APPENDIX - 1 RESULTS OF LANDSAT IMAGE ANALYSIS

A1.1 Introduction

On this study, to grasp the condition of the Anzali wetland, such as vegetation cover, land use, urbanization, etc., satellite image data is useful to analyze the conditions, because the Anzali wetland watershed is too large and too steep in the mountainous area.

To analyze the vegetation cover condition, the season of satellite image data is best in the middle summer. The LANDSAT data is commonly used in he world, then the Study team search the LANDSAT satellite image in summer, June to September, and also cloud area less than 10 %, then the data of 5 July 1987 and 7, 14 July 1991 and August 2002 is exist. The images of these period are shown in Figure A1.1.1, A1.1.2 and A1.1.3 as follow;

Figure A1.1.1 Image shoot on 5 July 1987

Figure A1.1.2 Image shoot on 14 June 1991

Figure A1.1.3 Image shoot on 7 August 2002

In these image, the image of 1991 is somehow less vegetation cover depend on early summer season picture.

A1.2 Results of Land Use Analysis

A1.2.1 Land Uses based on the LANDSAT Image Analysis

LANDSAT 7 has 7 bands (infrared 3 bands, radiant 3 bands and temperature 1band) and its pixel of data is 20 to 30 m. In order to analyze a wide area, the land use and vegetation condition was analyzed using radiant 3 bands.

The categories of land use considering the vegetation and land use are grouped into eight items shown in Table A1.2.1.1, and the images of result of analysis are shown from Figure A1.2.1.1 to A1.2.1.9.

On the LANDSAT image analysis, land use categories can be classified eight categories shown in Table A1.2.1.1. Among these categories, forest has the largest share of 37~42 % and following by paddy field/farmland (30~27%) and orchard (13~9%) in order. According to the analysis, no drastic change in land use is found from 1987 to 2002. But, the urban area and forest are increasing with development of the watershed.

- El. 2,500 m – higher — Bare land
- EL. 1,500 m – EL. 2,500 m — Rangeland
- EL. 100 m – EL. 2,300 m — Forest
- EL. 100 m – lower — Orchard (mostly tea garden), paddy field, other farmland and urban areas

Table A1.2.1.1 Land Use Based on LANDSAT Images

Category	1987 5 July		1991 16 June		2002 7 August	
	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: NRGO, Summary of information of basin 1996.

From 1987 to 1991, the areas of lagoon and pond have not changed, but from 1991 to 2002, the areas of lagoon and pond have decreased 12.2km^2. In a satellite image, near the Anzali wetland, the areas of lagoon and pond have not changed, but ponds of southern part and north west part of Rashut have changed (see Figure A1.2.1.10 – A1.2.1.12). The decrease of lagoon and pond from 1991 to 2002 is causing of reclamation of ponds.

Moreover the areas of wetland have increased 57 km^2 from 1991 to 2002, it was the result of the vegetation cover which indicate same as wetland has increased at south and south west part of Rashut city and also Anzali wetland.

The areas of orchard have increased from 1991 to 2002, it was the result of orchard areas have changed to forest at the mountainous areas near the plane because of orchard garden changed to more dense vegetation cover.

The areas of paddy/farmland have decreased about 100km^2 from 1991 to 2002, it can be assumed that the areas of forest have increased in the plane area then paddy/farmland have decreased.

The areas of forest have increased about 182km^2 from 1987 to 2002. It is not only increasing in the mountain areas but also increasing in the plane area. In the mountainous areas, the high rate areas of increasing of forest are Masuhehroudkhan, Kahlkai, Morghak, and Chafroud watershed.

The area of rangeland (mountain grass) and bare land were 430.4km^2 in 1987, 356.3km^2 in 1991 and 363.6km^2 in 2002. In 1987, the mountainous area of Anzali wet land watershed were widely devastated by tree cutting and it was counted these devastated areas as a bare land. The result of this reason, the area of bare land is largest in 1987, but in 1991 and 2002, the total area of bare land and range land is about 360km^2. So it is assumed that the wide meaning of rangeland was about 360km^2.

The urban areas of Anzali wetland have surely increased in the plane area from 1987 to 2002, especially near the Rashut city, Anzali city and southern part of Anzali city.

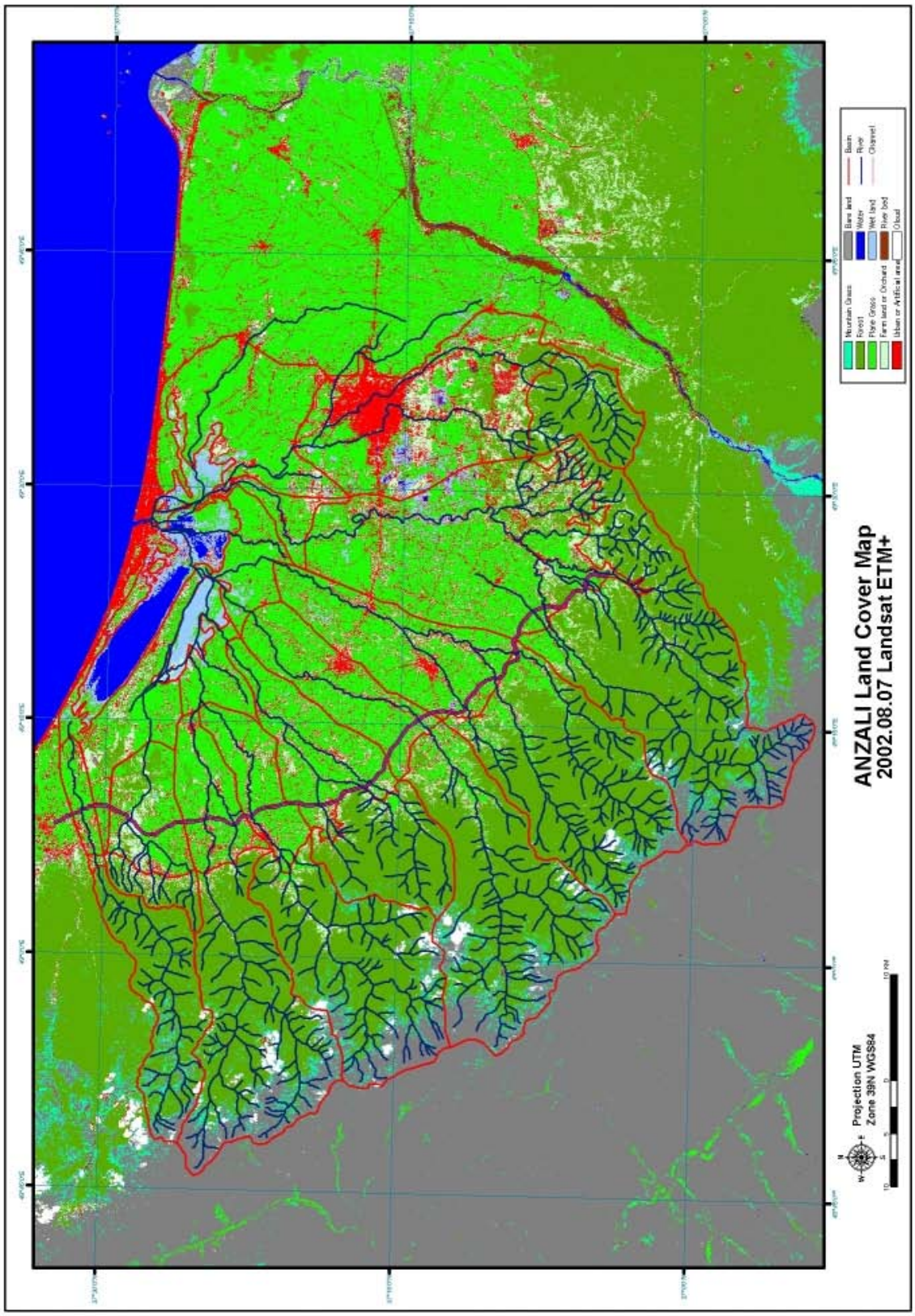

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Figure A1.2.1.1
Land Use Map of the Anzali Wetland Watershed (Satellite Image 2002 LANDSAT)

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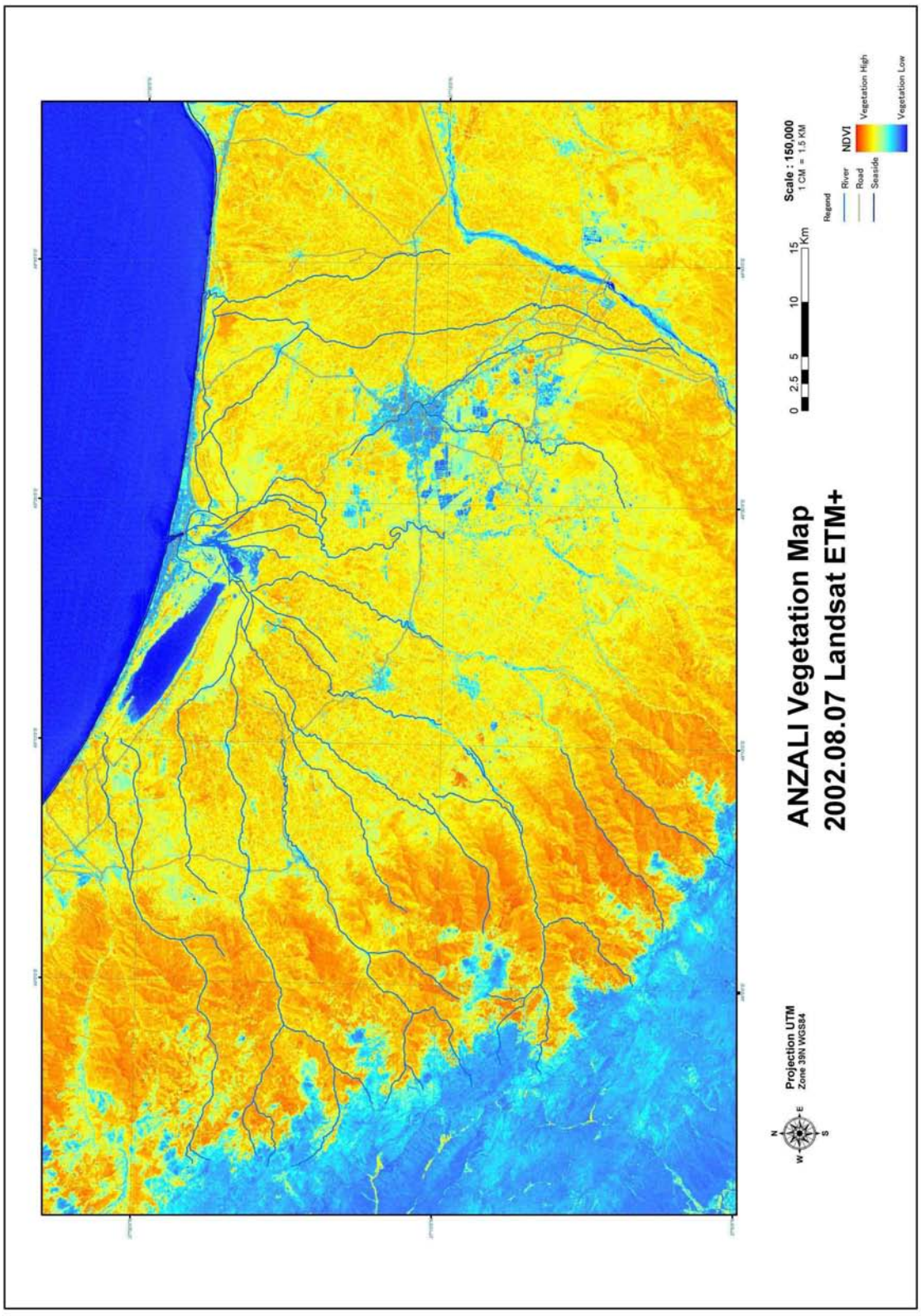
Figure A1.2.1.2
LANDSAT Image True Color (2002 LANDSAT)



