Part 4: Watershed Management

THE STUDY ON INTEGRATED MANAGEMENT FOR ECOSYSTEM CONSERVATION OF THE ANZALI WETLAND

FINAL REPORT
Volume III Supporting Report

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CHAPTER 1 INTRODUCTION

1.1 General

The watershed management plan is one of the components of the Master Plan Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran, which has been carried out by the JICA Study Team since February 2003. The Study itself aims to formulate an integrated master plan for conservation of the Anzali Wetland and develop the capacity of the organizations concerned through the course of the Study. The Anzali Wetland has a total catchment area of 3,610 km^2. Needless to say, the sound management of the watershed is indispensable for the sustainable management of the Anzali Wetland. In general, the watershed has the following functions for the wetland.

- Securing the quantity of water of major rivers entering the wetland
- Supporting the bio-diversity of the wetland by provision of habitats of wildlife
- Maintaining the quality of water of major rivers through reduction of sediment

In case the watershed is not properly managed, it would lose the functions listed and cause the deterioration of wetland environment. Hence, this study report put its focus on identifying issues/limitations related to the watershed management and coming up with requisite countermeasures for maximizing the watershed's functions to maintain the environment of the Anzali Wetland.

1.2 Scope of the Study

1.2.1 Study Area

The study area is the entire watershed of the Anzali wetland. Administratively, the study area is under the jurisdictions of six (6) township offices, namely, Shaft, Fuman, Somehsara, Masal, Anzali and Rezvanshahr. On the other hand, the study area is topographically divided into the following land types:

a) Plain and orchard area (25 m - 500 m)
b) Forest area (500 m - 1,500/2,000m)
c) Rangeland (1,500/2,000m - 3,000m)

1.2.2 Coverage of the Study

The watershed ranges from plain areas to mountain peaks. In particular, the focus of the Study is put on: i) soil erosion control and prevention of land slides in the upper watershed; ii) forest and rangeland management; and iii) sediment control in the plain areas, and iv) livelihood development of local people who reside in the mountains. These aspects of watershed management are significantly related to the environmental condition of the Anzali Wetland. Other aspects related to the wetland environment, such as Hydrology, Wetland Ecological Management, Urbanization, Wastewater Management and Solid Waste Management are discussed in other supporting reports.

1.3 Composition of the Study Report

This report is composed of seven (7) chapters. In Chapter 1, the general background and coverage of the study are described. Chapter 2 shows the present condition of the watershed and issues related to the wetland environment. Chapter 3 clarifies the present management activities and the management issues/limitations. In Chapter 4, a watershed management plan containing necessary activities to improve the environmental situation of the watershed as well as the wetland is proposed. Chapter 5 gives the estimated costs of the proposed activities. An implementation schedule of the proposed watershed management plan is presented in Chapter 6. The last chapter, Chapter 7, introduces priority projects.

CHAPTER 2 PRESENT CONDITIONS OF THE WATERSHED

2.1 Natural Conditions of the Watershed

2.1.1 Topography

The Anzali Wetland watershed is located approximately between N36 º 55' to 37 º 32' and E48º45' to 49º42' in the northern part of the country and along the coast of the Caspian Sea. The watershed ranges from about EL.-25 m at the Caspian Sea coast to about EL. 3,105 m in the mountains. The watershed of the Anzali Wetland is bordered by the fan of the Sefiroud River in the east, the Alborz Mountain chain to the south and west, and the Caspian Sea to the north.

The watershed is geomorphologically divided into two (2) types of landforms, that is, i) lower plain flat land in the north and ii) mountainous area in the south. The lower plain flat land, the so called Anzali Plain, is approximately 60 km long and 20 to 40 km wide, and the mountainous area is approximately 70 km wide and 25 km long. The relation between the topography and land uses in the Anzali Wetland watershed is shown in Figure 2.2.1.

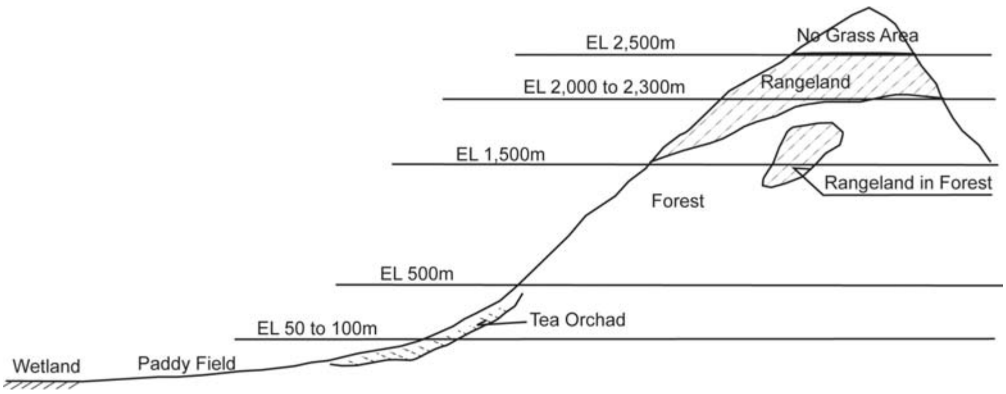

Figure 2.1.1 Typical Profile of the Anzali Watershed

2.1.2 Major Rivers and Sub-watersheds

There are 10 major river systems entering the wetland. Nine (9) of them originate in the mountains in the study area, while the other, the Khomamroud River, runs westward from outside of the study area. The catchment area of the Anzali Wetland is about 3,610 km^2 in total. Figure 2.1.2 presents the locations of the major rivers with their basin boundaries and Table 2.1.1 shows the areas of each basin, respectively.

