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DEPARTMENT OF THE ENVIRONMENT
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THE STUDY ON INTEGRATED MANAGEMENT FOR ECOSYSTEM CONSERVATION OF THE ANZALI WETLAND IN THE ISLAMIC REPUBLIC OF IRAN

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

FINAL REPORT

Volume III : SUPPORTING REPORT

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CHAPTER 1 PRESENT SOCIO-ECONOMIC CONDITIONS OF THE STUDY AREA

1.1 National Socio-Economy

1.1.1 National Economy

The GDP of Iran in 2001[1] was 741,068 billion Rials (USD 86 billion) at the current currency value in 2003. The average annual growth rate of GDP was 23.1% between 1997 and 2001 (SCI, 2002[2]). Iran has the second largest oil and gas reserves in the world, and the national economy heavily depends on oil-related sectors. As much as 16.1% of the GDP is from the oil-related sectors in 2001. The GDP shares of major sectors[3] are mining (15.5%), manufacturing (15.1%), wholesale and retail (14.5%), real estate (11.6%) and agriculture (10.9%). However, the highest percentage of employment is seen in the agricultural sector at around 23%. To protect the livelihood of the farmers, the Government subsidizes various kinds of agricultural products to stabilize their domestic prices by providing guaranteed purchasing prices.

1.1.2 National Budget

The total governmental budget in 2003 was about 968,000 billion Rials (USD 112 billion), comprising public budget, governmental corporation budget, bank budget, and budget of governmental affiliated enterprises. Among the budget items, the government public budget to be used by executive bodies for the annual programs including development projects is 436,022 billion Rials (USD 50 billion)[4]. Approximately 50% of government revenues and 70 - 75% of exports are derived from the oil sector (IMF, 2002).

[1] Under the Iranian calendar, the year starts on 21 March of the Christian year and ends on 20 March in the next year. In addition, to convert the Iranian year into Christian year, 621 is added to the former; ex. 1383 in Iranian year equals 2004 in Christian year.
[2] Iran Statistical Yearbook 1381, Statistical Center of Iran (SCI), Autumn 2003
[3] The categories of the major economic sector are based on the International Standard Industrial Classification (ISIC), and the oil-related sectors are included in a number of different sectors in the ISIC system.
[4] The amount of the governmental budget includes budgets used by both central and provincial governments.

Table 1.1.1 Summary of the National Government Budget*[1]

(Unit: billion Rials)

Items	1999	2000	2001	2002	2003
Government public budget	109,699.5	127,816.2	164,266.9	273,228.3	436,022.8
Government corporation budget*[2]	162.959.3	213,579.8	265,247.9	391,187.9	495,256.5
Banks budget*[3]	16,992.0	21,033.9	28,317.2	37,586.1	51,350.2
Budget of government-affiliated enterprises*[4]	3,062.5	5,474.5	6,861.3	7,140.8	7,730.4
Duplications	16,498.2	7,254.2	8,715.0	15,840.8	22,098.8
Total	276,215.2	360,668.1	455,978.2	693,302.2	968,261.1

Note: *[1]- The figures in the table are the primary approved budget.
*[2]- Comprising institutes, government corporations and insurance companies included in the Budget Law for mentioned years.
*[3]- Including Central Bank and ten other banks. Also including Post-Bank Co. as 1999.
*[4]- Including Defense Industries Organization, Port and Shipping Organization and other institutions included in the Budget Law for the mentioned years.
Source: Iran Statistical Yearbook 1381, Statistical Center of Iran (SCI), Autumn 2003

Table 1.1.2 Breakdown of Government Budget in 2000

(Unit: billion Rials)

Items	2000	(%)
1. Revenues	104,640.8	100
(1) Oil and gas	59,448.5	56.8
(2) Taxes	32,842.1	31.4
(3) Government monopolies and ownerships	439.9	0.4
(4) Sale of goods and services	6,615.3	6.3
(5) Miscellaneous	5,294.7	5.1
2. Expenditures	108,316.2	100
(1) Current expenditures	85,865.4	79.3
(2) Development expenditures	22,450.8	20.7

Note: Special revenues and expenditures are excluded in the above figure. Minor discrepancies in total are due to rounding the figures.
Source: Government budget law (referred and summarized from the Annual Review 2000, Central Bank of the Islamic Republic of Iran)

1.1.3 Domestic Price

Inflation in Iran has been continued for long with large price escalation rate at around 20%/year on average as follows.

Table 1.1.3 Consumer Price Indices of Goods and Services

Year		Urban Area		Rural Area		Average %
		Index	Inc. Rate	Index	Inc. Rate	
1374	1995	69.2	49.5%	100.0		
1375	1996	85.2	23.1%	126.6	26.6%	24.9%
1376	1997	100.0	17.4%	150.5	18.9%	18.1%
1377	1998	118.1	18.1%	191.6	27.3%	22.7%
1378	1999	141.8	20.1%	244.5	27.6%	23.8%
1379	2000	159.7	12.6%	291.8	19.3%	16.0%
1380	2001	177.9	11.4%	335.0	14.8%	13.1%
1381	2002	206.0	15.8%	401.4	19.8%	17.8%
1382	2003	252.8	22.7%	N/A	N/A	22.7%
1383*[1]	2004	265.0	4.8%	N/A	N/A	4.8%
					Annual average=>	19.9%
					Past 5-year average between 1999 and 2003=>	18.7%

Note: *[1] - as of June (May 21 ~ June 20), 2004, N/A: The data is not available.
Source: Central Bank of the Islamic Republic of Iran

1.1.4 Population

According to the 1996 Census, the total population of Iran was about 60.1 million in 1996. The estimated total population in 2003 is about 66.4 million (SCI, 2002). According to the population structure by age group, there is a remarkable feature that the age group under 30 years old covers about 68% of the total population. Under the situation, creation of job opportunities is one of the important issues in the national five-year development plan.

1.1.5 Five-year Development Plan

The national economy of Iran is planned by the five-year development plan, and activities and required budgets in each fiscal year are considered based on the five-year development plan. The third five-year development plan for 2000 – 2004 is under implementation. Overhaul of state enterprises, reduction of government subsidies, control of inflation, and job creation were among the priorities of the third five-year plan. Each province develops its provincial five-year development plan based on the national plan. From the 1st to 3rd five-year development plans, each province has prepared a provincial five-year development plan based on the national five-year development plan. The top-down planning approach has caused difficulties for the provinces in trying to realize target figures in many of the economic aspects. Considering the past lessons, preparation of provincial 4th five-year development plans will be led by each province, according to the MPO.

1.2 Regional Socio-Economy

1.2.1 Administrative Division

There are in total 16 Shahrestans (townships) in Guilan province. The study area consists of 6 Shahrestans, 13 Bakhshes (counties), 10 Shahrs (cities), and 32 Dehestans (rural agglomerations), as shown in Table 1.2.1. There are 6 Bakshes in the Rasht Shahrestan, but only 3 Bakhshes are included in the study area. In other Shahrestans, all Bakhshes are located in the study area.

Table 1.2.1 Administrative Divisions in the Study Area

Ostan	Shahrestan	Bakhsh	Shahr / Dehestan
Province	Township (or Sub-province)	District (or County)	City or Town/ Rural district (or Rural agglomeration)
Guilan	Rasht	Khomam	Khomam, Chopark Khaneh, Chokam
		Markazi (central)	Rasht (Provincial capital), Peerbazar, Humeh, Pasikhan, Lakan
		Sanger	Sanger, Sanger, Saravan, Eslam Abad
	Anzali	Markazi (central)	Bandar Anzali, Lichar Kihassanrood, Chahar Farizeh
	Somehsara	Tolam	Tolam, Hendokhaleh, Tolam
		Markazi (central)	Somehsara, Ziabar, Tahergoorab, Kasma
		Mirzakoochak Jangali	Markien, Gorab zarmikh
	Shaft	Markazi (central)	Shaft, Molasara, Jirdeh
		Ahmadsargorab	Chobar, Ahmadsargorab
	Fuman	Markazi (central)	Fuman, Rood Peesh, Looleman, Gasht, Gurab Pas
		Sardar Jangal	Masuleh, Alian, Sardar Jangal
	Masal	Shanderman	Sheikh Neshin, Shaderman
		Markazi (central)	Masal, Humeh, Masal

Source: JICA Study Team

1.2.2 Population

The total population of Guilan province and study area are estimated at around 2.5 million and 1.1 million in 2004 respectively based on the 1996 Census. Estimated population of the study area by Shahrestan (township) for 2004 (Table 1.2.2) shows that the population is dense in the urban area, especially in Rasht. 56% of the population is concentrated in Rasht, followed by Somehsara (12%) and Anzali (11%) in the total population of the study area. 46% of the total provincial population lives in the study area.

As mentioned in the third five-year development plan of Guilan Province, slowing of the population growth is greater than in other parts of the country due to successful results of the population program in the province[5]. According to the MPO, the population increase in the

[5] According to MPO Guilan, the population program commenced in 1996, 10-years earlier than other provinces in Iran. In addition, the net immigrant rate between inflow and outflow of the population at provincial level is very low.

urban cities is not only due to increase of population density, but also due to the merging of suburb municipalities into the urban cities.

Table 1.2.2 Population of Study Area by Township (Estimate for 2004)

Township	Total Population		
	Total	% to Total Study Area	% to Total Province
Anzali	132,297	11.4%	5.3%
Rasht	647,452	56.0%	25.8%
Shaft	75,512	6.5%	3.0%
Somehsara	138,665	12.0%	5.5%
Fuman	110,579	9.6%	4.4%
Masal	52,111	4.5%	2.1%
Total of Study Area	1,156,616	100.0%	46.1%
Province Total	2,508,605	-	100.0%

Source: Estimated by JICA Study Team based on MPO's estimation

1.2.3 Regional Economy

The GRDP of Guilan province in 2000 was 16,361.8 billion Rials (SCI, 1381)[6]. The GRDP of Guilan province is ranked at 10 out of 28 main provinces in Iran. The vehicle and personal/household goods category is ranked 1st in terms of the value added in 2000, and agriculture/hunting/forestry and manufacturing follow as main sectors.

Guilan province is a major agricultural area for rice, silkworm, and tea; rice cultivation is the main agricultural activity in the province. In addition, the province is one of the major domestic tourist destinations in the northern part of Iran for the summer season, especially along the coastal area of the Caspian Sea including the Anzali Wetland area.

Regarding the manufacturing industrial sector, there are six industrial estates in the study area contributing to the creation of employment opportunities in urban areas other than the agricultural sector. Among the industries, the number of factories for food and beverages is largest because of the abundance of water compared to other areas in Iran. Fur garment factories are the second largest industry.

Regarding the employment rate in Guilan province, since its fall in 1998 at 83.4%, the employment rate has gradually recovered, but it was still at a lower level at 86.8% in 2001 than that at 89.3% in 1997.

The current economic development activities in Guilan province are based on the third five-year development plan of Guilan province for 2000–2004. Although strengthening of

[6] According to MPO Guilan, only the data of GRDP in 2000 is available at the provincial level and no estimation for the past and subsequent years, including future estimation, is available.

agricultural-related industry has been emphasized in the 1st and 2nd provincial five-year development plans, introduction and expansion of non-agricultural sectors such as new manufacturing and tourism industries were also prioritized in the third five-year plan. In terms of shift from an oil dependent national economy to a non-oil industrial economy in the future, Guilan province is an important province with rich natural resources and favorable climates along with other northern provinces.

1.2.4 Household Income

The average annual net incomes of households in urban and rural area in Guilan province are 28,641 and 19,316 thousand Rials/year/family, respectively, in 2002. Compared to the national average in 2002 at 33,105 and 19,003 thousand Rials/year/family in urban and rural areas respectively, the average annual net income in the urban area is lower while that in the rural area is slightly higher in Guilan Province since agriculture is dominant in the rural area.

Table 1.2.3 Average Annual Income of Household in Guilan Province

(Unit: thousand Rials/year)

Year	Urban	Inc. Rate	Rural	Inc. Rate	Average	
1999	14,221 (18,565)	20.1% (22.5%)	11,376 (11,562)	21.1% (23.4%)	12,799 (15,063)	20.5% (22.9%)
2000	18,752 (22,388)	31.9% (20.6%)	12,047 (13,047)	5.9% (12.9%)	15,400 (17,718)	20.3% (17.6%)
2001	20,625 (25,832)	10.0% (15.4%)	16,007 (15,200)	32.9% (16.5%)	18,316 (20,516)	18.9% (15.8%)
2002	28,641 (33,105)	38.9% (28.2%)	19,316 (19,003)	20.7% (25.0%)	23,979 (26,054)	30.9% (27.0%)
2003*	35,857 (40,277)	25.2% (21.7%)	23,203 (22,698)	20.1% (19.4%)	29,530 (31,487)	23.2% (20.9%)
2004*	44,892 (49,002)	25.2% (21.7%)	27,873 (27,112)	20.1% (19.4%)	36,383 (38,057)	23.2% (20.9%)

Note: The figures in the parenthesis are national average data.
* - Estimated by JICA Study Team
Source: Guilan Statistical Yearbook 2003, Iran Statistical Yearbook 2002, Statistical Center of Iran

The proportions of the population below the poverty line as an absolute poverty index in urban and rural areas of Guilan province in 2001 are 10.4% and 13.7%, respectively, as shown below. According to the criteria for low-income family as a relative poverty index in the country in 2001, monthly income levels in urban and rural areas are 1,738,687 Rials/month and 1,470,965 Rial/month, respectively. In Guilan province, the rates of the low-income families except the population under the poverty line in urban and rural areas in 2001 are 16% (195,168 persons) and 26.5% (319,446 persons), respectively. In total, about 26.8% of urban residents and 40% of rural residents of Guilan province are fallen under the categories of

below the poverty line or low-income family[7].

Table 1.2.4 Poverty Line of Urban Residents in Guilan Province

Year	Number of People under Poverty Line	% of the Population	Monthly Poverty Line of a Family with 4.5 members (Rials/household/month)	Annual per Capita Poverty Line (Rials/person/year)
1995	213,497	20.9	242,350	759,322
1996	293,995	27.6	439,880	1,281,203
1997	269,353	25.3	698,383	2,009,735
1998	198,774	17.8	559,085	1,711,487
1999	124,176	11.0	688,350	2,065,081
2000	123,003	10.6	1,219,914	3,724,927
2001	123,490	10.4	1,122,243	3,333,394

Source: Evaluation and Analysis of the Distribution of Income, Poverty and Economic Conditions of Families in Guilan Province (1995 – 2001), MPO Guilan, 2003

Table 1.2.5 Poverty Line of Rural Residents in Guilan Province

Year	Number of People under Poverty Line	% of the Population	Monthly Poverty Line of a Family with 5 members (Rials/household/month)	Annual per Capita Poverty Line (Rials/person/year)
1995	309,898	25.9	282,669	696,515
1996	357,355	29.7	326,778	827,286
1997	310,088	26.5	459,875	1,137,614
1998	251,270	18.4	489,996	1,278,250
1999	131,744	11.3	555,940	1,437,777
2000	134,186	11.2	969,439	2,359,690
2001	165,270	13.7	972,921	2,560,318

Source: Evaluation and Analysis of the Distribution of Income, Poverty and Economic Conditions of Families in Guilan Province (1995 – 2001), MPO Guilan, 2003

1.2.5 Provincial Budget in Guilan Province

A summary of provincial revenue and expenditure of Guilan province is shown below. The total revenue/expenditure in 2002 was about 2,007 billion Rials (USD 232 million). The expenditure used for development projects in 2001 was about 508 billion Rials (USD 59 million).

[7] The latest data on % of population under poverty line and low-income family at national level are not available.

Table 1.2.6 Summary of the Budget of Guilan Provincial Government*[1]

(Unit: million Rials)

Item	1998	1999	2000	2001	2002
1. Revenue	758,121	853,109	1,081,499	1,437,840	2,006,661
(1) Provincial public revenue*[2]	199,890	283,850	380,358	436,530	479,056
(2) National public revenue*[3]	558,231	569,259	701,141	1,001,310	1,527,605
2. Expenditure	758,121	853,109	1,081,499	1,437,840	2,006,661
(1) Current expenditure*[4]	616,137	695,870	897,776	1,118,579	1,498,614
(2) Development expenditure*[5]	141,984	157,239	183,723	319,261	508,047

Note: *[1]- The figures in the table are the actual and realized figures.
*[2]- The provincial revenue consists of taxes, government monopoly and ownership, merchandise sale and services, insurance premium and other revenue.
*[3]- The national public revenue is a budget allocated from the central governmental budget to province.
*[4]- The current expenditure is used to maintain the level of government's socio-economic activities.
*[5]- The development expenditure is used for development projects.
Source: Guilan Statistical Yearbook 2003

The breakdown of the expenditures from provincial budgets in 2002 is shown below. These figures show budget allocation only from provincial budget since data on national budgets allocated to the organization are not available. Total development expenditures among the related organizations related to the M/P, which were used for the project activities, were about 199 billion Rials (USD 23 million). In addition to this, substantial budget is allocated from the central government directly to various local organizations for national projects.

Table 1.2.7 Expenditures from Provincial Budget by Executive Organization Related to M/P in 2002

(Unit: million Rials)

Organization	Current Expenditure*[1]	Development Expenditure*[2]	Total
1. MOJA	59,984	32,995	92,979
2. DOE	7,653	2,270	9,923
3. NRGO	17,117	16,505	33,622
4. GWWC	-	20,071	20,071
5. RWWC	3,475	93,368	96,843
6. Tourism Organization	-	882	882
7. Municipalities	-	32,873	32,873
Sub-total	88,229	198,964	287,193
8. Other organizations	1,410,384	309,083	1,719,467
Total	1,498,613	508,047	2,006,660

Note: *[1]- The current expenditure is used to maintain the level of government's socio-economic activities.
*[2]- The development expenditure is used for development projects.
Source: Guilan Statistical Yearbook 2003

CHAPTER 2 SOCIO-ECONOMIC FRAMEWORK

2.1 Introduction

A socio-economic framework is outlined in this section to indicate the likely future directions of socio-economic changes in the study area. The socio-economic framework is of interest to the study, because it has large impacts on the environmental conditions of the wetland and its basin, and it is the basis of the master plan development. For example, population is the main determinant of pollution loads related to domestic wastewater and amount of solid waste generated. To develop plans to manage wastewater and solid waste, thus, information on future population is essential. Similarly, growth of regional economy, such as agriculture and industry, and major development projects in the basin, are important factors affecting the environmental impact on the wetland.

2.2 Population of the Study Area

The 2004 population of the study area is estimated at about 1.16 million, nearly 50% of which lives in Rasht City. The future population of the area is estimated at 1.17 million in 2005 and 1.52 million in 2019, with an average increase rate of 1.8%/year, and a 30% growth of the population in the 15-year Master Plan period as shown below. While the total population of the urban area will increase by around 44% in 15 years, the total population in the rural area is predicted to decrease slightly at 0.3%.

Table 2.2.1 Summary of Population Forecast in the Study Area from 2005 to 2019

(Unit: thousand persons)

Year	Anzali	Rasht	Shaft	Somehsara	Fuman	Masal	Total	Urban *	Rural **
2004	132.3	647.5	75.5	138.7	110.6	52.1	1,157	763	394
2005	133.9	662.8	76.3	139.3	111.6	52.9	1,177	783	394
2006	135.5	678.6	77.1	140.1	112.5	53.6	1,197	804	394
2007	137.0	694.8	77.7	140.9	113.5	54.3	1,218	825	394
2008	138.5	711.4	78.3	141.8	114.6	55.1	1,240	846	393
2009	140.1	728.6	78.9	142.8	115.6	55.9	1,262	869	393
2010	141.6	746.2	79.5	143.9	116.6	56.6	1,284	891	393
2011	143.2	764.2	80.2	145.1	117.7	57.4	1,308	915	393
2012	144.9	782.8	80.8	146.4	118.8	58.2	1,332	939	393
2013	146.5	801.9	81.5	147.9	119.8	59.0	1,357	964	393
2014	148.2	821.5	82.2	149.5	120.9	59.8	1,382	989	393
2015	149.9	841.7	82.9	151.2	122.0	60.7	1,408	1,016	393
2016	151.7	862.3	83.6	153.0	123.2	61.5	1,435	1,043	393
2017	153.1	883.5	84.4	155.0	124.3	62.4	1,463	1,070	393
2018	154.5	905.3	85.1	157.1	125.4	63.3	1,491	1,098	393
2019	155.9	927.7	85.9	159.4	126.5	64.2	1,520	1,127	393

Note: * - Total population of urban area covers cities ("Shahr" in Farsi).
** - Total population of rural area covers rural districts ("Dehestan" in Farsi).

Source: The above figures are estimated based on preliminary estimate by the Statistics Unit of MPO Guilan only taking account of the past 20-year trend of the census data from 1976 to 1996 and without consideration of other factors such as birthrate, mortality and social increase/decrease.

Table 2.2.2 Population Forecast of the Study Area from 2005 to 2019

Township	District	City/Rural District	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Anzali	Central District	Chahar Farizeh	14,769	14,705	14,551	14,398	14,247	14,098	13,950	13,804	13,659	13,516	13,375	13,234	13,092	12,951	12,811
		Licharaki	6,322	6,295	6,229	6,164	6,099	6,035	5,972	5,909	5,848	5,786	5,726	5,666	5,605	5,544	5,485
		Anzali City	112,795	114,500	116,210	117,946	119,708	121,496	123,311	125,153	127,022	128,920	130,846	132,800	134,392	136,002	137,632
Total			**133,885**	**135,500**	**136,990**	**138,508**	**140,055**	**141,630**	**143,233**	**144,866**	**146,529**	**148,222**	**149,946**	**151,700**	**153,088**	**154,497**	**155,928**
Rasht	Central District	Homen	10,948	10,975	11,002	11,029	11,056	11,083	11,110	11,138	11,165	11,192	11,220	11,247	11,268	11,289	11,310
		Pirbazar	18,026	18,071	18,115	18,160	18,204	18,249	18,293	18,338	18,383	18,428	18,473	18,518	18,553	18,588	18,622
		Pasikhan	10,153	10,178	10,203	10,228	10,253	10,279	10,304	10,329	10,354	10,380	10,405	10,431	10,450	10,470	10,489
		Lakan	18,591	18,637	18,682	18,728	18,774	18,820	18,866	18,912	18,959	19,005	19,052	19,098	19,134	19,170	19,206
		Rasht City	535,285	550,236	565,613	581,419	597,667	614,370	631,539	649,188	667,330	685,979	705,150	724,856	745,076	765,860	787,224
	Sub-total of district		**593,003**	**608,097**	**623,616**	**639,564**	**655,955**	**672,800**	**690,113**	**707,905**	**726,191**	**744,984**	**764,299**	**784,150**	**804,481**	**825,377**	**846,852**
	Khomen	Chokam	16,627	16,669	16,709	16,750	16,791	16,832	16,874	16,915	16,956	16,998	17,040	17,081	17,113	17,145	17,177
		Chaparkhaneh	7,926	7,946	7,965	7,985	8,004	8,024	8,043	8,063	8,083	8,103	8,122	8,142	8,158	8,173	8,188
		Khomen city	11,000	11,308	11,624	11,949	12,282	12,626	12,979	13,341	13,714	14,097	14,491	14,896	15,312	15,739	16,178
	Sub-total of district		**35,554**	**35,922**	**36,298**	**36,683**	**37,078**	**37,482**	**37,896**	**38,319**	**38,753**	**39,198**	**39,653**	**40,120**	**40,583**	**41,057**	**41,543**
	Sangar	Sangar	9,253	9,276	9,299	9,322	9,345	9,368	9,391	9,414	9,437	9,460	9,483	9,506	9,524	9,542	9,560
		Saravan	7,586	7,605	7,624	7,642	7,661	7,680	7,698	7,717	7,736	7,755	7,774	7,793	7,808	7,822	7,837
		Eslam Abad	8,511	8,532	8,553	8,574	8,595	8,616	8,637	8,658	8,679	8,701	8,722	8,743	8,760	8,776	8,792
		Sangar City	8,896	9,145	9,401	9,663	9,933	10,211	10,496	10,790	11,091	11,401	11,720	12,047	12,383	12,729	13,084
	Sub-total of district		**34,247**	**34,558**	**34,876**	**35,201**	**35,534**	**35,874**	**36,222**	**36,578**	**36,943**	**37,316**	**37,698**	**38,090**	**38,474**	**38,869**	**39,273**
Total			**662,804**	**678,577**	**694,790**	**711,449**	**728,567**	**746,156**	**764,230**	**782,803**	**801,887**	**821,499**	**841,651**	**862,360**	**883,538**	**905,302**	**927,668**
Shaft	Central District	Mola Sara	14,187	14,243	14,300	14,358	14,415	14,473	14,530	14,589	14,647	14,706	14,764	14,823	14,882	14,942	15,001
		Jirandeh	20,707	20,790	20,873	20,956	21,040	21,124	21,209	21,293	21,379	21,464	21,550	21,636	21,722	21,809	21,896
		Shaft City	8,653	9,189	9,510	9,842	10,185	10,541	10,909	11,289	11,683	12,091	12,513	12,950	13,403	13,872	14,357
	Sub-total of district		**43,547**	**44,222**	**44,683**	**45,155**	**45,640**	**46,137**	**46,648**	**47,171**	**47,709**	**48,261**	**48,828**	**49,410**	**50,008**	**50,622**	**51,254**
	Ahmad Sar Goorab	Chobar	15,130	15,190	15,251	15,312	15,373	15,435	15,496	15,558	15,621	15,683	15,746	15,809	15,872	15,935	15,999
		Ahmad Goorab City	17,609	17,679	17,750	17,821	17,892	17,964	18,036	18,108	18,180	18,253	18,326	18,399	18,473	18,546	18,620
	Sub-total of district		**32,739**	**32,870**	**33,001**	**33,133**	**33,266**	**33,399**	**33,532**	**33,666**	**33,801**	**33,936**	**34,072**	**34,208**	**34,344**	**34,481**	**34,619**
Total			**76,286**	**77,091**	**77,684**	**78,288**	**78,906**	**79,536**	**80,180**	**80,838**	**81,510**	**82,197**	**82,899**	**83,618**	**84,352**	**85,104**	**85,873**
Somehsara	Cetral District	Tahergoorab	11,809	11,634	11,462	11,292	11,125	10,960	10,798	10,639	10,481	10,326	10,173	10,023	9,874	9,728	9,584
		Ziabar	10,483	10,328	10,175	10,024	9,876	9,730	9,586	9,444	9,304	9,167	9,031	8,898	8,766	8,636	8,508
		Kasma	18,294	18,024	17,757	17,494	17,235	16,980	16,729	16,482	16,238	15,998	15,761	15,528	15,298	15,072	14,849
		Somehsara City	42,058	43,765	45,490	47,282	49,145	51,082	53,094	55,186	57,361	59,621	61,970	64,412	66,987	69,664	72,449
	Sub-total of district		**82,644**	**83,751**	**84,884**	**86,093**	**87,382**	**88,753**	**90,208**	**91,751**	**93,384**	**95,111**	**96,935**	**98,860**	**100,925**	**103,100**	**105,390**
	KoochaK Jangali	Goorab Zarmikh	19,247	18,962	18,681	18,405	18,133	17,864	17,600	17,340	17,083	16,830	16,581	16,336	16,094	15,856	15,621
		Markie	6,165	6,074	5,984	5,895	5,808	5,722	5,637	5,554	5,472	5,391	5,311	5,233	5,155	5,079	5,004
	Sub-total of district		**25,412**	**25,036**	**24,665**	**24,300**	**23,941**	**23,586**	**23,237**	**22,894**	**22,555**	**22,221**	**21,892**	**21,568**	**21,249**	**20,935**	**20,625**
	Toolam	Toolam	9,732	9,588	9,446	9,306	9,168	9,033	8,899	8,767	8,638	8,510	8,384	8,260	8,138	8,017	7,899
		Hendeh Khaleh	12,727	12,538	12,353	12,170	11,990	11,813	11,638	11,466	11,296	11,129	10,964	10,802	10,642	10,485	10,330
		Toolam City	8,807	9,165	9,526	9,901	10,291	10,697	11,118	11,556	12,011	12,485	12,977	13,488	14,027	14,588	15,171
	Sub-total of district		**31,266**	**31,291**	**31,325**	**31,377**	**31,450**	**31,542**	**31,655**	**31,789**	**31,945**	**32,124**	**32,325**	**32,550**	**32,807**	**33,090**	**33,399**
Total			**139,321**	**140,077**	**140,873**	**141,771**	**142,772**	**143,881**	**145,100**	**146,434**	**147,884**	**149,456**	**151,153**	**152,978**	**154,981**	**157,125**	**159,415**
Fuman	Central District	Alian	5,472	5,500	5,527	5,555	5,582	5,610	5,638	5,667	5,695	5,723	5,752	5,781	5,808	5,835	5,862
		Gasht	17,913	18,003	18,093	18,183	18,274	18,365	18,457	18,549	18,642	18,735	18,829	18,923	19,011	19,100	19,190
		Goorab Pass	13,696	13,765	13,834	13,903	13,972	14,042	14,112	14,183	14,253	14,325	14,396	14,468	14,536	14,604	14,672
		Loleman	11,243	11,299	11,355	11,412	11,469	11,526	11,584	11,642	11,700	11,758	11,817	11,876	11,932	11,987	12,044
		Rood Pish	14,141	14,211	14,282	14,354	14,426	14,498	14,570	14,643	14,716	14,789	14,863	14,938	15,008	15,078	15,148
		Sardar Jangal	11,989	12,049	12,109	12,170	12,231	12,292	12,353	12,415	12,477	12,539	12,602	12,665	12,724	12,784	12,844
		Fuman City	36,406	37,017	37,643	38,279	38,926	39,585	40,254	40,935	41,627	42,330	43,046	43,774	44,502	45,242	45,994
		Masoleh City	693	697	700	704	707	711	714	718	722	725	729	733	736	739	743
Total			**111,554**	**112,541**	**113,544**	**114,559**	**115,588**	**116,629**	**117,683**	**118,750**	**119,831**	**120,926**	**122,034**	**123,156**	**124,256**	**125,369**	**126,496**
Masal	Central District	Masal	7,240	7,319	7,395	7,471	7,548	7,626	7,705	7,784	7,865	7,946	8,028	8,111	8,199	8,289	8,379
		Homeh	3,760	3,801	3,840	3,879	3,920	3,960	4,001	4,042	4,084	4,126	4,169	4,212	4,257	4,304	4,351
		Masal Town	18,818	19,200	19,584	19,975	20,374	20,781	21,196	21,620	22,052	22,492	22,942	23,400	23,845	24,299	24,762
	Sub-total of district		**29,818**	**30,320**	**30,818**	**31,325**	**31,842**	**32,367**	**32,902**	**33,446**	**34,000**	**34,564**	**35,138**	**35,722**	**36,302**	**36,892**	**37,492**
	Sander Man	Sheykh Neshin	7,620	7,703	7,782	7,862	7,944	8,026	8,108	8,192	8,277	8,362	8,448	8,535	8,629	8,723	8,818
		Shonderman	15,416	15,584	15,745	15,907	16,071	16,237	16,405	16,574	16,745	16,918	17,092	17,268	17,457	17,647	17,840
	Sub-total of district		**23,035**	**23,286**	**23,527**	**23,770**	**24,015**	**24,263**	**24,513**	**24,766**	**25,021**	**25,280**	**25,540**	**25,804**	**26,086**	**26,370**	**26,658**
Total			**52,853**	**53,606**	**54,345**	**55,095**	**55,856**	**56,630**	**57,415**	**58,212**	**59,021**	**59,844**	**60,678**	**61,526**	**62,388**	**63,262**	**64,150**
Total of Urban Area			**782,718**	**803,524**	**824,599**	**846,256**	**868,513**	**891,387**	**914,896**	**939,058**	**963,892**	**989,417**	**1,015,654**	**1,042,623**	**1,069,927**	**1,097,995**	**1,126,851**
(Annual increase rate)			**(2.65%)**	**(2.66%)**	**(2.62%)**	**(2.63%)**	**(2.63%)**	**(2.63%)**	**(2.64%)**	**(2.64%)**	**(2.64%)**	**(2.65%)**	**(2.65%)**	**(2.66%)**	**(2.62%)**	**(2.62%)**	**(2.63%)**
Total of Rural Area			**393,984**	**393,869**	**393,627**	**393,414**	**393,230**	**393,074**	**392,946**	**392,845**	**392,772**	**392,726**	**392,707**	**392,715**	**392,677**	**392,664**	**392,679**
(Annual increase rate)			**-(0.04%)**	**-(0.03%)**	**-(0.06%)**	**-(0.05%)**	**-(0.05%)**	**-(0.04%)**	**-(0.03%)**	**-(0.03%)**	**-(0.02%)**	**-(0.01%)**	**(0.00%)**	**(0.00%)**	**-(0.01%)**	**(0.00%)**	**(0.00%)**
Grand Total			**1,176,703**	**1,197,393**	**1,218,226**	**1,239,671**	**1,261,743**	**1,284,461**	**1,307,842**	**1,331,903**	**1,356,664**	**1,382,143**	**1,408,361**	**1,435,338**	**1,462,603**	**1,490,660**	**1,519,530**
(Annual Increase Rate)			**(1.74%)**	**(1.76%)**	**(1.74%)**	**(1.76%)**	**(1.78%)**	**(1.80%)**	**(1.82%)**	**(1.84%)**	**(1.86%)**	**(1.88%)**	**(1.90%)**	**(1.92%)**	**(1.90%)**	**(1.92%)**	**(1.94%)**

Note: The above figures are based on preliminary estimate by Statistics Unit of MPO Guilan with taking account of only past 20-year trend of the census data from 1976 to 1996 and without consideration of other factors such as birthrate, mortality and social increase/decrease.

2.3 Regional Economy

The GRDP of Guilan province in 2000 was 16,361.8 billion Rials (USD 1,908 million)[8], which is equivalent to about 6.8 million Rials/capita (USD 793/capita). This is about 70% of the national per capita GDP at around 9.9 million Rials/capita (USD 1,154/capita). The area is endowed with a mild climate and productive agricultural lands, but has no oil resources, and this would be one of the reasons why the per capita GRDP is lower than the average per capita GDP of Iran.

2.3.1 Agriculture

Guilan province is a major agricultural area for rice, silk, and tea, and the province is also one of the major domestic summer tourist destinations, especially along the coast of the Caspian Sea, including the Anzali Wetland area. Rice production is the main agricultural activity in the province. In the third five-year development plan of Guilan province, the following priorities for the agricultural sector are considered for the plan period.

- Increase of productivity per unit area for agricultural produce such as rice, wheat, vegetables, oats, peanuts, tobacco, forage, and summer crops.
- Increase of biological control against pests, herbal diseases and weeds.

Quantitative targets of the agricultural plan for the third five-year development plan are shown in the following table.

Table 2.3.1 Agricultural Targets during the Third Plan in Guilan Province

Target Item	2000	2004 Target
1)Fighting with pests and herbal diseases	352,800 ha	388,080 ha
2)Increase in efficiency of agricultural automation	0.68 hp/ha	1.03 hp/ha
3)Increase of production of rice seed	700 ton	950 ton
4)Increase of agricultural produce by using breeding and other methods	982,000 ton	1,180,000 ton
5)Increase of wet-wheat produce	5,136 ton	7,000 ton
6)Increase in production of rain-fed farming	8,344 ton	12,000 ton

Source: Third Socio-Economic and Cultural Development Plan of the Guilan Province 2000–2004

2.3.2 Industry

There are six industrial estates in the study area contributing to urban employment opportunities other than in the agricultural sector. The number of factories for food and beverages is the largest in the province due to the abundance of water resources compared to

[8] Iran Statistical Yearbook, SCI, 1381. According to MPO Guilan, only the above data is available and any estimation for both past and subsequent years has not been done so far.

other areas in Iran. Fur garment factories are the second largest industry. The third five-year development plan of Guilan province[9] presented the following targets for the establishment of industrial parks. However, the strategies for specific industrial sectors to be promoted in Guilan province are not mentioned in the plan.

Table 2.3.2 Planned Industrial Parks during the Third Development Plan in Guilan Province

(Unit: ha)

Type of Industrial Park	Land Area
1)Development of urban industrial park to be started	203
2)Development of urban industrial park to be completed	527
3) Development of rural industrial park to be started and completed	390
Total	1,120

Source: Third Socio-Economic and Cultural Development Plan of the Guilan Province 2000–2004

The expected investment amount for establishment of industrial parks during the third five-year development plan is shown below. In the table, there is no information on the investment from some sectors such as private companies.

Table 2.3.3 Investment Plan for Establishment of Industrial Parks

(Unit: million Rials)

Year	2000	2001	2002	2003	2004	Total
1)National and provincial budget	25,813	4,254	4,150	6,640	7,470	48,327
2)Public and non-governmental organization	0	0	16,748	19,269	21,826	57,843
3)Others	0	3,096	0	0	0	3,096
Total	25,813	7,350	20,898	25,909	29,296	109,266

Source: Third Socio-Economic and Cultural Development Plan of the Guilan Province 2000–2004

2.3.3 Tourism

Guilan Province, especially the Bandar Anzali area along the Caspian coast, is one of the largest domestic destinations for summer holidays in Iran. Around 184,000 domestic tourists came into Guilan province in 2002, mostly from nearby provinces, whilst around 3,100 foreign tourists visited the area. The main tourist attractions are located at Bandar Anzali, Rasht, Masuleh, and Fuman. Tourism accommodation in the study area is concentrated in Rasht and Anzali. Tourism targets according to the third five-year development plan for Guilan province are shown below.

- Increase of annual tourists from 124,000 people to 280,000 people.
- Increase of capacity of tourist accommodation from 3,000 beds to 4,600 beds

[9] Third Socio-Economic and Cultural Development Plan of the Guilan Province 2000 – 2004

The total cost for the above is estimated at around 40 billion Rials from government and 12 billion Rials from the private sector and NGOs.

2.4 Major Development Plan

2.4.1 Long Term Development Plan for Guilan Province 1996 – 2021

A long-term development plan for Guilan province was published in 1997. The period of the long-term plan is 25 years from 1996 to 2021. The target period of the long-term plan is close to the target year of the Master Plan. The plan outlines the future direction of provincial development for various aspects such as the social, industrial, educational, and cultural sectors.

In the plan, it is forecasted that the percentage of the workforce in the agricultural sector will gradually decrease in the rural area, while that of the service sector will increase. In the urban area, the proportion of the workforce in the industrial sector will increase, while that in service sector will decrease, but will still represent more than 50% of the total population.

2.4.2 Third Five-Year Plan of Guilan Province 2000 - 2004

The Third Socio-Economic and Cultural Development Plan of Guilan Province 2000 – 2004 (The third five-year plan) was prepared with a review of past implementation of the previous five-year plan. This is essentially a compilation of sectoral development plans developed by provincial offices of various ministries.

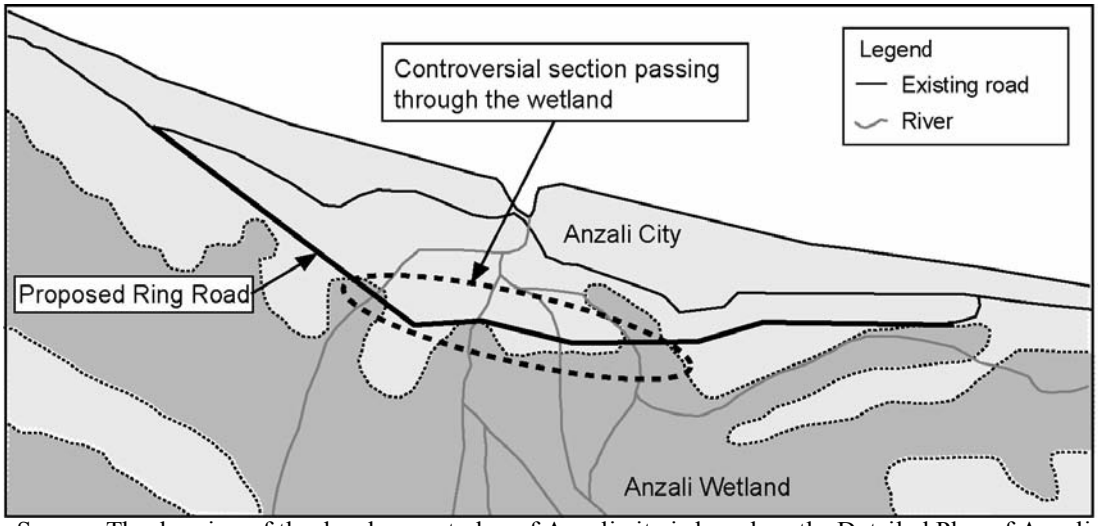
2.4.3 Urban Development Plan for Rasht City

An Integrated and Detailed Design of Rasht City was published by the Housing and Urban Development Organization of Guilan in 2000. The target period of the 10-year plan is from 2000 to 2010. In the plan, land use zones are designated based on the past and present details of various aspects of Rasht City. This plan is now expected to be revised in the near future.

2.4.4 Urban Development Plan for Anzali City

A detailed urban development plan for Anzali City was prepared by the Housing and Urban Development Organization of Guilan in 2001, based on a master plan prepared in 1989. In the detailed plan, land area by type of land use is designated for several zones of Anzali City. However, this plan seems to have become outdated already.

The southern boundary for the detailed plan is based on a ring road, which was planned to be newly constructed as shown in the following figure. The development plan for the ring road has been postponed since DOE raised an objection based on the potential serious environmental impact on Anzali Wetland. This has not been solved so far, but according to the Housing and Urban Development Organization of Guilan, it is planned that the master plan be revised from next year. Based on the detailed plan, a set of regulations for building construction standards and other kinds of development control in the plan area was published in 2001.



Source: The drawing of the development plan of Anzali city is based on the Detailed Plan of Anzali City, 2001.

Figure 2.4.1 Overlay of Environmental Zones and Anzali Development Plan

2.4.5 Urban Development Plan for Somehsara City

A master plan for Somehsara City was prepared in 1989. The target year of the plan was 1998/99. In the plan, construction rules by type of urban land use to be regulated are proposed. According to the plan, around 1 km^2 of land area is needed for expansion, mainly for residential use.

2.5 Future Economic Forecast

The general revenue of Guilan provincial government for past five years is shown below. The average increase of the total revenue estimated using 2002 currency values from 1998 to 2002 is at 5.8%/year. This annual increase rate would be an index for the future economic growth of Guilan province. By applying the annual increase rate, the total revenue of Guilan province is estimated at about 567 billion Rials in 2005 and 1,250 billion Rials in 2019.

Table 2.5.1 General Revenue of the Guilan Provincial Budget

(Unit: million Rials)

Item	1998	1999	2000	2001	2002
Total revenue at actual current price*[1]	199,890	283,850	380,358	436,531	479,056
Estimated at constant price of 2001*[2]	382,549	438,661	506,795	514,269	479,056
Increase rate (%)	-7%	15%	16%	1%	-7%

Note: *[1]- The provincial revenue consists of taxes, government monopoly and ownership, merchandise sale and services, insurance premium and other revenue.
*[2]- Estimated by JICA Study Team by applying average national consumer price index in urban and rural areas.
Source: Guilan Statistical Yearbook, 2003

In this context, assuming an annual economic growth rate at 5%, the GRDP of Guilan province is estimated at 20,882 billion Rials in 2005 and 41,345 billion Rials in 2019.