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure A1.2.1.3** **LANDSAT Image False Color (2002 LANDSAT)**
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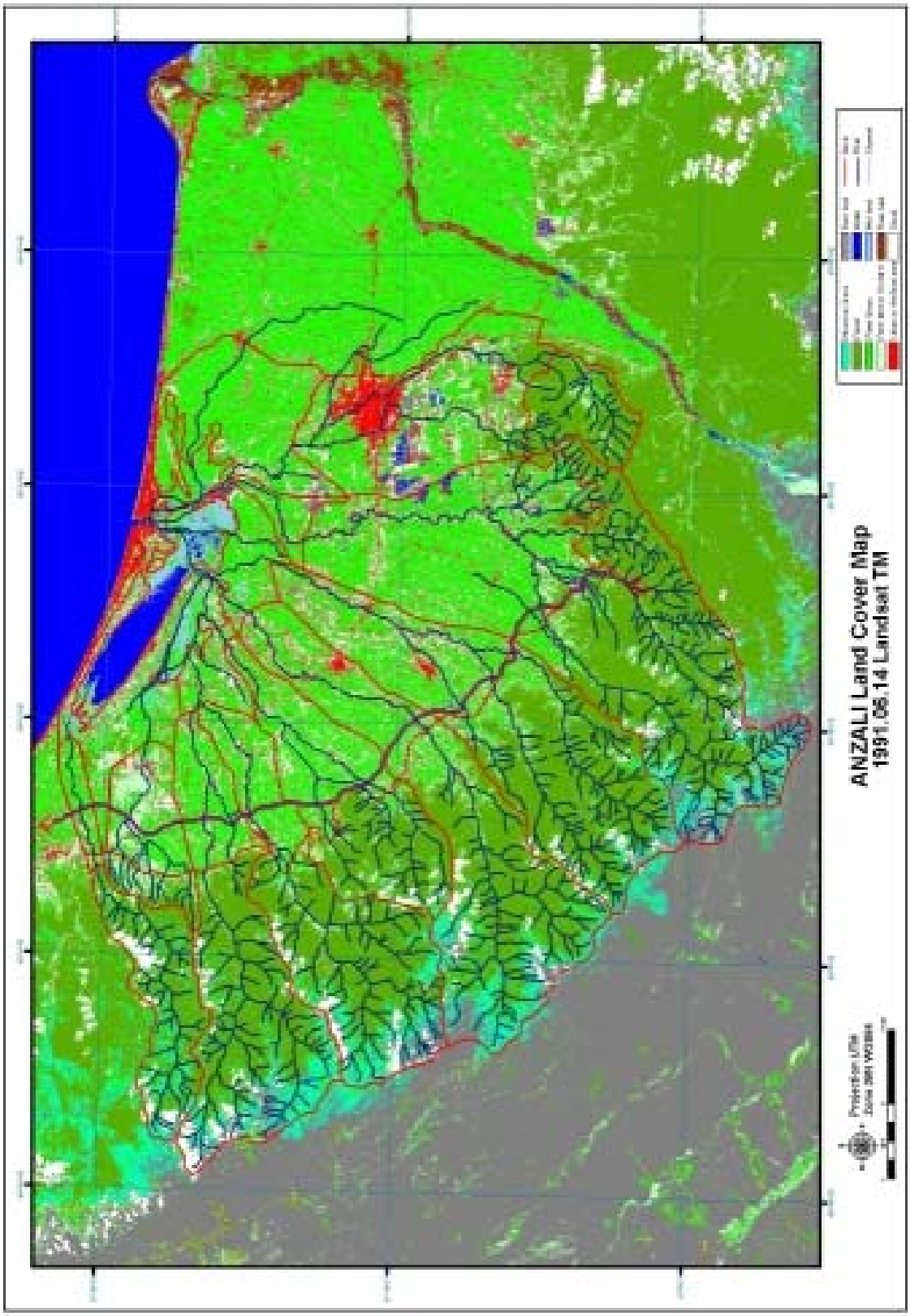

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Figure A1.2.1.4
Land Use Map of the Anzali Wetland Watershed (Satellite Image 1991 LANDSAT)

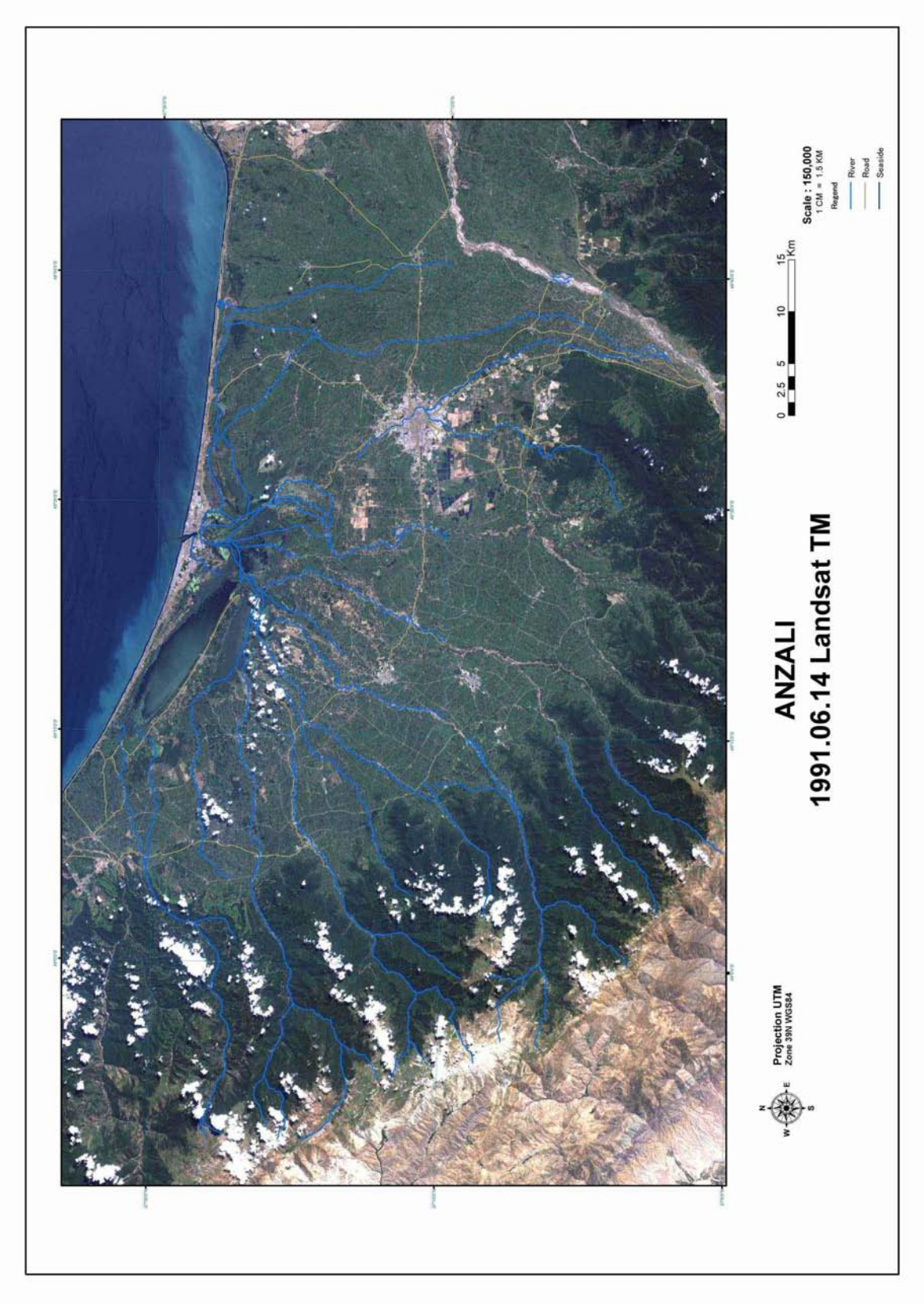

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Figure A1.2.1.5
LANDSAT Image True Color (1991 LANDSAT)

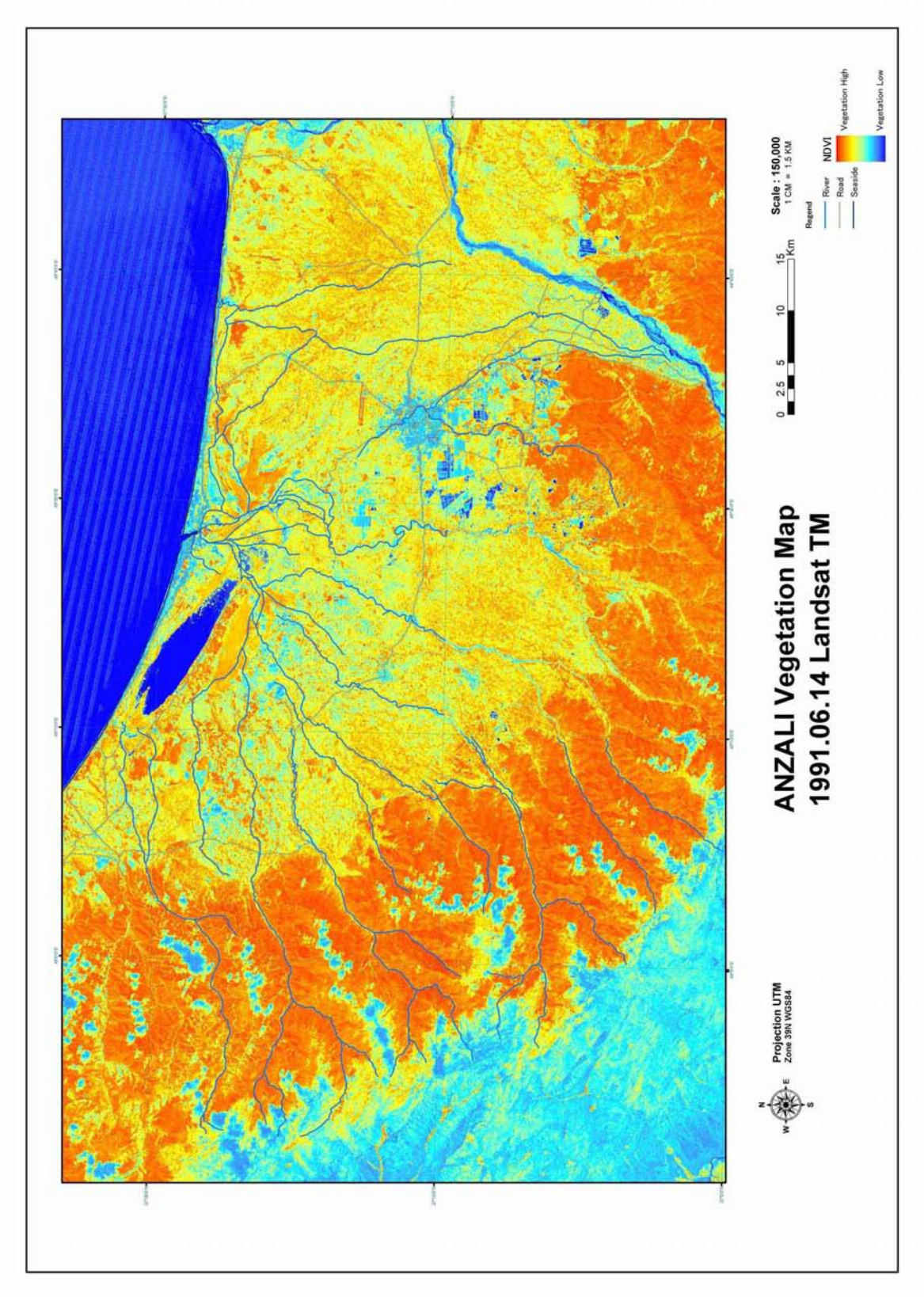

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Figure A1.2.1.6
LANDSAT Image False Color (1991 LANDSAT)