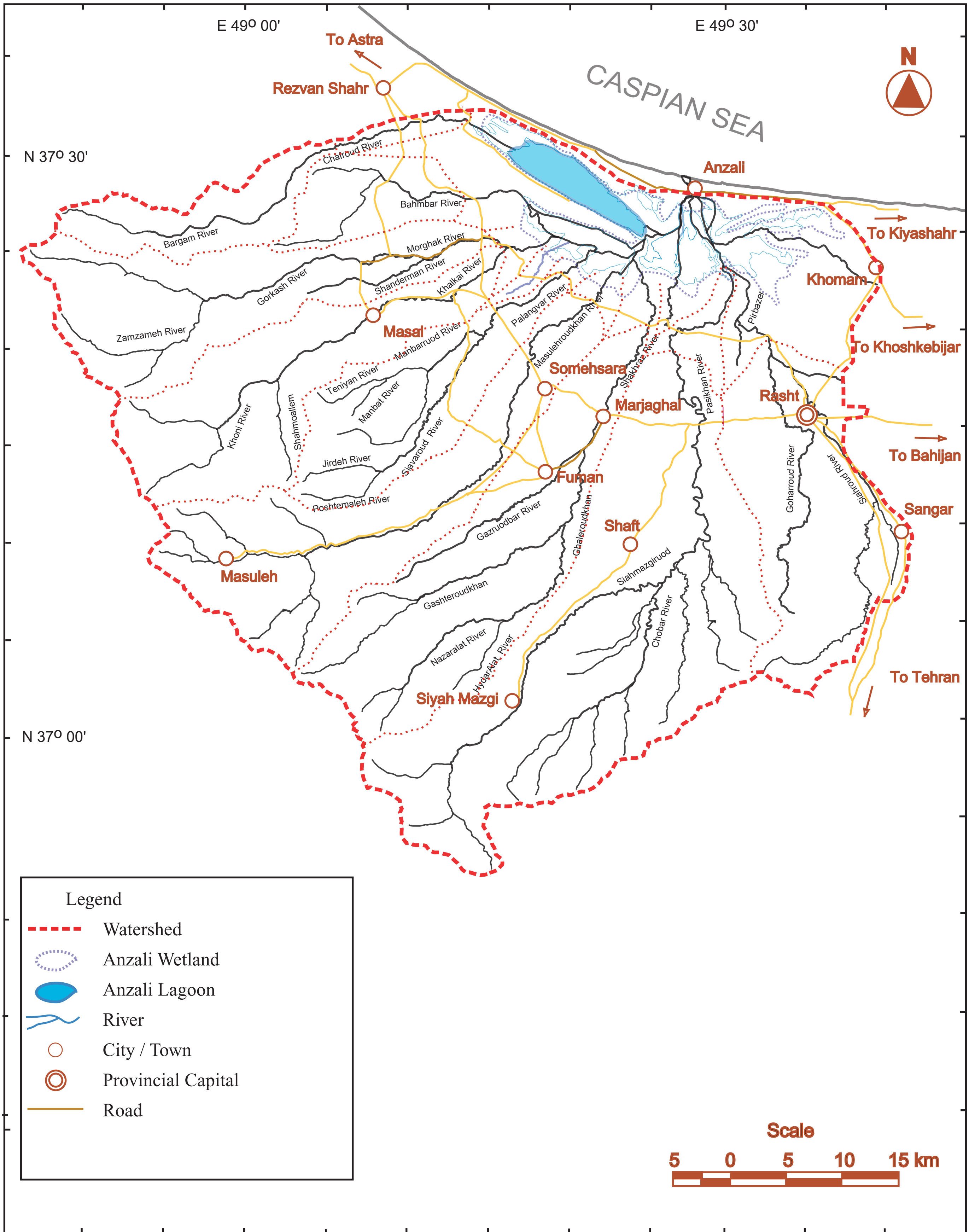

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Figure 2.1.2
Location of Major Rivers and Basin Boundaries in the Anzali Wetland Watershed

Table 2.1.1 Sub-watersheds in the Study Area

Sub-watershed	River (Tributaries)	Area (km^2)
Chafroud	Chafroud	123.6
Bahmbar	Bahmbar	141.4
Morghak	Morghak (Shandarman, Gorkash, Zamzameh)	529.5
Khalkai	Khalkai (Khoni, Shahmoallem)	494.4
Palangvar	Plangvar (Manbarruod, Siavaroud)	213.1
Masulehroudkhan	Masulehroudkhan	591.8
Pishroudbar	Pishroudbar (Gazruodbar, Gashteroudkhan, Ghaleroudkhan)	467.4
Pasikhan	Pasikhan (Siahmazgiruod, Chobar)	810.4
Pirbazer/Khomamroud	Pirbazer (Siahroud, Gohrroud), Khomamroud	251.0
Total	-	3,606.8

Source: JICA Study Team (2003)

2.1.3 Geology and Soil

(1) Geology

According to the Geological Map of Guilan Province shown in Figure 2.1.3 (published by Guilan Geological Project at the scale of 1: 250,000 in 1991 and modified after Quadrangle Maps (D2, D3, D4 and E3-4) published by the Geological Survey of the Iran), the geology of the watershed is roughly classified into two geological zones. The plain area in the northern part of the watershed is widely covered by the Quaternary geology, Pleistocene to recent sediments, whereas the mountainous area in the southern part is underlain by Pre-Tertiary geology, Lower Paleozoic to Neogene Formations and some intrusive rocks.

The oldest bedrock in the watershed is the Pre-Paleozoic formation. It consists of green schist, gneiss biotite schist, schistose phyllite and mica schist, and outcrops mainly along the upstream of the Shiamazgiroud River, the Gashutroudkhan River, the east bank of the Masulehroudkhan River and the Morghak River. These rocks are well fractured and easily weathered and collapsed

Above the Pre-Paleozoic formation is Paleozoic Formation, which is subdivided into two formations, namely the Lower Paleozoic formation and the Upper Paleozoic formation. The Lower Paleozoic formation, consisting of reddish arenaceous rock (sandstone), basaltic and andesitic rocks, red limestone, calcareous sandstone and marly limestone, is of limited occurrence in the watershed. The Upper Paleozoic formation, consisting of slaty to phillytic sediments, basic to andesitic volcanics and limestones, is widely developed along the upstream of the Khalkaii River, the Shahmoalem River and the Teniyan River. Among these formations, slaty to phillytic sediments are fractured and easily weathered and collapsed.

Triassic-Jurassic, lower and upper Cretaceous formations are scattered around the eastern and western parts of the mountainous area, upstream of Masulehroud River and the south part of the Rasht.

The Quaternary zone is represented by marine and alluvial deposits that unconformably overlie the older formations. These deposits are distributed along the foot of the mountainous area and in the plain area and are unconsolidated and easily eroded and scoured.

Along the foot of the mountainous area, recent deluvial and fluvial deposits are developed in the form of a narrow bank from east to northwest. In the plain area of the watershed, the underlying geology is older in the southern part than in the northern part and is subdivided into 1) lower alluvial, flood-plain and deltaic deposits (Q1al) distributed only along some rivers, specially in the eastern part of the watershed; 2) Pleistocene marine deposits (Q1m) distributed widely in the plain; 3) beach deposits (Q1b, Q2b) overlying Q1m in a narrow strip; 4) upper alluvium and flood plain deposits (Qal, Qle) distributed along the rivers; recent deposits (Qtv, Q2m, Qd) distributed along the Caspian Sea; and most recent deposits (Qdg), deposits of the Sefiroud River's fan, distributed south-east of Rasht.

Surface soils of the Plain are mainly formed from the marine deposits (Q1m, Q2m) and alluvium and flood plain deposits (Qal), (see Figure. 2.1.3).