Table 2.5.2 Forecast of GRDP in Guilan Province

(Unit: billion Rials)

Year	GRDP
2000*[1]	16,362
2005*[2]	20,882
2019*[2]	41,345

Note: Estimated at constant price of 2001/02
Source: *[1] GRDP in 2000/01 was obtained from MPO Guilan
*[2] GRDPs between 2005 and 2019 were estimated by JICA Study Team

CHAPTER 3 PROJECT COST AND FINANCIAL PLAN

3.1 Conditions of Cost Estimate

Necessary costs for the M/P are estimated under the following conditions.

(1) The Project costs in the project period from 2005 and 2019 are estimated based on June 2004 constant prices in the Iranian Rials (IRR).
(2) The exchange rate of USD 1 = IRR 8,652 and JPY 100 = IRR 7,955 as of 30 June in 2004 are applied.
(3) Tax and fee: The value added tax (VAT) for all cost components and import tariffs for imported equipment are included in the cost estimation.
(4) Cost components consist of the following items.
    1) Project cost
        a) Construction cost
        b) Land acquisition
        c) Compensation
        d) Administration cost (5% of a))
        e) Engineering cost (10% of a))
        f) Physical contingency (20% of a) to c))
        g) Project cost (Total of a) to f))
    2) Operation and maintenance cost
        a) Personnel cost
        b) Expenses

3.2 Cost Estimate

The total cost of the M/P between 2005 and 2019 is about 4,479.3 billion Rials (USD 518 million) as shown in Table 3.2.1.

Table 3.2.1 Cost of the Master Plan

(Unit: billion Rials)

Sub-plans	Project Cost	Total O&M Cost*
1. Wetland Ecological Management Plan	30.8	15.3
2. Watershed Management Plan	726.8	43.3
3. Wastewater Management Plan	2,449.9	439.8
4. Solid Waste Management Plan	146.2	548.3
5. Environmental Education Plan	1.2	38.5
6. Institutional Plan	1.3	37.9
Total	3,356.2	1,123.1

Note: *- Total operation and maintenance (O&M) cost for 15 years of master plan period.
The above costs include the physical contingency.

Among the proposed plans, the wastewater management plan, which constructs major sewerage systems in Rasht, Anzali and Somehsara, covers a significant part of the total cost of the M/P at about 73.0% of the total project cost (2,450 billion Rials), followed by the watershed management plan (21.7%) and the solid waste management plan (4.4%). The cost for wetland ecological management plan is 1.0% of the total cost, reflecting the fact that the main direction of the wetland ecological management plan is to keep the wetland as natural as possible. The wastewater management and solid waste management require significant operation and maintenance cost (O&M cost) in order to provide regular services to the residents. The Environmental Education Plan and the Institutional Plan are the soft components and do not require much investment cost, though require sizable O&M costs.

3.3 Annual Cost Disbursement Schedule

A disbursement schedule for the M/P between 2005 and 2019 based on the implementation schedule of the proposed management plans is summarized in Tables 3.3.1 and 3.3.2. The average annual total disbursement of the project and O&M costs are about 224 billion Rials/year (USD 26 million/year) and 75 billion Rials/year (USD 8.7 million/year), respectively. The maximum annual total disbursement of the project and O&M costs are about 408 billion Rials (USD 47 million/year) in 2008 and 94 billion Rials (USD 10.9 million/year) in 2019/20, respectively.

Table 3.3.1 Cost Disbursement Schedule for the Master Plan

(Unit: million Rials)

	Year	Wetland Ecological Management		Watershed Management		Wastewater Management		Solid Waste Management		Environmental Education		Institutional Plan		Total		
		Project Cost	O&M	Project Cost	O&M	Project Cost	O&M	Project Cost	O&M	Project Cost	O&M	Project Cost	O&M	Project Cost	O&M	Total
1	2005	0	252	98,847	65	185,444	6,328	32,478	26,007	0	1,932	1,319	2,528	318,088	37,110	355,198
2	2006	0	508	48,669	275	259,670	9,412	6,764	31,287	0	2,201	0	2,528	315,103	46,211	361,314
3	2007	3,069	752	132,625	990	298,151	12,352	7,334	31,542	0	2,301	0	2,528	441,179	50,465	491,643
4	2008	532	773	109,458	2,500	362,941	16,215	7,524	32,698	0	2,201	0	2,528	480,455	56,916	537,371
5	2009	3,980	853	97,686	3,360	354,820	19,333	6,384	33,411	0	2,401	0	2,528	462,869	61,886	524,755
6	2010	6,473	851	44,711	4,679	120,423	25,272	16,454	36,969	587	2,954	0	2,528	188,647	73,252	261,900
7	2011	5,058	1,059	48,010	4,605	96,644	29,139	5,624	37,508	0	3,106	0	2,528	155,336	77,944	233,281
8	2012	4,336	1,386	45,251	3,954	163,404	32,736	7,904	38,565	0	2,493	0	2,528	220,895	81,660	302,555
9	2013	3,600	1,206	33,255	3,705	171,504	36,333	15,000	38,218	0	2,961	0	2,528	223,359	84,950	308,310
10	2014	3,600	1,206	28,652	3,317	174,729	41,618	6,194	38,840	0	2,484	0	2,528	213,175	89,992	303,167
11	2015	0	1,276	19,655	3,281	64,799	41,837	9,804	39,393	587	2,695	0	2,528	94,845	91,009	185,854
12	2016	0	1,206	8,484	3,190	64,799	42,001	5,624	39,850	0	3,224	0	2,528	78,907	91,998	170,906
13	2017	163	1,446	5,790	3,162	63,869	42,281	6,764	40,630	0	2,536	0	2,528	76,586	92,582	169,168
14	2018	0	1,276	3,204	3,119	34,208	42,281	6,764	41,417	0	2,488	0	2,528	44,176	93,108	137,284
15	2019	0	1,206	2,487	3,130	34,463	42,634	5,624	41,994	0	2,486	0	2,528	42,574	93,978	136,552
	Sub-total	30,811	15,256	726,785	43,331	2,449,866	439,766	146,239	548,329	1,175	38,460	1,319	37,920	3,356,195	1,123,061	4,479,255
	Total	**46,067** (1.0%)		**770,115** (17.2%)		**2,889,632** (64.5%)		**694,568** (15.5%)		**39,635** (0.9%)		**39,239** (0.9%)		**4,479,255** (100.0%)		

Note: The above costs were estimated at June 2004 constant price in theIranian Rials and include the physical contingency.
Price year of the above costs is June 2004. The above costs do not include price escalation.
Source: Estimated by JICA study team.

Table 3.3.2 Disbursement Schedule of Project Costs and O&M Costs of the Component Plans of the Master Plan (1/2)

(Unit: million Rials)

Compnent Plan	Year 1 2005	Year 2 2006	Year 3 2007	Year 4 2008	Year 5 2009	Year 6 2010	Year 7 2011	Year 8 2012	Year 9 2013	Year 10 2014	Year 11 2015	Year 12 2016	Year 13 2017	Year 14 2018	Year 15 2019	Total
Wetland Ecological Management Plan																
Project Costs	0	0	3,069	532	3,980	6,473	5,058	4,336	3,600	3,600	0	0	163	0	0	30,811
1. Environmental Zoning	0	0	58	0	0	3,600	3,600	3,658	3,600	3,600	0	0	58	0	0	18,175
2. Conservation of Wildlife	0	0	2,134	0	0	0	0	58	0	0	0	0	58	0	0	2,251
3. Conservation of Habitat	0	0	818	246	0	122	0	0	0	0	0	0	0	0	0	1,186
4. Promotion of Wise Use	0	0	58	286	3,980	2,751	1,458	619	0	0	0	0	47	0	0	9,199
O&M Costs	252	508	752	773	853	851	1059	1386	1206	1206	1276	1206	1446	1276	1206	15,256
1. Zoning and Ecological Management	85	85	43	43	43	43	43	43	43	43	43	43	43	43	43	732
2. Conservation of Wildlife	0	0	20	55	55	55	55	55	55	55	55	55	55	55	55	682
3. Conservation of Habitat	0	0	20	246	316	287	287	357	287	287	357	287	287	357	287	3,664
4. Promotion of Wise Use	0	0	40.32	40.32	50.32	77.32	285.32	302.32	432.32	432.32	432.32	432.32	432.32	432.32	432.32	3,822
5. Monitoring and Feedback	167	423	628	388	388	388	388	628	388	388	388	388	628	388	388	6,356
Total Cost of Wetland Ecological Management Sub-plan	252	508	3,821	1,305	4,833	7,324	6,117	5,722	4,806	4,806	1,276	1,206	1,609	1,276	1,206	46,067
Price Contingency (3%/year)	4	23	293	142	688	1,294	1,297	1,421	1,373	1,559	465	488	720	626	646	11,039
Total Cost with Price Escalation	256	531	4,114	1,447	5,521	8,618	7,414	7,143	6,179	6,365	1,741	1,694	2,329	1,902	1,852	57,105
Watershed Management Plan																
Project Costs	98,847	48,669	132,625	109,458	97,686	44,711	48,010	45,251	33,255	28,652	19,655	8,484	5,790	3,204	2,487	726,785
1. Soil Erosion Control and Prevention of Land Slides	17,601	21,719	32,925	31,604	41,681	25,211	27,650	21,519	15,975	15,606	11,215	1,129	1,129	0	0	264,965
2. Forest and Rangeland Management	4,336	12,461	12,040	15,951	18,153	19,372	20,360	23,732	17,281	13,045	8,439	7,356	4,661	3,204	2,487	182,877
3. Plain Area Management	0	0	0	83	628	0	0	0	0	0	0	0	0	0	0	711
4. Livelihood Development	1,110	1,152	1,152	64	0	0	0	0	0	0	0	0	0	0	0	3,477
5. Institutional Arrangement	0	128	511	511	256	128	0	0	0	0	0	0	0	0	0	1,533
6. Project Cost for the Livestock Resettlement Program	75,801	13,209	85,997	61,246	36,968	0	0	0	0	0	0	0	0	0	0	273,221
O&M Costs	65	275	990	2,500	3,360	4,679	4,605	3,954	3,705	3,317	3,281	3,190	3,162	3,119	3,130	43,331
1. Soil Erosion Control and Prevention of Land Slides	0	175	175	438	438	1,044	1,044	1,088	1,381	1,381	1,381	1,405	1,405	1,405	1,405	14,164
2. Rangeland Management	0	0	653	1,699	2,447	2,790	2,790	2,170	1,797	1,518	1,579	1,506	1,497	1,461	1,472	23,377
3. Plain Area Management	0	0	0	0	0	216	216	216	216	216	216	216	216	216	216	2,163
4. Environmental Monitoring	65	100	162	364	476	629	555	479	311	202	105	64	44	37	37	3,627
Total Cost of Watershed Management Sub-plan	98,912	48,944	133,615	111,959	101,046	49,390	52,615	49,205	36,960	31,969	22,935	11,675	8,951	6,323	5,617	770,115
Price Contingency (3%/year)	1,484	2,224	10,263	12,217	14,388	8,725	11,153	12,219	10,562	10,369	8,350	4,728	4,003	3,102	3,007	116,793
Total Cost with Price Escalation	100,395	51,168	143,879	124,175	115,434	58,115	63,768	61,423	47,522	42,338	31,285	16,403	12,954	9,424	8,623	886,908
Wastewater Management Plan																
Project Costs	185,444	259,670	298,151	362,941	354,820	120,423	96,644	163,404	171,504	174,729	64,799	64,799	63,869	34,208	34,463	2,449,866
1. Management of Domestic Wastewater in Urban Areas	185,178	254,294	292,775	320,315	319,303	100,508	74,979	159,489	167,589	170,559	55,384	55,384	54,454	24,793	24,793	2,259,796
2. Management of Domestic Wastewater in Rural Areas	0	4,860	4,860	4,860	5,250	3,915	3,915	3,915	3,915	4,170	3,915	3,915	3,915	3,915	4,170	59,490
3. Management of Industrial Effluent	266	266	266	37,766	30,266	16,000	17,750	0	0	0	5,400	5,400	5,400	5,400	5,400	129,580
4. Management of Livestock Waste	0	250	250	0	0	0	0	0	0	0	100	100	100	100	100	1,000
O&M Costs	6,328	9,412	12,352	16,215	19,333	25,272	29,139	32,736	36,333	41,618	41,837	42,001	42,281	42,281	42,634	439,766
1. Management of Domestic Wastewater in Urban Areas	5,441	8,360	11,280	14,199	17,119	22,799	26,396	29,993	33,590	38,522	38,522	38,522	38,522	38,522	38,522	400,303
2. Management of Domestic Wastewater in Rural Areas	0	165	165	165	363	528	528	528	528	726	891	891	891	891	1,089	8,349
3. Management of Industrial Effluent	273	273	273	1,217	1,217	1,311	1,581	1,581	1,581	1,736	1,736	1,900	2,170	2,170	2,325	21,344
4. Management of Livestock Waste	0	0	20	20	20	20	20	20	20	20	74	74	84	84	84	560
5. Management of Pollution from Farmland	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	3,960
6. Environmental Monitoring	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350	5,250
Total Cost of Wastewater Management Sub-plan	191,772	269,082	310,502	379,156	374,152	145,694	125,783	196,140	207,837	216,347	106,636	106,800	106,149	76,489	77,097	2,889,632
Price Contingency (3%/year)	2,877	12,230	23,851	41,373	53,276	25,739	26,661	48,706	59,394	70,171	38,823	43,254	47,464	37,522	41,268	572,608
Total Cost with Price Escalation	194,648	281,312	334,353	420,528	427,428	171,433	152,444	244,845	267,230	286,518	145,459	150,053	153,614	114,011	118,365	3,462,240
Solid Waste Management Plan																
Project Costs	32,478	6,764	7,334	7,524	6,384	16,454	5,624	7,904	15,000	6,194	9,804	5,624	6,764	6,764	5,624	146,239
1. Provision of Efficient Waste Collection Services to the Whole Area	14,795	6,764	7,334	7,524	6,384	16,454	5,624	7,904	8,094	6,194	9,804	5,624	6,764	6,764	5,624	121,651
2. Composting of Municipal Solid Waste	17,083	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17,083
3. Sanitary Landfill Construction	0	0	0	0	0	0	0	0	6,906	0	0	0	0	0	0	6,906

Table 3.3.2 Disbursement Schedule of Project Costs and O&M Costs of the Component Plans of the Master Plan (2/2)

(Unit: million Rials)

Compnent Plan	Year 1 2005	Year 2 2006	Year 3 2007	Year 4 2008	Year 5 2009	Year 6 2010	Year 7 2011	Year 8 2012	Year 9 2013	Year 10 2014	Year 11 2015	Year 12 2016	Year 13 2017	Year 14 2018	Year 15 2019	Total
4. Proper Treatment of Hazardous Industrial Solid Waste	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600
O&M Costs	26,007	31,287	31,542	32,698	33,411	36,969	37,508	38,565	38,218	38,840	39,393	39,850	40,630	41,417	41,994	548,329
1. Provision of Efficient Waste Collection Services to the Whole Area	18,240	18,843	18,743	19,591	20,011	23,396	23,680	24,505	24,402	24,821	25,068	25,351	25,906	26,460	26,745	345,761
2. Composting of Municipal Solid Waste	6,328	10,820	11,088	11,347	11,600	11,766	12,013	12,177	12,423	12,587	12,887	13,054	13,273	13,471	13,723	178,557
3. Sanitary Landfill Construction	922	960	964	1,009	1,046	1,049	1,053	1,056	562	597	599	601	603	605	640	12,265
4. Proper Treatment of Hazardous Industrial Solid Waste	402	516	519	522	526	529	533	566	570	574	578	583	588	620	625	8,252
5. Environmental Monitoring	114	149	229	229	229	229	229	261	261	261	261	261	261	261	261	3,494
Total Cost of Solid Waste Sub-plan	58,484	38,051	38,876	40,222	39,795	53,423	43,132	46,469	53,218	45,034	49,197	45,474	47,394	48,181	47,618	694,568
Price Contingency (3%/year)	877	1,729	2,986	4,389	5,666	9,438	9,142	11,539	15,208	14,607	17,911	18,417	21,192	23,636	25,489	182,227
Total Cost with Price Escalation	59,361	39,781	41,862	44,611	45,461	62,861	52,274	58,008	68,426	59,640	67,109	63,891	68,586	71,817	73,107	876,795
Environmental Education Plan																
Project Costs	0	0	0	0	0	587	0	0	0	0	587	0	0	0	0	1,175
1. Public Awareness Raising and Participation (General Public and Tou	0	0	0	0	0	587	0	0	0	0	587	0	0	0	0	1,175
O&M Costs	1,932	2,201	2,301	2,201	2,401	2,954	3,106	2,493	2,961	2,484	2,695	3,224	2,536	2,488	2,486	38,460
1. Environmental Education in Schools	141	179	229	129	229	174	314	178	284	194	323	264	294	148	244	3,324
2. Environmental Education in Higher Education	479	491	476	476	476	486	486	61	496	46	126	576	46	71	46	4,838
3. Professional Development for Decision Makers	0	109	99	99	99	199	199	209	199	199	199	199	199	209	199	2,416
4. Public Awareness Raising and Participation (Religious Leaders)	26	26	26	26	26	99	161	99	36	99	36	224	36	99	36	1,053
5. Public Awareness Raising and Participation (Business and Industry)	40	40	40	40	40	235	235	235	235	235	90	90	90	90	90	1,825
6. Public Awareness Raising and Participation (Farmers and Rural Com	516	466	541	541	641	741	691	691	691	691	741	691	691	691	691	9,715
7. Public Awareness Raising and Participation (General Public and Tou	320	480	480	480	480	810	810	810	810	810	970	970	970	970	970	11,140
8. Public Awareness Raising and Participation (NGOs)	410	410	410	410	410	210	210	210	210	210	210	210	210	210	210	4,150
Total Cost of Environmental Education Sub-plan	1,932	2,201	2,301	2,201	2,401	3,541	3,106	2,493	2,961	2,484	3,282	3,224	2,536	2,488	2,486	39,635
Price Contingency (3%/year)	29	100	177	240	342	626	658	619	846	806	1,195	1,306	1,134	1,220	1,331	10,628
Total Cost with Price Escalation	1,960	2,301	2,478	2,441	2,743	4,166	3,764	3,111	3,807	3,289	4,477	4,529	3,670	3,708	3,817	50,262
Institutional Plan																
Project Costs	1,319	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,319
1. Establishment of Anzali Wetland Department	890	0	0	0	0	0	0	0	0	0	0	0	0	0	0	890
2. DOE 'Apprenticeship' Training	159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159
3. Overseas Exchange Visits	270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	270
O&M Costs	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	37,920
1. Establishment of Anzali Wetland Department	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	2,224	33,360
2. Formation of Anzali Sub-Group of WGLEP	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	870
3. Annual Anzali Forum	67	67	67	67	67	67	67	67	67	67	67	67	67	67	67	1,005
4. In-country Cross-sectoral Training	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179	2,685
Total Cost of Institutional Sub-plan	3,847	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	2,528	39,239
Price Contingency (3%/year)	58	115	194	276	360	447	536	628	722	820	920	1,024	1,130	1,240	1,353	9,823
Total Cost with Price Escalation	3,905	2,643	2,722	2,804	2,888	2,975	3,064	3,156	3,250	3,348	3,448	3,552	3,658	3,768	3,881	49,062
Grand Total at June 2004 Price	**355,198**	**361,314**	**491,643**	**537,371**	**524,755**	**261,900**	**233,281**	**302,555**	**308,310**	**303,167**	**185,854**	**170,906**	**169,168**	**137,284**	**136,552**	**4,479,255**
- Total Project Cost at June 2004 Price	**318,088**	**315,103**	**441,179**	**480,455**	**462,869**	**188,647**	**155,336**	**220,895**	**223,359**	**213,175**	**94,845**	**78,907**	**76,586**	**44,176**	**42,574**	**3,356,195**
- Total O&M Cost at June 2004 Price	**37,110**	**46,211**	**50,465**	**56,916**	**61,886**	**73,252**	**77,944**	**81,660**	**84,950**	**89,992**	**91,009**	**91,998**	**92,582**	**93,108**	**93,978**	**1,123,061**
Total Price Contingency (3%/year)	5,328	16,422	37,765	58,637	74,721	46,268	49,447	75,131	88,106	98,331	67,665	69,216	75,643	67,346	73,093	903,118
- Price Contingency of the Project Cost (3%/year)	4,771	14,321	33,888	52,426	65,909	33,327	32,926	54,853	63,830	69,142	34,531	31,957	34,245	21,671	22,789	570,587
- Price Contingency of the O&MCost (3%/year)	557	2,100	3,876	6,211	8,812	12,941	16,521	20,278	24,276	29,188	33,134	37,259	41,398	45,675	50,304	332,531
Grand Total with Price Contingency	**360,526**	**377,736**	**529,408**	**596,007**	**599,475**	**308,168**	**282,727**	**377,686**	**396,416**	**401,497**	**253,519**	**240,122**	**244,811**	**204,630**	**209,645**	**5,382,373**
- Total Project Cost with Price Contingency	**322,859**	**329,425**	**475,067**	**532,881**	**528,778**	**221,974**	**188,262**	**275,748**	**287,189**	**282,317**	**129,376**	**110,865**	**110,831**	**65,847**	**65,363**	**3,926,782**
- Total O&M Cost with Price Contingency	**37,667**	**48,311**	**54,341**	**63,126**	**70,697**	**86,193**	**94,466**	**101,938**	**109,226**	**119,180**	**124,143**	**129,257**	**133,979**	**138,783**	**144,282**	**1,455,592**

CHAPTER 4 ECONOMIC EVALUATION

4.1 Approach to the Economic Evaluation of the Proposed Master Plan

The proposed master plan is expected to bring substantial benefits to the area, and thus contributes to the welfare of the area. However, the master plan also requires a large amount of funding for its implementation. Therefore, the benefits and the costs of the master plan are examined, and whether the master plan is worth implementing is evaluated from the economic perspective. In a conventional economic analysis of a development project, as in a typical transportation development project, the economic benefits of the project (e.g., the driving time reduced by the project and the reduced fuel consumption) are compared against the economic costs in monetary term. However, economic benefits of the proposed master plan are not easy to quantify for the following reasons:

- The master plan involves various intangible benefits, e.g. the benefit of protecting threatened species or the benefit of improving water quality. These benefits are difficult to put prices on.
- The effects of the proposed measures on the environment and the regional economy (e.g., the increase in fish production due to improved water quality) are not simple to predict because the environmental system is very complex, and is influenced by external factors, such as the fluctuation of the Caspian Sea or climate change. In addition, information required to predict the environmental conditions is often not available.
- While the main goal of this study is conservation of the Anzali Wetland, the proposed measures have other benefits, such as improvement of public health and living environment, environmental protection of the Caspian Sea, disaster prevention, etc. In many cases, the main benefits are accrued from these components than from wetland conservation.

Considering these problems, the economic evaluation of the master plan was conducted. The benefits of the proposed plan are firstly identified qualitatively in the economic evaluation in the Study. Then, monetary evaluations for the selected benefits are attempted as much as possible. Based on these analyses, whether the proposed plan is worth implementing or not was judged, as presented below.

4.2 Basic Assumptions for Economic Evaluation

The economic evaluation was conducted under the following basic conditions and assumptions.

a) The economic life of the project was assumed to be 50 years since this type of environmental conservation project takes a longer time to deliver a return than that of ordinary infrastructure development projects.
b) The price contingencies, taxes and other kinds of transfer payments were excluded from the estimated financial costs for estimation of the economic costs by applying a conversion factor of 0.9 to the financial cost items.
c) Based on some references to other development studies in Iran, a social discount rate for the economic analysis was applied at 12%.
d) Regarding the "without-project" case as a base for the economic analysis, it is supposed that the environmental conditions in the Anzali wetland and its watershed area would be degraded further by uncontrolled human interventions without adequate environmental management. On the other hand, it is supposed that current environmental conditions would be improved or maintained at least in the "with-project case". By considering the difference in the environmental conditions between the without-project and with-project cases as the economic benefits of the project implementation, the net present value (NPV), benefit-cost ratio (B/C) and economic internal rate of return (EIRR) are calculated for the assessment of the economic viability of the Project based on the projected economic cash flow.

4.3 Values of the Anzali Wetland and Economic Benefit of the Wetland Ecological Management Plan

The Wetland Ecological Management Plan (WEMP) consists of the following five components.

1) Environmental zoning
2) Conservation of wildlife
3) Conservation of habitat
4) Promotion of wise use
5) Monitoring and feedback

The wetland is internationally recognized as among the ecologically most important wetlands in the world, and became a Ramsar site as early as 1975. This fact clearly signifies the ecological importance of the wetland. In addition, the wetland has various other values that are worth examining. Thus, the values of the wetland were examined with respect to (i) economic activities, (ii) environmental services, (iii) option and quasi-option values, (iv) existence value, and (v) environmental and public awareness value, based on a valuation framework recommended by the Ramsar Convention. Table 10.3.1 summarizes some of the

important values of the Anzali Wetland, and how they are affected by the Wetland Ecological Management Plan. Though the analysis is not exhaustive, it is clear that the wetland has substantial values, and the proposed Wetland Ecological Management Plan significantly enhances these values.

Table 4.3.1 Economic Benefits of the Wetland Ecological Management Plan

Economic Benefits of the Wetland and Benefits
1. Economic activities - Fishery in the Anzali Wetland is worth about 10 billion Rials/year, and hunting is about 3 billion Rials/year (see Section 2.3.2 of the Main Report). The WEMP will maintain and possibly increase these values by, e.g., providing better spawning conditions for fishes, providing better management of these activities, and putting additional economic values, e.g., sports fishing as oppose to conventional commercial fishing. - The wetland receives about 40,000 tourists/year, who pay about 3 billion Rials/year. WEMP will increase this by constructing facilities for tourists, and by promoting eco-tourism.
2. Environmental service - The wetland provides important habitats for various species including as many as 200,000 migratory birds (see Section 2.3 of the Main Report). This value is enhanced by WEMP by improving the management of protected areas, and other habitats. - The wetland has a substantial water purification function, which help reduce the pollution of the Caspian Sea including the beach area. The WEMP will help maintain this function, and prevent loss of this function due to encroachment and other development activities. - External ecosystem will be supported for wildlife that utilize the wetland as feeding/ breeding grounds such as migratory birds from other area.
3. Option and quasi-option value - Options on potential future uses will be secured by conserving or improving present natural conditions of the wetland.
4. Existence value - There are a number of threatened species in the wetland (see Section 2.3 of the Main Report). WEMP has programs to protect these species, and thus contribute to maintain these species including their genetic resources. - The wetland has a significant aesthetic value, and this is the main reason that the wetland attracts tourists. The aesthetic value of the wetland will be increased by the WEMP through management of vegetation and control of garbage coming into the wetland. - Future generations can enjoy the natural environment of the wetland because of the conservation. This value is known as the bequest value. - By implementing the WEMP, Iran will be able to lift the Anzali Wetland from the Montraux Record, and fulfill the responsibility of the Ramsar Convention.
5. Environmental education and public awareness - The wetland has significant potentials to provide opportunities for environmental education, public awareness, and scientific research. In the past, these assets have been underutilized. However, the WEMP will make the wetland much accessible to the general public, including children, and a Wetland Education Center has already been constructed as a part of this study.

Source: JICA Study Team

Efforts were made to quantitatively evaluate the values of the wetland and the benefits accrued by the WEMP in monetary terms. This was a difficult task due to the complexity of wetland ecosystem, lack of information, and inherent problems of putting monetary values to intangible values, such as the value of habitats and the bequest value of the wetland. Nonetheless, the present values of the Anzali wetland were roughly estimated by the benefit transfer method using average unit values of ecosystem services valued in similar wetlands

elsewhere in the world. By applying the unit values of the wetland ecological services selected for the Anzali wetland with conversion of the reference price into current Iranian price, the total economic value of the Anzali wetland is estimated at around 223 billion Rials/year (USD 26 million/year). It seems the wetland has a significant value from wastewater treatment, and the recreational and cultural values are also potentially significant.

Table 4.3.2 Estimate of Ecosystem Value of the Anzali Wetland

Item	Annual Value per ha (thousand Rials/ha/year)	Total Value for the Anzali Wetland: 193 km^2 (billion Rials/year)
1. Waste treatment	4,400	84.9
2. Habitat	1,200	23.2
3. Food production	125	13.0*
4. Recreation	1,300	25.1**
5. Cultural	4,500	86.9
Total	11,525	233.1

Note: The ecosystem service items in the table are selected from other kinds of services, considering the present conditions of the Anzali wetland. Explanations on each ecological service are shown below as mentioned in the referenced research paper.
1) Waste treatment- waste treatment, pollution control, detoxification,
2) Habitat- nurseries, habitat for migratory species, regional habitats for locally harvested species, or wintering grounds,
3) Food production- production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing,
4) Recreation- eco-tourism, sport fishing, and other outdoor recreational activities,
5) Cultural- aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.
*- As mentioned in the previous table, present productions of fishery and hunting in the Anzali Wetland are used.
**- As mentioned in the previous table, present income from tourism at around 3 billion Rials/year is smaller than that in this table. However, it is supposed that this value would be increased by promoting tourism in and around the Anzali wetland.
Source: Modified by JICA Study Team referring to "The value of the world's ecosystem services and natural capital", Robert Costanza et al., NATURE, 1997

4.4 Economic Benefit of the Watershed Management Plan

The watershed management plan consists of the following six components.

1) Soil erosion control and prevention of land slides
2) Forest and rangeland management
3) Plain area management
4) Livelihood development
5) Environmental monitoring
6) Institutional arrangement

The proposed watershed management plan (WMP) is anticipated to have primarily positive social and environmental impacts, especially as concerns local people (graziers and forest dwellers). As designed, the project is intended to promote more sustainable management of the watershed, which will result in enhancing the values of the wetland as well as watershed and improving livelihoods of the local people. Main envisaged effects are summarized below.

Table 4.4.1 Economic Benefits of the Watershed Management Plan

Economic Benefits of the Watershed Management
1. Reduction of sediment load from the watershed - A total of 326,000 ton/year of sediment are presently discharged into rivers from the upper watershed. The WMP will reduce the sediment load by about 58,700 ton/year through recovering the degraded rangelands of 77 km^2 and reforesting the degraded forests of 182 km^2. - The WMP will reduce the progress of soil erosion by applying structural erosion control measures to potentially hazardous areas, and thus reduce the sediment load as well as an outbreak of flood/debris flow.
2. Mitigation of damages by floods and debris flow - For the last decade, a total of 12 floods have occurred in the watershed, of which eight cases concentrated in the last five (5) years. These floods caused extensive damage to the downstream areas. The WMP will mitigate the occurrence of floods and debris flows by taking countermeasures against landslides and slope failures and reforest the degraded areas.
3. Restoration and protection of the fabric of the watershed - Owing to its rich natural resources, the watershed is the habitats for many animals, especially birds and fishes. There is a need to restore and protect the natural environment of the watershed. The WMP will contribute to restoration and protection of the fabric of the watershed by conservation of the forests and rangelands.
4. Improvement of livelihood of graziers - Livelihood support to graziers is very limited in the present management system, and therefore, there is a high possibility that living condition of graziers will become worse, even if the graziers can have monetary compensation by the resettlement program. Depression of household economy will make them more resource-dependant and eventually cause the degradation of forests and rangelands. The WMP aims to improve their livelihood by involving them in forest and rangeland management works as contractors and developing the capacity of NRGO local offices to assist graziers in establishing alternative livelihoods. As a result of the WMP, graziers who would participate in forest and rangeland management works will receive 4.4 ~ 7.7 million Rials/year of supplemental annual income until year 2019.
5. Sustainable use of rangeland - The rangeland extends between EL. 1500 m and EL. 2000 m, and the total area of the rangeland is about 280 km^2. By applying unit stocking capacity of 3 units/ha for the sustainable use of the rangeland, the stocking capacity of the whole rangeland is estimated at about 840,000 units, which is equivalent to about 8.4 billion Rials[1].
6. Recharge of water sources in the watershed - An important role of the watershed is to secure the water sources for the wetland as well as irrigated paddy fields in the plain area. It is said that the volume of river flow has decreased recently, though there is no clear data to proof its phenomenon. Reforestation of the degraded forests (182 km^2) will enhance the recharge of water sources in the watershed.
7. Carbon sequestration - A major function of forest to the global environment is the carbon sequestration. Reforestation proposed in the WMP will increase carbon storage in the watershed. Based on the IPPC Guidelines for National Greenhouse Gas Inventories (1997), the total sequestered carbon is estimated at 1 ton C/ha/year. Though it is an indicative figure, there is no doubt that the WMP will contribute to improving a global environmental issue.
8. Increase of timber production - Four (4) sub-watersheds are presently used for timber production, and therefore reforested trees in those sub-watersheds could be harvested in future. The area of about 4,740 ha will be reforested in the four sub-watersheds. In future, approximately 4,830 m^3 of timber can be extracted from the reforested area by applying the present exploitation rate of 1.0 m^3/ha/yr.

Source: JICA Study Team

[1] Total value of livestock is computed by applying the estimated price of livestock (100,000 Rials / Unit) presently used by NRGO.

The WMP will make several types of effects as enumerated above. Like other management plans, many of the effects derived from the WMP are difficult to evaluate quantitatively due to lack of information and their types, while some can be converted into monetary value. In particular, the benefits of "Improvement of biodiversity" and "Improvement of livelihoods" are not evaluated in the section. The others, except for those of carbon sequestration and timber production, are evaluated by using either benefit transfer method or least cost method as summarized below.

a.	Reduction of sediment load:	Least cost method
b.	Mitigation of flood	Benefit transfer method
c.	Improvement of biodiversity:	Not economically evaluated
d.	Improvement of livelihood:	Not economically evaluated
e.	Water recharge:	Benefit transfer method
f.	Carbon sequestration:	Using estimated international value
g.	Timber production:	Using present market prices

The analyses made are summarized in the following table.

Table 4.4.2 Quantitative Evaluation of Economic Benefits of the Watershed Management Plan

Benefits	Outline of Analysis	Economic Benefits
1. Reduction of sediment load	The total cost required for the construction as well as operation of sediment traps to remove the sediment load of 67,900 ton/year are estimated. In the estimation, the same trap rate with the plain area management (1.25 ton/ha = 25,000 ton / 20,000 m^2) is employed and the total area for the sediment traps is estimated at 54,320 m^2.	Construction cost: 1.2 billion Rials Annual operation cost: 0.6 billion Rials/year
2. Carbon sequestration	Various sources place the economic value of sequestered carbon at US$ 5 to 10 per ton, and thus the total value is estimated by multiplying US$ 5 with 18,200 ton C per annum.	Annual benefit: 0.8 billion Rials/year
3. Timber production	As described above, about 4,830 m^3 of timber can be extracted from the reforested area in the future. According to the forestry plan prepared by NRGO, reforested trees are cut at intervals of about 100 years. Though the benefit will emerge 100 years later, the total benefit is computed by applying the estimated market log price of 900,000 Rials/m^3.	Total Benefit: 4.3 billion Rials
4. Mitigation of damages by floods and debris flow	The unit value of flood prevention effect of the forest in Japan was used for evaluation since the conditions of forests in the study area are similar to that of Japan in terms of the following items. - tree species such as Beach and Oak - climate: El. up to 500m with warm temperatures, high moisture and abundant rainfall during the summer with mild climate during the winter; El. 500m to 3,000m with cooler temperatures, drier conditions and less rainfall - soils composed under vegetative and climate conditions similar to Japan above. With conversion of the reference price into current Iranian price, the total economic value of the benefit is estimated at about 4,288,000 Rials/ha/year.	Benefit of the reforestation of 182 km^2: 78 billion Rials/year.
5. Recharge of water sources	Likewise, the unit value of water cultivation (water reserve) of the forest in Japan was use for evaluation. The total economic value is estimated at about 6,729,000 Rials/year by employing the same manner as mentioned above.	Benefit of the reforestation of 182 km^2: 122 billion Rials/year.

Source: Modified by JICA Study Team referring to "Valuation of Public Benefit Function of Forest in Japan, Forest Agency of Japan, 2000"

4.5 Economic Benefit of the Wastewater Management Plan

The proposed Wastewater Management Plan (WMP) consists of the following six components.

1) Management of domestic wastewater in urban areas
2) Management of domestic wastewater in rural areas
3) Management of industrial effluent
4) Management of livestock waste

5) Management of pollution from farmland
6) Environmental monitoring

Table 4.5.1 summarizes the anticipated benefits of the WMP with respect to (i) improvement of the environmental conditions, (ii) improvement of public health, (iii) improvement of living environment, (iv) improvement of service efficiency, and (v) other.

Table 4.5.1 Economic Benefits of the Wastewater Management Plan

Economic Benefits of the Wastewater Management
1) Improvement of environmental conditions - If the WMP were not implemented, it is estimated that 87,151 ton/year of COD pollution load and 1,120 ton/year of T-P pollution load would be discharged into Anzali Wetland in 2019. The WMP is expected to reduce about 30 % of pollution load into Anzali Wetland. - These reductions of pollution loads to the wetland will result in significant improvement of the wetland ecosystem, such as reduction of eutrophication and improvement of fish habitats in the wetland. - The WMP will also contribute to control water pollution in the rivers and the Caspian Sea. - The WMP will reduce the environmental risks by toxic agrochemicals and heavy metals on the wetland, rivers and the sea.
2) Improvement of public health - Untreated wastewater discharge causes water bone diseases. Common waterborne diseases in the Study Area are diarrhea and conjunctivitis. It is recorded in 2001, that the number of patients of these diseases as below. Diarrhea Conjunctivitis Total Rasht 1,471 260 1,858 Anzali 260 733 1,133 The WMP will significantly reduce these waterborne disease, and contribute to reducing related medical expenses and lost earnings due to illness. - The WMP will also contribute to improving the public health conditions in the wetland as well as the coastal beaches.
3) Improvement of Living Environment - The rivers in the downstream of urban areas have odor and aesthetic problems. The WMP will reduce these problems. - The reduction of pollution also improve the living environment in the wetland and also the coastal areas. This will enhance the values of the wetland and the beaches as tourism resources. - The WMP will promote centralization of the factories, and thus reduce problems of living environment caused by existence of factories in residential or agricultural areas.
4) Improvement of service efficiency - Currently the entire urban population (763,000 residents) are without proper wastewater treatment. However, if the WMP were implemented, about 70% of the urban population, or 818,000 out of 1,200,000 residents in the urban area will receive adequate wastewater treatment service in 2019. - Installation of the sewerage system is more efficiency than installation of the individual waste water treatment system in terms of cost and necessary resources such as materials.
5) Others - The value of the land is expected to increase, in general, if the sewerage system is improved. Current value of land in the urban area is about 1.5 million Rials/m2, and proposed sewerage service area is about 10,000 ha. In case of 5 % increase of the land values, 75,000 million Rials of the value will be generated by the sewerage system development in Rasht.

Source: JICA Study Team

As is evident from this table, the SWP is expected to bring significant improvement in environmental conditions of the rivers, the wetland, and the coastal area of the Caspian Sea, as well as the improvement of the public health and improvement of the living environment in the area.

The main components of the SWP are the development of sewerage systems in Rasht and Anzali, and the Iranian Government has already committed to construction of these facilities. The economic viability of the sewerage system development projects for Rasht and Anzali townships are shown in the feasibility studies for both townships. Moreover, reduction of pollution in the coastal area is the responsibility of member countries of the Caspian Environment Program. In addition, the proposed Wastewater Management Plan itself was examined at the minimum cost approach comparing with a case of installation of individual sewage treatment systems as a conceivable alternative.

4.6 Economic Benefit of the Solid Waste Management Plan

The Solid Waste Management Plan (SWMP) consists of the following three components.

1) Municipal solid waste management,
2) Industrial and medical solid waste management
3) Environmental monitoring

The economic benefits of the SWMP were evaluated with respect to (i) improvement of environmental conditions, (ii) improvement of living environment, (iii) improvement of public health, (iv) improvement of efficiency of material uses, and (v) other benefits (see JICA, 2003)[2]. Table 4.6.1 summarizes the benefits of the SWMP.

[2] JICA, Study on Methods of Economic Evaluations of Development Study, Solid Waste Management, 2004

Table 4.6.1 Economic Benefits of the Solid Waste Management Plan

Economic Benefits of the Solid Waste Management
1. Improvement of Environmental Conditions - Due to insufficient waste collection and lack of environmental awareness, roughly 66 tons/day of solid waste is dumped into rivers polluting the water bodies. By expanding the collection to rural areas and by providing programs for environmental awareness raising, the SWMP will significantly reduce illegal dumping into rivers, and prevent pollution of rivers. - The reduction of illegal dumping of wastes into river will also reduce the risks of accidental ingestion of waste by birds and fishes in the wetland. - None of the solid waste dumping sites in the area has leachate control facility. By constructing 2 sanitary landfills with adequate leachate control, the SWMP will eliminate the problem of groundwater pollution by leachate. - The SWMP constructs a hazardous waste solidification facility, and thus reduces the risk of environmental pollution by toxic substances, especially heavy metals from plating industries in the area.
2. Improvement of Living Environment - There are numerous illegal dumping sites in the study area, which are the major sources of bad odors and aesthetic problems. The SWMP will provide efficient solid waste collection services even in rural areas, and thus significantly reduce these problems.
3. Public health improvement - The illegal dumping sites are the sources of pests, such as rats. The SWMP will eliminate these illegal dumping sites, and thus contribute to improvement of public health conditions. - The infectious wastes generated from the hospitals will be properly incinerated eliminating the people's risk of contracting infectious diseases from medical waste.
4. Improvement of efficiencies of material uses - The SWMP promotes recycling of organic wastes and other recyclables (e.g., papers, bottles, etc.). These will help improve the efficiencies of materials use, and also reduces the landfill cost by reducing the amount of waste to be landfilled. - The SWMP promotes recycling of materials in factories. By streamlining material flows in production processes, the factories will be able to reduce material losses, recycle raw materials, and save energy consumption.
5. Other - The reduction of waste thrown into rivers (66 tons/day) will reduces the amount of waste in the wetland, improve the aesthetic aspect of the wetland, and increase the sightseeing value of the wetland.

Source: JICA Study Team

As identified above, the SWMP is expected to bring various economic benefits, though many of them are intangible and difficult to be evaluated quantitatively. Moreover, solid waste management is an essential public service, and under the new solid waste management law, provision of the service became mandatory in the entire study area. Thus, the economic viability of the domestic waste management was evaluated using the least cost approach, i.e., whether the proposed measure provides the service at the minimum cost. The analysis was done by using a simulation model, in which, cost implications of various alternatives such as collection frequencies, collection points, recycling/composting, number and locations of final disposal sites, were compared. The existing policies and plans, such as the use, locations and capacities of composting plants in Rash and Anzali, were also taken into consideration. Based on the results, the least cost option was selected (see the Supporting Report, Solid Waste Management). Similarly, the plans for industrial and medical waste management can be

implemented with minimal investment. Thus, it was concluded that the proposed SWMP itself is economically justifiable.

