the area. Igneous rocks in the watershed are fairly limited not only in areal extend but also in varieties. The rocks consist mainly of red andesites which can be seen at the south of Fazel-Abad and in an area south of Khan-Bebin. In the south of Fazel Abad, these andesites were the main source of materials, which formed the red Cambrian sandstones.

(2) Foothill Region

Foothill region connects Elbourz Mountains and Gorgan Plain in about 10 or 15km range along the Mountains.

Eolian deposits consisting mainly of loess are scattered in various parts of the foothill region as found in south of the city of Gorgan. The cause of the loess is believed that, during early Quaternary time (Pleistocene, about 2 million–11 thousand years ago), the weather in Gorgan had become extremely warm, resulting in melting of much of the perennial snow-fields in the area. This rise in temperature caused a significant decrease in atmospheric pressure. A high-pressure cold front from the Northeast Turkistan Desert invaded the low pressure Gorgan area at this time, carrying a lot of particulate matter consisting of silt, fine sand and clay into the area. Upon contacting the Elbourz range, precipitation was caused by cerographic lifting and the loess deposits now seen in the foothills were gradually formed. Melting of the great masses of ice resulted in heavy floods which transported some of the loess deposits northward depositing them in the northern plain area.

Loess thickness are about 150m in Kalaleh area, 130m to 70m depth and this loess layer deceasing from North to South in Gorgan city area and in the vicinity Nahar-Khoran, the loess is non-existent. These fine grained deposits are semi-pervious and would be in the class of aquicludes rather than aquifers.

(3) Plain Region

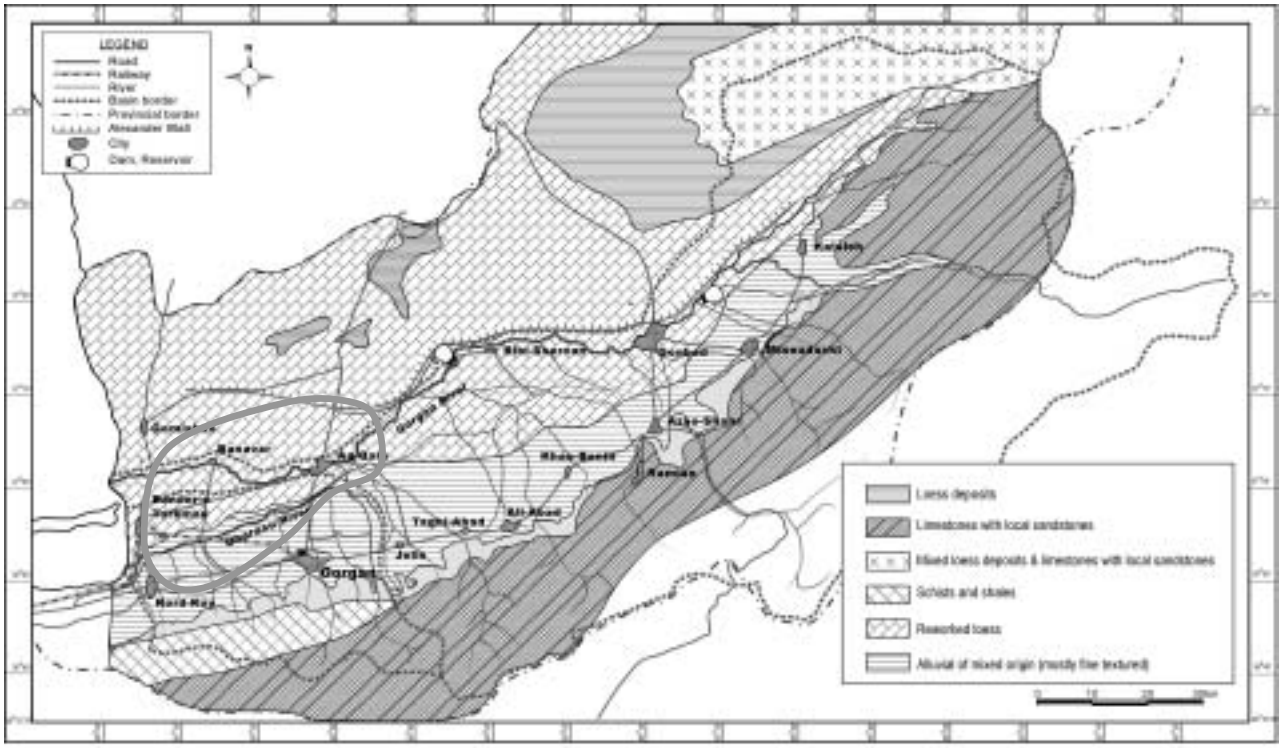
The Gorgan Plain is generally flat, having a gentle slope originating as a result of regression of the ancestral Caspian Sea.

In almost all area of the Plain, a veneer of fine-grained sediments covers the surface. This veneer consists of silt and clay and ranges from zero to 50 m thick. Under this surface layer, a layer of marine sediments exists. This layer is composed of mainly of marls and interbedded alluvium and sandstone with various degrees of consolidation. In the upper part of this marly layer, some silt and clay can be found which forms a transition zone; however, this zone does not seem to have any significant thickness. Generally speaking, the marl deposits are fine-grained having been deposited in a quiet marine environment. In most areas, shells can be found in abundance, which were dated as Mio-Pliocene in age.

Similar marine sediments can be noticed along the coast of the sea, where marly layers are not separated from the alluvium and sandstone but are inter-bedded in an inhomogeneous fashion. The alluvium and poorly consolidated sandstones form the main aquifers of the northern Gorgan Plain area: however, the high degree of anisotropy and inhomogeneity existing in the Plain makes prediction of aquifer depths at any given location very difficult.

The Marls are blue-gray in color and somewhat calcareous. Generally, hydraulic conductivities are quite low in these sediments. It was reported that the marls extend up to the foot of Elbourz range, underlying the alluvial fans in most parts. Geologic logs of exploratory wells drilled within the alluvial fans reveal that alluvial and marine formations also interfinger horizontally in a transition zone, which is the result of successive transgression and regression of the ancestral Caspian Sea.

It is said that bedrock in the Gorgan area is composed of the Gorgan Schist. It is also correlated with the extrapolation of these outcrops in the southern mountain area, based on previous seismic refraction studies. (The schists extend under the alluvium from south to north with a steep slope with a few east-west trending synclinal and anticlinal structures being noticed. The average depth to these schists ranges from 500 m in the southern foothill region to 800 m in the northern reaches of the plain.)



Surface Geology of Gorgan Region (Mahler, 1971)

(4) Hydrogeology of the Plain

1) Alluvial Fans

Generally, the alluvial fans are very important for exploitation of the groundwater resources and for function of recharging water into ground in hydrological circulation. In the Gorgan area ,there are twelve alluvial fans deposited by rivers, and all of them overlie marine marls

and sandstone formations.

To define the areal extend of these fans, maximum use was made of topographic studies as well as a critical review of qanats and wells. The northern most limit of an alluvial fan can be distinguished by the sudden change of slope where it contacts the plain. Geological cross-sections A-A', B-B' and C-C' show the general extension of sediments and also the interfingering of alluvial fans with marine deposits.

2) Fine-Grained Sediments in the Northern Plain Area

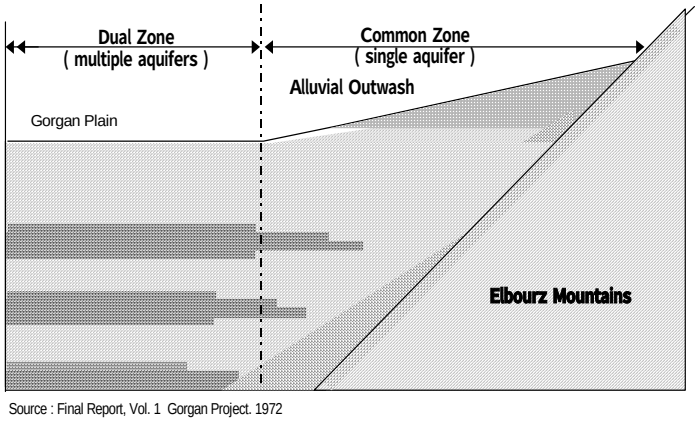
In the north of the alluvial fans, the geology of the fine-grained deposits of the plain can be generally described as consisting of a thin veneer of Eolian deposits overlying marine marls and sandstones which are interbedded with some alluvial sands and gravels.

In the recent past, the Gorgan area was occupied by an inland sea having several periods of transgressive and regressive overlap. During this time, alluvial deposits were also formed by the action of mountain streams with their lateral extent directly depending upon the existing shorelines at any particular time. It is therefore virtually impossible to predict with exact certainty the areal extent, depth and thickness of the aquifer system at any given location in the Plain due to the high degree of inhomogenity and anisotropy developed. However, certain basic facts regarding these aquifers have been clarified through previous drilling and testing, namely:

A. Unconfined or near surface aquifer exists in the Gorgan area which seems to be uniform in areal extent and varying in thickness from about 5 to 50 m. Water levels in this aquifer fluctuate due to effective precipitation (precipitation minus evapotranspiration), irrigation return flow and shallow well pumping and qanat extraction.

B. Underlying the unconfined aquifer at varying depths are layers of impervious to semi-pervious fine-grained deposits rich in silt and clay. This layer of silt and clay varies in thickness throughout the Plain and forms like a barrier between the shallow (phreatic, unconfined) and deep (artesian) aquifer systems. The most logical concept of the deep aquifer zone is that of a series of confined aquifers consisting of alluvium or weakly consolidated sandstone separated by layers of silty clay or clayey silts. Determination of the exact nature and areal extent of an individual aquifer is quite random due to the lack of necessary data. In other words, on a microscopic scale (i.e. on an individual aquifer basis) the problem is quite undetermined. However, on a macroscopic scale (regional), a dual aquifer system can be visualized. The upper or unconfined aquifer, being one zone, and the sum of all the deep confined and semi-confined aquifers being another zone.

Dual Aquifer System Concept



Source : Final Report, Vol. 1 Gorgan Project. 1972

C. Close to the mountains, but at varying distances, the dual-aquifer system concept vanishes. In other words, near the mountains a sudden checking in stream velocities due to a change in topographic slope caused the bed load of the mountain streams to be deposited. This natural geologic process resulted in accumulation of coarse-grained alluvial material near the mountain fronts. Farther down the slope, fine-grained deposits accumulated according to the natural law of stream deposition.

The deposits of coarse-grained materials near the head of the alluvial fans forms a zone whereby recharge from infiltration and subsurface inflow is allowed to percolate downward generally uninhibited by confining layers. It is through this coarse-sediment zone where the duel-aquifer system is commonly recharged (thus the name “common zone” has been adopted). The width or the common zone is a direct function of the magnitude of the alleviation processes – being wider in large alluvial fans, and narrower in smaller ones.

3) Limit of Artesian Aquifers and Pressurized Fine-Sand Formations

The transition between the common and dual aquifer zones may vary several hundred meters in any given location. The distinction between the common zone (single aquifer with a unconfined water table) and the dual zone (multiple confined and semi-confined aquifers with usually static water levels above the ground surface) was made strictly on the basis of exploratory borings and the study of existing wells and qanats. Boundary between the artesian aquifers (dual zone) and the non-artesian aquifer near the mountain front (common zone) can be defined almost same of alignment of frontline of alluvium fans.

It must be remembered that in the dual zone one may encounter many artesian aquifers, each with a different piezometric surface. This is due strictly to the advanced degree of inhomogeneity of the sediments causing many individual systems to be formed which hydro-dynamically may or may not be connected.

The pressurized sand formations are merely those fine-sand layers, which occur in the dual aquifer zone where artesian pressures may cause problems of well completion due to sand flowing into the well. The limit of these pressurized fine-sand layers for al practical purposes can be considered as the boundary between artesian and non-artesian flow (i.e. the boundary between the duel and common-aquifer zone).

However, the problem of fine sands are more pronounced in the further north as the result of more wide spread deposition of fine-grained deposits, and relatively higher artesian pressures on the underlying aquifers as compared to those higher in elevation towards the south (i.e. in a south to north direction, the topographic slope decreases much more rapidly than the slope of the piezometric surface).

(5) Surface geological conditions

It can be summarized that the Study Area is founded with marl and fine sand which was provided in the process of transregression and regression of Caspian Sea, in the vessel of Gorgan schist. Stratum of silty clay or alluvial sand and gravel covers the parent foundation in about 50m deep in the profile. Profile of the southern outskirts near the Mount piedmont is little bit different from the Plain. Loess as wind-blow deposit exists on the Gorgan schist like drift which complements ramp between the schist slope and the marl foundation. Silty clay layer is covering the loess and forming piedmont condition.

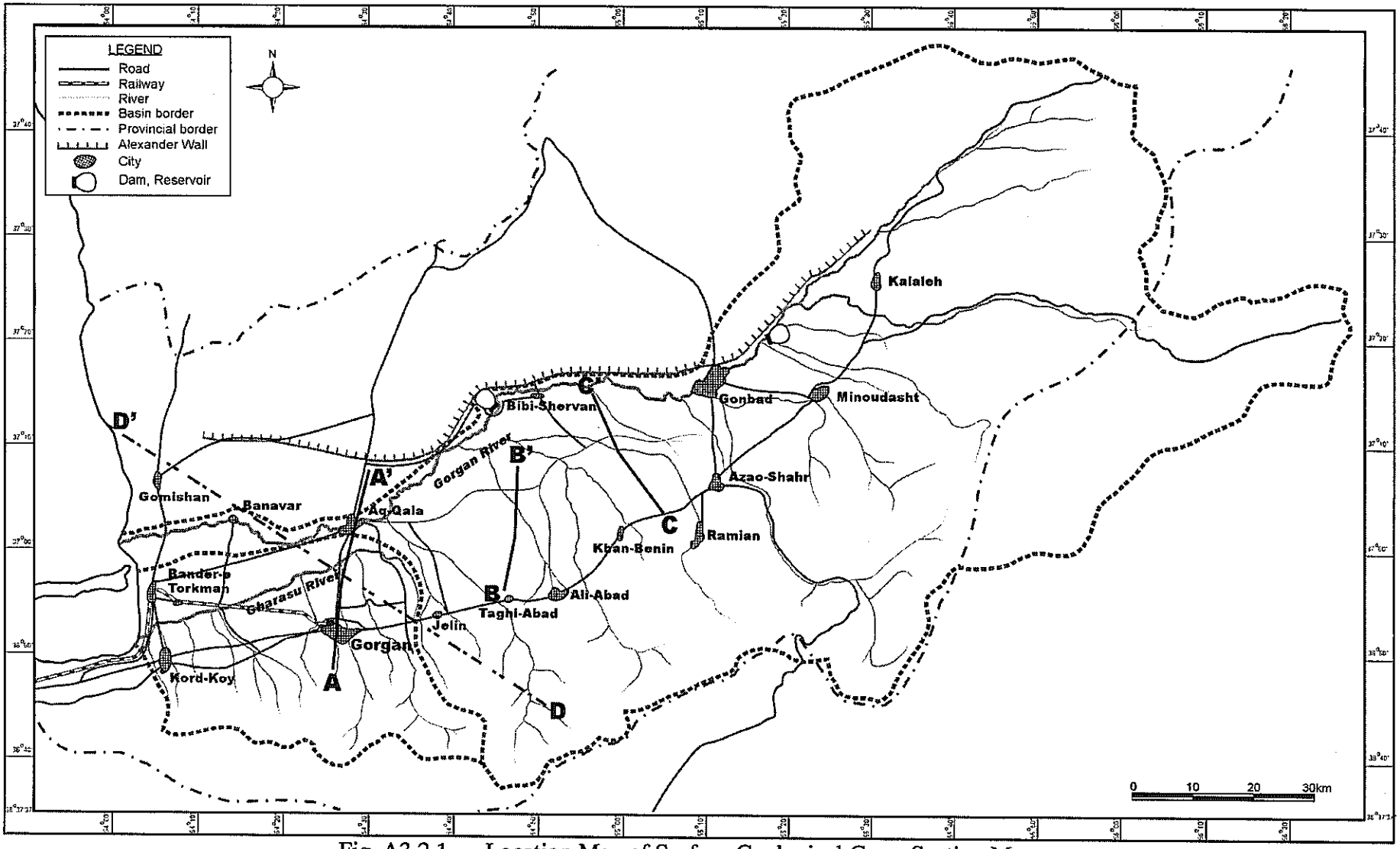
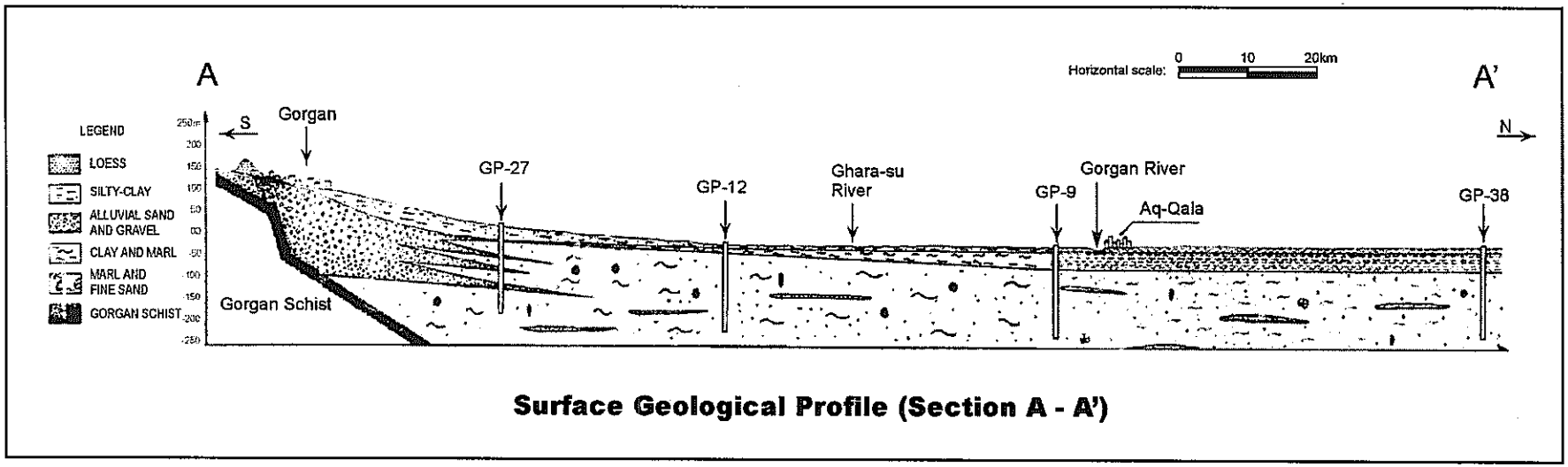


Fig. A3.2.1 Location Map of Surface Geological Cross Section Maps



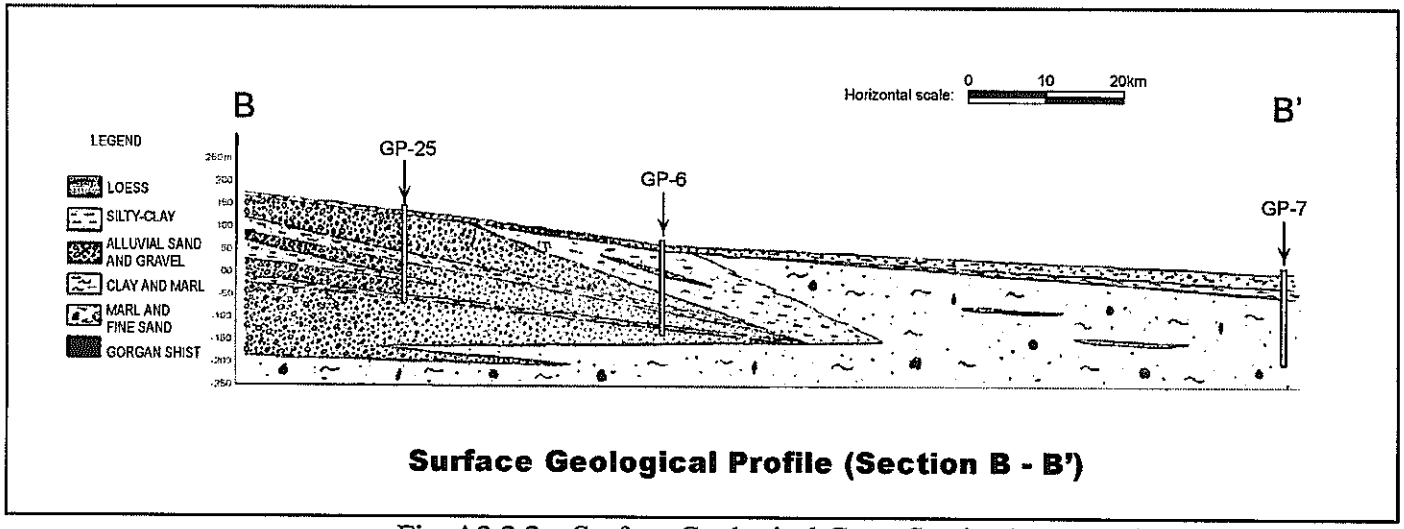
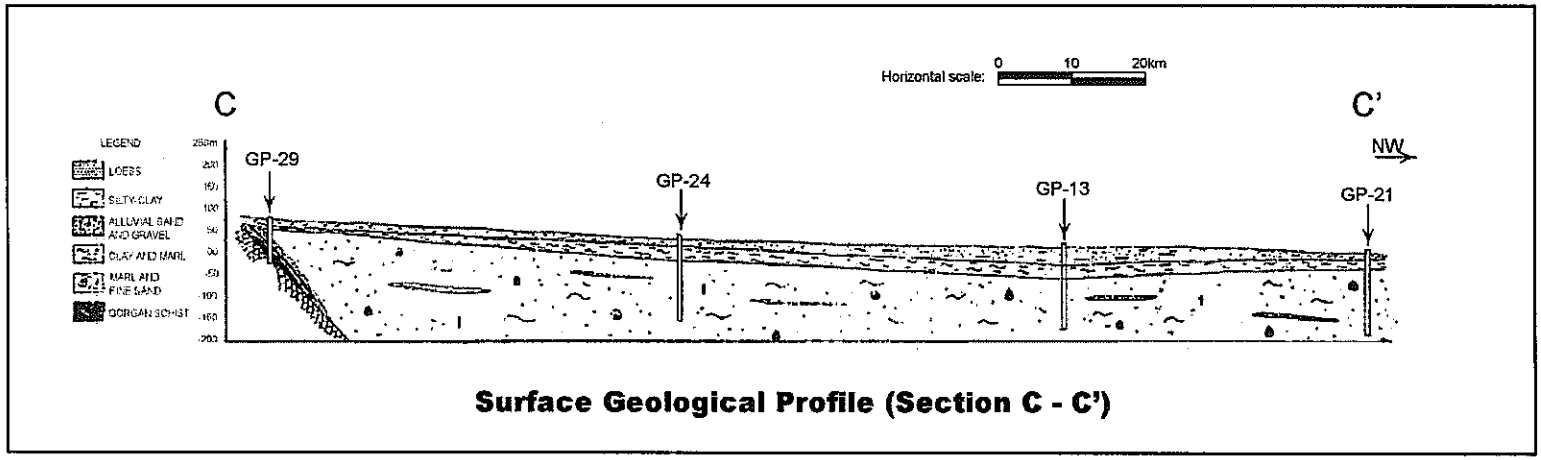
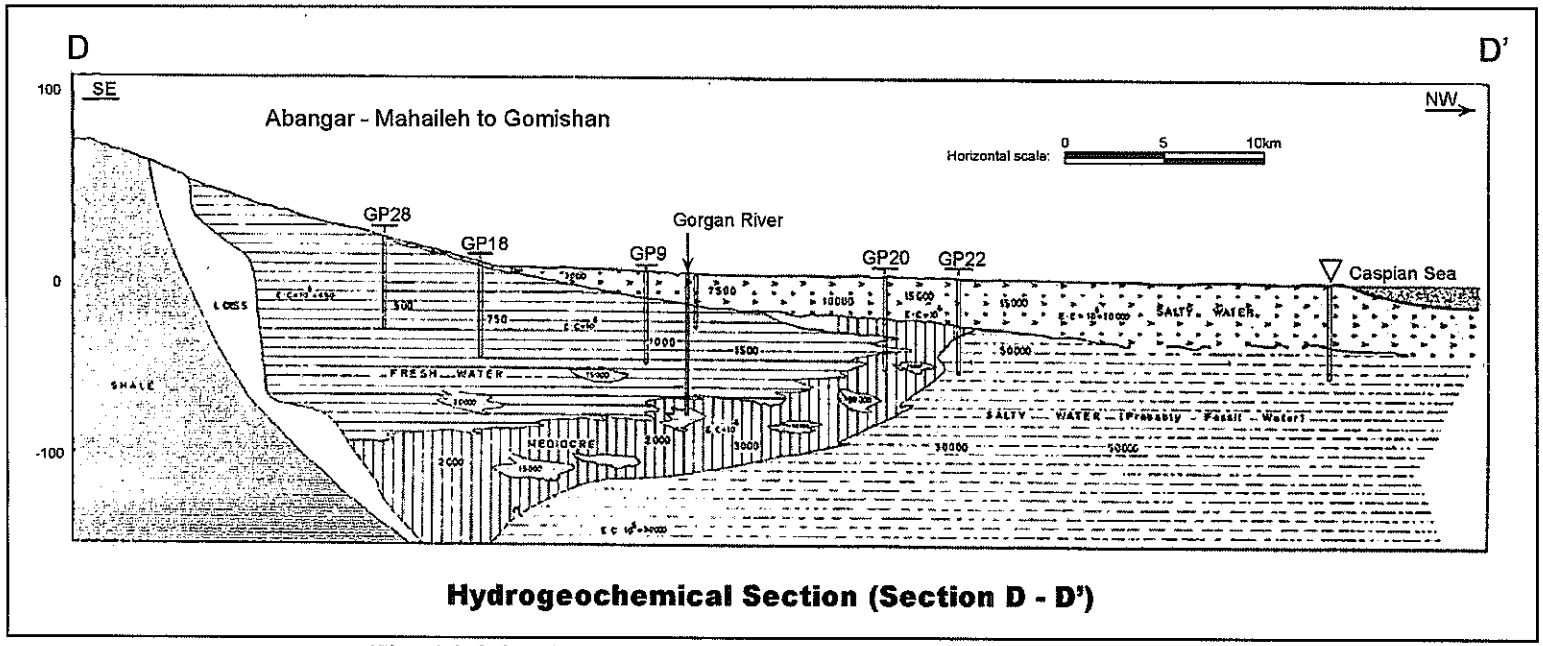


Fig. A3.2.2 Surface Geological Cross Section Maps of the Study Area (1)



Surface Geological Profile (Section C - C')



Hydrogeochemical Section (Section D - D')

Fig. A3.2.2 Surface Geological Cross Section Maps of the Study Area (2)

A3.3 Soil Survey and Mapping

In Iran, soil survey and land evaluation studies are carried out by the Soil and Water Research Institute (SWRI) associated with Agriculture Research, Education and Extension Organization (AREEO) of the Ministry of Agriculture. SWRI has been involved in mapping of the soils of Iran for about 50 years and about 20 million ha[1] of land areas have been surveyed until now at three levels (reconnaissance, semi-detailed and detailed). SWRI is responsible for producing the National Soil Maps at 1:2,500,000 scale (Dewan and Famouri, 1964) and at 1:1,000,000 scale in digital format (Banaei, et.al, under press).

During the past 50 years period, the surveys have been carried at three levels in the Golestan province and semi-detailed soil and land classification maps were prepared by SWRI, in 1972. These maps of the province, which are available at a scale of 1:50,000 were prepared from the field maps of 1:20,000 and aerial photographs. The surveys were also carried out after 1972 and the information was compiled into three soil resource and land capability maps of 1:250,000 scale in 1996 for the Mazandaran province, which included Golestan province.

A3.4 Soil Resource and Land Capability of Golestan province

A3.4.1 Soil Resource and Land Capability Map of Golestan province

The soil resource and land capability map of Golestan province is shown in Fig.A3.4.1. As shown in the map, the province can be broadly divided into the land types as shown below:

1. Elbourz Mountainous area at the southern part of the province
2. Hilly areas mostly distributed at the northeastern part
3. Plateaus and upper terraces distributed in the northwest and eastern parts and a small portion of southern parts
4. Piedmont plains distributed along the middle of the province
5. Sedimentary and alluvial plains along the Gorgan river and Atrak river
6. Lowlands and saline areas at the western part
7. Other areas including small areas of fan shaped colluvium at the upper part of piedmont plain.

A detailed description of each of the above unit including soil characteristics, natural vegetation, climate, major limitations, land capability and the required development are briefly described in the Table A3.4.1.

[1] Moameni, A, Production Capacity of Land Resources of Iran, SWRI, MOA, Dec. 2000.

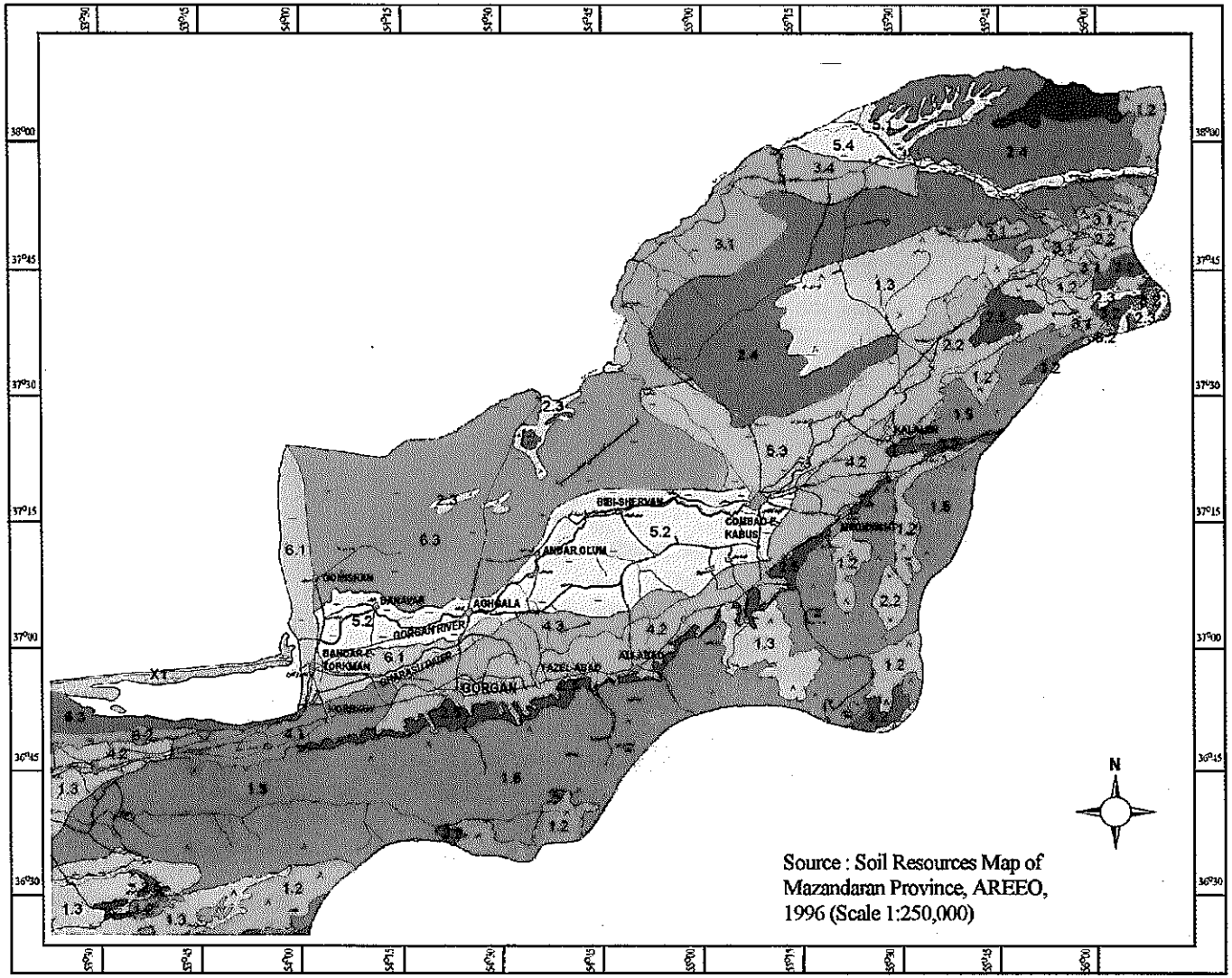


Fig. A3.4.1 Soil Resource and Land Classification Map of Golestan Province

Table 3.4.1 Description of the Soil Resources and Land Capability Map

Legend	Land Type	Land Characteristics	Soil Characteristics and FAO Classification	Natural Vegetation and Actual Land Use	Climate and Other features	Major Limitations	Land Capability	Required Development	Land Capability after Development
1.2	Mountains	Relatively high mountainous area composed of lime sand stones; gradient 10 to 90%; Altitude 2000-2600m above msl.	Monotonic superficial soil cover and little rock protrusions; Lithic Leptosols; Calcaric Regosols	Little to middle pasture vegetation and trees and shrubs. Dry farming of cereals in some areas.	Cold semi humid climate; Deep soils are developed in some parts; Calcaric Cambisol	High slope and Erosion problem ; Limitation of soil depth	Medium capability for seasonal pasture	Consideration of Pasture control and management; Soil conservation	Relatively proper capability for controlled pasture.
1.3		Low to relatively high forest mountainous area of Elbourz chains composed of sand, clay, conglomerate and limestones; gradient 30 to 60%; Altitude -900m above msl.	Acidic semi deep soils with heavy texture; Dystric Cambisols and Haplic Kastanozems	Relatively condensed forest; Exploiting forest wood charcoal; Small citrus orchards and dry farming in some parts.	Cold semi humid climate; Cold winter; include low heights of Elbourz.	High slope and Erosion problem ; Very cold winters	Medium capability for forestry	Preservation of cattle crazing and wood cutting; reclamation of forest	Relatively proper capability for controlled pasture.
1.4		Low to relatively high mountainous, cut and eroded composed of calcaric saline and sand marls; gradient 40 to 70%; Altitude -1000 to 2600m above msl.	Acidic semi deep soils with heavy texture upon calcaric-saline marls; Gypsic Regosols	Arid lands; low vegetation cover in some parts; random pasture area.	Cold and dry climate ; High erosion and prolonged valleys	Very high slope and high erosion ; weakness of parent material	Arid lands	Conservation of watershed basin	Conserved region in view of watershed management
2.3	Hills	Low hills composed of limestone and relatively petrified conglomerate; Gradient 40-45%; Altitude 1000 to 1450m above msl	Generally superficial soils with gravel and middle to heavy texture; Calcaric Regosols	Very low vegetation cover; random pasture areas	Very extreme erosion in some parts and a lot of rock protrusions	High slope and limitation of soil depth; extreme erosion	Arid lands	Conservation of watershed basin	Conserved region in view of watershed management
2.5		Low hills composed of conglomerate formation, sandstone and loess formation; Gradient 20-30%; Altitude 100 to 400m above msl	Semi-deep to deep soil cover with heavy texture; Haplic Kastanozems	Often include medium forest cover; Dry farming and cereals cultivation in some parts.	Very cold winters; Wood cutting in some parts	High slope ; lateral and land slide erosion	Medium capability for forestry	Conservation of forest and prevention of wood cutting; soil conservation and prevention of erosion	Relatively proper capability for forestry.
3.1		Upper terrace and relief plateau composed of lime and loess formations; gradient 5 to 8%; altitude 150 to 400m above msl.	Deep soil cover with heavy texture and condensation of calcaric materials; Haplic Calcisols, Calcaric Regosols	Low vegetation cover; Dry farming of cereals and sunflower in some parts.	Temperate winters; extreme erosion some parts; and medium salinity in some parts	Erosion due to slope and uneven relief	Medium capability for dry farming and in some parts medium capability for seasonal pasture	Pasture management; soil conservation and prevent erosion; management for retention of soil moisture	Medium capability for controlled pasture.