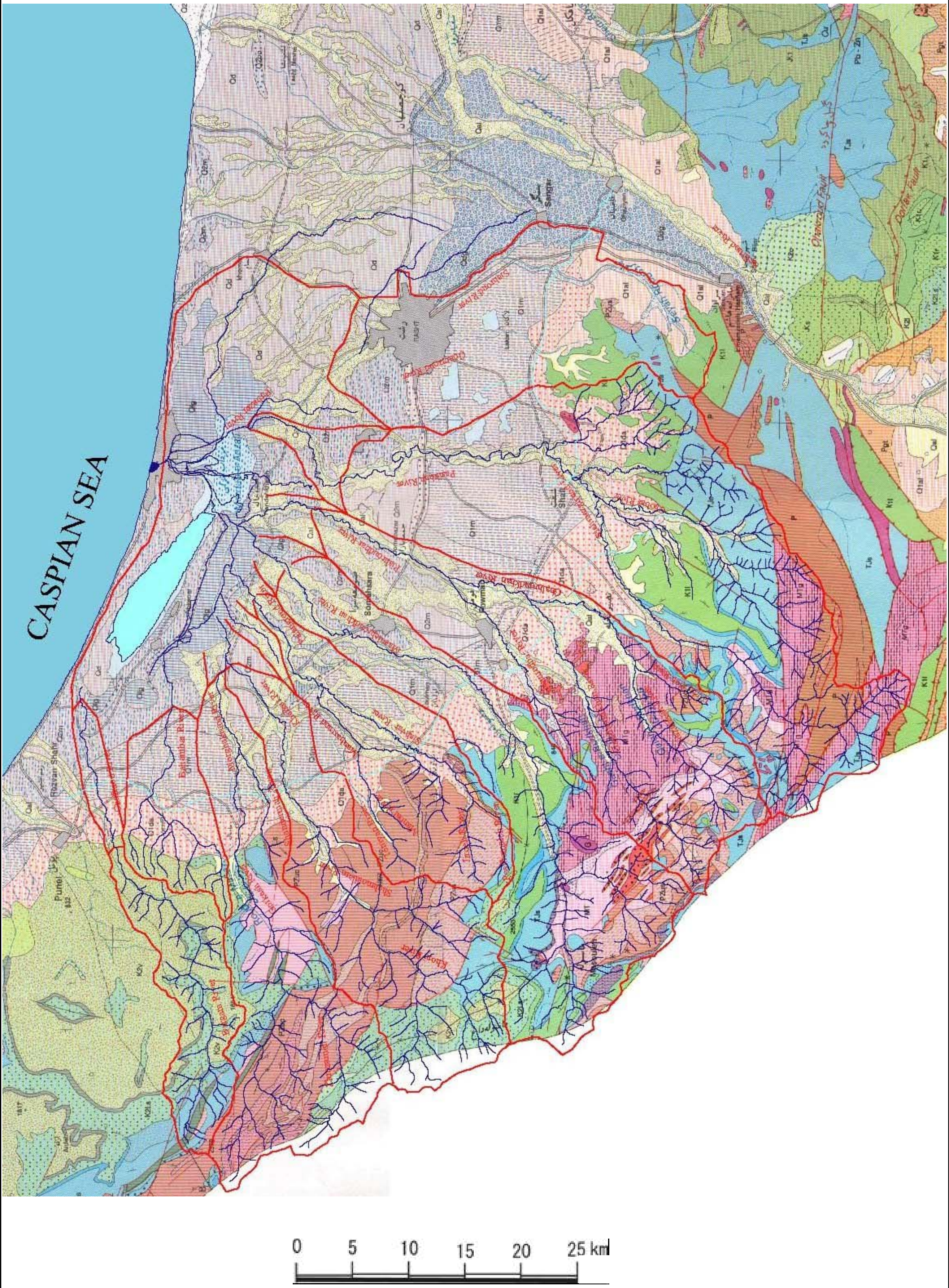

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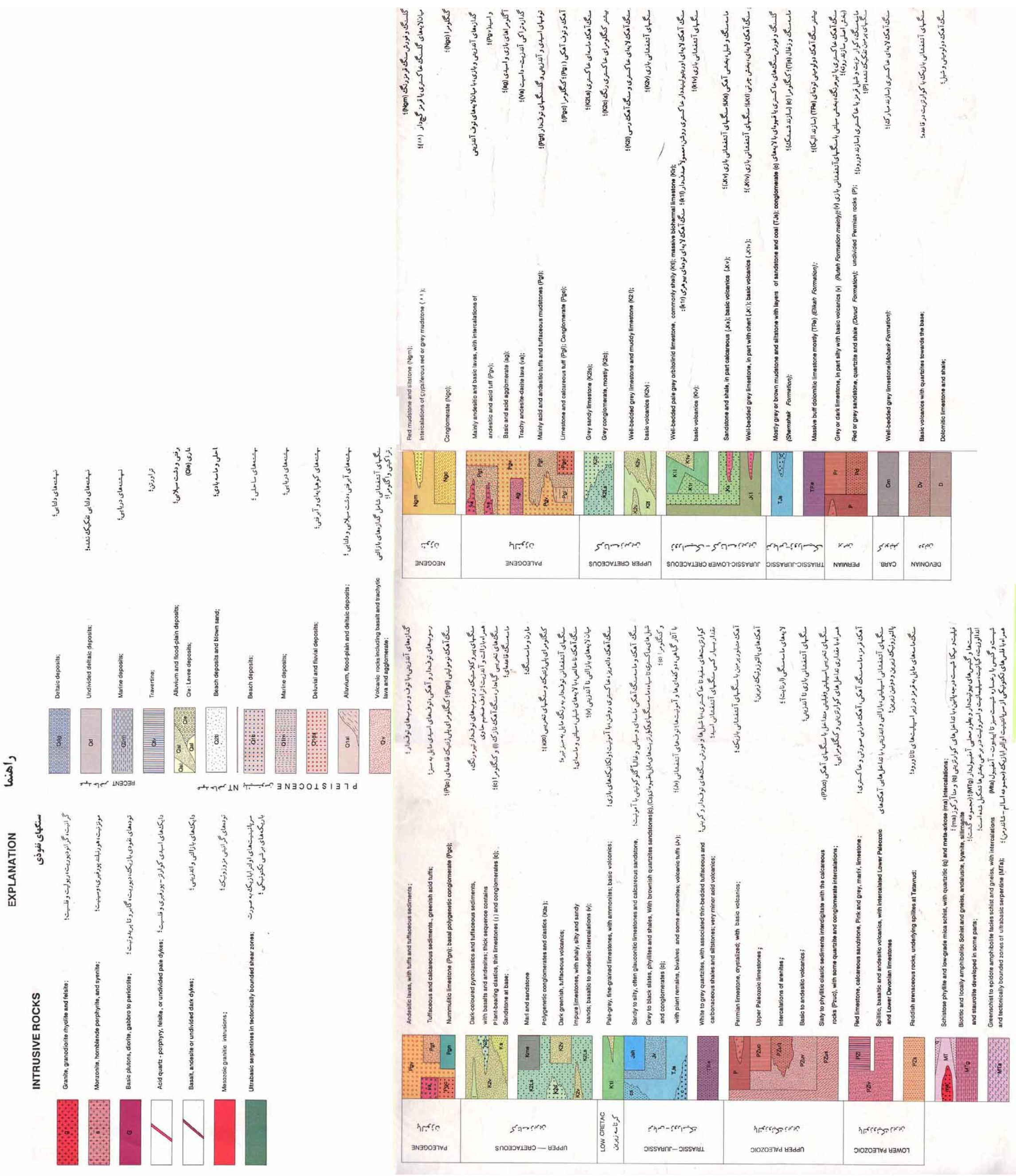
Figure 2.1.3 (1/2)
Geological Map of the Anzali Wetland Watershed (Ministry of Interior Governorship of Guilan)



(Ministry of Interior Governorship of Guilan)

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Figure 2.1.3 (2/2)
Geological Map of the Anzali Wetland Watershed (Legend)

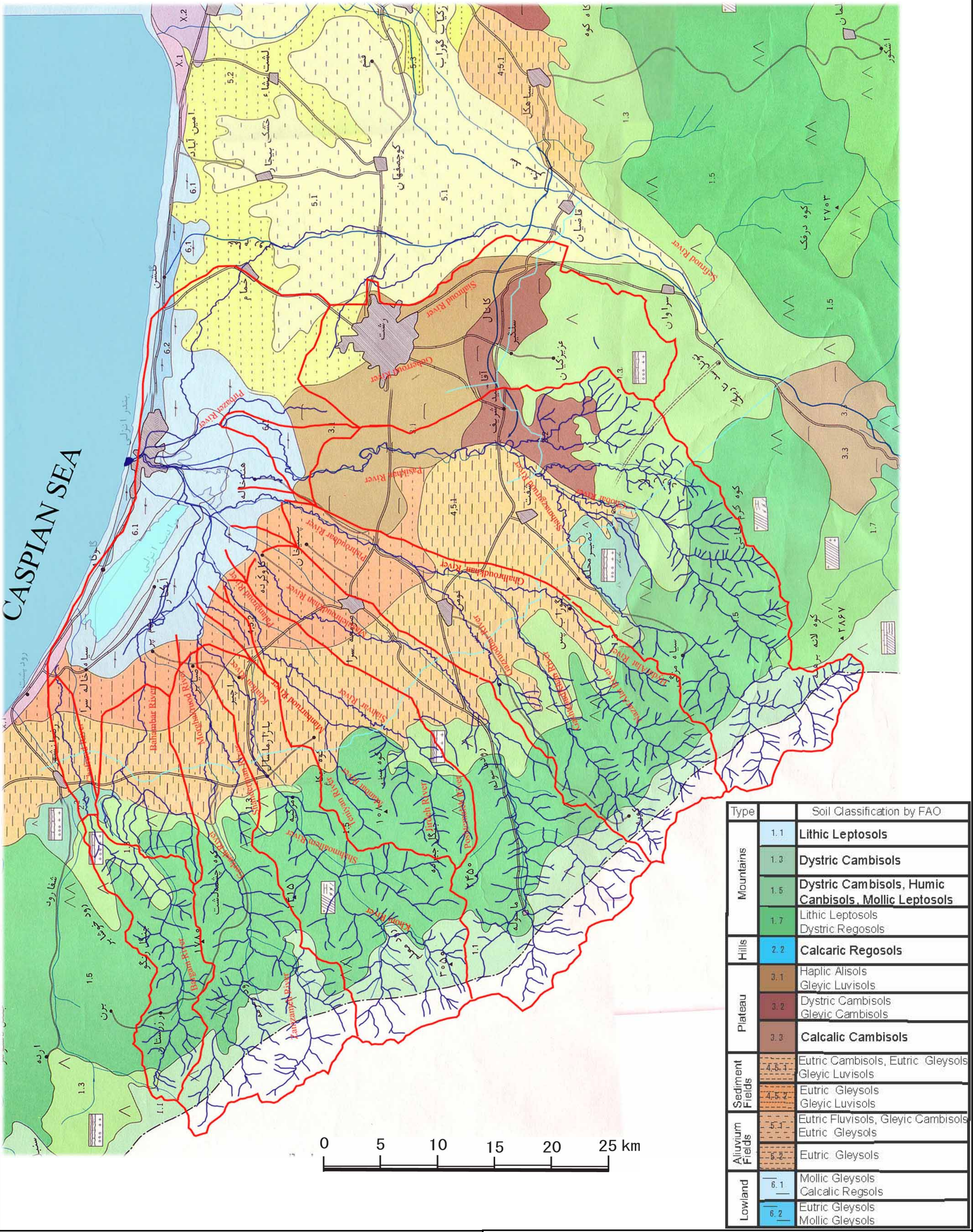
(2) Soil

According to the soil map of Guilan published by the Ministry of Agriculture in 1992, the surface condition of soils is grouped into two types, namely mountainous soils and plain soils. The mountainous soils, which are Lithic Leptosols, Dystric Cambisols, Humic Cambisols, Mollic Leptosols, Calcaric Regosols, Haplic Alisols, Gleyic Cambisols and Calcaric Cambisols, are distributed in the upper watershed.