4.7 Economic Benefit of Environmental Education and Institutional Plans

Environmental education, public awareness activities, and institutional arrangements are indispensable to implement all the proposed management plans mentioned above. Therefore, economic benefits accrued by the Environmental Education and Institutional Plans are considered to be included in the economic benefits of the other management plans.

4.8 Economic Evaluation of the Master Plan

By combining the economic benefit items of the wetland values on its various functions, forest values on its various functions, and estimated benefits accrued from the sewerage system development projects, which were valued in the monetary values in the above, the net present value (NPV), benefit-cost ratio (B/C) and economic internal rate of return (EIRR) are calculated for the assessment of the economic viability of the M/P based on the projected economic cash flow with all economic costs for the M/P.

4.8.1 Methodology of Benefit Valuation

The following benefits were used in the economic evaluation below.

1) Wetland values on its various functions

Assuming that the wetland values mentioned above will decrease at certain level in the without-project case and will be improved or at least maintained in the with-project case, difference of the wetland values between with-project and without-project cases are considered as economic benefits for with-project case. Economic benefits of the wetland functions for the M/P period are shown in Table 4.8.1.

2) Forest and rangeland values on its various functions

Assuming that the forest values mentioned above will be gradually appeared through the reforestation as with-project case while there is no benefit in the without-project case, difference of the forest values between with-project and without-project cases are considered as economic benefits for with-project case. Likewise, value of rangeland through the proposed rangeland management are considered by applying unit benefit of the forest on prevention of sediment loss and prevention of slope. Economic benefits of the forest functions for the M/P period are shown in Table 4.8.2.

3) Benefits accrued from the sewage system development

Based on the results of economic evaluations in the F/S for Rasht and Anzali Sewage Development Projects, economic benefits of alternative option, decrease of health expenses, and agricultural revenue are applied. Regarding the sewerage system development project in Somehsara and community wastewater treatment system in rural areas, average unit benefit from the above projects are applied by multiplying the service population. Economic benefits of the sewerage development projects for the M/P period are shown in Table 4.8.3.

4.8.2 Economic Cost of the Projects

As mentioned above, conversion factor at 0.9 is applied to convert from financial prices to economic prices of the M/P.

4.8.3 Cost-Benefit Analysis

The net present value (NPV), benefit-cost ratio (B/C) and economic internal rate of return (EIRR) are calculated for assessment of the economic viability of the M/P based on the projected economic cash flow as shown in Table 4.8.4. The results of the calculation are summarized below. The NPV is estimated at about 216 billion Rials worth. The B/C at 1.1exceeds 1.0. The EIRR is estimated at about 13%, which exceed the social discount rate at 12% as generally-applied criteria in Iran and other countries. All economic values show economic viability of the M/P.

Table 4.8.1 Results of the Economic Evaluation

Economic Criteria	Results
NPV	216.4 billion Rials
B/C	1.10
EIRR	13.1 %

Table 4.8.2 Economic Benefit of the Wetland Functions

(Unit: million Rials)

Year		Waste Treatment (mil. Rials/year)	Habitat (mil. Rials/year)	Food production (mil. Rials/year)	Recreation (mil. Rials/year)	Cultural (mil. Rials/year)	Total (mil. Rials/year)
		(Incremental Rate fo the Value)					
		(5%)	(5%)	(5%)	(10%)	(5%)	
1	2005	85,692	23,160	13,000	3,000	86,850	211,702
2	2006	89,977	24,318	13,650	3,300	91,193	222,437
3	2007	94,475	25,534	14,333	3,630	95,752	233,724
4	2008	99,199	26,811	15,049	3,993	100,540	245,592
5	2009	104,159	28,151	15,802	4,392	105,567	258,071
6	2010	109,367	29,559	16,592	4,832	110,845	271,194
7	2011	114,835	31,037	17,421	5,315	116,387	284,995
8	2012	120,577	32,588	18,292	5,846	122,207	299,511
9	2013	126,606	34,218	19,207	6,431	128,317	314,779
10	2014	132,936	35,929	20,167	7,074	134,733	330,839
11	2015	139,583	37,725	21,176	7,781	141,469	347,735
12	2016	146,562	39,611	22,234	8,559	148,543	365,511
13	2017	153,891	41,592	23,346	9,415	155,970	384,214
14	2018	161,585	43,672	24,513	10,357	163,769	403,896
15	2019	169,664	45,855	25,739	11,392	171,957	424,608
16	2020	178,148	48,148	27,026	12,532	180,555	446,408
17	2021	187,055	50,555	28,377	13,785	189,583	469,355
18	2022	196,408	53,083	29,796	15,163	199,062	493,512
19	2023	206,228	55,737	31,286	16,680	209,015	518,946
20	2024	216,539	58,524	32,850	18,348	219,466	545,727
21	2025	227,366	61,450	34,493	20,182	230,439	573,931
22	2026	238,735	64,523	36,218	22,201	241,961	603,637
23	2027	250,671	67,749	38,028	24,421	254,059	634,929
24	2028	263,205	71,136	39,930	26,863	266,762	667,896
25	2029	276,365	74,693	41,926	29,549	280,100	702,634
26	2030	290,184	78,428	44,023	32,504	294,105	739,243
27	2031	304,693	82,349	46,224	35,755	308,810	777,831
28	2032	319,927	86,467	48,535	39,330	324,251	818,510
29	2033	335,924	90,790	50,962	43,263	340,463	861,402
30	2034	352,720	95,330	53,510	47,589	357,486	906,635
31	2035	370,356	100,096	56,185	52,348	375,361	954,346
32	2036	388,874	105,101	58,995	57,583	394,129	1,004,681
33	2037	408,317	110,356	61,944	63,341	413,835	1,057,794
34	2038	428,733	115,874	65,041	69,675	434,527	1,113,851
35	2039	450,170	121,668	68,294	76,643	456,253	1,173,027
36	2040	472,678	127,751	71,708	84,307	479,066	1,235,511
37	2041	496,312	134,138	75,294	92,738	503,019	1,301,502
38	2042	521,128	140,845	79,058	102,012	528,170	1,371,214
39	2043	547,184	147,888	83,011	112,213	554,579	1,444,875
40	2044	574,544	155,282	87,162	123,434	582,308	1,522,729
41	2045	603,271	163,046	91,520	135,778	611,423	1,605,037
42	2046	633,434	171,198	96,096	149,356	641,994	1,692,078
43	2047	665,106	179,758	100,901	164,291	674,094	1,784,150
44	2048	698,361	188,746	105,946	180,720	707,799	1,881,572
45	2049	733,279	198,184	111,243	198,792	743,189	1,984,687
46	2050	769,943	208,093	116,805	218,671	780,348	2,093,861
47	2051	808,440	218,497	122,645	240,539	819,365	2,209,487
48	2052	848,862	229,422	128,778	264,592	860,334	2,331,988
49	2053	891,306	240,893	135,217	291,052	903,350	2,461,817
50	2054	935,871	252,938	141,977	320,157	948,518	2,599,461

Table 4.8.3 Economic Benefit of the Forecast and Rangeland Functions

(Unit: million Rials)

		Benefit of the Reforestation								Benefit of the Rangeland			
Year		Planting schedule (ha)	Water reserve	Flood prevention	Water quality conservation	Erosion prevention	Soil erosion prevention	Carbon sequestration	Total Benefit	Planting schedule (ha)	Erosion prevention	Soil erosion prevention	Total Benefit
1	2005	500	16	10	24	52	16	1	119		0	0	0
2	2006	1,430	79	50	115	255	76	4	579	561.3	1,471	439	1,910
3	2007	1,750	198	126	290	640	191	11	1,457	642.6	3,154	941	4,096
4	2008	1,840	377	240	553	1,219	364	21	2,773	1,542.3	7,195	2,148	9,343
5	2009	1,960	619	394	908	2,003	598	34	4,557	1,875.8	12,110	3,614	15,724
6	2010	2,010	927	590	1,359	2,997	895	51	6,819	1,363.7	15,683	4,681	20,363
7	2011	3,100	1,335	850	1,957	4,317	1,288	74	9,821	1,282.4	19,042	5,684	24,726
8	2012	2,700	1,830	1,166	2,684	5,919	1,767	102	13,467	382.7	20,045	5,983	26,028
9	2013	2,010	2,390	1,523	3,506	7,732	2,308	133	17,592	49.2	20,174	6,021	26,195
10	2014	900	2,980	1,898	4,371	9,640	2,877	169	21,935	7,700.0	20,174	6,021	26,195
11	2015		3,570	2,274	5,236	11,547	3,446	205	26,278		20,174	6,021	26,195
12	2016		4,160	2,650	6,101	13,454	4,016	241	30,621		20,174	6,021	26,195
13	2017		4,749	3,025	6,965	15,362	4,585	277	34,963		20,174	6,021	26,195
14	2018		5,339	3,401	7,830	17,269	5,154	313	39,306		20,174	6,021	26,195
15	2019		5,929	3,777	8,695	19,176	5,724	349	43,649		20,174	6,021	26,195
16	2020		6,518	4,152	9,560	21,084	6,293	385	47,992		20,174	6,021	26,195
17	2021		7,108	4,528	10,425	22,991	6,862	421	52,335		20,174	6,021	26,195
18	2022		7,698	4,904	11,290	24,898	7,432	457	56,678		20,174	6,021	26,195
19	2023		8,287	5,279	12,155	26,806	8,001	493	61,021		20,174	6,021	26,195
20	2024		8,877	5,655	13,020	28,713	8,570	529	65,363		20,174	6,021	26,195
21	2025		9,467	6,031	13,884	30,620	9,139	565	69,706		20,174	6,021	26,195
22	2026		10,056	6,406	14,749	32,528	9,709	601	74,049		20,174	6,021	26,195
23	2027		10,646	6,782	15,614	34,435	10,278	637	78,392		20,174	6,021	26,195
24	2028		11,236	7,158	16,479	36,343	10,847	673	82,735		20,174	6,021	26,195
25	2029		11,825	7,533	17,344	38,250	11,417	709	87,078		20,174	6,021	26,195
26	2030		12,399	7,899	18,185	40,105	11,970	744	91,301		20,174	6,021	26,195
27	2031		12,926	8,234	18,958	41,810	12,479	776	95,184		20,174	6,021	26,195
28	2032		13,396	8,534	19,648	43,332	12,933	806	98,649		20,174	6,021	26,195
29	2033		13,807	8,796	20,251	44,661	13,330	832	101,676		20,174	6,021	26,195
30	2034		14,155	9,017	20,760	45,784	13,665	854	104,235		20,174	6,021	26,195
31	2035		14,437	9,197	21,174	46,697	13,938	873	106,315		20,174	6,021	26,195
32	2036		14,619	9,313	21,441	47,285	14,113	887	107,656		20,174	6,021	26,195
33	2037		14,713	9,373	21,579	47,590	14,204	895	108,353		20,174	6,021	26,195
34	2038		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
35	2039		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
36	2040		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
37	2041		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
38	2042		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
39	2043		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
40	2044		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
41	2045		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
42	2046		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
43	2047		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
44	2048		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
45	2049		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
46	2050		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
47	2051		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
48	2052		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
49	2053		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195
50	2054		14,742	9,391	21,622	47,684	14,232	819	108,490		20,174	6,021	26,195

Note: "Valuation of Public Benefit Function of Forest in Japan, Forest Agency of Japan, 2000" was referred for unit benefits of the forest functions.

Table 4.8.4 Economic Benefit of the Sewerage Development Projects

(Unit: million Rials)

Year		Rasht				Anzali				Somehsara		Rural		Grand Total
		Alternative Option	Decrease of Health Expenses	Agricultural Revenue	Total	Alternative Option	Decrease of Health Expenses	Agricultural Revenue	Total	Service Population	Benefit	Service Population	Benefit	
1	2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2006	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2007	160,107	2,975	4,774	167,855	17,843	2,727	613	21,183	0	0	650	153	189,192
4	2008	85,008	3,058	6,209	94,275	28,684	2,803	1,496	32,983	0	0	1,950	459	127,718
5	2009	39,663	3,143	7,587	50,393	16,300	2,882	1,929	21,111	0	0	3,850	907	72,411
6	2010	35,610	3,232	9,156	47,998	9,462	2,962	2,393	14,817	11,396	2,684	6,510	1,533	67,032
7	2011	35,610	3,232	9,156	47,998	9,462	2,962	2,393	14,817	22,792	5,367	9,930	2,338	70,521
8	2012	43,790	3,322	11,070	58,181	9,794	3,045	2,886	15,726	34,188	8,051	14,110	3,323	85,281
9	2013	43,790	3,322	11,070	58,181	9,794	3,045	2,886	15,726	45,584	10,735	19,050	4,486	89,128
10	2014	46,137	3,414	13,399	62,950	10,122	3,131	3,410	16,663	56,980	13,419	22,850	5,381	98,413
11	2015	46,137	3,414	13,399	62,950	10,122	3,131	3,410	16,663	56,980	4,966	27,410	6,455	91,034
12	2016	60,962	3,511	16,189	80,662	10,455	3,218	3,965	17,638	56,980	4,966	32,730	7,708	110,974
13	2017	60,962	3,511	16,189	80,662	10,455	3,218	3,965	17,638	56,980	4,966	38,810	9,140	112,406
14	2018	78,077	3,609	19,420	101,105	10,782	3,308	4,547	18,638	56,980	4,966	45,650	10,750	135,460
15	2019	78,077	3,609	19,420	101,105	10,782	3,308	4,547	18,638	56,980	4,966	51,350	12,093	136,802
16	2020	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
17	2021	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
18	2022	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
19	2023	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
20	2024	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
21	2025	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
22	2026	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
23	2027	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
24	2028	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
25	2029	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
26	2030	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
27	2031	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
28	2032	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
29	2033	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
30	2034	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
31	2035	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
32	2036	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
33	2037	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
34	2038	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
35	2039	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
36	2040	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
37	2041	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
38	2042	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
39	2043	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
40	2044	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
41	2045	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
42	2046	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
43	2047	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
44	2048	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
45	2049	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
46	2050	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
47	2051	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
48	2052	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
49	2053	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463
50	2054	26,652	3,609	19,420	49,680	4,485	3,308	4,547	12,340	56,980	4,966	51,350	4,476	71,463

Source: The Feasibility Studies for the Rasht and Anzali Sewerage Development Projects are referred for the above calculations.

Table 4.8.5 Economic Cash Flow and Cost-Benefit Analysis

(Unit: million Rials at constant price of June 2004)

Year		Economic Cost	Economic Benefit				Net Benefit
		Total Cost of M/P	Various functions of Wetland	Various functions of Forest and Rangeland	Benefits from Sewerage	Total	
		(a)	(b)	(c)	(d)	(e)=(b)+(c)+(d)	(f)=(e)-(a)
1	2005	251,625	10,585	119	0	0	-240,920
2	2006	313,387	21,688	2,489	0	0	-289,211
3	2007	365,174	33,335	5,552	189,192	189,192	-137,095
4	2008	428,530	45,556	12,116	127,718	127,718	-243,141
5	2009	438,295	58,381	20,281	72,411	72,411	-287,223
6	2010	235,607	71,842	27,183	67,032	67,032	-69,550
7	2011	209,850	85,972	34,547	70,521	70,521	-18,808
8	2012	272,197	100,809	39,495	85,281	85,281	-46,611
9	2013	277,376	116,390	43,788	89,128	89,128	-28,070
10	2014	272,747	132,754	48,130	98,413	98,413	6,549
11	2015	167,166	149,943	52,473	91,034	91,034	126,285
12	2016	153,712	168,003	56,816	110,974	110,974	182,081
13	2017	152,148	186,981	61,159	112,406	112,406	208,397
14	2018	123,452	206,926	65,502	135,460	135,460	284,435
15	2019	122,794	227,891	69,845	136,802	136,802	311,744
16	2020	88,977	249,932	74,187	71,463	71,463	306,605
17	2021	88,977	273,108	78,530	71,463	71,463	334,124
18	2022	88,977	297,482	82,873	71,463	71,463	362,841
19	2023	88,977	323,120	87,216	71,463	71,463	392,822
20	2024	88,977	350,092	91,559	71,463	71,463	424,136
21	2025	88,977	378,472	95,902	71,463	71,463	456,860
22	2026	88,977	408,340	100,245	71,463	71,463	491,070
23	2027	88,977	439,779	104,587	71,463	71,463	526,852
24	2028	88,977	472,878	108,930	71,463	71,463	564,294
25	2029	88,977	507,731	113,273	71,463	71,463	603,490
26	2030	88,977	544,438	117,497	71,463	71,463	644,420
27	2031	88,977	583,105	121,379	71,463	71,463	686,970
28	2032	88,977	623,846	124,845	71,463	71,463	731,177
29	2033	88,977	666,780	127,871	71,463	71,463	777,138
30	2034	88,977	712,036	130,431	71,463	71,463	824,953
31	2035	88,977	759,749	132,511	71,463	71,463	874,745
32	2036	88,977	810,063	133,852	71,463	71,463	926,400
33	2037	88,977	863,133	134,549	71,463	71,463	980,167
34	2038	88,977	919,122	134,686	71,463	71,463	1,036,294
35	2039	88,977	978,207	134,686	71,463	71,463	1,095,378
36	2040	88,977	1,040,573	134,686	71,463	71,463	1,157,744
37	2041	88,977	1,106,419	134,686	71,463	71,463	1,223,591
38	2042	88,977	1,175,959	134,686	71,463	71,463	1,293,130
39	2043	88,977	1,249,418	134,686	71,463	71,463	1,366,590
40	2044	88,977	1,327,040	134,686	71,463	71,463	1,444,212
41	2045	88,977	1,409,084	134,686	71,463	71,463	1,526,255
42	2046	88,977	1,495,827	134,686	71,463	71,463	1,612,999
43	2047	88,977	1,587,567	134,686	71,463	71,463	1,704,738
44	2048	88,977	1,684,620	134,686	71,463	71,463	1,801,792
45	2049	88,977	1,787,329	134,686	71,463	71,463	1,904,500
46	2050	88,977	1,896,057	134,686	71,463	71,463	2,013,229
47	2051	88,977	2,011,197	134,686	71,463	71,463	2,128,369
48	2052	88,977	2,133,169	134,686	71,463	71,463	2,250,340
49	2053	88,977	2,262,423	134,686	71,463	71,463	2,379,595
50	2054	88,977	2,399,445	134,686	71,463	71,463	2,516,617

Note: CF=0.9, Social discount rate=12%

NPV =	216,365
B/C =	1.10
IRR =	13.1%

4.9 Economic Evaluation by Contingent Valuation Method

As another approach to economic evaluation of the master plan, a questionnaire survey targeting 1,750 residents was conducted in September 2004 in order to assess their willingness-to-pay (WTP) for the conservation of the Anzali Wetland and its watershed[3]. In this survey, the respondents were asked whether they were willing to pay the indicated amount of money for environmental causes. About 1,000 questionnaires were returned (60% collection rate). The results are summarized as below.

Table 4.9.1 Willingness-to-Pay of Residents for Environmental Improvement

Indicated Amount (Rials/month/household)	Respondents prepared to pay the indicated amount for environmental improvement (% of respondents)
20,000	42.3%
40,000	36.1%
80,000	33.4%
120,000	27.0%
200,000	22.5%

Source: JICA Study Team

The level of WTP amount to make the proposed master plan economically feasible was estimated at 85,000 Rials/month/household. The average WTP was 58,000 Rials/month/household, and is not sufficient to cover the total cost of the master plan. However, according to the result, about 30% of the residents agreed to pay more than 85,000 Rials/month/household and also 22.5% agreed to pay more than 200,000 Rials/month/household. In addition, more than 90% of the residents answered positively toward conservation of the Anzali wetland and its watershed. Thus, it was concluded that the proposed master plan is likely to become viable with environmental awareness raising.

[3] Results of the questionnaire survey are shown in Appendix-1.

CHAPTER 5 FINANCIAL EVALUATION

5.1 General Principles

In this section, the financial viability of the proposed master plan is evaluated. As reviewed in the economic evaluation, the main benefits of the proposed measures are conservation of the environmental conditions of the wetland and its watershed, and improvement of related environmental and public services, such as erosion control, water quality control, wastewater treatment, and solid waste management, etc. Provision of these benefits and services generally falls under the responsibilities of the government, and because many of the proposed measures do not have any revenues, these measures have to be financed publicly, by injecting the governmental budgets. There are two important issues in financing public projects, and the financial evaluation in this study focuses on these issues:

1) Scale of the Proposed Measures

The first issue is whether the scales of the proposed measures are reasonable compared to the relevant governmental budgets and the affordability of local residents.

2) Financial Responsibility and Equity

The second issue is the allocation of financial responsibilities. Provision of basic and uniform public services is an important policy goal. However, if the benefits and the services of the proposed measures are not received uniformly among those who share the costs, there is a problem of equity. Thus, the potentials of introducing other financial mechanisms, in particular charges collected from polluters and users of environmental services were examined under the Polluter-Pays-Principle and User-Pays-Principle.

Because most measures depend strongly on public financing, and because the fiscal policies in Iran is quite precarious, detailed cash flow analyses of revenues and costs were beyond the scope of this study.

5.2 Financial Sources

There are 6 types of financial sources for implementation of the master plan as shown in the Table 5.2.1.

Table 5.2.1 Financial Sources for Implementation of the Master Plan

Financial Source	Typical Use
1. Provincial General Budget	Salary, daily operation costs, other recurrent costs, and investment cost that the provincial government deemed necessary
2. Provincial Development Budget	Medium/small-scale projects to be implemented by executing agencies
3. National Project	Large development projects
4. Purpose Tax	Part of project and O&M cost for specific projects/activities
5. User Charges	Operation costs
6. Others	International grants and loans, domestic loans

The main sources for funding are a general provincial budget and a national project budget. In principle, the provincial general budget is used for salaries, daily activities and investment projects that the provincial government deemed necessary. The national project budget is used for large investment projects. Apparently, the provincial budgets in the recent years are barely enough to cover salaries, and not sufficient for daily activities and large development projects. As a result, many government organizations orient their programs toward receiving budgets for short-lived national projects rather than daily activities.

From the fourth 5-year plan starting in 2005, however, it seems the central government is going to increase the proportion of the national grant component in a provincial general budget. This could increase the financial autonomy of the local government, and make it possible to finance more activities from the provincial government, enabling more stable funding for daily activities. At any rate, it is still premature to judge exactly how these financial sources are utilized from 2005. Thus, the relevant organizations are urged to reanalyze the financial plan as soon as the fourth 5-year plan and related fiscal policies become available.

5.3 Basic Conditions for Financial Evaluation

The financial evaluation was conducted under the following basic conditions.

a) All costs in the master plan, i.e., the project (investment) costs and O&M costs during the entire master plan period between 2005 and 2019 are estimated based on June 2004 constant prices in Iranian Rials (IRR). The exchange rates of USD 1 = IRR 8,652 and JPY 100 = IRR 7,955 as of 30 June 2004 are applied. The value added tax (VAT) for all cost components and import tariffs for imported equipment are included in the cost estimation.
b) Based on the average household incomes in the study area, average disposable incomes of the household in urban and rural areas are 20,275 thousand Rials/year and 15,797 thousand Rials/year, respectively.

5.4 Financial Evaluation of the Proposed Management Plans

5.4.1 Overall Evaluation

The estimated GRDP in Guilan province and total costs of the M/P during the M/P period are compared as shown below. It is said that costs of the public utilities in the developing countries occupy the GRDP at between 3% and 5% approximately in general. Under this, the total costs of the M/P will be affordable from viewpoint of the regional economic scale since the percentage of the GRDP range between 0.2% and 1.3% on the annual cost for the M/P.

Table 5.4.1 Comparison between GRDP and Total Cost of the M/P

(Unit: billion Rials, June 2004 constant price)

Year	Estimated GRDP	Total Cost of M/P*	% of GRDP
2005	35,793	355	1.0%
2006	37,582	361	1.0%
2007	39,462	492	1.2%
2008	41,435	537	1.3%
2009	43,506	524	1.2%
2010	45,682	262	0.6%
2011	47,966	233	0.5%
2012	50,364	302	0.6%
2013	52,882	308	0.6%
2014	55,526	303	0.5%
2015	58,303	186	0.3%
2016	61,218	171	0.3%
2017	64,279	169	0.3%
2018	67,493	137	0.2%
2019	70,867	136	0.2%

Note: Total cost of the M/P consists of the total project costs and O&M costs.

In terms of affordability of the governmental budget, the national project budget will become the main financial source for the initial investment cost, at least for now. Unfortunately, practically no information is available on the national project budgets of the relevant organizations, and detailed financial assessment of the national project budget was not possible. However, it was noted that the average investment cost of the proposed master plan (224 billion Rials/year) is about 0.05% of the national budget to be used by executive bodies for the annual programs and development projects, 436,022 billion Rials in 2003. In short, there is a large pool of the national project budget, and the budget is theoretically available for the implementation of the master plan, i.e., the availability of the national project budget is not the main issue.

The main issue is how the national government values the conservation of this internationally important wetland and its watershed, which over 90% of the residents believe important (see Appendix-1). See Section 5.6 about how the master plan could be promoted both at the national and the local level.

While the master plan can be initiated by injecting the national investment, the sustainability of the measures is dependent on the flow of the O&M budgets. Since most of the O&M cost consists of personnel cost, the required O&M costs were compared with the total provincial budget consisting of current and development budgets as shown below.

Table 5.4.2 Annual O&M Costs for the master Plan and Provincial Budgets Plan for Relevant Agencies

(Unit: million Rials/year)

Main Executing Bodies	Annual Provincial Budget Allocated*	Annual O&M Costs for M/P	% of the Budget
1. MOJA	92,979	330 ~ 2,100	0.4% ~ 2.3%
2. DOE	9,923	2,600 ~ 4,100	26.2% ~41.3%
3. NRGO	33,622	0 ~ 2,790	0.0% ~ 8.3%
4. GWWC	20,071	5,600 ~ 39,000	27.9% ~ 194.3%
5. RWWC	96,843	180 ~ 1,300	0.2% ~ 1.3%
6. Ministry of Education	1,041,599	219 ~ 840	0.0% ~ 0.0%
7. Local governments	32,873	25,500 ~ 41,000	77.6% ~ 124.7%

Source: *- The budget is total of the current and development expenditure in 2002, Statistical Yearbook of Guilan 2003

The O&M costs to be prepared by the MOJA, NRGO, RWWC, and Ministry of Education are relatively small, and the costs may be covered by rearranging the present provincial budget or by a slight increase in the present budget. On the other hand, the required O&M cost of the DOE is relative large compared with the present DOE's budget level. This is because various new tasks, such as development of eco-tourism, are included in the wetland ecological management plan. Thus, the provincial budget allocation to the DOE may have to be increased. In addition, the O&M costs for GWWC and local government exceed the present levels of the provincial budgets for these organizations. This is because the sewage and solid waste management services have to be strengthened over the next 15 years. A large part of the O&M costs for these services can be collected from the users. In order to evaluate the capacities of the local residents to absorb increased service charges, an affordability analysis based on disposal income of local residents was carried out. The results showed that the required service costs are well within the affordability of the local residents.

Based on these analyses of overall investment costs and O&M costs, it was concluded that the proposed master plan is financially viable, though rearrangement of provincial budgets and the financial support of the central government for large investment projects will be essential. With this general assessment, the financial evaluation of each component plan is presented below.

5.4.2 Financial Evaluation of the Wetland Ecological Management Plan

Necessary costs for the Wastewater Management Plan are shown below. The land acquisition under the Zoning and Ecological Management and establishment of relevant facilities for eco-tourism under the Promotion of Wise Use are a large percentage of the total project cost at about 58% and 30%, respectively.

Table 5.4.3 Necessary Cost for the Wetland Ecological Management Plan

(Unit: billion Rials, June 2004 constant price)

Components	Project Cost	Total O&M Cost
1. Environmental Zoning	18,175	732
2. Conservation of Wildlife	2,251	682
3. Conservation of Habitat	1,186	3,664
4. Promotion of Wise Use	9,199	3,822
5. Monitoring and Feedback	-	6,356
Total	30,811	15,256
Average Annual	2,054	1,017

As mentioned in Chapter 9 of the Main Report, it would be expected that various existing sources of income would be transferred to the Conservancy to implement the Wetland Ecological Management Plan, thus making it self-sufficient. Some or all of: the existing boat licensing fees (PSO), the DOE hunting and fishing license fees (325 million Rials/year and 125 million Rials/year respectively), and DOE 'abandan' rental fees (225 million Rials/year) could be directed to the conservancy. A local tourism tax could also be possible.

In addition, the Executive Bylaw of 1989 requires 0.1% of the gross sales income of all factories to be assigned to environmental conservation works. Each of these works has to be approved by the provincial DOE. The total annual expenditure of factories in Rasht and Anzali on such environmental works must be a very considerable sum (not yet determined, but estimated at USD 250,000). A part of this budget may be used to cover the cost for the relevant projects. The cost for the daily environmental monitoring would be covered by the provincial budget as regular work.

The project costs for proposed activities which start in the initial stage of the M/P should be covered by the national budget such as land acquisition cost for the environmental zoning and installation of facilities for the promotion of eco-tourism since these costs are newly required and high in addition to the regular budget for the relevant agencies such as DOE.

5.4.3 Financial Evaluation of the Watershed Management Plan

The necessary costs of the Watershed Management Plan are shown below.

Table 5.4.4 Necessary Cost for the Watershed Management Plan

(Unit: billion Rials, June 2004 constant price)

Components	Project Cost	Total O&M Cost
1. Soil Erosion Control	264,965	14,164
2. Forest and Rangeland Management	182,877	23,377
3. Plain Area Management	711	2,163
4. Livelihood Development	3,477	-
5. Environmental Monitoring	-	3,627
6. Institutional Arrangement	1,533	-
7. Livestock Resettlement Program	273,221	-
Total	726,785	43,331
Average Annual	48,452	2,889

The required budget for soil erosion control, forest management, plain area management and capacity development are much larger than current budget allocated to the relevant agencies such as MOJA and NRGO. Therefore, the project costs should be funded by national budget under the decree on northern forest conservation. The O&M costs for the soil erosion control and forest management should be budgeted under the provincial budget as regular work. However, these costs are also additional to the present budget. Thus, support from the central government may be necessary in the beginning. The cost for the environmental monitoring should be covered by the provincial budget as regular work.

5.4.4 Financial Evaluation of the Wastewater Management Plan

The necessary costs for the Wastewater Management Plan are shown below.

Table 5.4.5 Necessary Cost for the Wastewater Management Plan

(Unit: billion Rials, June 2004 constant price)

Components	Project Cost	Total O&M Cost
1. Management of Domestic Wastewater in Urban Areas	2,259,796	400,586
2. Management of Domestic Wastewater in Rural Areas	59,490	8,349
3. Management of Industrial Effluent	128,250	21344
4. Management of Livestock Waste	1,000	560
5. Management of Pollution from Farmland	-	3,960
6. Environmental Monitoring	-	5,250
Total	2,448,865	440,049
Average Annual	163,324	29,337

The project cost for the domestic wastewater management, especially for urban area, is quite large so that the project cost should be covered by the governmental budget, especially from the national budget through NWWEC. On the other hand, the O&M cost is expected to be covered by the user charge as it has already been applied in some local governments such as Rasht and Anzali cities at present. A part of the project costs for Phase 1 for the sewerage system constructions in Rasht and Anzali will be secured by using a loan scheme under the

World Bank. This is now under the appraisal process, at 531 billion Rials and 365 billion Rials, respectively (71.7% and 71.5%of the total project costs, respectively).

Under the proposed domestic wastewater management in both urban and rural areas, average user charge for a household is estimated between 48 and 233 thousand Rials/year/household, and between 31 and 174 thousand Rials/year/household, respectively, to cover all of the O&M cost in the study area.

Table 5.4.6 Average User Charges Estimated for the Wastewater Management

(Unit: Rials/year/household)

Item	Urban Area (Shahr)	Rural Area (Dehestan)
Estimated user charge for recovery of O&M cost*	48,000 ~ 233,000	31,000 ~ 174,000
1% of disposal household income**	203,000	158,000
Annual total income (= annual total O&M cost)	5,441~38,522 million Rials	165 ~ 1,089 million Rials

Note: *- The figures above are average values during M/P over 15 years.
**- The data year on household income is in 2001.

This will be an acceptable level at about 1% of the disposable income level of the households for the wastewater management at 203 and 158 thousand Rials/year/household in the urban and rural areas, respectively as shown in Table 10.4.6, considering future increase in the household income and the current national average of the user charge at about 120 thousand Rials/year/household in the urban area. In practice, the user charge for the waste management is set by the Committee for Water and Wastewater Pricing represented by the city council in the province and representatives from Water and Wastewater Companies. Though the amount is within the affordable level under the disposable household income as explained in the following section, it would be difficult to raise the user charge at once, especially in rural areas. Thus, support from the local and central governments may be necessary in the beginning.

Regarding the management of industrial effluent, relevant industries are supposed to cover the necessary cost for both the project and O&M cost based on the polluters-pays-principle under direction of DOE. In the same way, the cost for the management of livestock waste should be covered by the industrial livestock keepers.

For the management of pollution from farmland, financial support from the provincial budget will be necessary as regular governmental assistance.

The cost for the environmental monitoring should be covered by the provincial budget as regular work.

5.4.5 Financial Evaluation of the Solid Waste Management Plan

The necessary costs for the Solid Waste Management Plan are shown below.

Table 5.4.7 Necessary Cost for the Solid Waste Management Plan

(Unit: billion Rials, June 2004 constant price)

Components	Project Cost	Total O&M Cost
1. Provision of Efficient Waste Collection Services	121,651	345,761
2. Composting	17,083	178,557
3. Sanitary Landfill	6,906	12,265
4. Proper Treatment of Hazardous Industrial Waste	600	8,252
5. Environmental Monitoring	-	3,494
Total	146,239	548,329
Average Annual	9,749	36,555

The domestic solid waste management cost is expected to increase after the new system under the M/P is introduced, especially in rural area (Dehestan) where solid waste management will be introduced under the new regulations on the solid waste management that state that the Governors of counties (Bakhsh) should be newly responsible for wastes in rural area (Dehestan). According to MPO, any additional budgeting plan such as budget allocation from the provincial budget has not yet been decided for the rural areas under the new regulations.

In order to ease the budget pressure on the local governments, it is recommended to charge the SWM fee to the residents, because even now, the municipalities do not have enough budget. This can be achieved by adding the solid waste management cost to the local governmental tax, which is currently charged based on the area of house in some urban areas (Shahr). For example, the rate in Rasht city is 100,000 Rial/household/year to a resident living in a house with 80 m^2.

It is desirable to fully-recover the solid waste management cost by local governmental tax or user charge. The full cost recovery requires a household with 4 members to pay 163,000 Rial/year in urban areas and 311,000 Rial/year in rural areas. Though the amount is within the affordable level at below 2% of the disposable household income[4], it would be difficult to raise the tax at once, especially in rural areas. Thus, support from the local and central governments may be necessary in the beginning.

[4] Information and Modeling Issues in Designing Water and Sanitation Subsidy Scheme, May 2000, The World Bank

Table 5.4.8 Average User Charge Estimated for Domestic Waste Management

(Unit: Rials/year/household)

Item	Urban Area (Shahr)	Rural Area (Dehestan)
Estimated user charge for full cost recovery*	163,000	311,000
2% of disposal household income**	406,000	316,000
Annual total income (= annual total cost)	35,000 ~ 49,000 million Rials	1,850 ~ 13,700 million Rials

Note: *- The figures above are average values during M/P over 15 years.
**- The data year on household income is in 2001.
The number of household members is supposed as 4 persons.

Regarding the pre-treatment of industrial hazardous waste, relevant industries are supposed to cover the necessary costs for both the project and O&M based on the polluters-pays-principle under direction of DOE. In the same way, the cost for the treatment of the infectious waste should be covered by the hospitals/medical facilities.

The cost for the environmental monitoring should be covered by the provincial budget as regular work.

5.4.6 Financial Evaluation of the Environmental Education Plan

Necessary costs for the Environmental Education Plan are shown below.

Table 5.4.9 Necessary Cost for the Environmental Education Plan

(Unit: million Rials)

Components	Project Cost	Total O&M Cost
1. Environmental Education in Schools	-	3,324
2. Environmental Education in Higher Education	-	4,838
3. Professional Development for Decision Makers	-	2,416
4. Activities for Religious Leaders	-	1,053
5. Activities for Business and Industry	-	1,825
6. Activities for Farmers and Rural Communities	-	9,715
7. Activities for the General Public	1,175	11,140
8. Activities for NGOs	-	4,150
Total	1,175	38,461
Average Annual	78	2,564

Various stakeholders will be involved in the Environmental Education Plan. Most of the proposed activities are continuously implemented year after year and the cost of each component is relatively small. Though relevant costs may be borne by relevant stakeholder by rearrangement and coordination in their budget, further financial support from the provincial budget should be provided to ease the budget pressure on the stakeholders, especially in the initial stage.

5.4.7 Financial Evaluation of the Institutional Plan for Implementation

Necessary costs for the Institutional Plan are shown below.

Table 5.4.10 Necessary Cost for the Institutional Plan for Implementation

(Unit: million Rials)

Components	Project Cost	Total O&M Cost
1. Establishment of a Conservancy (or similar body)	890	-
2. DOE 'Apprenticeship' Training	159	-
3. Initial Overseas Exchange Visits	270	-
4. Regular Administration of the Conservancy	-	27,150
5. WGLEP Anzali Sub-Group Meetings	-	870
6. Annual Anzali Forum	-	1,005
7. Annual Anzali State of the Environment Report	-	2,250
8. In-country Cross-sectoral Training	-	2,685
9. DOE Technical Support for Municipalities	-	3,450
10. Monitoring and Auditing the Conservancy Performance	-	510
Total	1,319	37,920
Average Annual	88	2,528

Proposed activities for the institutional plan will be regular works for implementation of the M/P under the operational cost except for the establishment of a Conservancy, DOE 'apprenticeship' training and initial overseas exchange visits. It is suggested that relevant cost for the Institutional Plan be borne by provincial budget due to the relatively low project and O&M costs.

5.5 Price Contingency

While the economic and financial evaluation were conducted by using the constant price in June 2004 in the above sections, examples of total cost of the M/P at current price are shown assuming future price escalations at several levels. Based on the statistics in Iran, average annual price escalation based on the consumer price index (CPI) for past 5 years is very high at around 18.7%/year, though this high level of the inflation is not realistic figure to assume future price escalations. As shown in the following table, only 3% of the annual price escalation causes about 20% of increase for the total cost of the M/P.

Table 5.5.1 Total Cost of the M/P at Current Price under Conceivable Price Escalations

(Unit: billion Rials)

Annual Price Escalation	Total Cost of M/P at 2004 Constant Price	Total Price Contingency in 2019	% of Total Cost of M/P
3%/year Case	4,478	903	20.2%
5%/year Case		1,633	36.5%
10%/year Case		4,050	90.4%

Source: JICA Study Team

5.6 Suggested Preparations

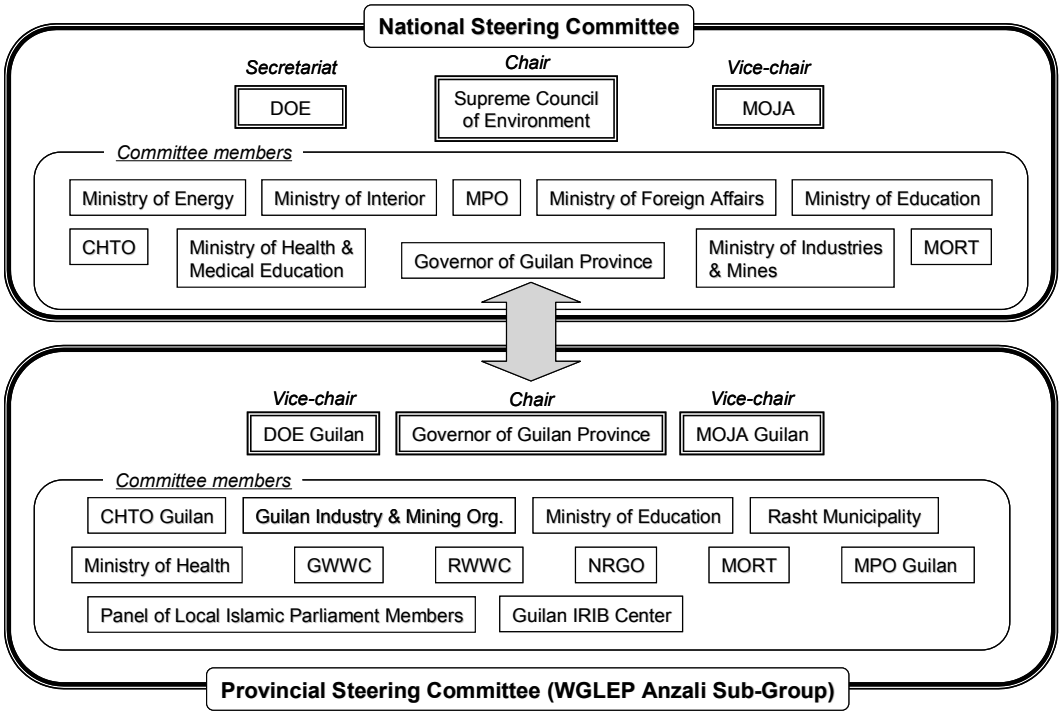
Because a significant budget is required for the implementation of the master plan, and as it is essential that the proposed measures are implemented in a coordinated manner, the relevant organizations are urged to take coordinated actions to secure necessary budget.

5.6.1 Application for the National Five-Year Development Plan

First step to secure the necessary budget for the M/P for both national and provincial budgets is that implementation of the M/P is clearly prescribed in the 4th national five-year development plan after approval in the Majlis. The period of the 4th national five-year development plan is between 2005 and 2009. To secure the budget of the M/P over the M/P period continuously, the M/P needs to be approved for the next period of the five-year development plan and then prescribed in the subsequent five-year development plans. Therefore, the application for the five-year development plan has to be made every 5 years by phasing the M/P. Based on the five-year development plan, fiscal budgeting will be decided year by year after the performance of the previous year is reviewed by MPO.

5.6.2 Organizing Special Committees at National and Provincial Levels

The issue of the organizational arrangement for the implementation of the master plan were discussed at the 5th National Steering Committee Meeting and the 11th Local Steering Committee Meeting. It was decided that coordinating mechanisms are organized at the national, provincial and local levels. It is envisaged that the national-level coordination structure is organized under the Supreme Council for the Environment, and the provincial-level coordination mechanism is organized under the Provincial Governor by involving concerned organizations and stakeholders. At the local level, working groups on land use, environment, watershed management, etc., would be organized in order to enable active participation of local communities, NGOs and other local stakeholders, and to reflect the voices of such stakeholders to decision making. The proposed organizational structure and the main tasks of the proposed committees are shown below.