Legend	Land Type	Land Characteristics	Soil Characteristics and FAO Classification	Natural Vegetation and Actual Land Use	Climate and Other features	Major Limitations	Land Capability	Required Development	Land Capability after Development
3.2	Plateau and Upper Terrace	Old colluvium with low to medium relief laid upon rock and gravel; gradient 5 to 8%; altitude 150 to 400m above msl.	Superficial soils with gravel and without profile development; Calcaric Regosols	Medium vegetation cover; Seasonal pasture	Temperate winters; Land surface is covered by gravel in some parts.	Limitation of soil depth; gravel ; inundation risk	Low capability for seasonal pasture	Pasture control and consideration of pasture management	Medium capability for controlled pasture.
3.4		Cut and eroded plateau composed of marl and loess materials; gradient 8 to 10%; lateral gradient 30 to 35%	Deep soil cover composed of loess, marl and calcaric materials without profile development; Calcaric Regosols	Low cover of pasture; Random pasture	Extreme erosion is some parts; low hills in some parts	Erosion due to slope and uneven relief	Low capability for seasonal pasture; arid lands	Conservation of watershed basin	Conserved region in view of watershed management
4.1	Piedmont Plains	Piedmont plains (Kordkuy) with slight slope, with very little relief and deep soil cover; gradient 1 to 2%; altitude 20 to 50m above msl.	Deep soils with very heavy to heavy texture and profile development; Calcaric and Eutric Cambisol	Generally under cotton and dry wheat cultures	Poor condition of drainage in some parts; Gleyic Cambisols; remaining of old forests in some parts.	Inundation risk; high water table in some parts; salinity in some parts.	Good capability for irrigated cultivation	Drainage; prevention of inundation ; land improvement and leaching	Very good capability for irrigated cultivation
4.2		Piedmont plains (Gorgan) with relatively flat alluvials of river, slight and regular slope - 2 to 3%; altitude 20 to 150m above msl.	Deep clay soils and in alluvial parts with clay, gravel and loamy soils; Calcic Kastanozems, Chromic Luvisols, Eutric Cambisols, Calcaric Fluvisols	Mostly under cotton, wheat, orchard, tobacco and rice cultivation; Rest of the old forests in some parts.	Temperate winter; Repeatedly exposed to flood; upper parts alluvial with high gravel.	Inundation risk; high water table in some parts	Good capability for annual and perennial irrigated cultivation	Prevention of inundation ; Drainage and improvement of soil texture	Very good capability for annual and perennial irrigated cultivation
4.3		Piedmont plains (Torang Tappeh) and land with relatively flat alluvials of river, slight and regular slope - at most 1%; altitude 10 to 60m above msl.	Deep soils with heavy to heavy texture and rice field with heavy texture; Dystric Cambisols, Gleyic Cambisols, Humic Cambisols	Mostly under irrigated cultivation; Rice cultivation and citrus orchard	Temperate winter; exposed to flood.	Inundation risk; salinity in small quantity in some parts	Good capability for annual and perennial irrigated cultivation and citrus orchards	Prevention of inundation ; Drainage and improvement of soil texture	Very good capability for annual and perennial irrigated cultivation; citrus orchards
5.1	Sedimen-tary and Alluvial Plains	Alluvial plains and lands of river borders, sedimentary and alluvial plains, gradient less than 1%; altitude-20m above msl.	Deep soils with moderate to heavy texture wihtout profile development; Calcaric Fluvisols and Calcaric Cambisols	Generally under cotton, maize, soybean and citrus orchards and rice cultivation	Temperate winter; sometimes cotton is irrigated.	Inundation risk	Good capability for annual and perennial irrigated cultivation and citrus orchards	Prevention of inundation ; Irrigation system	Very good capability for irrigated cultivation; citrus orchards

Legend	Land Type	Land Characteristics	Soil Characteristics and FAO Classification	Natural Vegetation and Actual Land Use	Climate and Other features	Major Limitations	Land Capability	Required Development	Land Capability after Development
5.2		Middle and downstream sedimentary plains of Gorgan river, mostly flat, gradient less than 1%; altitude upto 80m above msl.	Deep soils with moderate to heavy texture with middle to high salinity; Haplic solonchaks and Gleyic solonchaks	Generally under wheat, cotton and sunflower cultivation	Temperate winter; sometimes cotton is irrigated.	Inundation risk; salinity; poor condition of drainage	Relatively good capability for annual and perennial irrigated cultivation	Land improvement and leaching and construction of drainage system	Good capability for irrigated cultivation
5.3		Upstream sedimentary plains of Gorgan river in north of Gonbad region with unevenness, mostly flat, gradient 2-3%; altitude 30-100 m above msl.	Deep soils with moderate to heavy texture with low to medium salinity; Calcaric Fluvisols and Haplic Solonchaks	Generally pasture and dryland farming of wheat cultivation	Temperateto a little dry winter; Very deep cuts are created in some parts.	Inundation risk; salinity in some parts; erosion in some parts	Pasture in north of Gonbad	Local leveling and prevention of inundation	Good capability for irrigated cultivation
5.4		Alluvial plains of Atrak river in Tehat plain with a lots of cut and relief, gradient 1-2%; altitude - 100 m above msl.	Deep soils with light to medium texture with high to very high salinity; Haplic Solonchaks	Seasonal pasture areas	Very Temperate winter; It is dry about 8 months of the year	Very high salinity	Low capability for pasture	Land improvement and leaching and construction of drainage system; Improvement of soil texture	Medium capability for irrigated cultivated after improvement works.
6.1	Low land and Saline Area	Lowlands nearly flat and little concave with coast sands; altitude 15 to 25m above msl.	Deep soils with light to medium texture with high salinity; Haplic Solonchaks, Calcaric Arenosols	Vegetation of saline and swampy region; Arid lands, small rice fields in some parts	Temperate winter; Swamps in some parts	Very high salinity; Poor condition of drainage and swampy state	Arid lands	More studies on drainage and land improvement	Land capability need to be determined after further studies
6.3		Lowlands of Atrak river basin and inter-valley flood water plains nearly flat and sometimes gradient of 0.5%	Deep soils with medium to heavy texture with a high salinity and very saline groundwater; Gleyic Solonchaks, Mollic Gleysols and Salic Fluvisols	Generally under irrigated cultivation; Swampy areas in some parts	Temperate winter; Relatively a lot of improvement operations are carried out in these areas.	Salinity; Poor condition of drainage	Medium capability for agriculture	Relatively a lot of improvement operations are carried out in these areas.	Relatively good capability for irrigated cultivation
8.2	Fan shaped colluvium with gravel	Fan shaped colluvium and upper parts of piedmont plains ; gradient 1 to 2%	Semi-deep soils with gravel with medium to heavy texture upon gravel and calcaric materials; Calcaric Regosols	Low cover of pasture	Orchards in some areas irrigated cultivation in some parts	A lot of gravel; limitation of soil depth	Medium capability for pasture; relatively good capability for tree planting in some parts	Consideration of Pasture control and management; drainage system	Relatively good capability for controlled pasture; good capability for tree planting
X1	Other areas	Low sand hills and sandy coasts with low to middle reliefs in some parts.	Deep sandy soils with medium to light texture; Calcaric Aeronosols	Recreational place; citrus orchards in some parts; wild pomegranate and shrubs in scattered areas.	Moderate winter	Relief; light texture; water logging	Good capability for recreational places.	Prevention of sea advancement; providing recreational facilities; prevention of inundation	Very good capability for recreational places.

Note : The table is prepared based on the legend of the Soil Resources and Land Capability Map, AREEO, 1996.

A3.4.2 Major Soils of the Province

The major soils of the Province according to FAO (1988) classification, the corresponding USDA classification and their main characteristics are as follows.

Major Soils of the Province

FAO Classification	Main Characteristics**	Equivalent USDA Classification
Eutric, Dystric Calcaric, Gleyic, and Humic Cambisol	These are the soils conditioned by their limited age and represent the soils, which were changed of their color, structure and consistency resulting from weathering in situ. They are characterized by slight or moderate weathering of the parent material and by absence of appreciable amount of org. matter, aluminium or iron compounds. These soils may be Eutric (fertile), Dystric (infertile), Humic (rich in organic matter), and Gleyic (excess of water). Cambisols make good agriculture lands depending on the relief and climate.	Eutropepts, Dystropepts, Xerochrepts Eutrochrepts, and Humitropepts
Calcaric and Salic Fluvisols	These soils are conditioned by the relief and are developed in recent fluvial or marine deposits, particularly in periodically flooded places. Most fluvisols are fertile and are on flat lands. It may be Calcaric (accumulation of calcium carbonate) or Salic. Fluvisols are very productive for dryland crops and rice.	Xerofluvents
Mollic Gleysols	These are the soils influenced by groundwater. The formation of gleysols is conditioned by water logging at shallow depth for some time of the year. Gleysols occur in association with Fluvisols and Cambisols. Mollic gley soils represent the soils of good surface structure. Agriculture potential depends on flooding time and drainage.	Calcixerolls / Haploaquolls
Haplic and Gleyic Solonchaks	These are the saline soils conditioned by limited leaching, low rainfall and high evaporation. High salt accumulation limits plant growth to salt tolerant crops, and limits growth because nutrients are less available. These soils can not be used for normal cropping unless the salts are leached. They may be Haplic (soils with simple horizon sequence) or Gleyic (excess of water). The high accumulation limits plant growth to salt tolerant crops.	Torriorthents, Calciorthids
Haplic and Calcic Kastanozems	These are soils conditioned by a steppe environment in a drier and warmer areas. Downward percolation leaches nutrients from top soil and lime (and sometimes gypsum) accumulates in the subsoil. The main constraint of these soils is the dry climate. They are also susceptible to erosion and sometimes suffer from	Haplustolls, Calcixerolls

FAO Classification	Main Characteristics**	Equivalent USDA Classification
	high sodicity. They may be Haplic (soils with simple, normal horizon sequence) or Calcic (strong accumulation of calcium carbonate). Irrigation is needed to produce arable crops and grazing is an important land use of these soils.	
Calcaric and Gypsic Regosols	These are soils of eroding landscape and have a morphology determined by type of parent material and climate. In dry climate, the surface horizon is thin and low in organic matter. They may be Calcaric (strong accumulation of calcium carbonate) or Gypsic (presence of gypsum). Landuse and management depend on climate and the relief. In the warmer areas, these soils can be used for dry farming, but often need supplementary irrigation.	Xerorthents Pssamments
Lithic Leptosols	These are soils of eroding landscape and are characterized by their shallow depth (less than 30cm of soil cover hard rock) or by high gravel content. The limited soil volume makes them subject to drought and water logging. Most of the soils remain under natural vegetation and have a potential for grazing and forestry.	Lithic subgroup
Haplic Calcisols	These are the soils conditioned by limited leaching. The most prominent feature of these soils is the translocation of CaCO3 from the surface horizon to some depth. They are well drained and fertile soils, but high calcium is not favorable for many crop, which also results in iron and zinc deficiency. Calcisols are mainly used for grazing, but may yield well when carefully irrigated for fodder crops, cotton or sunflower, amongst others.	Caciustepts
Chromic Luvisols	Soils conditioned by pronounced movement of clay from surface to some depth. They are in general fertile soils and their physical characteristics are favorable. Luvisols are suitable for agriculture incl. grains, sugarbeet, fodder crops in flat areas. On sloping lands, they are used for orchard.	Haploxeralfs
Calcaric Arenosols	These are the soils developed in sands. Aeronosols are defined by their sandy particle size and by the absence any significant soil profile development. These soils are very permeable and storage of available water is low. Inherent soil fertility is also low, but they are easy to till and tend to form a dry surface quickly, which protects soil moisture from evaporation. In semi-arid climates, dry farming is possible, while high yields are possible with irrigation.	Pssamments

** - (Source: World Soil Resources, FAO 1991; World reference base for Soil Resources, FAO 1998)

A3.5 Soils of the Study Area

A3.5.1 Soil Survey Carried Out in the Study Area

Soil survey is carried out during the first field survey as mentioned below:

1) Soil profile survey and sampling – 11 locations (Fig. A3.5.1)
2) Soil sampling by auger – 20 locations by grid sampling (Fig. A3.5.2)

In both the cases, 3 samples were collected at each location and detailed soil analyses were carried out in the laboratory. The results of the soil analysis for the 11 profile locations and 20 auger locations are shown in Tables A3.5.1 and A3.5.2 respectively. Interpretation of soil analysis in the Golestan province is shown in Table A3.5.3 and the fertilizer recommendation is normally made based on this interpretation. The results of the physical properties including hydraulic conductivity, infiltration rate, and other parameters including field capacity, wilting point and plant available water are shown in Table A3.5.4, A3.5.5 and A3.5.6 respectively. The results of the soil profile examination is shown in Table A3.5.7 at the end of this chapter.

A3.5.2 Characteristics of the Soils of the Study Area

Based on the results of the soil survey, field survey, and the other information collected, the characteristics of the soils of the Study Area are described below.

As shown in Figure A3.5.3, the Study Area can be broadly divided into the 6 land units of 4.1, 4.2, 4.3, 5.2, 6.1 and 6.3 and the characteristics of each land unit is different based on the geology, climate and other factors. The discussion of soil characteristics is made based on these five land units. Soil Texture, Salinity and Alkalinity of the Study Area are shown in Fig.3.5.4 to 6 respectively.

1) Kordkuy land unit (4.1) of Piedmont plains, which occupies about 9.5% of the Study Area is located close to the Caspian Sea, at the foot of the mountainous range. The area is flat with a deep soil cover and a gradient of 1 to 2%. The altitude varies from 20 to 50m above msl.

In accordance with the FAO soil classification, these soils are classified as Calcaric and Eutric Cambisol (USDA: Xerochrepts, Eutropepts) and these are the soils conditioned by their limited age and represent the soils, which were changed of their color, structure and consistency resulting from weathering in situ. They are characterized by slight or moderate weathering of the parent material.

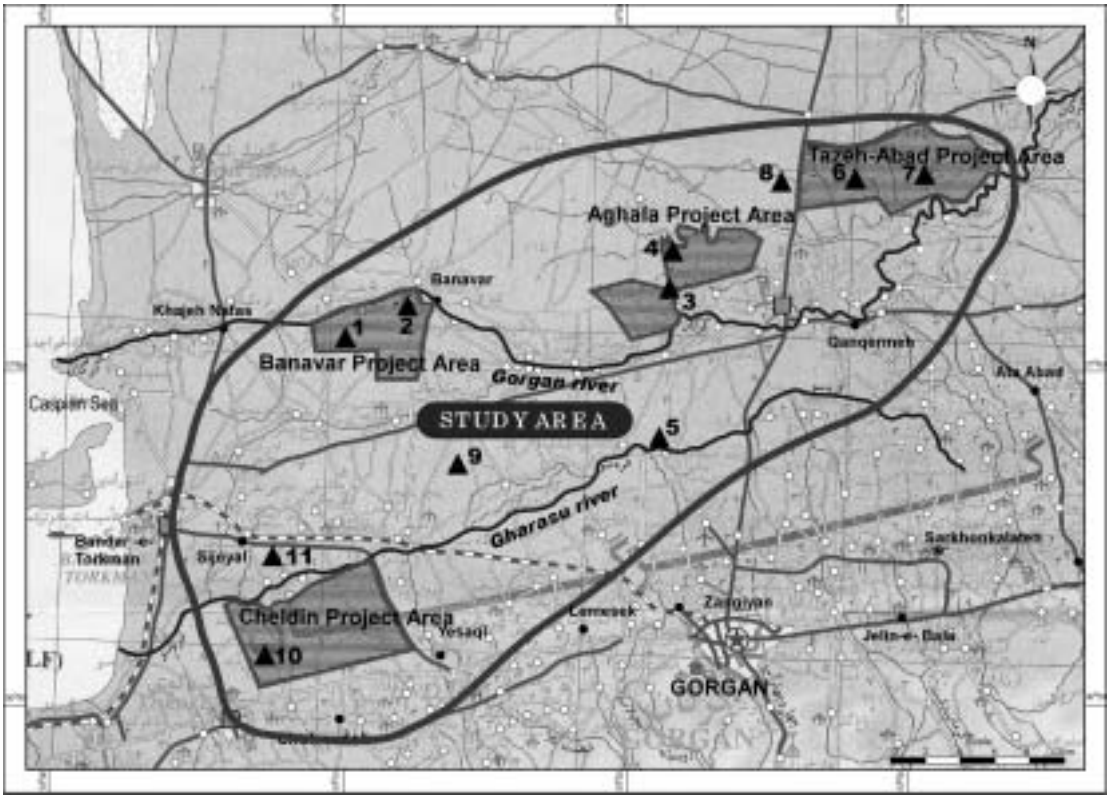


Fig.A-3.5.1 Sampling Locations of the Soil Profiles

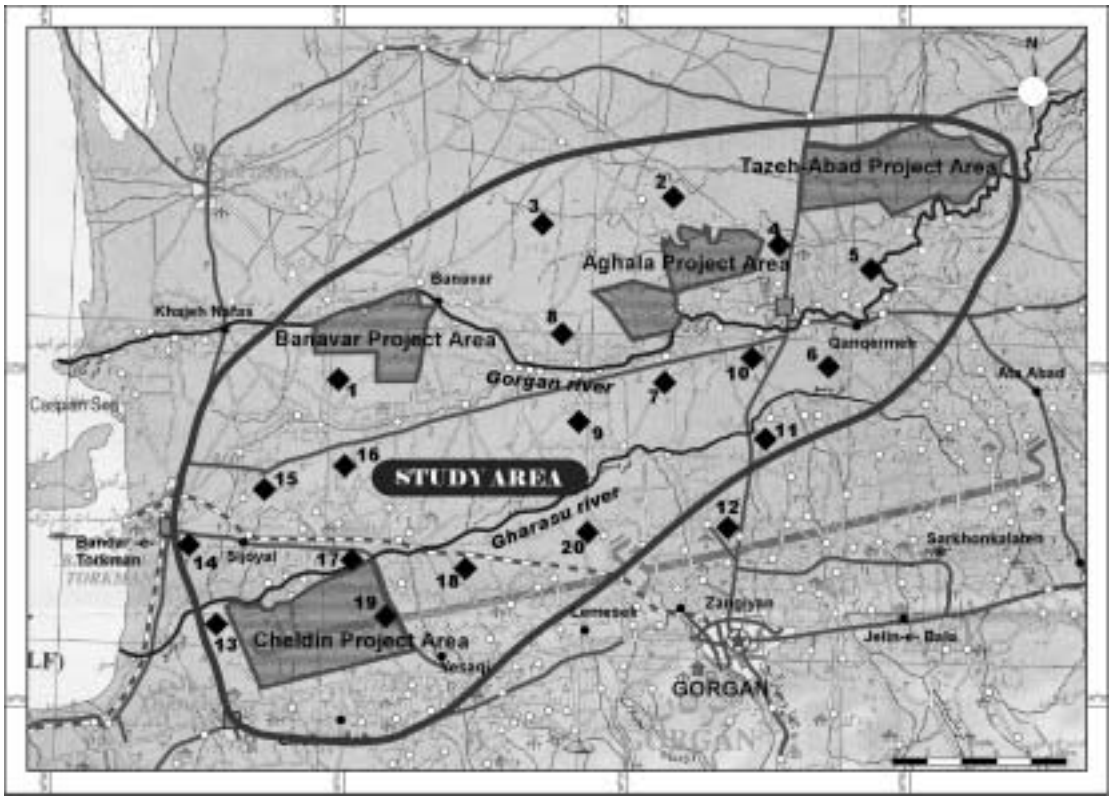


Fig.A-3.5.2 Sampling Locations of the Auger Sampling

Table A3.5.1 Results of Soil Analysis of Samples from the Study Area (11 Profile Samples)

Profile No.	Depth	pH	EC	CEC	SAR	CaCO3	O.C	Total N	P (Ava)	K (Ava)	NO3- N	NH4+ N	Ex. Ca	Ex. Mg	Fe (Ava)	Zn (Ava)	Cu (Ava)	Mn (Ava)
	cm		mS/cm	me/100g		%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1	0-18	7.7	23.2	13.5	24.8	18.0	0.70	0.07	5.0	180	11.2	2.1	4,700	580	5.0	0.8	1.5	1.9
	18-42	7.7	21.0	8.5	21.0	18.5	0.38	0.03	3.5	60	9.8	2.8	2,440	380	5.4	0.8	1.7	1.6
	42-80	7.9	10.7	6.5	15.3	26.5	0.32	0.02	3.0	30	4.2	2.1	1,580	200	7.9	0.3	0.7	2.6
2	0-25	7.7	11.6	13.5	14.6	16.5	0.67	0.07	5.5	160	9.1	2.1	1,880	360	3.3	0.4	1.2	2.3
	25-50	7.8	12.9	13.0	17.7	7.0	0.36	0.04	4.0	80	2.1	2.8	2,060	380	6.1	0.3	1.1	1.9
	50-90	7.9	14.2	7.5	18.2	29.5	0.23	0.03	3.0	60	2.1	2.1	1,580	240	5.3	0.5	0.9	2.3
3	0-22	7.9	13.9	24.5	24.0	14.0	0.94	0.10	7.7	28	2.8	2.1	2,180	400	7.5	0.6	2.2	2.5
	22-53	7.7	22.9	10.3	34.1	21.0	0.27	0.03	2.5	80	2.8	1.4	2,460	140	2.2	0.5	1.1	0.7
	53-100	8.1	24.4	6.0	36.8	27.0	0.18	0.01	2.0	40	2.1	2.1	1,400	160	3.5	0.6	0.9	1.2
4	0-20	8.0	13.1	11.7	19.3	15.0	0.74	0.08	2.1	250	6.3	2.1	1,140	200	10.9	0.8	1.7	4.8
	20-40	8.1	23.4	10.3	31.1	15.5	0.47	0.04	4.5	160	3.5	2.8	1,220	220	4.0	0.8	1.3	4.8
	40-100	8.2	28.8	8.7	35.7	16.0	0.32	0.03	4.5	110	2.8	1.4	840	220	5.0	0.6	1.3	1.0
5	0-28	8.0	0.9	14.5	1.5	15.0	1.12	0.10	6.0	310	2.1	2.8	840	80	2.4	0.5	1.1	2.1
	28-48	7.8	3.9	11.5	2.3	18.5	0.43	0.05	2.5	90	7.7	2.1	2,540	220	3.2	0.4	1.1	1.2
	48-100	8.2	9.2	7.5	13.4	18.0	0.22	0.02	2.2	60	1.4	1.4	900	180	2.6	0.2	0.6	0.8
6	0-22	8.0	7.9	14.0	10.9	14.5	0.86	0.09	13.5	460	18.2	1.4	1,020	220	2.6	0.5	1.2	2.2
	22-54	8.0	9.7	12.0	12.6	17.0	0.36	0.04	4.0	300	8.4	1.4	1,440	260	2.3	0.3	1.0	0.6
	54-90	8.1	12.1	12.2	17.3	18.5	0.16	0.03	3.0	160	4.9	2.8	1,040	320	2.2	0.3	0.7	0.4
7	0-23	8.0	7.5	22.0	12.6	12.5	1.33	0.13	6.5	290	10.5	2.8	1,000	340	2.9	0.6	1.7	3.3
	23-70	7.9	12.3	19.6	16.4	18.0	0.47	0.06	2.7	300	2.8	3.5	1,160	400	3.6	0.4	1.4	1.1
	70-100	8.1	9.6	15.0	19.4	22.5	0.18	0.03	3.0	190	2.1	1.4	800	340	3.2	0.5	0.9	0.8
8	0-15	8.1	2.3	21.0	5.1	12.5	1.55	0.15	6.5	360	3.5	2.1	960	220	4.5	0.6	1.7	2.0
	15-45	8.1	8.8	19.6	18.5	20.5	0.43	0.06	3.2	250	2.8	2.8	1,400	380	3.7	0.4	1.3	1.7
	45-120	7.9	12.1	19.6	19.1	15.0	0.16	0.04	4.5	150	2.8	2.1	4,620	380	2.8	0.5	0.6	0.7
9	0-23	7.8	4.3	18.0	6.5	14.5	1.19	0.12	5.5	180	2.8	2.8	1,720	240	4.2	0.4	1.2	2.6
	23-40	7.6	16.4	13.5	19.0	18.0	0.36	0.04	1.5	70	4.2	2.1	1,700	420	4.5	0.8	1.5	1.6
	40-65	7.8	14.3	9.5	17.5	18.5	0.32	0.02	1.5	60	2.1	2.1	1,300	340	5.6	0.9	1.1	1.8
10	0-35	7.9	1.6	28.0	6.6	4.0	1.84	0.16	40.0	250	2.8	2.8	1,620	600	3.5	0.8	5.9	4.2
	35-75	8.3	1.4	20.5	6.2	9.0	1.94	0.16	2.0	90	1.4	1.4	1,400	740	5.5	0.3	1.5	1.3
	75-100	8.3	1.4	23.5	4.9	3.5	0.36	0.04	1.0	130	1.4	1.4	1,020	860	4.9	0.3	1.4	1.2
11	0-25	7.7	4.0	31.0	4.2	21.0	1.58	0.16	8.5	260	1.4	2.8	2,940	620	8.5	0.6	2.0	1.5
	25-40	7.7	5.7	28.0	7.8	17.5	0.76	0.09	4.0	180	4.2	2.1	4,380	620	8.6	0.6	2.4	1.2
	40-100	7.8	7.1	17.5	9.2	22.5	0.28	0.04	2.0	120	2.8	1.4	3,000	460	4.8	0.5	1.4	1.2

Table A3.5.1 Results of Soil Analysis of Samples from the Study Area (11 Profile Samples)

Profile No.	Depth, cm	Cations and Anions, milliequivalents per liter									Ex. Na meq/100g	Sol K meq/lit	%Sand	%Silt	%Clay	Classification
		Na^{+}	Mg^{++}	Ca^{++}	Sum Cation	Cl^{-}	$SO4^{--}$	$HCO3^{-}$	$CO3^{--}$	Sum Anion						
(1)	(2)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)
1	0-18	197.5	78.0	49.0	324.5	228.0	91.8	5.2	0.0	325.0	2.11	1.00	16	62	22	Si-L
	18-42	170.0	82.0	51.0	303.0	206.0	93.8	3.2	0.0	303.0	1.57	0.20	18	72	10	Si-L
	42-80	85.0	24.0	38.0	147.0	91.0	53.2	2.8	0.0	147.0	0.90	0.10	66	30	4	Sa-L
2	0-25	90.0	37.0	39.0	166.0	90.0	73.0	3.0	0.0	166.0	1.70	0.50	10	70	20	Si-L
	25-50	115.0	27.0	57.0	199.0	94.0	102.2	2.8	0.0	199.0	2.40	0.40	6	76	18	Si-L
	50-90	124.0	59.0	34.0	217.0	122.0	90.8	4.2	0.0	217.0	1.80	8.00	34	60	6	Si-L
3	0-22	136.0	24.0	40.0	200.0	103.0	92.8	4.2	0.0	200.0	3.80	0.40	8	48	44	Si-C
	22-53	232.5	51.0	42.0	325.5	220.0	100.8	4.2	0.0	325.0	1.80	0.20	22	54	24	Si-L
	53-100	255.0	50.0	46.0	351.0	230.0	118.6	2.4	0.0	351.0	2.00	0.30	50	44	6	Sa-L
4	0-20	119.0	37.0	39.0	195.0	89.0	100.0	6.0	0.0	195.0	1.60	1.20	16	64	20	Si-L
	20-40	232.5	69.0	43.0	344.5	201.0	141.2	2.8	0.0	345.0	2.10	0.90	18	68	14	Si-L
	40-100	300.0	101.0	40.0	441.0	269.0	167.8	4.0	0.2	441.0	3.47	0.70	18	70	12	Si-L
5	0-28	3.1	4.0	5.0	12.1	8.0	0.0	4.6	0.0	12.6	0.38	0.50	14	70	16	Si-L
	28-48	11.0	21.0	24.0	56.0	42.5	10.1	3.4	0.0	56.0	0.31	0.20	12	72	16	Si-L
	48-100	78.0	38.0	30.0	146.0	21.0	120.0	4.8	0.2	146.0	1.80	0.20	18	74	8	Si-L
6	0-22	62.0	34.0	31.0	127.0	29.0	95.6	2.4	0.0	127.0	2.90	1.00	12	62	26	Si-L
	22-54	82.0	50.0	34.0	166.0	49.0	112.2	4.8	0.0	166.0	1.80	1.20	10	74	16	Si-L
	54-90	110.0	49.0	32.0	191.0	68.0	119.8	3.2	0.0	191.0	2.40	0.50	8	64	28	Si-CL to Si-L
7	0-23	60.0	13.0	32.0	105.0	56.0	45.4	3.6	0.0	105.0	3.70	0.80	10	50	40	Si-C to Si-CL
	23-70	110.0	54.0	36.0	200.0	82.0	115.0	3.0	0.0	200.0	3.10	0.60	8	44	48	Si-C
	70-100	93.0	25.0	21.0	139.0	68.0	68.2	2.8	0.0	139.0	3.10	0.60	6	46	48	Si-CL
8	0-15	16.3	5.5	14.5	36.3	7.0	26.0	3.2	0.0	36.2	1.70	0.30	10	58	32	Si-CL
	15-45	85.0	17.0	25.0	127.0	65.0	57.2	4.8	0.0	127.0	4.20	0.40	8	44	48	Si-C
	45-120	120.0	33.0	46.0	199.0	75.0	121.6	2.4	0.0	199.0	3.50	0.20	10	48	42	Si-C
9	0-23	26.5	9.5	23.5	59.5	26.0	29.6	3.4	0.0	59.0	1.90	0.30	18	58	24	Si-L
	23-40	140.0	55.0	54.0	249.0	146.0	100.0	3.0	0.0	249.0	1.90	0.20	16	72	12	Si-L
	40-65	120.0	54.0	40.0	214.0	116.0	32.2	2.8	0.0	151.0	1.30	0.20	22	68	10	Si-L
10	0-35	13.8	4.0	4.7	22.5	10.3	5.1	7.6	0.0	23.0	1.66	0.15	6	54	40	Si-C to Si-CL
	35-75	11.3	2.0	4.7	18.0	13.0	1.0	3.8	0.2	18.0	1.25	0.10	4	54	42	Si-C
	75-100	10.0	3.6	4.7	18.3	11.7	2.8	3.2	0.3	18.0	2.59	0.10	6	54	40	Si-C to Si-CL
11	0-25	20.0	16.5	30.0	66.5	6.5	53.9	5.6	0.0	66.0	1.60	0.30	8	66	26	Si-L
	25-40	40.0	25.0	28.0	93.0	17.0	72.8	3.2	0.0	93.0	1.50	0.20	6	38	56	C
	40-100	53.0	38.0	28.0	119.0	23.0	93.6	2.4	0.0	119.0	1.40	0.15	4	60	36	Si-CL

Table A3.5.2 Results of Soil Analysis of Samples from the Study Area (Auger Samples)

Loc. No.	Depth	pH	EC	CEC	SAR	CaCO3	O.C	Total N	P (Ava)	K (Ava)	NO3- N	NH4+ N	Ex. Ca	Ex. Mg	Fe (Ava)	Zn (Ava)	Cu (Ava)	Mn (Ava)
	cm		mS/cm	me/100g		%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1	0-30	7.6	4.6	34.0	8.5	6.0	2.22	0.20	21.5	310	2.8	2.8	2,020	460	8.5	0.7	2.6	2.2
	30-60	7.7	9.1	31.0	14.6	9.5	1.23	0.14	8.0	200	2.8	2.8	1,920	540	10.0	0.4	2.8	3.3
	60-90	7.7	11.3	25.0	17.1	16.5	0.63	0.07	6.0	210	2.1	2.8	2,380	520	8.2	0.8	2.1	3.5
2	0-30	7.8	23.1	13.0	29.8	13.5	1.16	0.10	15.5	360	9.1	2.8	1,680	360	2.3	0.7	1.4	1.4
	30-60	7.8	44.3	12.0	49.4	17.0	0.78	0.06	5.0	290	14.0	2.8	1,660	440	3.7	0.7	1.3	1.5
	60-90	7.7	53.7	10.5	57.2	16.5	0.55	0.04	3.2	190	7.7	2.1	1,320	480	5.0	0.7	1.2	1.6
3	0-30	7.7	36.4	16.5	40.2	11.5	1.63	0.14	8.5	270	7.7	3.5	1,720	440	4.6	1.1	1.6	2.7
	30-60	7.5	41.2	13.5	45.6	16.5	0.63	0.05	4.5	150	14.7	2.8	1,360	420	3.3	1.0	1.6	1.5
	60-90	7.6	33.0	14.0	39.4	17.5	0.32	0.04	2.0	130	7.7	2.1	1,760	380	3.7	0.9	1.3	1.1
4	0-30	7.7	15.8	18.5	21.5	15.0	1.90	0.17	12.0	410	5.6	3.5	1,620	300	3.7	2.0	1.6	2.2
	30-60	7.7	37.1	34.0	50.8	17.0	0.89	0.08	6.0	210	3.5	2.8	1,660	420	4.5	1.2	1.6	1.8
	60-90	8.0	48.8	11.0	66.7	18.0	0.32	0.03	4.0	80	1.4	2.8	1,680	440	5.6	0.9	1.6	1.5
5	0-30	7.8	18.6	17.5	26.2	14.0	1.04	0.09	6.5	240	7.7	2.1	3,420	340	4.2	0.7	1.8	1.4
	30-60	7.8	27.9	11.5	40.7	16.0	0.38	0.03	4.0	110	11.9	2.1	2,340	320	3.9	0.7	1.7	1.2
	60-90	8.0	25.5	11.5	40.1	16.5	0.30	0.03	3.5	90	9.8	2.1	2,500	320	4.7	0.9	1.1	1.3
6	0-30	7.9	8.9	12.0	10.9	16.5	0.82	0.07	14.0	580	9.1	2.1	2,820	260	4.3	0.5	1.4	1.4
	30-60	8.0	13.6	9.5	18.4	17.0	0.53	0.04	6.5	560	6.3	2.1	2,860	280	4.3	0.4	1.2	1.3
	60-90	8.0	11.6	8.0	16.1	16.0	0.34	0.03	5.0	530	4.9	1.4	1,800	240	4.2	0.3	1.0	0.9
7	0-30	7.8	23.7	10.2	32.9	16.5	0.57	0.05	12.5	220	8.4	2.1	2,060	340	2.5	0.6	1.2	1.4
	30-60	7.9	22.0	9.5	27.2	16.5	0.42	0.03	10.5	130	11.2	1.4	1,300	360	4.1	0.7	1.3	2.2
	60-90	8.0	32.1	9.5	41.5	15.0	0.34	0.03	5.5	150	6.3	2.8	1,540	320	3.9	0.8	1.5	1.3
8	0-30	7.9	7.2	12.0	9.9	15.0	0.99	0.08	9.5	250	2.1	3.5	1,120	200	4.3	0.9	1.3	3.3
	30-60	7.6	13.0	10.5	14.3	16.0	0.55	0.05	4.5	140	16.1	3.2	1,180	260	3.4	0.5	1.2	1.8
	60-90	7.7	8.9	10.0	9.9	16.5	0.42	0.03	4.5	120	3.5	2.1	1,240	260	5.3	0.2	1.2	2.0
9	0-30	7.6	3.4	20.0	3.8	13.0	1.42	0.03	10.0	330	7.0	4.2	1,720	200	3.3	0.5	1.5	5.1
	30-60	7.6	7.2	20.2	11.7	15.5	0.72	0.08	3.0	130	2.1	2.1	1,600	260	4.8	0.2	1.4	2.9
	60-90	7.6	11.0	14.5	14.6	17.5	0.51	0.05	3.0	80	1.4	2.1	1,700	300	4.2	0.3	1.3	2.5
10	0-30	7.8	3.4	19.0	5.6	14.0	1.43	0.12	9.5	300	2.1	2.8	1,260	240	3.9	0.4	1.5	2.2
	30-60	7.9	4.9	18.0	8.1	15.0	0.86	0.08	4.5	230	3.5	2.1	1,220	300	5.3	0.5	1.8	4.9
	60-90	7.7	7.1	19.0	10.0	15.5	0.55	0.05	2.5	130	2.1	1.4	1,500	360	3.9	0.4	1.4	1.9

Table A3.5.2 Results of Soil Analysis of Samples from the Study Area (Auger Samples)

Loc. No. (1)	Depth cm (2)	pH (3)	EC mS/cm (4)	CEC me/100g (5)	SAR (6)	CaCO3 % (7)	O.C % (8)	Total N % (9)	P (Ava) ppm (10)	K (Ava) ppm (11)	NO3- N ppm (12)	NH4+ N ppm (13)	Ex. Ca ppm (14)	Ex. Mg ppm (15)	Fe (Ava) ppm (16)	Zn (Ava) ppm (17)	Cu (Ava) ppm (18)	Mn (Ava) ppm (19)
11	0-30	7.8	2.0	20.0	2.8	24.5	1.65	0.16	9.5	320	1.4	2.8	1,780	400	6.5	1.0	1.8	3.9
	30-60	7.7	6.9	22.0	7.8	28.0	0.68	0.07	2.5	170	2.1	1.4	2,140	480	5.3	0.5	1.6	2.6
	60-90	7.9	2.3	18.0	2.5	21.5	0.42	0.05	3.0	130	1.4	1.4	4,140	580	4.8	0.5	1.0	2.4
12	0-30	7.8	6.8	20.4	8.2	25.5	1.46	0.13	31.0	330	2.1	2.1	1,420	240	9.5	1.0	2.4	3.9
	30-60	7.9	1.5	37.0	2.0	25.0	1.50	0.13	17.0	320	4.2	2.1	1,400	260	7.8	0.8	2.2	2.8
	60-90	7.7	3.9	19.0	2.4	23.5	1.37	0.11	6.5	180	2.8	2.1	1,700	380	9.3	0.7	2.2	1.5
13	0-30	8.2	3.3	16.0	12.8	8.0	1.12	0.08	19.5	190	2.1	2.1	1,160	200	8.2	0.5	4.1	4.0
	30-60	8.2	1.9	16.0	8.2	4.0	0.80	0.07	4.5	110	1.4	1.4	1,140	200	11.4	0.5	4.0	2.8
	60-90	8.0	2.1	25.0	6.7	3.5	0.82	0.07	3.5	130	0.7	1.4	1,240	380	9.4	0.6	3.7	3.9
14	0-30	8.1	38.2	9.5	40.0	13.5	0.82	0.06	8.0	190	0.7	1.4	2,620	540	5.3	1.0	2.5	1.1
	30-60	8.0	32.1	6.7	34.1	16.5	0.40	0.03	4.5	150	0.7	1.4	1,260	340	7.7	1.0	2.0	1.4
	60-90	7.9	18.4	6.2	22.2	16.0	0.29	0.02	4.0	120	0.7	2.1	1,160	240	6.7	0.8	2.0	1.9
15	0-30	7.4	30.0	12.0	30.1	16.5	0.87	0.08	8.0	210	48.3	2.1	1,580	260	1.7	0.8	1.4	1.5
	30-60	7.6	19.3	8.8	22.6	17.5	0.38	0.03	3.0	80	18.2	2.8	1,160	180	3.3	0.8	1.4	1.2
	60-90	7.8	10.2	6.5	16.7	18.0	0.30	0.02	3.5	60	4.9	1.4	960	140	3.7	0.5	1.3	1.6
16	0-30	8.1	16.4	17.5	23.6	14.0	1.46	0.11	26.0	190	5.6	1.4	2,500	440	3.8	0.9	2.2	1.4
	30-60	8.0	12.6	11.0	17.1	16.5	0.49	0.04	5.0	140	4.2	1.4	1,580	300	2.9	0.5	1.7	1.0
	60-90	8.0	9.2	13.5	12.7	17.0	0.42	0.04	5.0	160	0.7	1.4	2,280	380	4.6	0.5	1.5	1.4
17	0-30	7.9	2.8	23.0	3.3	13.0	1.52	0.15	25.5	520	2.1	2.1	1,500	480	6.8	1.2	2.5	1.8
	30-60	7.8	4.7	23.5	5.9	14.0	1.18	0.12	12.0	360	6.3	0.7	1,480	440	4.3	0.6	1.9	1.0
	60-90	7.9	7.8	11.0	9.6	25.0	0.36	0.04	2.5	120	9.1	0.7	1,900	380	2.4	0.5	1.6	0.6
18	0-30	7.9	5.1	21.0	4.9	14.5	1.39	0.12	7.5	250	2.1	1.4	1,540	320	8.3	1.0	2.6	2.5
	30-60	7.8	2.8	21.0	3.1	14.0	1.08	0.11	2.5	160	8.4	1.4	1,660	480	7.8	0.5	1.9	1.0
	60-90	8.2	11.4	11.5	11.8	21.5	0.34	0.03	2.0	90	10.5	1.4	1,840	560	3.4	0.5	1.5	0.8
19	0-30	8.0	1.9	23.0	3.5	33.0	1.08	0.12	7.5	190	1.4	2.1	1,500	520	19.7	1.0	3.1	1.7
	30-60	7.9	1.6	25.0	3.2	31.5	0.89	0.10	2.5	130	0.7	1.4	1,780	560	15.3	0.6	3.0	1.5
	60-90	7.9	3.4	28.0	6.2	24.5	0.95	0.11	2.0	150	0.7	0.7	1,740	660	13.8	0.8	3.3	1.5
20	0-30	8.0	1.4	25.0	2.8	29.5	1.69	0.16	29.5	320	1.4	3.5	1,580	700	19.3	1.0	3.8	3.9
	30-60	8.0	2.2	23.5	2.9	24.0	0.89	0.09	8.5	220	1.4	1.4	1,460	680	9.0	1.0	2.7	2.0
	60-90	8.1	1.9	19.5	4.1	26.0	0.49	0.06	3.5	160	2.8	1.4	1,300	640	4.9	0.3	2.0	1.3

Table A3.5.2 Results of Soil Analysis of Samples from the Study Area (Auger Samples)