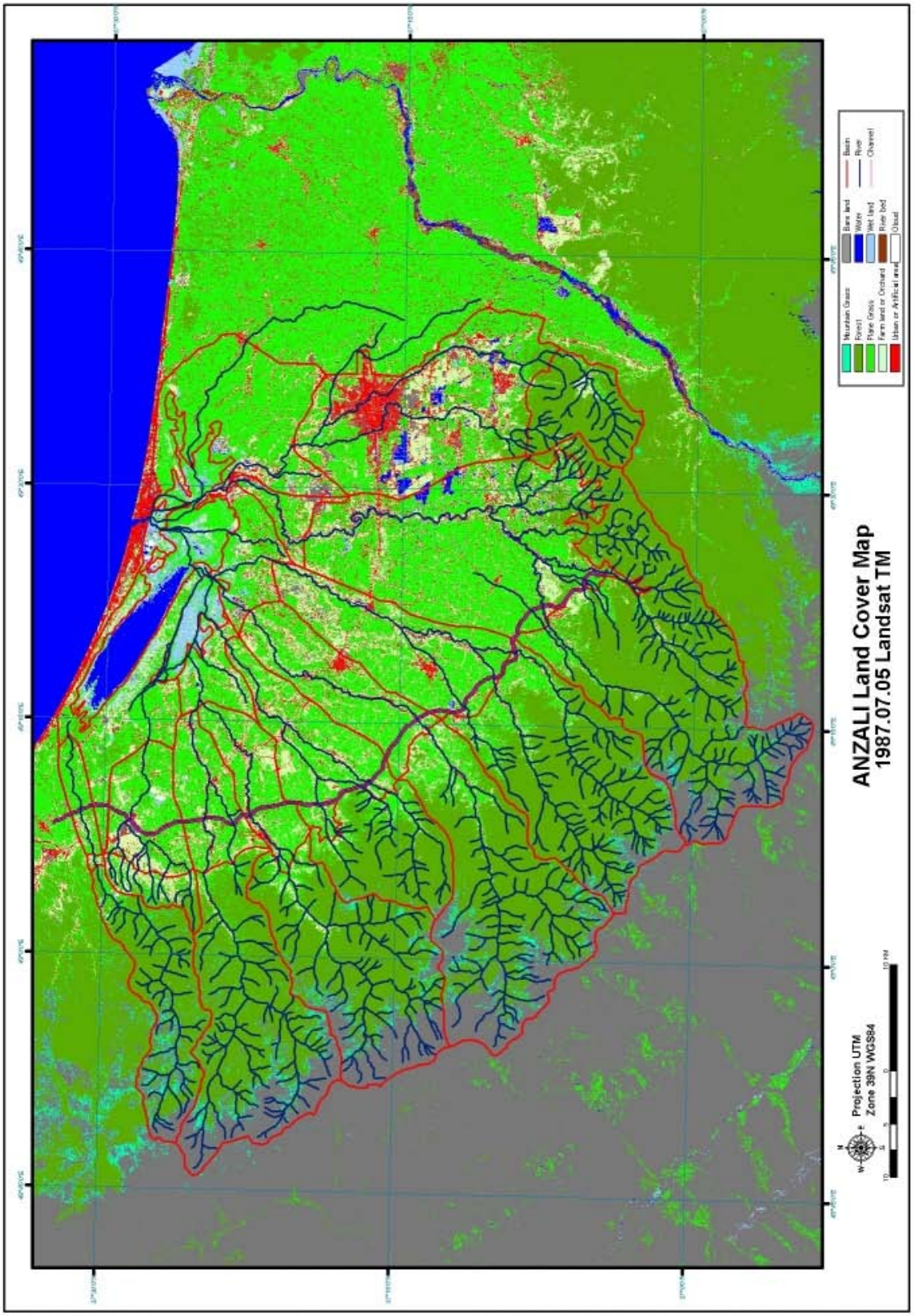

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Figure A1.2.1.7
Land Use Map of the Anzali Wetland Watershed (Satellite Image 1987LANDSAT)

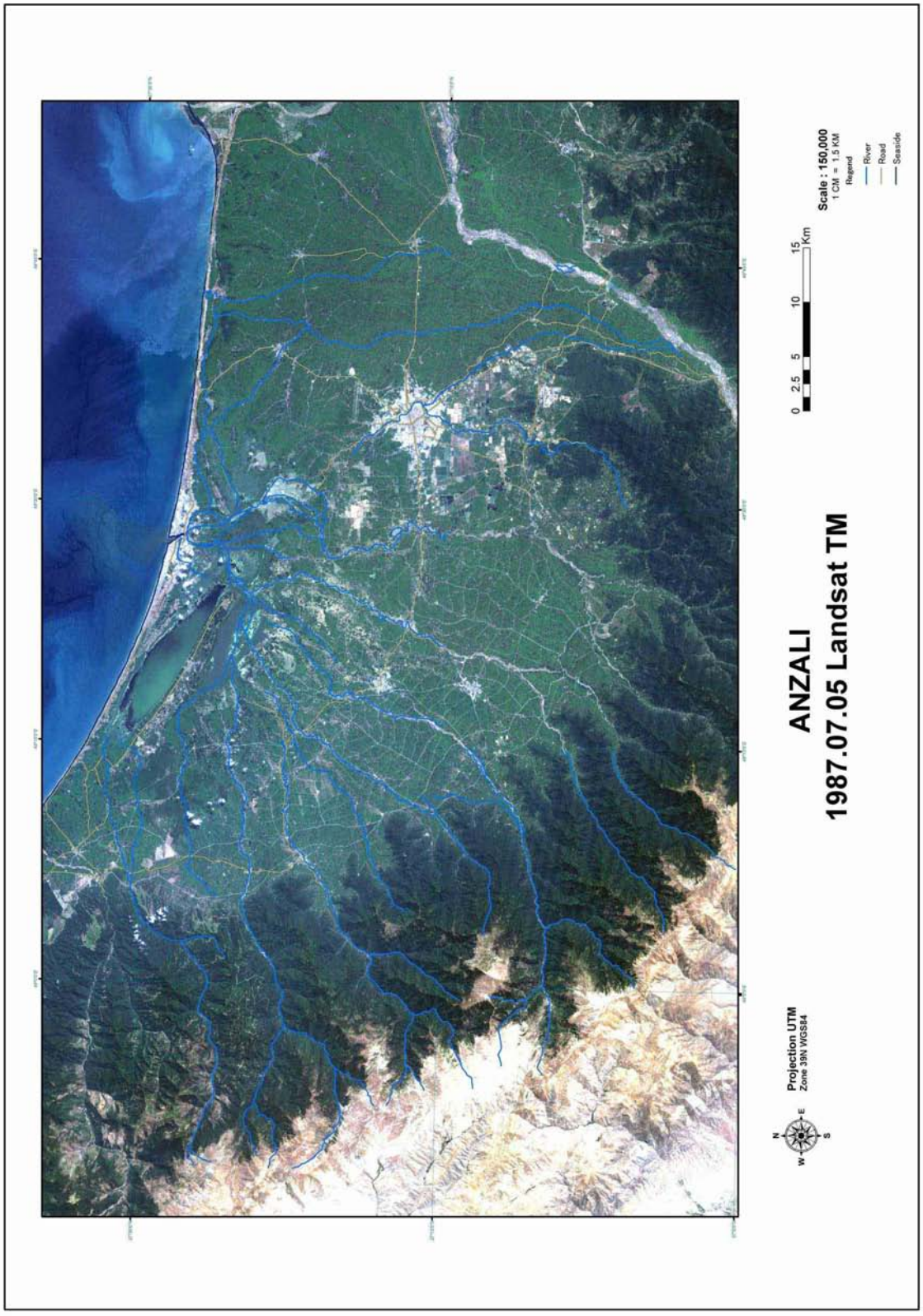

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Figure A1.2.1.8
LANDSAT Image True Color (1987 LANDSAT)

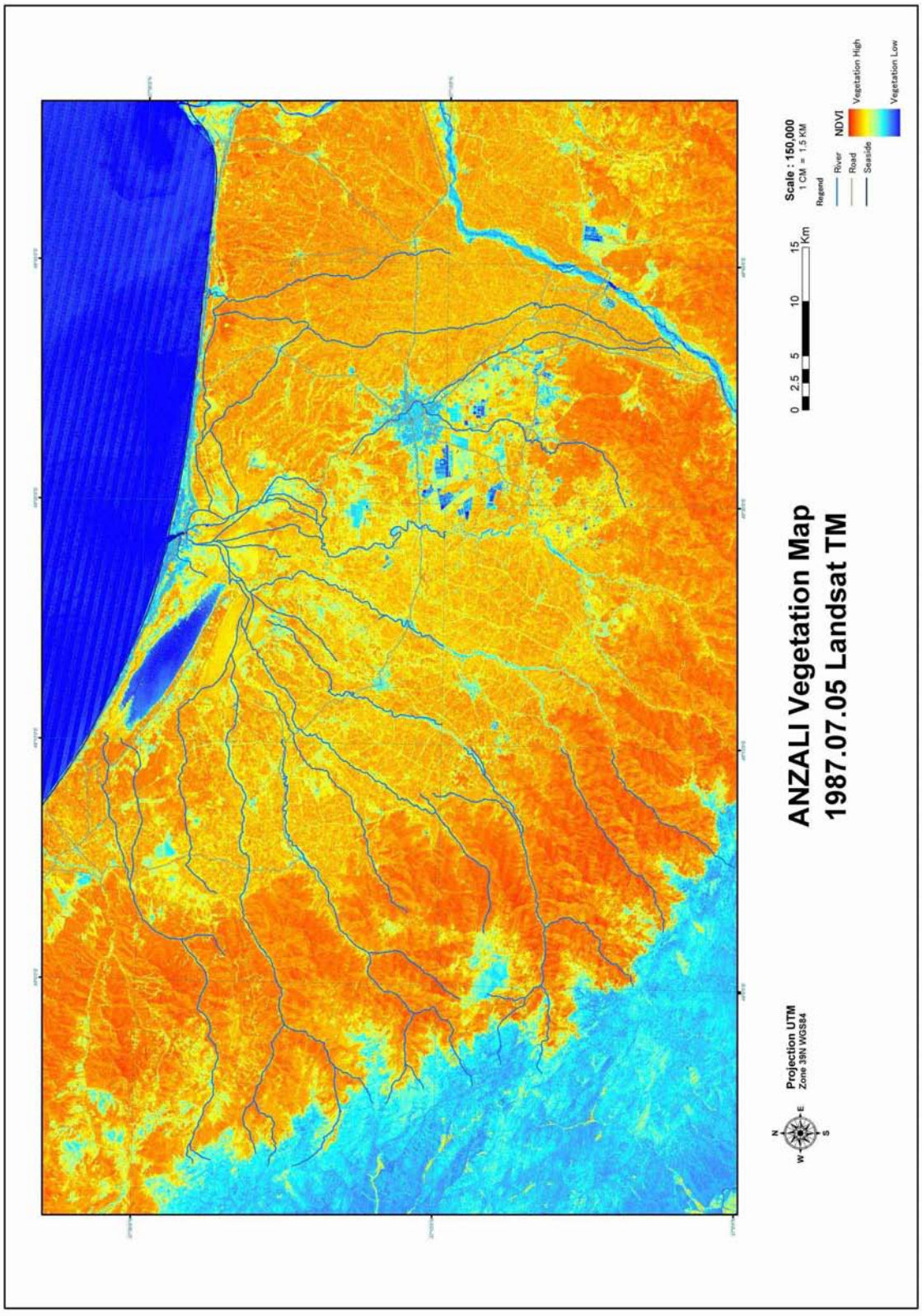

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Figure A1.2.1.9
LANDSAT Image False Color (1987 LANDSAT)