Lithic Leptosols and Mollic Leptosols are shallow soils (less than 30 cm soil over hard rock) or those with a high gravel content. Dystric Cambisols, Humic Cambisols, Gleyic Cambisols and Calcaric Cambisols are moderately developed soils characterized by slight or moderate weathering of the parent material and by the absence of appreciable quantities of accumulated clay, organic matter, aluminum or iron compounds. Calcaric Regosols are determined by the type of parent calcareous materials, and the subsoil generally reflects the weathered rocks on which the Regosols developed. Haplic Alisols are the product of intense weathering and generally have a high exchangeable aluminum content. Clay migration takes place and a dense clay accumulation layer occurs in the subsoil.

In the plateau area, south and east part of Rasht, Haplic Alisols, Gleyic Luvisols, Dystric Cambisols and Gleyic Cambisols are distributed.

In the plain areas, Eutric Cambisols, Eutric Gleysols, Eutric Fluvisols, Gleyic Cambisols Molilic Gleysols and Cacalic Regsols are distributed. These soils are formed by fluvial and Caspian Sea deposits. The soil map of the study area is presented in Figure 2.1.4.



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 2.1.4** **Soil Map of the Anzali Wetland Watershed (Water and Soil Research Institute 1992)**
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2.1.4 Vegetation

The vegetation in the watershed can be roughly divided, based on the present vegetation and topographic features, into five zones, namely (1) High mountain bare area, (2) High land grass area, (3) Forest area, (4) Plain area and (5) Wetland.

(1) High Mountain Bare Area

High mountain bare area, generally above the elevation of 2500 meters, is distributed along mountain ridges in the southern part of the watershed with little or no vegetation cover because of severe climatic conditions.

(2) High Land Grass Area

High land grass areas are located along some mountain ranges and isolated hills between about 1,500 m and 2,500 m above sea level, where trees have difficulty in growing because of the unfavorable weather.

(3) Forest Area

Approximately 42% of the study area is covered by broad leaf forests, known as the Hyrcanian Forest, in a narrow band along the Caspian Sea. The area extends between elevation 2100 m and 200 m in general. The forests in the watershed can be divided into three types of forests depending on the elevation, namely, lower elevation forests; intermediate forests; and higher elevation forests.

The higher elevation forests (EL. 800-2,100 m) consist of two associations of Fagetum hyrcanum, namely, Rusco-Fagetum on calcareous soil and Arctostaphylo-Fagetum on silt soil with acidic pH. In both associations Beech (*Fagus orientalis*) and Banyan-tree are the dominant tree species. Other important tree species are *Carpinus betulus, Alnus glutinosa, Fraxinus coriarifolia, Acer insign,* and *Quercus mucranthera, Carpinus betulus* as well as *Ulmus glabra* on southern slopes.

The intermediate forests (EL. 200-800 m) consist of Querco-Carpinetum and Parrotio-Carpinetum associations. The main species are *Carpinus betulus, Quercus castaneifolia, Zelkowa carpinifolia, Acer insign, Alnus subcordata, Diospyrus lotus* and *Fraxinus coriarifolia*.

Lower elevation forests (below EL. 200 m) in the Querco-Buxetum association are composed of *Alnus subcordata, Quercus castaneifolia, Gleditsia caspica, Carpinus betulus, Tilia begonifolia, Buxus sempervirens, Diospyrus lotus* and *Parotia persica*. Among others, two species, *Quercus castaneifolia* and *Buxus sempervirens,* are scarce due to intensive cutting.

(4) Plain Area

The plain areas, generally below 100 meters, are used for farming of crops such as paddy, other horticulture crops, tea, and orchard, and for poplar plantation.

2.1.5 Land Use

(1) Land Use and Vegetation in 1993 (based on the data of MOJA)

Figure 2.1.5 shows the land use map of the Anzali Wetland watershed prepared by MOJA in 1993. Land uses are divided into 7 categories: farm land, rangeland, forest and savanna, uncultivated, damp land, surface water, urban and infrastructure. Furthermore, the farm lands are divided into eight farming types. Of these eight categories, three, such as low or no limitation farm land, mixed cultivation, and orchard farm land, are dominant in the study area. Almost all forests are dense and mainly located in the upper watershed, but some semi-dense forests are also found at high altitude.

(2) Changes of Land Uses between 1987 and 2002

The Study Team analyzed LANDSAT satellite images to grasp the present land use in the study area as well as changes during the last decade. Satellite images captured in different years, namely, July 1987; June 1991; and August 2002, were used for analysis. As a result of the satellite image analysis, the present land uses of the study area were classified into eight (8) categories as shown below. The land use of the watershed in August 2002 is presented in Figure 2.1.6.

Table 2.1.2 Land Use based on LANDSAT Images

Category	July 1987		June 1991		August 2002	
	km^2	%	km^2	%	km^2	%
Lagoon/Pond	57.5	1.6	57.7	1.6	45.5	1.3
Wetland	72.0	2.0	61.0	1.7	118.0	3.3
Orchard	460.2	12.8	467.7	13.0	311.2	8.6
Paddy/Farmland	1,073.6	29.8	1,062.6	29.5	962.5	26.7
Forest	1,331.6	36.9	1,401.3	38.9	1,513.5	42.0
Rangeland (Mountain Grass)	73.6	2.0	211.2	5.9	107.7	3.0
Bare land	356.8	9.9	145.1	3.9	255.9	7.1
Urban area (Include Road)	181.4	5.0	200.2	5.6	292.4	8.0
Total	3,606.8	100.0	3,606.8	100.0	3,606.8	100.0

Source: JICA Study Team (2003)

Results of the satellite image analysis are compiled in Attachment-1. Some findings in the land use analysis are highlighted as below.