Profile No.	Depth, cm	Cations and Anions, milliequivalents per liter									Ex. Na meq/100 g	Sol K meq/lit	%Sand	%Silt	%Clay	Classification
		Na^{+}	Mg^{++}	Ca^{++}	Sum Cation	Cl^{-}	$SO4^{--}$	$HCO3^{-}$	$CO3^{--}$	Sum Anion						
(1)	(2)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)
1	0-30	35.0	14.0	20.0	69.0	35.5	28.9	4.6	0.0	69.0	2.00	0.40	10	38	52	C
	30-60	73.0	21.0	29.0	123.0	72.0	47.0	4.0	0.0	123.0	3.40	0.30	6	36	58	C
	60-90	95.0	25.0	37.0	157.0	78.0	76.6	2.4	0.0	157.0	3.40	0.40	4	38	58	C
2	0-30	212.5	48.0	54.0	314.5	249.0	61.2	3.8	0.0	314.0	1.90	2.70	14	64	22	Si-L
	30-60	450.0	94.0	72.0	616.0	527.0	86.0	3.0	0.0	616.0	4.10	2.70	12	76	12	Si-L
	60-90	575.0	122.0	80.0	777.0	686.0	87.8	3.2	0.0	777.0	3.00	2.00	12	70	18	Si-L
3	0-30	350.0	62.0	90.0	502.0	424.0	73.6	4.4	0.0	502.0	3.00	1.10	14	64	22	Si-L
	30-60	410.0	84.0	78.0	572.0	496.0	70.0	6.0	0.0	572.0	3.20	0.60	8	68	24	Si-L
	60-90	325.0	68.0	68.0	461.0	382.0	74.8	4.2	0.0	461.0	2.90	0.37	10	84	6	Si
4	0-30	134.0	29.0	49.0	212.0	159.0	4.2	5.8	0.0	169.0	2.40	1.75	6	74	20	Si-L
	30-60	390.0	61.0	57.0	508.0	398.0	105.2	4.8	0.0	508.0	8.10	0.80	10	70	20	Si-L
	60-90	585.0	102.0	52.0	739.0	546.0	189.6	3.4	0.0	739.0	0.30	0.40	8	86	6	Si
5	0-30	170.0	38.0	46.0	254.0	160.0	165.2	5.2	0.0	330.4	3.20	0.70	8	66	26	Si-L
	30-60	287.5	56.0	44.0	387.5	260.0	125.0	3.0	0.0	388.0	3.20	0.50	8	72	20	Si-L
	60-90	275.0	58.0	36.0	369.0	231.0	135.6	2.4	0.0	369.0	2.50	0.40	6	76	18	Si-L
6	0-30	67.0	38.0	38.0	143.0	51.0	88.4	3.6	0.0	143.0	1.10	0.90	12	70	18	Si-L
	30-60	115.0	38.0	40.0	193.0	88.0	102.0	3.0	0.0	193.0	1.10	1.50	12	82	6	Si
	60-90	95.0	28.0	42.0	165.0	63.0	99.4	2.6	0.0	165.0	1.60	1.50	14	74	12	Si-L
7	0-30	237.0	64.0	40.0	341.0	210.0	127.0	4.0	0.0	341.0	2.30	1.50	10	84	6	Si
	30-60	205.0	76.0	38.0	319.0	200.0	115.8	3.2	0.0	319.0	2.50	0.80	18	68	14	Si-L
	60-90	350.0	100.0	42.0	492.0	318.0	171.6	2.4	0.0	492.0	2.00	1.00	12	74	14	Si-L
8	0-30	55.0	30.0	32.0	117.0	32.0	79.4	5.6	0.0	117.0	1.20	1.00	12	72	16	Si-L
	30-60	100.0	56.0	42.0	198.0	108.0	186.4	3.6	0.0	298.0	1.60	0.70	12	74	14	Si-L
	60-90	65.0	52.0	34.0	151.0	54.0	94.2	2.8	0.0	151.0	1.40	0.60	10	76	14	Si-L
9	0-30	16.0	17.0	19.0	52.0	29.0	19.0	4.0	0.0	52.0	1.10	0.60	8	58	34	Si-CL
	30-60	55.0	14.0	30.0	99.0	70.0	26.6	2.4	0.0	99.0	2.10	0.20	4	60	36	Si-CL
	60-90	90.0	44.0	32.0	166.0	98.0	65.2	2.8	0.0	166.0	2.60	0.20	4	70	26	Si-L
10	0-30	21.0	13.0	15.0	49.0	22.0	22.6	4.4	0.0	49.0	1.20	0.40	14	60	26	Si-L
	30-60	33.5	15.0	19.0	67.5	25.0	38.5	4.0	0.0	67.5	1.20	0.30	8	60	32	Si-CL
	60-90	55.0	28.0	32.0	115.0	34.0	78.2	2.8	0.0	115.0	2.10	0.20	8	60	32	Si-CL

Table A3.5.2 Results of Soil Analysis of Samples from the Study Area (Auger Samples)

Profile No.	Depth, cm	Cations and Anions, milliequivalents per liter									Ex. Na meq/100 g	Sol K meq/lit	%Sand	%Silt	%Clay	Classification
		Na^{+}	Mg^{++}	Ca^{++}	Sum Cation	Cl^{-}	$SO4^{--}$	$HCO3^{-}$	$CO3^{--}$	Sum Anion						
(1)	(2)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)
11	0-30	9.5	12.0	11.0	32.5	6.0	22.5	4.0	0.0	32.5	1.50	0.40	8	50	42	Si-C
	30-60	47.5	42.0	32.0	121.5	36.0	82.3	3.2	0.0	121.5	1.00	0.30	6	58	36	Si-CL
	60-90	9.3	14.0	14.0	37.3	11.0	21.1	5.2	0.0	37.3	3.70	0.90	4	46	50	Si-C
12	0-30	48.0	36.0	32.0	116.0	14.0	98.8	3.2	0.0	116.0	1.30	0.20	8	64	28	Si-CL
	30-60	6.3	7.0	13.0	26.3	6.0	14.7	5.6	0.0	26.3	0.90	0.70	6	68	26	Si-L
	60-90	12.5	24.0	29.0	65.5	9.0	53.3	3.2	0.0	65.5	7.70	0.30	8	58	34	Si-CL
13	0-30	30.0	3.0	8.0	41.0	24.0	10.8	6.2	0.2	41.2	2.30	0.20	6	74	20	Si-L
	30-60	16.3	2.0	6.0	24.3	11.0	8.9	4.4	0.2	24.5	2.30	0.10	4	72	24	Si-L
	60-90	16.3	5.0	7.0	28.3	13.0	10.9	4.4	0.0	28.3	2.30	0.10	4	56	40	Si-C to Si-CL
14	0-30	400.0	162.0	38.0	600.0	396.0	199.2	4.8	0.0	600.0	1.60	2.40	14	70	16	Si-L
	30-60	300.0	111.0	44.0	455.0	340.0	110.6	4.4	0.0	455.0	3.00	2.20	22	70	8	Si-L
	60-90	160.0	64.0	40.0	264.0	174.0	86.0	4.0	0.0	264.0	0.80	1.30	20	70	10	Si-L
15	0-30	262.5	58.0	94.0	414.5	338.0	73.3	3.2	0.0	414.5	2.40	1.40	14	70	16	Si-L
	30-60	160.0	50.0	50.0	260.0	200.0	56.8	3.2	0.0	260.0	1.60	0.40	20	68	12	Si-L
	60-90	85.0	34.0	18.0	137.0	88.0	45.4	3.6	0.0	137.0	1.40	0.30	24	66	10	Si-L
16	0-30	160.0	56.0	36.0	252.0	92.0	155.2	4.8	0.0	252.0	3.40	0.90	10	78	12	Si-L
	30-60	115.0	56.0	34.0	205.0	76.0	125.8	3.2	0.0	205.0	2.00	0.40	12	78	10	Si-L
	60-90	75.0	38.0	32.0	145.0	48.0	93.8	3.2	0.0	145.0	2.10	0.30	16	54	30	Si-CL
17	0-30	12.5	14.0	14.0	40.5	7.0	29.1	4.4	0.0	40.5	1.80	1.00	8	52	40	Si-C to Si-CL
	30-60	27.5	18.0	26.0	71.5	24.0	43.9	3.6	0.0	71.5	0.70	0.60	10	48	42	Si-C
	60-90	60.0	52.0	26.0	138.0	24.0	110.0	4.0	0.0	138.0	1.10	0.20	8	62	30	Si-CL
18	0-30	27.5	24.0	38.0	89.5	20.0	65.1	4.4	0.0	89.5	1.00	0.20	8	60	32	Si-CL
	30-60	11.8	9.0	19.0	39.8	10.0	25.0	4.8	0.0	39.8	1.90	0.30	8	58	34	Si-CL
	60-90	87.0	100.0	8.0	195.0	38.0	152.6	4.4	0.2	195.2	1.90	0.20	10	66	24	Si-L
19	0-30	10.0	8.0	8.0	26.0	10.0	11.2	4.8	0.0	26.0	0.80	0.20	6	52	42	Si-C
	30-60	8.8	6.0	9.0	23.8	5.0	14.0	4.8	0.0	23.8	1.30	0.10	4	54	42	Si-C
	60-90	20.5	9.0	13.0	42.5	20.0	17.7	4.8	0.0	42.5	0.60	0.20	6	44	50	Si-C
20	0-30	6.8	4.0	8.0	18.8	6.0	7.6	5.2	0.0	18.8	0.70	0.30	8	46	46	Si-C
	30-60	9.3	8.0	12.0	29.3	10.0	15.3	4.0	0.0	29.3	0.70	0.20	8	42	50	Si-C
	60-90	11.3	7.0	8.0	26.3	9.0	13.3	4.0	0.0	26.3	0.60	0.10	2	46	52	Si-C

Table A3.5.3 Interpretation of Soil Analysis in Golestan Province

Critical Limits of Macronutrients

Level	O.C, %	Total N, %	P (Ava), ppm	K (Ava), ppm
Low	0-1	<0.05	0-5	<120
Medium	1-1.5	0.1-0.150	5-10	120-200
High	1.5-2.0	>0.2	10-20	>200

Critical Limits of Micronutrients

Limit	Micronutrients, ppm				
	Fe	Mn	Zn	Cu	B
Critical	<5	5	<1	0.2	<0.5
Average	10	9	2	0.5	1
High	>25	30	6	>2	>2

Table A3.5.4 Hydraulic Conductivity and Bulk Density

Profile No. (1)	Depth cm (2)	K cm/hr (3)	BD g/cc (4)	Profile No. (1)	Depth cm (2)	K cm/hr (3)	BD g/cc (4)
1	18-42	1.15	1.65	7	23-70	1.50	1.50
	42-80	2.30	1.65		70-100	2.50	1.45
	80-100	1.08	1.55	8	15-45	0.91	1.60
2	25-50	1.55	1.40		45-100	1.50	1.60
	50-90	1.02	1.50	9	23-40	1.54	1.45
	90-110	0.77	1.45		40-65	1.70	1.55
3	22-53	1.13	1.70		65-80	1.30	1.45
	53-100	2.47	1.60		80-100	1.10	1.45
4	20-40	2.30	1.65	10	35-75	1.04	1.55
	40-100	1.69	1.55		75-100	1.33	1.60
	100-120	1.03	1.45	11	25-40	0.66	1.65
5	28-48	1.66	1.35		40-100	0.83	1.65
	48-100	0.78	1.45				
6	22-54	2.19	1.45				
	54-90	1.84	1.40				
	90-120	0.84	1.45				

Classification of Hydraulic Conductivity Values

K, cm/h	Conductivity Class
<0.8	Very slow
0.8-2.0	Slow
2.0-6.0	Moderate
6.0-8.0	Moderately rapid
8.0-12.5	Rapid
>12.5	Very rapid

Table A-3.5.5 Average Infiltration Rate (cm/hr)

Location	Average Infiltration Rate (cm/hr)
Profile No.1	2.90
Profile No. 2	1.53
Profile No. 3	3.80
Profile No. 4	0.70
Profile No. 5	4.50
Profile No. 6	4.27
Profile No. 7	5.30
Profile No. 8	6.33
Profile No. 9	4.55
Profile No. 10	1.55
Profile No. 11	2.30

Infiltration Category

Class	Infiltration Category	I, cm/hr
1	Very slow (non-irrigable)	<0.1
2	Slow	0.1-0.5
3	Moderately Slow	0.5-2.0
4	Moderate	2.0-6.0
5	Moderately Rapid	6.0-12.15
6	Rapid	12.5-25.0
7	Very Rapid	>25.0

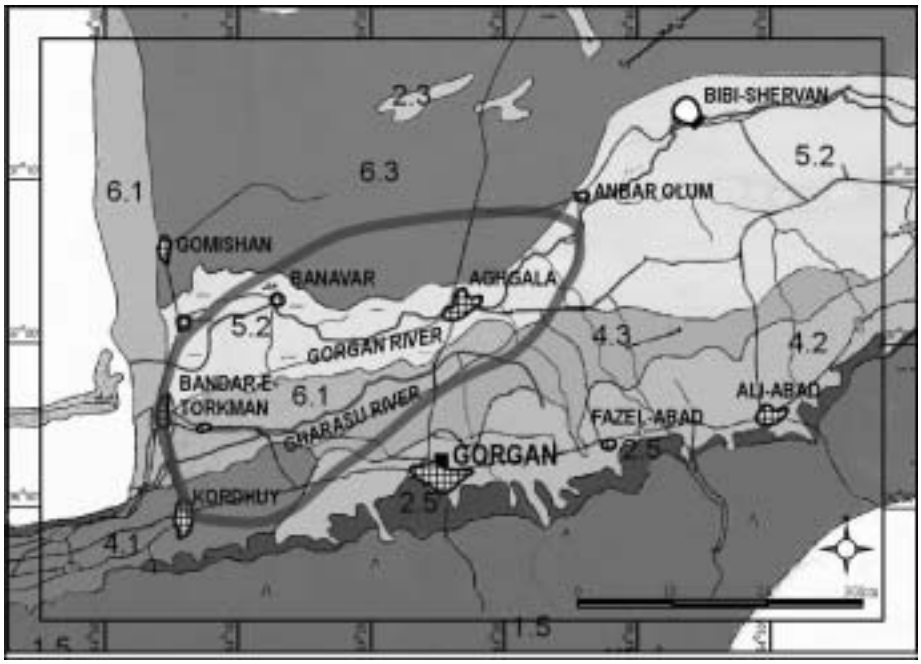
I, cm/hr	Suitability for Surface Irrigation
<0.1	Unsuitable (too slow), but suitable for rice
0.1-0.3	Marginally suitable
0.3-0.7	Suitable; unsuitable for rice
0.7-3.5	Optimum
3.5-65	Suitable
6.5-12.5	Marginally suitable (too rapid)
12.5-25.0	Suitable under special conditions, small basins required

Table A-3.5.6 Field Capacity, Wilting Point and Plant Available Water in the Study Area

Profile No.	Depth	Soil Moisture % by Weight						BD g/cc	Soil Moisture % by Volume						Available Water (%) by vol	Available Water per 30cm depth
		1/3 Bar (FC)	1 Bar	3Bar	5Bar	7 Bar	15Bar (PWP)		1/3 Bar	1 Bar	3Bar	5Bar	7 Bar	15Bar		
	pF	2.52	3.00	3.48	3.70	3.85	4.18		2.52	3.00	3.48	3.70	3.85	4.18		
1	18-42	27.20	20.00	15.10	13.50	13.20	10.60	1.65	44.88	33.00	24.92	22.28	21.78	17.49	27.39	8.22
1	42-80	33.50	19.60	13.00	11.80	11.50	8.40	1.65	55.28	32.34	21.45	19.47	18.98	13.86	41.42	12.42
1	80-100	32.70	21.60	14.70	13.20	13.00	9.50	1.55	50.69	33.48	22.79	20.46	20.15	14.73	35.96	10.79
2	25-50	32.40	16.90	11.60	10.30	10.30	7.70	1.40	45.36	23.66	16.24	14.42	14.42	10.78	34.58	10.37
2	50-90	22.70	9.60	6.80	6.60	6.40	4.50	1.50	34.05	14.40	10.20	9.90	9.60	6.75	27.30	8.19
2	90-110	31.00	13.40	9.10	8.70	8.50	5.00	1.45	44.95	19.43	13.20	12.62	12.33	7.25	37.70	11.31
3	22-53	25.40	20.80	16.50	15.20	14.20	12.10	1.70	43.18	35.36	28.05	25.84	24.14	20.57	22.61	6.78
3	53-100	23.00	12.50	8.70	7.90	6.60	5.50	1.60	36.80	20.00	13.92	12.64	10.56	8.80	28.00	8.40
4	20-40	24.90	14.80	10.40	9.50	8.00	6.60	1.65	41.09	24.42	17.16	15.68	13.20	10.89	30.20	9.06
4	40-100	30.30	25.20	20.10	17.80	16.40	14.00	1.55	46.97	39.06	31.16	27.59	25.42	21.70	25.27	7.58
4	100-12	27.80	14.40	9.20	8.20	7.00	5.80	1.45	40.31	20.88	13.34	11.89	10.15	8.41	31.90	9.57
5	28-48	20.70	10.40	7.90	7.30	6.00	5.30	1.35	27.95	14.04	10.67	9.86	8.10	7.16	20.79	6.24
5	48-100	19.80	8.90	5.40	4.60	4.40	3.80	1.45	28.71	12.91	7.83	6.67	6.38	5.51	23.20	6.96
6	22-54	27.20	19.80	14.80	11.60	11.00	9.60	1.45	39.44	28.71	21.46	16.82	15.95	13.92	25.52	7.66
6	54-90	26.50	14.00	14.00	12.80	11.40	9.50	1.40	37.10	19.60	19.60	17.92	15.96	13.30	23.80	7.14
6	90-120	27.80	16.70	14.00	12.70	11.70	9.80	1.45	40.31	24.22	20.30	18.42	16.97	14.21	26.10	7.83
7	23-70	31.50	24.20	23.30	22.00	20.20	19.30	1.50	47.25	36.30	34.95	33.00	30.30	28.95	18.30	5.49
7	15-45	28.90	24.90	21.40	19.40	17.90	15.50	1.45	41.91	36.11	31.03	28.13	25.96	22.48	19.43	5.83
8	15-45	23.90	21.90	21.30	20.40	19.50	19.00	1.60	38.24	35.04	34.08	32.64	31.20	30.40	7.84	2.35

Table A-3.5.6 Field Capacity, Wilting Point and Plant Available Water in the Study Area

8	45-100	22.20	21.50	21.00	19.50	19.30	15.00	1.60	35.52	34.40	33.60	31.20	30.88	24.00	11.52	3.46
9	23-40	19.10	18.30	17.90	18.30	16.00	14.20	1.45	27.70	26.54	25.96	26.54	23.20	20.59	7.11	2.13
9	40-65	19.00	18.50	17.90	17.70	16.60	16.00	1.55	29.45	28.68	27.75	27.44	25.73	24.80	4.65	1.40
9	65-80	6.00	5.10	4.50	4.30	4.00	4.00	1.45	8.70	7.40	6.53	6.24	5.80	5.80	2.90	0.87
9	80-100	24.20	23.00	22.30	21.10	20.80	20.80	1.45	35.09	33.35	32.34	30.60	30.16	30.16	4.93	1.48
10	35-70	38.00	33.20	26.10	19.30	19.00	14.30	1.55	58.90	51.46	40.46	29.92	29.45	22.17	36.74	11.02
10	75-100	34.00	27.50	23.20	19.60	19.10	18.50	1.60	54.40	44.00	37.12	31.36	30.56	29.60	24.80	7.44
11	25-40	34.00	28.30	24.00	22.50	21.00	20.00	1.65	56.10	46.70	39.60	37.13	34.65	33.00	23.10	6.93
11	40-100	30.40	20.90	14.50	11.40	10.80	9.60	1.65	50.16	34.49	23.93	18.81	17.82	15.84	34.32	10.30



Legend

4.1 Kordkuy landunit of Piedmont plains

4.2 Gorgan land unit of Piedmont plains

4.3 Torang Tappeh land unit of Piedmont plains

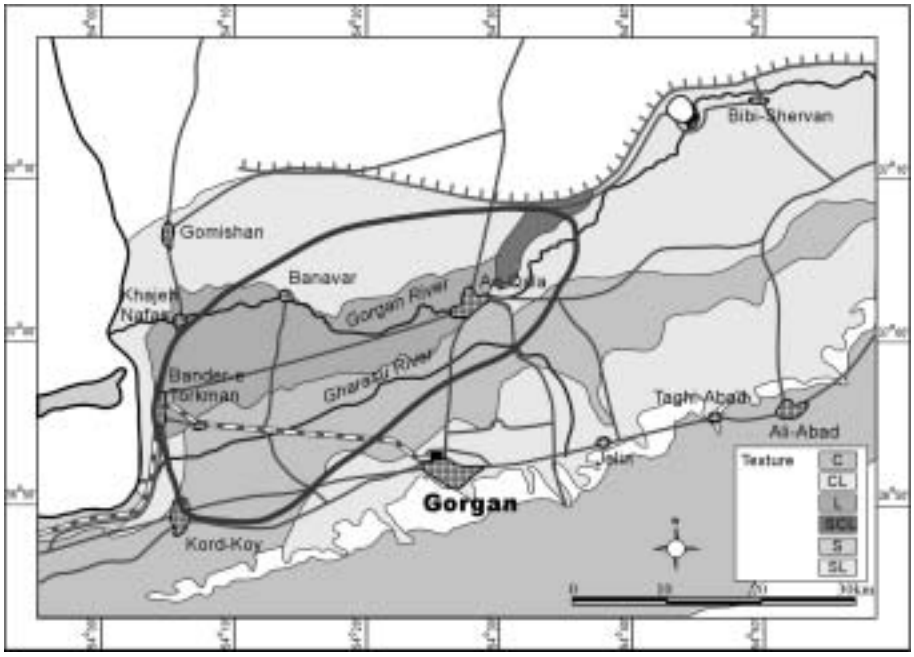
5.2 Sedimentary plains of Gorgan river

6.1 Low lands and Saline Area

6.3 Low lands of Gomishan Area

Fig.A3.5.3 Soil Resources and Land Classification of the Study Area

(Source : Map of Soil Resources and Land Classification, AREEO, MOA, 1996)



Legend

C - Clay

CL – Clay Loam

SCL – Sandy Clay Loam

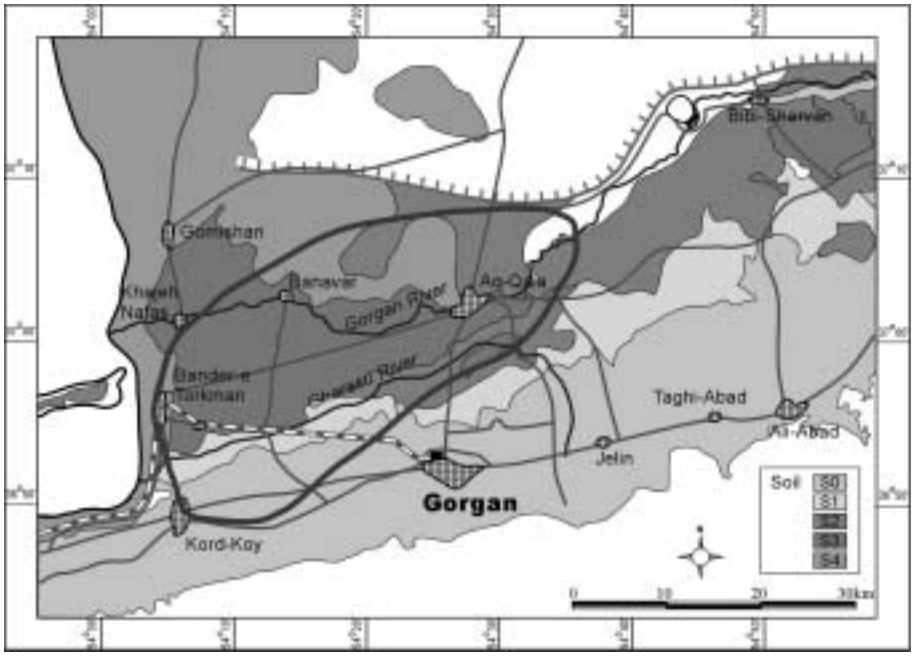
L - Loam

SL- Sandy Loam

S - Sand

Fig. A3.5.4 Soil Texture in the Study Area

(Source : GIS Section, MOA, Golestan Province)



Legend

S0 – EC<4mS/cm (No Salinity)

S1 – EC 4-8 mS/cm (Slight Salinity)

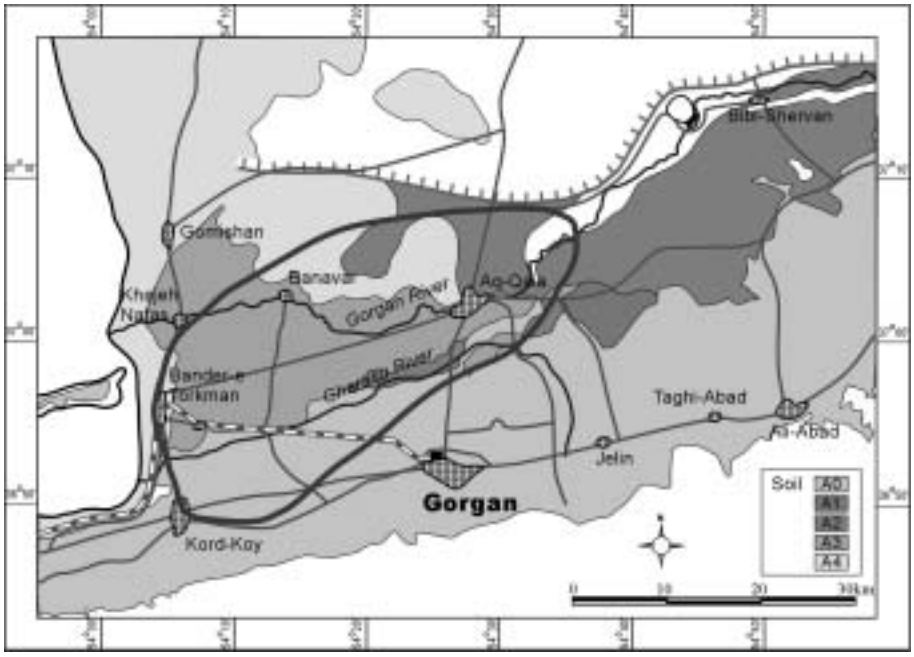
S2 – EC 8-16 mS/cm (Moderate Salinity)

S3 – EC 16-32 mS/cm (Severe Salinity)

S4 – EC >32 mS/cm (Very Severe Salinity)

Fig. A3.5.5 Salinity in the Study Area

(Source : GIS Section, MOA, Golestan Province)



Legend

A0 – SAR<8, pH<8.5 (No Alkalinity)

A1 – 8<SAR<13, pH>8.5 (Slight Alkalinity)

A2 – 13<SAR<30, pH=8.5-9 (Moderate Alkalinity)

A3 – 13<SAR<30, pH=9-9.5 (Severe Alkalinity)

A4–30<SAR>70, pH>9.5 (Very Severe Alkalinity)

Fig. A3.5.6 Alkalinity in the Study Area

(Source : GIS Section, MOA, Golestan Province)

These are deep soils with very heavy to heavy texture and profile development. The results of the soil analysis show that the dominant soil texture in this area is heavy textured silty clay, clay and silty clay loam. Because of the heavy texture, there is poor drainage condition in some areas and are associated with Gleyic Cambisol. This area has a problem of inundation risk.

From that soil analysis, it was found that these areas have relatively low salinity with a top layer EC values of 1.6 to 2.8 mS/cm. In this range, the salinity effect can be considered as negligible. Although the EC values increases with root zone depth, it is within reasonable level. The pH value of less than 8 and SAR values of 3.3-6.6 indicates that these areas have low alkalinity. CEC values are comparatively higher in the range of 20-25 meq/100g of soil.

The percentage of organic carbon in this area is moderate to high (above 1%), but it decreases with root zone depth. The soil has a medium level of total N percentage is about 0.1 to .15%. Availability of P is moderate to high level (>20 ppm). Similarly, the availability of K is also high. Micronutrients such as Fe, Mn, Cu and Zn are in the low to moderate level. In general, these soils make good agriculture lands depending on the relief and climate. In order to prevent inundation, drainage and land improvement works are necessary.

2) Gorgan land unit (4.2) of Piedmont plains, which occupies a small area of 1.8% of the Study Area, is located in the southern part of Gharasu river. It has relatively flat alluvials of river, with a slight and regular slope of 2 to 3%. The altitude ranges from 20 to 150m above msl. The Gorgan land unit has a higher elevation because of large alluvial fans, built up by the streams pouring from the mountains into the plains.

In accordance with the FAO soil classification, these soils are classified into Calcic Kastanozems (Calcixerolls), Chromic Luvisols (Haploxeralfs), Eutric Cambisols (Eutropepts), and Calcaric Fluvisol (Xerofluvents). They are normally deep clay soils and in alluvial parts with clay, gravel and loamy soils. The results of the soil analysis in this area show that the soils are primarily heavy textured silty clay loam.

The salinity and alkalinity is also low. The EC of the top layer of the soil sample taken in this area is 1.4 mS/cm (S0) to 6.8 mS/cm and SAR is 3 to 8 (A0). The organic carbon is 1.5 to 1.7% and the fertility level and availability of major and micro nutrients are moderate to high level. CEC values are comparatively higher in the range of 20-25 meq/100g of soil.

The major limitation in this area is inundation and high water table in some areas. These soils have good capability for annual and perennial irrigated cultivation and can be improved further by the prevention of inundation, drainage and improvement of soil texture.

3) Torang Tappeh land unit (4.3) of Piedmont plains with relatively flat alluvials of river, occupies about 5.9% of the Study Area. These areas have slight and regular slope of at most 1% and have an altitude 10 to 60m above msl. This unit occupies a small area at the northern part of the Study Area.

In accordance with the FAO soil classification, these soils are classified as Dystric Cambisols, Gleyic Cambisols, Humic Cambisols (Dystropepts, Eutrochrepts, and Humitropepts) and these soils are conditioned by their limited age. They are characterized by slight or moderate weathering of the parent material.

They are deep soils with heavy to very heavy texture. The main limitations of this soil are inundation risk and salinity (S1) and alkalinity (A1) in small quantity in some parts. The EC of the top layer of the soil sample taken in this area is 2.0 mS/cm (S1) and SAR is 2.8 (A0). The organic carbon is 1.65% and the quantity of NPK is in the moderate to high level. CEC values are in the range of 20 meq/100g of soil.

These soils have good capability for annual and perennial irrigated cultivation and orchards and they can be improved further through the prevention of inundation, drainage and improvement of soil texture.

4) Middle and downstream sedimentary and alluvial plains of Gorgan river (5.2), which occupies about 38.2% of the Study Area are mostly flat with a gradient of less than 1%. These areas are located at an altitude upto 80m above msl.

According to FAO soil classification, these soils are classified as Haplic and Gleyic solonchaks (Torriorthents, and Calciorthids). These are the saline soils, which are conditioned by limited leaching, low rainfall and high evaporation. High salt accumulation limits plant growth to salt tolerant crops, and limits growth because of less available nutrients. These soils can not be used for normal cropping unless the salts are leached. These are deep soils with moderate to heavy texture. The results of the soil analysis in this area show that the soils are primarily moderate textured silty loam with silty clay loam and clay at some locations.

The soil samples these areas show a wide range of EC values of 10 to 25 mS/cm (S2 to S3) at the top layer and normally the EC values of bottom layers are slightly higher than the top layer. Although the pH value is less than 8, the SAR values of these samples range from 15-35 (A2-A3), which indicates that these areas have moderate to severe alkalinity. These soils are poorly drained with a fluctuating saline groundwater table of 1 to 4m. CEC values ranges widely from 10 to 34, but most of the CEC values are in the lower range of about 10 me/100g of soil.

The percentage of organic carbon in this area is low (less than 1%), and it decreases with root zone depth. The soil has a low to medium level of total N percentage in the range of 0.07 to .10%. Availability of P is low to moderate level (<10 ppm). The availability of K is in the moderate to high level (160-250 ppm). In most cases, these nutrients reduce with depth. Micronutrients such as Fe, Mn, Cu and Zn are in the low to moderate level.

In general, these soils have relatively good capability for annual and perennial irrigated cultivation. Moderate to severe salinity and alkalinity are the major problems in these areas. By land improvement, leaching and construction of drainage system, these areas can be used for irrigated cultivation.

5) Low lands (6.1) of Gharasu depression close to the Caspian Sea and extends over the eastern part of the Study Area covers an area of 23.4% of the Study Area. These areas have an altitude 15 to 25m above msl.

In accordance with the FAO soil classification, these soils are classified as Haplic Solonchaks (Torriorthents), and Calcaric Arenosols (Pssamments). These are saline alluvial soils, which are suitable for salt tolerant species. These are deep soils of medium texture and the texture of the soil samples taken in the Study Area are normally medium textured silty loam, with silty clay loam, and silty clay at some locations.

The salinity varies widely from low level (S1) to very severe level (S4) based on their locations. For e.g., the soil samples taken close to the Caspian sea show a salinity values of as high as 38.2 mS/cm at the root zone depth although the salinity level decreases with respect to depth. The salinity levels at the inner part of the Study Area shows a salinity value of only 4.0 mS/cm. Similarly, the alkalinity also ranges from 4.2 (A0) to 40 (A4) depending on the location. CEC values are comparatively in the lower range of about 10 me/100g of soil.

The percentage of organic carbon in this area is low (less than 1%), which decreases further with root zone depth. The soil has a low level of total N percentage in the range of 0.06%. Availability of P and K are in the moderate level of 8 and 190 ppm respectively. Micronutrients such as Fe, Mn, Cu and Zn are in the low to moderate level.

In general, rainfed wheat and cotton are cultivated in these area. The major problems in this area are swampy state because of poor conditions of drainage and high salinity. Drainage and land improvement are necessary in these areas.

6) Coastal low lands (6.3) of Atrak river basin, the areas around Gomishan and inter-valley flood water plains of nearly flat and sometimes with a gradient of 0.5% occupies an area of 21.2% of the Study Area.

In accordance with the FAO soil classification, these soils are classified as Gleyic Solonchaks (Torriorthents), Mollic Gleysols (Calcixerolls / Haploaquolls) and Salic Fluvisols (Xerofluvents). These soils are poorly drained and with a high salinity and very saline groundwater. These are deep soils with medium to heavy texture The texture of the soil samples taken in the Study Area are mostly medium textured silty loam and heavy textured silty clay loam.

The salinity varies from severe (S3) to very severe (S4). The soil samples taken in this area show a salinity values of as high as 16 - 36 mS/cm at the root zone depth and the salinity level also increases with respect to depth. Similarly, the alkalinity is also very severe with SAR values ranging from 21.5 (A3) to 40 (A4). CEC values are about 15 me/100g of soil.

The percentage of organic carbon in this area is moderate to high (higher than 1%), and it decreases with root zone depth. The soil has a moderate level of total N percentage in the range of 0.14 to .17%. Availability of P is in the moderate to high level of 8.5 and 12 ppm and the availability of K is in the higher level of 250 ppm. Micronutrients such as Fe, Mn, Cu and Zn are in the moderate level.

There are swampy areas in some parts, and these areas are used for rainfed cultivation. Relatively a lot of improvement operations are carried out in some of these areas. The major problems in these areas are salinity and poor condition of drainage. These areas have medium capability for agriculture. With enough irrigation, these areas can be used for irrigated cultivation.

7) Summary

A brief summary of the soil characteristics based on the main land units is given below in the following Table:

Major Characteristics of the Soils of the Study Area

Land Unit	Area (%)	Main Soil Characteristics
Piedmont Plain (4.1,4.2 and 4.3)	17.2	These are deep soils with very heavy to heavy texture (silty clay, clay and silty clay loam). The salinity and alkalinity problems are at a much lower level. The fertility status is usually at a moderate to high level. The major limitations of the soils are very heavy texture in some areas, and inundation due to poor drainage condition.
Sedimentary and Alluvial Plains of Gorgan River (5.2)	38.2%	These are deep soils with medium to heavy texture (silt loam and silty clay loam). They are poorly drained soils with fluctuating saline groundwater table. The salinity and alkalinity problems are at moderate (S2A2) to severe level (S3A3). The fertility status is usually low to moderate level. Salinity, alkalinity, and poor drainage are the major limitations of the soils.
Low lands of Gharasu depression (6.1)	23.4%	These are deep soils with medium to heavy texture (silt loam and silty clay loam). The salinity and alkalinity problems vary widely from low (S1A1) to severe level (S4A4) depending on the drainage and the proximity to Caspian sea. The fertility status is usually low to moderate level. Salinity, alkalinity, and poor drainage are the major limitations of the soils.
Lowland and Saline Areas of Atrak river basin around Gomishan (6.3)	21.2%	These are deep soils with medium texture (silt loam). The salinity and alkalinity problems are severe (S3A3) to very severe level (S4A4). The fertility status is usually moderate level. Salinity, alkalinity, and poor drainage are the major limitations of the soils.

In regard to the physical characteristics, the bulk density is within the range of 1.40 to 1.70 g/cc, which is the normal range for silty loam, silty clay loam and loam soils. The infiltration rate and the hydraulic conductivity of the soils in the Study Area range between slow to moderate levels and these soils are considered to be suitable for surface irrigation.

A3.5.3 Soil Surveys by the Golestan Jihad-e-Agriculture Organization

(1) Soil Characteristics Analyzed by Recent Survey in 2001

Before making the fertilizer recommendation to the farmers, the soil analysis is carried out which normally include the following parameters:

- pH
- Electrical Conductivity (EC)
- Organic matter (Organic Carbon)
- Total nitrogen
- Available Phosphorus
- Available Potassium
- Soil Texture

The fertilizer recommendation is normally made based on these parameters. For some farms, the analysis of micronutrients is also carried out. The results of soil analysis carried out in 2001 are shown in Tables A3.5.8.

As it can be seen from the Tables, the soils of the Study Area such as Torkman and Aq Qala, have much higher EC values and the O.C values are comparatively lower. Most of the soils in this area are medium textured silt loam soils, although there are also heavy textured silty clay loam or silty clay soils in some parts of the sedimentary plains.

The soils in the southern part of the province in the Piedmont plain such as Ali abad, Bandar Gaz, Kordkuy have good soils with lower E.C values, and a higher organic matter content. However, the soils in this area are mostly heavy textured silt clay loam or clay loam. There are also some medium-textured silt loam soils in some parts of the piedmont plain.

About three fourths of the soils of the province have a medium level of organic carbon and more than 85% of the soils have a medium level of phosphorus and potassium. However only 25% of the soils have a higher level of organic carbon and more than 50% of the soils have higher level of phosphorus and potassium While comparing southern piedmont plain and the northern parts, the southern plain has more nitrogen and phosphorus, where as the soils of the northern parts have more potassium.