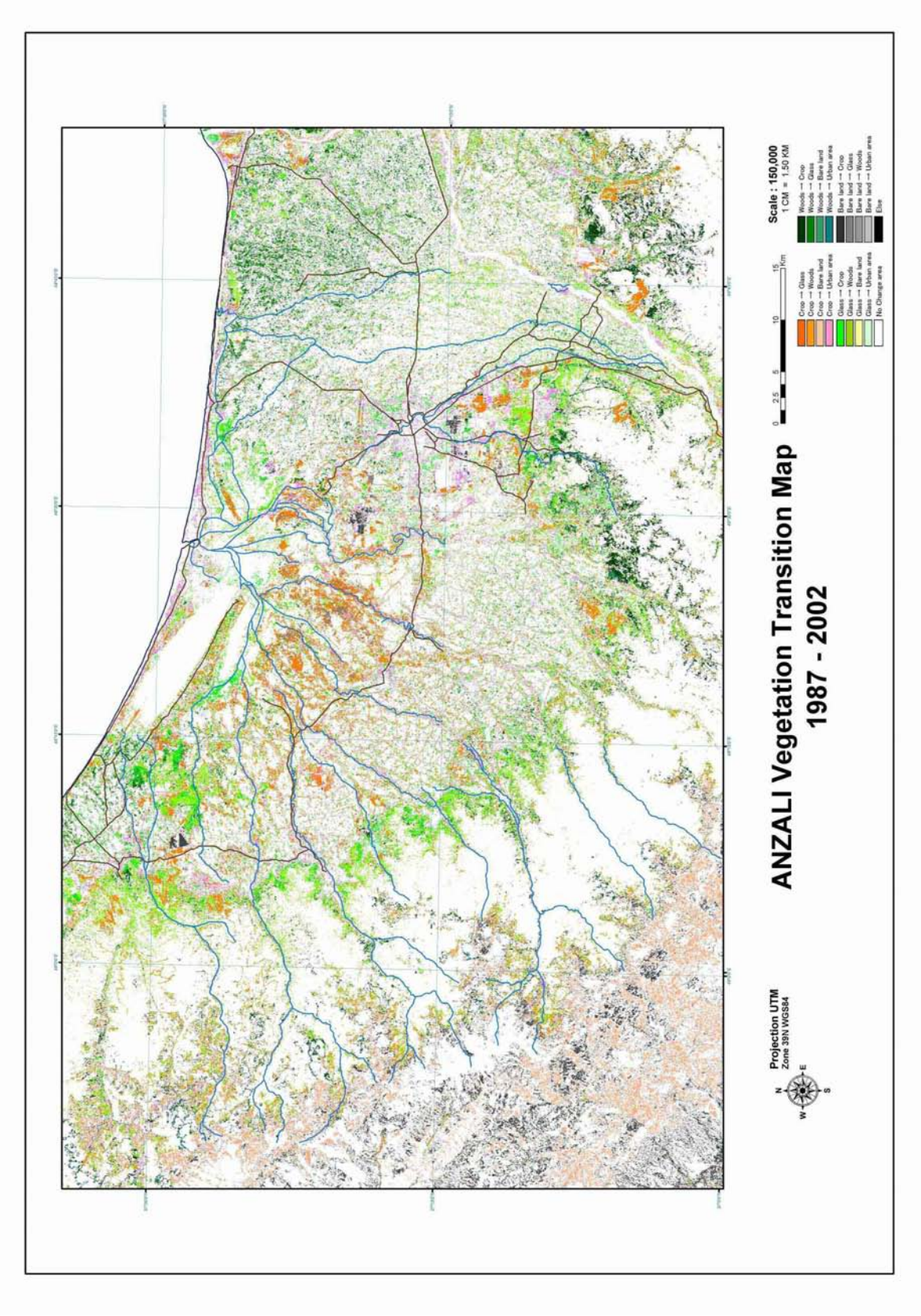

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Figure A1.2.1.10
LANDSAT Image Vegetation Transition Map (1987 to 2002)

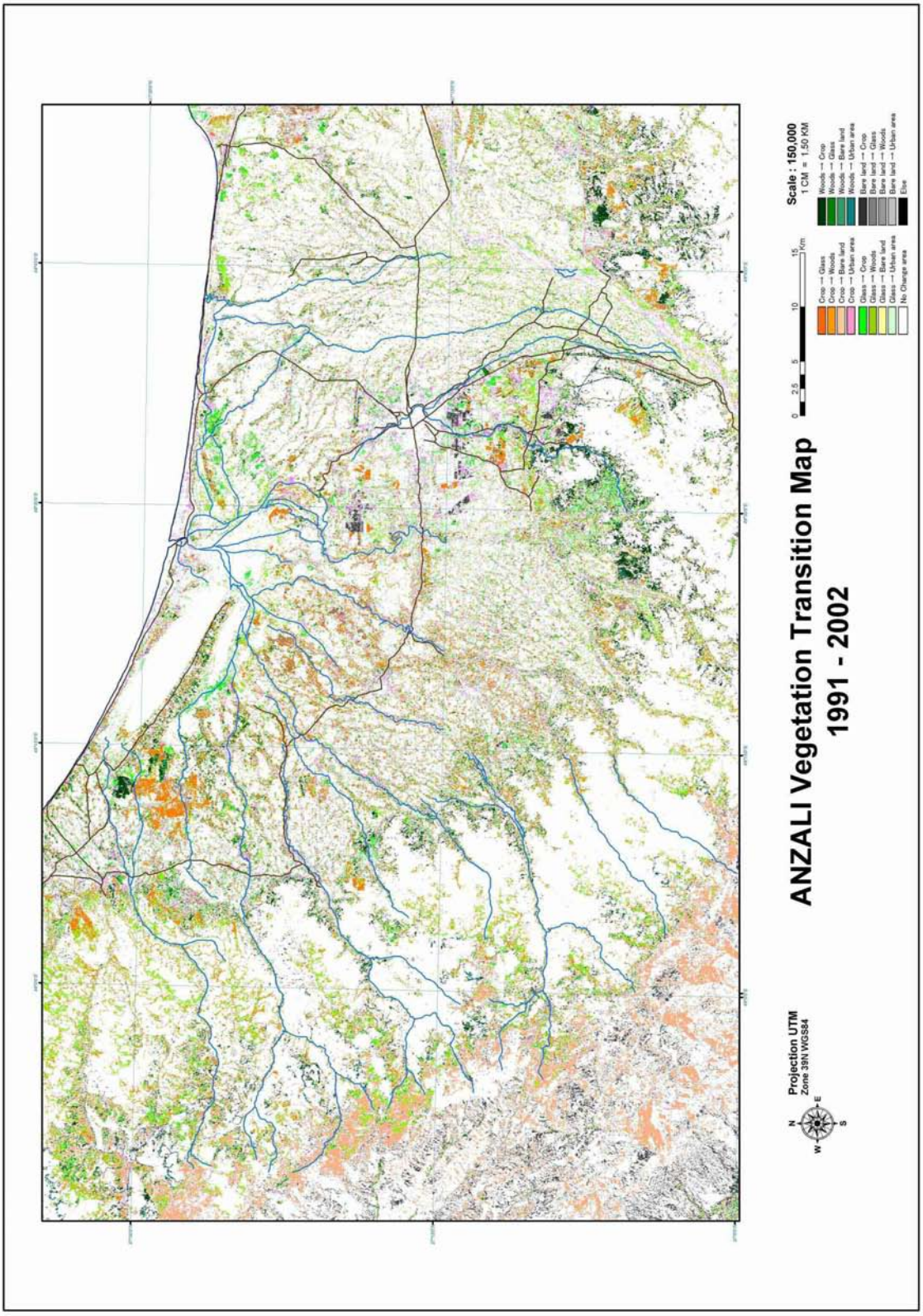

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Figure A1.2.1.11
LANDSAT Image Vegetation Transition Map (1991 to 2002)

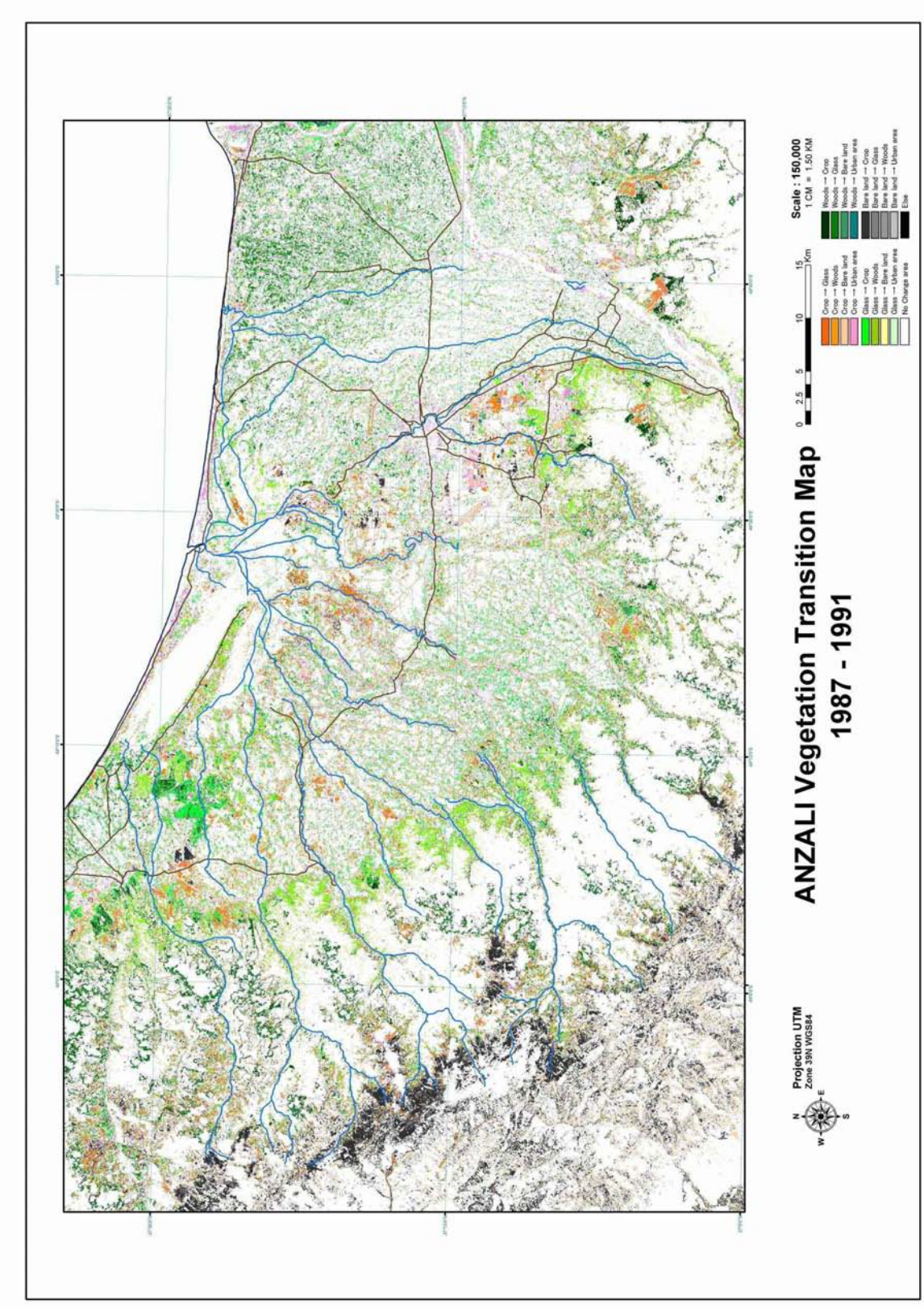

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Figure A1.2.1.12
LANDSAT Image Vegetation Transition Map (1987 to 1991)

A1.2.2 Method of Vegetation Cover Analysis in the Mountain Area

In order to analyze the vegetation cover of mountainous area in detail, the analysis method which emphasized the vegetation cover condition more unlike the usual analysis is required. As the picture used for this analysis, 7th August, 2002, LANDSAT picture also has little covered of clouds, and since vegetation is also clear, the detailed image analysis of vegetation is possible for it. The band used for analysis 3 bands, green, blue and red which was used for analysis since a difference was hardly produced with the result of a red band even if it used the infrared band although it was considered as the infrared band and the red.