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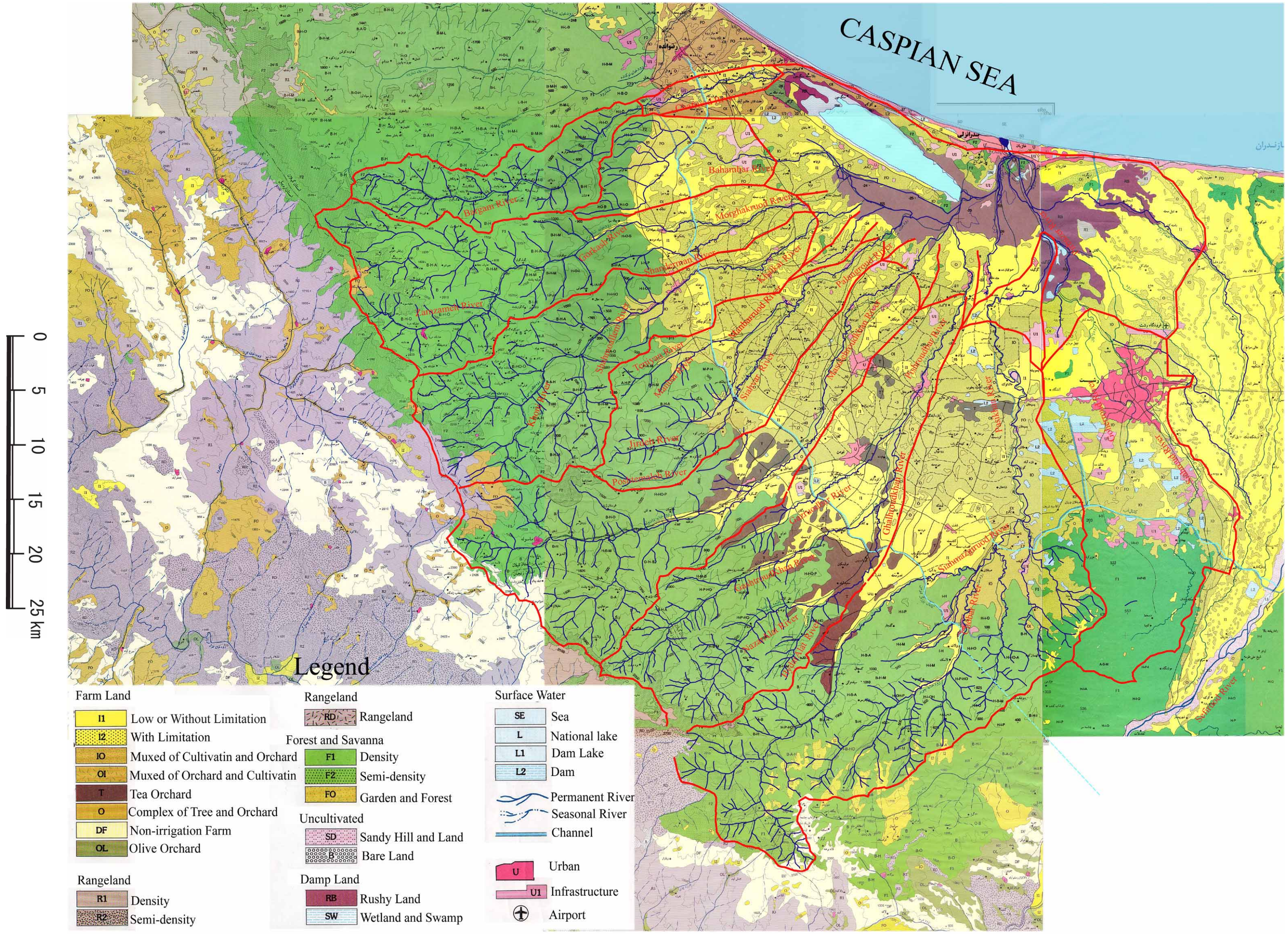

Figure 2.1.5
Land Use Map of the Anzali Wetland Watershed
(MOJA 1993)

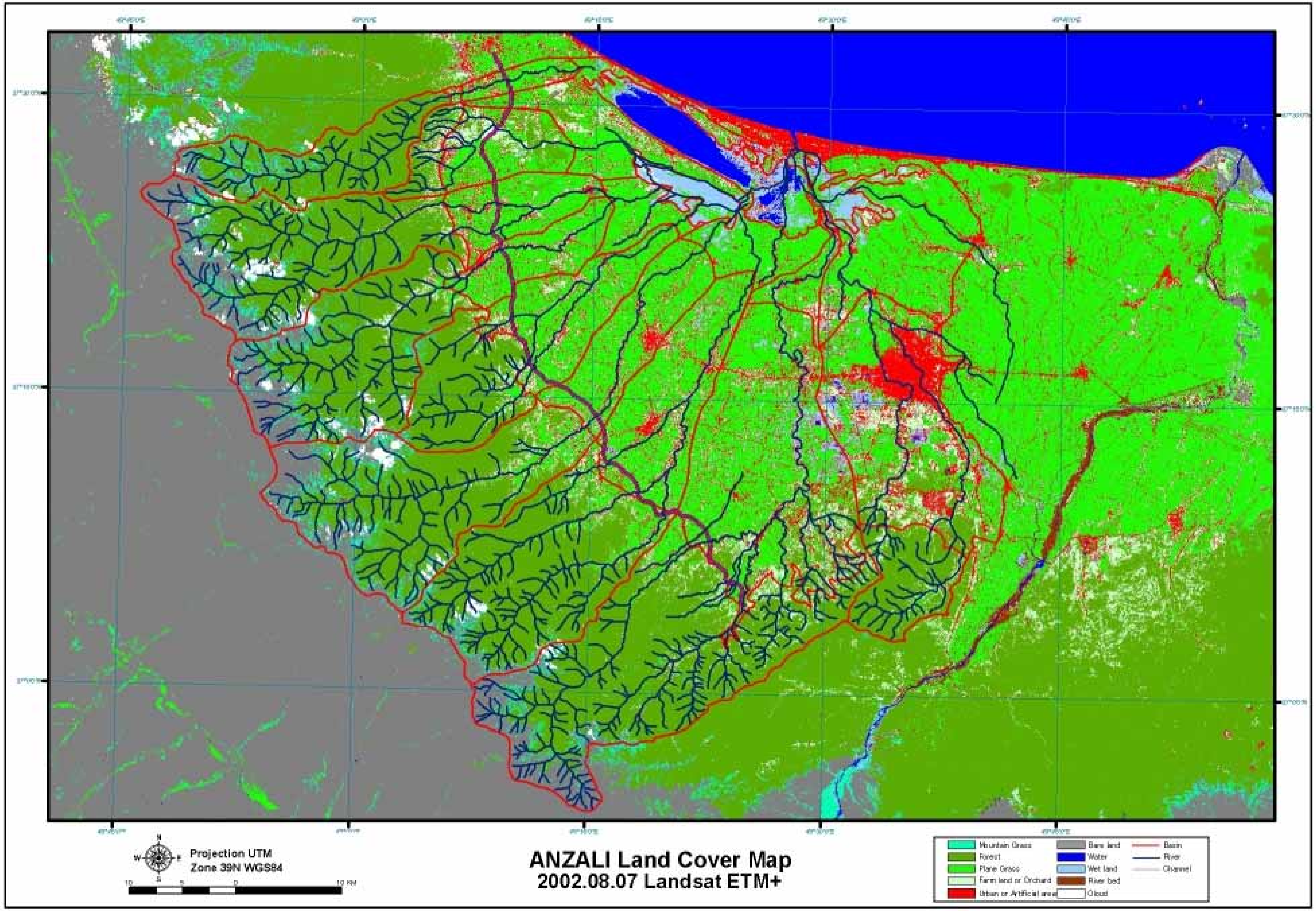

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Figure 2.1.6
Latest Land Use of the Anzali Wetland Watershed
(August 2002)

a. There was no change in the area of lagoon/pond between 1987 and 1991, while the area decreased for the decade (1991-2002) by 12.2 km^2. The decrease of lagoon/pond was caused by the reclamation of ponds.
b. The wetland increased from 61 km^2 to 118 km^2 between 1991 and 2002. It was caused by the expansion of the same vegetation as that in the wetland.
c. Paddy/farmland reduced by about 100 km^2 from 1991 to 2002. It is probably attributed to the increase of tree plantations (poplar plantation) in the plain area.
d. Consequently, it is assumed that the expansion of forests from 1,401 km^2 to 1,513 km^2 between 1991 and 2002 were owing to the conversion of farmlands to tree plantations.
e. The areas of rangeland (mountain grasses) and bare land have fluctuated year by year. This is mainly because:
   - the bare land in 1987 might include opened forests since clear cutting was the main practice of forest exploitation in the 1980's; and
   - the weather conditions in the respective years might affect the growth of grasses in the rangeland.
d. The sum of rangeland and bare land has not changed since 1991 (356 km^2 in 1991 and 363 km^2 in 2002), though the areas of rangeland and bare land have fluctuated in the same period. It is, therefore, speculated that the total of rangeland and bare land would be approximately 360 km^2.

2.2 Socio-economic Conditions of the Watershed

2.2.1 Administration and Demography

The entire watershed covers six (6) townships or 38 Shahrs/Dehestans in Guilan province. Based on the 1996/97 census, a total of 512,000 families live in Guilan province and more than 50% of them reside in the study area. Demographic data of the study area are summarized as follows:

Table 2.2.1 Population and Households in the Watershed

Township	No. of Shahrs/Dehestans	Total Families	Total Population
Rasht	9	169,126	713,913
Anzali	3	29,180	120,471
Somehsara	8	30,789	136,710
Shaft	6	14,392	70,292
Fuman	7	22,635	103,192
Masal	5	9,713	46,572
Subtotal	38	275,754	1,191,150
Provincial total	-	512,007	2,241,896

Source: Statistical Year Book of Guilan 2002/2003, Guilan Statistical Yearbook 1381

2.2.2 Household Income

According to the Provincial Statistical Yearbook of Guilan (1381), the average annual net incomes of households in urban and rural areas in Guilan province are 20.6 and 16.0 million Rials/annum/family, respectively. The Statistical Yearbook also shows the major sources of income in the study area, which are:

- Agricultural sector (Rice farming, Livestock grazing, Industrial cattle raising, Poultry raising, Sericulture, Fish culture, and Horticulture);
- Industry sector (Food, Non-metal minerals, Textile, Chemicals, Metal industries and Handicrafts); and
- Service sector (Public service, Transportation and storage, Hotel and restaurant and Trading).