Note: MPO- Management & Planning Organization, GWWC- Guilan Water and Wastewater Company, RWWC- Rural Water and Wastewater Company, NRGO- Natural Resources General Office, MORT- Ministry of Road and Transport, IRIB- The Islamic Republic of Iran Broadcasting
Source: JICA Study Team

Figure 5.6.1 Organizational Chart for the Proposed Special Committee for Financial Arrangement of the M/P

Table 5.6.1 Main Tasks of the Special Committees

Level	Main Tasks
National	1) Coordination among relevant ministries and organizations at national level 2) Evaluation of accomplishment of the M/P 3) Re-schedule of the Implementation Program (I/P) based on the accomplishments evaluation 4) Application to the 5-year Development Plan and national budget for the M/P
Provincial	1) Coordination among relevant governmental agencies and organizations at the provincial level 2) Detailed planning and periodical revising of the plans 3) Monitoring the accomplishment of the M/P 4) Report to the National Committee on the accomplishment
Local	1) Coordination among local stakeholders 2) Voicing local needs and concerns to the provincial level committee 3) Participation in planning / reviewing sessions

Source: JICA Study Team

APPENDIX - 1

RESULTS OF THE QUESTIONNAIRE SURVEY ON ENVIRONMENTAL CONSERVATION FOR ANZALI WETLAND WATERSHED AREA

A1.1 Objectives and Survey Method

Through the questionnaire survey, public awareness of the residents in the Anzali watershed on environmental conservation of the Anzali wetland and its watershed area was examined as well as situation of solid waste disposal and utilization of the Anzali wetland by the residents.

In addition to qualitative evaluation of the public awareness, quantitative evaluation on implementation of the proposed M/P was conducted by using the Contingent Valuation Method (CVM), which asked the respondents on their willingness-to-pay under the assumed case for the payment to the environmental service.

A1.2 Survey Method

(1) Study area: Anzali wetland watershed

(2) Survey method: Questionnaire survey

(3) Survey sample: 1) Ordinary residents, 2) Members of environmental NGO

(4) Distribution method of the questionnaire for the ordinary residents:

The questionnaires were distributed to the students in the every level of the school from primary to high schools through the teachers. After the parents of the students answered the questionnaire, questionnaires answered were collected in the school.

(5) Selection method of the sample for ordinary residents:

1) Proportionally distribute by population of municipality,
2) Schools in surrounding area of the Anzali wetland to get information on economical use of the Anzali wetland

(6) Number of the total questionnaire distributed: Total 1,950 sets (1,750 sets for ordinary residents and 200 sets for the NGOs)

Table A1.1 Number of Distribution for the Questionnaire

Shahrestan	Bakhsh	Shahr / Dehestan	Number of school	Number of sheet	Type of school
Rasht	Khomam	Chokam	1	100	Primary school
	Markazi (central)	Rasht	3	100	Primary school
				100	Secondary school
				100	High school
		Peerbazar	1	100	Primary school
Anzali	Markazi (central)	Bandar Anzali	2	100	Primary school
				100	Secondary school
		Lichar Kihassanrood	1	100	Primary school
		Chahar Farizeh	1	100	Primary school
Somehsara	Tolam	Hendokhaleh	1	100	Primary school
	Markazi (central)	Somehsara	3	40	Primary school
				80	Primary school
				80	Secondary school
		Kasma	1	100	Primary school
Shaft	Markazi (central)	Shaft	1	75	Primary school
	Ahmadsargorab	Chobar	1	75	Primary school
Fuman	Markazi (central)	Fuman	1	100	Primary school
	Sardar Jangal	Alian	1	100	Primary school
Masal	Shanderman	Sheikh Neshin	1	50	Primary school
	Markazi (central)	Masal	1	50	Primary school
Total			20	1,750	-

Table A1.2 Number and Allocation of Questionnaire Distributed to Schools Based on Indicated Price of WTP

	Allocation of the Questionnaire						
Indicated Price for WTP	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	
(1) 5,000 Rials	20	20	20	15	20	10	
(2) 10,000 Rials	20	20	20	15	20	10	
(3) 20,000 Rials	20	20	20	15	20	10	
(4) 30,000 Rials	20	20	20	15	20	10	
(5) 50,000 Rials	20	20	20	15	20	10	
Total questionnaires/school	100	100	100	75	100	50	Total
Number of schools	5	4	4	2	2	2	19
Total	500	400	400	150	200	100	1,750

Table A1.3 Number and Allocation of Questionnaire Distributed to NGOs Based on Indicated Price of WTP

	Allocation of the Questionnaire				
Indicated Price	NGO(1)	NGO(2)	NGO(3)	NGO(4)	
(1) 5,000 Rials	10	10	10	10	
(2) 10,000 Rials	10	10	10	10	
(3) 20,000 Rials	10	10	10	10	
(4) 30,000 Rials	10	10	10	10	
(5) 50,000 Rials	10	10	10	10	
Total	50	50	50	50	200

Note: NGO(1) = Sabz Aien (Environmental NGO in Fuman)
NGO(2) = Anjoman Sabze (Environmental NGO in Masal)
NGO(3) = Women Against Pollution (Environmental NGO in Rasht)
NGO(4) = Sabzcaran (Environmental NGO in Rasht)

A1.2 Design of the Survey

Main items to be surveyed and structure of the questionnaire are shown below.

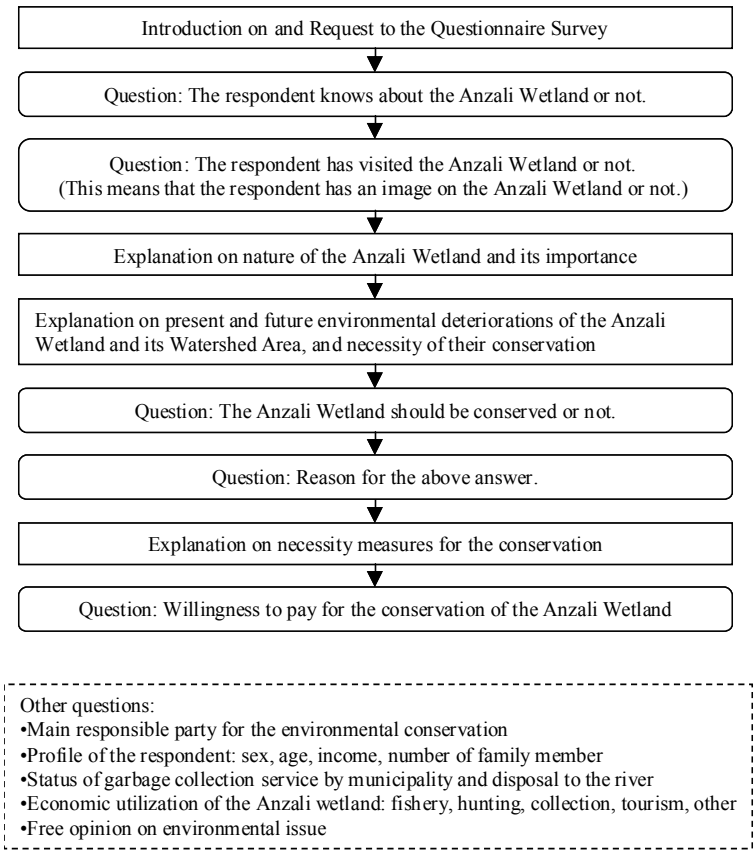


Figure A1.1 Structure of the Questionnaire

Table A1.4 Comparison Between Single and Separated Question Cases

	Case 1: Ask overall willingness-to-pay for the M/P by 1 question	Case 2: Ask willing-ness-to-pay for each of the main 4 components by 4 questions
Advantage	Due to small number of the question, the disadvantage in the case 2 can be avoided related to the plural number of the questions.	Can know the willingness-to-pay for each of the main 4 components Can know priority for the respondents among the main 4 components
Disadvantage	Possible low willingness-to-pay due to misperception that the respondents focus on only wetland conservation, not other benefits brought by proposed measures in the watershed area.	• Due to increase of number of the questions, respondents may tired of reading text in the question. It may cause low understanding of the questions. • 4 questions on willingness-to-pay may cause reluctance of feeling on the willingness-to-pay and cause lower amount of the willingness-to-pay question by question. • As result that respondents prioritize the 4 components, the respondents may select component(s) that the respondents pay. Consequently, only wastewater management and solid waste management are selected and wetland ecological management and watershed management may not be subject to the willingness-to-pay regardless to the level of the amount and show nearly "0" willingness-to-pay on average.

A1.3 Implementation of the Pre-test

In order to test if the questionnaire is adequate, the pre-test survey was conducted prior to the above full-scale survey. For the pre-test survey, staff of the Ministry of Education were cooperated as volunteer. Out of 50 questionnaires, 14 questionnaires were returned. Rate of the return was relative low due to short notice and very limited period for the answer and just before the school start period. Based on the preliminary survey, the questionnaire was revised and improved for the full-scale survey.

A1.4 Statistical Analysis of the Survey Results

(1) Result of Collection of the Questionnaire

Table A1.5 Collected Ratio of the Questionnaire

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Distributed	500	400	400	150	200	200	1,750	200
Collected	312	229	284	61	98	82	1,066	143
Ratio	62.4%	57.3%	71.0%	40.7%	49.0%	41.0%	60.9%	71.5%

(2) Profile of Interviewee

Table A1.6 Sex of Interviewee

Sex	Residents	NGOs
1) Male	496 (53.0%)	70 (50.7%)
2) Female	440 (47.0%)	68 (49.3%)
Total	936 (100.0%)	138 (100.0%)

Table A1.7 Age of Interviewee

Age	Residents	NGOs
1) Below 20 years old	138 (15.8%)	0 (0.0%)
2) 20 – 29 years old	208 (23.8%)	84 (60.0%)
3) 30 – 39 years old	310 (35.5%)	28 (20.0%)
4) 40 – 49 years old	179 (20.5%)	19 (13.6%)
5) 50 – 59 years old	24 (2.7%)	8 (5.7%)
6) 60 – 69 years old	9 (1.0%)	1 (0.7%)
7) Over 70 50 – 59 years old	5 (0.6%)	0 (0.0%)
Total	873 (100.0%)	140 (100.0%)

Table A1.8 Annual Income of Interviewee

Annual Income	Residents	NGOs
1) Below 10 mil. Rials/year	401 (46.0%)	20 (16.0%)
2) 10 – 20 mil. Rials/year	177 (20.3%)	28 (22.4%)
3) 20 – 30 mil. Rials/year	113 (13.0%)	31 (24.8%)
4) 31 – 50 mil. Rials/year	36 (4.1%)	14 (11.2%)
5) 51 – 80 mil. Rials/year	31 (3.6%)	19 (15.2%)
6) 81 – 100 mil. Rials/year	29 (3.3%)	1 (0.8%)
7) 101 – 150 mil. Rials/year	33 (3.8%)	8 (6.4%)
8) 151 – 200 mil. Rials/year	21 (2.4%)	1 (0.8%)
9) Over 200 mil. Rials/year	31 (3.6%)	3 (2.4%)
Total	872 (100.0%)	125 (100.0%)

Table A1.9 Number of Family Member of Interviewee

Number of Family Member	Residents	NGOs
1) 1 person	9 (0.9%)	2 (1.5%)
2) 2 persons	8 (0.8%)	6 (4.4%)
3) 3 persons	106 (10.7%)	20 (14.6%)
4) 4 persons	397 (40.0%)	43 (31.4%)
5) 5 persons	265 (26.7%)	27 (19.7%)
6) 6 persons	109 (11.0%)	16 (11.7%)
7) 7 persons	52 (5.2%)	11 (8.0%)
8) 8 persons	29 (2.9%)	7 (5.1%)
9) 9 persons	9 (0.9%)	4 (2.9%)
10) 10 persons	3 (0.3%)	0 (0.0%)
11) 11 persons	2 (0.2%)	0 (0.0%)
12) 12 persons	2 (0.2%)	1 (0.7%)
13) 13 persons	0 (0.0%)	0 (0.0%)
14) 14 persons	0 (0.0%)	0 (0.0%)
15) 15 persons	1 (0.1%)	0 (0.0%)
Total	993 (100.0%)	137 (100.0%)

(3) Recognition of the Anzali Wetland

Table A1.10 Do You Know about the Anzali Wetland?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Yes	252 (80.8%)	207 (90.4%)	211 (77.3%)	39 (65.0%)	61 (62.9%)	56 (69.1%)	826 (78.5%)	110 (79.1%)
No	60 (19.2%)	22 (9.6%)	62 (22.7%)	21 (35.0%)	36 (32.1%)	25 (30.9%)	226 (21.5%)	29 (20.9%)
Total	312	229	273	60	97	81	1,052	139

Table A1.11 Have you ever visited the Anzali Wetland?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Yes	233 (75.6%)	195 (85.9%)	189 (69.5%)	35 (60.3%)	48 (50.5%)	41 (54.7%)	741 (71.6%)	114 (84.4%)
No	75 (24.4%)	32 (14.1%)	83 (30.5%)	23 (39.7%)	47 (49.5%)	34 (45.3%)	294 (28.4%)	21 (15.6%)
Total	308	227	272	58	95	75	1,035	135

Table A1.12 Purpose of Visit Among Respondents Who Have Visited the Anzali Wetland

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Picnic	108 (45.6%)	76 (39.2%)	95 (50.8%)	20 (58.8%)	19 (41.3%)	22 (53.7%)	340 (46.0%)	59 (51.8%)
Fishing	44 (18.6%)	61 (31.4%)	39 (20.9%)	1 (2.9%)	12 (26.1%)	2 (4.9%)	159 (21.5%)	12 (10.5%)
Boating	108 (45.6%)	103 (53.1%)	68 (36.4%)	11 (32.4%)	19 (41.3%)	7 (17.1%)	316 (42.8%)	56 (49.1%)
Hunting	17 (7.2%)	22 (11.3%)	14 (7.5%)	0 (0.0%)	5 (10.9%)	3 (7.3%)	61 (8.3%)	9 (7.9%)
Bird watching	48 (20.3%)	46 (23.7%)	54 (28.9%)	6 (17.6%)	5 (10.9%)	15 (36.6%)	174 (23.5%)	44 (38.6%)
Collection of plants	6 (2.5%)	15 (7.7%)	8 (4.3%)	0 (0.0%)	1 (2.2%)	0 (0.0%)	30 (4.1%)	9 (7.9%)
Others	7 (3.0%)	8 (4.1%)	9 (4.8%)	2 (5.9%)	1 (2.2%)	2 (4.9%)	29 (3.9%)	4 (3.5%)

(4) Necessity of the Conservation for the Anzali Wetland

Table A1.13 Do You Think that the Conservation of the Anzali Wetland Is Necessary?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Yes	267 (87.8%)	199 (91.7%)	253 (94.1%)	54 (96.4%)	68 (81.0%)	73 (93.6%)	914 (90.7%)	137 (97.9%)
No	7 (2.3%)	3 (1.4%)	3 (1.1%)	0 (0.0%)	7 (8.3%)	3 (3.8%)	23 (2.3%)	1 (0.7%)
No idea	30 (9.9%)	15 (6.9%)	13 (4.8%)	2 (3.6%)	9 (10.7%)	2 (2.6%)	71 (7.0%)	2 (1.4%)
Total	304	217	269	56	84	78	1,008	140

Table A1.14 Why do you think that the Anzali Wetland should be conserved?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Reason 1	62 (23.4%)	52 (25.7%)	47 (18.8%)	9 (17.0%)	8 (12.1%)	19 (27.5%)	197 (21.8%)	43 (32.6%)
Reason 2	197 (74.3%)	148 (73.3%)	192 (76.8%)	44 (83.0%)	52 (78.8%)	51 (73.9%)	684 (75.6%)	95 (72.0%)
Reason 3	9 (3.4%)	9 (4.5%)	10 (4.0%)	1 (1.9%)	2 (3.0%)	4 (5.8%)	35 (3.9%)	6 (4.5%)
Reason 4	4 (1.5%)	11 (5.4%)	3 (1.2%)	1 (1.9%)	3 (4.5%)	0 (0.0%)	22 (2.4%)	1 (0.8%)
Reason 5	6 (2.3%)	5 (2.5%)	8 (3.2%)	0 (0.0%)	3 (4.5%)	1 (1.4%)	23 (2.5%)	1 (0.8%)

Note: Reason 1- Natural environment of the Anzali Wetland is so important.
Reason 2- Precious natural environment should be conserved for future generations.
Reason 3- The wetland is registered as Ramsar Convention site.
Reason 4- I utilize the wetland such as fishing and hunting.
Reason 5- Other reason
The percentage shows ratio under the number of respondents who answered including multiple answers. Therefore, total percentage exceeds 100%.

Table A1.15 Why do you think that it is not necessary to conserve the Anzali Wetland.?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total	NGOs
Reason 1	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Reason 2	5 (100.0%)	1 (50.0%)	1 (33.3%)	0 (0.0%)	1 (33.3%)	2 (66.7%)	10 (62.5%)	0 (0.0%)
Reason 3	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	2 (66.7%)	0 (0.0%)	3 (18.8%)	0 (0.0%)
Reason 4	0 (0.0%)	1 (50.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	3 (18.8%)	1 (100.0%)
Reason 5	0 (0.0%)	1 (50.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (12.5%)	0 (0.0%)

Note: Reason 1- Natural environment of the Anzali Wetland is not so important.
Reason 2- The Anzali Wetland is useless.
Reason 3- It is better to use the Anzali Wetland for development purpose even the number of fish and birds in the wetland decline.
Reason 4- I do not understand why the Anzali Wetland should be conserved.
Reason 5- Other reason
The percentage shows ratio under the number of respondents who answered including multiple answers. Therefore, total percentage exceeds 100%.

(5) Responsibility and Participation of the Conservation Activity

Table A1.16 Who should conduct the environmental conservation in general?

Area	Residents Total	NGOs
1) Citizens	100 (10.3%)	11 (8.1%)
2) Government	179 (18.4%)	6 (4.4%)
3) Industry	33 (3.4%)	2 (1.5%)
4) Total 1) to 3)	629 (64.6%)	112 (83.0%)
5) Other opinion	32 (3.3%)	4 (3.0%)
Total	973 (100.0%)	135 (100.0%)

Note: "1) Citizens" - We, the citizens, should tackle the environmental conservation on our own initiative.
"2) Government" - The government should responsible for the environmental conservation.
"3) Industry" - Industry has responsibility for the environmental conservation.
"4) Total 1) to 3)"- The citizens, industry, and government should jointly implement the environmental conservation.

Table A1.17 How can you participate in environmental improvement and conservation activity for the Anzali Wetland and its Watershed Area including your residential area?

Area	Residents Total	NGOs
1) Program/campaign	414 (43.4%)	70 (52.6%)
2) Conservation activity	113 (11.8%)	35 (26.3%)
3) Workshop/seminar	157 (16.4%)	55 (41.4%)
4) Change of behavior	367 (38.4%)	54 (40.6%)
5) Do not want to participate	82 (8.6%)	8 (6.0%)
6) Other opinion	30 (3.1%)	4 (3.0%)

Note: "1) Program/campaign" - I can participate in an environmental conservation program or campaign such as tree/flower planting in the mountain and collection of garbage in the river, if any.
"2) Conservation activity" - I can participate in conservation activity as an environmental volunteer in the wetland such as removal overgrowing aquatic plant, if any.
"3) Workshop/seminar" - I can participate and study in workshop/seminar on the environmental conservation, if any.
"4) Change of behavior"- I can change my behavior to improve environmental condition such as less use of detergent and segregation of garbage, if necessary.
"5) Do not want to participate"- I do not want to participate in any environmental conservation activities.
The percentage shows ratio under the number of respondents who answered including multiple answers. Therefore, total percentage exceeds 100%.

(6) Garbage Disposal

Table A1.18 Is the garbage of your family collected by municipality?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total
Yes	222 (73.5%)	172 (77.5%)	170 (64.6%)	24 (41.4%)	38 (42.7%)	16 (21.9%)	642 (63.8%)
No	80 (26.5%)	50 (22.5%)	93 (35.4%)	34 (58.6%)	51 (57.3%)	57 (78.1%)	365 (36.2%)
Total	302	222	263	58	89	73	1,007

Table A1.19 How do you dispose of the garbage?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total
Answer 1	214 (72.1%)	154 (72.6%)	178 (67.7%)	27 (48.2%)	51 (60.7%)	32 (42.1%)	656 (66.4%)
Answer 2	57 (19.2%)	46 (21.7%)	45 (17.1%)	17 (30.4%)	13 (15.5%)	29 (38.2%)	207 (21.0%)
Answer 3	26 (8.8%)	12 (5.7%)	45 (17.1%)	13 (23.2%)	22 (26.2%)	15 (19.7%)	134 (13.6%)
Answer 4	0 (0.0%)	14 (6.6%)	28 (10.6%)	2 (3.6%)	0 (0.0%)	0 (0.0%)	44 (4.5%)
Total	297	212	263	56	84	76	988

Note: Answer 1- Solid waste collection service,
Answer 2- Self-disposal by burning or burying in my garden,
Answer 3- Dispose near my house, Answer 4- Others
The percentage shows ratio under the number of respondents who answered including multiple answers. Therefore, total percentage exceeds 100%.

Table A1.20 How often does your family dispose of the garbage near your house?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total
Answer 1	111 (45.5%)	35 (20.6%)	68 (31.6%)	15 (28.8%)	22 (31.4%)	33 (50.8%)	284 (34.8%)
Answer 2	61 (25.0%)	52 (30.6%)	80 (37.2%)	16 (30.8%)	31 (44.3%)	12 (18.5%)	252 (30.9%)
Answer 3	30 (12.3%)	21 (12.4%)	34 (15.8%)	9 (17.3%)	3 (4.3%)	8 (12.3%)	105 (12.9%)
Answer 4	15 (6.1%)	29 (17.1%)	11 (5.1%)	1 (1.9%)	3 (4.3%)	8 (12.3%)	67 (8.2%)
Answer 5	13 (5.3%)	14 (8.2%)	10 (4.7%)	4 (7.7%)	1 (1.4%)	1 (1.5%)	43 (5.3%)
Answer 6	14 (5.7%)	19 (11.2%)	12 (5.6%)	7 (13.5%)	9 (12.9%)	3 (4.6%)	64 (7.8%)
Total	244	170	215	52	70	88	816

Note: Answer 1- Almost every day, Answer 2- Once two days, Answer 3- Once a week,
Answer 4- 2~3 times a month, Answer 5- Once a month,
Answer 6- Less than once a month, but sometimes

Table A1.21 If you can have a recycling system in your community, can you separate your recyclables such as paper, can and bottle?

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total
Answer 1	187 (64.5%)	118 (55.9%)	169 (64.5%)	29 (50.9%)	44 (58.7%)	46 (69.7%)	593 (61.7%)
Answer 2	36 (12.4%)	28 (13.3%)	30 (11.5%)	10 (17.5%)	8 (10.7%)	19 (28.8%)	131 (13.6%)
Answer 3	18 (6.2%)	13 (6.2%)	15 (5.7%)	4 (7.0%)	7 (9.3%)	0 (0.0%)	57 (5.9%)
Answer 4	49 (16.9%)	52 (24.6%)	48 (18.3%)	14 (24.6%)	16 (21.3%)	1 (1.5%)	180 (18.7%)
Total	290	211	262	57	75	66	961

Note: Answer 1- Yes, I am willing to separate.,
Answer 2- If I can exchange with money, Answer I will separate.,
Answer 3- No, I will not., Answer 4- I do not know.

(7) Utilization of the Anzali Wetland

Table A1.22 Utilization of the Anzali Wetland

Area	Rasht	Anzali	Somehsara	Shaft	Fuman	Masal	Total
1) Fishery	34 (12.1%)	51 (25.5%)	40 (15.3%)	5 (8.6%)	9 (10.8%)	0 (0.0%)	139 (14.6%)
2) Hunting	8 (2.7%)	20 (9.7%)	21 (8.0%)	2 (3.6%)	11 (12.1%)	0 (0.0%)	62 (6.3%)
3) Collection of plant/fruit	2 (0.7%)	19 (9.2%)	12 (4.7%)	2 (3.5%)	6 (6.7%)	0 (0.0%)	41 (4.2%)
4) Tourism	13 (4.4%)	14 (6.6%)	24 (9.3%)	0 (0.0%)	4 (4.5%)	1 (1.4%)	56 (5.7%)
5) Other business	1 (0.4%)	7 (3.5%)	4 (1.6%)	0 (0.0%)	1 (1.1%)	0 (0.0%)	13 (1.4)
Total	58	111	101	9	31	1	311

A1.5 Result of the Survey and Analysis on the Willingness-to-Pay

In the following tables, figures on the answer show protest bid, that the respondent disagree to pay any amount in the designated payment method regardless to the amount of the indicated price.

Table A1.23 Answers to WTP on Wetland Ecological Management Measures

	Indicated Price (Rials/month/household)				
	5,000	10,000	20,000	30,000	50,000
Answer 1	78 (42.4%)	69 (32.7%)	61 (31.1%)	46 (24.5%)	47 (22.6%)
Answer 2	59 (32.1%)	85 (40.3%)	85 (43.4%)	101 (53.7%)	119 (57.2%)
Answer 3	47 (25.5%)	57 (27.0%)	50 (25.5%)	41 (21.8%)	42 (20.2%)
Total	184 (100.0%)	211 (100.0%)	196 (100.0%)	188 (100.0%)	208 (100.0%)

Note: Answer 1- Yes, I am willing to pay for the amount in the case.
Answer 2- No, I think it is NOT acceptable. (I think the level of payment is high.)
Answer 3- I think that the payment for the conservation of the Anzali Wetland is not necessary.

Table A1.24 Answers to WTP on Wastewater Management Measures

	Indicated Price (Rials/month/household)				
	5,000	10,000	20,000	30,000	50,000
Answer 1	86 (46.5%)	81 (38.6%)	73 (37.4%)	53 (28.5%)	52 (25.7%)
Answer 2	64 (34.6%)	87 (41.4%)	83 (42.6%)	96 (51.6%)	115 (56.9%)
Answer 3	33 (17.8%)	42 (20.0%)	39 (20.0%)	36 (19.4%)	35 (17.3%)
Total	185 (100.0%)	210 (100.0%)	195 (100.0%)	186 (100.0%)	202 (100.0%)

Note: Answer 1- Yes, I am willing to pay for the amount in the case.
Answer 2- No, I think it is NOT acceptable. (I think the level of payment is high.)
Answer 3- I think that the payment for the conservation of the Anzali Wetland is not necessary.

Table A1.25 Answers to WTP on Solid Waste Management Measures

	Indicated Price (Rials/month/household)				
	5,000	10,000	20,000	30,000	50,000
Answer 1	76 (41.5%)	87 (41.6%)	66 (34.4%)	59 (31.7%)	45 (22.1%)
Answer 2	68 (37.2%)	86 (41.1%)	87 (45.3%)	97 (52.2%)	117 (57.4%)
Answer 3	38 (20.8%)	36 (17.2%)	38 (19.8%)	30 (16.1%)	41 (20.1%)
Total	183 (100.0%)	209 (100.0%)	192 (100.0%)	186 (100.0%)	204 (100.0%)

Note: Answer 1- Yes, I am willing to pay for the amount in the case.
Answer 2- No, I think it is NOT acceptable. (I think the level of payment is high.)
Answer 3- I think that the payment for the conservation of the Anzali Wetland is not necessary.

Table A1.26 Answers to WTP on Watershed Management Measures

	Indicated Price (Rials/month/household)				
	5,000	10,000	20,000	30,000	50,000
Answer 1	70 (38.9%)	64 (31.4%)	60 (30.8%)	42 (23.1%)	40 (19.7%)
Answer 2	66 (36.7%)	88 (43.1%)	85 (43.6%)	98 (53.8%)	120 (59.1%)
Answer 3	42 (23.3%)	51 (25.0%)	45 (23.1%)	40 (22.0%)	39 (19.2%)
Total	180 (100.0%)	204 (100.0%)	195 (100.0%)	182 (100.0%)	203 (100.0%)

Note: Answer 1- Yes, I am willing to pay for the amount in the case.
Answer 2- No, I think it is NOT acceptable. (I think the level of payment is high.)
Answer 3- I think that the payment for the conservation of the Anzali Wetland is not necessary.

A1.6 Econometrics Analysis on the Willingness-to-pay

(1) Simple Model Analysis

Amount of the willingness-to-pay was estimated by simple model, that probability distribution function for WTP consists of only constant. The Logit model was applied for the estimation of the probability distribution function for WTP. Based on the estimated probability distribution function for WTP, median and average amounts of the WTP were calculated under the maximum indicated price at 50,000 Rials/month as shown below.

Table A1.27 Estimated Amounts of WTP for the M/P

(Unit: Rials/month/household)

Sub-plans	Ordinary Residents		Environmental NGOs	
	Median*	Average	Median*	Average
1) Wetland Ecological Management	1,050	13,997	25,500	26,980
2) Watershed management	750	12,855	13,800	23,527
3) Wastewater Management	2,000	16,001	42,100	28,497
4) Solid Waste Management	1,500	15,471	19,200	25,078
Total	5,300	58,324	100,600	104,082

Note: An amount of the WTP at 50% probability under the estimated probability distribution function for WTP

As the results, there are some findings as follows;

1) Average amount of the WTP for the NGOs is much higher than that of residents at around 2 times. This reveals the hypothesis that environmental NGOs who have high level of environmental awareness have higher WTP than that of the ordinary residents.
2) Assuming that order of the WTP among the sub-plans shows priority of the sub-plans for the respondents, priority of the sub-plans for both ordinary residents

and environmental NGOs are shown below. For ordinary residents, priority of the sub-plans is closely related to the life environment. I addition, this order consistent with the amount of necessary cost for each sub-plan. On the other hand, environmental NGOs put the wetland ecological management as 2nd rank. This shows high awareness of the environment put more high priority on the conservation of the natural environment as the Anzali wetland.

Table A1.28 Rank of Sub-plans based on the Amount of WTP

Rank	Ordinary Residents	Environmental NGOs
1) Wetland Ecological Management	3rd	2nd
2) Watershed management	4th	4th
3) Wastewater Management	1st	1st
4) Solid Waste Management	2nd	3rd

3) Although the amount of WTP among the sub-plans are different as above-mentioned, there was no large difference among the amount of WTP.

Sheet No.

Japan International Cooperation Agency
Department of the Environment
Ministry of Jihad-E-Agriculture

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland

Questionnaire on Environmental Conservation for Anzali Wetland Watershed Area

Dear Madam/Sir, Please kindly cooperate to answer the following questions after reading each description in order.

About This Questionnaire Survey

"The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland" is being implemented jointly by Department of the Environment and Ministry of Jihad-e-Agriculture of Iran, and Japan International Cooperation Agency Study Team of Japan.

This questionnaire survey under the above study aims to examine public awareness on the environmental conservation for local residents in the Anzali Wetland Watershed Area, consisting of Rasht, Anzali, Somehsara, Masal, Fuman, and Shaft Townships. Results of this questionnaire survey will be utilized for planning of environmental conservation for the Anzali Wetland and its Watershed area including your residential area.

We would like you to answer the following questions frankly and honestly without hesitation.

Question (1) – Do you know about the Anzali Wetland?

(Please put only one check " √ " on one of the following choices.)

1) Yes 2) No => (Please skip the Question (2) and continue after it.)

Question (2) – Have you ever visited the Anzali Wetland?

(Please put only one check " √ " on one of the following choices.)

1) Yes => What main reason have you visited the Anzali Wetland?

(Please put check " √ " on the following choices. You can select more than one choice.)

a) Picnic, b) Fishing, c) Boating, d) Hunting, e) Bird watching,

f) Collection of the plants,

g) Other reason: Please write => _____

2) No

About the Anzali Wetland and its Conservation

The Anzali Wetland is registered in June 1975 as a wetland of international importance in accordance with an international convention of the Ramsar, since it acts as an important spawning and nursery ground for fish, and as a breeding, staging and wintering area for a wide variety of waterfowl from Siberia and other parts of the world (700,000 birds came flying in 2003). The Anzali Wetland is also utilized for economic purposes for local residents such as fishery, bird hunting, and farming (ex. more than 10 billion Rials/year worth of fish catch) as well as recreational purpose for the tourists such as boating and picnic.

However, the water quality of the wetland is deteriorating due to the inflow of wastewater and solid waste from neighboring cities and pollution from farming and industrial activities. The inflow of sediment from the mountain areas as a result of deforestation in the forest and overgrazing in the rangeland is also a concern. As the results, environmental conditions of the wetland are becoming worsened year by year.

In order to mitigate negative environmental impacts to the Anzali Wetland, environmental conservation of the whole watershed area from mountain area to the wetland including residential and commercial/industrial area, agricultural land, rivers, and forest in the mountain, is necessary as well as conservation of the wetland itself.

Based on our study, if no necessary measures are implemented with sustainable manner in near future, it is expected that environmental situation of <u>the Anzali Wetland and its watershed area</u> including your residential area will continue to be worsen more and more!!

Question (3) - Do you think that the conservation of the Anzali Wetland is necessary?

(Please put only one check " √ " on one of the following choices.)

1) Yes, the Anzali Wetland should be conserved.	=> (Please go to the Question (4).)
2) No, the conservation is not needed.	=> (Please go to the Question (5).)
3) No Idea	=> (Please continue after the Question (5).)

(For respondent who answered the Question (3) as "**Yes**")

Question (4) – Why do you think that the Anzali Wetland should be conserved?

(Please put only one check " √ " on one of the following choices.)

1) Natural environment of the Anzali Wetland is so important.
2) Precious natural environment should be conserved for future generations.
3) The wetland is registered as Ramsar Convention site.
4) I utilize the wetland such as fishing and hunting.
5) Other reason: Please write =>

(For respondent who answered the Question (3) as "**No**")

Question (5) - Why do you think that it is not necessary to conserve the Anzali Wetland.?

(Please put only one check " √ " on one of the following choices.)

1) Natural environment of the Anzali Wetland is not so important.
2) The Anzali Wetland is useless.
3) It is better to use the Anzali Wetland for development purpose even the number of fish and birds in the wetland decline.
4) I do not understand why the Anzali Wetland should be conserved.
5) Other reason: Please write =>

In order to prevent the environmental degradation in the Anzali Wetland and its watershed area including your residential area, various kinds of measures have to be implemented as soon as possible. However, it needs large amount of the cost to implement the following measures to solve the environmental issues. Under the situation, please consider 4 cases below.

In the Anzali Wetland

The following **wetland conservation measures/activities** have to be implemented in and around the Anzali Wetland for conservation of the Anzali Wetland to keep adequate level of nature of the Anzali Wetland.

- Land use regulation in and around the wetland
- More effective management of the fishing and hunting activities to conserve wildlife and habitat
- Promotion of eco-tourism and sport fishing with environmentally sustainable manner
- Environmental monitoring & research, and education program

Assuming that 5,000 Rials per family per month has to be paid by all of the residential families in Guilan province to implement the above measures **due to limitation of governmental budget.**

(Attention: This is only an assumed case and it will not be realized, but please consider realistically.)

Question (6) – In this case, will your family pay for the above amount?

(Please put only one check " √ " on one of the following choices.)

1) Yes, I am willing to pay for the amount in the case.
2) No, I think it is NOT acceptable. (I think the level of payment is high.)
3) I think that the payment for the conservation of the Anzali Wetland is not necessary.

In Your Residential Area (Wastewater issue)

The following **wastewater management measures** should be conducted in order to not only secure adequate sanitary condition in your residential area, but also to prevent from inflow of polluted water into the rivers and the Anzali Wetland.

- Establishment of sewage treatment plant
- Expansion of sewerage connection coverage area
- Use of non-phosphorus detergent

Assuming that 5,000 Rials per family per month has to be paid by all of the residential families in Guilan province to implement the above measures **due to limitation of governmental budget.**

(Attention: This is only an assumed case and it will not be realized, but please consider realistically.)

Question (7) – In this case, will your family pay for the above amount?

(Please put only one check " √ " on one of the following choices.)

1) Yes, I am willing to pay for the amount in the case.
2) No, I think it is NOT acceptable. (I think the level of payment is high.)
3) I think that the payment for the wastewater issue is not necessary.

In Your Residential Area (Solid waste issue)

The following **solid waste management measures** should be conducted in order to not only secure adequate sanitary condition in your residential area, but also to prevent from solid waste dumping into the rivers and polluted leachate in the waste dumping site flowing into the Anzali Wetland through the rivers and groundwater.

- Expansion of waste collection coverage area
- Establishment of sanitary landfill site (No polluted leachate from this waste dumping site)
- Establishment of compost plant
- Promotion of recycle of valuables from the waste

Assuming that 5,000 Rials per family per month has to be paid by all of the residential families in Guilan province to implement the above measures **due to limitation of governmental budget.**

(Attention: This is only an assumed case and it will not be realized, but please consider realistically.)

Question (8) – In this case, will your family pay for the above amount?

(Please put only one check " √ " on one of the following choices.)

1) Yes, I am willing to pay for the amount in the case.
2) No, I think it is NOT acceptable. (I think the level of payment is high.)
3) I think that the payment for the solid waste issue is not necessary.

In the Forest and Rangeland in the Mountain Area

The following **watershed conservation measures** should be conducted in order to prevent from degradation of rangeland and forest such as soil erosion, which cause disaster such as land slide and flood, and also sediment flow into the Anzali Wetland through the rivers.

- Forest conservation / reforestation
- Restoration of rangeland
- Engineering measures for slope protection and erosion prevention such as check dam establishment
- Regulation of overgrazing

Assuming that 5,000 Rials per family per month has to be paid by all of the residential families in Guilan province to implement the above measures **due to limitation of governmental budget.**

(Attention: This is only an assumed case and it will not be realized, but please consider realistically.)

Question (9) – In this case, will your family pay for the above amount?

(Please put only one check " √ " on one of the following choices.)

1) Yes, I am willing to pay for the amount in the case.
2) No, I think it is NOT acceptable. (I think the level of payment is high.)
3) I think that the payment for the conservation of forest and rangeland is not necessary.

Question (10) – Who should conduct the environmental conservation in general?

(Please put only one check " √ " on one of the following choices.)

1) We, the citizens, should tackle the environmental conservation on our own initiative.
2) The government should responsible for the environmental conservation.
3) Industry has responsibility for the environmental conservation.
4) The citizens, industry, and government should jointly implement the environmental conservation.
5) Other opinion. => Please write _____

Question (11) – How can you participate in environmental improvement and conservation activity for the Anzali Wetland and its Watershed Area including your residential area?

(Please put check " √ " on the following choices. You can select more than one choice.)

1) I can participate in an environmental conservation program or campaign such as tree/flower planting in the mountain and collection of garbage in the river, if any.
2) I can participate in conservation activity as an environmental volunteer in the wetland such as removal overgrowing aquatic plant, if any.
3) I can participate and study in workshop/seminar on the environmental conservation, if any.
4) I can change my behavior to improve environmental condition such as less use of detergent and segregation of garbage, if necessary.
5) I do not want to participate in any environmental conservation activities.
6) Other opinion. => Please write _____

Please tell us about you.

Question (12) – Your Sex. (Please put only one check " √ " on one of the following choices.)

1) Male 2) Female

Question (13) – Your Age. (Please put only one check " √ " on one of the following choices.)

1) 20 – 29 years old 2) 30 – 39 3) 40 – 49 4) 50 – 59 5) 60 – 69 6) Over 70

Question (14) – Approximately how much is total annual income in your family?

(Please put only one check " √ " on one of the following choices.)

1) Less than 10 million Rials/year, 2) 10 ~ 20 million Rials/year,
3) 20 ~ 30 million Rials/year, 4) 31 ~ 50 million Rials/year, 5) 51 ~ 80 million Rials/year,
6) 81 ~ 100 million Rials/year, 7) 101 ~ 150 million Rials/year,
8) 151 ~ 200 million Rials/year, 9) Over 200 million Rials/year

Question (15) – How many family members do you live together?

_____ **persons (including you)**

Questions on Garbage Disposal

Question (16) – Is the garbage of your family collected by municipality?

(Please put only one check " √ " on one of the following choices.)

1) Yes 2) No

Question (17) – How do you dispose of the garbage?

(Please put check " √ " on the following choices. You can select more than one choice.)

1) Solid waste collection service 2) Self-disposal by burning or burying in my garden
3) Dispose near my house
=> **How often does your family dispose of the garbage near your house?**
a) Almost every day, b) Once two days, c) Once a week, d) 2~3 times a month,
e) Once a month, f) Less than once a month, but sometimes.
4) Others: Please write => _____

Question (18) – If you can have a recycling system in your community, can you separate your recyclables such as paper, can and bottle?

(Please put only one check " √ " on one of the following choices.)

1) Yes, I am willing to separate. 2) If I can exchange with money, I will separate.
3) No, I will not. 4) I do not know.

Questions on Utilization of the Anzali Wetland

Question (19) – Does your family member including you engage in fishery/fishing in the Anzali Wetland? (Please put only one check " √ " on one of the following choices.)

1) Yes => **What kind of fish does your family member catch mainly?**

Please write :_____

Approximately how much does your family member earn from the fishery/fishing annually? (Only for family consumption and not for sale, please write "0".)

About _____ Rials/year

2) No => (Please answer the next question.)

Question (20) – Does your family member including you engage in hunting of the birds in the Anzali Wetland? (Please put only one check " √ " on one of the following choices.)

1) Yes => **What kind of birds does your family member catch mainly?**

Please write :_____

Approximately how much does your family member earn from the hunting annually? (Only for family consumption and not for sale, please write "0".)

About _____ Rials/year

2) No => (Please answer the next question.)

Question (21) – Does your family member including you collect any fruit and plant in the Anzali Wetland? (Please put only one check " √ " on one of the following choices.)

1) Yes => **What kind of fruits and plants does your family member collect mainly?**

Please write :_____

Approximately how much does your family member earn from the collection annually? (Only for family consumption and not for sale, please write "0".)

About _____ Rials/year

2) No => (Please answer the next question.)

Question (22) – Does your family member including you engage in tourism business in the Anzali Wetland? (Please put only one check " √ " on one of the following choices.)

1) Yes => **What kind of tourism does your family member engage in mainly?**

a) Boating service, b) Restaurant in the wetland,

c) Sports fishing such as rental of fishing gear,

d) Others =>Please write. :_____

Approximately how much does you/your family member earn from the tourism business annually?

About _____ Rials/year

2) No => (Please answer the next question.)

Question (23) – Does your family member including you engage in any other business in the Anzali Wetland? (Please put only one check " √ " on one of the following choices.)

1) Yes => **What kind of business does your family member engage in?**

Please write :_____

Approximately how much does your family member earn from the business annually?

About _____ Rials/year

2) No => (Please answer the next question.)

Free Comment from You

Question (24) – Please write any your opinion about environmental conservation and issue.

Thank you very much for your cooperation for this questionnaire survey.

Part 2: Hydrology

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

FINAL REPORT
Volume III Supporting Report

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PART 2 HYDROLOGY

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CHAPTER 1 INTRODUCTION

The Anzali wetland is a small but distinguished landform on the southern coast of the Caspian Sea. Its watershed has a northing from N368-55' to N378-32', an easting from E488-45' to E498-42', and a total area of 3,610 km^2. The watershed is shown in Figure 1.1.1. The wetland is located at the northern part of the watershed, having a northing from N378-23' to 378-33', an easting of E 498-15' to 498-38', and an area of 193 km^2. The wetland is shown in Figure 1.1.2.