The example of the detailed analysis result of vegetation, Masuleh area is made into an example and shown.

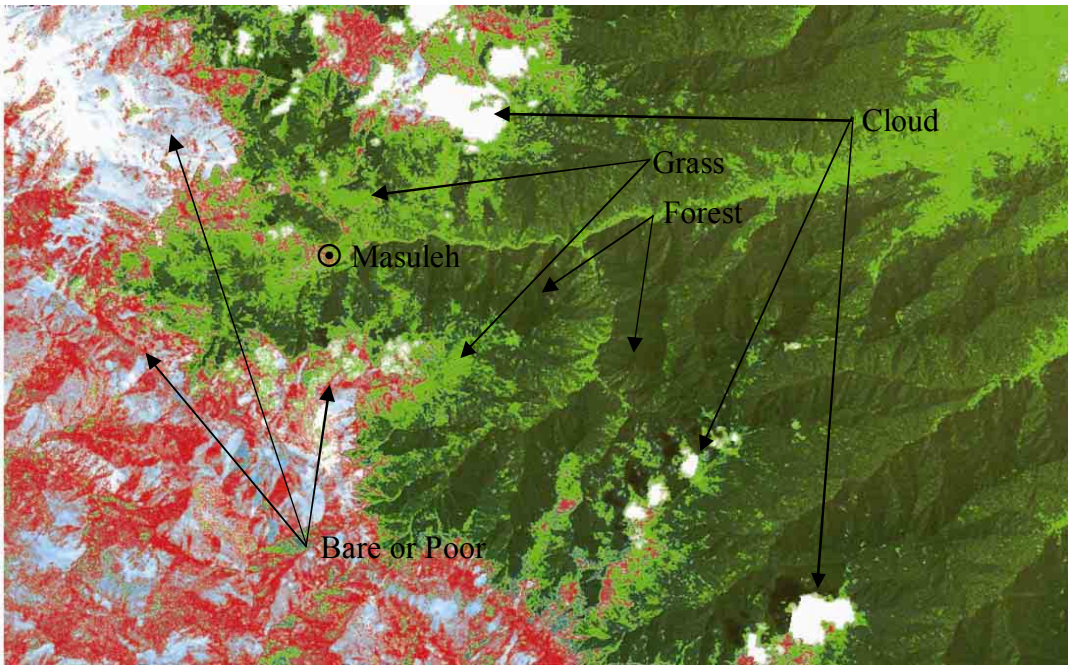
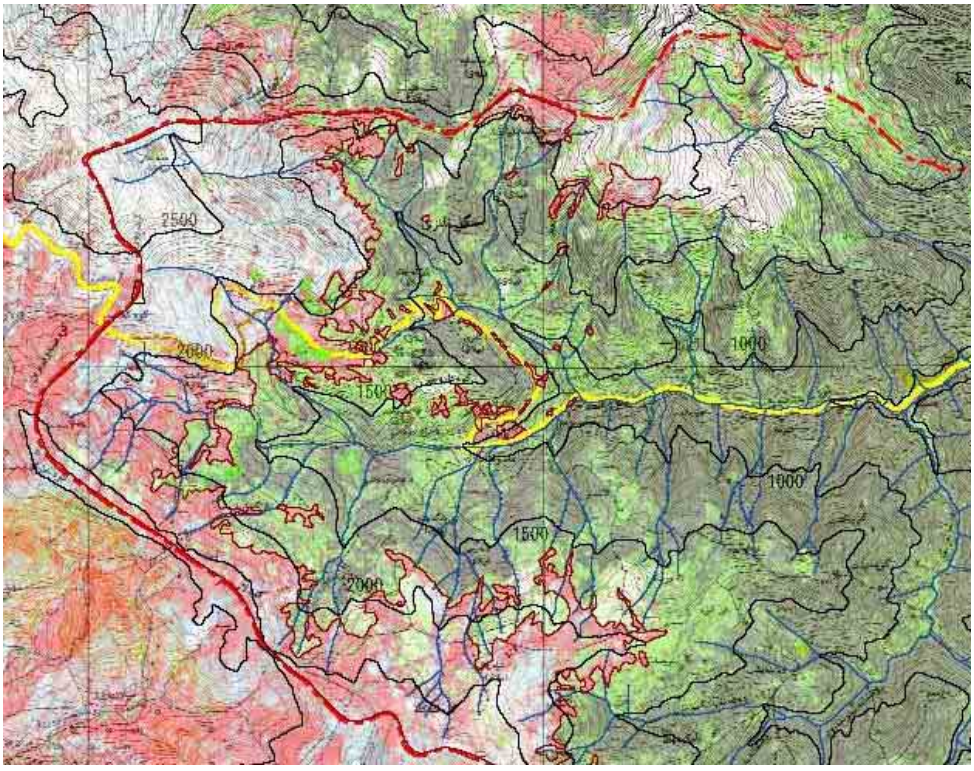


Figure A1.2.2.1 Result of LANDSAT Data Analysis

And map of scale 1/50,000 was over-rapped on the results of detail analysis, and boundaries of vegetation cover were drawn in the map.



FigureA1.2.2.2 Map and LANDSAT Data

A1.2.3 Vegetation Cover Condition of Each Watershed

(1) Chafroud Watershed

This watershed exist north-western part of Anzali wetland watershed and it has 120.2 km^2 wide in mountainous area above elevation 100 meters. The vegetation cover of mountainous area of Chafroud watershed has a character that the half of eastern part of watershed is good vegetation of forest, but half of western pert has large amount of grass areas and no vegetation or very little vegetation areas where are originally assumed forest. It is assumed that these grass areas and no vegetation areas are changed by tree cutting and road construction works for transportation of timbers.

In high altitude areas, some grass areas remained but no vegetation or very little vegetation areas spread widely. These areas are assumed originally grass land but it are degraded by the grazing because grass area distribute on the lower part of degraded areas

(2) Bahmbar Watershed

This watershed is located eastern part of Chafroud watershed, relatively low altitude and it has 29.5 km^2 in mountainous area above elevation 100 meters. The vegetation cover of this watershed is mainly grass because of low altitude. Only high part of area remains forest, but

it is assumed that some grass areas are changed grass land from forest by tree cutting of NRGO and habitant.

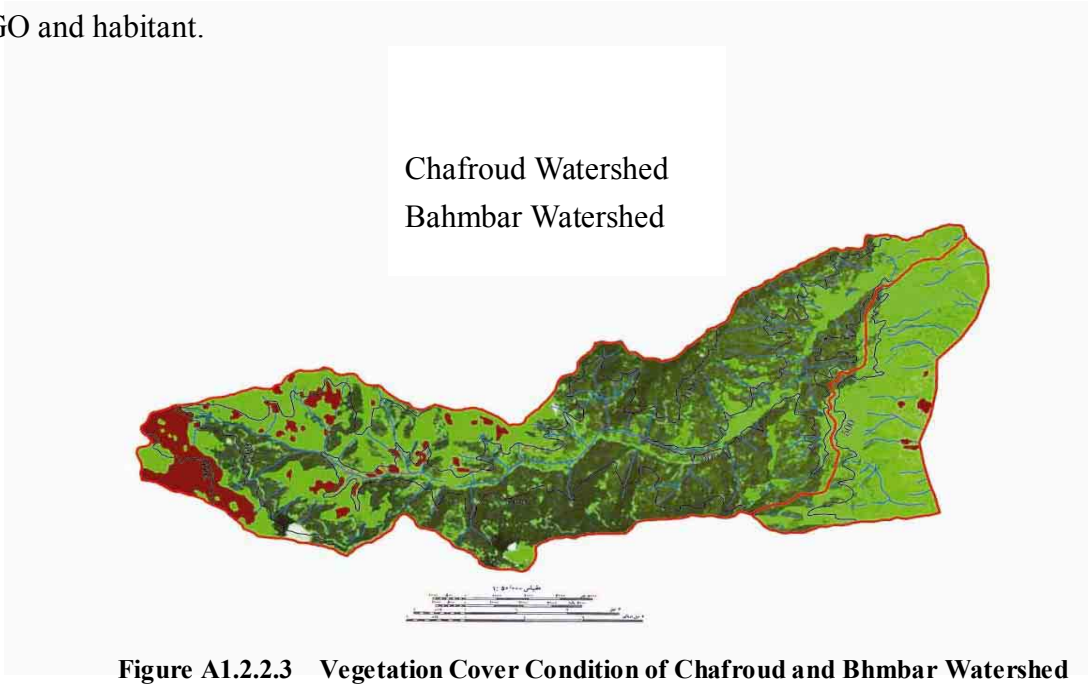


Figure A1.2.2.3 Vegetation Cover Condition of Chafroud and Bhmbar Watershed

(3) Morghak Watershed

This watershed is located south part of Chafroud watershed and it has 248.1 km^2 wide in mountainous area above elevation 100 meters. This watershed also has good vegetation in the eastern part of watershed, but western part, high altitude areas, has large amount of degraded areas. It is assumed that these degraded areas were mainly produced by over grazing.