2.2.3 Job Opportunities in the Study Area

The agriculture sector creates jobs for about 35% of the workforce in the study area, while the service sector also absorbs about 41% of the workforce. About 23% of the workforce in the study area engage in the industry sector. Table 2.2.2 shows the job opportunities created by each sector in the study area.

Table 2.2.2 Job Opportunities Created by Major Sectors

Township	Agriculture		Industry		Services	
	No.	Share (%)	(No.)	(%)	(No.)	(%)
Rasht	48,220	24	53,760	27	95,140	48
Somehsara	23,410	57	4,630	11	13,360	32
Shaft	12,490	61	2,990	15	5,070	25
Fuman	19,170	53	7,080	20	9,460	27
Masal	7,730	58	1,560	12	4,030	30
In the Study area	111,020	35	70,020	23	127,060	41
Provincial total	249,200	40	129,330	21	243,180	39

Source: Statistical Year Book of Guilan 2002

2.2.4 Ethnicity

A variety of ethnic groups reside in the study area without any social conflicts. The main ethnic groups are *Talesh, Gilak* and *Azari (Turk)*. Among others, *Taleshs* constitute the majority in the study area. They can be divided into two (2) groups by location, that is, plains and mountains. People in the mountains rear sheep and lead a semi-nomadic lifestyle, while those on the plains engage in rice farming. *Taleshs* can be recognized by their language, clothing, housing, culture, and way of livestock farming, although their style has been changing rapidly. The livestock farming methods that *Taleshs* used to operate, which is close to a nomadic life-style, have undergone major changes and presently are on the verge of disappearing as a result of government policies and programs. Due to changes in the animal husbandry methods and restrictions on the uses of forests and rangelands, their housing style has also changed from the traditional type (tents and wooden huts) to a modern one (wooden cottages with mud, stone, cement, bricks, etc.).

2.3 Major Environmental Issues related to the Wetland

2.3.1 General

The most critical issue in relation to the environment of the Anzali wetland is the inflow of sediment from the watershed. All soil erosion processes from sheet erosion to gully erosion are found in the upper watershed, especially the rangelands. Soil erosion is caused mainly by rangeland degradation. In addition to rangeland degradation, forests in the area have also been degraded, which has drawn the government's attention recently.

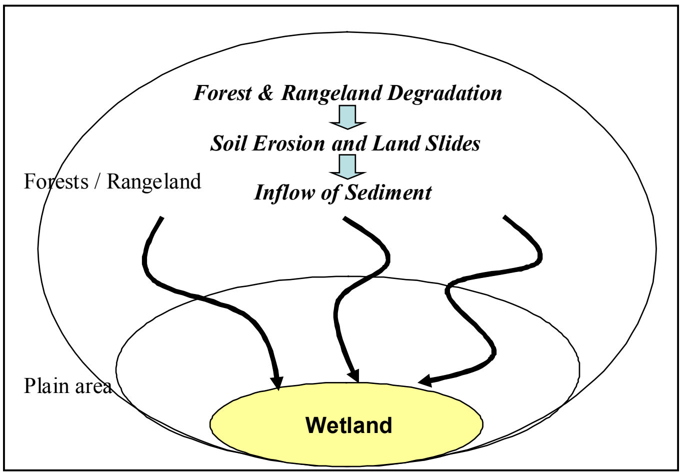


Figure 2.3.1 Major Environmental Issues

2.3.2 Situation of Soil Erosion

The rangelands in the upper part of the watershed, the area from EL. 1,500 m to 2,500 m in general, have been used for grazing. Overgrazing has been the principal cause of rangeland degradation.

Figure 2.3.2 Example of Erosion (Upper Reach of Masuleh)

(1) Erosion Process

Overgrazing spurs erosion processes in the rangelands of the watershed. The initial stage of the erosion is generally known as sheet erosion (see Figures 2.3.2, 2.3.3 and 2.3.4). At this stage, surface soils are thinly eroded with roots of grass, and grass lands change to bare land.

Figure 2.3.3 Example of Sheet Erosion (Upper Reach of Masuleh)

Figure 2.3.4 Example of Sheet Erosion (Upper Reach of Khalkai)

The next stage of erosion is called rill erosion. Rill erosion occurs as small channels develop over the soil surface (Figure 2.3.5). After this, rill erosion develops into gully erosion with wider and deeper channels and a large amount of debris flowing down with water into rivers (Figures 2.3.5 and 2.3.6).

Figure 2.3.5 Example of Rill Erosion and Gully Erosion (Upper Reach of Masuleh)


Figure 2.3.6 Example of Gully Erosion (Upper Reach of Masuleh)

Flowing water from a rill/gully channel erodes river beds and river side walls (Figure 2.3.7), and causes landslides and slope failures. Landslides and slope failures release enormous amount of sediments into a river, and creates debris flow and floods. At this stage, it is necessary to construct a check dam, such as a gabion check dam, stone masonry check dam, concrete check dam and/or some kinds of channel works that decrease riverbed gradient.


Figure 2.3.7 Example of Erodible Valley (Upper Reach of Masuleh)

(2) Estimated Release of Sediment from the Watershed

To grasp the effect of sediment from the watershed on the wetland, the Study Team estimated the sediment yields from the upper watershed by using two (2) empirical models, namely, Erosion Potential Method (EPM) and Pacific Southwest Inter-agency Committee Method (PSIAC). Details of the models used were explained in the Supporting Report Part 2 "Hydrology". The estimation reveals that a total of 326,000 tons/year of sediment are released from the upper watershed.

Table 2.3.1 Estimate of Annual Sediment Yield from Mountains

(Unit: m^3/year)

Sub-watershed	Forest	Grassland	Bare land	Total
Chafroud	5,000	1,500	6,000	12,500
Bahmbar	2,000	0	0	2,000
Morghak	11,000	3,500	29,000	43,500
Khalkai	12,000	3,000	26,500	41,500
Palangvar	6,500	0	0	6,500
Masulehroudkhan	18,000	5,000	33,000	56,000
Pishroudbar	16,000	1,000	8,000	25,000
Pasikhan	22,000	2,000	34,000	59,500
Pirbazer	4,000	0	0	4,000
Total (m3/yr)	96,500	16,000	136,500	250,000
Total (ton/yr) *1	125,500	20,800	177,500	326,000

Note: *1: Assuming soil bulk density of 1.3 ton/m^3
Source: JICA Study Team (2003)

Sediment is also released from the plain areas, such as paddy fields, other farms and pasture lands, river-bank erosion and urban areas. In total, the sediment release from the plain area is estimated at 74,000 ton/year. Detailed estimation is presented in the Supporting Report Part 2.

Table 2.3.2 Estimate of Annual Sediment Yield from the Plain Areas

Source	Quantity	Sediment Rate	Total	
		(ton/km^2/yr)	(ton/yr)	(%)
Rice paddy	1,280 km2	21	26,900	47
Farm and pasture land	240 km2	100	24,000	32
River bank	111,300 m	0.05	5,600	10
Urban runoff	60 km2	100	6,000	10
Total (ton/yr) *1	-	-	74,000	100

Note: *1: Assuming soil bulk density of 1.3 ton/m
Source: JICA Study Team (2003)

(3) Sediment Transport and Deposition Mechanism

The amount of sediment reaching the wetland was estimated using the HEC-6 computer software, which has the capability to simulate transport and deposition of sediment along rivers. Figure 2.3.8 summarizes the quantity of the mountain-derived sediment, plain-derived sediment, and sediment transport in the watershed. The resulting inflow of the sediment to the wetland is approximately 400,000 tons/year.