The wetland plays a key role as a habitat for many indigenous plant and animal species, and as a temporary refuge for migratory birds during the winter. Due to increased human activity upstream of the watershed however, concern has been raised over the impact of sediment runoff on the wetland. Specifically, concern has been given to increased suspended solids (which results in decreased visibility for birds and fish) and increased sedimentation (which results in a shallower wetland habitat).

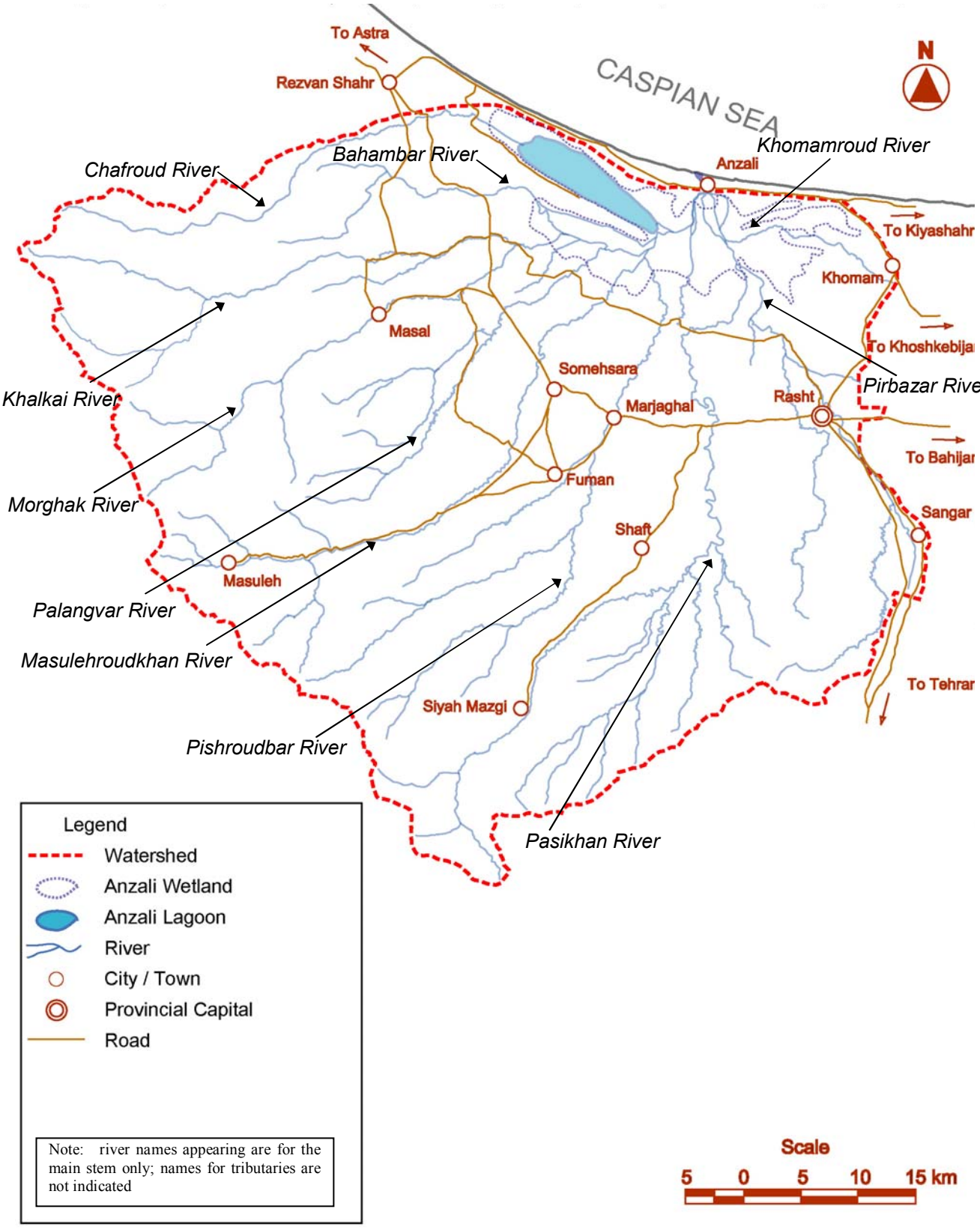
Unfortunately, the degree of sedimentation in the wetland is largely unknown due mainly to lack of investigation. Instead, accuracy is limited to statements by villagers. Some statements include: "large boats once being able to navigate in the Anzali wetland" and "depths were up to 8 m"[1].

This study was conducted to shed light on the impacts of the sediment runoff and sedimentation using a hydrological approach.

The objectives of the study are as follows.

- to grasp the general hydrological characteristics of the wetland,
- to grasp the sediment transport mechanisms within the watershed,
- to grasp the sediment transport mechanisms within the wetland, including locations of deposition and amount exiting to the Caspian Sea,
- to suggest appropriate countermeasures based on the above findings.

[1] Nezami, 1991



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 1.1.1** **Location Map of the Anzali Wetland Watershed**
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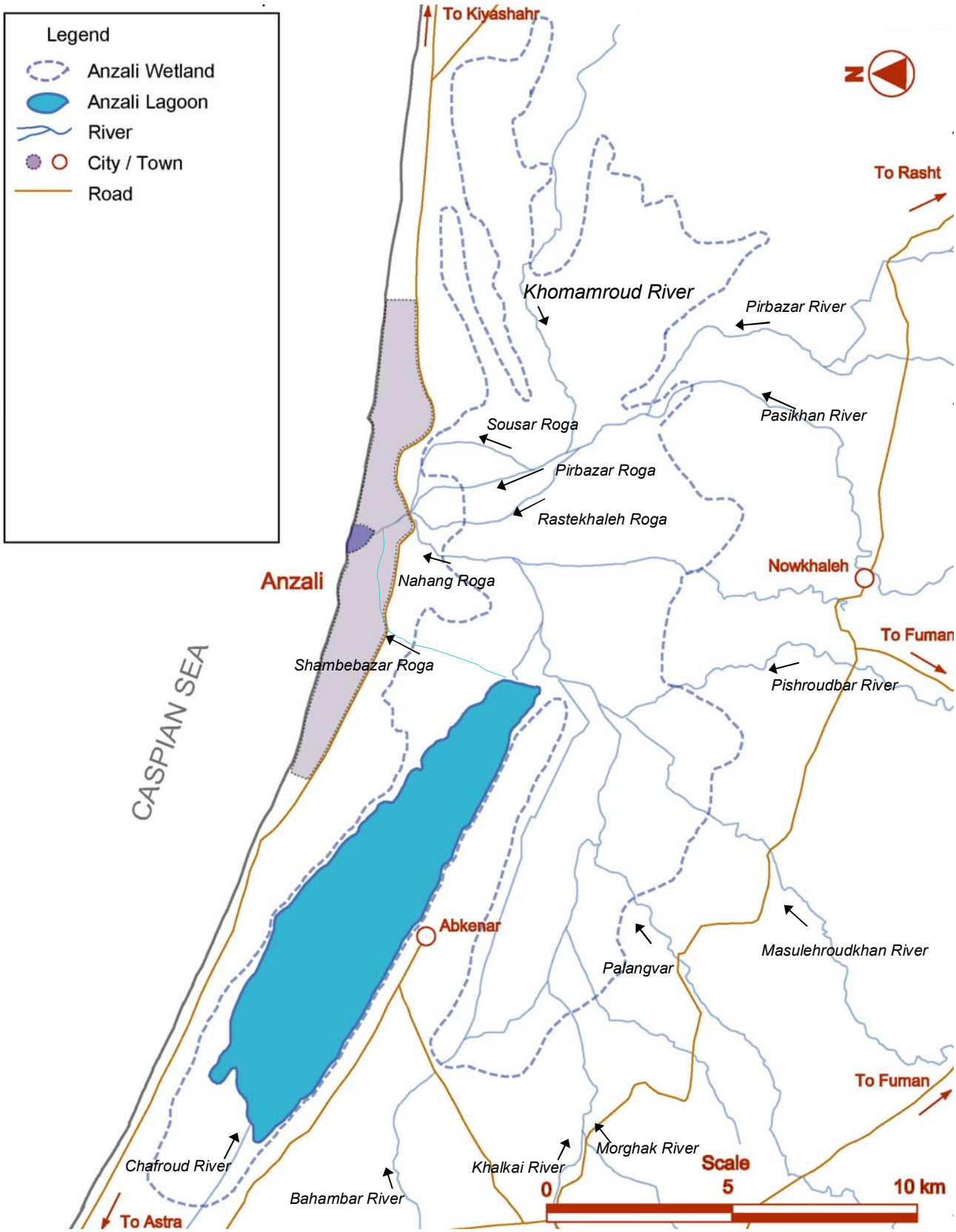

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 1.1.2** **Location Map of the Anzali Wetland**
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CHAPTER 2 METEO-HYDROLOGICAL CONDITIONS

2.1 Climate

The climate in the northern region of Iran (comprising of Guilan, Mazanadaran and Golestan provinces) is referred to as the Caspian or Hyrcanian climate. Its influence on this thin coastal strip of land along the Caspian Sea, coupled with the close proximity of the Alborz Mountain Range (EL. 2,836 m) to the south, results in a climate that is unique from the typically arid climate that is typical in the rest of Iran.

Wind in this region comes from two main directions. The predominant wind is from the north-west as a result of continental air movements, namely the Atlantic and Mediterranean fronts, while the Alborz mountain range causes a local southerly wind which starts in the mountains and moves northwards down the mountains and towards the plains and coast. Rainfall is abundant in this region, varying greatly between 400-2,000 mm per year. The rainfall is the greatest in the west and gradually decreases towards the east. Evaporation increases from west to east with a regional average of 800 mm. Temperature is mild, and ranges between -0.8°C - 37.3°C with an average of 17°C. Relative humidity varies depending on the location and season, having ranges between 24-100% and a regional average of 66%.

The climate in the Anzali watershed can be divided into three main zones based on elevation. In the lowlands, having elevation between EL. - 20 m and 100 m, humidity and rainfall is high, especially along the coast, while temperatures are mild to warm. The rainfall along the coast of the watershed is especially high with Anzali Port rainfall station reporting the greatest mean annual rainfall along Iran's Caspian coast of 1,800 mm. This is attributed to the northwesterly winds which carry moisture from the Caspian Sea and is trapped at the base of the Alborz Mountains. The rainfall decreases southward along the lowlands. In the midlands between EL. 100 m to 800 m, there is again an increase in rainfall but it is relatively less humid and cooler. The highlands above EL. 800 m are generally dry and cool with decreased rainfall.

2.2 Meteorological and Hydrological Monitoring

(1) Meteorological Monitoring

The Islamic Republic of Iran Meteorological Organization (IRIMO) and the Ministry of Energy (MOE), Water Resources Investigation Section both collect meteorological and

rainfall data in Iran. The number of stations each organization manages, both nationally and within the Anzali wetland watershed, is shown in Table 2.2.1.

Table 2.2.1 Meteorological Stations by Organization

(Unit: no. of stations)

Organization	National	Anzali Wetland Watershed
IRIMO	2,420	2
MOE	1,619	15
Total	4,039	17

Source: data by IRIMO and MOE

At the stations, temperature, relative humidity, wind, precipitation and rainy days are measured. Data collected by MOE was readily available was used in this Study. The climate data availability is shown in Table 2.2.3 and locations are shown in Figure 2.2.1.

(2) Discharge Measurement

The responsibility for hydrological discharge measurements lies solely with the MOE. They maintain discharge gaging stations throughout Guilan Province, including 21 stations for rivers within the Anzali watershed. Their activities include periodic (once or twice a month) discharge measurements as shown in Figure 2.2.1, preparation of rating curves, and gage maintenance. The data availability for gages in the Anzali watershed is shown in Table 2.2.4 and their locations are shown in Figure 2.2.2. Their breakdown, based on station type, is shown in Table 2.2.2.

Figure 2.2.1 Discharge measurement by MOE (Pasikhan River)

Table 2.2.2 Breakdown of Discharge Stations by Type

(Unit: no. of stations)

Type of Station	National	Anzali Wetland Watershed
Staff gage only	350	12
Staff gage with Data Recorder	400	3
Staff gage, Data Recorder and Cable Car	350	6
Total	1,100	21

Source: data by MOE

(3) Sediment Measurement

The MOE collects suspended sediment samples at the same location that discharge measurements are made. The samples are collected manually in standard 500 ml bottles by wading or cable car. The samples are brought back to their laboratory and tested in house. All results are sent to MOE Tehran for further analysis and compilation.

Table 2.2.3 Climate Data Availability

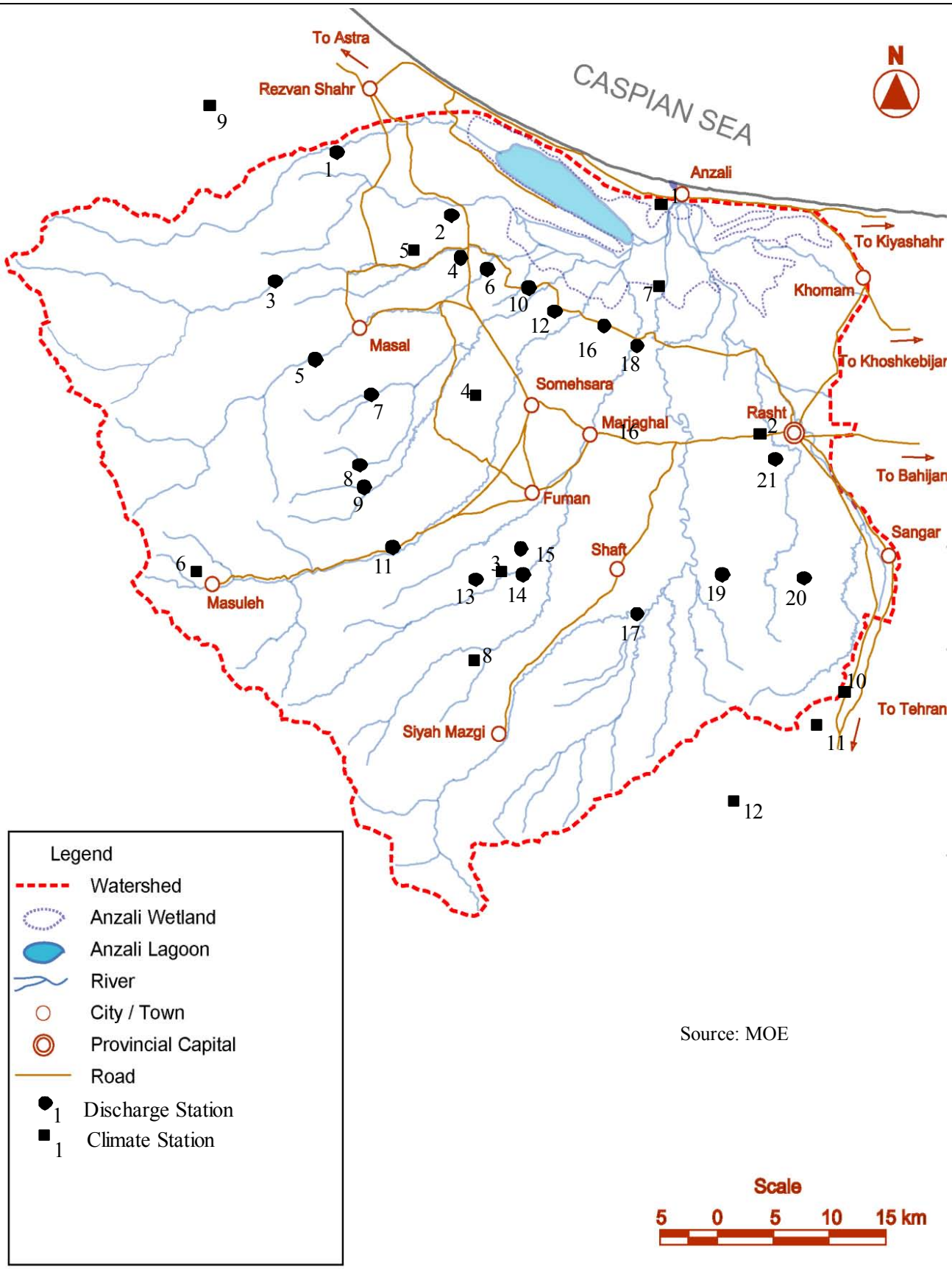
No.	Station	MOE Code	Northing	Easting	Elevation (m)	Year																																Number of Years
Within watershed						67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96			
1	Anzali	18002	37-28	49-28	-16	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■				■			26
2	Rasht	17082	37-15	49-36	-3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■			28
3	Ghaleroudkhan	18003	37-05	49-15	125	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					■	■	■	■	■	■			24
4	Kasma	18007	37-19	49-17	-5	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■		■	■				■	■	■	■	■	■	■	■			24
5	Shanderman	18017	37-26	49-08	31	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■			26
6	Masoleh	18105	37-09*	48-49*	950																									■	■	■	■	■	■				5
7	Chaparpar	18108	37-26	49-28	-19																										■	■	■	■	■	■			4
8	-	18059	37-05	49-14	170																				■	■	■		■	■	■	■	■	■	■				9
Near watershed																																						
9	Ponel	18021	37-32	49-05	75	■	■	■	■	■	■	■	■											■	■	■	■	■	■	■	■	■	■	■	■	■			20
10	Sarvan	17089	37-01	49-40	90																			■	■	■	■	■	■	■	■	■	■	■	■	■			12
11	Baragvar	17049	37-00	49-38	130			■	■	■	■	■	■	■	■		■	■	■	■																			12
12	Tarikroud	17047	36-59	49-33	120		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■														19

Note:
* - reporeted coordinates are incorrect
Source: MOE

Table 2.2.4 Discharge Data Availability

No.	River	Station	MOE Code	Northing	Easting	Elevation (m)	Catchment Area (km^2)	Year																																No. Years*
								49	50	51	×	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	
1	Chafroud	Roudbarsara	18019	37-29-19	49-05-51	135	131.7				×	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■		27
2	Bahmbar	Aghamahaleh	18095	37-27-41	49-14-02	-15	150.6				×													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		16
3	Morghak	Imamzadeh Shafe	18067	37-24-16	49-03-27	160	235.7				×											■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		17
4	Morghak	Kotemjan	18093	37-27-15	49-16-24	-19	328.4				×													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		16
5	Khalkai	Taskooh	18065	37-19-56	49-04-25	190	215.9				×									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		20
6	Khalkai	Kotemjan	18091	37-25-12	49-16-41	-19	310.8				×													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		16
7	Tanianroud	Mianbar	18921	37-19-06	49-10-07	68	39.8				×																									■	■	■	■		4
8	Siavaroud	Siavaroud Alian	18923	37-15-16	49-08-57	100	12.5				×																									■	■	■	■		4
9	Palangvar	Masjed Pish Alian	18920	37-18-57	49-09-03	54	48.3				×																										■	■	■		3
10	Palangvar	Kalsar	18089	37-23-48	49-19-52	-23	227				×												■	■			■	■	■	■	■	■	■	■	■	■	■	■	■		15
11	Masulehroudkhan	Kamadol	18063	37-10-30	49-07-45	240	223.7	■	■	■	×											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		18
12	Masulehroudkhan	Chomesghal	18087	37-22-23	49-21-52	-22	406.8				×													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			15
13	Gashteroudkhan	Pirsara	18061	37-08-06	49-12-34	200	72.5				×											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		18
14	Nazaralat	Ghaleroudkhan	18059	37-06-21	49-16-16	140	83.8				×											■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■		17
15	Ghaleroudkhan	Ghaleroudkhan	18030	37-06-25	49-16-35	140	112				×																							■	■	■			■		4
16	Shakhraz	Laksar	18083	37-21-12	49-25-17	-20	429.3				×											■		■	■	■	■	■	■	■	■	■	■		■	■	■	■			15
17	Imamzadeh Ibrahi	Mobarakabad	18106	37-04-04	49-24-58	60	118.8	■	■	■	×																					■	■	■	■		■	■	■		7
18	Pasikhan	Nokhaleh	18081	37-20-59	49-27-09	-20	751.2				×													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			15
19	Goharroud	Lakan	17967	37-10-56	49-34-04	40	29.2				×																	■	■	■	■	■	■	■	■	■	■	■	■		12
20	Siahroud	Behdan	17111	37-10-15	49-38-53	40	93.1				×														■	■	■	■	■		■			■	■	■	■	■	■		12
21	Siahroud	Polesazeman	17053	37-15-28	49-36-46	4	147.2				×	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		27

Note:
■ each year refers to September of indicated year to August of following year
* records prior to 1974 are not included in the total
Source: MOE



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran

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Figure 2.2.2
Location of Climate and Discharge Gaging Stations

2.3 Meteorological Conditions

Coastal precipitation is highest in the watershed (Anzali Station: 1,828 mm/year, 21 years) and decreases southward (Rasht Station: 1,271 mm/year, 30 years, Ghalehroudkhan Station: 1,619 mm/yr, 27 years). An isoheytal map based on limited data was prepared and is shown in Figure 2.3.1.

Precipitation is most abundant between October and January, while it is the least abundant between April and July as shown by the monthly precipitation records for selected stations in Table 2.3.1 below. This seasonal change is less apparent towards the mountains. The average annual rainfall for the watershed was 1,200 mm[2]. Monthly records are summarized below and are also given in the Data Book.

Table 2.3.1 Monthly Precipitation

(Unit: mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Anzali	182.8	133.1	111.2	50.7	50.9	43.0	46.0	130.2	197.1	338.8	299.7	244.6	1,828.1
Rasht	131.4	121.7	76.6	59.0	46.3	44.6	53.4	119.5	195.1	177.2	150.2	110.8	1,271.5
Shanderman	63.7	83.3	54.5	67.7	52.8	39.3	65.6	124.5	157.1	110.2	89.6	68.1	890.0
Ghalehroudkhan	105.9	117.5	95.5	106.1	105.4	108.8	119.5	238.7	220.0	170.5	143.7	101.5	1,618.9

Source: data by MOE

The average annual temperature at Rasht station is 16.3°C with the coldest month being January and warmest month being July. Air temperature at Rasht Station is shown in Table 2.3.2.

Table 2.3.2 Maximum, Average and Minimum Monthly Air Temperature at Rasht

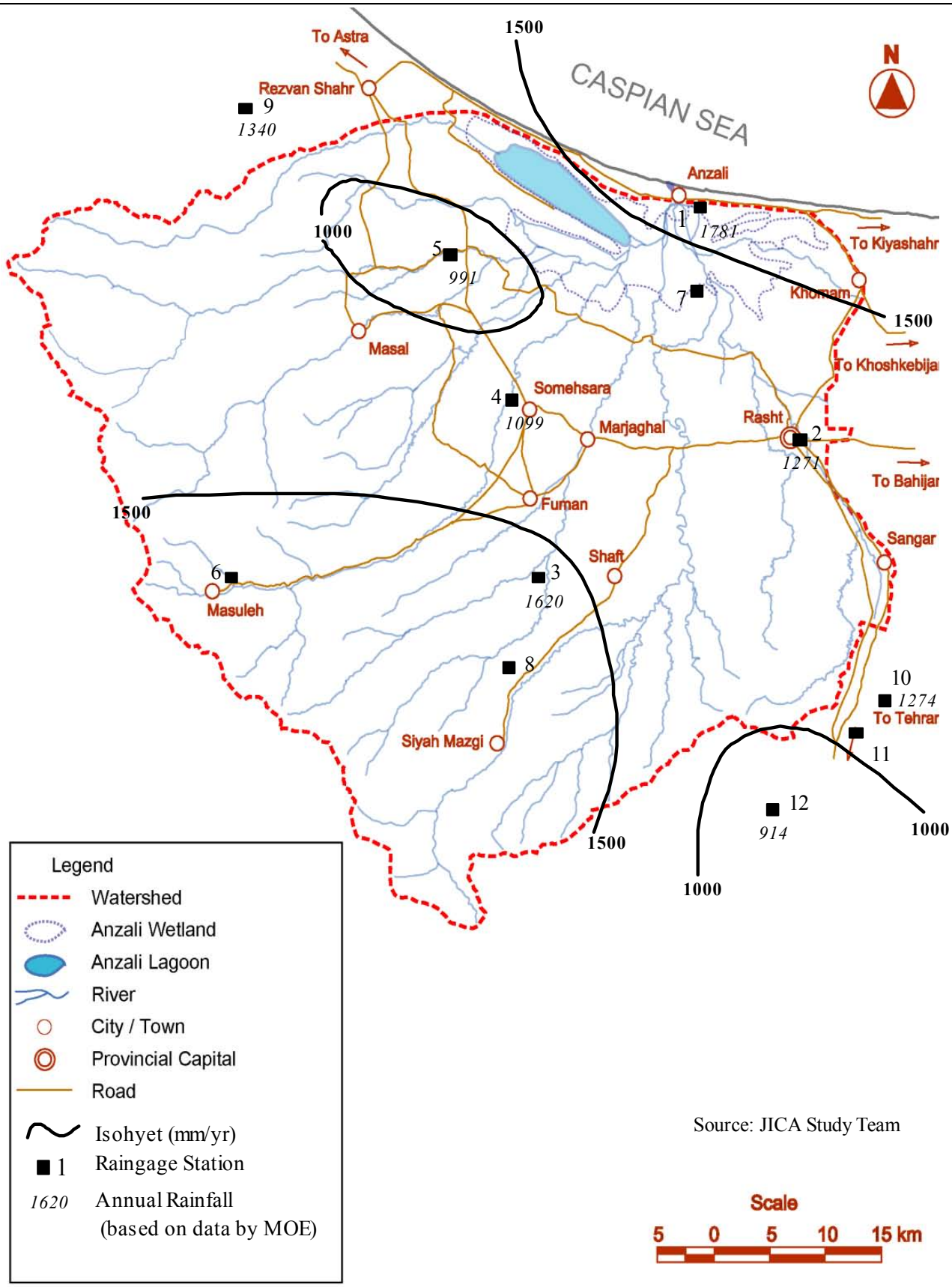
(Unit: °C)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
Max.	11.4	12.4	18.4	23.7	27.9	30.7	31.3	29.0	25.2	19.8	16.0	12.6	21.5
Avg.	6.8	8.1	13.4	18.3	22.6	25.3	26.0	23.8	19.8	14.8	10.8	7.8	16.3
Min.	2.1	3.8	8.2	13.0	17.2	19.9	20.7	18.6	14.3	9.8	5.5	2.9	11.3

Source: data by MOE

Evaporation is greatest during the summer months of June and July while they are at their lowest during November and December as shown in Table 2.3.3.

[2] Calculated in this Study based on rainfall data by MOE .



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran

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Figure 2.3.1
Isohyetal Map

Table 2.3.3 Monthly Evaporation

(Unit: mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rasht	39.9	35.5	71.1	92.0	139.6	166.2	151.5	141.0	68.3	43.8	38.9	33.5	1,038.5
Shanderman	36.4	38.5	68.6	88.4	128.5	163.3	151.3	103.7	64.4	46.7	36.8	35.0	819.2
Ghalehroudkhan	37.2	38.5	67.2	89.9	111.8	126.3	131.2	93.4	59.7	39.5	36.9	39.7	875.3

Source: data by MOE (values do not consider pan correction)

Relative humidity in the area is considered high, reaching a monthly mean of 86% during the wet months and monthly low of 73% during the dry months. Table 2.3.4 shows the relative humidity at Anzali and Rasht.

Table 2.3.4 Monthly Relative Humidity

(Unit: %)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Anzali.	83	86	86	84	82	76	73	77	82	85	86	85	82
Rasht	84	87	85	80	74	76	75	78	82	87	86	87	82

Source: The Port Sector Study of the Islamic Republic of Iran, Volume IV -Anzali, JICA 1995

2.4 Hydrological Conditions

The Anzali Wetland watershed has a catchment area of 3,610 km^2. There are 10 major river systems entering the wetlands. The subcatchment area ranges between 100 to 700 km^2. These rivers have perennial flow with origins in the Alborz Mountains to the south. Starting from the eastern-most side of the wetland, the Khomamroud River flows westward and enters the wetland from the east. The Pirbazar and Pasikhan Rivers flow northward and merge just before entering the wetland. The Pishroudbar (also called Shakhraz), Masulehroudkhan, Palangvar, Khalkai, Morghak and Bahambar Rivers flow northeast and enter the wetland area. The Chafroud River alone enters the Anzali lagoon from the west. All rivers eventually drain into the Caspian Sea via the Anzali wetland. The location of the rivers is shown in Figure 1.1.2.

The water year for rivers of the Anzali watershed starts roughly in September (exact month is based on the Iranian calendar) until August of the following year. Examination of monthly discharge data reveals that there are two periods of high flow for the rivers in the Anzali Wetland watershed. The first occurs in October/November due primarily to runoff during the rainy season. The second occurs in February/March due to snowmelt from the mountain areas.

The annual mean discharge into the wetlands is estimated to be 76.14 m^3/s, or 2,400 MCM. This value is similar to that estimated in MOJA, 1989 which was reported to be 75 m^3/s. Annual average discharge by river at MOE discharge stations is given in Table 2.4.1 below.

Table 2.4.1 Average Annual Discharge of Rivers in the Anzali Wetland Watershed

No.	River	Station	Number of Recording Years	Average Annual Discharge (m^3/s)
1	Chafroud	Roudbarsara	27	2.13
2	Bahmbar	Aghamahaleh	16	1.91
3	Morghak	Imamzadeh Shafee	17	4.72
4	Morghak	Kotemjan-M	16	3.55
5	Khalkai	Taskooh	20	4.79
6	Khalkai	Kotemjan -K	16	4.62
7	Tanianroud	Mianbar	4	(0.71)
8	Siavaroud	Siavaroud Alian	4	(0.40)
9	Palangvar	Masjed Pish Alian	3	(1.17)
10	Palangvar	Kalsar	15	7.09
11	Masulehroudkhan	Kamadol	18	4.40
12	Masulehroudkhan	Chomesghal	16	5.84
13	Gashteroudkhan	Pirsara	17	2.55
14	Nazaralat	Ghaleroudkhan	17	(2.49)
15	Ghaleroudkhan	Ghaleroudkhan	4	(2.76)
16	Shakhazar	Laksar	15	10.45
17	Imamzadeh Ibrahim	Mobarakabad	7	4.14
18	Pasikhan	Nokhaleh	15	22.98
19	Goharroud	Lakan	12	0.88
20	Siahroud	Behdan	12	2.07
21	Siahroud	Polesazeman	27	5.53

Source: JICA Study Team

The values in parentheses are questionable due to either their short duration or due to possible station location error.

During the rainy season, some of the rivers overtop their banks in the lower reaches just prior to entering the Anzali wetland. Based on flood damage records collected by MOJA Guilan (records from 1996 to 2003), low-lying areas (generally between EL. -20 to -25 m) surrounding the Pasikhan, Pishroudbar, Masulehroudkhan and Khalkaii rivers underwent flooding which caused damage to agricultural land, transmission lines and to a lesser extent buildings. When the dates which the floods occurred were cross checked with MOE discharge records, they indicate that the periods of high water level generally lasted for 2 to 4 days. Due to the fact that these events occur annually, the floods are not due to extreme storm events but due to the combination of insufficient flood conveyance capacity of the rivers and the lack of flood plain management.

Irrigation water shortages or drought in the watershed was not reported to be a problem by MOJA Guilan. This is because any irrigation water shortages as a result of natural runoff are supplemented by trans-basin inflow from two diversions on the Sefidroud river. The first is via the Tarik dam which lies approximately 35 km downstream of the Sefidroud dam. Water is diverted by the dam through the Fuman tunnel (L=15 km, capacity 8 m^3/s) where it feeds

the Fuman irrigation system, a gravity-fed system which covers most of the irrigated areas in the watershed through a series of gates, siphons and open channels. The second diversion is via the Sangar dam which lies a further 20 km downstream of the Tarik dam. This diversion dam supplies irrigation and commercial water to the area surrounding Rasht.

The annual total volume is shown in Table 2.4.2 which shows the distribution of river flow into the wetland. The lagoon, Siakeshim and central/eastern areas receive 3%, 46% and 51% of the inflows respectively. Monthly discharge is given in the Data Book.

Table 2.4.2 Annual River Discharge

Unit: MCM

Year	Chafroud	Bahmbar	Morghak	Khalkai	Palangvar	Masulehroudkhan	Shakhazar	Pasikhan	Pirbazar	Remainder**	Total
1965-84	71.3		75.1	118.3	170.9	135.9	322.6	433.9	173.4	61.8	1,563
1986	70	65 *	128 *	182 *	263	199 *	375 *	714 *	168	256	2,419
1987	64	60	118	168	218 *	186	351	670	158	256	2,251
1988	71	66	124	161	221 *	188	335	629	161	256	2,212
1989	57 *	53	110	124	182 *	155	316	708	177	256	2,139
1990	65 *	63	118	141	225	192	359	788	204	256	2,411
1991	47	46	89	110	182	161	265	509	128	256	1,792
1992	83	78	179	210	325	280	479	952	177	256	3,019
1993	90	90	194	232	315	298	502	1,128	235	256	3,339
1994	73	53	144	215	174	222	331	771	218	256	2,456
1995	36	31	68	93	156	84	184	482	148	256	1,538
1996	120	61	105	161	233	222	281 *	735	173	256	2,348
1997	55	62	102	137	251	169	378 *	770	172	256	2,354
1998	63	78	118	150	218	220	345	844	204	256	2,496
1999	45	50	41	67	148	121	222	494	117	256	1,562
2000	72	68	71	110	184	133	327	783	174	256	2,179
2001	55	39	81	105	178	128 *	316 *	635 *	141	256	1,934
Avg	67	60	112	148	217	185	336	726	172	256	2,278

Groups			
	67	1,057	1154
	2.9%	46.4%	50.7%

Note: * - supplemented using closest station
Source: MOE and JICA Study Team

CHAPTER 3 HYDROLOGICAL FEATURES OF THE ANZALI WETLAND AND ITS WATERSHED

3.1 Recent Hydrological Change of the Anzali Wetland

Data on the hydrological conditions of the Anzali wetland was limited however records of its change were available. The change in water surface area over the past 70 years is given in Table 3.1.1 below and is shown in Figure 3.1.2. The surface area in 1989 is about one fifth of the surface area in 1930.

Table 3.1.1 Change in Anzali Wetland Water Surface and Caspian Water Level

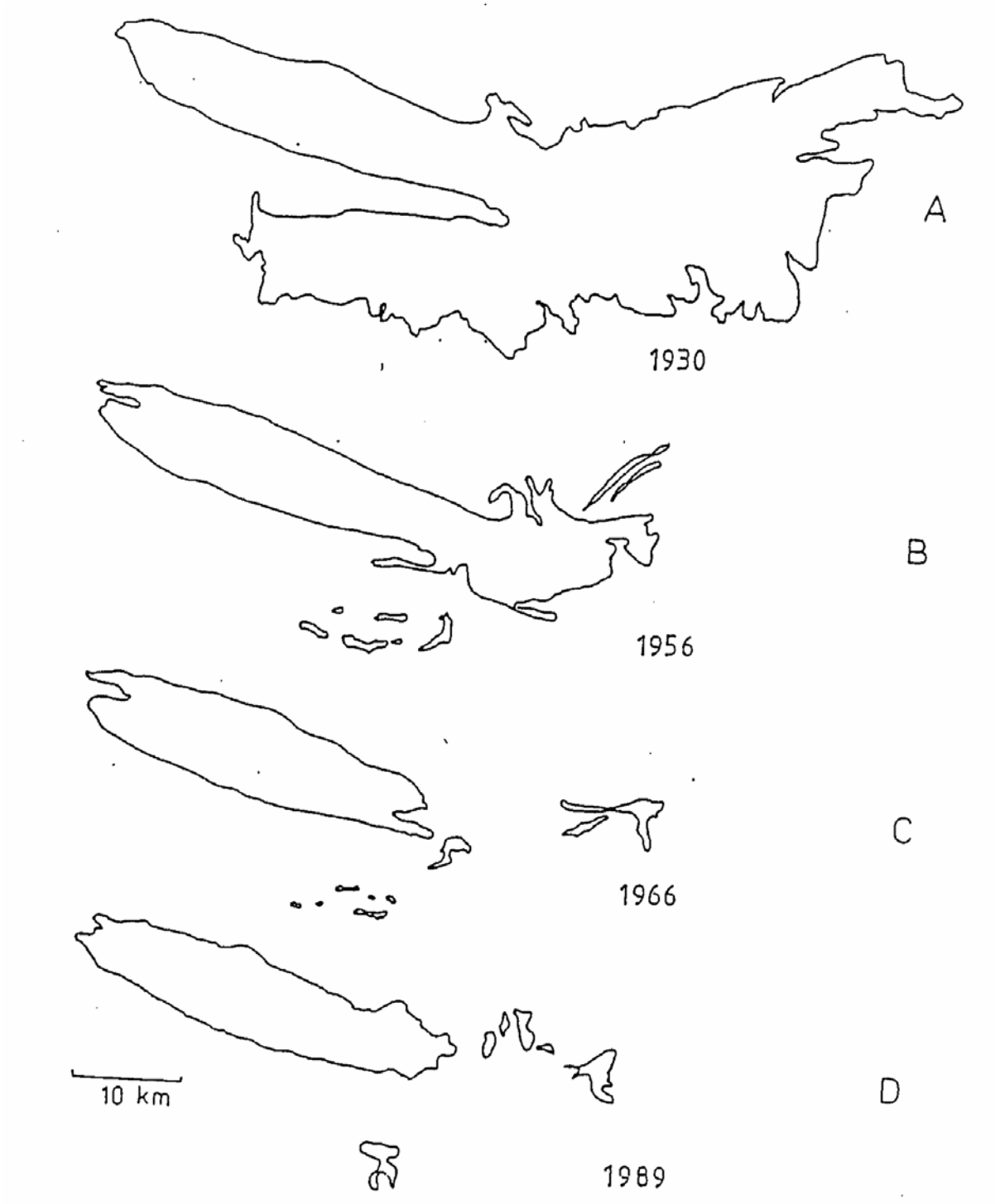
Year	Water Surface (km^2)	Caspian WL_{avg}
1930	258	-25.39m
1956	88	-27.63m
1966	54	-27.71m
1977	-	-28.44m
1989	57	-26.99m
2002	-	-26.47m

Source: maps by Nezami, 1991 (measured by Study Team);
WL data by Caspian Port Authority

The average annual water level of the Caspian Sea (the only outlet of the Anzali wetland) is also indicated in the table. The data suggests a casual correlation between changes in surface area and Caspian Sea water level.

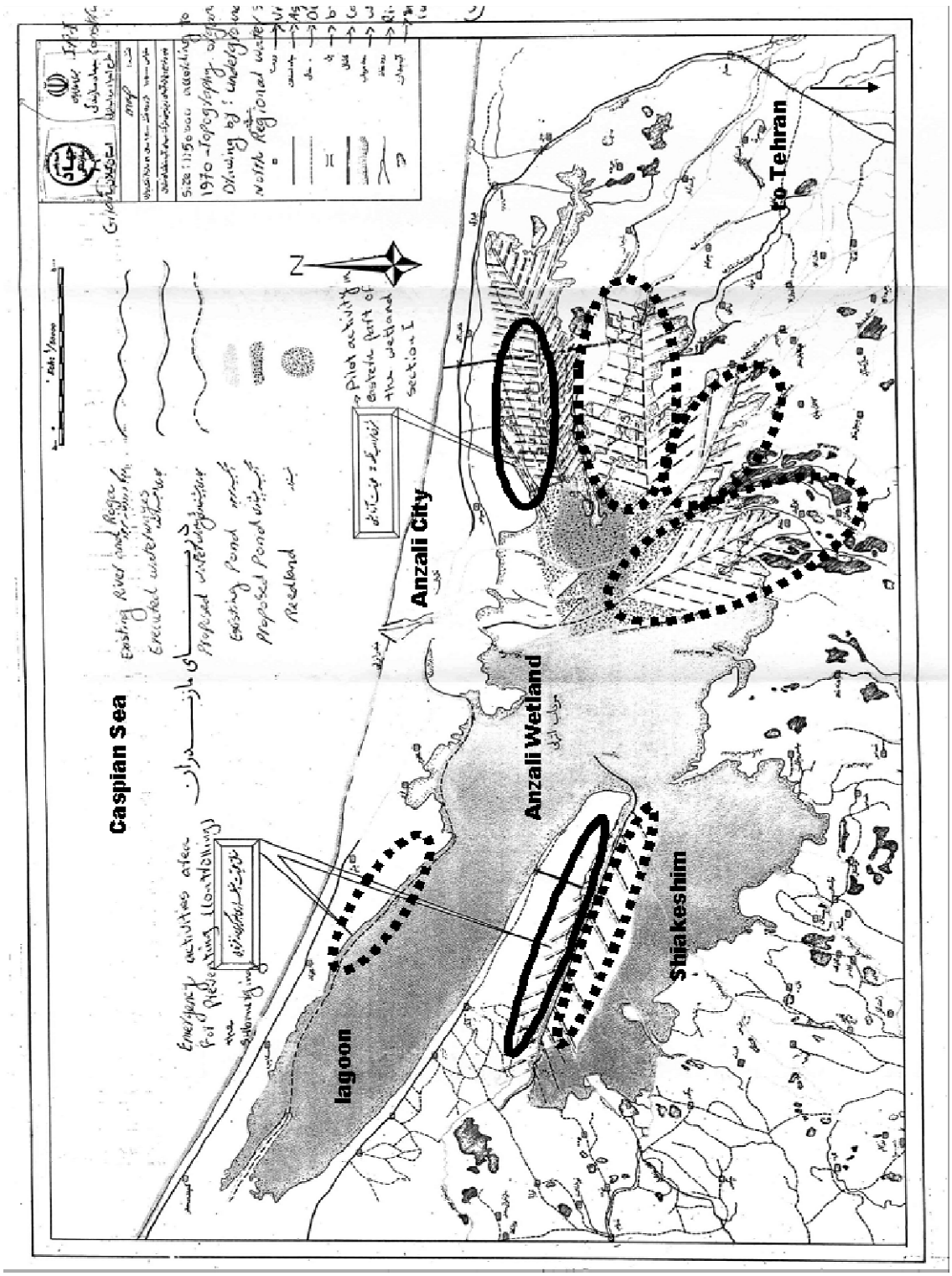
Figure 3.1.1 Remnants in the Talebabad

Old land use plans for the area surrounding the wetland also support the above. Using the irrigation schematic shown in Figure 3.1.3, MOJA officials explained that during the 1970's, many parts of the wetland were dry and therefore, could to be converted into rice paddy fields. Aerial photos taken in the 1970's indicated that the plan was partially implemented. By the late 1980's and early 1990's (when the Caspian Sea level rose) however, much of the low lying areas were flooded. There was extensive damage to crops, houses and property as shown in Figure 3.1.1.



Source: Nezami 1991

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 3.1.2** **Changes in Surface Area of the Anzali Wetland**
JAPAN INTERNATIONAL COOPERATION AGENCY	



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 3.1.3** **Plan of Irrigable Areas in the Wetland by MOJA in 1971**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Attempt to construct mud dyke walls to prevent water inflow had limited success. Most of the area remains submerged today, however some farmers are attempting to reclaim their land by dredging and dewatering.