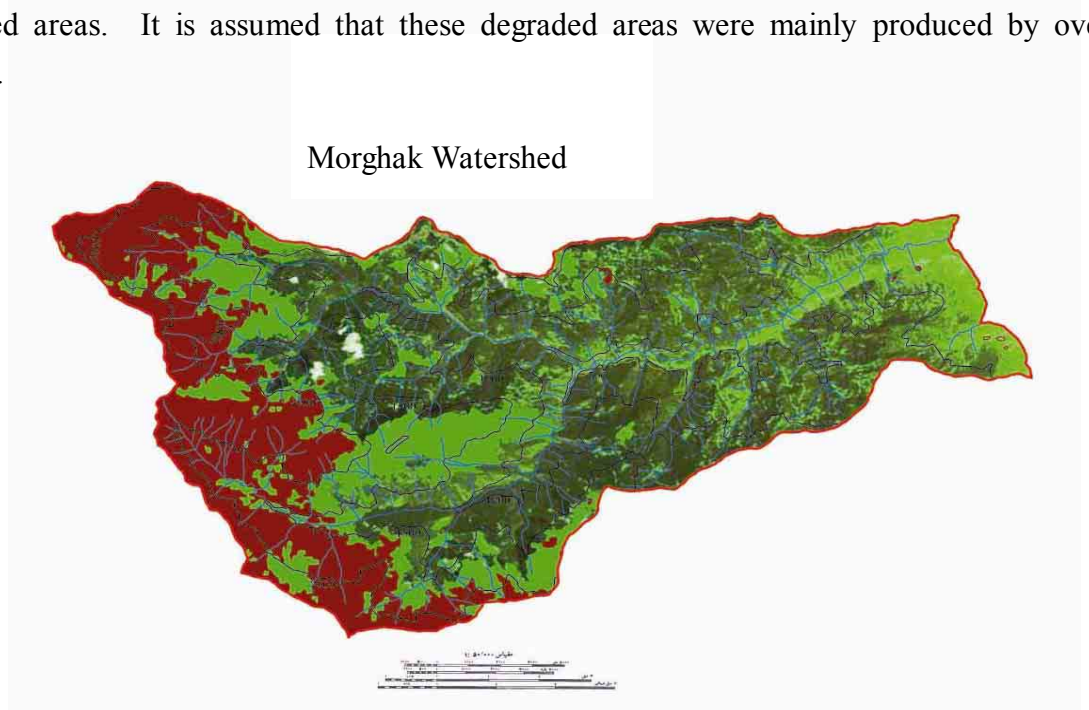


Figure A1.2.2.4 Vegetation Cover Condition of Morghak Watershed

(4) Khalkai Watershed

This watershed is located south part of Morghak watershed and it has 238.7 km^2 wide in mountainous area above elevation 100 meters. This watershed also has good vegetation in the eastern part of watershed, but western part, high altitude areas, has large amount of degraded areas. It is assumed that these degraded areas were mainly produced by over grazing.

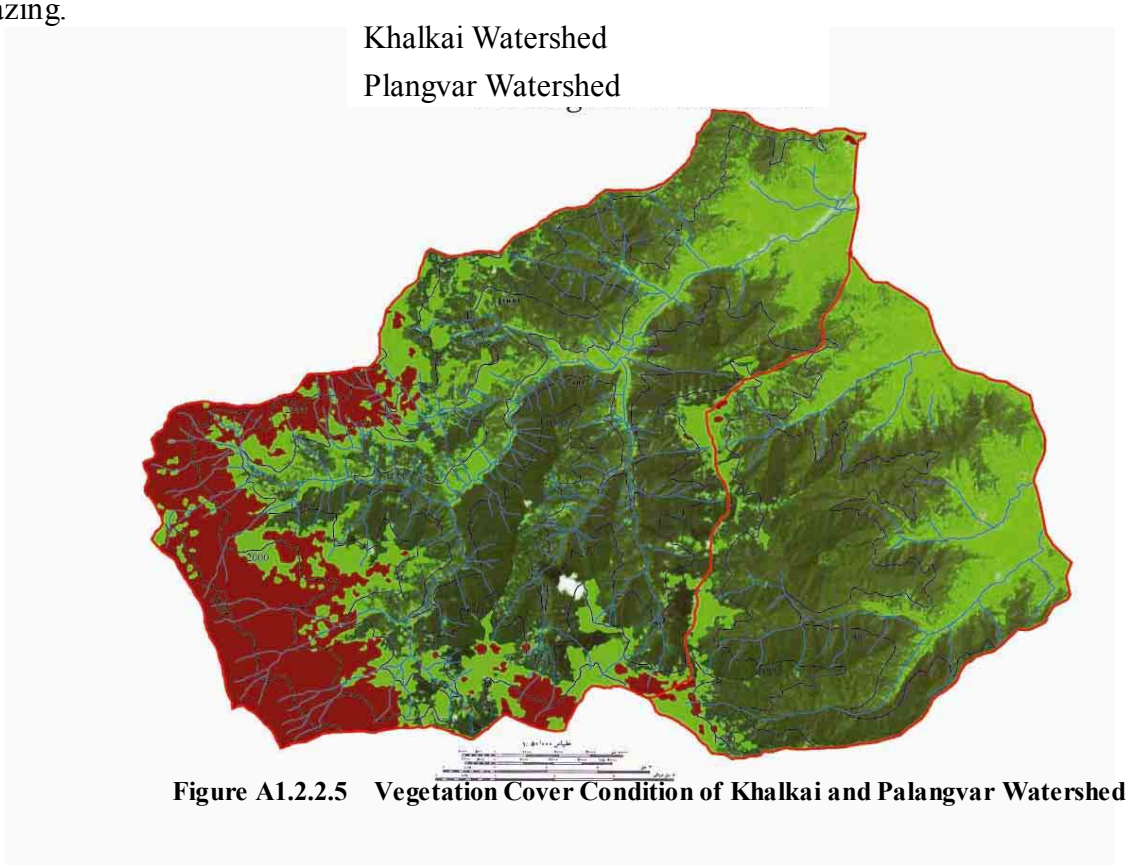


Figure A1.2.2.5 Vegetation Cover Condition of Khalkai and Palangvar Watershed

(5) Plangvar Watershed

This watershed is located east part of Khalkai watershed and it has 116.2 km^2 wide in mountainous area above elevation 100 meters. This watershed also has good vegetation in the center of watershed, but grass areas exist in high altitude area near watershed boundary of Khalkai watershed,. It is assumed that these grass areas were mainly produced by tree cutting.

(6) Masulehroudkhan Watershed

This watershed is located center part in the Anzari watershed of mountainous area and it has 322.4 km^2 wide in mountainous area above elevation 100 meters. This watershed has good vegetation cover of dense forest in eastern part of watershed, but in western part of watershed has many areas of grass and no vegetation or very little vegetation. It is assumed that these grass areas were mainly produced by tree cutting.

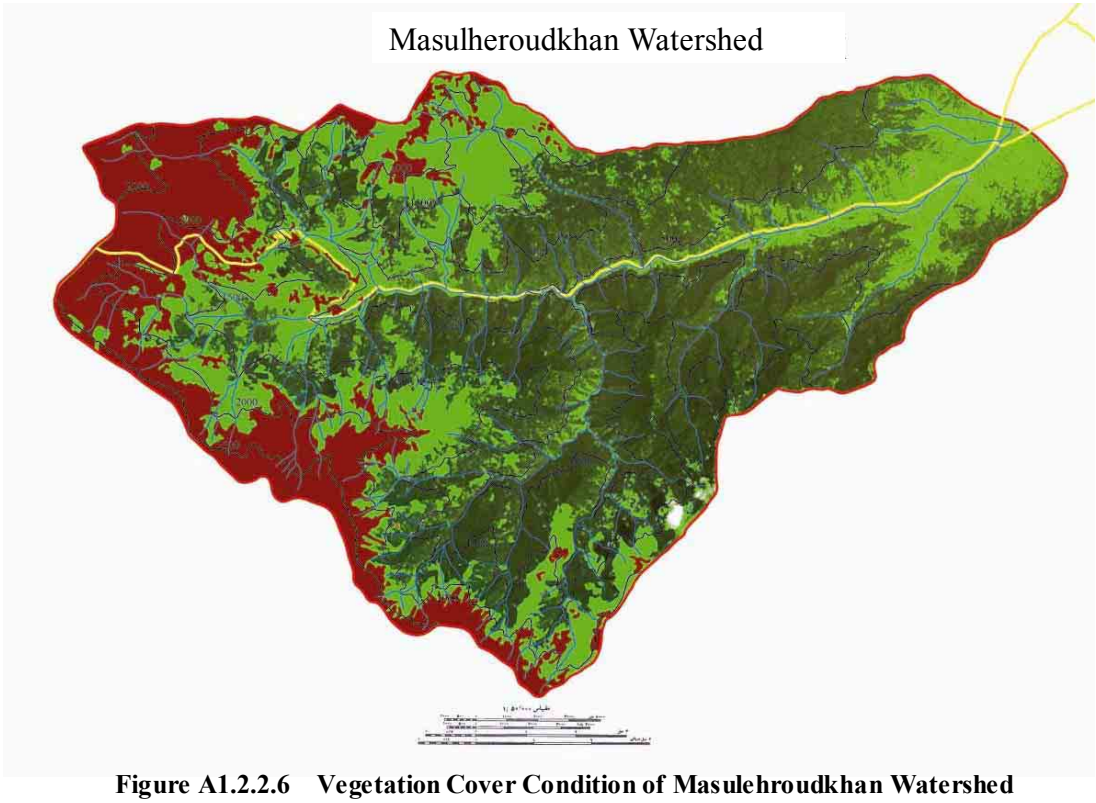


Figure A1.2.2.6 Vegetation Cover Condition of Masulehroudkhan Watershed

(7) Shakhraz Watershed

This watershed is located South east part of Masulehroudkhan watershed and it has 242.0 km^2 wide in mountainous area above elevation 100 meters. This watershed is reserved natural protection area one of the Shaft-Siahmezgi protected area, and it devided into two sub-watersheds, namely Gashuteroudkhan sub-watershed and Nazarlat sub-watershed. This watershed has good vegetation cover of dense forest almost whole watershed.

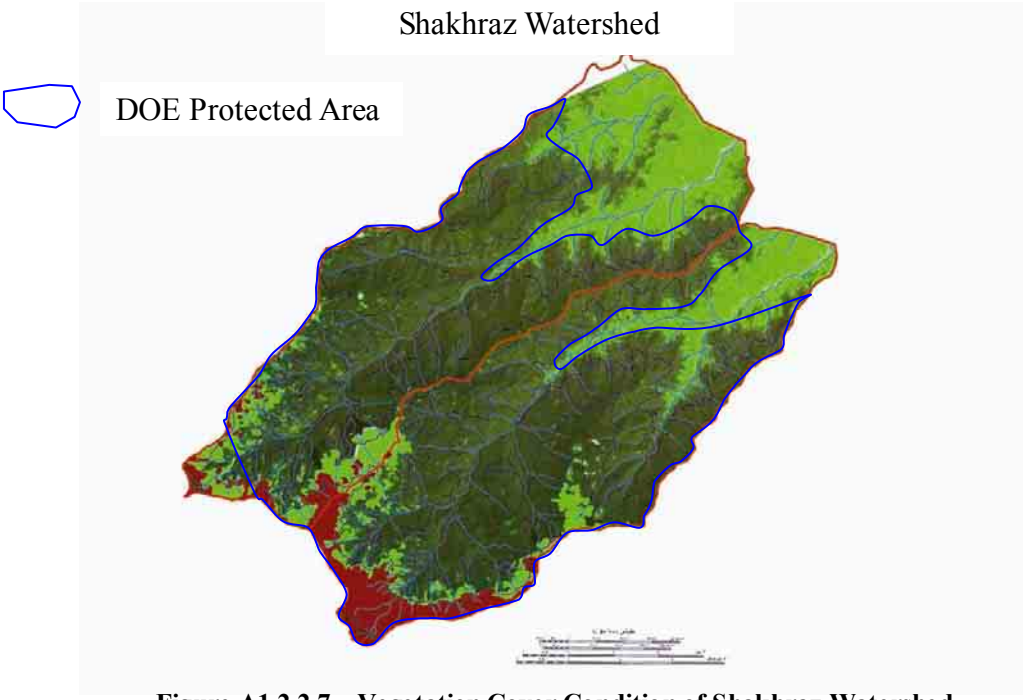


Figure A1.2.2.7 Vegetation Cover Condition of Shakhraz Watershed

(9) Pasikhan Watershed

This watershed is located South east part of Shakhraz watershed and it has 390.1 km^2 wide in mountainous area above elevation 100 meters. In this watershed, drainage area of Siahmezgi river is also reserved natural protection area one of the Shaft-Siahmezgi protected area. This watershed has relatively good vegetation cover of dense forest altitude less than 1500 meters, but above 1500m areas, no vegetation or very little vegetation areas widely spread in the mountain hills.