In regard to micronutrients, about 26% and 46% of the soils have average levels of boron and copper respectively. However, only about 7% and 5% of the soils have average levels of iron and manganese respectively.

Table A3.5.8 Soil Analysis of Macro and Micronutrients (October 2001)

City	Village	pH	EC mS/c	O.C %	CaCO3 %	Total N **	P(ava.)	K(ava.)	Fe ppm	Mn ppm	Zn ppm	Cu ppm	B ppm	Clay %	Silt %	Sand %	Texture
Aq Qala	Anbar Olum	7.8	3.6	0.87	14.5	9.8	8	300	1.9	2	0.3	1.1	2.2	24	62	14	si-l
Aq Qala	Aq Qala	7.7	8.6	1.31	12	7.7	7.5	240	2.6	5.8	0.3	1.7	3.8	22	68	10	si-l
Aq Qala	Aq Qala	7.9	9.0	0.95	13.5	14.7	6	300	3.3	4.8	0.3	2.2	5.6	34	56	10	si-c-l
Aq Qala	Aq Qala	7.9	18.0	1.01	16	18.9	3	270	3.3	1	0.4	1.2	3.9	20	62	18	si-l
Aq Qala	Aq Qala		27.2	1.01		0.1	7	320									
Aq Qala	Bagh Yulmeh	7.9	6.9	0.85	21	7	7	280	12	3.7	0.6	1.9	2.3	34	52	14	si-c-l
Aq Qala	Bagh Yulmeh	7.9	10.6	1.19	14.5	30.1	8.5	400	3.4	3.3	0.7	1.6	4.8	34	56	10	si-c-l
Aq Qala	Bagh Yulmeh		6.3	1.15		0.12	5.5	260									
Aq Qala	Bagh Yulmeh		5.3	0.94		0.09	10	460									
Aq Qala	Chin Sivili	7.7	10.9	0.97	13	9.8	5	390	2	4	0.4	1.5	2.8	24	60	16	si-l
Aq Qala	Chin Sivili	7.8	8.2	1.16	14.5	3.5	7.5	310	2.6	3	0.2	1.7	3.2	32	54	14	si-c-l
Aq Qala	Chin Sivili		5.7	0.95	15		5	260									
Aq Qala	Chin Sivili		10.2	1.06	6.5		7	520									
Aq Qala	Gharh Tapeh		12.1	0.91		0.09	7.5	280									
Aq Qala	Gharh Tapeh		7.2	1.12		0.11	5.5	260									
Aq Qala	Gerey	7.7	7.7	1.04	24.5	43.4	6	370	6.5	3.9	0.6	1.3	2.3	28	48	24	c-l
Aq Qala	Gerey	7.8	7.8	1.31	13.5	22.4	6.5	480	5.1	3.3	0.6	2	1.4	38	52	10	si-c-l
Aq Qala	Gerey	7.9	4.3	1.12	23.5	3.5	4	260	16.3	3.9	0.9	2	1.9	40	44	16	si-c
Aq Qala	Gerey		2.8	1.66		0.17	4	480									
Aq Qala	Gerey		2.0	1.48		0.15	4	280									
Aq Qala	Habib Ishan	7.7	3.6	1.31	12.5	26.6	10	340	1.2	3.2	0.3	1.1	1.2	22	64	14	si-l
Aq Qala	Habib Ishan	7.8	1.7	1.16	13	24.5	18	400	1.1	2.8	0.3	1	0.9	16	68	16	si-l
Aq Qala	Habib Ishan		5.0	0.65		0.07	18	300									
Aq Qala	Keselkheh		21.4	0.74		0.07	8	200									
Aq Qala	Mohammad Abad	7.7	3.9	1.56	16	16.8	10	260	6.3	5.2	0.4	1.9	4	28	50	22	si-c-l
Aq Qala	Anbar Olum		1.6	1.06		0.11	8.5	380									
Aq Qala	Anbar Olum		4.8	1.1		0.11	9	390									
Aq Qala	Anbar Olum		12.6	1.05		0.11	7	280									
Aq Qala	Anbar Olum		6.3	1		0.1	6	300									
Aq Qala	Anbar Olum		22.4	0.91		0.09	8	270									
Aq Qala	Sad Abad	7.9	10.3	1.81	18	40.6	10.5	310	3.2	1.4	0.7	1.2	2.3	28	58	14	c-l
Aq Qala	Sahneh Sofla	7.6	28.5	1.08	15	16.8	7.5	180	3.9	1.9	0.3	0.9	3.6	20	64	16	l
Aq Qala	Sahneh Sofla	7.7	4.4	1.12	13	8.4	6	280	4.6	3	0.3	2.1	1.4	10	74	16	si-l
Aq Qala	Sahneh Sofla	7.7	17.4	0.89	15.5	11.9	9.5	20	2.9	2.6	0.5	1.4	2.6	22	72	6	si-l
Aq Qala	Sherecat Peivand		7.9	1.27		0.13	8	440									
Aq Qala	Sherecat Peivand		8.4	1.05		0.11	4	290									
Aq Qala	Sherecat Peivand		15.6	1.12		0.11	12	640									
Aq Qala	Solagh Yolghi	7.7	10.3	1.12	17.5	10.5	4	300	2.6	4.4	0.3	1.4	5.6	26	64	10	si-l
Aq Qala	Solagh Yolghi	7.8	9.5	0.97	15	10.5	3	210	2.9	3.2	0.3	1.5	4.8	24	64	12	si-l
Aq Qala	Solagh Yolghi		8.2	0.88		0.09	10	260									
Aq Qala	Yampi	7.8	5.4	1.79	10.5	11.2	12.5	340	6.3	2.4	0.6	3.2	4.1	14	76	10	si-l
Aq Qala	Yampi		17.0	2.05		0.21	11.5	160									
Aq Qala	Yolmeh Kkhandan		8.6	0.97		0.1	5.5	250									
Aq Qala	Aq Qala		9.8	0.95		0.1	4.5	290									
Aq Qala	Aq Qala		6.1	0.76		0.08	4.5	220									
Aq Qala	Aq Qala		18.3	1.24		0.12	17	270									
Aq Qala	Aq Qala		26.9	0.91		0.09	5.5	340									
Bandar torkman	Arekh Bozorg		7.6	0.95		0.1	10	280									
Bandar torkman	Arekh Bozorg		20.1	0.87		0.09	4	220									
Bandar torkman	Arekh Bozorg		2.7	1.16		0.12	10	510									
Bandar torkman	Ashoor Abad		1.1	2.07		0.21	6.5	310									
Bandar torkman	Banavar		12.5	0.93		0.09	3	210									
Bandar torkman	Bandar Torkaman	7.5	9.2	1	15	23.8	5.5	260	2.4	5.6	0.3	0.9	1.1	16	72	12	si-l
Bandar torkman	Basir Abad		6.5	1.27		0.13	15.5	310									
Bandar torkman	Charghli	7.6	28.0	0.86	17	8.4	7	370	5.2	1.6	0.4	1.9	3.1	30	58	12	si-c-l
Bandar torkman	Eslam Abad	7.7	4.7	0.91	14	42	10	210	2	5.8	0.3	0.7	2.8	12	72	16	si-l
Bandar torkman	Ghafar Haji		4.8	1.04		0.1	5.5	200									
Bandar torkman	Ghafar Haji		14.2	1.52		0.15	4	270									
Bandar torkman	Ghafar Haji		6.3	1.29		0.13	18.5	500									
Bandar torkman	Ghaleh	7.9	21.3	0.82	14.5	42	6.5	170	2	3.6	0.3	0.7	4.2	24	60	16	si-l
Bandar torkman	Ghareh Ghashli	7.8	4.7	1.44	20	15.4	11.5	190	7.2	3.6	0.3	1.6	4.9	24	64	12	si-l
Bandar torkman	Ghareh Ghashli		2.2	1.27		0.13	8	310									
Bandar torkman	Ghareh Tapeh		0.7	1.25		0.13	6.5	190									
Bandar torkman	Gharghi	7.8	12.7	0.98	17.5	9.8	10.5	260	4.9	5	0.36	1.52	1.5	18	64	18	si-l
Bandar torkman	Gharghi	7.8	15.4	0.69	17.5	11.2	3	190	3.8	2.46	0.36	1.22	108	12	70	18	si-l
Bandar torkman	Gharghi		12.4	1.1		0.11	6.5	260									
Bandar torkman	Gharghi		5.2	1.46		0.15	11.5	180									
Bandar torkman	Gomishan	7.5	17.5	1.4	42	16.8	12	380	7.3	1.4	0.5	2.5	6.6	40	54	6	si-c
Bandar torkman	Gomishan		15.7	1.33		0.13	62.5	1000									
Bandar torkman	Gomishan		11.1	1.16		0.12	6.5	240									
Bandar torkman	Gomishan		18.7	1.37		0.14	10	360									
Bandar torkman	Gomishan		14.9	1.58		0.16	6.5	390									
Bandar torkman	Iran Abad		6.5	1.23		0.12	6.5	160									
Bandar torkman	Kapoor Chal	7.8	5.1	1.11	14	2.1	2.7	240	2.6	3.12	0.14	0.98	2.5	12	74	14	si-l
Bandar torkman	Khajeh Ler		3.4	1.22		0.12	9	320									
Bandar torkman	Khajeh Nafas	7.8	3.3	0.97	16.5	11.2	11	310	3.7	1.4	0.3	1.6	1.4	32	60	8	si-c-l
Bandar torkman	Khajeh Nafas		24.5	1.42		0.14	8	310									
Bandar torkman	Khajeh Nafas		8.2	0.97			7	260									
Bandar torkman	Morad Bardi	7.8	1.5	1.08	14.5	6.3	6.5	310	3.9	6.8	0.5	2	0.9	34	60	6	si-c-l
Bandar torkman	Oket Haji		5.9	1.2		0.12	16	330									
Bandar torkman	Panj Peykar		18.0	1.22		0.12	8.5	270									
Bandar torkman	Panj Peykar		6.6	1.35		0.14	6.5	280									

Table A3.5.8 Soil Analysis of Macro and Micronutrients (October 2001)

City	Village	pH	EC mS/c	O.C %	CaCO 3 %	Total N **	P(ava.)	K(ava.)	Fe ppm	Mn ppm	Zn ppm	Cu ppm	B ppm	Clay %	Silt %	Sand %	Texture
Bandar torkman	Sijual	7.9	1.5	1.22	14.5	14	6.5	300	4.1	1.6	0.4	1.3	0.8	28	64	8	si-c-l
Bandar torkman	Sijual		25.1	1.31		0.13	11	190									
Bandar torkman	Zabol Mahaleh		4.2	1.71		0.17	16	330									
Bandar torkman	Zabol Mahaleh		2.7	1.16		0.12	15	370									
Gorgan	Hidar Abd		0.6	1.27		0.13	5	440									
Gorgan	Jelin		0.7	0.86		0.09	27	120									
Gorgan	Nodijeh		0.7	1.05		0.1	8.5	180									
Gorgan	Sad Abad		0.7	1.42		0.14	12	170									
Gorgan	Shoshak Olia		0.7	0.61		0.06	3	130									
Gorgan	Toshan		0.7	1.25		0.13	14	180									
Gorgan	Toshan		2.9	0.95		0.1	22.5	180									
Gonbad	Amanlo	7.8	7.2	1.82	7.5	16.1	18.5	360	24.1	7.1	1.5	4.1	3.4	48	40	12	si-c/c
Gonbad	Aq Abad	7.7	4.5	0.78	10.5	13.3	3.5	340	2.6	13.2	0.44	1.26	1.7	18	66	16	si-l
Gonbad	Aq Abad	7.7	4.8	0.87	11	15.4	5	330	2.5	14	0.42	1.22	1.7	16	66	18	si-l
Gonbad	Aq Abad	7.7	7.0	0.35	13	0	1	130	3.1	7.4	0.36	1.54	2.2	26	58	16	si-l
Gonbad	Aq Abad	7.8	46.0	0.74	11	92.4	9	290	2.5	6.4	0.52	1.3	1.7	20	64	16	si-l
Gonbad	Aq Abad	8.0	23.9	0.37	15.5	23.8	2.5	200	2.5	2.8	0.7	1.3	3.5	22	64	14	si-l
Gonbad	Aq Abad	8.1	3.8	0.28	15.5	0	1	130	2.9	2.8	0.22	1.24	2.2	28	56	16	si-c-l
Gonbad	Avaz Haji	7.8	1.8	0.48	13.5	18.9	4	220	1.5	2.7	0.3	0.8	0.7	20	68	12	si-l
Gonbad	Avaz Haji	7.9	1.1	0.74	11.5	19.6	5.5	380	2.2	11.2	0.28	1.3	1.7	16	66	18	si-l
Gonbad	Avaz Haji	8.0	1.2	0.63	17	11.2	5	380	2.4	9.4	0.36	1.52	0.5	16	66	18	si-l
Gonbad	Baghi Marama	7.7	3.5	1.78	6	10.5	4	580	7.7	2.2	0.8	1.1	0.9	30	48	22	c-l
Gonbad	Baghi Marama	7.9	1.2	1.58	7.5	7	5.5	350	3	1.4	0.7	1.2	0.3	30	50	20	si-c-l
Gonbad	Bagli Marameh	7.5	9.2	1.94	7	51.8	20	260	10.5	6.6	0.7	3.1	1.7	28	44	28	c-l
Gonbad	Bagli Marameh	7.6	8.4	1.62	7.5	16.8	7.5	180	6	3	0.5	2.4	0.9	44	48	8	si-c
Gonbad	Chay Ghoshan	7.9	0.9	0.76	7	7	3	390	2.9	10	0.34	1.46	0.4	22	62	16	si-l
Gonbad	Fendereck		1.8	1.48		0.15	16	570									
Gonbad	Fendereck		1.0	0.97		1	21	240									
Gonbad	Fendereck		3.6	1.39		0.14	14.5	340									
Gonbad	Fendereck		0.7	1.31		0.13	14	240									
Gonbad	Fendereck		1.5	1.39		0.14	18	320									
Gonbad	Fendereck		1.1	1.25		0.13	28	300									
Gonbad	Fendereck		1.2	1.5		0.15	19.5	270									
Gonbad	Fendereck		0.9	1.6		0.16	43	290									
Gonbad	Ghareh Mohd	7.9	1.2	0.55	14	7	6	220	1.3	2.6	0.4	0.8	0.4	38	46	16	si-c-l
Gonbad	Ghazel Jeh	7.7	0.9	1.62	3	9.1	7	240	4.2	2.8	0.4	2	6	24	52	24	si-l
Gonbad	Gol Cheshmeh	7.7	1.5	1.5	5.5	9.1	9	180	7.8	2.4	0.4	1.8	2.8	24	52	24	si-l
Gonbad	Haji Foshan	7.9	0.7	0.82	9.5	15.4	11	320	1.4	6.6	0.5	0.7	0.3	14	72	14	si-l
Gonbad	Kesken Ghojugh	7.4	1.4	0.8	8	16.8	4.5	370	2.2	8.6	0.26	1.1	0.6	18	66	16	si-l
Gonbad	Malek Ali Tapeh	7.9	0.8	0.87	11	12.6	4	510	2.2	12.6	0.5	1.54	0.5	18	70	12	si-l
Gonbad	Malek Ali Tapeh	7.9	0.8	0.85	11	9.8	4.5	450	2.7	10.2	0.44	1.54	2.6	24	62	14	si-l
Gonbad	Malek Ali Tapeh	8.0	0.9	0.69	11.5	7	4.5	380	1.9	9.6	0.38	0.8	2	12	74	14	si-l
Gonbad	Malek Ali Tapeh	8.0	1.0	0.85	42	10.5	4.5	410	2.8	14.4	0.52	1.24	3	14	72	14	si-l
Gonbad	Marz Ban	7.5	0.9	1.52	3	11.9	10	265	5.9	1.6	0.3	2	0.4	28	52	20	si-c-l/c
Gonbad	Mohamad Zaman	7.6	0.7	1.48	17.5	3.5	10.5	140	12.5	2.2	0.5	2.5	0.9	28	50	22	c-l
Gonbad	Nazar Chagheli	7.6	4.4	1.69	9.5	9.1	9.5	380	3.2	2.4	0.4	1.4	2.4	30	52	18	si-c-l
Gonbad	Nazar Chagheli	7.8	4.1	1.84	8	11.2	18	270	39.2	7.6	1.6	4	0.9	22	44	34	l
Gonbad	Nazar Chagheli	7.8	2.8	2.49	12.5	13.3	12	200	16	3.6	0.6	3.4	3	38	46	16	si-c-l
Gonbad	Nazar Chagheli	7.8	2.2	2.47	18.5	9.8	20.5	330	2.9	1.2	0.6	2	2.2	26	54	20	si-l
Gonbad	Nezam Abad	7.7	1.3	2	4.5	9.8	9	240	11.6	2.8	0.6	2.8	0.5	28	48	24	c-l
Gonbad	Nezam Abad	7.8	1.3	2.72	25	14.7	11.5	140	16.4	1.7	0.6	3.2	1.3	30	46	24	c-l
Gonbad	Nezam Abad	7.9	3.2	1.98	5.5	17.5	38	280	25.4	6.6	0.7	4.2	1.7	36	48	16	si-c-l
Gonbad	Nodeh Khandooz	7.7	0.8	1.29	10	9.8	9	200	5	1.8	0.4	2	0.5	24	52	24	si-l
Gonbad	Pour Jan	7.7	0.8	2	0.5	7.7	19	300	15.2	3.4	0.4	2.5	0.34	36	52	12	si-c-l
Gonbad	Pourjan		1.5	1.86		0.19	12.5	250									
Gonbad	Sabzevaria		1.1	1.73		0.17	4	240									
Gonbad	Saryi Bakhsh		7.7	1.2		0.12	5.5	480									
Gonbad	Satlegh Amanloo	7.7	0.8	1.86	7	16.8	14	280	9.6	4.2	0.6	2.9	1.7	38	50	12	si-c-l
Gonbad	Satlegh Bay	7.6	2.3	2.15	6.5	9.1	9.5	390	3.3	5.8	0.5	2	0.8	28	52	20	si-c-l
Gonbad	Satlegh Bay	7.8	1.8	1.92	6	5.6	9.5	250	4.2	3.8	0.4	2.1	1.2	38	50	12	si-c-l
Gonbad	Sherecat Peivand		7.0	1.31		0.13	7	380									
Gonbad	Sherecat Peivand		16.9	1.22		0.12	14.5	450									
Gonbad	Soltan Ali	7.8	2.7	1.13	14	18.2	7.5	400	2.1	6.4	0.4	1	0.9	22	68	10	si-l
Gonbad	Tarigh Al Ghods	7.8	2.1	1.86	5.5	6.3	11.5	300	7.5	2.2	0.4	2.8	1.4	44	48	8	si-c
Gonbad	Tatar Olia	7.7	1.8	1.78	2	16.8	17	340	16.2	3.1	1.2	2.2	0.8	38	52	10	si-c-l
Gonbad	Tatar Olia	7.8	2.6	1.7	1	17.5	22.5	360	11.1	1.5	0.9	2	0.6	38	40	14	si-c-l
Gonbad	Tatar Sofla	8.0	1.7	1.4	6.5	10.5	12	240	5.8	1.1	0.8	1.8	0.4	32	50	18	si-c-l
Gonbad	Yanghageh	7.9	1.3	1.41	12.5	16.1	18	680	1.1	1.6	1	1.3	1.7	38	50	12	si-c-l
Gonbad	Yasi Tapeh	8.0	2.1	1.37	12	16.1	5	380	4.4	1.6	0.7	1.8	1.1	40	50	10	si-c/si-c
Gonbad	Zayer Sara	7.5	0.9	1.08	15	14.7	9	200	1.6	14	0.3	0.8	0.6	20	70	10	si-l
Gonbad	Zayer Sara	7.8	1.1	1.67	3.5	7.7	20	320	6	1.8	0.5	1.8	0.6	30	56	14	si-c-l
Minodasht	Bazgir		1.0	0.8		0.08	16	340									
Minodasht	Brenjun		0.9	1.08		0.11	6	310									
Minodasht	Dasht Halgeh	7.9	1.6	1.22	1	4.9	25	320	7.1	4.2	0.7	2.2	1.6	12	76	12	si-l
Minodasht	Dasht Halgeh	8.0	1.8	1.5	5	8.4	23	390	9.3	4.1	1.1	2.6	1.6	36	52	12	si-c-l
Minodasht	Dasht Halgeh	8.0	1.6	1.01	15.5	7.7	18	470	4.6	1.9	0.5	1.4	0.9	32	56	12	si-c-l
Minodasht	Dasht Halgeh	8.0	2.2	1.75	4	9.8	20	280	11.1	2	1	2.2	0.8	32	46	22	c-l
Minodasht	Dozin	7.7	0.8	1.03	8	9.8	12.5	180	2.1	1	0.6	1	0.5	20	66	14	si-l
Minodasht	Dozin		1.1	0.7		0.07	10.5	160									
Minodasht	Farsian Farang	7.9	0.5	0.74	6.5	14.7	12	320	2	2.4	0.5	1.3	0	18	68	14	si-l
Minodasht	Ganhdeh		2.2	1.39		0.14	8	160									
Minodasht	Ganhdeh		0.5	0.49		0.05	7.5	160									

Table A3.5.8 Soil Analysis of Macro and Micronutrients (October 2001)

City	Village	pH	EC mS/c	O.C %	CaCO 3 %	Total N **	P(ava.)	K(ava.)	Fe ppm	Mn ppm	Zn ppm	Cu ppm	B ppm	Clay %	Silt %	Sand %	Textur e
Minodasht	Gareh Cheshmeh	8.1	2.9	1.31	9.5	2.8	25	330	18.4	2.7	0.9	2.9	2.6	52	38	10	c
Minodasht	Ghaleche		0.8	1.01		0.1	17	150									
Minodasht	Ghaleche		0.6	1.03		0.1	17	180									
Minodasht	Ghareh Cheshmeh	7.6	2.8	1.35	1.5	9.1	24	540	3.9	1.4	0.8	1.5	0.3	28	64	8	si-c-l
Minodasht	Google		1.0	1.16		0.12	6	190									
Minodasht	Hassan Khanlo		1.1	1.27		0.13	13	260									
Minodasht	Jangdeh	7.4	0.7	1.1	5.5	7.7	22	180	13	2.2	1.5	1.6	0.3	28	58	14	si-c-l
Minodasht	Jangdeh	7.9	0.6	1.03	3	3.5	23	170	33.3	3.8	1.3	3.1	0.9	30	54	16	si-c-l
Minodasht	Jangdeh	7.9	1.0	0.68	13	2.8	14	120	22.2	3.3	1.5	2.6	0.2	32	54	14	si-c-l
Minodasht	Khat Gaz	7.7	0.6	0.89	2	2.1	17	250	7.5	1.7	0.8	1.7	0.22	34	54	12	si-c-l
Minodasht	Khat Gaz	7.7	0.8	1.25	3.5	9.1	27	440	4.8	1.7	1.2	1.7	0.22	28	60	12	si-c-l
Minodasht	Khordileg		0.9	1.37		0.14	7	140									
Minodasht	Klo Kand		0.5	0.74		0.07	6	140									
Minodasht	Klo Kand		0.7	1.12		0.11	9	140									
Minodasht	Kolah Sar	7.8	1.2	1.01	16	21	11	270	1.8	1.1	0.4	0.9	0.8	18	64	18	si-l
Minodasht	Safi Abad		3.1	1.37		0.14	14	140									
Minodasht	Tuska Chan		0.8	0.67		0.07	21.5	190									
Kalaleh	Aghiaji		0.9	0.9		0.09	5.5	460									
Kalaleh	Arab Ghari Haji	7.8	2.0	0.74	20.5	22.4	5.5	400	1.8	2.1	0.7	0.8	0.35	14	66	20	si-l
Kalaleh	Avar Jenli		0.5	1.33		0.13	12	290									
Kalaleh	Aziz Abad		0.9	0.99		0.1	5	180									
Kalaleh	Aziz Abad		0.8	0.82		0.08	4	240									
Kalaleh	Chenaran	7.8	4.6	0.7	8.5	32.9	4.5	380	1.6	0.8	0.5	0.9	1.2	26	56	18	si-l
Kalaleh	Dahaneh		0.7	1.1		0.11	10.5	100									
Kalaleh	Dahaneh		0.7	1.03		0.1	11.5	260									
Kalaleh	Eslam Abad		0.8	0.61		0.06	9.5	340									
Kalaleh	Foshe Su	7.7	1.1	1.56	3	11.9	5.5	400	2	1.2	0.5	0.7	1.1	20	70	10	si-l
Kalaleh	Ghapan Sofla		0.7	0.72		0.07	5	470									
Kalaleh	Ghapan Sofla		0.8	0.87		0.09	5	440									
Kalaleh	Ghareh Ji	7.6	1.5	1.12	2	32.9	11.5	660	1.4	7.2	0.9	0.9	0.4	12	74	14	si-l
Kalaleh	Ghareh Ji	7.7	1.3	0.87	5.5	39.9	8	240	1.6	8.3	0.6	0.9	0.9	12	70	18	si-l
Kalaleh	Ghareh Ji		1.0	1.31		0.13	29	360									
Kalaleh	Ghareh Ji		1.0	1.23		0.12	13	540									
Kalaleh	Ghareh Ji		0.9	1.33		0.13	7.5	200									
Kalaleh	Ghareh Ji		0.9	1.31		0.13	6.5	210									
Kalaleh	Ghareh Yesir Paiin		0.7	1.12		0.11	4	160									
Kalaleh	Ghareh Yesir Paiin		0.8	1.44		0.14	16	240									
Kalaleh	Ghazan Ghaleh	7.7	18.4	0.61	23	61.6	7	280	2.3	2.5	0.8	0.8	1.2	32	54	14	si-c-l
Kalaleh	Ghazan Ghaleh	7.8	5.4	0.99	18.5	17.5	10	320	5.6	2.6	0.8	1.3	1.3	34	52	14	si-c-l
Kalaleh	Goban Uli	7.7	1.3	0.59	18	11.9	6.5	340	1.6	3.8	0.5	0.7	0.3	12	72	16	si-l
Kalaleh	Goban Uli	7.9	3.0	0.56	19	28	4.5	280	1.7	4.6	0.4	0.7	0.5	14	70	16	si-l
Kalaleh	Gog Jeh		1.3	0.95		0.1	4	400									
Kalaleh	Gog Jeh		0.7	0.68		0.07	4	260									
Kalaleh	Gog Jeh		0.6	0.89		0.09	4	390									
Kalaleh	Golbedag		0.8	1.43		0.14	8.5	390									
Kalaleh	Golbedag		1.2	1.7		0.17	9	370									
Kalaleh	Gorgan Doz		0.8	1.49		0.15	11.5	340		.							
Kalaleh	Gorgan Doz		0.6	1.31		0.13	12	370									
Kalaleh	Gorgan Doz		0.5	1.22		0.12	4	240									
Kalaleh	Gorgan Doz		0.7	1.49		0.15	13	400									
Kalaleh	Haji Bek Sofla		0.9	1.05		0.11	7	250									
Kalaleh	Haji Bek Sofla		0.9	0.93		0.09	6.5	340									
Kalaleh	Haji Hasan		0.8	0.97		1	11	240									
Kalaleh	Haji Hasan		1.1	0.95		1	12.5	100									
Kalaleh	Haji Leg Olia		1.2	0.78		0.08	8	460									
Kalaleh	Im Bolagh		1.5	1.22		0.12	14	380									
Kalaleh	Kalaleh Air Port	8.0	0.9	1.35	1.5	2.8	8.5	440						18	68	14	si-l
Kalaleh	Kasr Pishkamar		1.1	0.59		0.06	6	240									
Kalaleh	Koli Bayender		1.2	0.93		0.09	22	420									
Kalaleh	Kongour	7.7	1.2	1.05	1	7	19.5	350	4.1	7.3	0.6	1.7	0.84	26	62	12	si-l
Kalaleh	Kongour	7.8	1.3	2.01	16.5	18.9	8	320	2.4	4.9	0.5	1.2	1.2	26	56	18	si-l
Kalaleh	Kongour	8.0	1.1	1.73	3	7	3.5	320	2.9	1.3	0.6	1	0.9	24	64	12	si-l
Kalaleh	Kongour		1.3	1.31		0.13	17.5	540									
Kalaleh	Kongour		1.0	1.62		0.16	13.5	520									
Kalaleh	Lah Ander		0.8	0.91		0.09	7	260									
Kalaleh	Maraveh Tapeh	7.8	6.4	0.49	19	18.2	6	400	1.7	3	0.6	0.6	2.2	18	60	22	si-l
Kalaleh	Maraveh Tapeh	7.9	6.3	0.51	19	11.2	6	280	1.9	2.1	0.5	0.7	1.2	24	60	16	si-l
Kalaleh	Pashai		0.8	0.8		0.08	12.5	350									
Kalaleh	Pashai		1.6	0.84		0.08	11.5	440									
Kalaleh	Pish Kamar		0.7	0.77		0.08	6	440									
Kalaleh	Pish Kamar		0.8	1.1		0.11	4	260									
Kalaleh	Pol Cheshmeh Olia		0.6	1.51		0.15	7.5	280									
Kalaleh	Pol Cheshmeh Olia		0.9	1.1		0.11	10.5	300									
Kalaleh	Shahrak Jomhoury	7.8	1.9	1.48	3.5	11.2	8.5	430						22	62	16	si-l
Kalaleh	Sheikh Lar	7.8	4.4	0.34	22	11.2	7.5	200	2.2	1.9	0.5	0.7	0.22	18	58	24	si-l
Kalaleh	Sheikh Lar		1.1	0.8		0.08	5.5	390									
Kalaleh	Sheikh Lar		1.0	0.87		0.09	5.5	350									

** - The total Nitrogen values of some villages are given in % and some in ppm (values greater than 1).

(2) Comparison of Soil Characteristics in 1970

In order to compare the soil characteristics and to verify the development or the deterioration of the soil characteristics during the past 30 years of agriculture cultivation, the result of the soil analysis carried out in 1969-70 is shown in the following Table.

Soil Characteristics in Golestan Province (1969-70)

City	Series	pH	EC, mS/cm	O.C %	P(ava.) (ppm)	K(ava.) (ppm)	Texture
Aq qala	Pahlavidezh(Aq qala)	7.9	2.5	1.70	1.5	380	Si-C
Aq qala	Ata abad	8.2	10.5	1.28	1.5	350	L
North of Aq qala	Voshmgir dam	7.8	3.2	1.48	10.0	1050	Si-C
Bandar Torkaman	Bandar Torkaman	7.9	2.2	1.28	7.0	480	Si-C
Gorgan	Turang tapeh	7.8	0.8	1.96	26.0	300	Si-C
Gorgan	Massom abad	8.0	0.7	1.07	5.0	440	C
Ramiyan	Ramiyan	7.5	1.4	1.77	7.0	250	C
Ali abad	Ali abad	7.7	1.5		1.5	230	C
North of Ali abad	Ghara Bulagh	7.7	1.7	1.69	1.0	460	Si-C
Minodasht	Minodasht	6.9	1.6	1.60	4.5	760	Si-C
Minodasht	Sufian	7.6	1.0	0.93	1.5	750	Si-C-L
Gonbad	Nezam abad	7.7	1.0	1.13	6.0	750	C

Although the range of pH values in 1970 and 2001 are almost similar, there is a significant difference in the range of EC values. Soils of 2001 have higher EC values because salt accumulation caused by poor drainage and low level of soil and water management. The level of organic carbon was also relatively high in 1970, which has been slowly lessened in the past 30 years. Although the phosphorus values in 2001 are higher than 1970, the range of potassium is in the same range as 1970.

In general, the EC values of soil samples in 2001 show that the soil salinization and alkalinization has increased in the course of time. Besides, the decrease in O.C values also implies that the fertility status of the soil is also decreasing by continuous fertilizer without adding organic fertilizers.

Therefore, suitable soil and water management practices are necessary by introducing suitable drainage system and suitable agronomic practices including the adaptation of crop rotation of forage crops for increasing the soil organic matter and the fertility status of the soil.

(3) Comparison of Army Farm

A farm of about 6,000 ha is managed by the farm experts of the army in an area closed to the Tazeh Abad Project Area. Suburface drainage systems were installed in most of the area about 30 years ago and drainage has been performed. This area was originally a highly saline area with low fertility status with a normal yield of about 0.5-0.8 t/ha. Using irrigation and subsurface drainage system, the yield of the farm is increased to a level of 4 to 6 t/ha and this farm is considered as one of the typical example of improving the soil and increasing the yield with good farm management and irrigation and drainage practices.

1) Soil Characteristics of Army Farm in 2002

Soil Characteristics of Army Farm in Golestan Province (April 2002)

No.	pH	EC mS/cm	O.C %	Total N (%)	P(ava.) (ppm)	K(ava.) (ppm)	Clay	Silt	Sand	Texture
1	7.7	2.4	1.27	0.13	23.5	610	38	50	12	si-c-l
2	7.6	2.6	1.29	0.13	29.5	620	36	54	10	Si-c-l
3	7.6	3.3	0.82	0.08	23	310	26	58	16	Si-c-l
4	7.7	3.1	0.91	0.09	24	310	26	58	16	Si-l
5	7.9	1.5	0.8	0.08	6.5	360	42	50	8	Si-C
6	7.6	2.9	1.04	0.1	14.5	500	40	52	8	Si-C to Si-c-l
7	7.9	1.8	0.86	0.09	7	380	42	48	10	Si-c
8	7.8	1.7	1.06	0.11	9	480	38	52	10	Si-c-l
9	7.6	2.5	2.2	0.22	60	920	36	48	16	Si-c-l
10	7.7	2.3	1.46	0.15	32	660	36	54	10	Si-c-l
11	7.5	2.8	2.09	0.21	66	740	36	52	12	Si-c-l

As it can be seen, the salinity is at a low level with the EC of the soils below 4.0 mS/cm. The fertility status including O.C and total nitrogen are at moderate to high level and the phosphorus and potassium are also at high levels.

There is also a small area of army farm, which is not installed with drainage systems and the

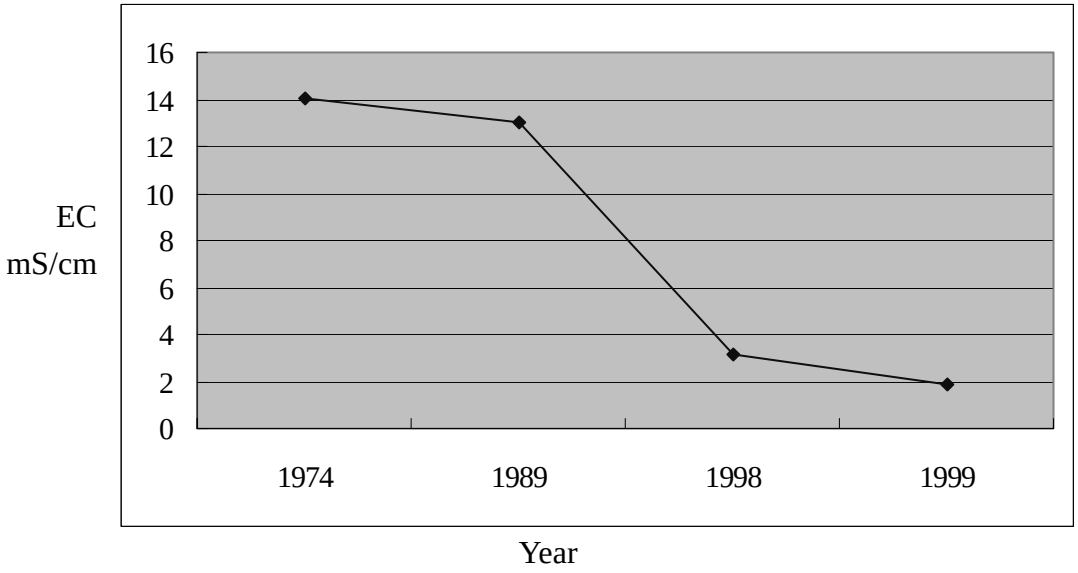
EC values in this area are above 10 mS/cm.

2) Change of Soil Characteristics in Time

The change of pH, EC in course of time in the army farm is shown in the following Table.

Change of pH and EC in Time in the Army Farm

Year	Number of Samples	pH	EC average mS/cm
1974	76	8.08	14.05
1989	68	7.96	13.06
1998	30	7.84	3.15
1999	54	8.15	1.87



Although the drainage system was installed in 1974, the maintenance of the drainage system was not fully active during the periods of 1980s and the maintenance of drainage system was started from 1991 and has been continuing until now. As shown in the above figure, the EC of the soil has lowered down by 10 mS/cm within the past 10 years period of subsurface drainage.

While the army farm can be considered as a good example for the effect of good drainage, the cost the subsurface drainage system is a major criteria, and the cost-benefit of introducing the subsurface drainage system needs to be verified.

A3.6 Soils of Tazeh Abad Project Area

During the 3rd field survey, the present conditions of the Soils in the Tazeh Abad Project Area were analyzed using the data and information collected through the following soil surveys:

1. Soil Survey by the Golestan Agriculture Organization
2. Soil Survey by the Soil and Water Research Institute
3. Soil Survey by the JICA Study Team

(1) Soil Surveys by the Golestan Agriculture Organization (GAO)

Before making the fertilizer recommendation to the farmers, the soil samples of the Project Area were collected through the Pevand cooperative and the soil analyses were carried out which included the following parameters:

- pH
- Electrical Conductivity (EC)
- Organic matter (Organic Carbon)
- Total nitrogen
- Available Phosphorus
- Available Potassium
- Soil Texture

The locations of soil sampling carried out in 2001 are shown in Fig.A3.6.1. Regarding the cost for the soil analysis, 50% of the cost is paid by the government and the remaining 50% is paid by the farmers. Since irrigation was carried out only in the eastern part of the Project Area in 2001, mostly the farmers in this area requested for soil sampling through the cooperative.

The results of soil analysis are shown in Table A3.6.1. As it can be seen from the Table, the average pH of the soil is about 7.8 and the EC of the soil varies from a very low salinity level of 1 mS/cm (S0) to a severe salinity level of 25 mS/cm (S3). However, most of the soils in the eastern part of the Project Area are in the low (S1) to moderate salinity (S2) level with an average value of 10 mS/cm.