3.2 Features of the Anzali Watershed

The watershed of the Anzali wetland is a very small part of the south Caspian Sea coastline. The entire area of the South Caspian coastal watershed is reported to be approximately[3] 177,000 km^2, while the Anzali watershed catchment area comprises of only 3,610 km^2 or roughly 2.0%.

Based on land cover and elevation, the watershed can be divided into three general landforms. The first landform is a mountainous area, occupying the southern-most part of the watershed. It has lush forests at the lower regions, grassland in the middle regions, and bare land in the upper regions. The highest elevation is approximately 3,100 m. The second landform is a relatively flat plain to the north of the mountains ranging in elevation from -25 m to 100 m. The third is the Anzali wetland situated on the northern part of the plain area with elevation of roughly -26 m. General features are shown in Table 3.2.1.

Table 3.2.1 Area of the Watershed by Major Landform

Landform	Measured Area (km^2 ,%)	Average Gradient
Mountain Area[4]	1,843 (51)	6-15%
Plain Area	1,597 (44)	0.2-0.9%
Wetland Area	170 (5)	<0.2%
Total	3,610 (100)	-

Source: measured by JICA Study Team using Landsat image

There are nine major rivers which originate in the mountain area and flow in a northerly direction to the wetland. The river names, catchment area, elevation, and slope are shown in Table 3.2.2. The Pasikhan River catchment is the largest at 751 km^2 and the Bahamber River catchment is the smallest at 151 km^2.

[3] according to Caspian Environment Program – Coastal Profiles
[4] Mountain area refers to the portion of the watershed that is higher than EL.100m.

Table 3.2.2 Features of the Rivers in the Anzali Wetland

No.	River	Elevation (m ASL)		River Length (m)		Average Slope		Catchment Area (km^2)
		Maximum	Minimum	Mountain	Plain	Mountain	Plain	
1	Chafroud	2,194	-23	31,400	13,000	6.7%	0.91%	131.7
2	Bahmber	925	-23	5,600	21,400	14.7%	0.44%	150.6
3	Morghak	2,846	-22	25,400	22,000	10.8%	0.77%	328.4
4	Khalkaii	3,110	-22	21,000	28,000	14.3%	0.62%	310.8
5	Palangvar	1,000	-23	11,200	25,000	8.0%	0.37%	227
6	Masulehroudkhan	3,110	-25	20,100	38,000	15.0%	0.43%	406.8
7	Shakhraz	2,200	-25	23,000	33,700	9.1%	0.29%	429.3
8	Pasikhan	2,900	-23	39,800	46,000	7.0%	0.19%	751.2
9	Pirbazar	810	-23	8,200	52,000	8.7%	0.26%	147.2

Source: JICA Study Team

3.3 Features of the Anzali Wetland

The area of the Anzali wetland that is registered under the Ramsar Convention[5] is 150 km^2, however based on GIS imagery, the area was determined to be 193 km^2 by the Study Team. Physically, it is characterized by a large oval-shaped lagoon to the west, the Shiakishim protected area to the southwest, ponded open water surfaces like the Hosenbekhandeh to the east, and multiple drainage channels with more ponds, including the Selke and Solkankol wildlife refuge in the center.

The lagoon is presently about 17 km in length, 3.5 km in maximum width and ranges between 2.5 m to 3 m in depth at the center. Using a depth–volume curve prepared by MOJA in 1991, the capacity is approximately 100 MCM. The surface area was roughly 49km^2. There is only one inlet to the lagoon, the Chafroud River from the west, while there are two outlets, namely the Nahang *roga*[6] to the east and Shambebazar *roga* to the north (refer Figure 1.1.2).

The Siakeshim area is a designated protected area in the south-western part of the wetland. Inflows include the Morghak/Khalkaii, Palangvar, Masuhelroudkhan and Bahambar Rivers from the west and south. The only outlet is to the east. It is surrounded by rice paddy fields.

The central channels are fed by Pasikhan and Pirbazar rivers which enter from the south while the east is fed by the Khomamroud river from the east. The channels range between 0.5 m to 2.5 m in depth and is lined with macrophyte and reeds.

[5] www.ramsar.org

[6] local Persian word meaning 'channel'

There are a total of five *roga*s, namely Shambebazar, Nahang, Rastekhaleh, Pirbazar and Sousar, which are the only means for water to escape to the Caspian Sea. Four flow in the central area and one from the lagoon. They are generally between 0.7 m to 3 m in depth. Two of the channels, Rastekhaleh and Nahang *roga*, were deepened by MOJA in the 1980s using dredging equipment purchased from the Netherlands.

CHAPTER 4 HYDROLOGICAL CHARACTERISTICS OF THE STUDY AREA

4.1 Watershed Hydrology

The hydrology of the watershed is affected mainly by the rainfall, evaporation and diverted amount from the Tarik and Sangar diversion structures as shown in Figure 4.1.1.

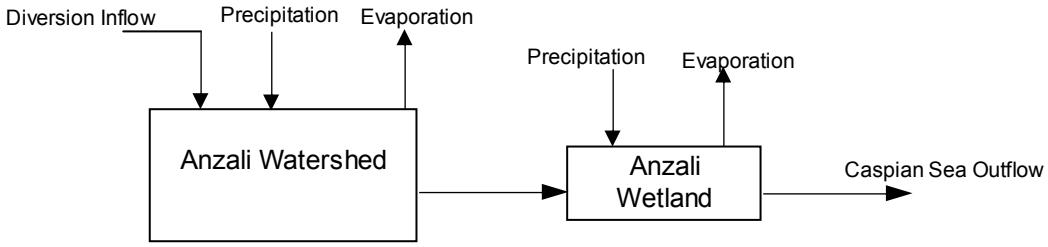


Figure 4.1.1 Water Flow in the Anzali Watershed

(1) Rainfall and Evaporation

Rainfall and evaporation data availability was shown in Table 2.2.2. Data for eight rainfall stations within the watershed and four stations near the watershed were collected, having an average of 23 years duration. Evaporation data was limited to four stations.

The average annual rainfall for the catchment area was estimated using the Thiessen polygon method. The basin average rainfall was approximately 1,160 mm (after applying an aerial reduction factor to the point rainfall). The calculations are shown in Table 4.1.1.

Average annual evaporation measurements were generally between 900 to 1,000 mm, having an arithmetic mean of 953 mm. By multiplying this value by 0.9 for pan correction, the annual average becomes 858 mm.

(2) Tarik and Sangar Diversion

The Tarik diversion weir and the Sangar diversion weir both lie on the neighboring Sefiroud River to the east of the Anzali watershed. They were constructed to divert irrigation water and industrial water into the Anzali watershed, especially during the cropping season when natural flows are low.

The Tarik diversion uses the Fuman Tunnel (roughly 16.5 km in length, dia.=3.5 m, irrigation area=65,000 ha) that runs through the mountains to the irrigation channels on the other side. It is directly connected to the Fuman irrigation channel which runs from east to west across the entire watershed by gravity.

The Sangar diversion uses irrigation pipes to convey water. MOE was responsible for construction and the present operators of the weirs.

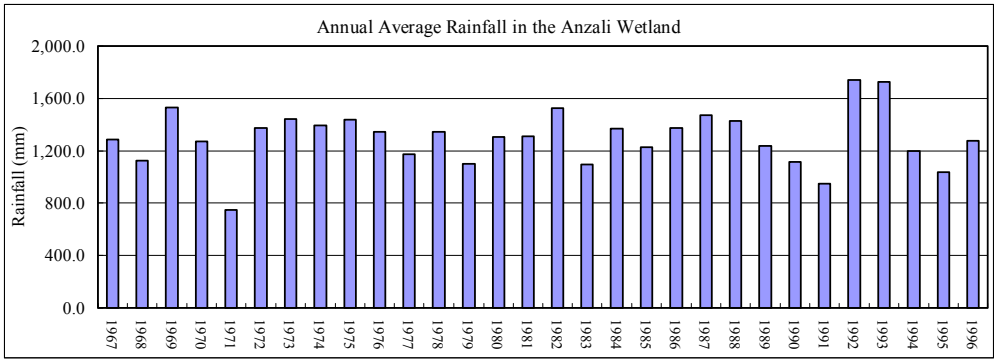
Table 4.1.1 Annual Average Rainfall

Unit:(mm)

	Raingage								Basin	Note
	Anzali	Rasht	Ghaleroudkhan	Kasma	Shanderman	Ponel	Sarvan	Tarikroud	Average	
	18002	17082	18003	18007	18017	18021	17089	17047		
Years	26	28	24	24	26	20	12	19	30	
1967	1,418.1	1,349.6	1,536.3	1,159.7	936.4	1,401.0	-	-	1,282.5	1
1968	1,716.1	1,432.7	-	1,069.1	934.6	1,297.0	-	858.5	1,124.2	2
1969	2,217.5	1,384.6	-	1,618.6	1,560.0	1,468.5	-	993.7	1,531.0	2
1970	1,588.3	1,170.4	1,745.3	1,012.2	854.9	1,861.0	-	917.0	1,271.2	3
1971	1,247.9	833.9	751.1	590.2	573.2	1,006.0	-	735.4	746.1	3
1972	2,149.4	1,494.7	1,254.3	1,399.4	1,188.5	1,427.5	-	1,031.9	1,373.2	3
1973	1,484.7	1,168.8	1,665.6	1,044.7	-	2,144.5	-	775.8	1,440.5	4
1974	1,695.8	1,122.3	1,652.3	1,021.5	-	1,760.0	-	1,025.7	1,394.5	4
1975	2,359.7	1,296.7	1,529.0	1,551.5	1,130.3	-	-	991.3	1,439.5	5
1976	2,239.3	1,278.7	1,804.0	1,154.1	814.4	-	-	873.6	1,341.3	5
1977	2,110.8	1,140.1	1,568.5	839.9	767.0	-	-	755.1	1,173.2	5
1978	1,947.6	1,333.7	1,819.0	935.9	1,046.8	-	-	770.5	1,346.4	5
1979	1,523.2	1,066.0	1,326.0	1,018.0	862.0	-	-	738.1	1,097.7	5
1980	1,542.8	1,143.3	1,670.5	1,180.7	1,065.7	-	-	1,053.5	1,303.9	5
1981	1,649.4	1,250.7	1,626.0	-	942.1	-	-	1,186.8	1,309.3	6
1982	2,420.1	1,600.8	1,702.5	-	1,081.8	-	-	1,065.1	1,524.7	6
1983	1,566.4	886.0	1,404.6	931.9	895.0	-	-	839.6	1,097.3	5
1984	1,943.2	1,408.2	1,611.1	-	979.2	-	-	978.5	1,367.0	6
1985	1,787.4	1,449.8	1,118.1	1,153.2	1,101.2	1,423.5	1,128.0	866.4	1,224.8	4
1986	2,098.4	1,167.5	1,611.3	1,308.0	1,122.3	1,133.0	1,210.0	927.0	1,372.7	3
1987	1,754.3	1,338.4	2,010.8	-	883.7	1,284.5	1,407.0	-	1,473.9	7
1988	1,701.9	-	-	-	-	1,276.5	1,326.0	-	1,426.0	8
1989	1,593.3	-	-	-	-	1,009.0	1,155.0	-	1,237.4	8
1990	1,237.6	1,396.0	-	1,074.5	920.8	1,041.5	1,221.0	-	1,115.3	9
1991	-	1,116.9	-	914.3	878.6	1,022.5	896.0	-	948.6	11
1992	1,786.9	1,562.5	2,377.6	1,429.5	1,301.6	1,595.0	1,596.0	-	1,738.5	10
1993	-	1,643.1	2,415.0	1,362.5	1,328.7	1,432.5	1,675.0	-	1,727.6	12
1994	-	1,319.5	1,567.5	954.0	892.0	928.5	1,291.0	-	1,197.9	12
1995	-	1,148.9	1,322.5	839.0	765.0	985.0	1,095.0	-	1,034.4	12
1996	1,527.9	1,099.3	1,809.5	821.5	961.0	1,310.0	1,298.0	-	1,278.7	10
Avg.	1,781.1	1,271.5	1,620.8	1,099.3	991.8	1,340.4	1,274.8	914.9	1,298.0	
								Area Reduction Factor:	1	
								Basin Average:	1,168.2	

Thiessen Weights

1	0.0921	0.1727	0.2964	0.1694	0.2376	0.0318			1
2	0.0921	0.1429		0.3410	0.2481	0.0318		0.1441	1
3	0.0921	0.1419	0.2717	0.1699	0.2382	0.0318		0.0544	1
4	0.0941	0.1451	0.2774	0.2686		0.1621		0.0527	1
5	0.0921	0.1419	0.2717	0.1699	0.2700			0.0544	1
6	0.1196	0.1637	0.3202		0.3429			0.0536	1
7	0.1214	0.1635	0.3380		0.3138	0.0319	0.0314		1
8	0.3170					0.3872	0.2958		1
9	0.0892	0.1620		0.3833	0.2455	0.0318	0.0882		1
10	0.0921	0.1475	0.2917	0.1694	0.2375	0.0318	0.0300		1
11		0.2040		0.4269	0.2483	0.0318	0.0890		1
12		0.1922	0.2924	0.2116	0.2420	0.0318	0.0300		1



Source: MOE and JICA Study Team

The salient features of the Tarik and Sangar Diversions are given in Table 4.1.2.

Table 4.1.2 Salient Features of Diversion into Anzali Watershed

Feature	Tarik Diversion	Sangar Diversion
Source	Sefidroud River	
Type	Concrete ogee, gated spillway	Concrete gated spillway
Year Completed	1966	1966
No. of Gates	9@15 m each	13 @ 15m each
Total Width	162 m	231 m
Height	15 m	7.5 m
EL., Crown	168 m	103.5 m

Source: Regional Irrigation and Drainage Committee of Guilan website

Table 4.1.3 are the quantities of water diverted into the Anzali watershed by the diversions.

Table 4.1.3 Summary of Diverted Water into Anzali Watershed

Month	Tarik Diversion	Sangar Diversion
Apr. – Jul.	32 m^3/s	8 m^3/s
Aug.-Mar.	1 m^3/s	0 m^3/s
Annual Volume	353MCM	83MCM

Source: information from MOE Guilan office

(3) Discharge

Daily discharge data for the 21 stations was collected. Data for 14 hydrologic stations was available for 15 years. Five stations had records of less than 10 years and four of those stations had less than 5 years. Two stations had durations longer than 20 years.

To assess the suitability of the hydrological data, the data was checked by creating double mass curves which are plots of mean discharge against individual station discharge. The double mass curves for each station are shown in Figure 4.1.2. From the graphs, it is shown that the stations generally exhibit a linear relationship indicating that the measurements are relatively consistent and are acceptable for use.

The annual discharge into the wetland was 76.1 m^3/s, or 2,400MCM/yr (which is similar to MOJA, 1989 which reported 75 m^3/s). It is noted that two major rivers (Pirbazar River and Khomanroud River) and some minor rivers (Ghannadi River and Bijroud River) also flow into the wetland but are not monitored at present. These rivers were monitored in the past and therefore, the historical averages were used to estimate the overall watershed discharge.

Using the above, the runoff rate was determined to be 55% as calculated in Table 4.1.4. This compares well to other basins which range from as low as 10% and as high as 65%[7]

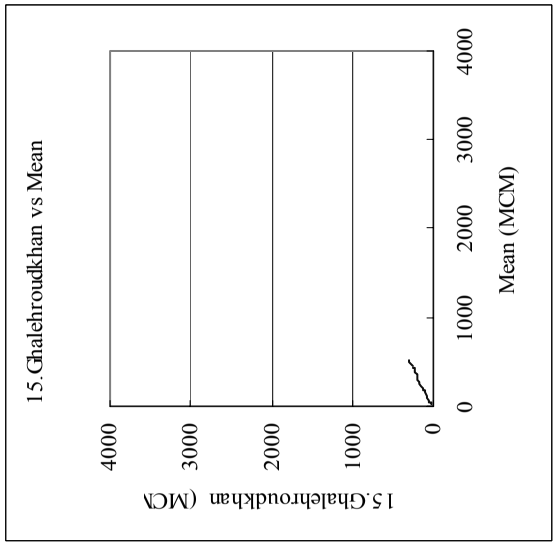
[7] Coastal Profiles, Caspian Environment Program, based on massifs in the western Caspian coastline

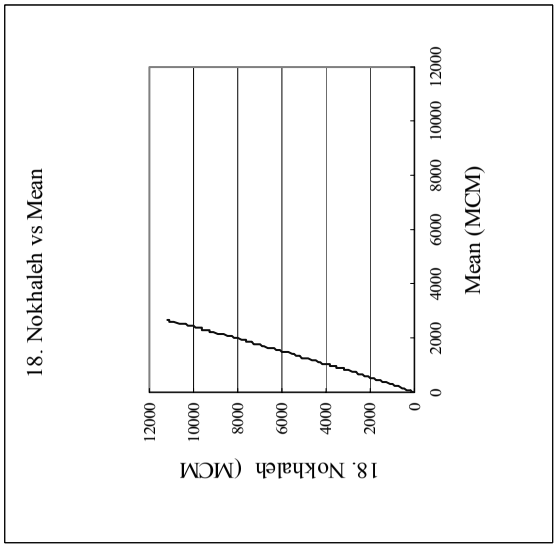
Figure 4.1.2 (1/4)
Mass Curves for Discharge Stations

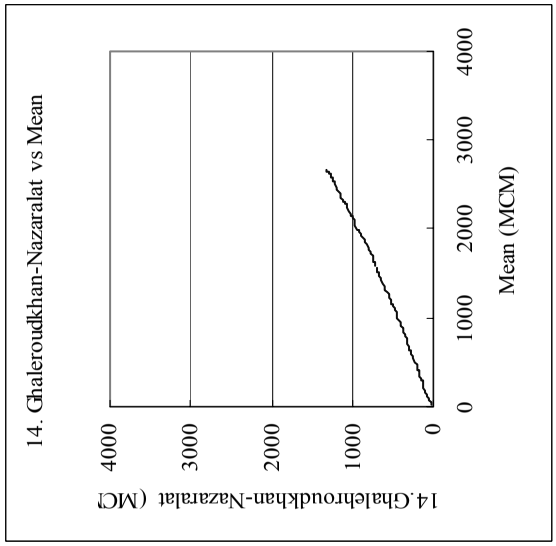
Source: MOE Analzi and JICA Study Team

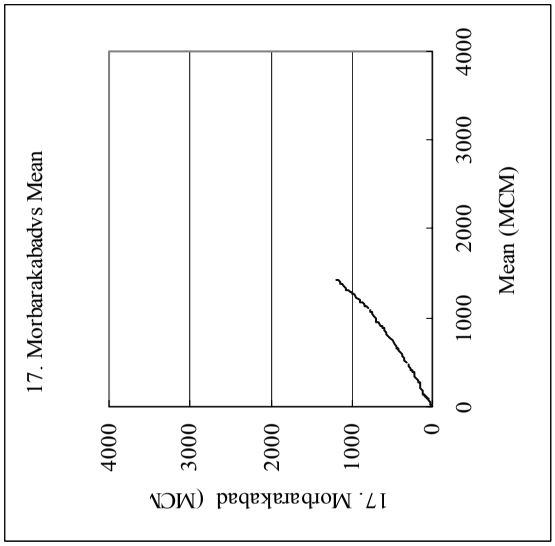
Figure 4.1.2 (2/4)
Mass Curves for Discharge Stations

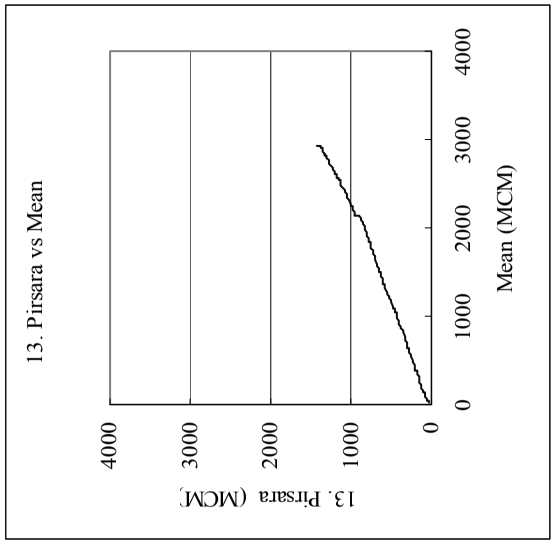
Source: MOE Analzi and JICA Study Team

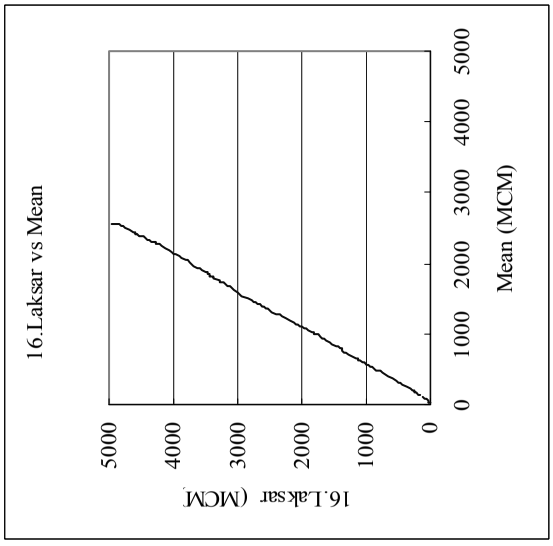












Source: MOE Analzi and JICA Study Team

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Figure 4.1.2 (3/4)
Mass Curves for Discharge Stations

Source: MOE Analzi and JICA Study Team

Figure 4.1.2 (4/4)
Mass Curves for Discharge Stations

Table 4.1.4 Watershed Runoff

Unit: MCM

Year	Rainall (R)	Evaporation (E)	Balance (R-E)	$Q_{diversion}$ Sangar	$Q_{diversion}$ Fuman	(R-E)+ $Q_{diversion}$	Q_{out}	Difference	Runoff Rate w/o Diversion	Runoff w/ Diversion	Note
1986	4,460.0	3,086.6	1,373.5	82.9	352.9	1,809.4	2,419.3	0.25	0.54	0.44	
1987	4,788.7	3,086.6	1,702.2	82.9	352.9	2,138.1	2,250.5	0.05	0.47	0.38	
1988	4,633.1	3,086.6	1,546.5	82.9	352.9	1,982.4	2,212.1	0.10	0.48	0.38	
1989	4,020.3	3,086.6	933.8	82.9	352.9	1,369.7	2,138.6	0.36	0.53	0.42	
1990	3,623.5	3,086.6	537.0	82.9	352.9	972.9	2,410.9	0.60	0.67	0.55	
1991	3,081.9	3,086.6	0.0	82.9	352.9	435.9	1,792.5	0.76	0.58	0.44	
1992	5,648.3	3,086.6	2,561.8	82.9	352.9	2,997.6	3,019.2	0.01	0.53	0.46	
1993	5,613.0	3,086.6	2,526.4	82.9	352.9	2,962.3	3,339.1	0.11	0.59	0.52	
1994	3,892.1	3,086.6	805.5	82.9	352.9	1,241.4	2,455.6	0.49	0.63	0.52	
1995	3,360.6	3,086.6	274.1	82.9	352.9	710.0	1,537.9	0.54	0.46	0.33	
1996	4,154.5	3,086.6	1,067.9	82.9	352.9	1,503.8	2,348.0	0.36	0.57	0.46	
	4,297.8	3,086.6					2,356.7		0.55	0.45	

Source: MOE and JICA Study Team

When the diversion inflow is not included in the overall flow, the natural runoff rate can be as low as 45%. This implies that the wetland inflow relies considerably on the diverted inflow. The total inflow volume (436 MCM = 353+83) is equivalent to about 1.5 times the wetland volume.

(4) Duration Curve

Duration curves were prepared for each river to determine their runoff characteristics. The curves were grouped by location within the watershed as shown in Figure 4.1.3. By observation, the figure confirms that the western basin rivers are generally smaller in flow than the eastern basins. This is likely because of the difference in rainfall distribution mentioned earlier.

In summary, the surface runoff from the watershed of the Anzali wetland is a large factor that drives the wetland hydrology. It is aided by water from two diversions which increase the wetland inflow by as much as 10% (compare 45% without diversion to 55% with diversion).

4.2 Wetland Hydrology

During site observations, it was confirmed that the boundary provided by MOE coincided with the conditions for wetland hydrology[8]. However, it should be pointed out that the portion of the Anzali wetland which is affected by wetland hydrology can vary over relatively

[8] conditions include submerged land, wetland vegetation, alluvial soils, abundant rainfall and depression topography

short periods of time (decades) as shown by the change in water surface in Figure 4.2.1.

While there was no data available for most of the items, general estimates based on available data are made here.

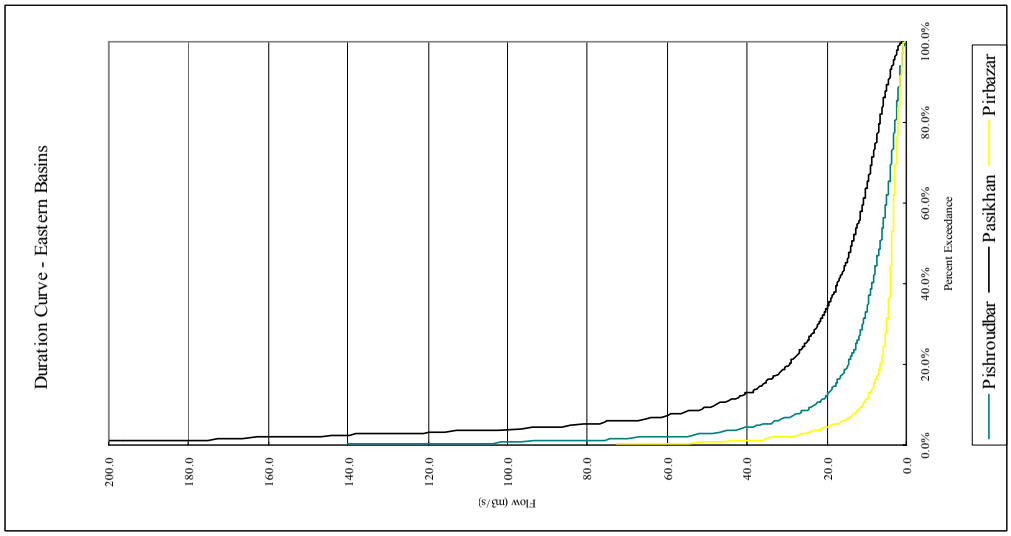
(1) Rainfall and Evaporation

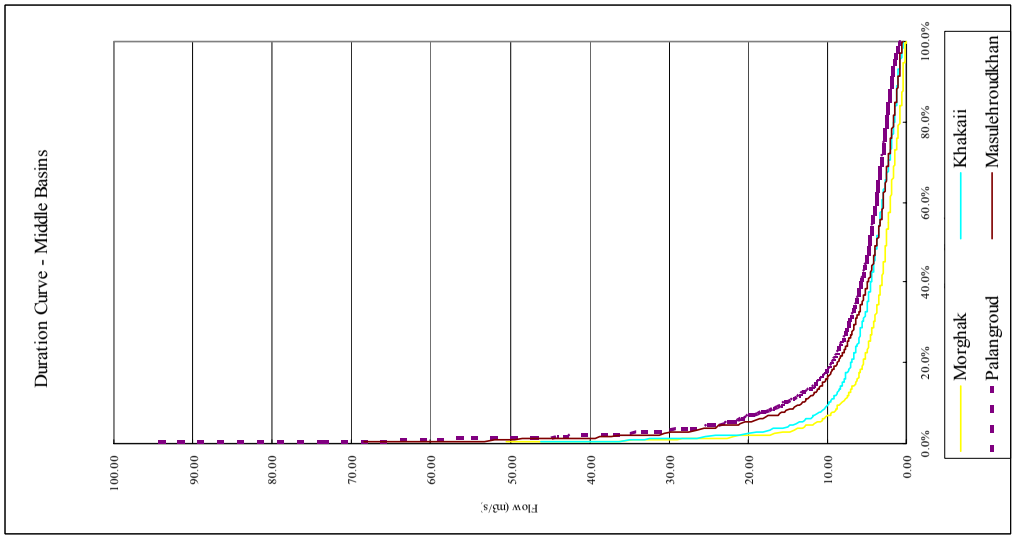
Using Anzali station rainfall and evaporation data, the net rainfall over the wetland was calculated to be 116.9 MCM (=1,802 mm x 0.9 -1,038 mm x 0.9=687.6 mm), or less than 5% of the total surface inflow of 2,400 MCM. While this percentage is low, the abundant Anzali rainfall helps to keep soils in a hydric condition.

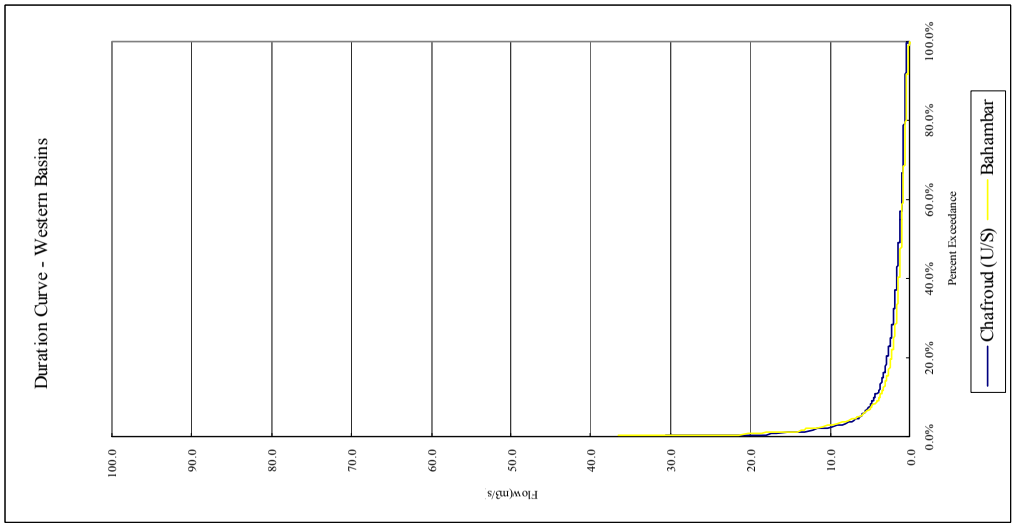
(2) Wetland Bathymetry

No data was available for the bathymetry which covered the entire wetland. Some surveys have been conducted by foreign and Iranian engineers in the past, but they focused primarily on the lagoon portion with the aim of developing fish culture facilities.

During the Study, a bathymetric study of the key areas of the wetland was conducted. They included the lagoon, channels and portions of Siakeshim. The results were summarized by drawing the longitudinal profiles as shown in Figure 2.2.1. Details of the survey are given in the Data Book. They show that the channels bottom slopes are smaller for the channel sections in the upstream of the lagoon (around 0.01-0.02%) than the channels reaches in the downstream of the lagoon towards the Caspian Sea (around 0.07-0.08%). They also show that the bottom elevation of the Siakeshim area is depressed as evidenced by an approximate depth change of 1.6m.







Source: JICA Study Team

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Figure 4.2.1
Flow Duration Curves

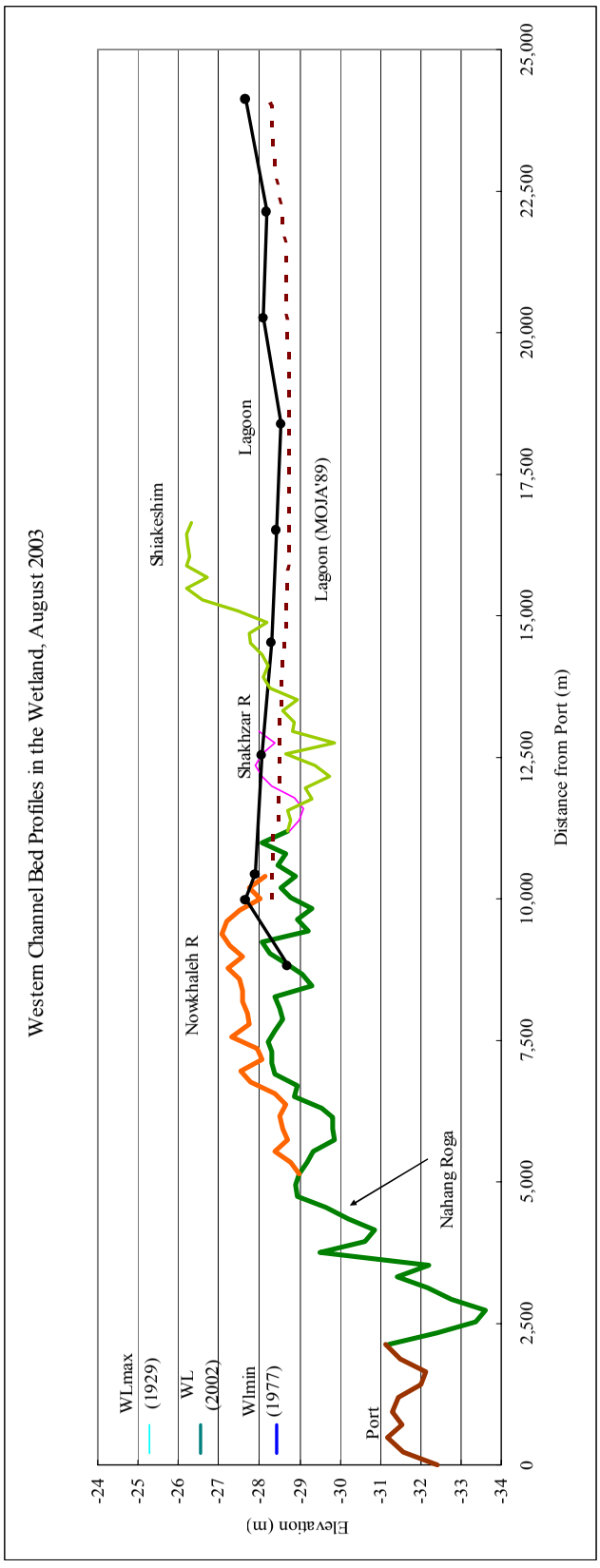
(3) Wetland Volume and Retention Time

As mentioned above, no surveys have been conducted for the entire wetland, thus the total volume could not be determined. Based on map study and bathymetric data collected during the Study, the total volume of the wetland is estimated to be approximately 300 MCM (water surface area of 193 km^2 and average depth of 1.55 m). Based on the annual inflows, the hydraulic retention time, or the time required to replenish the volume of the wetland, is estimated to be about 48 days(Overflow rate = 300 million m^3 / 71. 9 m^3/s ÷ 86,400 s/day = 48 days).

(4) Channel Velocity

The velocity in the channels of the wetland is not measured at present. Based on visual observations, velocities ranged from almost stagnant in the western lagoon and Siakeshim area to noticeably moderate in the eastern and central channels. Visual observation of the channel velocity during normal flow appeared to be about 0.6-1.4 m/s. Hydraulic simulation using the results of the bathymetric survey appears to agree with this observation as shown in Figure 4.2.2. The change in velocity can be attributed to 1) the steeper bed slopes and 2) past dredging activity in the eastern channels.

From the above, it can be inferred that while the surface water is vital to the wetland, it is not a constant inflow distribution but varies depending on wetland topography.



Source: JICA Study Team

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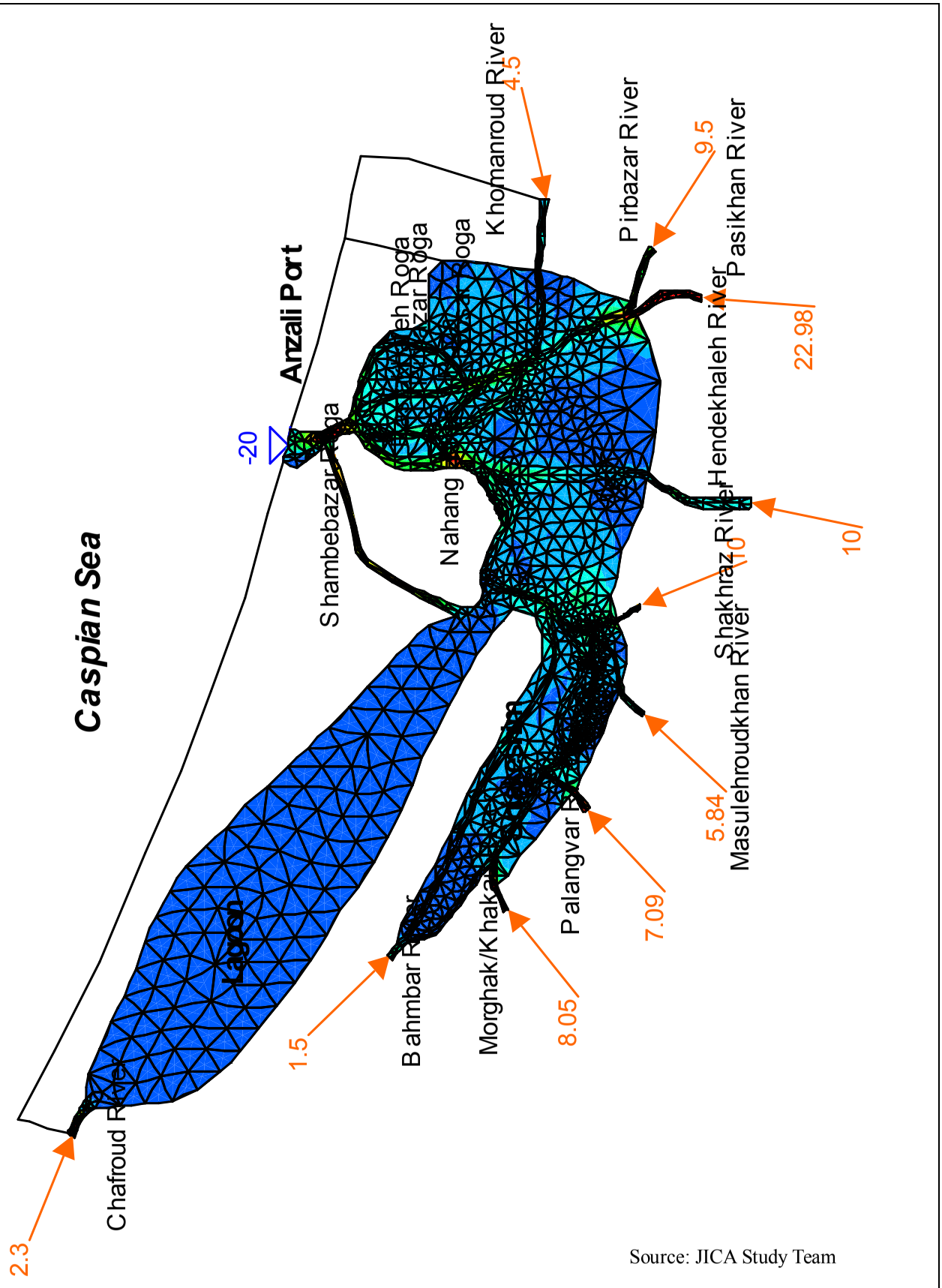
Figure 4.2.2
Longitudinal Channel Bed Profiles in the Wetland



Source: JICA Study Team

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 4.2.3** **Velocity Distribution in the Wetland**
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4.3 Hydraulic Influence from the Caspian Sea

In the previous section, the impact of surface water on the wetland was investigated. In this section, the impact from the downstream Caspian Sea, the only outlet, the Caspian Sea at Anzali port, is considered.

The Caspian Sea has a capacity of roughly 78,700,000 MCM[9] against a wetland capacity of 300 MCM. There are no structures between these two water bodies and no sudden breaks in water profile, therefore any fluctuation in Caspian Sea water level will affect the water level in the wetland. Due to its influence on the hydrology of the wetland, its characteristics are examined here.

4.3.1 Measurements of Caspian Sea Water Level

Water levels of the Caspian Sea are measured at Anzali Port and the average annual water level between 1930 and 2000 is shown in Figure 4.3.1. The maximum and minimum water levels are summarized below. They show that the level has dropped over 3 m in the past 70 years. Examination of the data in the last 30 years shows an even more significant rise of over 2 m as summarized in Table 4.3.1 below.

Table 4.3.1 Maximum and Minimum Caspian Water Levels since 1930

Item	Since 1930		Recent	
	Year	WL (msl)	Year	WL (msl)
Maximum	1929	-25.27	1994	-26.10
Minimum	1977	-28.44 (diff.=3.17m)	1977	-28.44 (diff.=2.34m)

Source: MOJA data received from Anzali Port Authority

It is noted that the Caspian Sea fluctuates in a sinusoidal pattern over long distinct periods of time, however year-to-year predictions of its fluctuation are impossible. This is due to the incomplete understanding of the interrelations between the inflowing hydrology and the meteorological conditions around the sea.

Next, the monthly fluctuation is analyzed. The annual fluctuation of the water level for the four years between 1999 and 2002 is shown in Figure 4.3.2. It shows a cyclic pattern characterized by a high in the summer and low in the winter. The amplitude ranges from 0.51 to 0.74 m each year. The water level at the port is measured three times a day and therefore the exact daily tidal fluctuation is unknown. The spread of the three readings each day is very small, suggesting that the daily tide is not significant.