(10) Siahroud Watershed

This watershed is located eastern part of Pasikhan watershed and it has 80.2 km^2 wide in mountainous area above elevation 100 meters. In this watershed, the highest mountain has only about 500 meters, then there is no degraded in the watershed.

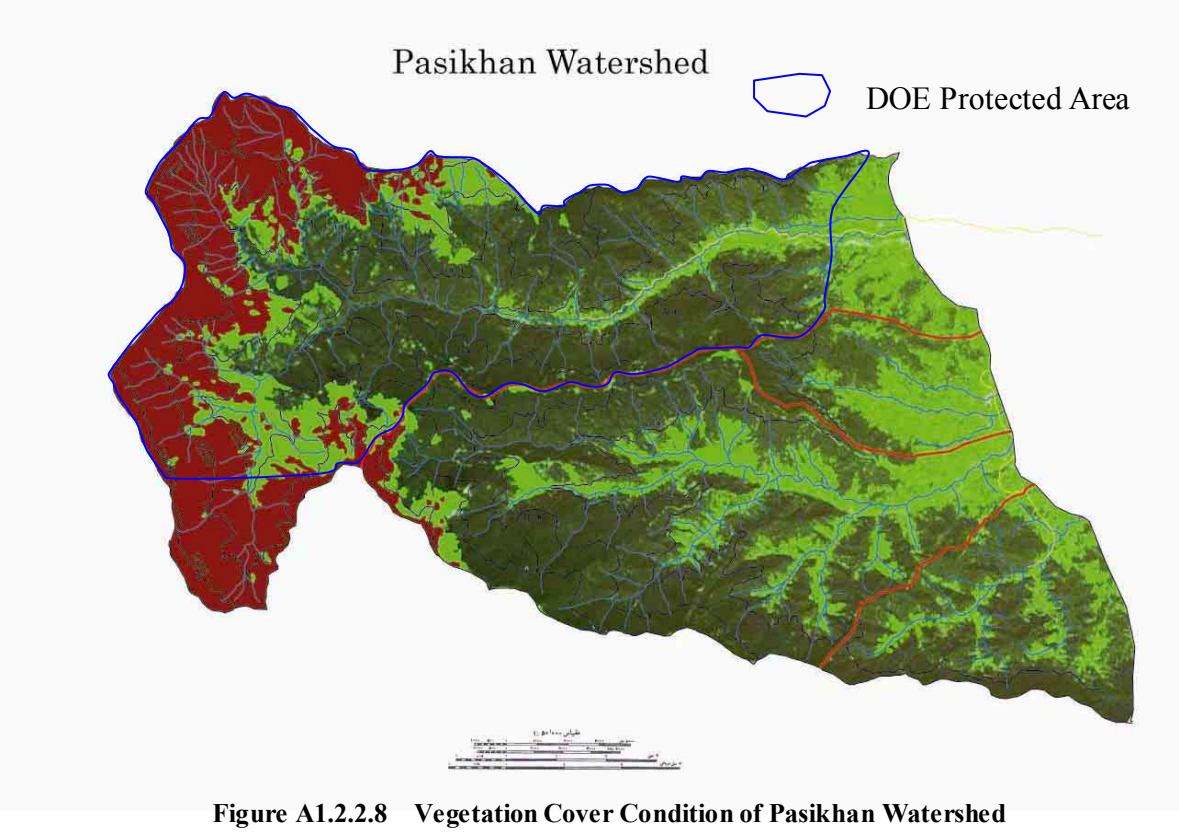


Figure A1.2.2.8 Vegetation Cover Condition of Pasikhan Watershed

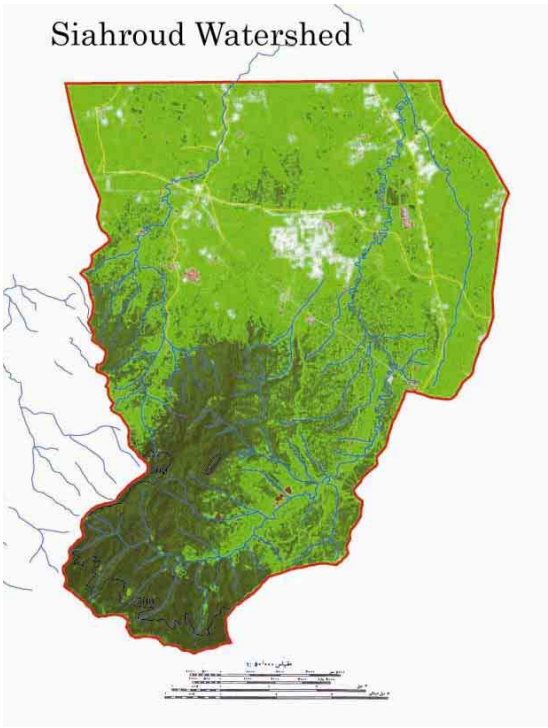


Figure A1.2.2.9 Vegetation Cover Condition of Siahroud Watershed

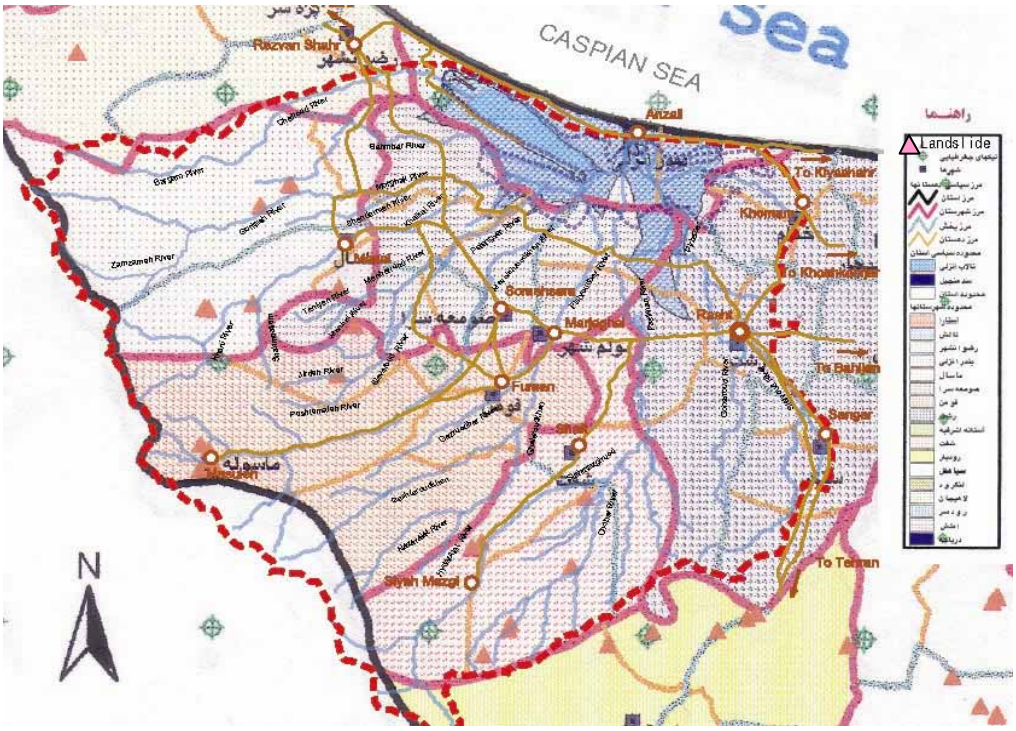
APPENDIX - 2 MEASURES FOR LANDSLIDE AND SLOPE COLLAPSE

A2.1 Slope Condition of Road in the Forest

A2.1.1 General

A number of roads are being constructed in the forest for timber transport and regional development. Unfortunately, these roads are constructed based on the standard cross-section designed for an area with stable geology and no slope protection is practiced. For this reason, slope collapse and landslide are common in geologically unstable areas. In the sections where a slope collapse or landslide have occurred, no countermeasures are taken due to lack of technique and finance, inducing a secondary slope collapse and landslide with heavy rains and snow melts, and blocking the road sections entirely.

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



Source: GIS Center of MOJA Guilan

Figure A2.1.1.1 Distribution Map of Landslide

Among 20 landslides, 5 landslides are distributed near Masulhe Town, and others are distributed in Morghac Watershed (2), Khalkai Watershed (3), Palangvar Watershed (3) and Shakhraz Watershed (7), and all of landslides are located in the mountainous forest areas.

A2.1.2 Classification of Landslides and Measures

Landslides occur due to the movement of the mountain mass itself. Initial movement therefore occurs in the form of rock slide. The repetition of slides many times during a long period over several thousand to several ten thousands of years causes considerable change in the geological properties of ground mass as follows:

Rock => Weathered Rock => Cilluvial Soil => Clay

This degradation in geological properties affects the formation of slip surface, regional geomorphology, and plane shape of slide area. Movement of ground mass occurs as different type owing to the degeneration, and so protective measures also differ from one another.

Measures against landslide and slope collapse should be carefully considered because of their large scale and complex mechanism. For this reason, design standard should be formulated for the measures against landslide or slope collapse, and before designing countermeasures, detailed investigation is necessary. Countermeasure works against landslide is divided into three categories, i) Avoid problem, ii) Reduce driving forces, iii) Increase resisting forces.

A2.1.3 Investigation of landslide

It is necessary to design countermeasure works against landslide based on a clear understanding of the causes and mechanics of landslide, so that investigation of landslide should be carefully promoted and landslide countermeasures should be implemented according investigations.

A2.2 Countermeasure Works

(1) Slope collapse

A slope collapse (see Photo A2.2.1.1) is usually caused by a surface failure of slope. This type of collapse can be controlled by a combined method of shotcrete, soil nail, and a gabion beside the road.