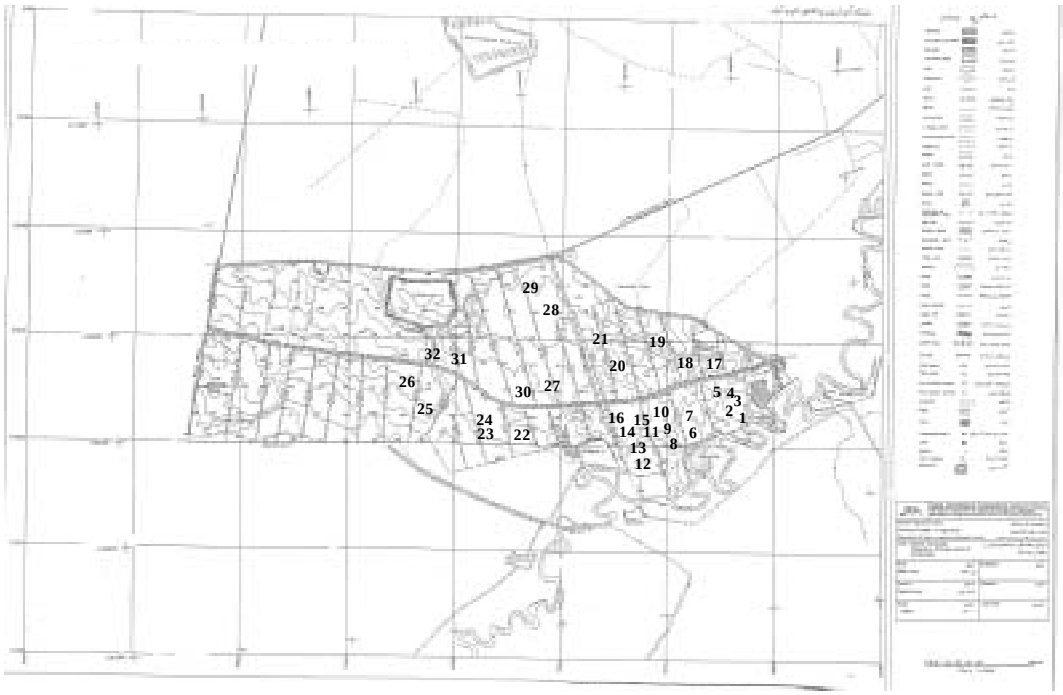


Fig.A3.6.1 Soil Sampling in Tazeh Abad Project Area Conducted through the Farmers' Cooperative (2001)

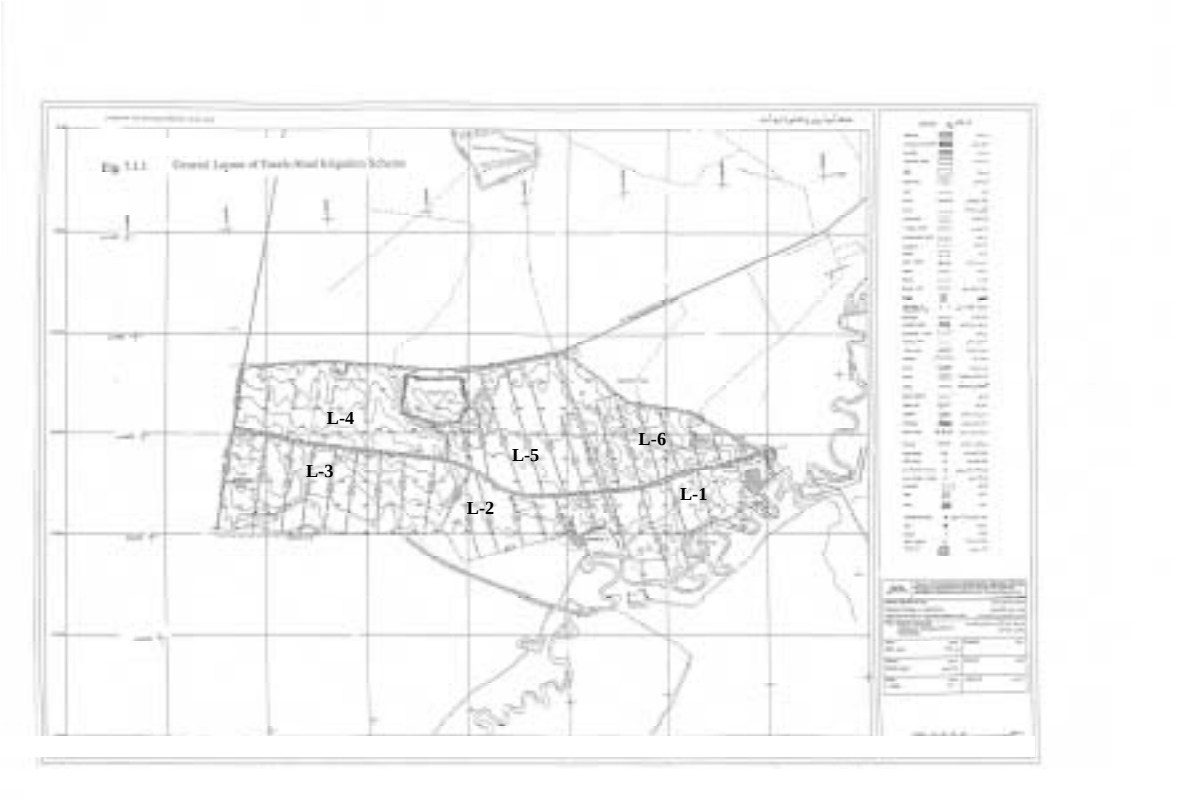


Fig. A3.6.2 Soil Sampling Locations in Tazeh Abad Project Area (JICA, Sep 2002)

Table A3.6.1 Soil Characteristics of Tazeh-Abad Project Area (2001)

Sl No.	pH	EC mS/cm	CaCO3 (%)	O.C (%)	Total N (%)	P(ava) (ppm)	K(ava) (ppm)	Clay (%)	Silt (%)	Sand (%)	Texture
1	7.8	12.5	17.0	0.9	0.20	11.5	300	18	64	18	Si-L
2	7.9	12.1	14.5	0.9	0.10	11.0	320	20	68	12	Si-L
3	7.8	8.0	12.0	1.0	0.10	6.0	290	18	70	12	Si-L
4	7.8	9.4	14.5	1.3	0.13	10.0	390	28	68	4	Si-C-L
5	7.9	1.1	14.5	1.1	0.11	2.0	300	30	58	12	Si-C-L
6	7.8	4.9	13.0	1.4	0.05	5.5	370	36	60	4	Si-C-L
7	7.8	5.2	14.5	0.9	0.05	3.5	240	22	68	10	Si-L
8	7.6	9.9	14.0	1.0	0.10	4.0	292	28	58	14	Si-C-L
9	7.9	5.8	17.0	0.6	0.00	3.0	180	16	72	12	Si-L
10	8.0	4.7	14.0	0.9	0.10	5.5	260	20	70	10	Si-L
11	7.8	25.6	12.5	0.7	0.07	2.5	210	14	78	8	Si-L
12	7.6	7.1	15.0	1.2	0.10	8.0	300	16	68	16	Si-L
13	7.7	16.3	12.5	0.8	0.08	2.5	275	20	70	10	Si-L
14	7.6	5.0	16.0	1.2	0.10	12.0	340	38	58	4	Si-C-L
15	7.9	5.1	13.0	1.0	0.10	4.0	310	48	50	2	Si-C
16	7.8	7.9	12.0	1.5	0.15	17.0	410	40	58	2	Si-C
17	7.8	9.4	13.0	1.2	0.12	4.8	400	34	62	4	Si-C-L
18	7.6	7.1	16.0	0.9	0.20	10.5	320	36	58	6	Si-C-L
19	7.7	10.4	14.5	1.0	0.10	2.0	220	32	56	12	Si-C
20	7.6	10.2	13.0	1.2	0.12	13.0	390	34	64	2	Si-C-L
21		7.9		1.3	0.13	8.0	440				
22	8.0	6.4	14.0	0.9	0.09	3.5	230	38	54	8	Si-C-L
23	7.6	14.9	14.0	1.1	0.11	2.2	190	18	74	8	Si-L
24	7.5	20.4	13.0	1.2	0.12	6.0	290	18	74	8	Si-L
25	7.8	3.7	15.5	0.9	0.05	8.0	280	30	58	12	Si-C-L
26	7.5	10.9	14.0	1.2	0.10	6.0	320	38	54	8	Si-C-L
27		7.0		1.3	0.13	7.0	380				
28	7.7	9.6	14.5	1.2	0.12	5.0	260	42	56	2	Si-C
29	7.7	10.4	16.0	0.9	0.09	5.0	230	20	74	6	Si-L
30		16.9		1.2	0.12	14.5	450				
31		8.4		1.1	0.11	4.0	290				
32		15.6		1.1	0.11	12.0	640				

The organic carbon content is mostly in the low to medium level of 1%; Similarly, the total nitrogen is also in the low to medium level of 0.10%. Although the level of phosphorus is low (<5 ppm) in some soils, it is normally in the medium level (5-10 ppm) in most of the soils in the eastern part of the Project Area. The level of potassium is in the high level of above 200 ppm for most of the soils. Texture of the soils normally varies from medium textured silt loam (silt > 60% and clay <20%) to heavy textured silty clay loam (silt >55% and clay >25%). There are also very heavy textured silty clay (silt >50% and clay >30%) soils at some locations of the Project area.

(2) Soil Survey by the Soil and Water Research Institute

The Soil and Water Research Institute conducted a semi-detailed soil survey in the Tazeh Abad Project Area, as a part of the soil survey and land classification study carried out in the Habibishan region in 1988-89[2]. The soil samples were taken at an interval of 800 m and the soil analysis was carried out. Based on the results of the soil analysis, salinity and alkalinity contours were drawn as shown in Fig.A3.6.3.

As it can be seen from the Fig.A3.6.3, the eastern part of the Project area has a moderate salinity and alkalinity level of S2A2, and the average EC values in the top, medium and bottom layers are of 8 mS/cm, 12 mS/cm, and 16 mS/cm respectively. The western part of the Project Area has a severe salinity and alkalinity level of S3A3 and the average EC values in the top, medium and bottom layers are 14 mS/cm, 26 mS/cm, and 34 mS/cm respectively. The area around the new reservoir has a very severe salinity and alkalinity level of S4A4 and the average EC values in the top, medium and bottom layers are of 34 mS/cm, 45 mS/cm, and 50 mS/cm respectively. In all the areas, the EC values in the middle and bottom layers are higher than that of the top layer of that area.

Comparing the soil analysis data of 2001 with that of 1989, it can be seen that the salinity and alkalinity levels of the Project area have not been changed significantly. The irrigation was carried out mainly in the eastern part of the project area only for one time in 2001 and the amount of water applied was not sufficient enough for drainage. Although the salinity level decreases immediately after the irrigation, the drained salts move upwards to the root zone by capillary rise because of insufficient drainage. The effect of the drainage system can be verified only after applying enough amount of irrigation and drainage water.

[2] Reference : Ahmad Mossavati, and Mohd. Yousef Naseri, Soil studies and semi-detailed land classification of Habibishan Dam Region of Gorgan-Mazandaran Province, 1989.

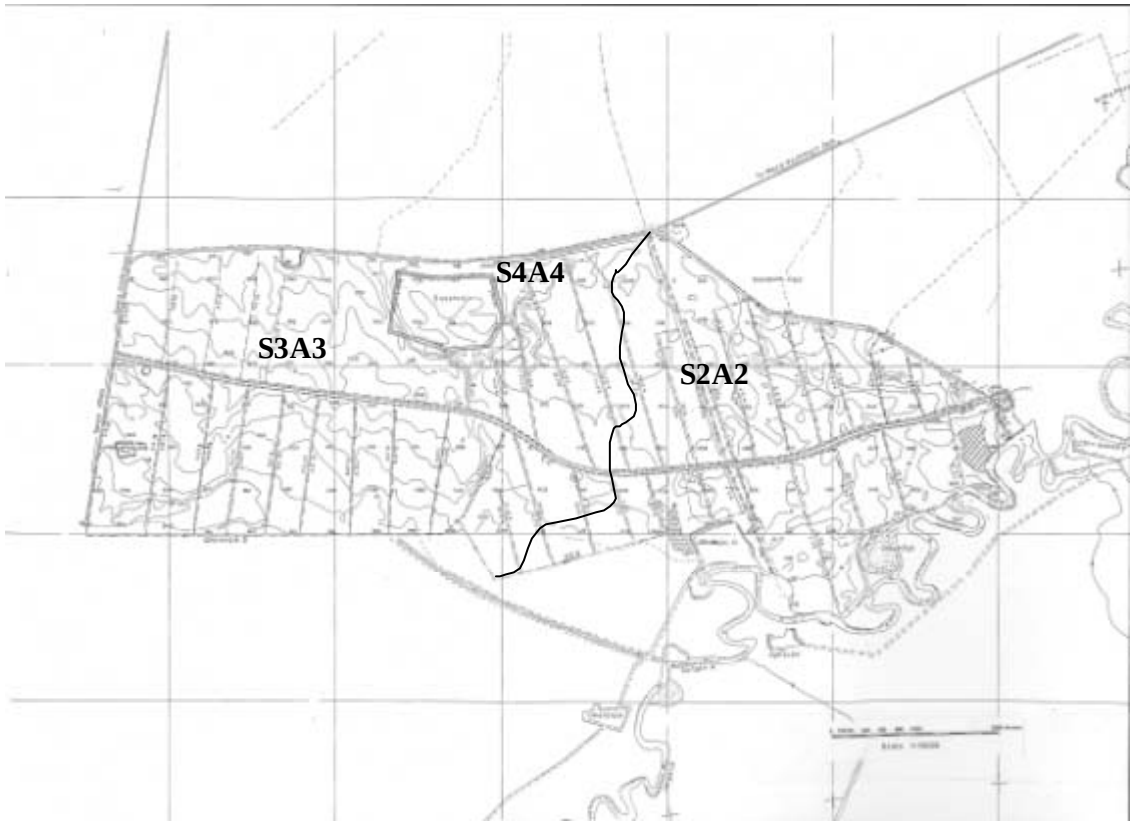


Fig.A3.6.3 Results of Semi-detailed Soil Survey in Tazeh Abad Project Area (1989)

(3) Soil Survey by JICA Study Team

Soil sampling was carried out at 6 locations of the Project Area as shown in Fig.A3.6.2 and 3 samples (one sample per each profile) were collected at each location. Some of the specific characteristics of each location are mentioned below:

Location	Area of the farm	Crops	Specific Characteristics (Yields in 2001)
1	4 ha	Wheat – Irrigated Colza – 2 years ago	Wheat – 3.2 t/ha Rape seed – 2 t/ha
2	9 ha	Barley- Irrigated	Barley - 1 t/ha
3	9 ha	Wheat – no irrigation	800-900 kg/ha
4	4.5 ha	Wheat – no irrigation	700 kg/ha.
5	8 ha	Barley – no irrigation	500 – 600 kg/ha
6	8 ha	Wheat – irrigated	2.3 t/ha

The results of soil analysis are shown in Table A3.6.2. As it can be seen from the Table A3.6.2, the pH of the soil ranges between 7.5 to 8.1, and the EC of the soil varies from a low salinity level of 7.2 mS/cm (S1) to a very severe salinity level of 32.6 mS/cm (S4). Compared to the other areas, the salinity and alkalinity level is lower in the location 1, which is located closer to the Gorgan river. The salinity levels in the bottom layers are normally higher than the top layer of that area. Sodim Adsorprtion Ratio (SAR) varies from a low level of 9.1(A1) to a severe level of 48.4 (A3).

The organic carbon content is mostly in the lower level of less than 1% and similarly the total nitrogen is in the lower level of less than 0.10%. The level of phosphorus is low (<5 ppm) in most of the locations. The level of potassium is in the higher level of above 200 ppm for upper layer, where as the potassium level reduces in the bottom layers. Cation Exchange Capacity (CEC) which shows the overall fertility status of the soil of the soils, is normally in the low (<15) to medium level (15-25).

Texture of the soils is mostly medium textured silt loam (silt > 60% and clay <30%) and silt (silt>80%). During the soil analysis, some of the samples flocculated repeatedly because of the high salt content of the soils.

Table A3.6.2 Results of Soil Analysis in Tazeh-Abad Project Area (Sep 2002)

Sample No.	Depth (cm)	pH	EC (mS/cm)	SAR	Sal / Alkali Classi-fication	CEC (me/100g)	$CaCO_3$ (%)	O.C (%)	Total N (%)	P (Ava) ppm	K (Ava) ppm	Cations (meq/l)			Clay (%)	Silt (%)	Sand (%)	Classification
												Na^{+}	$Mg^{++} + Ca^{++}$	Sum Cations				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
L1-1	0-30	7.7	7.2	9.1	S1A1	18.0	15.5	1.26	0.13	8.5	320	50.0	60.0	110.0	20	72	8	Si-L
L1-2	30-60	7.6	7.9	10.6	S1A1	17.0	20.5	0.48	0.05	3.5	180	60.0	64.0	124.0	6	90	4	Si
L1-3	60-90	7.6	9.3	14.4	S2A2	16.0	15.0	0.43	0.04	3.5	176	80.0	62.0	142.0	-	-	-	Flocculate
L2-1	0-30	7.9	29.1	43.0	S3A3	12.0	15.5	0.37	0.04	4.5	260	325.0	114.0	436.0	10	66	24	Si-L
L2-2	30-60	7.9	28.1	42.9	S3A3	10.0	17.0	0.24	0.02	3.5	136	315.0	108.0	423.0	16	70	14	Si-L
L2-3	60-90	8.0	31.2	48.4	S3A3	9.0	17.0	0.22	0.02	4.0	116	375.0	120.0	495.0	10	66	24	Si-L
L3-1	0-30	7.6	13.0	16.4	S2A2	18.0	13.0	1.18	0.12	5.5	290	104.0	80.0	184.0	-	-	-	Flocculate
L3-2	30-60	7.5	16.9	21.4	S2A2	14.0	18.5	0.30	0.03	5.0	130	150.0	98.0	248.0	6	78	16	Si-L
L3-3	60-90	7.5	20.1	21.3	S3A2	10.0	17.0	0.18	0.02	3.7	60	164.0	118.0	282.0	-	-	-	Flocculate
L4-1	0-30	7.9	8.2	22.2	S2A2	19.0	18.2	0.56	0.06	6.5	290	80.0	26.0	106.0	6	84	10	Si
L4-2	30-60	7.7	16.5	30.5	S3A3	19.0	22.0	0.37	0.04	4.7	176	170.0	62.0	232.0	-	-	-	Flocculate
L4-3	60-90	7.8	24.3	42.4	S3A3	12.0	18.0	0.21	0.02	3.2	100	275.0	84.0	359.0	-	-	-	Flocculate
L5-1	0-30	7.9	22.7	36.9	S3A3	12.0	16.5	0.85	0.09	6.7	380	250.0	92.0	342.0	-	-	-	Flocculate
L5-2	30-60	8.0	32.6	43.3	S3A3	7.0	19.5	0.14	0.01	4.5	140	360.0	138.0	498.0	-	-	-	Flocculate
L5-3	60-90	8.1	17.5	30.4	S3A3	6.0	19.5	0.13	0.01	4.2	80	180	70.0	250.0	-	-	-	Flocculate
L6-1	0-30	7.9	15.2	21.3	S2A2	16.0	15.5	0.82	0.08	11.2	400	140.0	86.0	226.0	8	84	8	Si
L6-2	30-60	7.9	17.1	25.4	S3A2	12.0	18.5	0.42	0.04	4.7	220	174.0	94.0	268.0	-	-	-	Flocculate
L6-3	60-90	7.9	16.2	24.2	S2A2	12.0	19.5	0.22	0.02	5.7	150	164.0	92.0	256.0	-	-	-	Flocculate

(4) Summary

In Tazeh Abad project area, pH of the soils is in the range of 7.5 to 8.1. When the pH is above 7.0, there is increasing liability of deficiency of micronutrients such as Zn, Mn, Cu, Fe etc. At a higher pH of above 8.0, the availability of Phosphorus to plants is reduced since calcium will be converted to calcium phosphate. In general, the salinity of the Project Area is in a severe (S3) level in the western part of the Project area, where as the eastern part of the Project Area has salinity in the moderate level (S2). Only some areas, which are close to the Gorgan river and has been irrigating has the salinity is in a lower (S1) level because of regular irrigation and drainage. Sodim Adsorprtion Ratio (SAR) varies from a low level of 9.1(A1) to a severe level of 48.4 (A3). The alkalinity level is also higher in the western part of the compared to eastern part of the Study Area. Both EC and SAR values increase at the bottom layers of the soils.

In regard to the fertility status of the soil, the CEC values indicate that the soils have a low (CEC<15) to moderate fertility (CEC<25). In the top layer of 0-30 cm, the levels of Nitrogen and Phosphorus are in the low to moderate level where as the level of K is normally in the higher level.

Texture of the soil is mostly medium textured silt-loam (silt > 60% and clay <30%). However there are also heavy textured silty clay loam (silt >55% and clay >25%) and very heavy textured silty clay (silt >50% and clay >30%) soils at some locations of the Project area.

Comparing the soil analysis data of 2001 with that of 1989, it was found that the salinity and alkalinity levels of the Project area have not been changed significantly. The irrigation was carried out mainly in the eastern part of the Project Area only for once in 2001 and the amount of water applied was not sufficient enough for drainage. Although the salinity level decreases immediately after the irrigation, the drained salts move upwards to the root zone by capillary rise because of insufficient drainage. The effect of the drainage system can be verified only after applying enough amount of irrigation and drainage water.

A3.7 Soils of Case Study Area in Mehtar Kalateh

The present conditions of the Soils in the Mehtar Kalateh Area were analyzed using the data and information collected through the following soil surveys:

1. Soil Survey by the Golestan Agriculture Organization
2. Soil Survey by the JICA Study Team

A3.7.1 Soil Surveys by the Golestan Jihad-e-Agriculture Organization

The soil samples of the Mehtar Kalateh Area were collected through the Rooyesh-e-Mehtar Kalateh cooperative and the soil analyses were carried out, which included the following parameters:

- pH
- Electrical Conductivity (EC)
- Organic matter (Organic Carbon)
- Total nitrogen
- Available Phosphorus
- Available Potassium
- Soil Texture

The locations of soil sampling carried out in 2001 are shown in Fig.A3.7.1. The results of soil analysis are shown in Table A3.7.1. As it can be seen from the Table A3.7.1, the average pH of the soil is about 8.0. The EC of the soil varies from a very low 0.7 to 3.4 mS/cm with an average value of 1.5 mS/cm. The organic carbon content is mostly in the medium level with an average value of 1.33% and similarly the total nitrogen is in the medium level of 0.14%. The level of phosphorus varies widely from a low value of 3.5 ppm to a very high value of 52.5 ppm and the average value is about 15 ppm. The level of potassium also varies widely from a low value of 120 ppm to a very high value of 580 ppm and the average value is about 260 ppm. In general, the fertility level of the northern part of the Mehtar Kalateh area towards the Gharasu river is slightly better than the southern part of the area.

Texture of the soils normally varies from medium textured silt loam (silt > 60% and clay <20%) to heavy textured silty clay loam (silt >55% and clay >25%). There are also very heavy textured silty clay (silt >50% and clay >30%) and clay (clay >40) soils at some locations of the Mehtar Kalateh area.

Fig.A3.7.1 Locations of Soil Sampling Carried out in 2001 in Mehtar Kalateh Area

Table A3.7.1 Soil Characteristics of Cheldin (Mehtar Kalateh) Project Area (2001)

Sl.No.	pH	EC mS/cm	CaCO3 (%)	O.C (%)	Total N (%)	P(ava) (ppm)	K(ava) (ppm)	Clay (%)	Silt (%)	Sand (%)	Texture
1	7.9	3.4	20.0	2.05	0.15	26.5	320	52	40	8	Si-C
2	7.8	1.3	26.5	1.64	0.16	9.5	320	44	52	4	Si-C
3	7.8	1.2	21.5	2.03	0.20	36.5	390	46	46	8	Si-L
4	7.9	1.4	19.0	2.07	0.20	52.5	580	42	32	26	C
5	8.0	1.1	22.0	1.37	0.14	16.5	210	42	48	10	Si-C
6	8.0	1.1	16.0	1.36	0.14	17.5	610	40	54	6	Si-C
7	8.1	1.3	12.0	1.39	0.14	14.0	350	38	44	18	Si-C-L
8	8.1	1.5	22.0	0.78	0.08	3.5	170	50	44	6	Si-C
9	8.0	1.6	20.5	1.13	0.11	25.0	240	30	54	16	Si-C-L
10	7.8	3.0	20.5	0.78	0.08	16.5	240	26	60	14	Si-L
11	8.2	1.4	18.0	0.98	0.10	25.0	320	20	54	26	Si-L
12	8.1	1.7	12.5	1.56	0.16	25.0	270	48	40	12	SI-C-L
13	7.9	1.2	29.5	1.42	0.14	6.5	280	40	54	6	Si-C
14	8.1	0.9	28.5	1.26	0.13	5.5	220	36	56	8	Si-C-L
15	8.2	0.8	31.0	1.02	0.10	6.0	150	26	44	30	L
16	8.1	0.7	33.5	1.08	0.11	8.0	280	30	60	10	Si-C-L
17	8.0	0.7	36.0	1.33	0.20	6.5	200	42	48	10	Si-C
18	7.9	1.2	36.0	1.24	0.12	9.5	150	34	50	16	Si-C-L
19	7.9	1.0	19.5	1.93	0.19	10.0	310	48	40	12	Si-C
20	8.0	2.2	18.0	1.08	0.10	10.0	200	28	60	12	Si-C-L
21	8.1	1.1	7.0	1.40	0.14	14.5	150	36	60	4	Si-C-L
22	8.1	0.7	19.0	0.65	0.10	5.5	120	36	54	10	SI-C-L
23	7.9	1.1	10.0	1.51	0.15	6.0	190	54	38	8	C
24	8.0	1.1	9.0	0.95	0.11	15.0	100	22	64	14	Si-L
25	8.4	2.7	5.0	1.08	0.11	20.0	170	50	24	26	C
26	8.2	2.5	5.0	1.45	0.15	15.0	200	38	58	4	Si-C-L

2) Soil Survey by JICA Study Team

Soil sampling was carried out at 4 locations of the Case Study Area as shown in Fig.A3.7.2 and 3 samples (one sample per each profile) were collected at each location. In 2002, rice was cultivated in the locations 1, 2 and 3 and soybean was cultivated in the location 4.

The results of soil analysis are shown in Table A3.7.2. As it can be seen from the Table A3.7.2, the average pH of the soil is about 8.0. The EC of the soil is at a very low salinity level of less than 2 mS/cm (S0). In general, if the soils have EC values of less than 2mS/cm, the salinity effects are negligible except for the most sensitive crops. Sodium Adsorption Ratio (SAR) is also low with values of less than 8 (S0=SAR<8).

Cation Exchange Capacity (CEC) values, which shows the overall fertility status of the soil are in the slightly higher range of above 25. Organic carbon and total nitrogen are also in the slightly higher range. Phosphorus and Potassium are also in the higher range at the root zone depth.

The most significant property of the soil in the Case Study Area is the texture of the soil with high clay content, which is mostly above 50%. In most of the cases, the clay content of the bottom layers are still higher than the top layers. Because of the clayey texture and the low infiltration rate, flooding occurs in the area, whenever there is heavy and sudden rain in and around the project area. Suitable drainage system is highly essential to solve the flooding problem of the area.

Fig.A3.7.2 Soil Sampling Locations in the Case Study Area

Table A3.7.2 Soil Characteristics of Cheldin (Mehtar Kalateh) Project Area (2001)

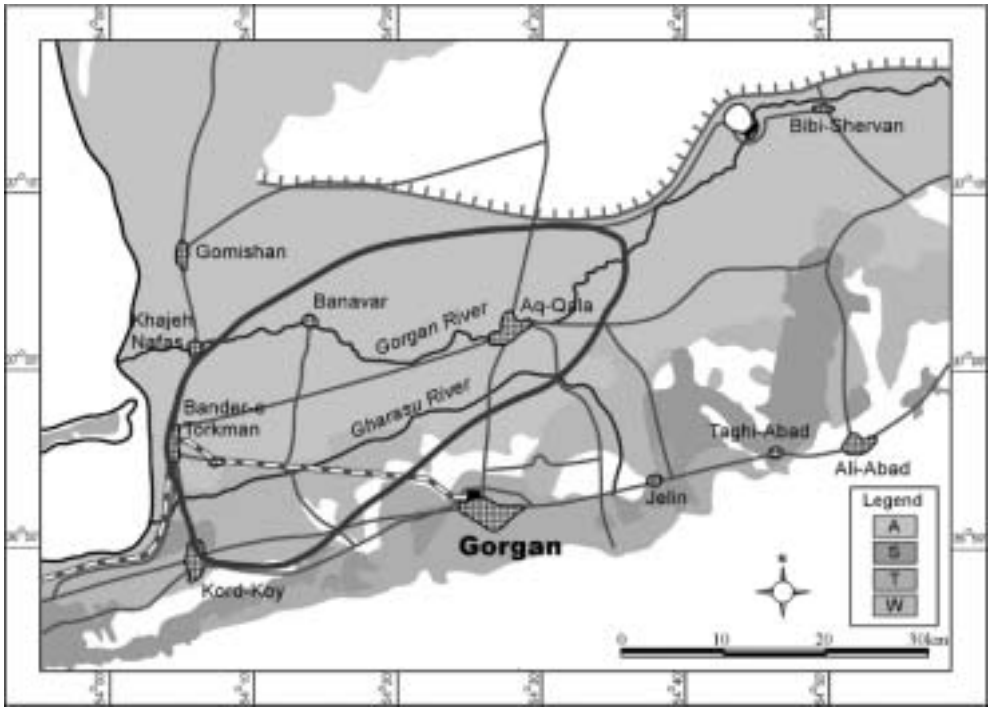
Sample No.	Depth (cm)	pH	EC (mS/cm)	SAR	CEC (me/100 g)	$CaCO_3$ (%)	O.C (%)	Total N (%)	P (Ava) ppm	K (Ava) ppm	Cations (meq/l)			Clay (%)	Silt (%)	Sand (%)	Classification
											Na^{+}	Mg^{++} + Ca^{++}	Sum Cations				
(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
L1-1	0-30	7.7	1.2	2.8	30.0	15.5	0.82	0.18	18.0	250	6.5	11.0	17.5	46	24	30	C
L1-2	30-60	8.0	1.0	2.8	32.0	18.0	0.22	0.12	4.5	180	6.0	9.0	15.0	70	26	4	C
L1-3	60-90	8.1	1.2	2.6	28.0	30.5	0.51	0.05	3.5	160	6.0	11.0	17.0	72	24	4	C
L2-1	0-30	7.9	2.1	7.8	33.2	17.5	1.67	0.17	12.5	260	17.5	10.0	27.5	62	30	8	C
L2-2	30-60	8.1	1.6	6.3	32.0	23.5	0.78	0.08	4.5	190	12.5	8.0	20.5	68	26	6	C
L2-3	60-90	8.2	1.3	4.3	30.0	30.0	0.38	0.04	4.5	130	10.0	11.0	21.0	68	22	10	C
L3-1	0-30	7.9	1.4	5.8	32.0	16.0	1.67	0.17	11.5	240	11.5	8.0	19.5	64	30	6	C
L3-2	30-60	8.2	1.0	3.7	26.0	31.0	0.57	0.06	3.5	140	7.3	8.0	15.3	62	32	6	C
L3-3	60-90	8.3	1.0	3.5	26.0	33.0	0.34	0.03	3.0	110	7.0	8.0	15.0	54	26	30	C
L4-1	0-30	7.9	1.0	2.4	33.0	15.5	1.58	0.16	8.0	290	5.0	9.0	14.0	56	40	4	Si-C to C
L4-2	30-60	8.1	1.3	4.6	30.0	19.5	0.95	0.10	4.0	200	9.2	8.0	17.2	58	36	6	C
L4-3	60-90	8.1	2.0	5.0	18.0	35.0	0.42	0.04	2.5	100	13.8	15.0	28.8	48	48	4	Si-C to C

A3.8 Major Problems of Soils of the Study Area

The major problems related to the soils in the Study Area are as follows:

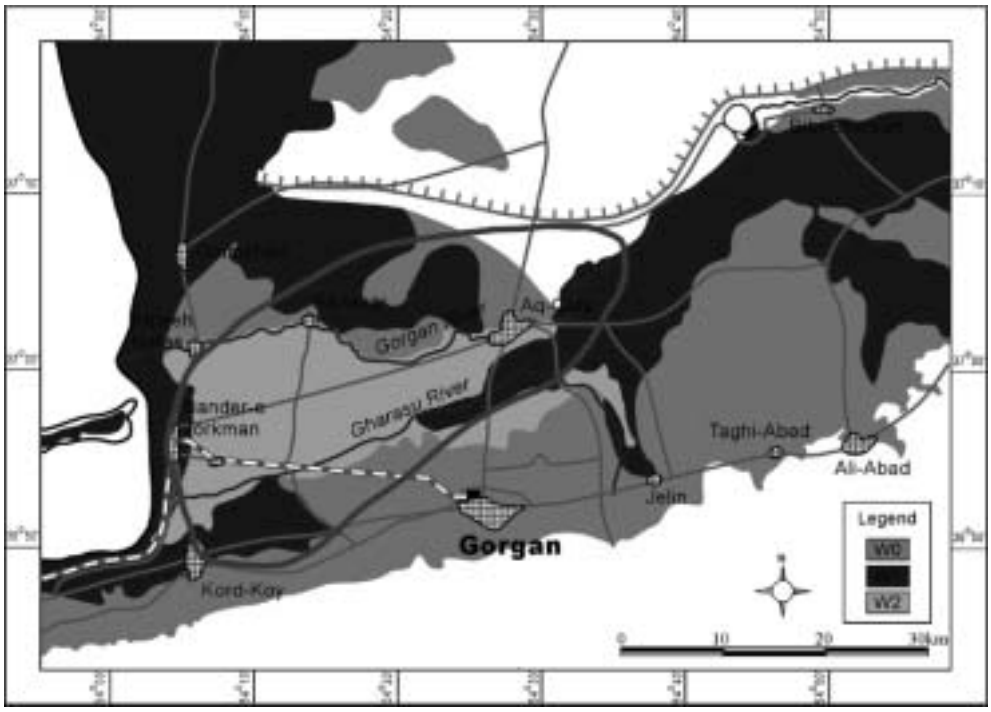
1) Salinization and alkalinization of the soils
2) Soil Limitation (texture, permeability, limiting layer, etc.)
3) Drainage limitation (groundwater depth, ponding problems, etc.)

As it can be seen from the following Figure, the northern part of the Study Area has severe salinity and alkalinity problem. The accumulation of excess amounts of soluble salts in the crop root zone is one of the major problems, which reduces the productivity of the soils. This salinization and alkalinization are caused due to various reasons, which includes geological composition of the parent materials of the soils, surface water, seawater intrusion, and poor soil and water management. Similarly, the Gaspian Sea water intrusion into the shallow groundwater in the Study Area has also lead to the salinization of the soils. The soluble salts have harmful effects due to the particular ions in excess level, which are harmful to the crops and raising the osmatic pressure of the solution around the roots of the crops. Salinity imposes serious limitations on economic crop production mostly because of lack of enough quantity of fresh water required to flash the soil out of the root zone.



Legend
A - Salinization and alkalinization
S - Soil Limitation (texture, permeability)
T - Topographic limitation
W – Drainage limitation

Major Limitations of the Soils in the Study Area
(Source : GIS Section, MOA, Golestan Province)



Legend

W0- No groundwater table limitation

W1 – Slight limitation (2-3m)

W2 – Moderate limitation (1.2-2m)

Limitations of Groundwater Depth in the Study Area

(Source : GIS Section, MOA, Golestan Province)

The soil limitation, which includes texture, and permeability are mostly in the area near Kordkuy in the Cheldin project area. This project area has a very heavy clay texture which causes water logging and ponding problem. If the soil moisture level is low, ploughing will be extremely difficult.

As it can be seen from the above Figure, the middle part of the study area has a groundwater depth of 2-3m and the groundwater depth in most of the Study Area lies within 1 to 3m. In the poorly drained areas, a large quantity of salts leached from the higher regions have accumulated in slowly flowing shallow groundwater, and the salts have ascended into the soil because of a high evapotranspiration rate.

Apart from these major limitations, other limitations include the fertility status of the soil which varies from a low to moderately high level. If leaching is carried out in an extensive manner, then there is fertility problem because of leaching of nutrients. Therefore balanced fertilization and balanced water management practices are necessary.

A3.9 Soil Improvement

The major soil improvement to be made to reclaim the soils of the Study Area can be broadly classified into two categories:

1) Reclamation of salinity, and alkalinity
2) Improving the soil fertility

A3.9.1 Reclamation of Salinity and Alkalinity

There are three basic ways to reclaim the salt affected soils as mentioned below:

1. Establish drainage through installation of drainage system
2. Leach out the soluble salts
3. Replace exchangeable sodium by gypsum, sulfer or sulfuric acid, enriched by Thiobacillus bacteria

In order to remove excess salts in these areas, establishment of an adequate drainage system along with the irrigation system is necessary. Drains of higher depths are necessary to leach out the surplus salts below the root zone. If adequate amount of low salt irrigation water is available, saline soils can be reclaimed by surface or subsurface drainage. Although the drainage system is installed in the pilot project areas, the EC values of the soils are still high because of the following reasons:

1. After installation of drainage system, the quantity of applied irrigation water is not sufficient enough to facilitate leaching.
2. The water quality of irrigation water itself is not good enough. If less amount of water is applied with the salty water, the salt content of the soil will increase.
3. In some cases, salty drainage water is pumped up and used for irrigation.

The main problem is to leach out the salts downwards and out of contact with irrigation water. The major factors determining the amount of water needed for leaching are 1) initial salt content of the soil; 2) the desired level of salt content for good growth of crops; 3) the depth to which the reclamation is required; 4) soil characteristics such as texture, permeability etc., and 5) crops and the variety to be grown. Since the water table in the Study Area is within 2 to 3m of the soil surface, leaching without drainage will have little lasting effect on soil salinity.

In order to reclaim the salty soils, sulphur (S) 200 to 500 kg/ha is recommended by Golestan J.A.O, although the actual need is more than 1 t/ha. Gypysum is not popular and is used only in very low level in the province. Although gypsum is considered to be better than sulphur, sulphur is normally recommended and applied, since it is cheaper and are readily available in the area. Although sulphur is recommended almost each year to improve the soil, only 5% of the farmers in the province apply sulphur on a regular basis.