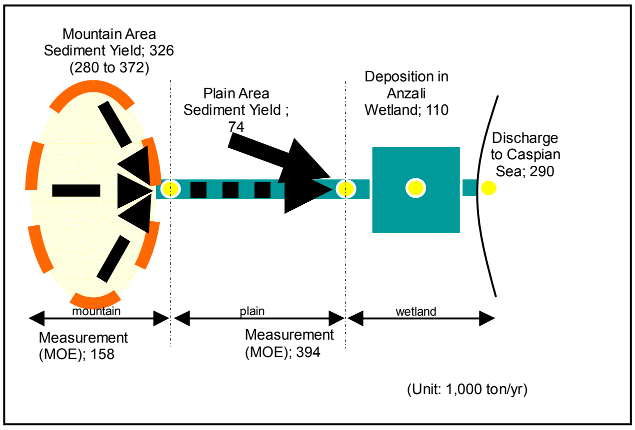
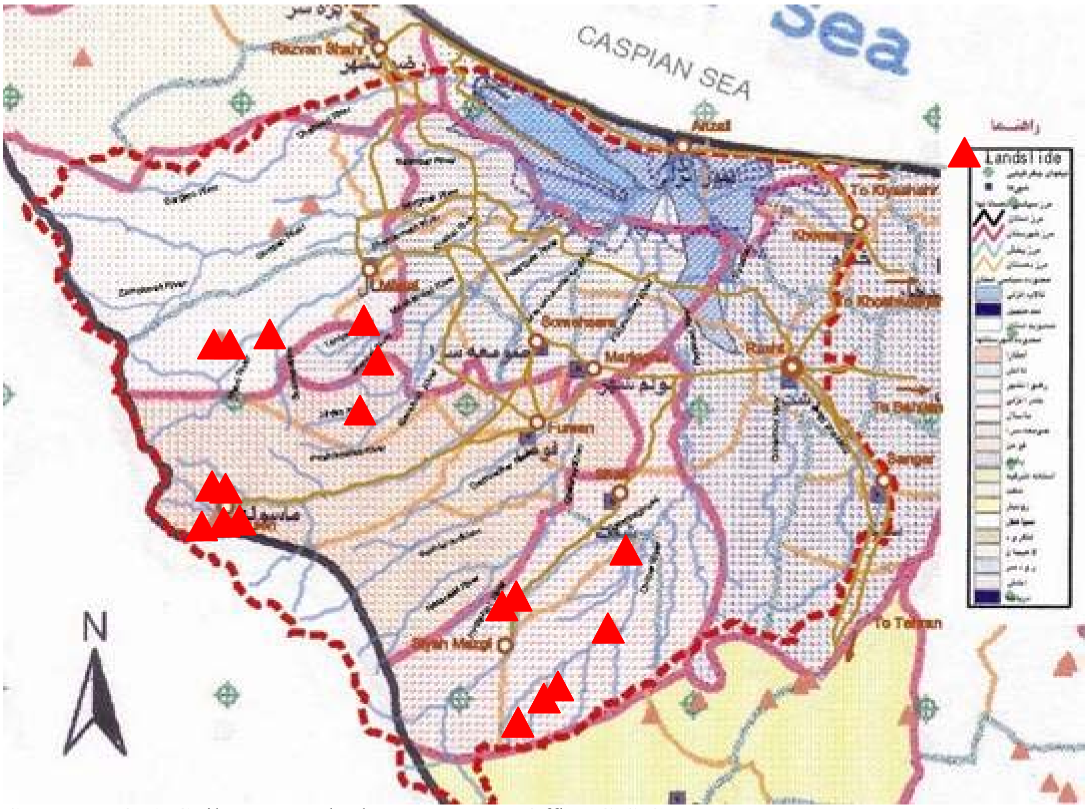


Figure 2.3.8 Sediment Budget in the Watershed

(4) Landslide

A number of roads have been constructed in the forestland for timber transport and regional development. Unfortunately, these roads were constructed based on the standard cross-section designed for an area with stable geology, and no slope protection was installed. For this reason, slope collapse and landslides are common in geologically unstable areas. In the sections where a slope collapse or landslides have occurred, no countermeasure is taken due to lack of technique and finance. This leads to secondary slope collapse and landslides when in heavily rains and/or snow melts.

According to the GIS Center of MOJA Guilan, there are 20 landslides in the Anzali Wetland Watershed.



Source: MOJA Guilan Watershed Management Office GIS Center

Figure 2.3.9 Distribution Map of Landslide

Among 20 landslides, 5 landslides are located near Masuleh town, and others are in Morghac Watershed (2), Khalkai Watershed (3), Palangvar Watershed (3) and Shakhraz Watershed (7), and all landslides are in the upper watershed.

2.3.3 Rangeland and Forest Degradation

(1) Causes of Rangeland Degradation

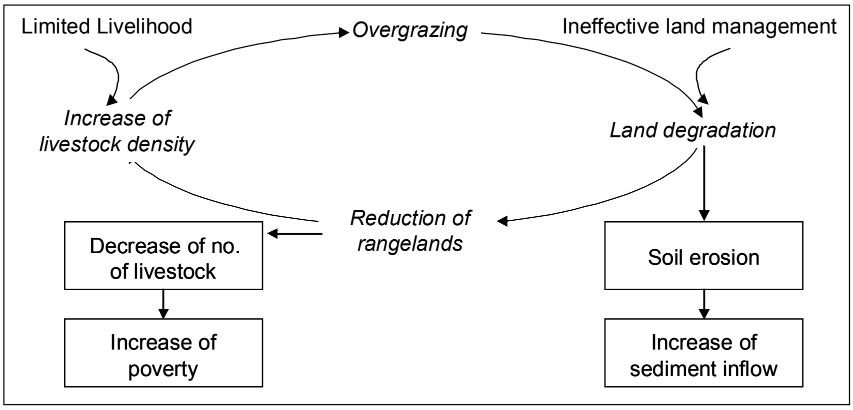


Figure 2.3.10 A Vicious Cycle of Overgrazing and Land Degradation

As described in the aforementioned section, overgrazing is considered a direct cause of the degradation of rangelands in the upper watershed. This issue is closely related to the socio-economic situation of graziers (who operate grazing activities in the upper watershed). Since they are economically-disadvantaged and less educated people, their sources of income are very limited and livestock grazing is a sole livelihood in many cases. A vicious cycle shown in Figure 2.3.10 has already been constructed in the upper watershed.

An inventory survey conducted by Natural Resources General Office (NRGO) in 1984 revealed about 3,900 families of graziers and 430,930 units[1] of livestock residing in the forests and using the rangelands for grazing. No inventory survey about the number of graziers and livestock in the area has been carried out since then. According to the staff of NRGO Guilan, graziers, who reside in forests, make up 80~90 % of the total registered graziers in the watershed. Consequently, the total numbers of graziers and livestock in the upper watershed are estimated to be about 4,600 and 507,000, respectively (see Table 2.3.3).

[1] NRGO uses the unit to estimate the livestock intensity in the rangeland and forest, in which one head of goat/sheep is counted as one unit while one head of cattle is regarded as 5 units.

Table 2.3.3 Number of Affected Graziers

Sub-watershed	Graziers in Forests (families)	Livestock in Forests (units)	Estimated Grazier s*1 (families)	Estimated Livestock *1 (units)
No. 10 (Chafroud)	344	24,398	405	28,704
No. 11 (Morghak)	610	59,059	718	69,481
No. 12 (Khalkai)	373	70,647	439	83,114
No. 13 (Palangvar)	438	44,322	515	52,144
No. 14 (Masulehroudkhan)	495	75,190	582	88,459
No. 15 (Ghalaroudkhan)	432	41,024	508	48,264
No. 16 (Siahmazgiroud)	317	22,806	373	26,831
No. 17 (Pasikhan)	681	70,708	801	83,186
No. 18 (Siahroud)	238	13,541	280	15,931
Total of Anzali watershed	3,928	430,930	4,621	506,976

Note: *1: No. of livestock units is estimated assuming 85 % of graziers and livestock stay in forests.
Source: NRGO Chalues

According to the Rangeland Management Department of NRGO, the total number of permitted livestock in the watershed is 162,152 units, which is far below the estimated number (506,980 units). Assuming the number of livestock has not changed since 1984, the stocking density of livestock in the study area is estimated at 11.5 units/ha, while that of the permitted is estimated at 3.7 units/ha. The data support the observation of overgrazing issue in the rangeland.