Photo A2.2.1.1 Slope Collapse at Upstream of the Chafroud River

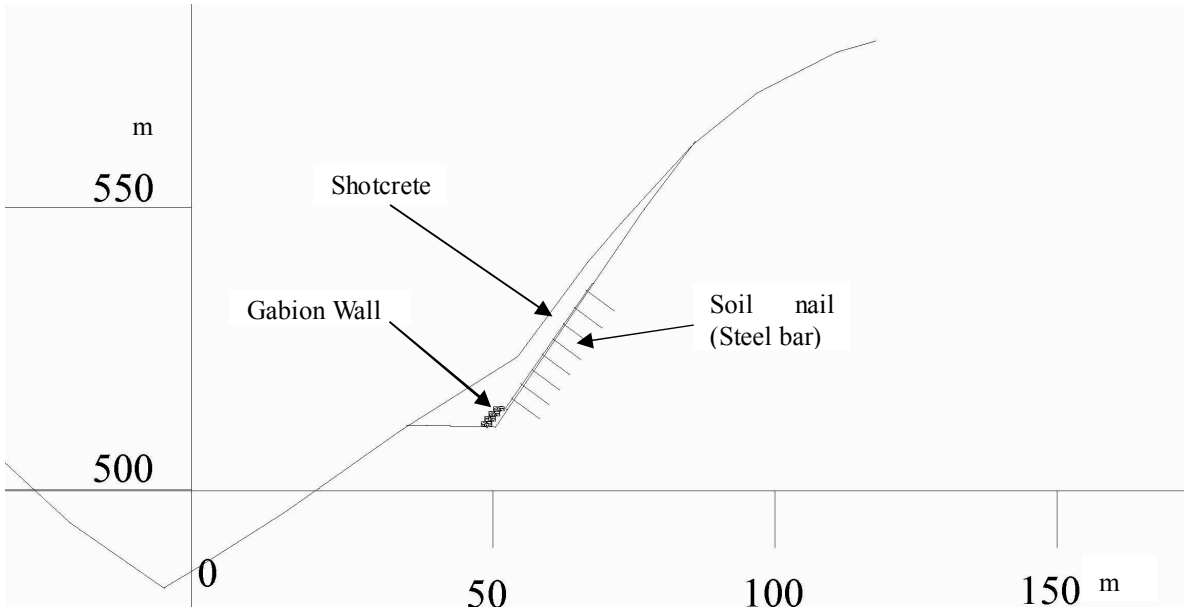


Figure A2.2.1.1 Example of Countermeasure against Slope Collapse

(2) Weathered Rock Slide

Slip surface of weathered rock slide like as shown Photo A2.2.1.2 generally is shaped linear, and countermeasure works is needed to increase the resistance force. Counter weight embankment and ground anchor are typical methods of increasing resistance force. In the case shown in Photo A2.2.1.2, there is no place to install the counter weigh embankment; ground anchors are the recommended option.

Photo A2.2.1.2 Landslide at upstream of the Shahamoallen River

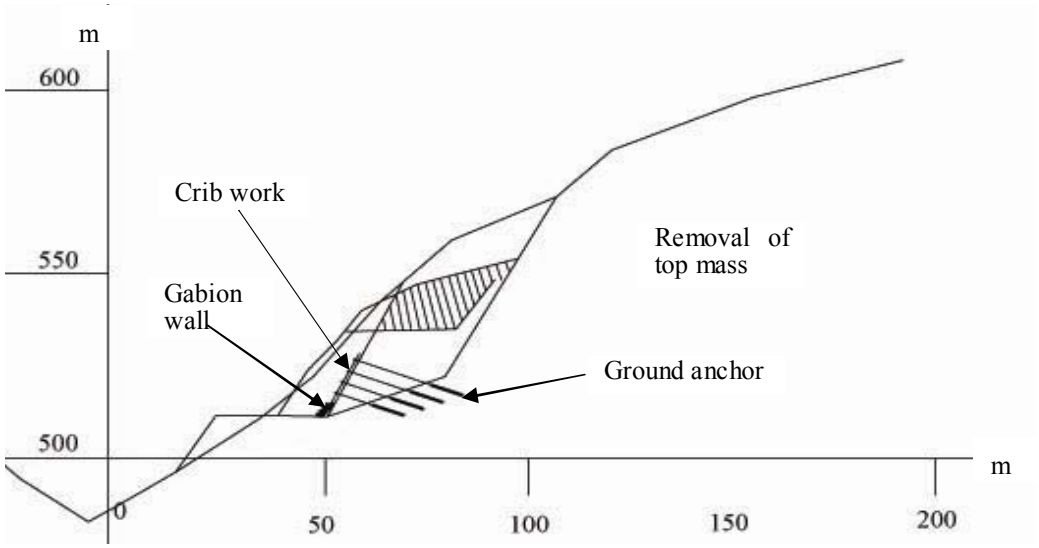


Figure A2.2.1.2 Example of Countermeasure against Weathered Rock Landslide using Ground Anchor

The construction order is first, to remove top mass of landslide, next to remove the mass on the road, and construct crib and anchors, finally to place gabion wall side of road.

(3) Colluvial Deposit Landslide

Most important matter of selection of countermeasure against landslide of colluvial deposit slide type (see Photo A2.2.1.3) is drainage works for surface water and groundwater like as channel works and horizontal gravity drain by drilling. After drainage works, then counter weight embankment and gabion wall should be constructed, and finally steel pile should be construct by pre-boring, insert steel pile, and grouting surround steel pile.

Photo A2.2.1.3 Landslide at Upstream of the Masuleroud River (Colluvial deposit type landslide)

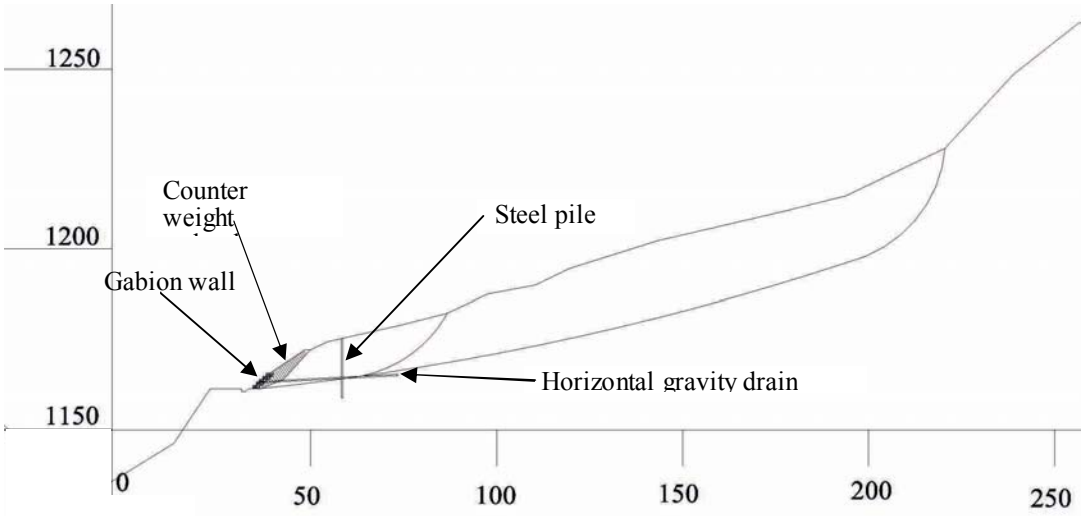


Figure A2.2.1.3 Example of Countermeasure against Colluvial Deposit Landslide using Horizontal Gravity Drains and Counter Weight Embankment

(4) Countermeasure against Masuleh Town Landslide

Masuleh Town Landslide (Photo A2.2.1.4) is very large, sized length and width several handed meters, and it has the character of medium type of weathered rock slide and colluvial deposit slide. The movement of landslide is divided into several small blocks. It is assumed that present moving landslide block is toe part of whole landslide, and its length about 200 m.

Photo A2.2.1.4 Landslide at Masuleh Town (Weathered rock type landslide)

Countermeasure works should be done the horizontal gravity drainage work at first, and next counterworks should be removed the top mass of moving landslide block, and then, should be done the counter weight embankment and gabion wall beside the road. Because it is needed to do the countermeasure works that at first movement of landslide will be less as possible as to do the groundwater level lower and to reduce driving force of landslide by the horizontal gravity drainage and removal pf top mass.

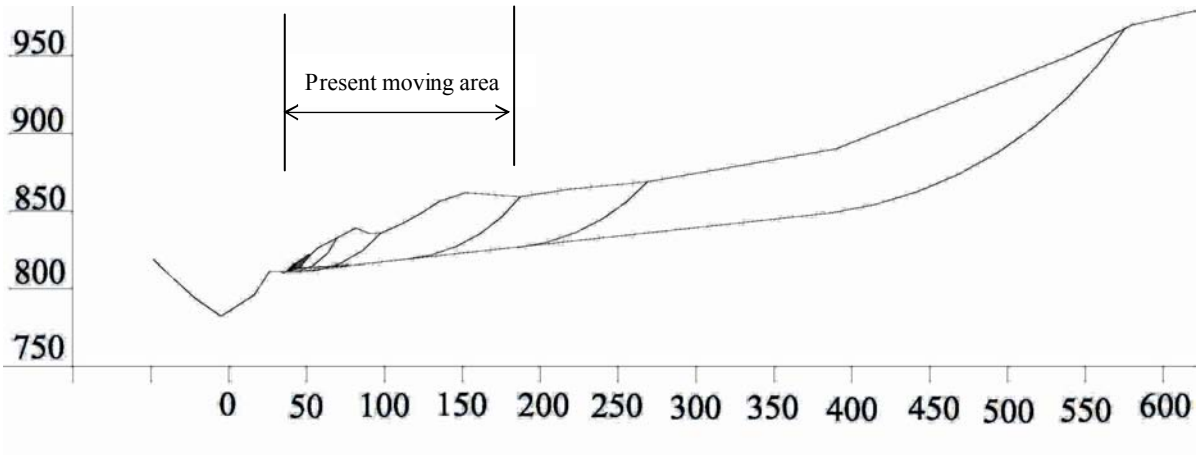


Figure A2.2.1.4 Cross Section of Masuleh Landslide

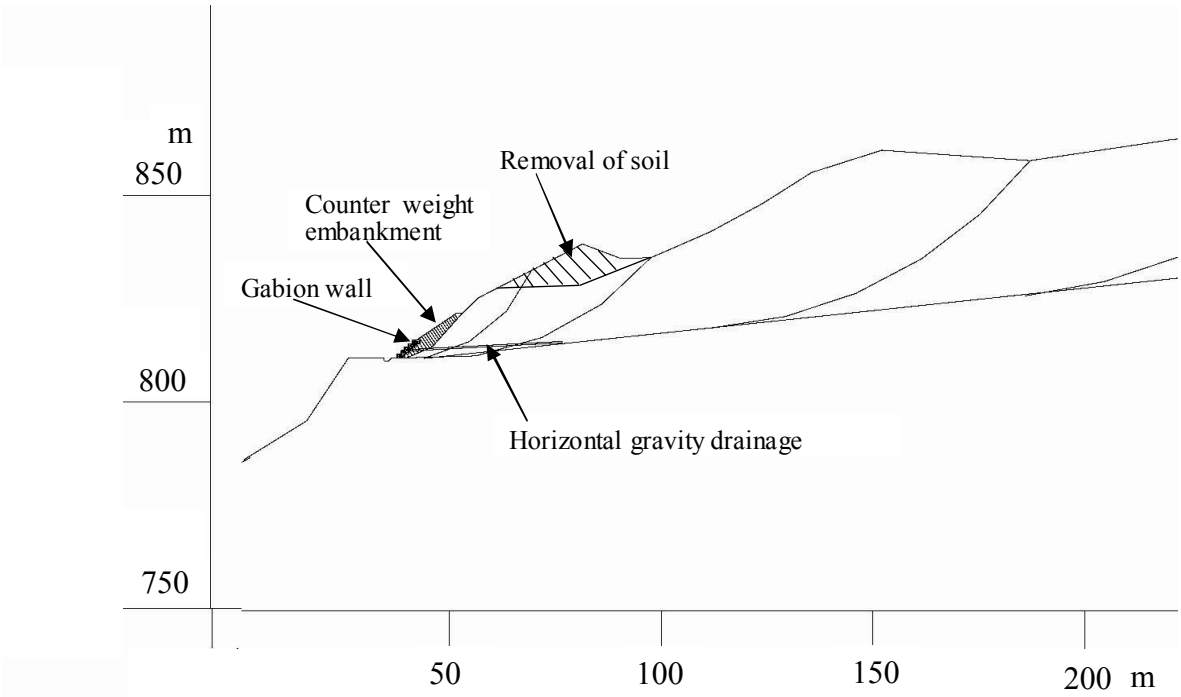


Figure A2.2.1.5 Example of Countermeasure against Masuleh Landslide