Recently, balanced fertilization is applied to various crops, grown on salt-affected soils, and irrigated with saline water. The results have demonstrated that the split application of N-fertilizers (mostly ammonium sulfate) and potassium sulfate at higher rates than that conventionally applied, give better yield on saline soils. Apart from these methods, use of salt tolerant crops and varieties and suitable agronomic management and cultural practices such as subsoiling can be practiced in these soils. Salt tolerant of selected crops according to the USDA rating are given below:

Salt Tolerance of Selected Crops According to USDA Rating

Crop	ECe, mS/cm	ECe at 50% Yield, mS/cm	Crop	ECe, mS/cm	ECe at 50% Yield, mS/cm
Field Crops			Vegetable Crops		
Barley	8.0	18.0	Beets	4.0	9.6
Cotton	7.7	17.0	Tomato	2.5	7.6
Sugarbeet	7.0	15.0	Cucumber	2.5	6.3
Wheat	6.0	13.0	Spinach	2.0	8.6
Soybean	5.0	7.5	Potato	1.7	5.9
Sorghum	4.0	11.0	Cowpea	1.3	9.1
Groundnut	3.2	4.9	Lettuce	1.3	5.2
Rice	3.0	7.2	Onion	1.2	4.2
Sugarcane	1.7	9.8	Forage Crops		
Corn	1.7	5.9	Bermuda grass	6.9	14.7
Fruit Crops			Ryegrass	5.6	12.1
Date Palm	4.0	17.9	Alfalfa	2.0	8.8
Olive	2.7	8.4			
Pomogranate	2.7	8.4			
Orange	1.7	4.8			

A3.9.2 Improving the Fertility

1) Improving Organic Matter Content

Most of the soils of the Study Area on both the sides of Gorgan river have low organic matter (<1% O.C), and therefore, it is necessary to increase the organic matter of the soil. It can be achieved by two ways:

- Application of organic fertilizer
- Crop rotation with forage crops

At present organic fertilizer of 5-30 ton/ha is normally recommended. However, this level is relatively low considering the poor organic matter content status of the soil. Besides, the cost of organic fertilizer is also high. It is necessary to consider the crop rotation with forage crops. The cultivation of forage crops will leave a huge amount of roots in the soil, which will be converted to organic matter. Besides, the forage can be fed to the animals and their excreta can again be used in the field to increase the organic matter content of the soil. In order to improve the fertility in a long-term basis and for sustainable improvement, it is necessary to consider the crop rotation with forage crops. The forage crops shall be experimented in the Study Area in order to increase the organic matter content of the soil.

2) Improving Fertility by Application of Fertilizers

Although the amount of fertilizer recommendation varies depends on the crop, the soil expert of the Golestan J.A.O makes the fertilizer recommendation based on Soil Analysis as mentioned below:

Recommendation of Macronutrients in Golestan Province

Nitrogen		Phosphorus		Potassium	
O.C, %	Urea, kg	P, ppm	Triple super phosphate	K, ppm	Potassium Sulfate
<0.5	400	<5	150	<150	150
.5 – 1.0	350	5-10	100	150-200	100
1.0 – 1.5	250	10-15	50	200-250	50
>1.5	200	>15	0	>250	0

Mostly the acidic fertilizers such as Triple super phosphate (TSP) Potassium Sulphate or ammonium sulphate and urea are recommended to improve the fertility. Amount of fertilizer recommended is higher for irrigated cultivation and is lower for dryland cultivation.

In general, the micronutrients including Zn, Mn, Fe and Cu are least available in basic (alkaline) soils. The fertilizers including Zn SO_4 (zn = 24%), Mn SO_4 (Mn = 24%), Fe SO_4, CuSO4 (Cu = 24%), and Boric acid (17% B) are normally recommended based on the soil analysis and the crops grown. The normal recommendation levels are as follows:

Zn = 50 kg/ha, Mn = 20 kg/ha, Fe = 100 kg/ha, Cu = Not used, B = no need (if needed, 15 kg/ha).

Among the micronutrients, Zn is recommended whenever necessary. However other micronutrients such as Mn and Fe are not applied by the farmers, since the micronutrients are expensive, and some times sulphur alone is applied instead of Fe and Mn.

Apart from the two major soil improvements mentioned above, it is also necessary to improve the heavy soil texture at some parts of the Study Area. Many physical soil properties such as infiltration into the soil, soil structure, compactability, and soil moisture capacity depends on the texture of the soil, especially the clay content. In general, the soils of the Study Area is medium textured silt loam with high silt content. However, the southwestern part has a heavy clay with a clay content of about 50% which needs careful management. Some farmers near Kowsar dam area also use sediments of the dam to improve the physical and chemical characteristics of soil. These characteristics of these sediments are shown below.

pH	EC mS/cm	O.C %	Total N (%)	P(ava.) (ppm)	K(ava.) (ppm)	Clay	Silt	Sand	Texture
7.6	2.6	0.74	0.07	3.0	100	18	32	50	Loam

Although the fertility status of these sediments is in the low level, the texture of the sediments is medium texture loam with 50% of sand, which will help to improve the heavy texture soils.

In Golestan province, it is recommended to apply compost of 5-30 t/ha, when the clay content is above 20%. Besides, it is recommended to apply 50kg/ha of more potassium for heavy texture soils. Application of Urea or Ammonium nitrate should be done for 3 times in heavy soils and 4 times in lighter soils.

Table A-3.5.7 Soil Profile Characteristics (1/11)

Profile No. 1

(1) General Information

Location : 37˚00'30" N 54˚10'06" E (Banavar Project Area)
Soil Classification : Typic Xerofluents, Fine Silty, Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Wheat
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: > 120 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-18	Pale brown (10YR 6/3) when dry and dull yellowish brown (10YR 4/3) when moist; silt loam; medium granular structure; common very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; clear and smooth boundary; ploughed
C1	18-42	Dark yellowish brown (10YR4/4) when moist; silt loam; massive; common very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; clear and smooth boundary;
C2	42-80	Yellowish brown (10YR5/4) when moist; sandy loam; massive; common very fine and fine pores; fine roots; friable when moist and sticky when wet; clear and smooth boundary;
C3	80-100	Dark yellowish brown (10YR4/4) when moist; silt loam to silty clay loam; massive; common very fine pores; fine and moderate roots; friable when moist and sticky when wet; Few fine faint mottling
C4	100-120	Yellowish brown (10YR5/4) when moist; loam; massive; common very fine and fine pores; very friable when moist and sticky when wet; common medium distinct mottling dark brown ((7.5 YR4/4).

Table A-3.5.7 Soil Profile Characteristics (2/11)

Profile No. 2

(1) General Information

Location : 37˚01'37" N 54˚11'45" E (Banavar Project Area)
Soil Classification : Typic Xerofluents, Fine Silty, Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Barley
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: > 110 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-25	Pale brown (10YR 6/3) when dry and dull yellowish brown (10YR 4/3) when moist; silt loam; medium granular structure; common very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; clear and smooth boundary; ploughed
C1	25-50	Dark yellowish brown (10YR4/4) when moist; silt loam; massive; common very fine and fine pores; very fine roots; friable when moist and sticky when wet; clear and smooth boundary;
C2	50-90	Yellowish brown (10YR5/4) when moist; silt loam; massive; common very fine and fine pores; very fine roots; friable when moist and sticky when wet; gradual and smooth boundary
C3	90-110	Reddish brown (2.5YR4/4) when moist; silt loam; massive; common very fine pores; friable when moist and sticky when wet; few fine faint mottling dark brown ((7.5 YR4/4)

Table A-3.5.7 Soil Profile Characteristics (3/11)

Profile No. 3

(1) General Information

Location : 37˚00'30" N 54˚23'12" E (Agghala Project Area)
Soil Classification : Aquic Xerofluents, Fine Silty, Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Aquic- Thermic
Drainage Class: Poorly drained
Land use : Barley
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding P1 (Slight limitation)
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: >100 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-22	Dark greyish brown (2.5Y4/3) when moist; silty clay; medium granular structure; common very fine and fine pores; very fine roots; friable when moist and sticky when wet; clear and smooth boundary; ploughed
C1	22-53	Olive brown (2.5Y4/4) when moist; silt loam; massive; common very fine and fine pores; very fine roots; friable when moist and sticky when wet; few fine faint mottling; gradual and smooth boundary
C2	53-100	Light olive brown (2.5Y5/4) when moist; sandy loam; massive; common fine pores; friable when moist and slightly sticky when wet; common medium distinct mottling

Table A-3.5.7 Soil Profile Characteristics (4/11)

Profile No. 4

(1) General Information

Location : 37˚02'10" N 54˚23'00" E (Agghala Project Area)
Soil Classification : Typic Aquisalids, Fine Silty, Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Aquic- Thermic
Drainage Class: Poorly drained
Land use : Fallow
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding P1 (Slight limitation)
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: 80 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-20	Brown (10YR4/3) when moist; silty loam; medium granular structure; common very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; gradual and smooth boundary
C1	20-40	Olive brown (2.5YR4/4) when moist; silt loam; massive; common very fine and fine pores; very fine roots; friable when moist and sticky when wet; gradual and smooth boundary
Cg1	40-100	Yellowish brown (2.5Y4/2) when moist; silt loam; massive; common fine pores; very friable when moist and sticky when wet; few fine faint mottling dark brown ((7.5 YR4/4); gradual and smooth boundary
Cg2	100-120	Olive brown (2.5Y4/4) when moist; silt loam; massive; common very fine and fine pores; friable when moist and sticky when wet; common medium distinct mottling dark brown ((7.5 YR4/4)

Table A-3.5.7 Soil Profile Characteristics (5/11)

Profile No. 5

(1) General Information

Location : 300 m North of Sanneh Bala
36˚56'50" N 54˚23'20" E
Soil Classification : Typic Haploxerolls

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Wheat
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: >100 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-28	Grayish brown (10YR5/2) when dry and very dark grayish brown (10YR3/2) when moist; silt loam; moderate fine medium granular structure; many very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; abrupt boundary; ploughed
Bk	28-48	Olive brown (2.5Y4/4) when moist; silt loam; medium angular blocky structure; many very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; gradual and smooth boundary
C	48-100	Light olive brown (2.5Y5/4) when moist; silt loam; massive; common fine pores; fine roots; common medium distinct mottling dark yellowish brown (10YR4/4); gradual and smooth boundary

Table A-3.5.7 Soil Profile Characteristics (6/11)

Profile No. 6

(1) General Information

Location : 37˚05'12" N 54˚32'30" E (Tazeh-Abad Project Area)
Soil Classification : Haploxerepts, Fine Silty, Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Wheat
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: >120 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-22	Pale brown (10YR6/3) when dry and brown (10YR4/3) when moist; silt loam; medium granular structure; common very fine and fine pores; very fine and fine roots; friable when moist; clear and smooth boundary
Bw1	22-54	Dark yellowish brown (10YR4/4) when moist; silt loam; coarse and medium angular blocky structure; common very fine and fine pores; very fine and fine roots; friable when moist; clear and smooth boundary
Bw2	54-90	Dark yellowish brown (10YR4.5/4) when moist; silty clay loam to silt loam; coarse and medium angular blocky structure; common very fine and fine pores; friable when moist; clear and smooth boundary
C	90-120	Yellowish brown 10YR5/4) when moist; silt loam; massive; common very fine and fine pores; friable when moist

Table A-3.5.7 Soil Profile Characteristics (7/11)

Profile No. 7

(1) General Information

Location : 37˚05'10" N 54˚28'05" E (Tazeh-Abad Project Area)
Soil Classification : Calcixerepts, Fine Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Barley
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 4 (Slow)
Stoniness/Rockiness : No
Depth to groundwater: >100 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-22	Brown (10YR4/3) when moist; silty clay to silty clay loam; medium granular structure; many very fine and fine pores; very fine and fine roots; firm when moist and very sticky when wet; clear and smooth boundary
Bw1	22-70	Dark yellowish brown (10YR4/4) when moist; silty clay; medium and fine subangular blocky structure; many very fine and fine pores; very fine and fine roots; very firm when moist and very sticky when wet; gradual and smooth boundary
Bw2	70-100	Dark yellowish brown (10YR5/4) when moist; silty clay loam; coarse and medium angular blocky structure; many very fine and fine pores; few medium roots; friable when moist; firm when moist and very sticky when wet

Table A-3.5.7 Soil Profile Characteristics (8/11)

Profile No. 8

(1) General Information

Location : 7 km North of Aghghala
37˚06'00" N 54˚28'10" E

Soil Classification : Calcixerepts, Fine Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Barley
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 4 (Slow)
Stoniness/Rockiness : No
Depth to groundwater: >120 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-15	Brown (10YR5/3) when dry and (10YR4/3) when moist; silty clay loam; medium granular structure; many very fine and fine pores; very fine and fine roots; friable when moist; clear and smooth boundary; ploughed
Bw	15-45	Dark yellowish brown (10YR4/4) when moist; silty clay; medium and fine subangular blocky structure; many very fine and fine pores; very fine roots; firm when moist and very sticky when wet; gradual and smooth boundary
Bk	45-120	Dark yellowish brown (10YR4.5/4) when moist; silty clay; coarse and medium angular blocky structure; many very fine and fine pores; firm when moist and very sticky when wet

Table A-3.5.7 Soil Profile Characteristics (9/11)

Profile No. 9

(1) General Information

Location : 3 km South of Aragh Kocheg
36˚56'15" N 54˚15'06" E
Soil Classification : Typic Haploxerolls

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Well drained
Land use : Barley
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 3 (Moderate)
Stoniness/Rockiness : No
Depth to groundwater: >100 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-23	Brown (10YR5/3) when dry and dark brown (10YR3/3) when moist; silt loam; coarse and medium granular structure; common very fine and fine pores; very fine and fine roots; friable when moist and sticky when wet; clear and smooth boundary; ploughed
C1	23-40	Dark yellowish brown (10YR4/4) when moist; silt loam; massive; common very fine and fine pores; fine and medium roots; friable when moist and sticky when wet; gradual and smooth boundary
Bb	40-65	Brown (10YR4/3) when moist; silt loam; medium and fine angular blocky structure; fine and medium roots; firm when moist and very sticky when wet ; gradual and smooth boundary
C11	65-80	Yellowish brown (10YR5/4) when moist; silt loam; massive; friable when moist ; gradual and smooth boundary
C12	80-100	Dark yellowish brown (10YR4/4) when moist; silt loam; massive; very friable when moist and sticky when wet

Table A-3.5.7 Soil Profile Characteristics (10/11)

Profile No. 10

(1) General Information

Location: 100 m East of Agriculture Education Center
36˚50'05" N 54˚08'07" E
Soil Classification : Typic Endoaquepts, Fine Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Very Poorly drained
Land use : Trifolium
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding P2 (Moderate limitation)
Permeability 4 (Slow)
Stoniness/Rockiness : No
Depth to groundwater: >100 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-35	Olive gray (5Y3.5/2) when moist; silty clay to silty clay loam; coarse and medium angular blocky structure; many very fine and fine pores; very fine and fine roots; friable when moist and very sticky when wet; clear and smooth boundary
Bk	35-75	Olive (5Y5/3) when moist; silty clay; coarse and medium angular blocky structure; many very fine and fine pores; fine roots; firm when moist and sticky when wet; clear and smooth boundary; Common medium distinct mottling of color of dark brown 7.5YR(4/4)
Bg	75-100	Olive gray (5Y4/2) when moist; silty clay to silty clay loam; medium and fine angular blocky structure; many very fine and fine pores; very firm when moist and very sticky when wet; Common medium distinct mottling of color of dark brown 7.5YR(4/4)

Table A-3.5.7 Soil Profile Characteristics (11/11)

Profile No. 11

(1) General Information

Location: 1 km South of Sigeval
36˚52'50" N 54˚07'00" E
Soil Classification : Typic Endoaquolls, Fine Mixed Thermic

(2) Site Characteristics

Parent material : Alluvium
Climate: Xeric- Thermic
Drainage Class: Imperfectly drained
Land use : Colza
Relief / Slope : 0 / A (0-2.0%)
Erosion : E0
Run off : Slow
Ponding No
Permeability 4 (Slow)
Stoniness/Rockiness : No
Depth to groundwater: >100 cm

(3) Soil Profile Characteristics

Horizon	Depth,cm	Profile Description
Ap	0-25	Gray (5Y5/1) when moist; silt loam; granular structure; many very fine and fine pores; very fine roots; firm when moist; clear and smooth boundary
Bg	25-40	Olive Gray(5Y5/2) when moist; Clay; coarse and medium angular blocky structure; many very fine and fine pores; fine roots; very sticky when wet; clear and smooth boundary; few fine faint mottling of color of dark brown 7.5YR(4/4) ; clear and smooth boundary
Bg	40-100	Olive (5Y4/3) when moist; silty clay; coarse and medium angular blocky structure; many very fine and fine pores; very sticky when wet; common medium distinct mottling of color of dark brown 7.5YR(4/4)

Fig. A3.5.7 Profile Sampling (1)

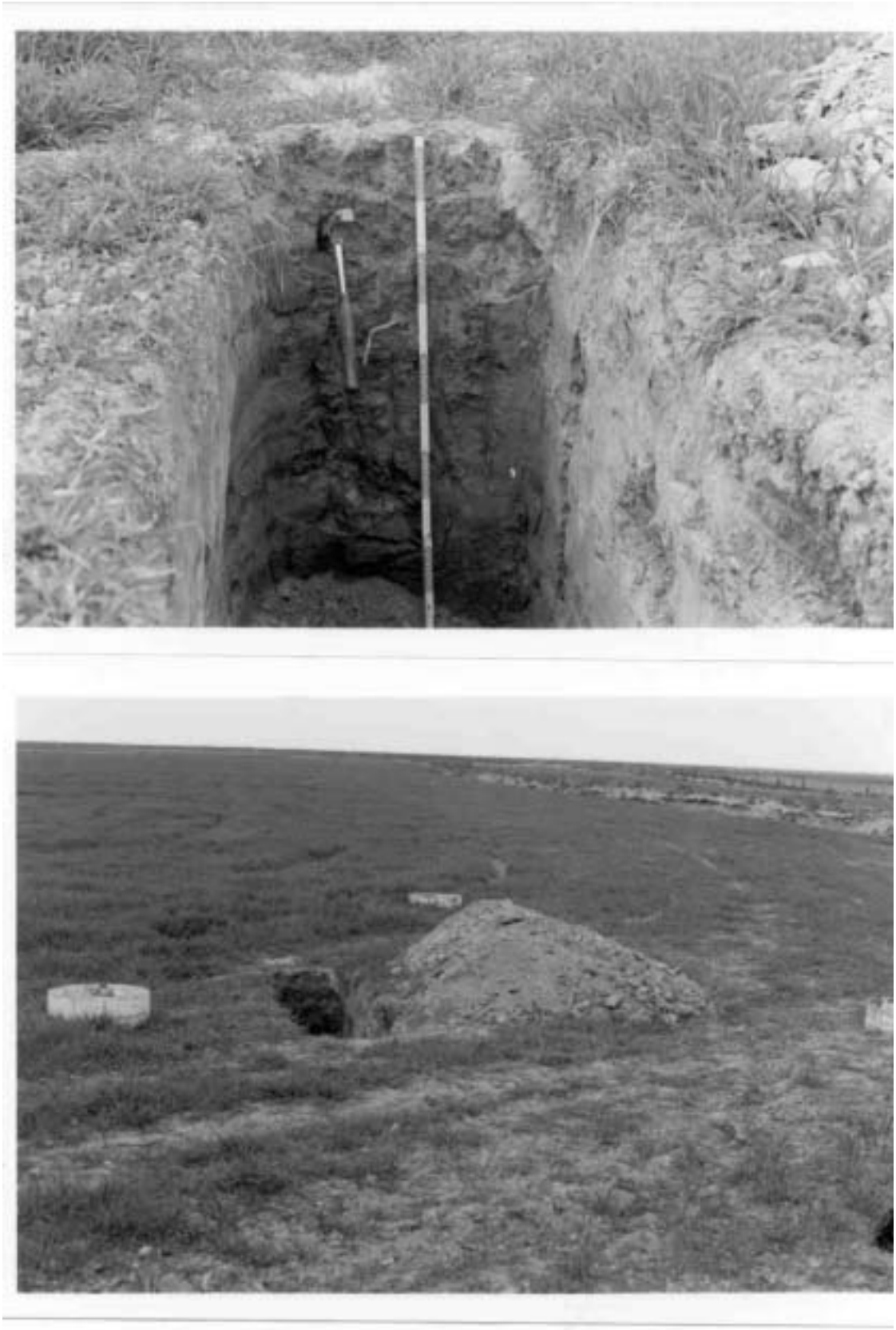


Fig. A3.5.7 Profile Sampling (2)

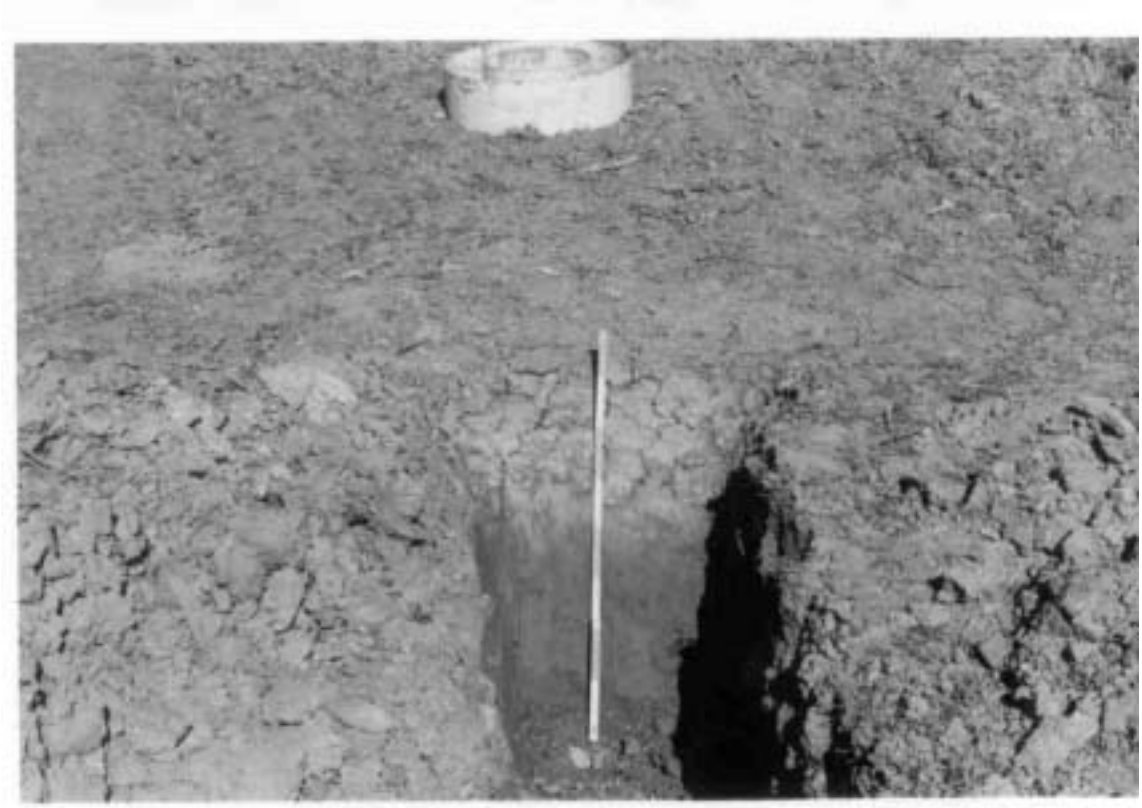


Fig. A3.5.7 Profile Sampling (2)

Fig. A3.5.7 Profile Sampling (3)

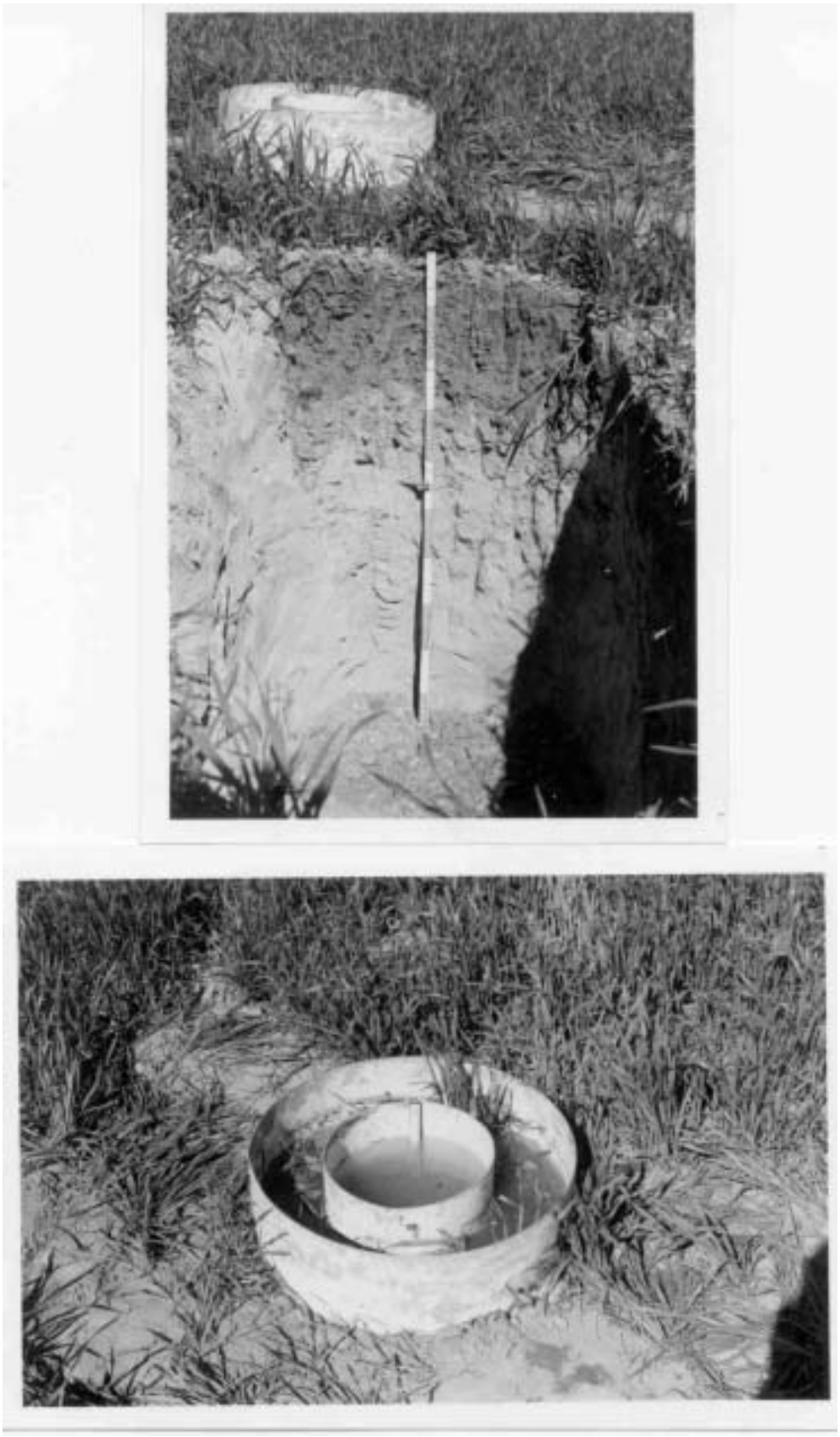


Fig. A3.5.7 Profile Sampling (4)

Annex 4 Irrigation and Drainage

ANNEX 4

IRRIGATION AND DRAINAGE

A4.1 Existing Irrigation and Drainage Schemes in the Study Area

This chapter reports the facts found through both of the 1st and the 2nd field survey on irrigation and drainage related aspects to provide references to nominate potential development area, while examining solution options for further improvement and development of existing irrigation and drainage schemes in the Study Area.

A4.1.1 Existing Conditions of the I&D Schemes

(1) Existing Irrigation Scheme in the Study Area

1) Number of Irrigation Scheme and Irrigated Area

There are 6 irrigation schemes in the Study Area. The Provincial Government provided primary facilities for 5 of them. The remaining Cheldin area has been developed by the farmers themselves from old days (refer to Table A4.1.1). The schemes area varies from 1,000 to 3,300 ha, totalizing an area of 14,000 ha. The total arable land is estimated in about 7,800ha (which might be 8,800 ha, if included the farm area that is now under construction). The mentioned arable land, 7,800ha, represents 18% of the total estimated farm area (48,000 ha) in the Study Area. So the area of the 6 schemes represents a minority. The dry land farming area shares majority in the Study Area.

The irrigation schemes provided by the Government's initiative are quite new approaches and might be called "extraneous farming" due to their shallow history (less than 10 years) and small area, comparing with the entire Study Area. Also, none of those 6 schemes irrigated completely their area since their establishment. So, the "irrigation farming" called by the Government seems to be "a measure to supplying supplemental water" to the dray farming in the actual condition.

The farm land classified as " Dry land farming area " is again divided into two groups: areas utilizing river water with private pumps or groundwater (classified as "Individual irrigation area") and dry farming area, with no irrigation water, that depends on rainfall only (classified as "Dry farming area"). " Individual irrigation area" is also not satisfied completely with water for irrigation, having part of his tenured land depending on rainfall to be cultivated. It is quite difficult to classify the properties in "Irrigated farm" and "Dry land farm" actually in the Study Area.

2) Project Area and Irrigation Area

The meaning of the "Project Area" here is not "irrigation benefited area", but area covered by an open drainage system which was provided as preparatory works about 10 years ago. At that time the local Government recognized the importance to provide such open channel drainage system to protect the land from the salinization. So, those systems were constructed during the initial stage of the water resources study to secure the introduction of irrigation practice in the Area.

The lack of storage facilities in the irrigation system carried to a variation of the irrigable

area from year to year. The irrigation area was affected by the river discharge changes. Information of areas of each irrigation schemes are summarized in Table A4.1.1and A4.1.2.

Comparing the planned irrigable area and actual irrigated area, no irrigation scheme has ever completed whole irrigation through the irrigation system. There is a big difference between the planned and real area.

3) Soil

Silt-Loam prevails in the soils of the irrigation schemes, with the occurrence of Silt-Clay in some parts. The permeability is classified as “Slow” or “ Moderate” closed to “Slow” with FAO criteria, which oscilates around 20cm/hr in the area. Regarding to the classification of salinity and alkalinity, the whole area, excluding Cheldin district, is considered “Risky Area”. Especially the west part of Banaver Scheme, Shad Mehr Scheme and Gomishan Kesht Scheme are considered “Quite High Risk Area” for ordinary agriculture.

(2) Classification of Irrigation Schemes By Water Sources

1) Water Source for Irrigation Schemes Provided by the Government

5 irrigation schemes, excluding Cheldin Area, depends on Gorgan River as irrigation water source. Almost half or more than half of the area still depends on the rainfall. The most utilized irrigation method is the “Basin Irrigation”. They are utilizing water from streams of the piedmonts and groundwater individually in Cheldin area.

2) Private Irrigation Scheme Along the Gorgan River

About 13,000 ha along the Gorgan river is under cultivation utilizing water from the Gorgan River by private pumps. The total number is assumed to be about 450 pumps according to the records of the Water Organization, Golestan, as reported in the sub-chapter of “Hydrology”. (The record is for whole downstream area of Voshmgir Dam).

Those pumped river water is used as supplement supply to the dry land farming. They convey the water through small ditches (0.3mW-0.2mH) from the pump outlet to their own farm. They are not providing drains particularly.

Most of those private irrigation had already been started before the introduction of the Government irrigation scheme.

3) Private Groundwater Irrigation Scheme

Many wells are concentrated in the downstream of the area bounded by Gorgan River and Gharasu River, which are utilized as irrigation source for private farms. It is said that total number of the well there reaches more than 2,600. According to the interview, well owners are using those wells for their own consumption, not sharing or selling water to others.

The “Irrigation scheme” in this sub-chapter is for “ Irrigation Scheme Provided the Government” hereunder if there is no explanation

Table A4.1.1 General Information of Existing Irrigation Schemes in the Study Area

Common Name in S/W			Tazeh-Abad	Agghala		Banaver		Cheldin
Number			No.1	No.2	No.3	No.4	No.5	No.6
Name of Irrigation Project			Tazeh-Abad	Aghghalla (Aghghabar)	Shadi Mehr	Gomishan	Gomishan	Mehtar Kola
Name of Cooperative			Peivand	Hemmat	Shadi Mehr	Banaver	Gomishan Kesht	Rooyesh-e-Mehtar
Name of District			Agghala	Agghala, Torkaman	Agghala	Bandar-e-Torkaman	Bandar-e-Torkaman	Kord Kuy
Name of Dehstan			Aghdakesh, Tazeh	Sahneh sofia, Delije	Delije Kashakheh	Banaver	BasirAbad- Camlar	Mehtar Kalate
Name of Deh			Tazeh Abad	Sahneh	Delije	Banaver, Gharghi, Katoelk	Gharghi Nardanly	Mehtar Kalate
Number of Farms			464	163	40	279	700	605
Number of Cooperative members			341	170	379	157	280	450
Project In-Charge Agency			JeAO	JeAO	JeAO	JeAO	Jihad > JeAO	JeAO
Water Sources			Gorgan River	Gorgan River	Gorgan River	Gorgan River	Gorgan River	Groundwater
Pump capacity			9 pumps @ 300 lit./sec	5 pumps @ 300 lit./sec	3 pumps @ 250lit./sec	5 pumps @ 300 lit./sec	5 pumps @ 160 lit./sec 5 pumps @ 240 lit./sec	individual pumps & streams
Project Area			3,500 ha	1,250 ha	1,170 ha	1,780 ha	4,800 ha	1,588.5 ha
Latitude			N37-05'-00" > 37-07'-	N36-58 > 37-1	N37-2-30	N36-59>37-1	N37-2	N36-50>36-51
Longitude			E54-28'-00" > 54-36'-	E54-21>54-26	E54-24-30	E54-11>54-12	E54-12	E54-11>54-13
Design irrigable area.			2,000.0 ha	900.0 ha	0.0 ha	1,450.0 ha	2,000.0 ha	1,400.0 ha
Present irrigated area.			1,200.0 ha	650.0 ha	0.0 ha	650.0 ha		1,400.0 ha
Main crops			Cotton, Wheat, Barley,	Cotton, Wheat, Barley	Cotton, Wheat, Barley	Cotton, Wheat, Barley	Cotton, Wheat, Barley	Cotton, Wheat, Barley,
Expected yield	Wheat		4,000.0 kg/ha	3,500.0 kg/ha	3,000.0 kg/ha	4,000.0 kg/ha	4,000.0 kg/ha	5,000.0 kg/ha
	Barley		3,000.0 kg/ha	3,000.0 kg/ha	2,000.0 kg/ha	3,000.0 kg/ha	3,000.0 kg/ha	4,000.0 kg/ha
	Cotton		2,500.0 kg/ha	2,500.0 kg/ha	2,000.0 kg/ha	3,000.0 kg/ha	3,000.0 kg/ha	4,000.0 kg/ha
	Sunflower		2,000.0 kg/ha	1,800.0 kg/ha	- - - - - -	2,000.0 kg/ha	2,000.0 kg/ha	2,500.0 kg/ha
	Way of the above estimation		Field experience	Field experience	Field experience	Field experience	Field experience	Field experience
Landuse	Farm		3,259.0 ha	1,182.0 ha	1,000.0 ha	1,450.0 ha	4,728.0 ha	
	Farm road		42.0 ha	22.0 ha	7.0 ha	19.4 ha	21.4 ha	
	Residential area		2.0 ha	1.0 ha	1.5 ha	1.0 ha	1.0 ha	
	Pond		150.0 ha	14.0 ha	80.0 ha	0.3 ha	0.0 ha	50.0 ha
	Canal		47.0 ha	31.0 ha	22.5 ha	30.5 ha	49.6 ha	
Soil Sampling Results *	EC	Top layer (mS/cm)	7.9 7.5	13.9	13.1	23.2 11.6		1.6
		Middle layer (mS/cm)	9.7 12.3	22.9	23.4	21.0 12.9		1.4
		Bottom layer (mS/cm)	12.1 9.6	24.4	28.8	10.7 14.2		1.4
	pH	Top layer	8.0 8.0	7.9	8.0	7.7 7.7		7.9
		Middle layer	8.0 7.9	7.7	8.1	7.7 7.8		8.3
		Bottom layer	8.1 8.1	8.1	8.2	7.9 7.9		8.3
	Texture	Top (Sand-Silt-Clay)	12-62-26 10-50-40	8-48-44	16-64-20	16-62-22 10-70-20		6-54-40
		Middle (Sand-Silt-Clay)	10-74-16 8-44-48	22-54-24	18-68-14	18-72-10 6-76-18		4-54-42
		Bottom (Sand-Silt-Clay)	8-64-28 6-46-48	50-44-6	18-70-12	66-30- 4 34-60-6		6-54-40
		Classification	Si-L Si-CL Si-L	Si-L	Si-L	Si-L Si-L		Si-C Si-CL
Electricity availability			Available	Available	Available	Available	Available	Available
Development History	Year : Planning		1993 - 1997	1992 - 1993	1997	1993	1998	1996
	Year : Drain started		1998	1994	1999	1994	1999	--
	Year : Pump station provided		1998	1994	2001	1994	2000	--
	Year : Watering started		1999	1996		1996	2002	99
	Year : Cooperative set		1997	1996	1998	1995	1997	1997
	Phase-1	Construction period	1998 - 2000	1994 - 1999	1997 - 2001	1994 - 1999	1998 - 2002	1996 - 1998
		Area developed	2,000.0 ha	900.0 ha	1,000.0 ha	650.0 ha	2,000.0 ha	400.0 ha
		Cost Disbursed	1,200.0 Million Rials	450.0 Million Rials	1,000.0 Million Rials	350.0 Million Rials	750.0 Million Rials	
	Phase-2	Construction period	2002 - 2004	2003 - 2005	2002 - 2004	2003 - 2006	2002 - 2006	1999 - 2004
		Area developed	1,200.0 ha	600.0 ha	0.0 ha	850.0 ha	2,800.0 ha	1,200.0 ha
		Cost Estimated						

* Note Results are referred from 1st Field Survey
Top : 0 - 20, Middle : 20 - 40/50, Bottom : 40/50 - 100

Source : Golestan Province JAO, Soil & Water

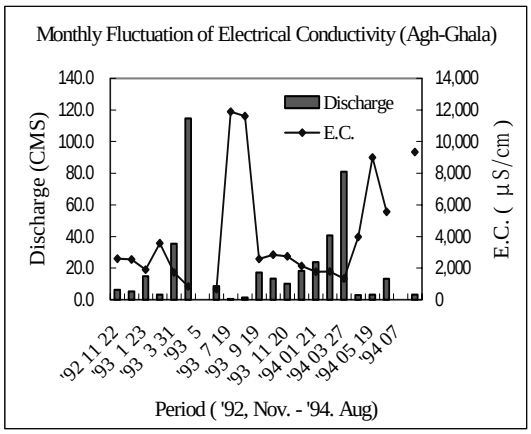
Table A4.1.2 Irrigation Canals of Existing Irrigation Schemes in the Study Area

Number		No.1	No.2	No.3	No.4	No.5	No.6
Name of Irrigation Project		Tazeh-Abad	Aghghalla (Aghghabar)	Shadi Mehr	Gomishan	Gomishan	Cheldin
Name of Cooperative		Peivand	Hemmat	Shadi Mehr	Partov	Gomishan Kesht	Rooyesh-e-Mehtar
Irrigation Canal : Main	Canal flow capability	2,400 lit./sec	1,250 lit./sec		1,250 lit./sec	800 lit./sec	
	Canal bottom width	0.70 m	0.76 m		0.60 m	0.55 m	
	Canal depth	1.25 m	0.95 m		1.10 m	0.80 m	
	Canal free board						
	Canal long-gradient	1 / 2,000	1 / 2,000		3 / 10,000	3 / 10,000	
	Canal side slope	1 : 1.5	1 : 1.5		1 : 1.5	1 : 1.5	
	Canal structure	Concrete lining	Concrete lining		Concrete lining	Concrete lining	
	Total length	0.50 Km	4.00 Km		0.70 Km	4.00 Km	
Irrigation Canal : Main (1dgre	Canal flow capability	1,200 lit./sec			870 lit./sec		
	Canal bottom width	0.50 m			0.60 m		
	Canal depth	0.90 m			0.90 m		
	Canal free board						
	Canal long-gradient	1 / 2,000			3 / 10,000		
	Canal side slope	1 : 1.5			1 : 1.5		
	Canal structure	Concrete lining			Concrete lining		
	Total length	5.00 Km			1.15 Km		
Irrigation Canal : Main (2dgre	Canal flow capability				330 lit./sec		
	Canal bottom width				0.30 m		
	Canal depth				0.75 m		
	Canal free board						
	Canal long-gradient				3 / 10,000		
	Canal side slope				1 : 1.5		
	Canal structure				C.L:1.6km. E.L:4.6km		
	Total length				6.20 Km		
Irrigation Canal : Main (2dgre	Canal flow capability				550 lit./sec		
	Canal bottom width				0.30 m		
	Canal depth				0.75 m		
	Canal free board						
	Canal long-gradient				3 / 10,000		
	Canal side slope				1 : 1.5		
	Canal structure				C.L:1.0km. E.L:5.0km		
	Total length				6.00 Km		
Irrigation Canal : Secondary	Canal flow capability	2,400 lit./sec	120 lit./sec		70 - 100 lit./sec	1,000 lit./sec	
	Canal bottom width	1.50 m	0.30 m		0.20 m	0.55 m	
	Canal depth	1.50 m	0.60 m		0.40 m	0.95 m	
	Canal free board						
	Canal long-gradient	1 / 2,500	6 / 10,000		1 / 2,500	3 / 10,000	
	Canal side slope	1 : 1.5	1 : 1.5		1 : 1.5	1 : 1.5	
	Canal structure	Earth lining	Earth lining		C.L:1.5km. E.L:8.5km		
	Total length	8.70 Km			10.00 Km	2.00 Km	
Drainage Canal : Main	Canal flow capability	- - -	- - -		- - -	- - -	
	Canal bottom width	1.00 m	6.00 m	1.40 m	3.00 m	5.50 m	
	Canal depth	2.00 m	2.50 m	2.00 m	2.50 m	1.40 m	
	Canal free board						
	Canal long-gradient	1 / 2,000	1 / 2,000	6 / 10,000	3 / 10,000	3 / 10,000	
	Canal side slope	1 : 1.5	1 : 1.5	1 : 1.5	1 : 1.5	1 : 1.5	
	Canal structure	Earth lining	Earth lining		Earth lining	Earth lining	
	Total length	11.50 Km	4.00 Km	7.00km+5.00km	8.80 Km	26.00 Km	
Drainage Canal : Secondary	Canal flow capability	- - -	- - -		- - -	- - -	
	Canal bottom width	0.50 m	1.00 m	1.00 m	1.50 m	1.00 m	
	Canal depth	1.50 m	1.50 m	1.40 m	1.50 m	1.30 m	
	Canal free board						
	Canal long-gradient	1 / 2,000	1 / 2,000	6 / 10,000	3 / 10,000	3 / 10,000	
	Canal side slope	1 : 1.5	1 : 1.5	1 : 1.5	1 : 1.5	1 : 1.5	
	Canal structure	Earth lining	Earth lining		Earth lining	Earth lining	
	Total length	34.00 Km	4.00 Km	26.50 Km	26.00 Km	45.00 Km	

Source : Golestan Province JAO, Soil & Water

(2) Irrigation Source

The Gorgan River discharge decreases from rainy season (November to February, 80CMS to 20CMS) to the dry season (less than 1.5CMS) at Aq Qala. The electrical conductivity (EC) raises from rainy season (about 1,800 μS/cm) to the dry season (about 12,000 μS/cm). This EC increase is observed when the discharge decreases in the dry season to the base flow only, which includes high quantity of salt coming from the deep soil layers and flows of agricultural drainages.