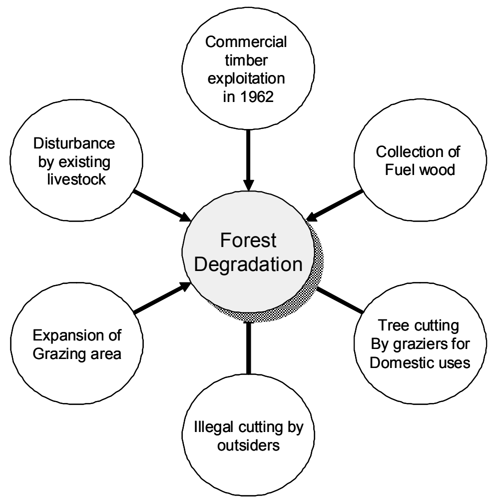
Table 2.3.4 Estimated Stocking Density of Livestock

Grassland (ha) *1, *2	Estimated Livestock (unit)	Permitted Livestock (unit) <1	Stocking Density (units/ha)	
			Actual	Permitted
44,126	506,976	162,152	11.5	3.7

Note: *1 – Data are obtained from the Rangeland Management Department of NRGO, Guilan.
*2 – Grassland consists of the rangeland and grasslands in the forest.
Source: NRGO, Guilan and Estimation of JICA Study Team

(2) Causes of Forest Degradation

As a whole, the condition of forests in the upper watershed is relatively good. However, parts of the forests have been degraded since 1963, although the total area of forests in the Study area has increased for the last decade. Considerable causes of forest degradation are enumerated in Figure 2.3.11.



Causes of Forest Degradation

Commercial timber exploitation in 1962:
When the ownership of forests was transferred to the present Government, many forests were exploited by commercial cutting.

Collection of Fuel wood
Forest dwellers (graziers or others) have cut trees for fuel wood / charcoal making.

Tree cutting for other domestic uses
Trees have also been cut by forest dwellers (graziers or others) for domestic uses, such as housing materials, etc.

Illegal cutting by outsiders
Forests have been damaged by illegal cutting activities by outsiders (persons who stay outside the forest).

Expansion of grazing area
When the forest gets sparse, graziers have opened the forest for grazing.

Disturbance by existing livestock
Regeneration capacity of the forest has declined because livestock cause damage to saplings by eating / trampling.

Figure 2.3.11 Causes of Forest Degradation

One of the major causes of deforestation in the upper watershed is overexploitation around the time the ownership of royal forests was transferred to the Government in 1963[2]. Traditional exploitation for domestic uses (fuel, charcoal making, housing materials, etc.) by forest dwellers as well as outsiders (who live in the plain area) has also caused forest degradation. Many NRGO workers also pointed out that grazing activities in forests have caused damage to forests and eventually changed the vegetative composition, and if anything, degraded forests were converted to grasslands for grazing. For instance, the area above EL. 1,500 m in the upper reaches of the Morgahk River, Masulehroudkhan River and Khalkaii River were originally forest areas, but are presently used for grazing as rangelands.

(3) Identified Degraded Areas

The Study team identified degraded areas of both rangelands and forests using the latest LANDSAT images (2002) and employing the following assumptions.

a. Forests fully extended in the areas below 1,500 m above see level in 1963.
b. The areas between 1,500 m and 2,000 m were covered by either forests or grasses in 1963.
c. Very poor vegetated lands or bare lands dominantly extended in the areas above 2,500 m in 1963.

[2] Law of Land Reform, which enacts that all the natural lands shall be owned by the Government, was declared in 1962.

In short, poor vegetated areas or bare lands between 1,500 m and 2,000 m are considered as degraded rangelands, while grasslands located below 1,500 m are regarded as degraded forests. The analysis shows that about 77 km^2 of rangelands and about 70 km^2 of forests are in degraded condition. Table 2.3.5 shows the degraded areas by sub-watershed and Figure 2.3.12 presents the location of the degraded areas.

Table 2.3.5 Degraded Area in Rangelands and Forests

Sub-watershed	Area (ha)	Rangelands		Forests	
		Area (ha)	Share (%)	Area (ha)	Share (%)
1)Chafroud	12,020	324	3	1,443	12
2)Bahambar	2,950	0	0	0	0
3)Morghak	24,810	2,017	8	1,094	4
4)Khalkai	23,870	1,566	7	1,268	5
5)Plangvar	11,620	0	0	194	2
6)Masulehroudkhan	33,240	1,328	4	1,664	5
7)Shakhraz	24,200	196	1	46	0
8)Pasikhan	39,010	2,235	6	932	2
9)Siahroud	8,020	0	0	337	4
Total area	184,290	7,666	4	6,969	4

Source: JICA Study Team

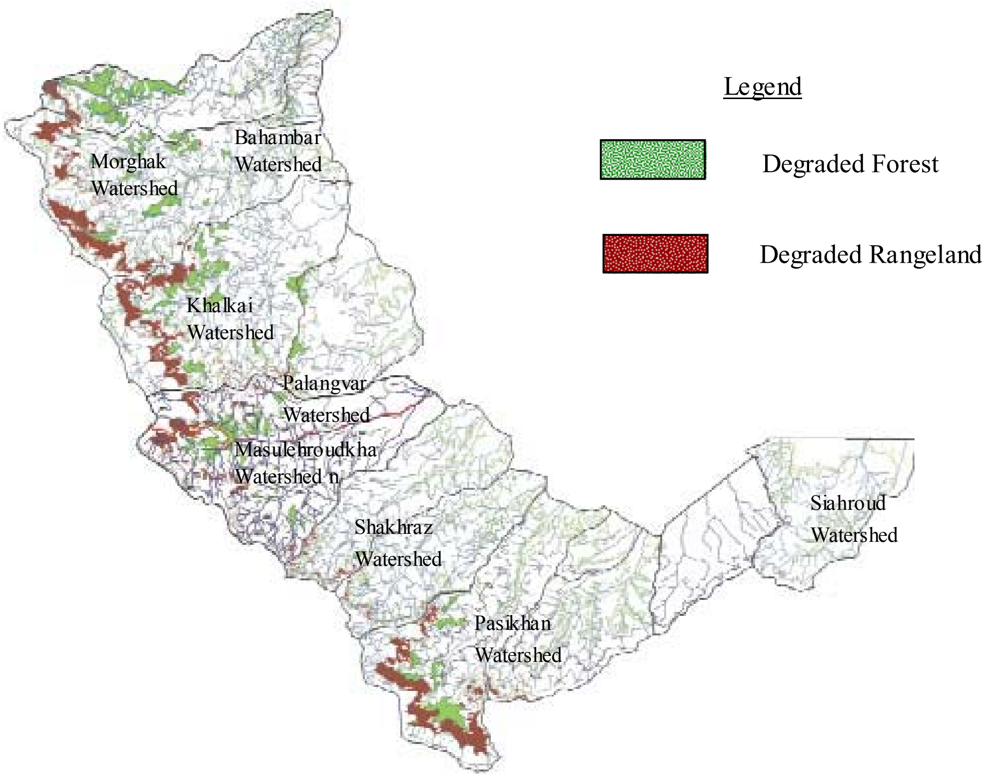


Figure 2.3.12 Degraded Rangelands and Forests based on Satellite Image Analysis

Another comparative study[3] of present land use with that in the 1960s showed that about 112 km^2 of grasslands along the boundaries between rangelands and forests have been converted from forests to grasslands since the 1960s. The breakdown of the converted areas is tabulated below.

Table 2.3.6 Converted Area from Forests to Rangelands

Sub-watershed	Area (ha)	Rangelands	
		Area (ha)	Share (%)
1)Chafroud	12,020	1,650	14
2)Bahambar	2,950	0	0
3)Morghak	24,810	2,510	10
4)Khalkai	23,870	2,900	12
5)Plangvar	11,620	210	2
6)Masulehroudkhan	33,240	1,040	3
7)Shakhraz	24,200	1,950	8
8)Pasikhan	39,010	970	2
9)Siahroud	8,020	0	4
Total area	184,290	11,230	6

Source: JICA Study Team

3 The study was undertaken by JICA Study Team together with NRGO in 2004.