[9] Caspian Environment Program, 78,700km^3 (http://www.caspianenvironment.org/caspian.htm)

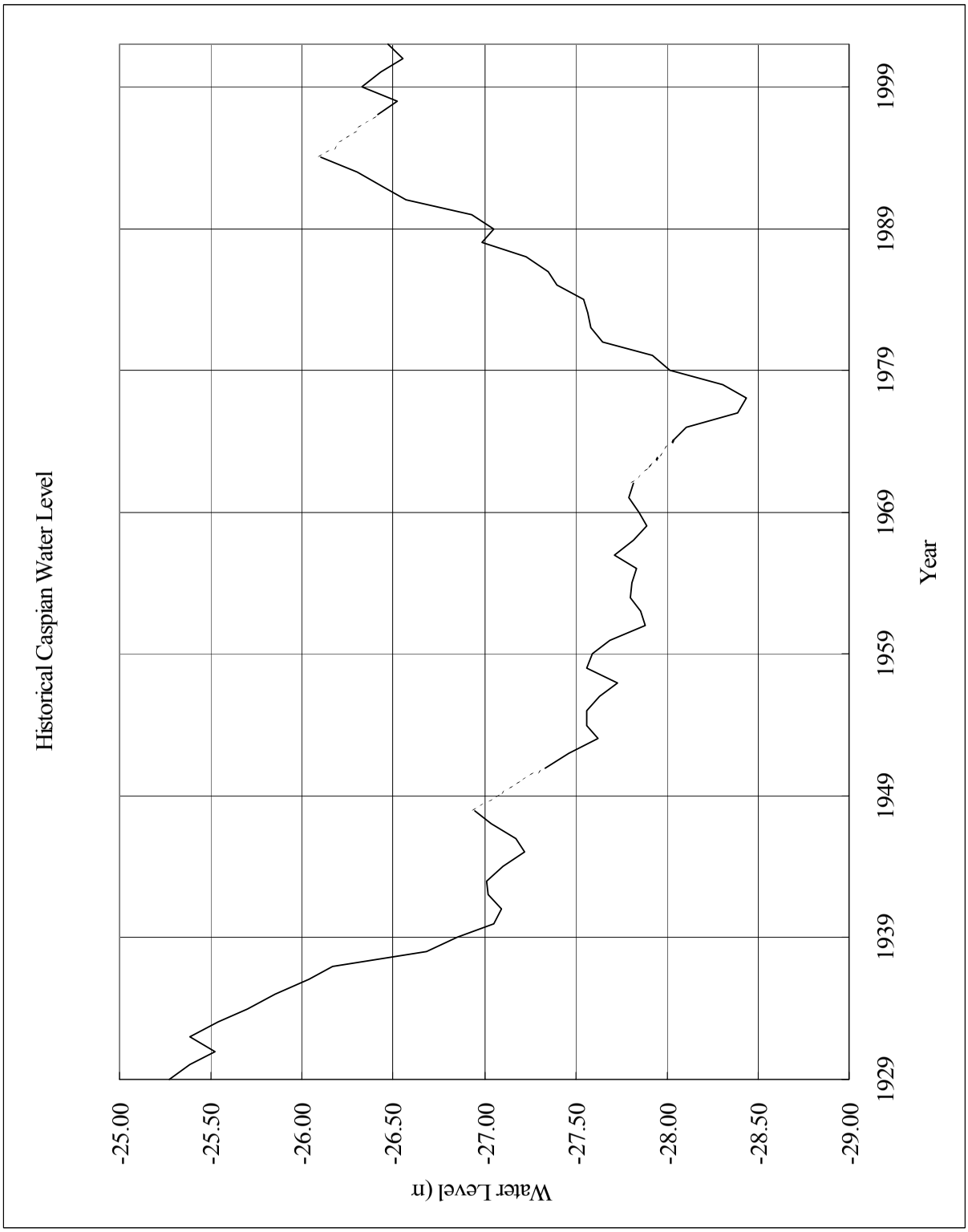

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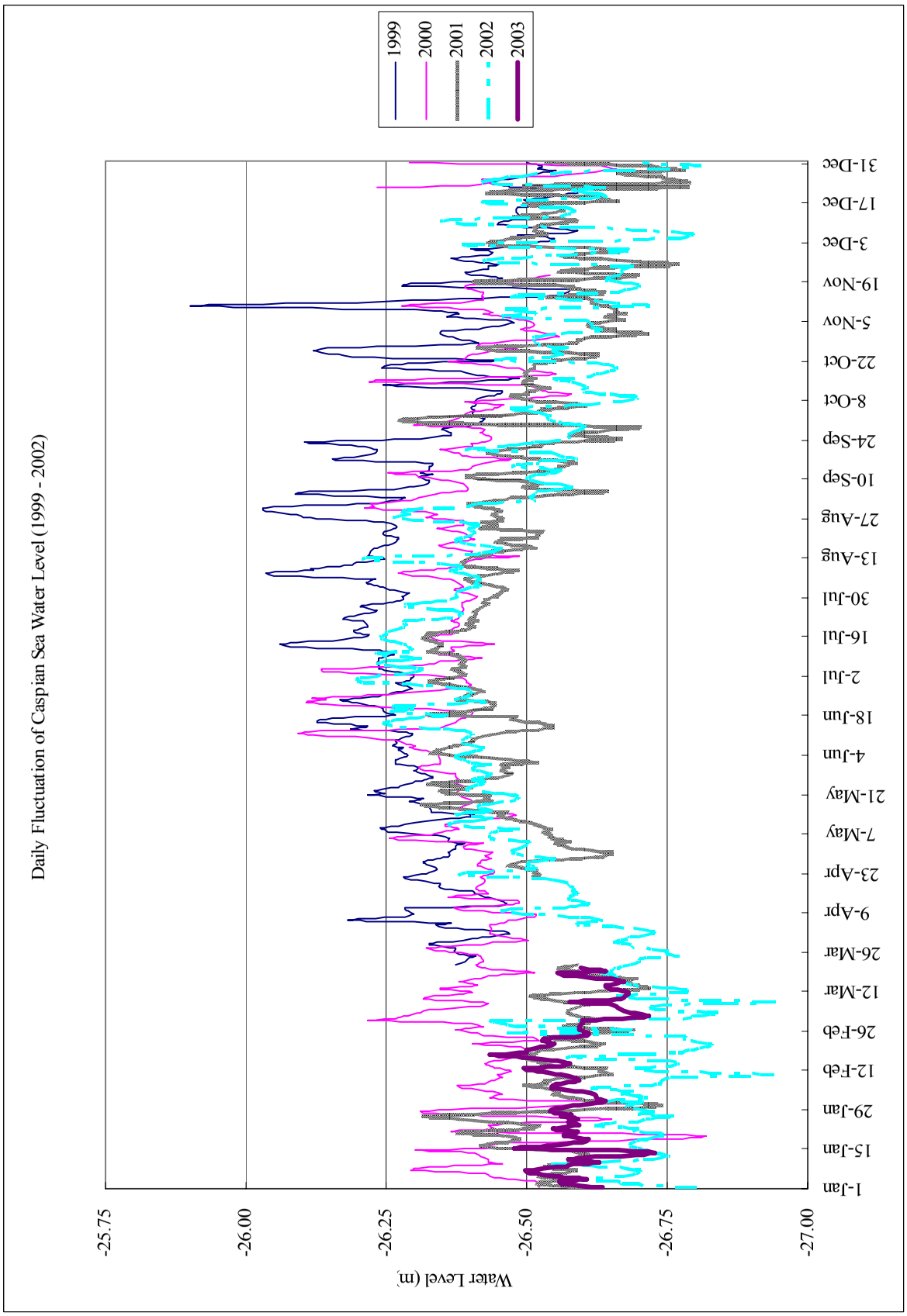
Figure 4.3.1
Average Annual Caspian Sea Water Level



Source: Anzali Port Authority

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Figure 4.3.2
Daily Caspian Sea Water Level

4.3.2 Measurements of Wetland Water Level

There are no measurements of wetland water level at present. During the Study, four staff gages were installed in the wetland as shown in Figure 4.3.3. They were intended for calibration of sounding equipment during the bathymetric survey however their data is also useful here. The water level was observed twice a day for 40 days between August 8 and September 16, 2003. The results of the water level and the Caspian Sea water level are shown in Figure 4.3.4 and summarized in Table 4.3.2. The readings between the four gages do not differ greatly and furthermore, fluctuate closely with the Caspian Sea.

Table 4.3.2 Summary of Water Level Gage Readings during the Study

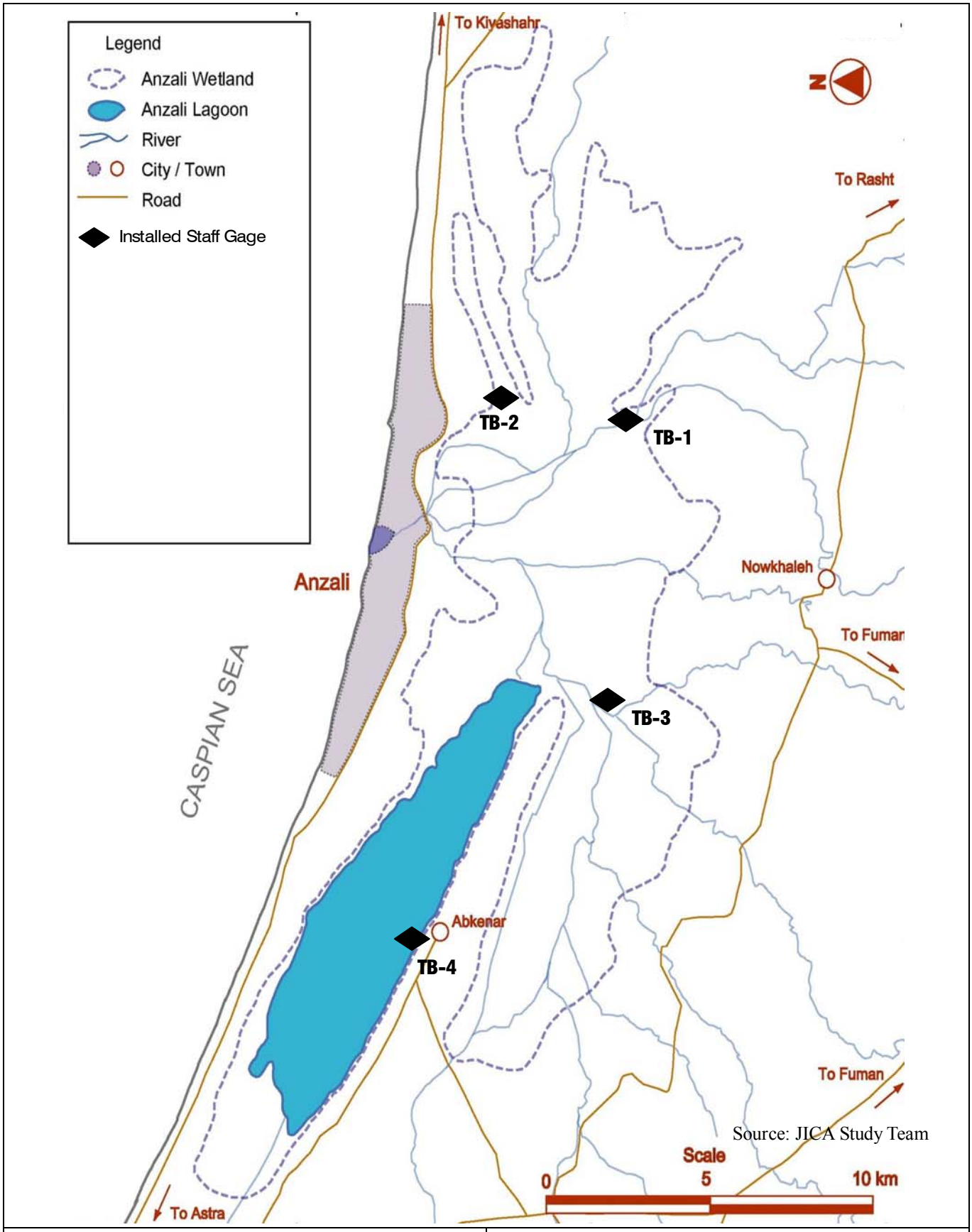
Gage No.	Gage Name	Average Water Level (m)	Difference from Anzali Gage	Distance to Anzali Gage (m)	Avg .Hydraulic Gradient
1	Pirbazar/Pasikhan	-25.86	0.47	8,000	1/17,000
2	Hosenbekhandeh	-25.91	0.42	4,500	1/11,000
3	Siakeshim outlet	-25.93	0.40	9,000	1/23,00
4	Abkenar	-25.95	0.38	14,500	1/38,000
Port	Anzali port	-26.33	-	-	-

Source: JICA Study Team

4.3.3 Estimation of Wetland Water Level

Visual observation shows that the wetland water level appears to be influenced by the water level of the Caspian Sea and not by the rivers discharging into the wetland. This can be demonstrated by considering the outlet of the wetland as a control point for the wetland and then checking its drainage capacity.

At the port area, there are two bridges which can be regarded as control points. The larger bridge, the Gazian Bridge, spans the main waterway of the wetland outlet while the smaller bridge, the Anzali Bridge, spans a small channel which is connected to the lagoon to the west. A simplification of the wetland and the cross section of the Gazain Bridge is shown in Figure 4.3.5.



Source: JICA Study Team

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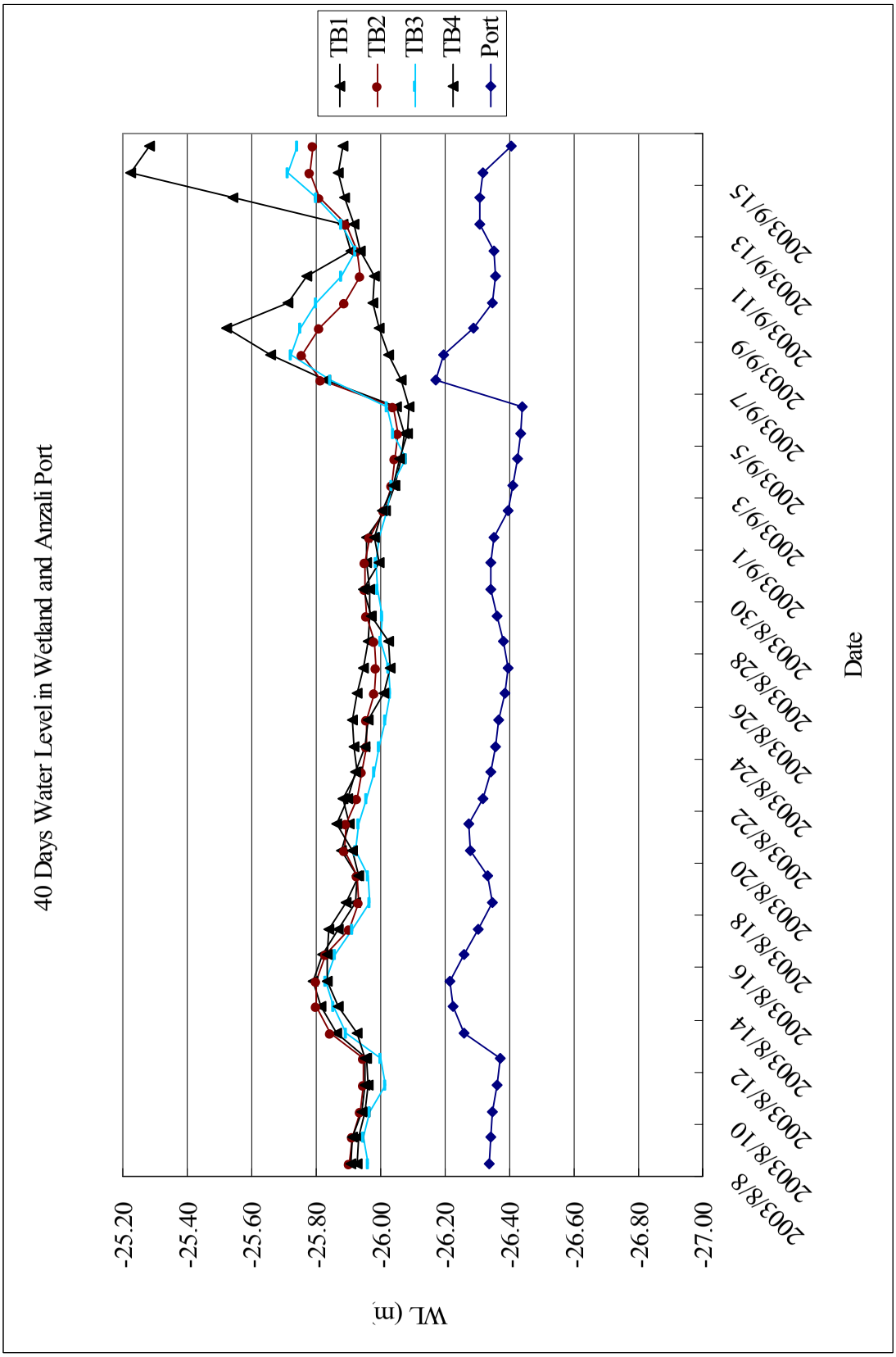
Figure 4.3.3
Location of Installed Staff Gages



Sta. Name
TB1 Pirbazar/Pasikhan confluence
TB2 Hosenbekhandeh (Talebabad)
TB3 Shiakeshim Outlet
TB4 Abkenar

Source: JICA Study Team

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Figure 4.3.4
Average Annual Caspian Sea Water Level

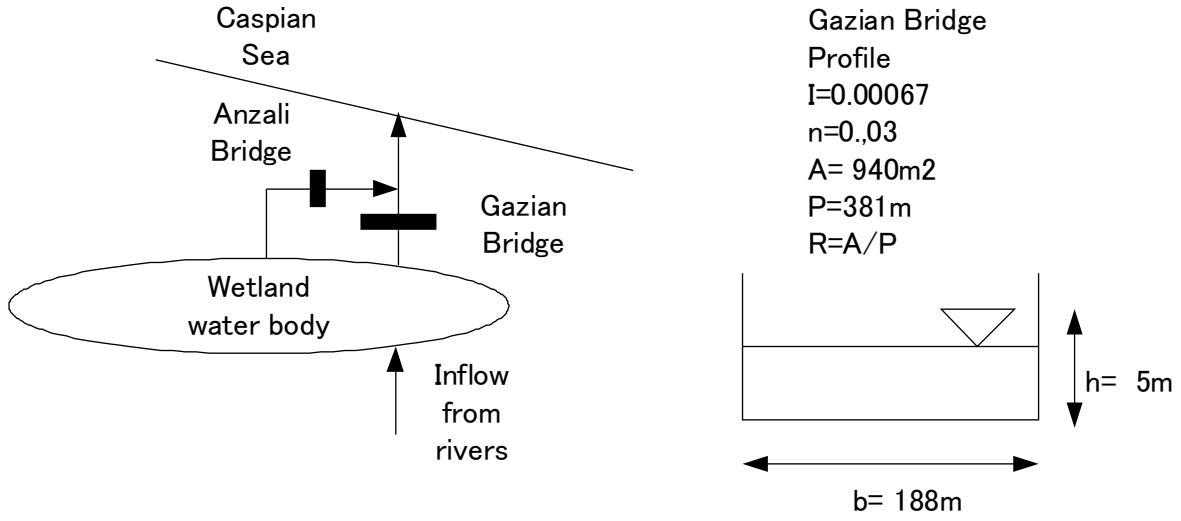


Figure 4.3.5 Simplified Model of Wetland Drainage and Section of Gazian Bridge

Applying manning's equation for discharge to the Gazian Bridge, and assuming that the Anzali bridge has no discharge capacity, then given the above dimensions, the capacity of the bridge can be calculated as follows.

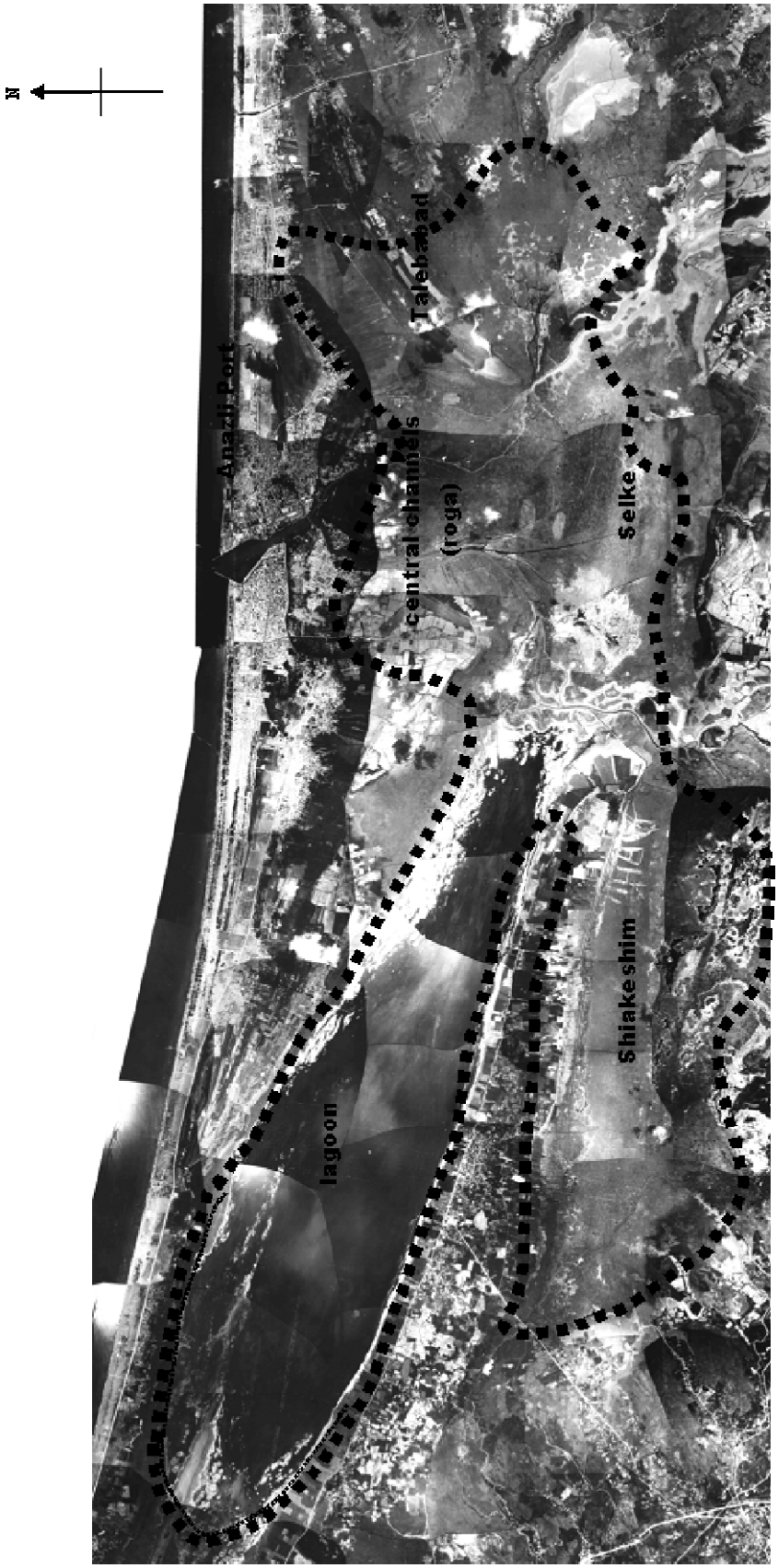
$Q = 1/n \times A \times R^{2/3} \times I^{1/2} = 1{,}481\ m^3/s$

This capacity should be compared to a large flood of the past. Based on the discharge records, a large flood occurred recently on October 9, 1998. This flood was approximately 15 times as large as the average annual discharge or 1,180 m^3/s. This flood affected all rivers in the Anzali basin, however compared to the bridge capacity, is not enough to cause a choking phenomenon, and thus would not affect the water level of the wetland. In other words, even with large floods, drainage capacity of the wetlands is large enough allow passage to the Caspian Sea and that any overflow of the rivers is attributed to the limited conveyance capacity of the channels.

4.3.4 Examination of Wetland by Aerial Photos

Further examination of the influence of the Caspian Sea on the wetland can be made by comparison of aerial photos of different time periods. Aerial photos provided by the Iranian counterpart agencies, taken in 1982 and 1994 respectively were compared. The scenes are shown in Figure 4.3.6.

Table 4.3.3 is a comparison chart of the two photos (measurement of area was difficult due to the quality of the photos provided however a noticeable increase in wet areas after the Caspian Sea has at its recent highest.).



Source: NCC

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 4.3.6 (1/2)** **Aerial Photo of Anzali Wetland**
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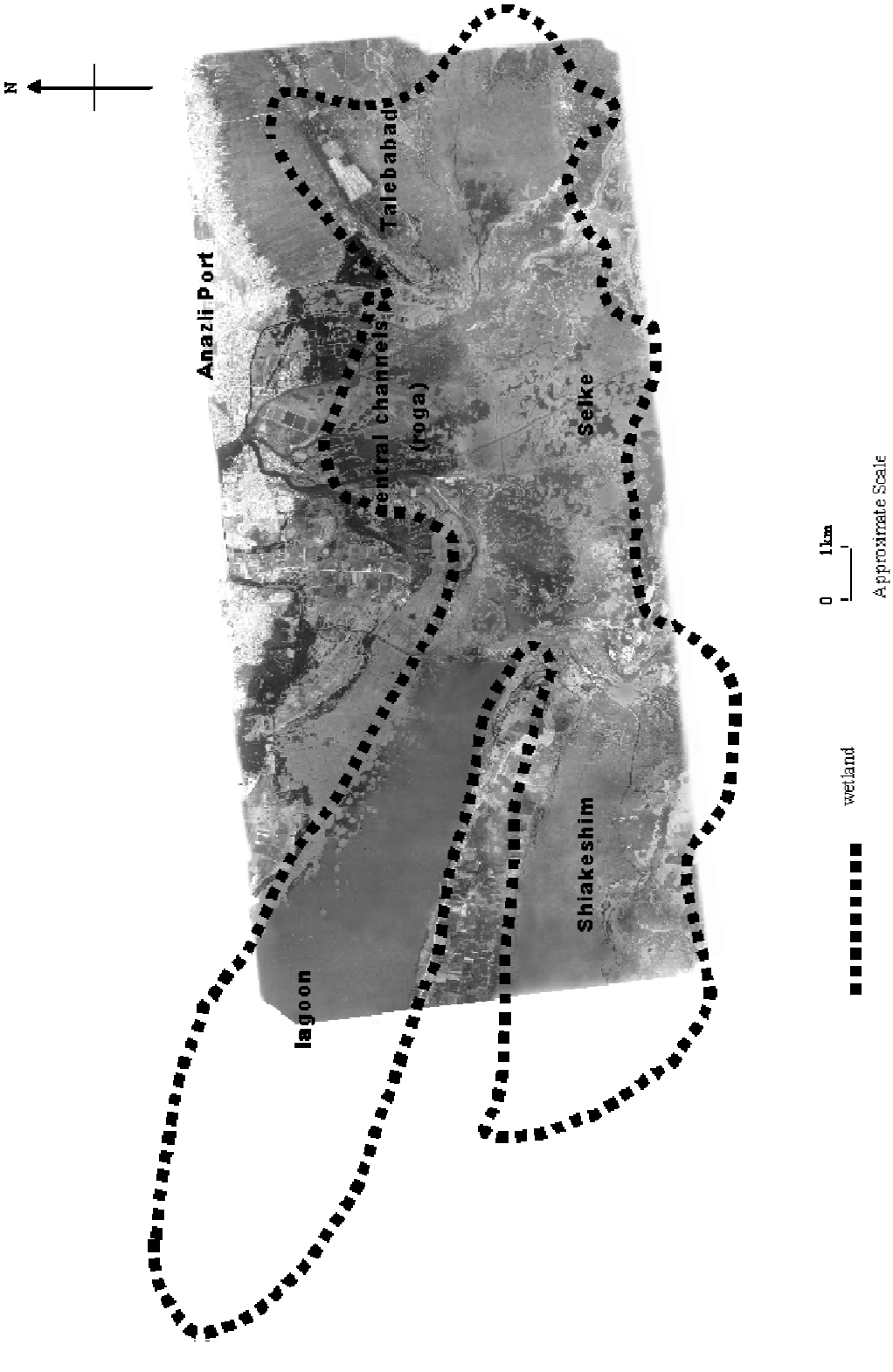

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Figure 4.3.6 (2/2)
Aerial Photo of Anzali Wetland

Table 4.3.3 Comparison of Aerial Photographs of Anzali Wetland

No	Item	1982 Scene	1994 Scene
1	Surface Cover	marshy land with dry areas	frequent open water surfaces amongst marshy land
2	Lagoon	Width at Abkenar: 3.0 km	Width at Abkenar: 3.6 km (+20%)
		Eastern side: 1.8 km	Eastern side: 2.6 km (+44%)
3	Shiakesim	Channel width from 200 m to 600 m	Channel width from 50 m to 100 m
4	Hosenbekhandeh	dry	water surface
5	Extent of Wetted Surface	1,000 m (from Anzali Port)	6,000 m (from Anzali port)
6	Others	Natural channels only	Artificial channels constructed by Ministry of Agriculture (along Pirbazar)
7	Caspian Level	-27.58 m	-26.10 m

Source: JICA Study Team

It is significant to note item 3 and 7. It shows that for a rise in Caspian Sea level, the Siakeshim area water surface decreased. This would support the observation that the backwater has minimal effect in this area. Favourable conditions for reed growth, such as shallow water level, ponded bathymetry and upstream sediment load, also contributed to reed growth.

CHAPTER 5 SEDIMENT

5.1 Outline of Sediment Balance

The sediment balance in the Anzali wetland watershed can be conceptualized as shown in Figure 5.1.1, based on the three landforms explained in Section 3.2.

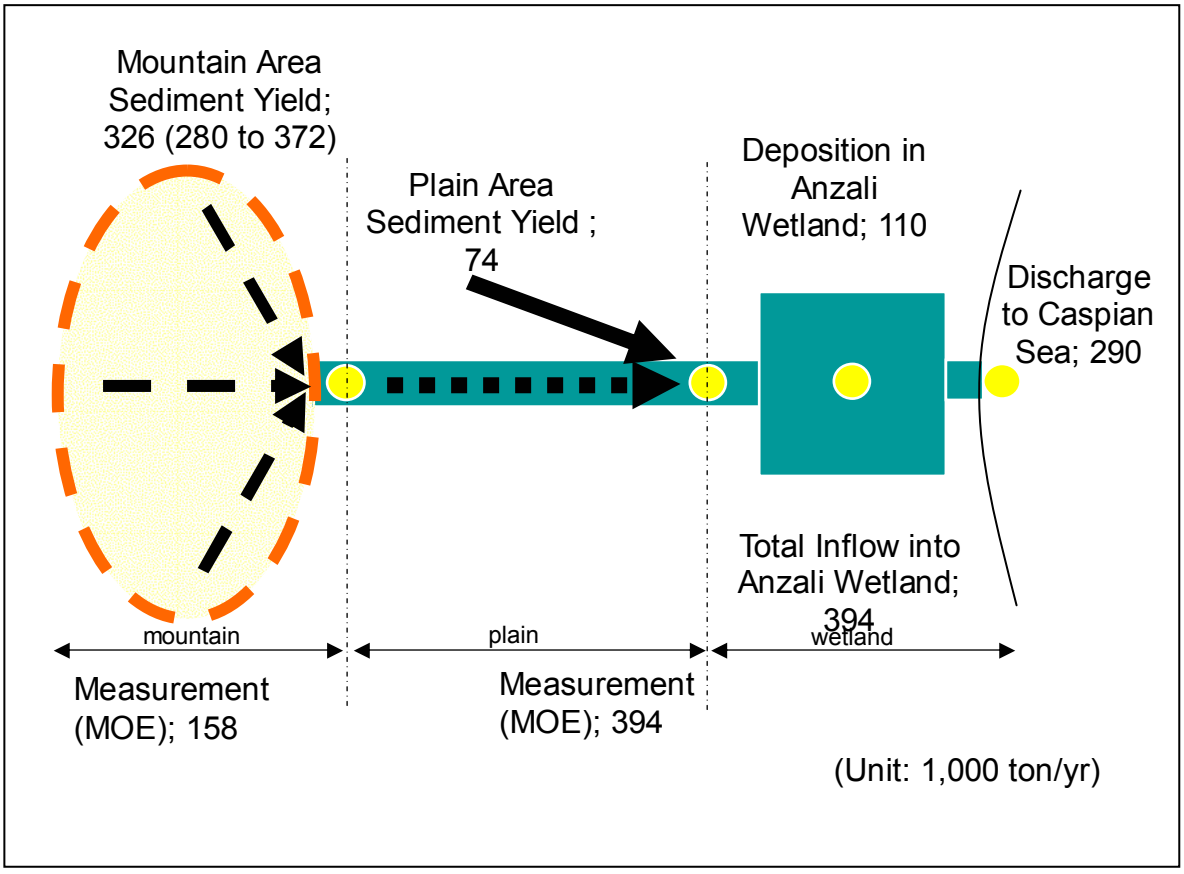


Figure 5.1.1 Sediment Balance in the Watershed

Sediment in the mountain area is largely as a result of natural erosion occurring at the highest elevation where the land is bare. In addition however, sediment is also generated by human activity in the mountainous grassland and forests. These activities include livestock grazing, rangeland farming, road construction and tree cutting. Shifting to the plain area, sediment is not as pronounced as the mountain area, due fortunately to the abundance of rice paddy fields which functions as a sediment trap. Sediment that enters the rivers from the mountain and plain areas are transported downstream to the Anzali wetland where they can deposit or remain suspended until reaching the Caspian Sea.

The analysis in this section begins with estimates of the sediment yield from both the mountain area and plain area. Next, the method of transport of the mountain area sediment

and plain area is computed using a sediment transport model. Sediment quantities are checked to measured values and the values are then used as input into a sediment deposition model to determine the amount of sediment that exits to the Caspian Sea.

5.2 Sediment in the Watershed

5.2.1 Sediment from the Mountain Area

(1) Methodology

To determine the sediment yield from the mountain area, empirical methods were used with the aid of satellite imagery. Based on discussion with Iranian experts, it was learned that two methods are generally used to estimate total erosion and sediment yield empirically in Iran. They are the Erosion Potential Method (EPM) which estimates the sediment yield, and the Pacific Southwest Inter-agency Committee Method (PSIAC) which also estimates the sediment yield. These two methods, together with a third method developed in Japan by Yamazaki and Oonishi which estimates the total erosion are introduced. Also, measured sediment data was used to create sediment-discharge curves and is also explained. (It is noted that the Universal Soil Loss Equation (USLE) was originally intended for soil loss of farm lands and is not applicable here).

(2) Data Inputs

To carry out the above-mentioned analysis, data on the watershed was required from various sources. Area and land cover are two of the most data inputs and these were obtained using Landsat images taken in July 2002. The results are shown in Table 5.2.1.

Table 5.2.1 Land Cover of the Mountain Area by River Basin

River Basin	Forest (km^2)	Grass (km^2)	Bare (km^2)
Chafroud	107	12	12
Bahambar	29	0	1
Morghak	182	20	54
Kahlkaii	182	17	46
Palangvar	112	2	1
Masulheroudkhan	226	24	50
Pishroudbar	251	8	13
Pasikhan	341	14	57
Siahroud	80	0	0
Total	1,510	98	235
Percentage	82%	5%	13%
Overall	1,843		

Source: measured by JICA Study Team using Landsat image taken in July 2002

The data shows that forest cover is the most abundant, followed by bare land and grass land. The images also revealed that apart from the bare land above the grass line (ie. above EL.2,000 m), portions of some basins had extensive bare land below the grass line which is indicative of human activity. Next, geological maps published in Iran (Geological Survey of Iran) were obtained to determine the lithology of the mountain area. The mountain area is underlain by Pre-Tertiary zone, Lower Paleozoic to Neogene Formations and some intrusive rocks. Approximately 75% of the mountain area is massive as opposed to 25% which is fractured. Soil distribution maps published by the Iran Ministry of Agriculture (based on FAO classification) were also obtained. The texture of the mountains is characterized by lithic leptosols and dystric regosols. These are thin layers of weakly developed soils usually overlaying hard rock. Climatic data and hydrologic data were obtained from MOE. Basin average rainfall was calculated to be 1,065 mm/year while the distribution was found to be greater in the east and lower in the west, based on isopluvial maps by MOE. Finally, site observations revealed that rill and gully erosion were prevalent at the higher elevations, greater than 2,000 m; below this line, erosion appeared predominantly in areas where human activity has disturbed the natural surface.

1) Erosion Potential Method (EPM)

The EPM was originally developed in Yugoslavia to calculate sediment yield. The equation used is as follows.

$$Z = Y * Xa (\Phi + I^{0.5})$$

Z : Soil loss coefficient from land (-)

Y : Soil resistance coefficient (-)

Xa : Land use coefficient(-)

Φ : Watershed erosion coefficient (-)

I : Average slope (decimal)

Next, the specific sediment is obtained as follows.

$Wsp = T H \pi Z^{(3/2)}$

Wsp : Specific sediment (m^3/km^2)

T : Temperature Factor, (t/10+0.1)0.5 (-)

t : temperature (°C)

H : annual precipitation (mm/yr)

π : 3.14 (-)

Z : soil loss coefficient (-)

The method also has suggestions for calculating the sediment yield. The equation is given as follows.

$RU = 4 (P \times D)^{1/2} / (L+10)$

RU : sediment delivery ratio (-)

P : perimeter of the watershed (km)

L : Length of the watershed(km)

D : Difference in height, calculated by (km):

$D=D_{av}-D_O$

D_{av} : average elevation of the catchment (km)

D :elevation at the exit of the watershed (km)

Finally, the sediment yield, Q_y, is calculated by multiplying Wsp by the surface area and RU. Table 5.2.2 is the calculation sheet for the EPM method.

2) PSIAC Method

This method was developed by the Pacific Southwest Inter-agency Committee (PSIAC) to calculate the sediment yield in arid and semi-arid areas in the southwestern United State in 1968. It involves nine factors, of which two are essentially concerned with climate and runoff characteristics, one which reflects land use, and the remaining six factors which are related to geology, soils, topography,

ground cover, upland erosion and channel erosion. Soil erosion is assessed by the total number (S) of marked scores (R1, R2,···R9) of factors.

$S = \Sigma R(i)$

The sediment yield is assessed by the total marked score (S), as shown in Table 5.2.3.

Table 5.2.2 Estimation of Sediment Yield by the EPM Method

Unit: m^3/year

Basin	y	Xa	Φ	I	Z	t	T	H	Pai	WSP	Area	P	D	L	RU	Yield	Total Volume
Chafroud	0.8	0.2	0.1	0.067	0.06	15	1.26	899	3.14	49.13	0.4	69080	947	31400	0.78	15.1	7,877
	0.8	0.2	0.1	0.067	0.06	9.7	1.03	899	3.14	40.17	107.1	69080	947	31400	0.78	3,362.1	
	0.9	0.3	0.2	0.067	0.12	9.7	1.03	899	3.14	127.34	0.4	69080	947	31400	0.78	41.9	
	0.9	0.3	0.2	0.067	0.12	9.7	1.03	876	3.14	124.15	12.1	69080	947	31400	0.78	1,169.1	
	0.9	0.5	0.3	0.067	0.25	9.7	1.03	876	3.14	359.07	0.1	69080	947	31400	0.78	23.2	
	0.9	0.5	0.3	0.067	0.25	9.7	1.03	876	3.14	359.07	11.6	69080	947	31400	0.78	3,265.6	
Bahambar	0.8	0.2	0.1	0.147	0.08	9.7	1.03	876	3.14	61.24	0.0	12320	312.5	5600	0.50	0.0	1,081
	0.8	0.2	0.1	0.147	0.08	9.7	1.03	876	3.14	61.24	28.6	12320	312.5	5600	0.50	882.1	
	0.9	0.3	0.2	0.147	0.16	9.7	1.03	876	3.14	178.00	0.0	12320	312.5	5600	0.50	0.0	
	0.9	0.3	0.2	0.147	0.16	9.7	1.03	876	3.14	178.00	0.1	12320	312.5	5600	0.50	9.4	
	0.9	0.5	0.3	0.147	0.31	9.7	1.03	876	3.14	485.58	0.0	12320	312.5	5600	0.50	0.0	
	0.9	0.5	0.3	0.147	0.31	9.7	1.03	876	3.14	485.58	0.8	12320	312.5	5600	0.50	189.5	
Moaghkroud	0.8	0.2	0.1	0.108	0.07	9.7	1.03	876	3.14	51.14	38.7	55880	1273	25400	0.95	1,885.0	33,903
	0.8	0.2	0.1	0.108	0.07	9.7	1.03	876	3.14	51.14	143.3	55880	1273	25400	0.95	6,982.3	
	0.9	0.3	0.2	0.108	0.14	9.7	1.03	876	3.14	153.53	0.9	55880	1273	25400	0.95	126.4	
	0.9	0.3	0.2	0.108	0.14	9.7	1.03	876	3.14	153.53	19.6	55880	1273	25400	0.95	2,864.7	
	0.9	0.5	0.3	0.108	0.28	9.7	1.03	876	3.14	428.39	0.2	55880	1273	25400	0.95	98.5	
	0.9	0.5	0.3	0.108	0.28	9.7	1.03	876	3.14	428.39	53.8	55880	1273	25400	0.95	21,946.0	
Khalkaii	0.8	0.2	0.1	0.143	0.08	9.7	1.03	876	3.14	60.25	27.7	46200	1405	21000	1.00	1,671.8	36,174
	0.8	0.2	0.1	0.143	0.08	9.7	1.03	876	3.14	60.25	153.8	46200	1405	21000	1.00	9,268.5	
	0.9	0.3	0.2	0.143	0.16	9.7	1.03	876	3.14	175.60	0.5	46200	1405	21000	1.00	95.3	
	0.9	0.3	0.2	0.143	0.16	9.7	1.03	876	3.14	175.60	16.7	46200	1405	21000	1.00	2,937.8	
	0.9	0.5	0.3	0.143	0.31	9.7	1.03	876	3.14	479.99	0.1	46200	1405	21000	1.00	24.2	
	0.9	0.5	0.3	0.143	0.31	9.7	1.03	876	3.14	479.99	46.2	46200	1405	21000	1.00	22,176.2	
Plangroud	0.8	0.2	0.1	0.08	0.06	9.7	1.03	1,168	3.14	57.55	25.2	24640	350	11200	0.55	802.7	4,062
	0.8	0.2	0.1	0.08	0.06	9.7	1.03	1,168	3.14	57.55	87.0	24640	350	11200	0.55	2,775.1	
	0.9	0.3	0.2	0.08	0.13	9.7	1.03	1,168	3.14	178.70	0.2	24640	350	11200	0.55	22.1	
	0.9	0.3	0.2	0.08	0.13	9.7	1.03	1,168	3.14	178.70	1.8	24640	350	11200	0.55	178.2	
	0.9	0.5	0.3	0.08	0.26	9.7	1.03	1,168	3.14	509.92	0.1	24640	350	11200	0.55	17.5	
	0.9	0.5	0.3	0.08	0.26	9.7	1.03	1,168	3.14	509.92	0.9	24640	350	11200	0.55	266.0	
Masulehroudkhan	0.8	0.2	0.1	0.15	0.08	9.7	1.03	1,168	3.14	82.65	86.9	44220	1405	20100	1.00	7,181.5	57,383
	0.8	0.2	0.1	0.15	0.08	9.7	1.03	1,168	3.14	82.65	138.7	44220	1405	20100	1.00	11,467.3	
	0.9	0.3	0.2	0.15	0.16	9.7	1.03	1,168	3.14	239.71	4.6	44220	1405	20100	1.00	1,106.8	
	0.9	0.3	0.2	0.15	0.16	9.7	1.03	1,168	3.14	239.71	19.8	44220	1405	20100	1.00	4,735.1	
	0.9	0.5	0.3	0.15	0.31	9.7	1.03	1,168	3.14	652.97	1.9	44220	1405	20100	1.00	1,217.1	
	0.9	0.5	0.3	0.15	0.31	9.7	1.03	1,168	3.14	652.97	48.5	44220	1405	20100	1.00	31,675.2	
Pishroudbar	0.8	0.2	0.1	0.091	0.06	9.7	1.03	1,168	3.14	61.85	173.6	50600	950	23000	0.84	9,022.6	20,261
	0.8	0.2	0.1	0.091	0.06	9.7	1.03	1,168	3.14	61.85	77.8	50600	950	23000	0.84	4,045.2	
	0.9	0.3	0.2	0.091	0.14	9.7	1.03	1,168	3.14	189.24	3.5	50600	950	23000	0.84	554.6	
	0.9	0.3	0.2	0.091	0.14	9.7	1.03	1,168	3.14	189.24	4.1	50600	950	23000	0.84	652.0	
	0.9	0.5	0.3	0.091	0.27	9.7	1.03	1,168	3.14	534.82	5.1	50600	950	23000	0.84	2,276.2	
	0.9	0.5	0.3	0.091	0.27	9.7	1.03	1,168	3.14	534.82	8.3	50600	950	23000	0.84	3,710.2	
Paskhan	0.8	0.2	0.1	0.07	0.06	9.7	1.03	1,460	3.14	66.85	70.9	87560	1300	39800	0.86	4,064.2	51,859
	0.8	0.2	0.1	0.07	0.06	9.7	1.03	1,460	3.14	66.85	270.1	87560	1300	39800	0.86	15,475.3	
	0.9	0.3	0.2	0.07	0.13	9.7	1.03	1,460	3.14	210.81	4.8	87560	1300	39800	0.86	860.8	
	0.9	0.3	0.2	0.07	0.13	9.7	1.03	1,460	3.14	210.81	9.0	87560	1300	39800	0.86	1,624.0	
	0.9	0.5	0.3	0.07	0.25	9.7	1.03	1,460	3.14	607.67	12.2	87560	1300	39800	0.86	6,372.5	
	0.9	0.5	0.3	0.07	0.25	9.7	1.03	1,460	3.14	607.67	45.1	87560	1300	39800	0.86	23,462.1	
Siahroud	0.8	0.2	0.1	0.087	0.06	9.7	1.03	1,460	3.14	75.38	0.0	18040	255	8200	0.47	0.0	2,872
	0.8	0.2	0.1	0.087	0.06	9.7	1.03	1,460	3.14	75.38	80.1	18040	255	8200	0.47	2,847.6	
	0.9	0.3	0.2	0.087	0.13	9.7	1.03	1,460	3.14	231.83	0.0	18040	255	8200	0.47	0.0	
	0.9	0.3	0.2	0.087	0.13	9.7	1.03	1,460	3.14	231.83	0.0	18040	255	8200	0.47	1.1	
	0.9	0.5	0.3	0.087	0.27	9.7	1.03	1,460	3.14	657.38	0.0	18040	255	8200	0.47	0.0	
	0.9	0.5	0.3	0.087	0.27	9.7	1.03	1,460	3.14	657.38	0.1	18040	255	8200	0.47	23.4	
																Total	215,471

Source: JICA Study Team

Table 5.2.3 Erodability Class and Sediment Yield for the EPM Method

Erodability Class	Erodability	Total Marked Score (S)	Sediment Yield (Q_s) ($m^3/km^2/year$)
1	Trace	1 to 20	Less than 95
2	Low	25 to 50	95 to 232
3	Fair	50 to 75	232 to 568
4	High	75 to 100	568 to 1,390
5	Severe	More than 100	More than 1,390

Note: $Qs = 38.77 \cdot e^{0.0358 \cdot S}$
Source: Explanatory Study of natural Resources Management in the Boshar and Mabor River Basin. By ZOUMAR consulting Engineers JIHAD, 1994.