Note : Both of river discharge and E.C.values are momentary.
Source : W.O, Golestan, MOE, Results of river water discharge observation.

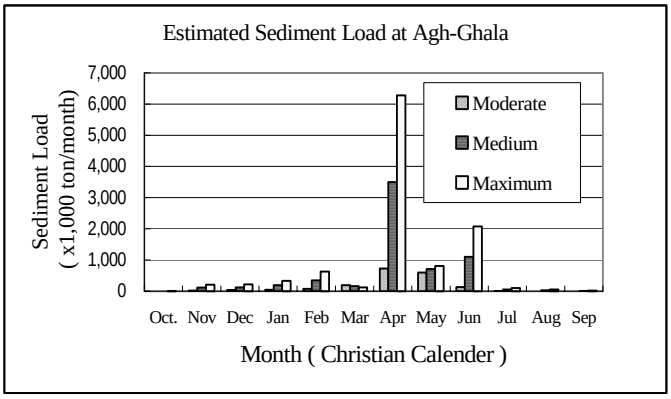
Also "sediment" is there as another characteristic of the river water. The river flows down while incising almost flat basin deposited with loess. Both side banks of the river section are forming vertical slide walls with about 10m fall. Seasonal high waters excavate those loess walls and river bed every time. Hence concentration of TSS is high through the year. Agency in charge of rivers estimates that about 6.36 million ton sediment per year at Aq Qala.

(3) Intake

All of existing schemes, excluding Cheldin Scheme, are taking water from Gorgan River. The pump capacity varies from 250 lit/sec to 300 lit/sec, with total head of about 25 m. They are obtaining design requirement with adjusting the number of pumps by each scheme.

The pump stations have no de-silting facility on the suction side. Instead of it, the suction pipes are set 50cm above the riverbed and has the inlet capped with silt screens.

One outlet chamber is provided at outlet side of the station. The water is discharged with overflowing from the crest of the chamber to the conveyance canal after rectification of turbulence flow.



Estimated Sediment Load at Agh-Ghala

unit : x1,000 ton / month

	Oct.	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Moderate	1.3	21.1	37.0	45.2	78.8	196.9	722.9	602.5	131.7	5.2	2.8	1.9
Medium	2.7	115.8	127.9	192.1	355.3	161.0	3,504	707.2	1,103	52.9	27.9	11.7
Max.	4.2	210.4	218.7	339.0	631.7	125.1	6,284	811.9	2,074	100.6	53.1	21.4

Source : Location of Study Field Areas and Topography of Watershed of Gorgan and Ghareh-Sou Rivers, W.O., Golestan, MOE

The dimension and specification of the pump station utilizes the same basic idea developed by the central government. Of course the original design is modified according to the necessity, revising the width of station, necessary equipments like control panels depending on the number of pumps. But the pumps adopted presently are electrical volute type with capacity of 300 lit./sec, arranged in a row on semi-underground flour, about 3m below the entrance of the station.

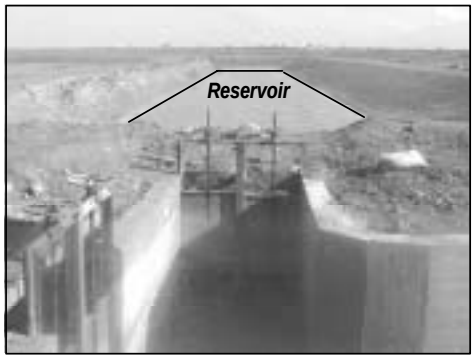
The pumps are operated by a fulltime operator. Records of pump operation and intake amount have never been kept.

Scene of River Water Suction
at Tezeh-Abad Pump Station

Scene of Inner Part of Tezeh-Abad Pump Station

(4) Distribution Rule of the Irrigation Water Among Farm Plots

The rule of irrigation water distribution is decided by the cooperative board every year. The allocation schedule and allocation amount is based on the scale of the farm (Tazeh Abad Scheme). There is no records about the real water distribuiton condition carried in the scheme. In other schemes they have no rule of water allocation and are adapting an way to supply water each time when the farmers request the water. At that time farmers should pay the operation cost to the cooperative each time. Hence their present manner is like a water vending system. So if a farmer has no enough money at that time, he should bear the thirsty.



Scene of Diversion Gates to Sediment
Depositing Reservoir At Tazeh-Abad Scheme

(5) De-Silting Pond

A de-silting pond is provided only in the Tazeh-Abad Scheme, with an area of 4.0ha and 2.5 m depth, just after the pump station. The total capacity of the pond is about 100,000 CM. It is explained that all of the water from the pump is stored in this pond before distributing irrigation water through the main canal. The completion of the pond construction was at the end of 2001.

At the other irrigation schemes without de-silting ponds, the water from the pumps is conveyed to the main canal directly without de-siltation. Hence the canals are aften filled up with sediment.

(6) Irrigation canal

Commonly the irrigation canal system consists of 1) Main canal, 2) Secondary canal and 3) Tertiary canal in an I&D scheme. Main canal is structured with concrete lining commonly with same slope of side wall as 1:1.5. The bottom widths vary from 0.55m to 0.76m and the depth from 0.8m to 1.25m. Longitudinal gradient is 1/2,000 or 3/10,000.

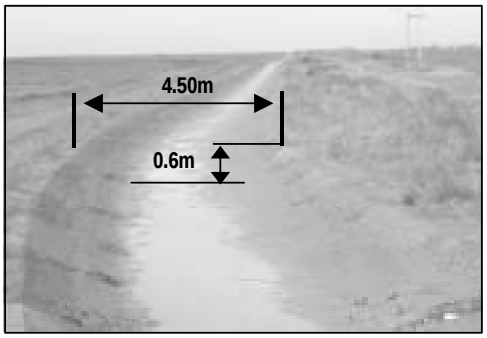
Secondary canal is constructed as earth lining structure basically and partially adopting concrete lining, depending on the budget. The ordinary dimension is 0.2 or 0.3 m for the

bottom width, 0.4 or 0.6 m for the canal depth with a side slope of 1:1.5. Longitudinal gradient varies from 1/2,500 to 6/10,000 aiming to obtain conveyance capacity of a range from 70 lit/sec to 120 lit/sec.

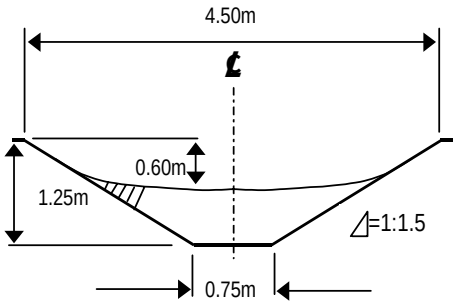
Tertiary canal is constructed in earth, with dimension of 0.2 or 0.3 m for the bottom width, 0.4 or 0.6 m for the depth with side slope of 1:1.5.

(7) Silting Condition in the Canals

The irrigation water distributed through the irrigation canal networks contains thick silts and it shares as one of constraints on irrigation practices.

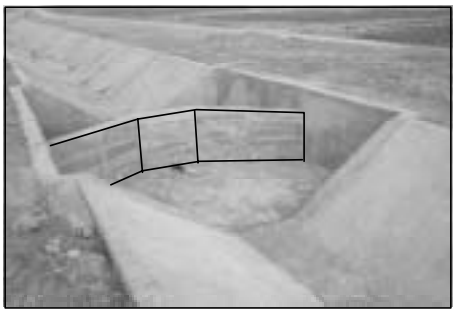


Scene of Main Canal Filled with Sediment in Tazeh-Abad Scheme



Almost all irrigation and drainage schemes are affected with sediment silting. The above picture shows the silting condition of the main canal in *Tarzer-Abad* I&D Scheme. About half of the canal sectional area is buried with silt and silting makes blockage along the canal.

Desilting Basins, as shown in a photo picture in right hand side of this page, are provided at some locations along the canal.They explained that farmers' cooperative has to excavate twice or thrice a year.



Desilting Basin Along Canal

Structure of the basin consists of squared basin with sediment trap wall, which is some 30cm lower than canal top as clearance as over-flowing space.

Silt Trap Condition in a Main Canal

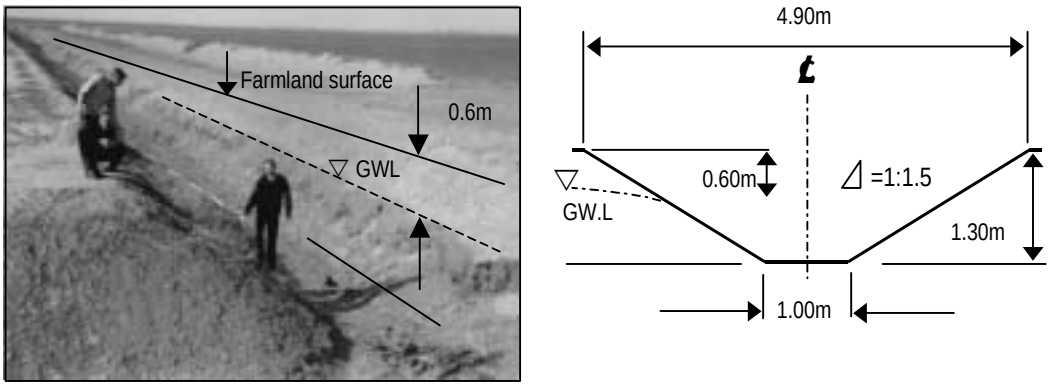
Scene of Silt Excavation from Irrigation Canal in Banavar I&D Scheme

7) Drainage Canal.

Drain system consists of main and secondary drainage canal in all schemes commonly. The original task of the drainage canal was to drain inundated water of seasonal rainfalls and was excavated before stating irrigation development by the Government.

Main canal is structured with earth lining. Its sectional dimension is bottom width: 1.0 or 1.5 m, side slope gradient: 1:1.5 and canal depth: 2.0 or 2.5 m. Longitudinal gradient is set as 1/2,000 or 1/10,000, little bit different by scheme. Secondary canal is structured with earth lining. Its sectional dimension is bottom width: 0.5 or 1.0 m, side slope gradient: 1:1.5 and canal depth: 0.8 or 1.25 m. Longitudinal gradient is set as 1/2,000 or 3/10,000, slightly different by scheme.

Those drain system, provided in ahead before introduction of irrigation system, has obviously contributed to down the groundwater level in the farm field. According to the officer in charge of Banaver Scheme, the groundwater level was at about 1.0 m below the ground surface when the excavation was started (1994). It was noticed at about – 2.0m in 1998. And the level was not found during the first field survey of this Study (January 2002). With those evidences, it might be said that the groundwater level is already below the canal bottom level, which is 2.5m below the ground surface. But it is required to investigate and examine more whether the present groundwater level at midway between two drainage canals is so or not, which interval is 300m or 400m. Continuous monitoring has never been conducted even though already been recognized the importance of groundwater management and setting measures against salinity.



Secondary Drainage Canal in Banavar I&D Scheme

Such situation is common over the schemes, excluding Cheldin Area. People provided small and shallow ditch by themselves aligned at the farm boundaries, which are subdivided in small and scattered form. Those small drainage ditches are drains to Gharasu River and its tributaries. The farm lands are always damp due to the low permeability characteristic of the soil and low capacity of drainage. Especially it is said that areas along the river streams are always flooded in rainy season.

There are so many items and aspects to be referred for the further examination for the future drainage plan among the experiences of the Provincial J.A.O. Observation record of seasonal groundwater level during years is also one of them. Information of shallow and deep hydrogeological information is also hardly to be found in the office. Hence such conditions make difficult to clarify whether impermeable layer exists or not, or whether cause of high groundwater level comes from partial artesian water or not, or just by lower permeable soil characteristic.

The Study Team requested to the counterpart agency to try to find out such primary and

primitive information by the next field survey.

(9) Irrigation Method

Border irrigation method is applied widely in the Study Area. Farmers are taking irrigation water by blocking the tertiary canal connected with an off-take gate provided along secondary canal, applying rotational irrigation by canal unit. They explained that the duration of the water intake for one block or proper water amount has not being measured exactly. Farmers have tendencies to intake water more than requirement because the yield of wheat can be increased by more water inputs.

Other different irrigation methods are noticed like linear mobil system, self-tractive rain gun system and fixed sprinkler system, but they only work in a very limited condition in the Study Area. Those systems are available only for the area which can use desilted water at dams or reservoirs. Hence tentatively those systems are not going to be considered in the Study Area.

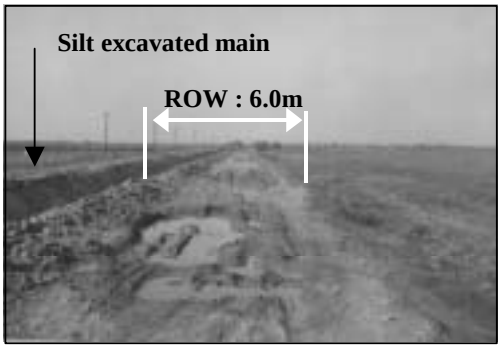
(10) Farmland Block

Generally the farmland block adopted in the Study Area is rectangular with about 400 m of width and 1,500 m of length, divided by tertiary drainage canals. Individual farmers are diving the block furthermore with some 60cm height levees. 1/2,000 slope is adopted for farmland surface gradient.

Size of Borders and Stream Size for Different Soil Type and Land Slope

Soil type	Slope (%)	Width (m)	Length (m)	Average flow (lit / sec.)
Sand	0.2 - 0.4 0.4 - 0.6 0.6 - 1.0	12 - 30 9 - 12 6 - 9	60 - 90 60 - 90 75	10 - 15 8 - 10 5 - 8
Loamy sand	0.2 - 0.4 0.4 - 0.6 0.6 - 1.0	12 - 30 9 - 12 6 - 9	75 - 150 75 - 150 75	7 - 10 5 - 8 3 - 6
Sandy loam	0.2 - 0.4 0.4 - 0.6 0.6 - 1.0	12 - 30 6 - 12 6	90 - 250 90 - 180 90	5 - 7 4 - 6 2 - 4
Clay loam	0.2 - 0.4 0.4 - 0.6 0.6 - 1.0	12 - 30 6 - 12 6	180 - 300 90 - 180 90	3 - 4 2 - 3 1 - 2
Clay	0.2 - 0.3	12 - 30	350+	2 - 4

Source : FAO Irrigation and Drainage Paper No.24



Farm Road Condition of Banavar I&D Scheme

The size of farm blocks might be within acceptable from the viewpoint of proper irrigation practice.

(11) Appurtenant Facilities

1) Farm Road

Farm roads (earth graded type) are provided along both of irrigation and drainage canal network, with 4.0m or 6.0m R.O.W for trunk road, 3.0 or 4.0m R.O.W for lateral road. Arrangement of route system is generally lattice type consisting of trunk and lateral roads.

The surface condition of the farm roads during the first field survey was little bit muddy, showing a very difficult traffic condition. It seems to be caused by the soil type of the farmland, roughly classified as clay loam or clay. Even though, the comment is superficial without direct interviews to farmers, some modification might be required like gravel

pavement.

Road bridges connected with farm road are only for roads crossing over main and secondary canals, which adopts RC board with 4.0 m width or applying RC box culvert.

2) Division Works

All of secondary canals are taking irrigation water through simple sluice-gate type intakes. The tertiary canals also takes water through same type but in a smaller size, as shown in the pictures. Farmers conduct irrigation water from tertiary canal, sometimes being classified as quaternary and just a man-excavate ditch, with blocking the flow with clod.

Although the canals in the pictures are lined with concrete, most of secondary and tertiary canals are unlined actually.

Division Work for 2ndary Canal .

Divisin Work for Tertiary Canal

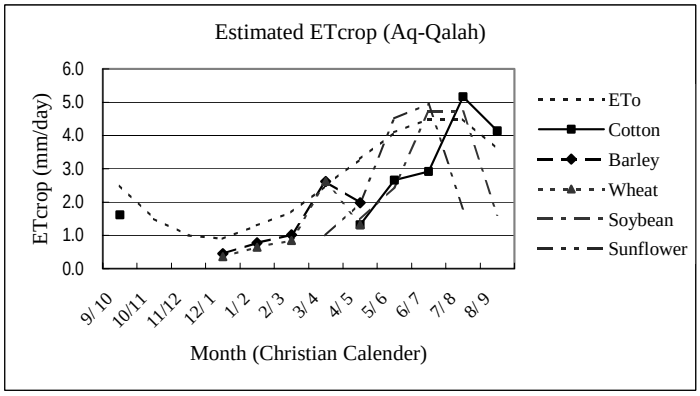
(12) Estimation of Irrigation Water Requirement

1) Objective

In this sub-chapter, irrigation water requirement is to be assumed and potential for developing new I&D scheme is to be examined roughly to obtain references for further discussions on the given proposition of this Study basing on existing information.

2) Crop Water Requirement

CROPWAT is well adopted for estimation of crop water requirement in the region widely, and Soil and Water Management of I&D section, J.A.O, Golestan had already provided summary of ETcrops of various locations in the province. Among those estimates, *Aq Qala* is to be applied tentatively because of its location in the Study Area as the table on right hand side.



Estimated Crop Water Requirement

Location : Aq-Qalah unit : mm/day

Iranian Calendar	7	8	9	10	11	12	1	2	3	4	5	6
Christian Calendar	9/10	10/11	11/12	12/1	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9
ETo	2.5	1.5	1	0.9	1.3	1.7	2.5	3.3	4.1	4.5	4.5	3.6
Cotton	1.62							1.32	2.66	2.92	5.17	4.14
Barley				0.45	0.78	1.02	2.62	1.98				
Wheat				0.36	0.65	0.85	2.62	1.32				
Soybean								1.48	2.46	4.72	4.72	1.62
Sunflower							1.0	1.98	4.51	4.95	1.8	

Source : Summary of Etcrop in Various Locations in Golestan Province, Mr. Mohsen Zamani, I&D, JAO, Golestan.

3) On-farm Water Balance and Demands for Irrigation

a) Crop Selection and Crop Calendar

Crop selection and cropping calendar is adopted as cotton for April/May to September/October and wheat for November/December to April/May tentatively for the calculation. It is assumed that cotton is to be planted for all farm plots fully as scheduled in the calendar diagram, while wheat is assumed to be started from November/December with half planting and reaches to full plantation after one month. Daily irrigation requirement varies from 0.36mm/day in November/December to 2.92 in June/July.

b) Irrigation Practice and Efficiency

Border irrigation with the irrigation efficiency of 0.48 is to be adopted, multiplying 0.80 of canal conveyance efficiency with 0.6 of field application rate.

c) Leaching Requirement

Electrical conductivity as reference point of irrigation water quality is referred to observed values at *Aq Qala* by MOE. Requirement for leaching, indicating percentage against irrigation water requirement, varies from 1% in June/July to 50% in July/August and August/September, reflecting the fluctuation of EC value of river water.

All of the requirement can be in a range of losses during irrigation, which are to be defined as Irrigation demand / (1-irrigation efficiency).

d) Effective Rainfall

Effective rainfall is applied from the results examined in the sub-chapter of meteorology of this report, which is descried as monthly effective rainfall and varies from nil (zero, 0) in summer months of July/August and August/September to 21.60mm/month in December / January. About 130mm/year seems to be available.

Table A4.1.3 Crop Tolerance and Yield Potential of Selected Crops as Influenced by Irrigation Water Salinity (ECw) or Soil Salinity (ECe), Yield Potential

unit : dS/m (mS/cm)

	100%		90%		75%		50%		0%	
Crops	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw
Barley	8	5.3	10.1	6.7	13.1	8.7	18	12	28.5	19
Cotton	7.7	5.1	9.6	6.4	12.6	8.4	18	12	27	18
Sugerbeet	7.1	4.7	8.7	5.8	11.3	7.5	15	10	24	16
Wheat	6	4	7.4	4.9	9.5	6.3	13.1	8.7	19.5	13
Soybean	5	3.3	5.6	3.7	6.3	4.2	7.5	5	10.1	6.7
Cowpea	5	3.3	5.7	3.8	7.1	4.7	9	6	13.2	8.8
Groundnut	3.2	2.1	3.6	2.4	4.1	2.7	5	3.3	6.6	4.4
Rice	3	2	3.9	2.6	5.1	3.4	7.2	4.8	11.4	7.6
Corn	1.7	1.1	2.6	1.7	3.8	2.5	5.9	3.9	10.1	6.7
Broadbean	1.7	1.1	2.7	1.8	3	2	6.8	4.5	12	8
Bean	1.1	0.7	1.5	1	2.3	1.5	3.6	2.4	6.3	4.2
Flax	1.7	1.1	2.6	1.7	3.8	2.5	5.9	3.9	10.1	6.7

Note. 1 ECe means average root zone salinity as measures by electrical conductivity of the saturation extract of the soil. ECw means Electtical Conductivity of the irrigation water in mS/cm at 25D.C. This assumes about a 15 to 20% leaching fraction (LF) and an salinity of soil water taken up by the crop about three times that of the irrigation water applied (ECsw = 3 ECw) & about twice that of the soil saturation extract (ECsw = 2ECe).

From the above, ECe = 1.5 ECw. New crop tolerance tables for Ecw can ce prepared for conditions which differ greatly from those assumed. The following are estimated relationships between ECe & ECw for various leaching fractions: LF = 10% (ECe = 2 ECw), LF = 30% (ECe = 1.1 ECw) and LF = 40% (ECe = 0.9 ECw)

2 Barley & wheat are less tolerant during germination & seedling stage. ECe should not exceed 4 or 5mS/cm.

Source : FAO (1979b); Ayers and Westcot (1976)

Table A4.1.4 Estimation of Monthly Irrigation Demand and Pond Capacity Requirement

Solar Calendar		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Iranian Calendar		10	11	12	1	2	3	4	5	6	7	8	9
		Bahm	Esfa	Farv	Ordi	Kord	Tur	Mord	Shah	Mehr	Aban	Azar	Dey
Monthly Rainfall (mm/month)		56	25	81	41	40	0	8	26	28	14	11	10
Wet / Dry Season		wet	wet	wet	dry	dry	dry	dry	dry	dry	dry	wet	wet
Major Crops & Cropping Calendar in the Area	Wheat		▲	▲ ▲	▲	△△	××					○▲△ ◎△	
	Barley		▲ □			××					○ ▲◎		
	Paddy Spring			○ △■▲	● □ ▲	◇ ▲	◇ ▲	◇ ▲	××				
	Paddy Summer				■○	▲●	■▲	◇	▲ ◇	▲ ×			
	Cotton				○▲□	◎◇	◇ △▲	◇△▲	◇△	××	× ××	××	
	Rape	□▲	▲	◇		×					○▲□	◎◎◎◎	
	Soybean Spring				○▲	□△◎		△◇	△	△ ×	×××		
	Soybean Summer						○▲	□△◎△	◇ △	◇△		×× ×	×
	Cabbage							○	■ ●	△▲	◇	×× ×	×
Cropping calendar : Cotton													
Cropping calendar : Wheat													
ET: Cotton mm/day						1.32	2.66	2.92	5.17	4.14	1.62		
ET: Wheat mm/day		0.36	0.65	0.85	2.62	1.32	0						
Total ET for farmblock		0.36	0.65	0.85	2.62	1.32	2.66	2.92	5.17	4.14	1.62	0	0
EC of Water (mS/cm)		2.6	2	3.6	1.8	0.9	0.8	0.7	12	12	2.6	2.9	2.7
Actual water vol. Cotton		0	0	0	0	1.35	2.71	2.96	7.76	6.21	1.72	0	0
Actual water vol. Wheat		0.39	0.69	0.95	2.76	1.35	0	0	0	0	0	0	0
Total Actual water inc. leach'g		0.01	0.04	0.08	1.45	0.36	0.72	0.86	4.01	2.57	0.28	0	0
Ratio : AW/ET		0.03	0.06	0.09	0.55	0.27	0.27	0.29	0.78	0.62	0.17	0	0
Demand for source (only irri.)		0.75	1.35	1.77	5.46	2.75	5.54	6.08	10.77	8.63	3.38	0	0
Leach'g coverage by loss		Cov'd	Cov'd	Cov'd	Cov'd	Cov'd	Cov'd	Cov'd	Cov'd	Cov'd	Cov'd	Need	Need
Effective rainfall mm/mon.		21.6	14.7	16.6	17.7	10.5	14.1	0	0	0	3.6	12.8	18.4
W.demand for 1000ha I&D		0.02	0.23	0.38	1.46	0.75	1.52	1.88	3.34	2.59	1.01	0.00	0.00

Annual water requirement for developing 1,000ha I&D scheme ; 13.18 MCM / year / 1,000ha (In case of everyday irrigation practice)

Crop selection and calender
Cotton : from 4/5 to 9/10 (Solar Calender)
Wheat : from 11/12 to 4/5 (Solar Calender)

Irrigation efficiency

Conveyance efficiency	Ec	0.80
Field application efficiency	Ea	0.60
Irrigation efficiency	Ei	0.48

W.demand for 1000ha I&D	0.0165	0.231	0.3827	0.3144	0.1425	0.3576	0.5472	0.9693	0.7767	0.2682	0	0

(As recommended by Govt)

Annual water requirement for developing 1,000ha I&D scheme ;	4.01	MCM / year / 1,000ha
Reuired Pond Capacity / 1,000ha for Dry Season from Apr. to Dec.)	3.38	MCM / 1,000ha
Required Pump capacity	883.00	lit / sec/1,000ha (60 days 18hr operation in Wet Season.)
Required number of pump of 300 lit / sec capacity for the above	2.94	Nos/set/1,000ha area. To fill farm pond with 60days 18 hrs operation in Wet Season

Adapted irrigation practice for the above estimation is 3-time irrigation in a month during dry season.

Required capacity of reservoir by irrigation scheme ;

Tazeh-Abad	3,300	ha	11.10	MCM	say	11.00	MCM	10	Nos pump required / Present ;	9 Nos
Hemmat	1,200	ha	4.10	MCM	say	4.00	MCM	4	Nos pump required / Present ;	5 Nos
Shadi Mehr	1,000	ha	3.40	MCM	say	3.50	MCM	3	Nos pump required / Present ;	5 Nos
Banaver	1,450	ha	4.90	MCM	say	5.00	MCM	4	Nos pump required / Present ;	5 Nos
Gomishan Kesht	4,700	ha	15.90	MCM	say	15.50	MCM	14	Nos pump required / Present ;	5 Nos

Legend of Marks in Crop Calendar

○ Tillage	△ Irrigation	◇ Pesticide
◎ Sowing	× Harvesting	
● Transplanting	■ Fungicide	
▲ Fertilization	□ Herbicide	

A4.1.2 Improvements Needed in the Present I & D Schemes

(1) Problems and Constraints Recognized by Farmers and the Government

The present situations of the irrigation and drainage in the Study Area are reported in the previous sections. In this section, the problems and constraints recognized by the farmers who are working in the field daily are presented. Also the same report is prepared from viewpoints of in-charge officers in the administration side.

1) Problems and Constraints Recognized by the Farmers

a) Stable supply of irrigation water is not obtained.
b) River is not flowing sufficient amount of water.
c) Hardly to obtain sufficient water when they need water.
d) Hardly to buy irrigation water from the station due to debt.
e) Never received irrigation water after completion of pump station construction.
(Mainly in the downstream area in an irrigation scheme)
f) Not available to convey water through secondary canals due to obstacle of slope slides.
g) Not available to get water due to the lack of tertiary and quarterly canals.
h) Hope to increase / provide more drains to increase crop yield.
i) Soil salinity causes low yield.
j) Improper land leveling causes imbalanced irrigation in a plot.
k) Number of agricultural machinery is not sufficient.
l) Muddy farm road avoids smooth farm works.
m) Hardly to accept to sell farm land for pond construction.

2) Problems and Constraints Recognized by the Government

a) Stable supply of irrigation water is not obtained.
b) River is not flowing sufficient amount of water.
c) Hardly to obtain sufficient water when they need water.
d) Farmers hardly accept water saving irrigation and continue to use the basin irrigation method.
e) Budget shortage of the Government causes delay of canal concrete lining.
f) Budget shortage of the Government makes hardly to increase drains.
g) Farmers are not conducting proper canal maintenance.
h) Ponds are necessary to keep sufficient water for dry season irrigation.
i) Budget shortage of the Government makes delay of project completion.
j) Non-lining canal caused water leakages.
k) Improper land leveling causes imbalanced irrigation in a plot.
l) Farmers have never become familiar with irrigation framing due to short experiences for it.
m) Basin irrigation has function to leach salt as preparatory practice before introducing furrow irrigation.
n) Present drainage canal interval ; 300m or 350m seems to be sufficient.

(2) Improvements Needed in the Present I & D Schemes

Some explanations are hereunder regarding to the problems / constraints related with irrigation and drainage aspects expressed by both farmers and officers in charge. Causes of unstable crop production exist under those conditions.

1) No Stable Water Intakes for Irrigation

Scarcity of irrigation water is the first thing at any irrigation schemes, during the interviews. The farmers well knew that wheat was the high sensitive crop for water when they were cultivating under dry farming practice. The present situation / achievements of wheat yield is far from the expected level or from the level explained for the farmers by the Government before adapting the irrigation farming. Present procedure of water delivery is direct supply to canal from the pump station, after pumping water of the river. Farmers are introducing the irrigation practice, but they are complaining that the river discharge decreases rapidly at the time when they need water for irrigation.

a) Water Balance between Discharge of Gorgan River and Irrigation Demand

5 irrigation schemes excluding Mehtar Kola Scheme in Cheldin Area depend on Gorgan River for the irrigation water. River flow fluctuates largely among seasons, and decreases to 1.5CMS level in dry season.

Besides that irrigation demand varies and raises the demand to July and August as the annual peak season. It is assumed that the demand is about 13.00MCM/1,000ha/year. Hence it is obvious that the discharge of the river in the dry season is not sufficient. Some countermeasures to reserve discharge in the rainy season is required.

b) Trade-off Conditions Between the Upstream and the Downstream, Considering the Water Use in the Upstream Dams.

Presently 3 (three) dams are under operation in the upstream of Gorgan River, which farmers in the Study Area depend on for irrigation water source. And furthermore Golestan No.2 Dam is under construction. Those dams are under the Ministry of Energy responsibility and most part of the water is consumed by the irrigation schemes of those dams. According to the explanation of the Provincial J.A.O, those dams have no responsibility to supply water to farm lands in the downstream, including the Study Area, basically. Only the environmental conservation discharge, that is 34 MCM/year can be assumed in the dry season.

Inflows to the Study Area consist of environmental conservation discharge through Voshmgir Dam and flows from two tributaries: Zaringol and Rahmatabad Rivers. The total amount of discharge in the dry season is not enough for the demand.

Diminution of river flow in the dry season affects also the water quality. While EC value varies from 1,800 μS／cm in the rainy season, the EC range raises to the level of 12,000 μS／cm in dry season due to accumulation of drainages from farm lands along the river. The highest value reaches almost the same value of the Caspian Sea. Direct intake from the river discharge and irrigation in the dry season means not only supplying water but also supplying salt to the farmland. It accelerates the salt accumulation decreasing the crop yield.

For avoiding such Devils Alternative it is required to set measures to solve both of improvement of seasonal discharge fluctuation and trade-off between the upstream and downstream as one of basin-wide water resources allotment theme. Obviously it is not a matter to be examined by each irrigation scheme level.

Also some big gaps between the upstream and downstream on unit water consumption is reported through the field survey this time. Schemes belonged to dams and area available to take water almost freely from rivers are consuming water 2 or 3 times more than the downstream, with basin irrigation method under the condition of less salinity risk of soil. It means available to reduce the consumption with "Furrow irrigation System" and to make surplus water to convey to the downstream.

c) Never Completed the Original Plan of Reservoir / Pond Provision.

Each existing irrigation scheme has a plan to provide reservoir / pond in the original plan, according to the Provincial J.A.O. But no irrigation scheme has reached to the original plan due to lack of the Government budget and matter of land acquisition. Those conditions also cause scarcity of water in dry season.

2) Hardly to Covey Water Through Irrigation Canals

Farmers raise opinion as above, hardly to convey water through irrigation canals. Two are the main problems, where one is "Obstruction of canal section by sedimentation" and "Obstruction by falls and deformation of earth canal section".

a) Obstruction of Canal Section by Sedimentation

The Gorgan River, the main water source in the Study Area, flows down while incising loess deposit prevailed basin. It contains sediment heavily and is pumped through pump station to the outlet basin. Irrigation schemes have no " De-siliting Function", excluding "Tazeh Abad Scheme" before conveying the water to the canal. Hence the canals are obstructed by sedimentation frequently.

All of existing pump station have no component of de-sedimentation before the intake, only suction attached screen, hence easily pumping mud and sediment from the river bottom. Provision of de-sediment facility in front of the suction pipe seems difficult due to the site conditions, without sufficient spaces to provide it.

The Provincial J.A.O has plans to provide reservoir for each irrigation scheme, at just downstream of pump outlet side, combining functions of water storage and de-silting. It is expected to make the water cleaner to avoid obstruction by the sediment, excluding Tazeh Abad Scheme.

b) Obstruction by Falls and Deformation of Section of Earth Canal

Most of irrigation canals in the schemes are earth lining type with 1:1.5 side slope. The condition of obstruction by falls and deformation of section of earth canal seems to be caused not only by expansion of gully erosion but also deformation by tamping by farm animals. Almost all of the sections obstructed by deformation are left as they are, because the restorations works are difficult for farmers who have no machinery.

Achievements of concrete lining works of canals have quite lower progress due to the lack of the Government's budget, according to the explanation of the Provincial J.A.O.

3) Drainage System to Avoid Salt Hazard

Request of provision of drain is raised from farmers commonly during the interviews. Reasons of their request come from “lower yield” which is doubted from “salt hazard” and “high groundwater table”. It is difficult to define the exact causes of their low yield whether from salinization only, draught condition of recent several years, lack of farming technology or others. But the present drain system is hardly to cause vertical water movement in the soil, which functions for salt leaching due to low density of the drain, as the Provincial J.A.O’s recognition.

As reported in the sub-chapter of “ Soil “ of this report, condition of salinization in the deeper layer are becoming clearer. 28.8 mS/cm of EC value can be found (Shadi Mehr. Tazeh Abad ; 12.1, 8.1 mS/cm, Banaver ; 10.7, 14.2 mS/cm). Hence it is assumable of salt hazard at midway area between existing drain canals with high possibility.

Provision of additional open drain canal, pipe drain and mole drain are seemed as possible countermeasures. Some farmers object for the open drain because of decreasing of farm land (10 sq.m per 1 meter open drain of main drain class is required, if the depth is 3 m.). Applying the pipe darn system is doubted for the implementation due to the cost, which is expected as permanent countermeasure. Mole drain system is seemed applicable, with imagination of low cost because of non-material utilization. But concrete research results are not found in the Study Area or under similar condition. Also the clay content rate of the soil is about 30 % or so, not more than 45%, which is reported as suitable condition for the mole drain. It seems that some trials of those alternatives are conducted urgently to gain references of adaptability.

4) Provision of Farm Pond / Water Storages to Alleviate Water Scarcity

As already explained in the sub-chapter of “ Hydrology “ of this report and in the previous section, discharges of Gorgan river in the dry season is not sufficient to supply water to the demand. For fulfilling to the demand, especially for the dry season, it is necessary to store the discharge of the rainy season or to convey the water from other outer basin. Most realistic measure is to construct farm pond by each irrigation scheme, which can store river water of the rainy season through existing pump station and utilize it in the dry season. Even though the Provincial J.A.O recognizing as the most important subject, both of budget shortage and land acquisition prevent the progress by now. And farmers are still under the lower yield.

5) Other Problems and Requests from Farmers.

Aspects reported in the previous part of this sub-chapter are related with “ irrigation and drainage “directly. Besides those aspects there are matters like 1) “ Farm Road Pavement “ because of the difficulty of wheel transportation under the muddy condition, especially the rainy season., 2) “Community Farm Machinery Workshop” to maintain their farm machinery because agents or manufacturers are accepting after care or maintenance very seldom.

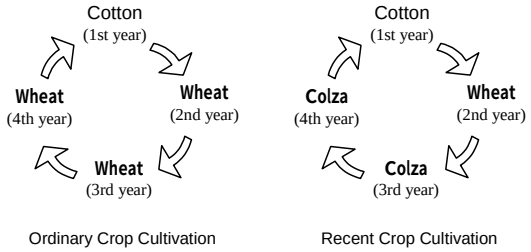
A4.2 Appraisal Procedures of Irrigation and Drainage Schemes

Appraising procedure of irrigation and drainage schemes in Iran are to be explained in this sub-chapter to understand stakeholders and task allocation of irrigation and drainage projects.

(1) Necessity of Enhancing Irrigation and Drainage Schemes

As already been stated in previous chapters, the Government aims to increase the food

self-sufficiency against heavy burden of staple food import. About 40% of domestic demand depends in the importation from foreign countries. The Government set measures to increasing the food production, mainly for wheat production. The *Gorgan* region, including to the Study Area, was nominated as potential area due to the wide extent for I&D scheme introduction and perennial rivers represented by *Gorgan* river system.



Recent Change of Cropping Pattern in the Study Area

On the other hand, even the farmers are accepting the government policy as an assistance source to improve their productivity, little bit different recognitions are noticeable among farmers. Their main intention is to improve their living standards securing a stable and sufficient income, not insisting in wheat production. They prefer to cultivate higher value crops than wheat like colza in recent few years.

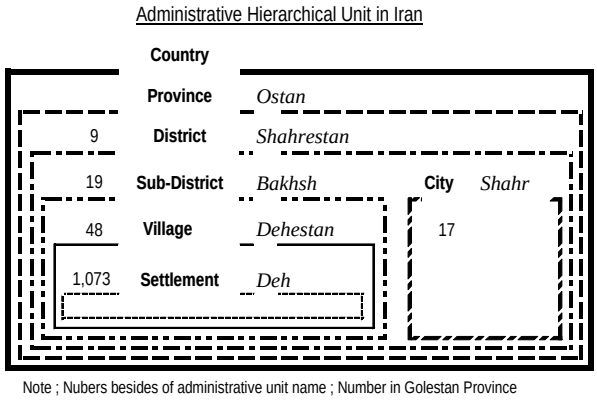
There are several causes to the changes in the crop selection, according to the interviews to the farmers, as follows:

1) They know well about the water scarcity in the region and recognize commonly that irrigation system not always ensures sufficient irrigation water in the case of depending on the river as water source.
2) They understand well that the climate condition of the recent years have already entered into drought years and their irrigation systems don't always keep sufficient water supply.
3) Colza is higher than wheat on both of gate price and water tolerance.
4) Farmers are sending younger generations from rural to urban areas, to get non-agriculture jobs, expecting to elevate their living standards and income.
5) Concluding the above recognition of the farmers, it can be said that the present irrigation and drainage system get only partial advantages of the modern I&D schemes and basically farmers are keeping their traditional cultivation manners.

Those understandings, especially the farmers situation, were obtained through interviews to farmers during the field survey. Hence, some considerations have to be taken from it to elaborate the concepts for the development planning.

(2) Appraising Procedure of Irrigation and Drainage Schemes

All I&D projects starts from the requests of the farmers or farmers' cooperatives to the government, according to the explanation of the local government. First, the request from farmers of a certain area is reported to a local Agriculture Office, which was provided by the Government to assist farmers for any agriculture-related constraints. Basically an Agriculture Office is set in each *Shahrestan* (District) and branch offices are provided at every Dehestan (Village). The I&D project is classified into three categories, based on fund sources, in *Shahrestan* (District) project, Ostan (Province) project or Central Government project. Quite minor matter is solved at *Shahrestan* level, like farm road maintenance,



Note ; Nubers besides of administrative unit name ; Number in Golestan Province

provision of small-scale bridge over main canal, and land leveling maintenance. Project to be adopted by a provincial government is little bit bigger than *Shahrestan* level project. Further bigger scale project is conveyed by the central Government. Reference points for those classifications are not clear, but obviously the scale of the project cost is considered.

A point that must be mentioned is the importance of the Technical & Infrastructure Deputy of the MOJA in Karaji city for the provincial and national level projects. Most of major aspects of planning and design like detailed design of facilities, cost estimation, implementation plan are handled by the Deputy, not in the Province.

(3) Project Cost Sharing System

Cost Sharing on Scheme Appraisal & Construction

		Government Side	Farmer Side	Remarks
Appraisal Stage	Preliminary survey	Only advise	100%	Soil, topo-survey
	Detailed plan & design	100%		
Construction Stage	Water source, main canal	100%		Ref. cost allocation between Govt. & farmer
	Appurtenant facilities	30～40%	70～60%	
	Main drainage	100%		
	On-farm facilities	30～40%	70～60%	

With no difference among the administrative hierarchies, the cost of any project are shared between the beneficiaries and the Government. All costs of water source facilities and main canal networks are responsibility of the government. Costs related to on-farm facilities and appurtenants are shared by both side. The farmers (or farmers' cooperative) should prepare the necessary fund from commercial bank under the government's authorization, with 14% interest rate. Its redemption period varies from 5 to 10 years.

It is explained that the Government has a policy to hand over the cost sharing gradually from the Government to the farmers and the ratios in the above table varies from year to year.

(4) Farmers Cooperative as Owner of Irrigation and Drainage Scheme.

It is said that the O&M of all irrigation schemes shall be done by the farmers cooperative. Though, the facilities provided by the Government shall belong to the Government. Hence, it has been enhanced to establish one farmers' cooperative for one I&D scheme and several cooperatives are functioning now.

In the initial stage of the facility provision, the Government encourages the establishment of farmers cooperative as a body to receive any assistance from the Government. The general procedure for establishing farmers' cooperative is as follows:

Establishing Procedure of Farmers' Cooperative.

	Major Steps for Cooperative Establishment	Farmers	Cooperative Board	Shahrestan Agriculture Office	Ostan Agriculture Organization
1	Project proposing	●			
2	Consultation to Agriculture Office	●		●	
3	Guide to farmers to establish cooperative	●			
4	Define sub-groups in a scheme by location	●			
5	To conduct election to select group leaders.	●			
6	To conduct election to define cooperative board	●			
7	To establish farmers' cooperative		●		
8	Provincial govt dispatch cooperative manager (generally 5 years)				●
9	Project appraisal			●	●

Source : Summarized interview results

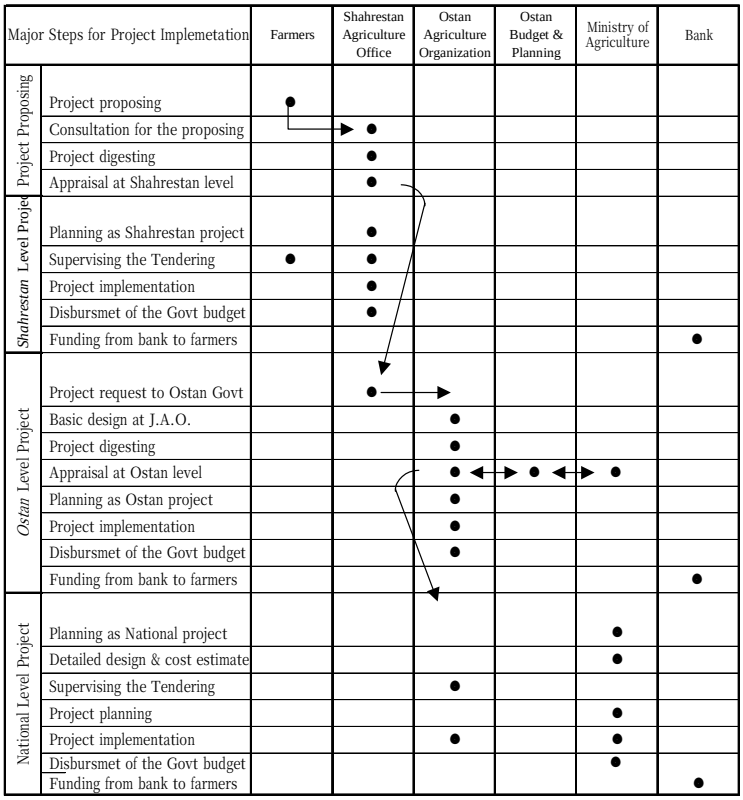
In the case of farmers requesting assistances to a local government office, a relevant agricultural office starts to guide the farmers to establish a farmers' cooperative, introducing the benefit principal and scope of government's assistances. The farmers select the cooperative board, generally consisted by seven members including a chairman, selecting the group heads by each area after it. In parallel to the cooperative formation, the local government, mainly the provincial

government, dispatches a manager who will take care of the cooperative in the first five years. The manager has to be approved by the cooperative members before starting the consultation. The farmers' cooperative, as a parent body of ownership of a certain scheme, is now completed.

Major tasks of the cooperative are:

a. To define admission fee and annual membership fee and their collection.
b. To set water allocation rule for the irrigation season.
c. To conduct public awareness for aspects which the members need to decide as a scheme owner.
d. To define cost allocation rule and its collection for certain expenditures.

Procedure of Project Appraisal and Implementation of I&D Scheme



A4.3 Irrigation and Drainage Conditions of Tazeh Abad Project Area

A4.3.1 Irrigation and Drainage Area and Water Source

(1) Irrigation and Drainage Area

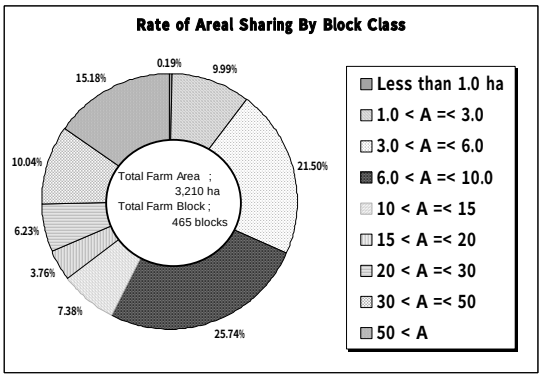
Tazeh-Abad Irrigation Scheme exists in total 3,320ha area and its present land use condition is shown in the followed table. The total cultivation area, which is listed in the land registration inventory of the coop, is 3,201ha. Originally farmers were cultivated crops, wheat and cotton mainly, with

Landuse Condition at Tazeh Abad

Farm	3,040.0 ha
Farm road	42.0 ha
Residential area	2.0 ha
Pond	150ha (170ha)
Canals	108.0 ha
Total	3,320.0 ha

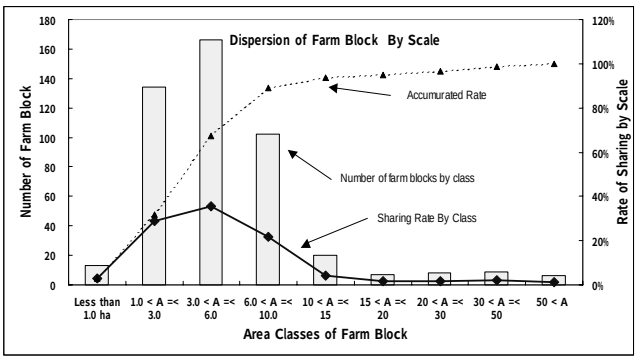
dry farming for the majority and water from Gorgan river for some areas along the stream, before establishing the cooperative in 1998. The cooperative was formed and established with about 400 farmers, under the Government's initiative initially.

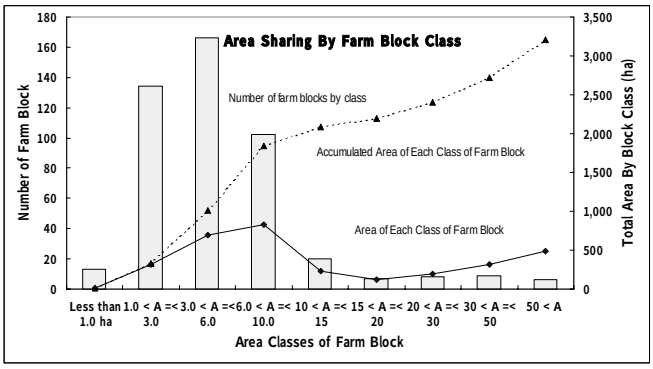
This Scheme area exists on the right bank of Gorgan River, about 10km down from Vosmgir Dam, facing to the national road from Gorgan city to the Iran - Turkmen country border via Aghala. North boundary is the road to the Army Farm, which runs on East-West direction.



The area extends under the topographical condition of downing slope of about 1/1,500 from Northeast to Southwest. The highest elevation is 47.40m at the far east location of the area and the lowest is 30.90m at the far southwest respectively. Gorgan rivers runs in south side of the scheme. The soil in the scheme is said to be classified as Silty-Clay with rate about 30:40:20 (clay:silt:sand) and seemed as good soil for agriculture due to the texture. But the soil includes salt and sodium which make damages for crop cultivation. Hence both of sufficient water and proper water management are indispensable to avoid salt and sodium hazard. The details of the soil is described in the chapter of soil in this report.

There are 465 farm plots in the scheme and each area of those blocks are not same. Block boundaries are the boundary of land tenure of each farmer (the number is as 2002 Sept.). It is said there are some blocks which one is divided and co-shared with several owners. Majority by farm block area is small scale less than 10ha, which shares about 90% (by number. About 2/3 by area). Average area of one block is 6.98ha, the maximum is 148.98ha and the minimum is 0.15ha.





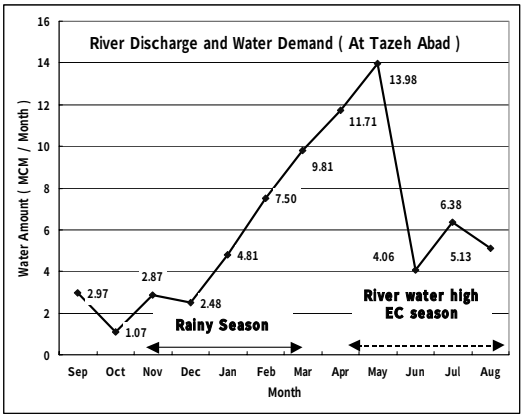
(2) Water Source

1) River water

Most of the area was cultivated as dry farming before introducing this present irrigation

scheme by the Government, as obvious from its history. Some parts of the area were developed as cotton plantation utilizing groundwater before the Revolution. Also for areas along Gorgan River farmers were running their own farms with river water taking with small pumps.

It seems that this irrigation scheme owes task to serve "supplemental water to dry farming ", not owing whole responsibility to supply sufficient irrigation water as estimated by that popular crop water requirement estimation method. Actually nobody can explain clear water balance between the demand and the capability of water supply of the river. Also farmers are proofing irrigation water scarcity by their low production and low income. At first the Government provided the intake pump station, as countermeasure to assist low and unstable productivity of dry farming, during the reconstruction stage of the country after that sad war. At that time farmers cooperative had never been established. With such understanding on the history, study on availability of river water seems never been concentrated so deeply.



It was preconditioned that the main water source for the irrigation is Gorgan river as reported in the chapter of hydrology of this report. River discharge fluctuates largely among seasons, as flow level from 4.81 MCM to 13.98 MCM in rainy season decreases to 2.97 – 1.07 MCM (Sept-Oct) in summer. Especially after completion of Golestan Dam, that barrage effects to reserve whole river discharge in a year. Hence only discharge of Zarigor River, one of tributaries, flowing into Gorgan at a point just hundreds meter upstream, becomes water source for Tazeh Abad Irrigation Scheme, if not floods occurred. Design monthly discharge at the pump station of Tazeh Abad is shown in the figure in the right side, which is reported as "1/10 year probable discharge".

Estimated Discharge of Gorgan River (At Tazeh Abad Pump Station.)

unit : MCM

Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	TOTAL
Voshmgir Dam	0.8	0.6	0.4	0.4	0.7	2.2	6.0	5.8	3.6	6.4	5.1	2.0	34.0
Zaringol River	0.2	2.3	2.1	4.4	6.8	7.6	5.7	8.2	0.4	0.0	0.0	1.0	38.8
Voshmgir Dam + Zaringol River	1.1	2.9	2.5	4.8	7.5	9.8	11.7	14.0	4.1	6.4	5.1	3.0	72.8
Balance (Available for Tazeh Abad)	1.07	2.87	2.48	4.81	7.50	9.81	11.71	13.98	4.06	6.38	5.13	2.97	72.8

Note : As 1/10 year probability discharge

The discharge fluctuation effects to water quality of the river water, especially to salinity and suspended solid. EC values become lower like 2,500mS/cm in the rainy season, and higher in the dry season. This change might be explained due to dilution by surface and sub-surface discharges in rainy season and it becomes weak in dry season. Also highly salt loaded drainage water by fertilizations from farmlands contributes to increase the value in the dry

season. Hence direct use of river water to irrigation in dry season should be called " salt distribution ", not to be counted as water source for agriculture.

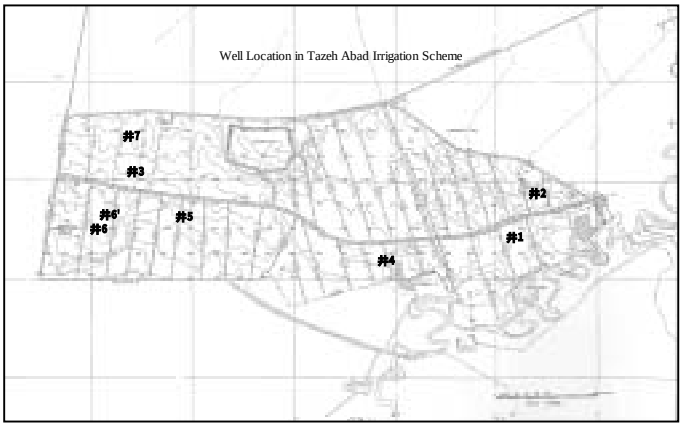
2) Groundwater

Only 8 wells are constructed and used for irrigation individually in the scheme area. The well owners are not going to use it commonly with next neighbors. Groundwater use is explained as followers;

List of Well in Tazeh Abad Irrigation Scheme

	Name of Well Owner	Year of Well Provision	Water Yield (")	Area of the Block (Ha)	Main Crop						Remarks
					Spring		Summer		Autumn		
1	Allahgholi Ghooshli	2002	5	27	Paddy Rice	3	Paddy Rice	6	Wheat	18	Crop rotation between rape seed & grains (Wheat & Barley)
2	Abdolaziz Gorgani	2000	5	19	Paddy Rice	3	Paddy Rice	6	Wheat	8	Crop rotation between rape seed & grains (Wheat & Barley)
3	Noormohammad Seghar	2001	5	14	Paddy Rice	3	Paddy Rice	4	Barley	7	
4	Mousa Yar Ali	2001	5	21	Paddy Rice	3	Paddy Rice	6	Wheat	12	Crop rotation between rape seed & grains (Wheat & Barley)
5	Melaiby ghelich Toumaj	1974	2	11			Paddy Rice	4	Barley	7	
6	Kalimi	1991 1989	5 3	65	Paddy Rice	11	Paddy Rice	9	Wheat	45	
7	Shah Mohammad Khandan	1975	2	10			Paddy Rice	2	Wheat	8	

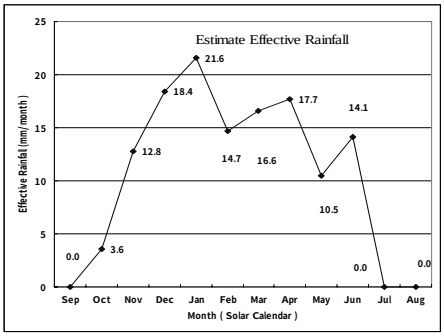
Mr.A, who is a deep well owner, is using his groundwater for rice cultivation, which is traded with the highest market price in crops presently. Paddy rice cultivation in the salty area effects as salt leaching. Mr.B, one of next neighbors of Mr.A, has already known the effect, but not owing well. So Mr.B requests to Mr.A to use Mr.B's farm plot for paddy rice cultivation. Mr.A will do the cultivation there in response to the request. In this case Mr.A pays land rental fee only, not to owe other obligation like co-sharing some % of the rice yield.



Persistently the well owner, Mr.A, is superior than Mr.B. In other words, water owner is superior absolutely in the water use. According to regulation issued by the government and managed by Water Organization, groundwater use for paddy rice cultivation is illegal but no be punished actually.

3) Rainfall

Besides those two water source rainfalls is precious water source for farmers from old days. They have used rainfall for dry farming in this region, which is expectable about 300mm per year. Rainy season is recognized from November to March/April (as solar calendar). Remained months are decreasing rains and



classified as dry season.

A4.3.2 Irrigation Method and Water Requirement

(1) Irrigation Method

The most popular irrigation method in this area is " Basin Irrigation Method". This comes from their farming history, not from farmers' selection. Actually most of farmers have never been familiar with other irrigation method. That is the only way for them to adapt the method. They grew and have been handed over the practice from the previous generation as the most acceptable method for dry farming.

The original intension for introducing this irrigation scheme was "as measure as supplemental water supply for dry farming area", with taking river water, not as " complete modern irrigation system" from initial stage. And now the system has been under developing. Hence farmers are hardly to depend their production on unstable irrigation system. They are still keeping dry farming practice.

Water management is conducted as following presently. At around August the cooperative starts interview to farmer on cultivation plan for the next year to sum up irrigation water demand with irrigation schedule in a coming year. While reporting and requesting to the Water Organization, they provide irrigation schedule by farming plot. After receiving confirmation from the Water Organization, some 20 staffs are to be employed as " Water Watchmen " temporally. They are going to owe tasks to manage water delivery at each turn-out. In case to deliver water to a interior plot of Mr.B, then those watchman should arrange permission from Mr.A, who has a plot faces to an irrigation canal, to pass water through Mr.A's plot to Mr.B's. Any charging will not be considered for such water passing.

Reference for completion for flooding one plot is 15 or 20cm water depth at intake mouth for the already leveled plot, while 20 to 25cm for a case of never leveled plot respectively. Frequency of irrigation is 3 times for whole 9 months in case of wheat and also 3 times for whole 8 months cotton cultivation actually. Reasons explained by farmers of such frequency are ; a) due to scarcity of irrigation water, b) due to no sufficient fund to pay for irrigation charge, though they know more watering will cause more yield.

(2) Water Requirement

Estimated Crop Water Requirement at Aq-Qalah (For Tazeh Abad)

unit : mm/day

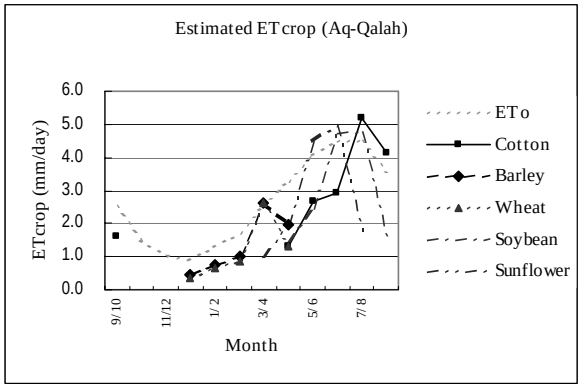
Iranian Calendar		7	8	9	10	11	12	1	2	3	4	5	6
Solar Calendar		9/ 10	10/11	11/12	12/ 1	1/ 2	2/ 3	3/ 4	4/ 5	5/ 6	6/ 7	7/ 8	8/ 9
Aq-Qalah	ETo	2.5	1.5	1	0.9	1.3	1.7	2.5	3.3	4.1	4.5	4.5	3.6
	Cotton	1.62							1.32	2.66	2.92	5.17	4.14
	Barley				0.45	0.78	1.02	2.62	1.98				
	Wheat				0.36	0.65	0.85	2.62	1.32				
	Soybean								1.48	2.46	4.72	4.72	1.62
	Sunflower							1	1.98	4.51	4.95	1.8	

Water demand to be discussed here is to be concentrated to irrigation demand, because the amount of water for potable has been obtained and managed by their own practice, mainly storing rainfall to individual water tank

at their houses.

1) Crop water requirement

(ETcrop)



Presently Agriculture Organization is applying a method originated the modified Pennman Method for estimating the crop water requirement. Soil and Water Department, in charge for such planning in the organization, recommends the method basing on their experiences. There is no results of verification for the estimation.

Table and figure on the right side are estimated ETcrops of cotton, wheat, barley , soybean and sunflower, provided by the Soil and Water Department of the Provincial Governmen. The requirements in dry season increase rapidly to 4 or 5 times of values in wet season. In this dry season river discharge decreases, actually dry upped. Hence it is obvious some countermeasures to secure irrigation water source are required. Alternatives might be a) water reserving facility like farm pond in the scheme 2) establishing water allotment rule to take water from existing dams in the upstream and 3) making rule to draw water through the Army Farm irrigation system, modifying the present system to reach to the scheme.

2) Irrigation efficiency

The existing irrigation system is used by farmers as "supplemental water serving measure" to dry farming actually as stated in the previous clauses. The present condition is remained as dry farming practice, not as modern irrigation system. The plots are enclosed with some 10cm height levee to pond water and farmers apply basin irrigation. Most of farm plots have been adapted " land leveling ", still under developing, which causes low efficiency of irrigation efficiency. Most of irrigation canal networks are left as earth canal, though planned as concrete lining, which is caused due to lack of implementation budget of the Government mainly. Hence net irrigation efficiency is assumed as the above table.

Assumed Irrigation Efficiency by Method

Descriptions		Basin Irrigation		Furrow Irrigation	Sprinkler
		Present	As planned		
Conveyance efficiency	Ec	0.80	0.90	0.90	0.90
Field canal efficiency	Eb	0.80	0.80	0.80	0.90
Field application efficiency	Ea	0.60	0.60	0.70	0.80
Irrigation Efficiency	Ei	0.38	0.43	0.50	0.65

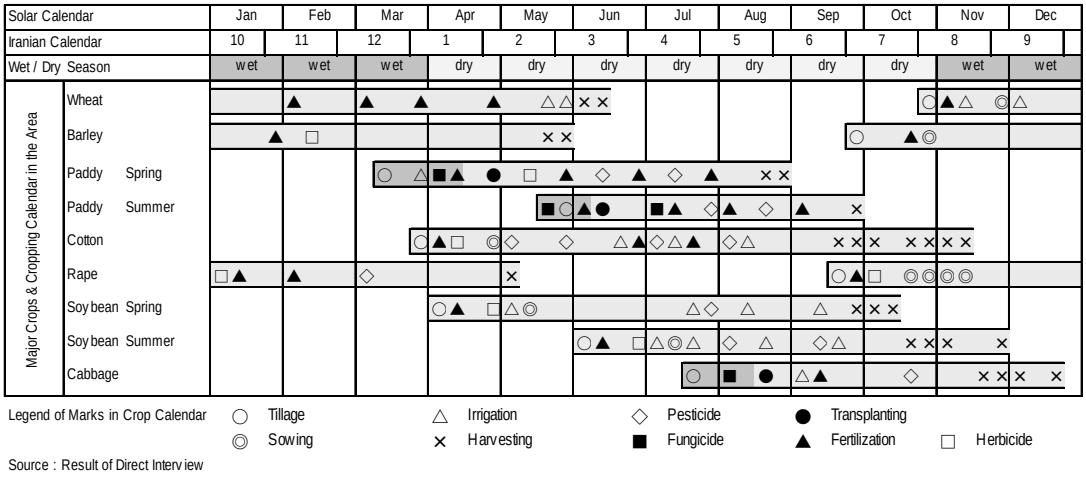
3) Irrigation frequency

The actual irrigation frequency applied by farmers is so limited as shown in the figure below. They are not going irrigate during the first month after seeding and once a month for

November and December. They don't irrigate water during winter from January to March / April by May for the last watering just before the harvest, for the wheat.

Similar watering practice can be found for cotton, which shares still one of major crop there. They are not going to do watering during the first three months after seeding, depending on soil water moisture only. Then starts once a month watering for continuous three months from June to August. They start cotton harvest from September.

Present Crop Cultivation Schedule



Source : Result of Direct Interview

Such watering practice indicates us that the role of the present irrigation system is just to supply supplemental water to crops to overcome thirsty season. Actually the supplied water functions to relief salt stress, which has been concentrated through, dry season to the ground surface and to supply soil moisture in the season.

4) Irrigation water requirement

The whole annual irrigation water demand for 1,000ha might be estimated as followed table, which indicated 13.18MCM per year per 1,000ha, basing on considerations stated in the previous clauses. (Cropping area for the estimation is 1,000ha whole, not divided and fixed into wheat plot and cotton plot in the estimation).

Estimation of Water Demand for Crop Cultivation

Solar Calendar	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Iranian Calendar	10	11	12	1	2	3	4	5	6	7	8	9
Wet / Dry Season	wet	wet	wet	dry	dry	dry	dry	dry	dry	dry	wet	wet
Cropping calendar : Cotton												
Cropping calendar : Wheat												
ET: Cotton mm/day					1.32	2.66	2.92	5.17	4.14	1.62		
ET: Wheat mm/day	0.36	0.65	0.85	2.62	1.32	0						
Effective rainfall mm/mon.	21.6	14.7	16.6	17.7	10.5	14.1	0	0	0	3.6	12.8	18.4
W.demand for 1000ha I&D (MCM)	0.02	0.23	0.38	1.46	0.75	1.52	1.88	3.34	2.59	1.01	0.00	0.00

Annual water requirement for developing 1,000ha I&D scheme ; 13.18 MCM / year / 1,000ha (In case of everyday irrigation practice)

This estimated volume is just a rough estimation to know the scale of the water demand, applying wheat and cotton for the whole scheme area. Actual water requirement might be one sixth of the amount because of one third planting area and farmers are not cultivating cotton and wheat in the same plot.

5) Farmers' recognitions on irrigation water availability

Opinions and recognitions of farmers on the availability of irrigation water are seemed complicated. Most of farmers knows have understanding that the irrigation system serves supplemental water to dry farming. It comes from their fixed idea that the river water is not sufficient to depend on their whole cultivation, because they live besides the river and know the discharge conditions. So besides of hoping water for irrigation, they are not going to have strong expectation to the system. Also the cooperative has similar understanding as above. Partial effects but not whole.

Such understandings of beneficiaries are considerable aspects for examining irrigation plan as references of maturity of technical level, of knowledge foundation, of development scheduling and capability of fund allocation under the cost sharing / privatization policy.

A4.3.3 Preparation of Topographic Map

Soil and Water Department has topographic map and cadastral map of the scheme with scale 1/20,000, provided in 1998. All of planning will be based on those existing products.

A4.3.4 Existing Facilities of Irrigation and Drainage System of the Scheme

This sub-chapter reports present condition of existing facilities of irrigation and drainage system of Tazeh Abad Irrigation Scheme.

(1) Intake facility

Two-story pump house is provided on slop of right side riverbank with 9 center fugal pumps with 300 lit/sec 25m head capacity with electric motor. Pumps are arranged in a row on semi-underground flour, some 3m below the entrance of the station. Ceiling crane is set, and it was explained that they are moving up pumps for evacuation from floods in sprig season. They are obtaining design requirement with adjusting number of pump operation by each scheme. There is no de-silting facility on suction side, instead of it, suction pipes are set at 50cm above from the riverbed capped with silt screens at each pipe inlet. Due to no water level regulator in river side and thick muddy condition, efficiency of pump intake should varies by season.

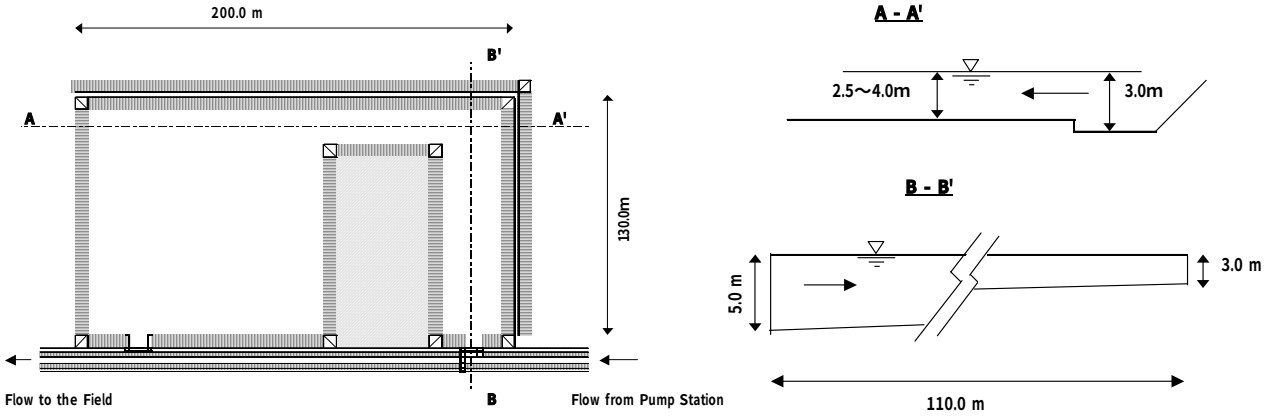
One outlet chamber is provided at outlet side of the station. The water overflows from the crest of the chamber to the conveyance canal after rectification of turbulence flow.

A fulltime operator who is stationed permanently manages pump operation. Record of pump operation and intake amount has never been kept.

(2) De-Silting Pond

A de-silting pond is provided with 1.5ha extent just after the pump station, with 2.5 m depth excavated type. Total capacity of the pond is about 100,000CM. It is explained that all of water discharged from the pump is to be reserved in here before distributing irrigation water through main canal. Completion of the pond construction was the end of 2001.

At other irrigation schemes without the de-silting pond the water discharged from pumps is conveyed to the main canal directly without de-siltation. Hence the canals are filled up with sediment often.



(3) Irrigation canal

Irrigation canal system consists of 1) Main canal, 2) Secondary canal 3) Tertiary canal in the scheme. Main canal is structured with concrete lining commonly with same slope of side wall as 1:1.5, while bottom widths and depth are adapted different sizes among I&D schemes. Bottom widths vary from 0.55m to 0.76m and a range from 0.8m to 1.25m for the depth respectively. Longitudinal gradient is 1/2,000 or 3/10,000.

Secondary canal is constructed as earth lining structure basically and partially adopting concrete lining, depending on financial sufficiency according to the Government's explanation.. Ordinary dimension is as 0.2or 0.3m bottom width, 0.4 or 0.6m as canal depth with gradient of canal side slope of 1:1.5. Longitudinal gradient varies from 1/2,500 to 6/10,000 aiming to obtain conveyance capacity of a range from 70 lit/sec to 120 lit/sec.

Tertiary canal is constructed as earth canal, with dimension of 0.2or 0.3m bottom width, 0.4

or 0.6m as canal depth with gradient of canal side slope of 1:1.5.

(4) Drainage Canal

Drain system is consisted of main and secondary drainage canal in all schemes. The original task of the drainage canal was to drain inundated water of seasonal rainfalls and to discharge drain of irrigated water from the canal slope.

Main canal is structured with earth lining. Its sectional dimension is bottom width;1.0 or 1.5m, side slope gradient ; 1:1.5 and canal depth ; 2.0 or 2.5m. Longitudinal gradient is set as 1/2,000. Secondary canal is structured with earth lining. Its sectional dimension is bottom width;0.5 or 1.0m, side slope gradient ; 1:1.5 and canal depth ; 0.8 or 1.25m. Longitudinal gradient is set as 1/2,000.

A4.4 Irrigation and Drainage Conditions of Cheldin Project Area

Present condition of irrigation and drainage in the Case study area is grasped through the field reconnaissance, and hearing from landholders of the farmland, the RPC, and the engineers of provincial government who are in charge of this area.

The present condition of the technical matters on irrigation and drainage in the Case study area is as follows.

(1) Location conditions of the farmland

The Case Stduy Area locates in Matah Kholate in Cheldin, closed to Gharasu River which runs from East to West while collecting many drains from tributaries. The location of the area is 1.5km west from the Yasaqi-Bandar-E-Torkaman Road. The Gharasu River located 1.7-2.0km north from the area running toward the west. It is about 16km from this point to Caspian Sea. The altitude of this area is around 42.0m. Farmland is scattered on all sides and topographical slope is 1/2,300 from the south to the north toward the Gharasu River.

A small drainage river named the Shast Kholah River runs about 650m away from the eastern part of the area. On the other side, the tributary divided from the Shast Khoran River at the upstream runs toward the north along with the west boundary of the area.

The farmland similar with that in the area is scattered at the northern and eastern sides of the area. Unpaved farm road whose total width is 4.5m runs from east to west in the southern part of the area and it ensures the transportation to Yasaqi - Bandar-E-Torkaman road.

(2) Soil conditions of the farmland

According to the soil survey conducted in this study, the soil of the area is that Clay-Silt-Sand

is70%-25%-5% of soil texture, and it is classified as “clay.” Permeability is low. Fertility is relatively high and CEC is 30. Moreover, EC which shows percentage of salinity, is 1.2mS/cm and there is no salt injury.

(3) Field plot

The area is divided into small or large 4 owners’ plots. These plots form field blocks. Each field block is divided into smaller plots and 20a of lots.

4) Water source

The water sources are rainfall and individual wells by owner plot in the area. There is no well in the northernmost farmland of the right figure therefore it is supplied water from Plot ①.

(5) Problems on irrigation and drainage

The problems on irrigation and drainage pointed out from the landowners are as follows.

a. It is impossible for a tractor to enter into the farmland due to frequent inundation during rainy season,
b. The Ghrasu River flows backward every several years. In this case, drainage of the drainage river is retarded, and
c. Groundwater level of the farmland is always high and it effects badly on crop cultivation.

These matters are as same as the problems which pointed out during the hearing conducted in the first and second field surveys in Cheldin Area. It is different from Tazeh Abad Project Area and drainage is the context of main problems.

The details are reported in the chapter of hydrology, but it finds that inundation damage reported from the farmers is not caused by a small drainage river flowing in the Gharasu River from the mountainous areas, as a result of examination. This situation is limitedly happened in case of the flood in around 1/50 possibility year.

The soil of the area includes more than 50% of clay and it is very high. Therefore, the boarders surroundoing the owner lots and the boarders formning the field plots deteriorates inundation.

Moreover, as reported before, in case of crop cultivation mainly by using agricultural machinery in the clayey soil, passing of the agricultural machinery often causes soil compaction.