The sediment yield, Q_y, is calculated by multiplying Q_s by the surface area. Table 5.2.4 is the calculation sheet for the PSIAC method.

3) Method of Miyazaki-Oonishi

This method was developed by Yamazaki and Oonishi in Japan by analyzing the record of sedimentation in dams around Japanese mountainous area in 1998. The assessment of this method involves four factors, which are selected on the basis of the results of multiple regression analysis.

$$\text{Log } qs = 0.68 \cdot S + 0.47 \cdot G + 0.95 \cdot Ls + 0.71 \cdot R_0 \quad (5\text{-}1)$$

qs : Annual sediment yield

S : Average gradient of slope

G : Type of geology

Ls: Area of collapsed slope

R_0 : Maximum rainfall of 10 years probability

This method is applicable to mountainous areas with much rainfall in temperate zones. Although this method is not used in Iran, conditions of climate and topography of Anzali Wetland basin are remarkably similar to Japanese area and therefore, it is strongly believed that this method could be used. Table 5.2.5 shows the values used for the Miyazaki-Oonishi method and Table 5.2.6 is the calculation sheet for the Miyazaki-Oonishi method.

Table 5.2.4 Estimation of Total Erosion by the PSIAC Method

Unit: m^3/year

Basin	R1	R2	R3	R4	R5	R6	R7	R8	R9	S	Qs	Area	Erosion Volume	Total Volume
Chafroud	10	0.00	5	5	20	-10	-10	0	0	20.00	79.33	0.4	31	17,158
	5	0.03	5	5	20	-10	-10	0	0	15.03	66.41	107.1	7,111	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	0.4	82	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	12.1	1,956	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	0.1	67	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	11.6	7,910	
Bahambar	10	0.00	5	5	20	-10	-10	0	0	20.00	79.33	0.0	0	2,536
	5	1.33	5	5	20	-10	-10	0	0	16.33	69.56	28.6	1,991	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	0.0	0	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	0.1	17	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	0.0	0	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	0.8	527	
Moaghkroud	10	0.20	5	5	20	-10	-10	0	0	20.20	79.89	38.7	3,090	52,719
	5	0.13	5	5	20	-10	-10	0	0	15.13	66.65	143.3	9,549	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	0.9	168	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	19.6	3,178	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	0.2	196	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	53.8	36,537	
Khalkaii	10	0.01	5	5	20	-10	-10	0	0	20.01	79.35	27.7	2,202	46,801
	5	0.35	5	5	20	-10	-10	0	0	15.35	67.18	153.8	10,334	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	0.5	105	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	16.7	2,716	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	0.1	41	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	46.2	31,403	
Plangroud	10	0.03	5	5	20	-10	-10	0	0	20.03	79.42	25.2	1,999	8,940
	5	0.68	5	5	20	-10	-10	0	0	15.68	67.97	87.0	5,915	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	0.2	43	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	1.8	292	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	0.1	50	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	0.9	640	
Masulehroudkhan	10	0.05	5	5	20	-10	-10	0	0	20.05	79.48	86.9	6,906	54,992
	5	0.87	5	5	20	-10	-10	0	0	15.87	68.44	138.7	9,496	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	4.6	896	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	19.8	3,207	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	1.9	1,515	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	48.5	32,971	
Pishroudbar	10	0.42	5	5	20	-10	-10	0	0	20.42	80.52	173.6	13,977	30,424
	5	1.14	5	5	20	-10	-10	0	0	16.14	69.09	77.8	5,377	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	3.5	677	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	4.1	665	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	5.1	4,117	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	8.3	5,611	
Paskhan	10	0.11	5	5	20	-10	-10	0	0	20.11	79.66	70.9	5,651	67,151
	5	0.96	5	5	20	-10	-10	0	0	15.96	68.65	270.1	18,544	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	4.8	925	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	9.0	1,459	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	12.2	9,948	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	45.1	30,624	
Siahroud	10	0.00	5	5	20	-10	-10	0	0	20.00	79.33	0.0	0	5,471
	5	0.53	5	5	20	-10	-10	0	0	15.53	67.61	80.1	5,418	
	10	5.00	5	5	20	0	0	0	0	45.00	194.15	0.0	0	
	5	5.00	5	5	20	0	0	0	0	40.00	162.33	0.0	2	
	10	10.00	10	5	20	10	10	10	0	85.00	812.93	0.0	0	
	5	10.00	10	5	20	10	10	10	0	80.00	679.70	0.1	51	
													Total	286,191

Source: JICA Study Team

Table 5.2.5 Parameters for Miyazaki-Oonishi Method

Item (Factor)	Category	Score	Detail
Average of Slope Angle	A	0.32	3.4°
	B	-0.07	5.7°
	C	-0.05	9.1°
	D	0.21	14°
Geology	Sn		Sedimentary Rock (pre Tertiary)
	Sp	0.04	Sedimentary Rock (post Tertiary)
	M	0.00	Metamorphic Rock (pre Tertiary)
	Vn	0.00	Igneous Rock (pre Tertiary)
	Vp	0.09	Igneous Rock (post Tertiary)
	Pn		Volcanic Rock (pre Tertiary)
	Pp	-0.12	Volcanic Rock (post Tertiary)
Density of Slope Failure	L	-0.78	
	M	-0.11	
	H	0.24	
	HH	1.08	
10-year probable rainfall 24hr	<100		Log R
	100< <160	-0.20	2.2
	160< <250	0.01	2.4
	250< <400	0.16	2.6
	400< <630	0.39	2.8
	630< <1000		3
Constant		2.89	

Rate of Annual Erosion

Vegetation	S (0.68)	G (0.47)	Ls (0.95)	Ro (0.71)	Const	Log(qs)	qs ($m^3/km^2/yr$)
Forest	-0.07	-0.12	-0.78	0.01	2.89	2.0521	112.7
Grassland	-0.07	-0.12	-0.11	0.01	2.89	2.6886	488.2
Bareland	-0.07	-0.12	0.24	0.01	2.89	3.0211	1049.8

Source: JICA Study Team

Table 5.2.6 Estimation of Total Erosion by Miyazaki-Oonishi Method

Unit: m^3/year

Basin	S	G	Ls	Ro	Constant	Log(qs)	Qs	Area	Erosion Volume	Total Volume
Chafroud	0.21	0	-0.78	-0.2	2.89	2.15	141.19	0.4	55.53	33,606
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	107.1	13,278.29	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	0.4	257.51	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	12.1	6,469.80	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	0.1	108.85	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	11.6	13,436.14	
Bahambar	0.21	0	-0.78	-0.2	2.89	2.15	141.19	0.0	0.00	4,502
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	28.6	3,549.78	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	0.0	0.00	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	0.1	56.54	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	0.0	0.00	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	0.8	895.67	
Moaghkroud	0.21	0	-0.78	-0.2	2.89	2.15	141.19	38.7	5,461.08	96,645
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	143.3	17,765.30	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	0.9	528.22	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	19.6	10,511.91	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	0.2	317.09	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	53.8	62,061.24	
Khalkaii	0.21	0	-0.78	-0.2	2.89	2.15	141.19	27.7	3,917.82	85,714
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	153.8	19,074.79	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	0.5	331.79	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	16.7	8,982.53	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	0.1	66.26	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	46.2	53,340.38	
Plangroud	0.21	0	-0.78	-0.2	2.89	2.15	141.19	25.2	3,553.76	16,615
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	87.0	10,790.20	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	0.2	136.46	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	1.8	966.43	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	0.1	81.64	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	0.9	1,086.86	
Masulehroudkhan	0.21	0	-0.78	-0.2	2.89	2.15	141.19	86.9	12,268.34	101,355
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	138.7	17,203.94	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	4.6	2,822.67	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	19.8	10,605.65	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	1.9	2,450.32	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	48.5	56,004.54	
Pishroudbar	0.21	0	-0.78	-0.2	2.89	2.15	141.19	173.6	24,508.47	54,680
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	77.8	9,650.04	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	3.5	2,132.13	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	4.1	2,201.05	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	5.1	6,657.63	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	8.3	9,530.30	
Paskhan	0.21	0	-0.78	-0.2	2.89	2.15	141.19	70.9	10,016.03	119,352
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	270.1	33,493.00	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	4.8	2,912.91	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	9.0	4,826.37	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	12.2	16,087.39	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	45.1	52,016.61	
Siahroud	0.21	0	-0.78	-0.2	2.89	2.15	141.19	0.0	0.00	10,029
	0.21	-0.12	-0.78	-0.2	2.89	2.09	123.99	80.1	9,936.52	
	0.21	0	-0.11	-0.2	2.89	2.79	611.36	0.0	0.00	
	0.21	-0.12	-0.11	-0.2	2.89	2.73	536.91	0.0	5.32	
	0.21	0	0.24	-0.2	2.89	3.12	1,314.62	0.0	0.00	
	0.21	-0.12	0.24	-0.2	2.89	3.06	1,154.52	0.1	87.28	
									Total	522,498

Source: JICA Study Team

(3) Results

The three methods were used to produce a unit sediment yield, which is then multiplied by the corresponding land area as explained earlier in this chapter. For comparison, the results by river basin are summarized in Table 5.2.7.

Table 5.2.7 Estimate of Annual Sediment Yield and Total Erosion from Mountain Area

No.	River	Sediment Yield[10] m^3/yr (ton/yr*)		Total Erosion m^3/yr (ton/yr)	
		EPM	PSIAC	Average	Miyazaki
1	Chafroud	8,000 (10,400)	17,000 (22,100)	12,500 (16,250)	34,000 (44,200)
2	Bahambar	1,000 (1,300)	3,000 (3,900)	2,000 (2,600)	4,000 (5,200)
3	Morghak	34,000 (44,200)	53,000 (68,900)	43,500 (56,550)	97,000 (126,100)
4	Khalkai	36,000 (46,800)	47,000 (61,100)	41,500 (53,950)	86,000 (111,800)
5	Palangvar	4,000 (5,200)	9,000 (11,700)	6,500 (8,450)	17,000 (22,100)
6	Masulehroudkhan	57,000 (74,100)	55,000 (71,500)	56,000 (72,800)	101,000 (131,300)
7	Shakhazar	20,000 (26,000)	30,000 (39,000)	25,000 (32,500)	55,000 (71,500)
8	Pasikhan	52,000 (67,600)	67,000 (87,100)	59,500 (77,350)	119,000 (154,700)
9	Pirbazar	3,000 (3,900)	5,000 (6,500)	4,000 (5,200)	10,000 (13,000)
	Total erosion	-	-	-	523,000 (679,900)
	Total yield	215,000 (280,000)	286,000 (372,999)	250,000 (326,000)	157,000 (204,000)

Source: JICA Study Team; Note: * - density = 1.3 ton/m^3 assumed

From the aspect of erosion potential, Pasikhan river has the greatest potential, followed by the three rivers of Mauslehroudkhan, Morghak and Khalkaii. Taking the average of the EPM and PSIAC methods, approximately 326,000 ton/yr is to be expected from the mountain area. The Miyazaki method estimate was rather low when using a sediment delivery rate of 30%. As this method was based on actual data in Japan where erosion controls were planned to be implemented, it seems reasonable to expect the conservative values.

5.2.2 Sediment from the Plain Area

As mentioned earlier, the northern part of the watershed is characterized by a relatively flat plain that stretches from the mountain and extends northward to the Caspian Sea. The dominant use of land in the plain area is rice cultivation, occupying over 80% (127,000 ha/152,400 ha x 100%, according to MOJA, 2001) of the total surface area. The presence of rice paddy fields indicate that sediment runoff rates would be very low because they tend to retain suspended sediments contained in irrigation water and at the same time, prevents surface erosion from occurring. For this reason, examination of the plain area was limited to

[10] note: sediment yield is taken to be the total sediment outflow from a drainage basin in a specific period of time while total erosion is defined as the total of all sheet, gully and channel erosion in a drainable basin in a

usage of typical unit rates of sedimentation to approximate the overall sediment yield from the plain area (unit rates for rice paddy, farm and pasture land, and urban runoff were found in published research papers; river bank erosion was estimated by identifying susceptible river banks through site investigation and questioning local residents of typical bank loss).

Sediment sources in the plain area other than rice paddy fields are farmland, river bank erosion and urban areas. The following Table 5.2.8 is a rough estimate of the sediment runoff from the basin as a whole.

Table 5.2.8 Estimate of Annual Sediment from Plain Area

No	Source	Quantity	Rate	Total (ton/yr)	Percent
1	Rice Paddy	1280 km^2	21 ton/km^2/yr	26,900	47%
2	Farm and pasture land	240 km^2	80 ton/km^2/yr	19,200	33%
3	River bank	111,300 m	0.05 m^3/m/yr	5,600	10%
4	Urban runoff	60 km^2	100 ton/km^2/yr	6,000	10%
	Total	-	-	57,700	100%

Source: JICA Study Team

As is to be expected, the largest quantity comes from the rice paddy, followed by sediment from farm and pasture lands. Urban sediment runoff is typically high, however due to the relatively small number of cities and towns in the watershed, their overall impact is low. Evidence of riverbank erosion was found in the mid-plain area of the Morghak and Khalkaii rivers, causing damage as the rivers continually meander. Again, the overall contribution from the riverbanks is rather low.

5.2.3 Sediment Transport in the Plain Area

(1) Methodology

The previous sections determined the sediment yield from the mountain and the plain area. In reference to the mountain area sediment, it is desirable to know how the sediment reaches the wetland and at what quantity. In order to answer this, a computer model was created to estimate the transport qualities in the rivers. The HEC-6 computer software that was developed by US Army Corps of Engineers was used for analysis. It has the capability to simulate transport, including scour/deposition along the river reach in a one dimensional direction, given the sediment yield from an upstream source (ie. the mountain area). Since the goal of the model was to determine the overall trend of the sediment movement along the rivers flowing in the plain area, a model of such accuracy was deemed to be adequate.

specific period of time

(2) Data Inputs

Input requirements for the model consist of geometry, discharge and sediment data.

The geometry of the rivers was taken from 1:25,000 and 1:50,000 topographic maps that were available from the NCC. The rivers generally flow straight along the plain area towards the north or northeast.

Cross sections were selected along the length of the river at one to two kilometer intervals. They were selected so that major river features were not missed, such as bridges and gages. Unfortunately, no cross-sectional data was available so typical sections and point measurements of water level were assumed[11]. A summary of the geometry data is given Table 5.2.9 and is shown in detail in Table 5.2.10.

Table 5.2.9 Topographical Features of the Plain Area

No.	River	Length (km)	Average Gradient in Plain Area	Number of Sections Used
1	Chafroud	13	0.91%	17
2	Bahambar	24	0.44%	21
3	Morghak	22	0.77%	17
4	Khalkaii	28	0.62%	24
5	Palangvar	28	0.37%	23
6	Masulehroudkhan	38	0.43%	21
7	Shakraz	39	0.29%	29
8	Pasikhan	46	0.19%	35
9	Pirbazar	52	0.26%	25

Source: measured by JICA Study Team using 1:50,000 and 1:25,000 maps

A comparison of the river gradients during the plain area is shown visually in Figure 5.2.1. The plot shows that the gradient is steepest for the western rivers and gradually decreases eastward.

[11] While it would have been preferential to use conduct filed survey to obtain detailed cross sections, it was assumed that enough accuracy to grasp the overall trend could be obtained using these rough approximations.

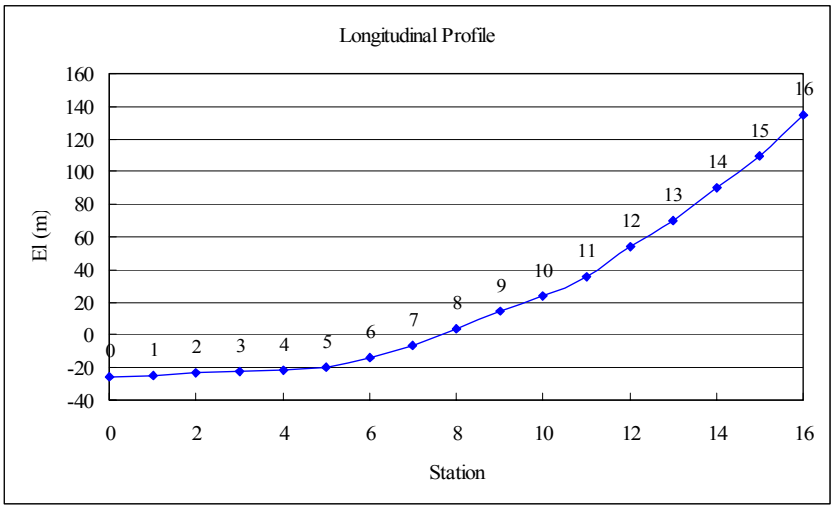
Table 5.2.10 Geometric Data for Sediment Transport Model (1 of 9)

River Name	Chafroud	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	17	

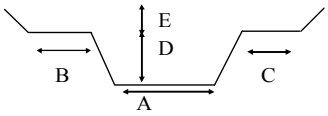
Sta. 3

(meters) (degree)

Feature	Station	Elevation (m)	Dimensions A	B	C	D	E	Side-Slopes LB	RB	LFP	RFP
	0	-26	20	4	4	2	1.25	45	45	45	45
	1	-24.8	20	4	4	2	1.25	45	45	45	45
	2	-23.6	20	4	4	2	1.25	45	45	45	45
bridge	3	-22.4	19	4	4	1.5	1.25	45	45	45	45
	4	-21.2	20	4	4	1.5	1.25	45	45	45	45
	5	-20	20	4	4	1.5	1.25	45	45	45	45
	6	-14	20	4	4	1.5	1.25	45	45	45	45
	7	-6	19	4	4	1.5	1.25	45	45	45	45
bridge	8	4	19	4	4	1.5	1.25	45	45	45	45
	9	15	19	4	4	1.5	1.25	45	45	45	45
	10	24	19	4	4	1.5	1.25	45	45	45	45
	11	36	19	4	4	1.5	1.25	45	45	45	45
	12	54	18	4	4	1.5	1.25	45	45	45	45
bridge	13	70	18	4	4	1.5	1.25	45	45	45	45
	14	90	18	4	4	1.5	1.25	45	45	45	45
	15	110	18	4	4	1.5	1.25	45	45	45	45
gage	16	135	18	4	4	1.5	1.25	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

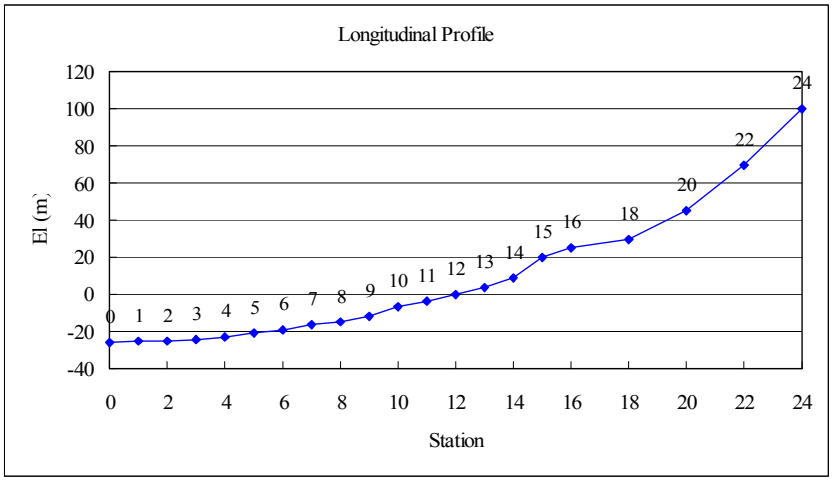
Table 5.2.10 Geometric Data for Sediment Transport Model (2 of 9)

River Name	Bahambar	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	21	

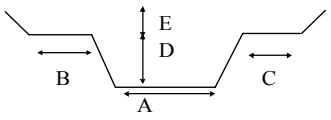
Sta.6

(meters) (degree)

Feature	Station	Elevation (m)	Dimensions					Side-Slopes			
			A	B	C	D	E	LB	RB	LFP	RFP
	0	-25.7	10	15	10	1.5	1.5	45	45	45	45
bridge	1	-25.4	10	15	10	1.5	1.5	45	45	45	45
	2	-25	10	10	10	1.5	1.5	45	45	45	45
	3	-24.6	10	10	10	1.5	1.5	45	45	45	45
	4	-23	10	10	10	1.5	1	45	45	45	45
	5	-21	10	10	10	1.5	1	45	45	45	45
gage	6	-19.5	10	10	10	1.5	1	45	45	45	45
	7	-16	10	10	10	1.5	1	45	45	45	45
	8	-15	9	10	10	1.5	1	45	45	45	45
	9	-12	9	10	10	1.5	1	45	45	45	45
	10	-7	9	10	10	1.5	1	45	45	45	45
	11	-4	9	10	10	1.5	1	45	45	45	45
	12	0	8	10	10	1.5	1	45	45	45	45
	13	4	8	10	10	1.5	1	45	45	45	45
	14	9	8	10	10	1.5	1	45	45	45	45
	15	20	8	10	10	1.5	1	45	45	45	45
bridge	16	25	7	10	10	1.5	1	45	45	45	45
	18	30	7	10	10	1.5	1	45	45	45	45
	20	45	7	10	10	1.5	1	45	45	45	45
	22	70	7	10	10	1.5	1	45	45	45	45
	24	100	7	7.5	7.5	1.5	1	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

Table 5.2.10 Geometric Data for Sediment Transport Model (3 of 9)

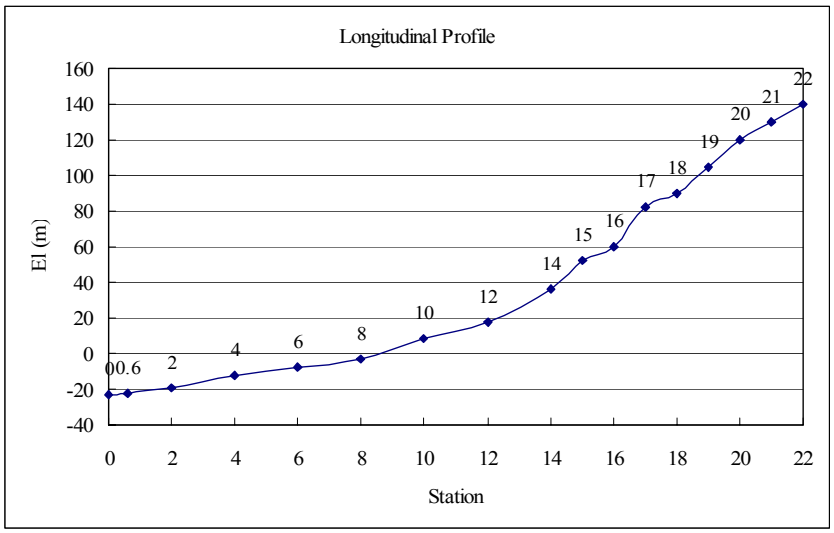
River Name	Morghak	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	17	

Sta. 0.6

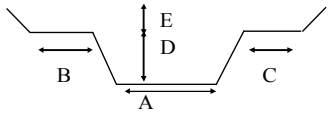
Sta.20

(meters) (degree)

Feature	Station	Elevation	Dimensions					Side-Slopes			
		(m)	A	B	C	D	E	LB	RB	LFP	RFP
	0	-23.4	11	8	8	2	1.25	45	45	45	45
gage	0.6	-22.2	11	8	8	2	1.25	45	45	45	45
bridge	2	-19.5	10.5	8	8	2	1.25	45	45	45	45
	4	-12.6	11	8	8	1.5	1.25	45	45	45	45
	6	-8	10	8	8	1.5	1.25	45	45	45	45
	8	-3	10	8	8	1.5	1.25	45	45	45	45
	10	8.6	9	8	8	1.5	1.25	45	45	45	45
	12	17.5	8	8	8	1.5	1.25	45	45	45	45
bridge	14	36	8	8	8	1.5	1.25	45	45	45	45
	15	52	9	8	8	1.5	1.25	45	45	45	45
	16	60	10	8	8	1.5	1.25	45	45	45	45
	17	82	10	8	8	1.5	1.25	45	45	45	45
	18	90	10	8	8	1.5	1.25	45	45	45	45
	19	105	10	8	8	1.5	1.25	45	45	45	45
	20	120	10	8	8	1.5	1.25	45	45	45	45
	21	130	10	8	8	1.5	1.25	45	45	45	45
gage	22	140	10	8	8	1.5	1.25	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



2 mm

Source: JICA Study Team

Table 5.2.10 Geometric Data for Sediment Transport Model (4 of 9)

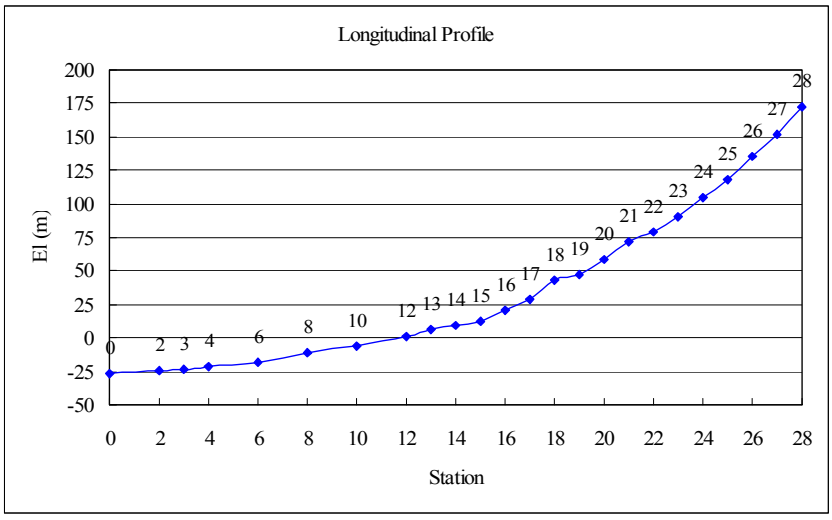
River Name	Khakai	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	24	

Sta. 4

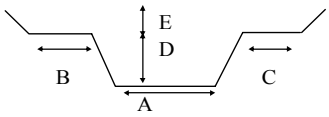
Sta. 28

(meters) (degree)

Feature	Station	Elevation (m)	Dimensions A	B	C	D	E	Side-Slopes LB	RB	LFP	RFP
	0	-26	12.5	10	10	1.25	1.25	45	45	45	45
	2	-24.3	12.5	10	10	1.25	1.25	45	45	45	45
Morghak	3	-23.1	12.5	10	10	1.25	1.25	45	45	45	45
bridge,ga	4	-21.8	11	10	10	1.25	1.25	45	45	45	45
	6	-17.9	10	10	10	1.25	1.25	45	45	45	45
bridge	8	-11.4	9	10	10	1.25	1.25	45	45	45	45
bridge	10	-6.2	9	10	10	1.25	1.25	45	45	45	45
	12	1.5	9	10	10	1.25	1.25	45	45	45	45
	13	6	9	10	10	1.25	1.25	45	45	45	45
	14	9	9	10	10	1.25	1.25	45	45	45	45
	15	13	9	10	10	1.25	1.25	45	45	45	45
	16	21	9	10	10	1.25	1.25	45	45	45	45
	17	29	9	10	10	1.25	1.25	45	45	45	45
	18	43.2	8	10	10	1.25	1.25	45	45	45	45
	19	47.5	8	10	10	1.25	1.25	45	45	45	45
	20	59	8	10	10	1.25	1.25	45	45	45	45
	21	72	8	10	10	1.25	1.25	45	45	45	45
	22	79	8	10	10	1.25	1.25	45	45	45	45
	23	90	8	10	10	1.25	1.25	45	45	45	45
	24	105	7.5	10	10	1.25	1.25	45	45	45	45
	25	118	7.5	7.5	7.5	1.25	1.25	45	45	45	45
	26	135	7.5	7.5	7.5	1.25	1.25	45	45	45	45
	27	152	7.5	7.5	7.5	1.25	1.25	45	45	45	45
gage	28	172	7.5	7.5	7.5	1.25	1.25	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

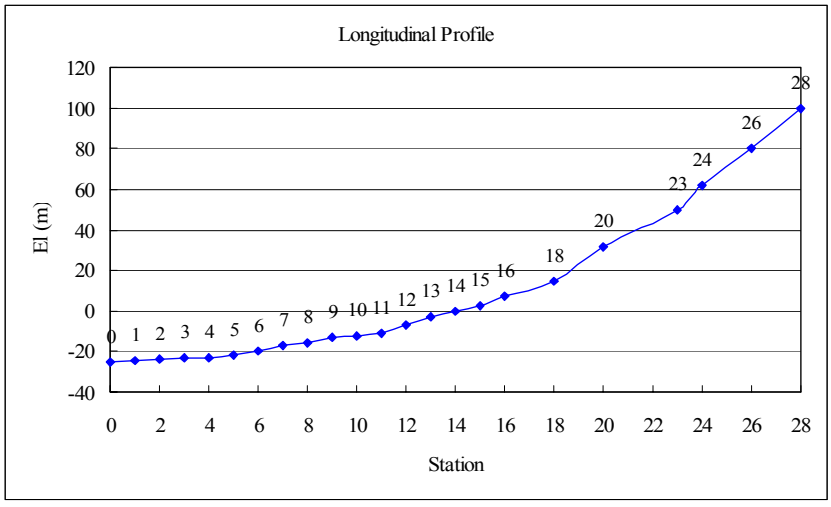
Table 5.2.10 Geometric Data for Sediment Transport Model (5 of 9)

River Name	Palangvar	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	23	

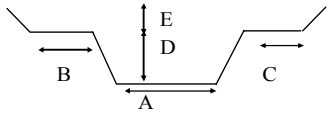
Sta.2

(meters) (degree)

Feature	Station	Elevation	Dimensions					Side-Slopes			
		(m)	A	B	C	D	E	LB	RB	LFP	RFP
	0	-25	12	15	10	1.5	1.5	45	45	45	45
	1	-24.5	12	15	10	1.5	1.5	45	45	45	45
gage	2	-24	12	10	10	1.5	1.5	45	45	45	45
bridge	3	-23.3	11.5	10	10	1.5	1.5	45	45	45	45
	4	-23	11.5	10	10	1.5	1	45	45	45	45
	5	-22	11.5	10	10	1.5	1	45	45	45	45
	6	-20	11.5	10	10	1.5	1	45	45	45	45
	7	-17	11.5	10	10	1.5	1	45	45	45	45
	8	-16	11.5	10	10	1.5	1	45	45	45	45
	9	-13	11.5	10	10	1.5	1	45	45	45	45
bridge	10	-12	11	10	10	1.5	1	45	45	45	45
	11	-11	11	10	10	1.5	1	45	45	45	45
	12	-7	11	10	10	1.5	1	45	45	45	45
	13	-3	11	10	10	1.5	1	45	45	45	45
	14	0	11	10	10	1.5	1	45	45	45	45
bridge	15	2.5	10.5	10	10	1.5	1	45	45	45	45
	16	7	10.5	10	10	1.5	1	45	45	45	45
	18	15	10.5	10	10	1.5	1	45	45	45	45
	20	31.3	10.5	10	10	1.5	1	45	45	45	45
	23	50	10.5	10	10	1.5	1	45	45	45	45
	24	62	10.5	7.5	7.5	1.5	1	45	45	45	45
bridge	26	80	10.5	7.5	7.5	1.5	1	45	45	45	45
	28	100	10.5	7.5	7.5	1.5	1	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

Table 5.2.10 Geometric Data for Sediment Transport Model (6 of 9)

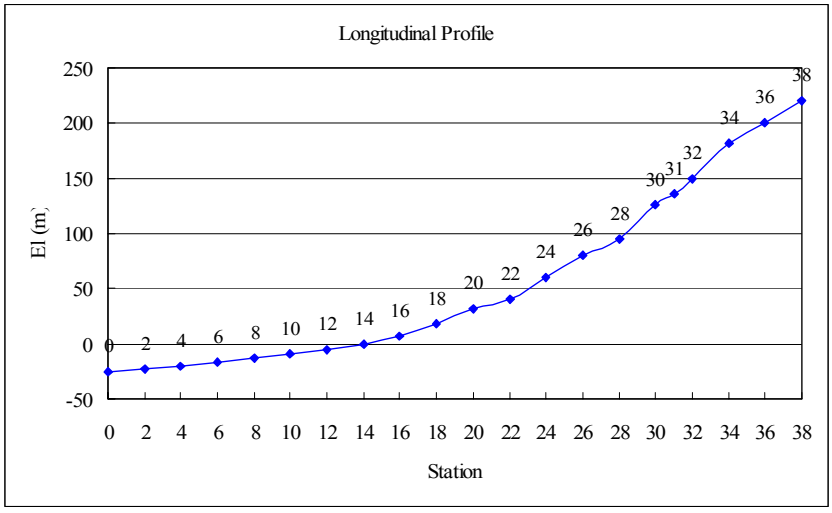
River Name	Masuleh	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	21	

Sta.2

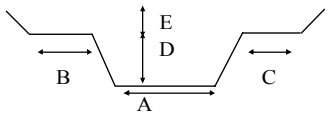
Sta. 36

(meters) (degree)

Feature	Station	Elevation	Dimensions					Side-Slopes			
		(m)	A	B	C	D	E	LB	RB	LFP	RFP
	0	-25	10	15	10	1.5	1.5	45	45	45	45
gage	2	-23.2	10	15	10	1.5	1.5	45	45	45	45
	4	-20.3	10	10	10	1.5	1.5	45	45	45	45
	6	-16.7	9	10	10	1.5	1.5	45	45	45	45
	8	-12.2	9	10	10	1.5	1	45	45	45	45
	10	-9.2	9	10	10	1.5	1	45	45	45	45
bridge	12	-5.5	7.5	10	10	1.5	1	45	45	45	45
bridge	14	-0.8	7.5	10	10	1.5	1	45	45	45	45
	16	7.6	9	10	10	1.5	1	45	45	45	45
	18	18.1	9	10	10	1.5	1	45	45	45	45
	20	31.9	9	10	10	1.5	1	45	45	45	45
	22	40	9	10	10	1.5	1	45	45	45	45
	24	60	8	10	10	1.5	1	45	45	45	45
	26	80	8	10	10	1.5	1	45	45	45	45
	28	95	8	10	10	1.5	1	45	45	45	45
	30	126	8	10	10	1.5	1	45	45	45	45
	31	136	8	10	10	1.5	1	45	45	45	45
	32	150	8	10	10	1.5	1	45	45	45	45
	34	182	8	10	10	1.5	1	45	45	45	45
gage	36	200	7.5	10	10	1.5	1	45	45	45	45
	38	220	7.5	7.5	7.5	1.5	1	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

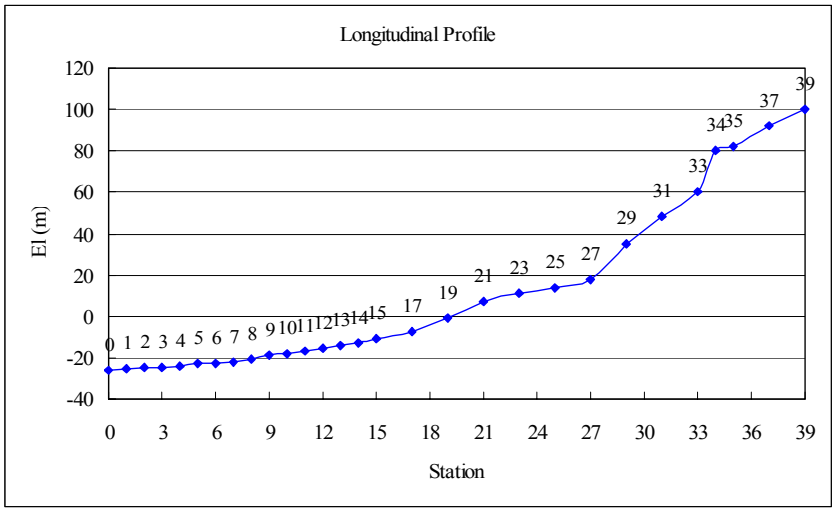
Table 5.2.10 Geometric Data for Sediment Transport Model (7 of 9)

River Name	Shakraz	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	29	

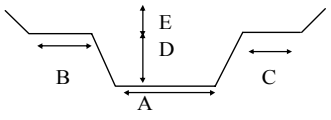
Sta.7

(meters) (degree)

Feature	Station	Elevation (m)	Dimensions A	B	C	D	E	Side-Slopes LB	RB	LFP	RFP
	0	-26	12	15	10	1.5	1.5	45	45	45	45
	1	-25.5	12	15	10	1.5	1.5	45	45	45	45
	2	-25	12	10	10	1.5	1.5	45	45	45	45
	3	-24.5	12	10	10	1.5	1.5	45	45	45	45
	4	-24	12	10	10	1.5	1	45	45	45	45
	5	-23	12	10	10	1.5	1	45	45	45	45
	6	-22.5	12	10	10	1.5	1	45	45	45	45
gage	7	-22	12	10	10	1.5	1	45	45	45	45
bridge	8	-20.5	11.5	10	10	1.5	1	45	45	45	45
	9	-19	11.5	10	10	1.5	1	45	45	45	45
	10	-18	11.5	10	10	1.5	1	45	45	45	45
	11	-17	11.5	10	10	1.5	1	45	45	45	45
	12	-15.5	11.5	10	10	1.5	1	45	45	45	45
	13	-14	11.5	10	10	1.5	1	45	45	45	45
	14	-12.5	11.5	10	10	1.5	1	45	45	45	45
	15	-11	11.5	10	10	1.5	1	45	45	45	45
	17	-7.5	11.5	10	10	1.5	1	45	45	45	45
bridge	19	-1	11	10	10	1.5	1	45	45	45	45
	21	7	11	10	10	1.5	1	45	45	45	45
	23	11	11	10	10	1.5	1	45	45	45	45
	25	14	11	7.5	7.5	1.5	1	45	45	45	45
	27	18	11	7.5	7.5	1.5	1	45	45	45	45
	29	35	11	7.5	7.5	1.5	1	45	45	45	45
	31	48	11	7.5	7.5	1.5	1	45	45	45	45
	33	60	11	7.5	7.5	1.5	1	45	45	45	45
	34	80	11	7.5	7.5	1.5	1	45	45	45	45
	35	82	11	7.5	7.5	1.5	1	45	45	45	45
	37	92	11	7.5	7.5	1.5	1	45	45	45	45
	39	100	11	7.5	7.5	1.5	1	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

Table 5.2.10 Geometric Data for Sediment Transport Model (8 of 9)

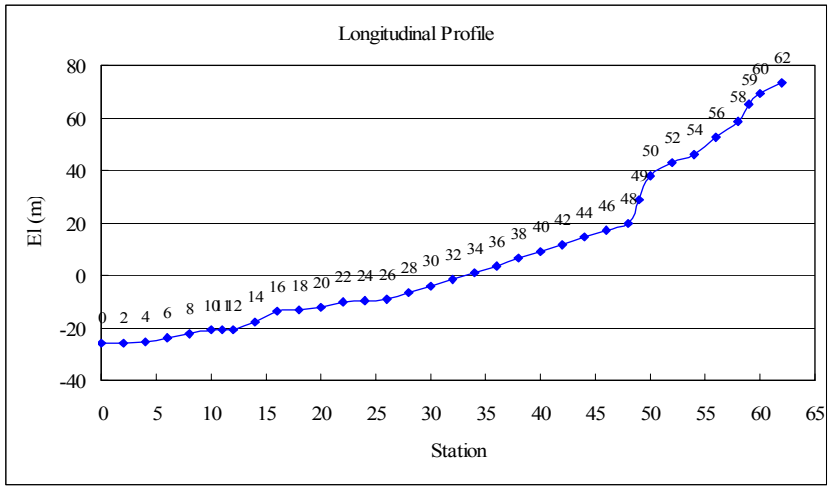
River Name	Pasikhan	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	35	

Sta. 12

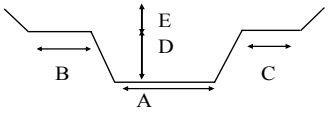
Sta. 60

(meters) (degree)

Feature	Station	Elevation (m)	Dimensions A	B	C	D	E	Side-Slopes LB	RB	LFP	RFP
	Sta.	-26	35	10	10	1.5	1.5	45	45	45	45
	Sta. 2	-25.6	35	10	10	1.5	1.5	45	45	45	45
	Sta. 4	-25.2	35	10	10	1.5	1.5	45	45	45	45
	Sta. 6	-23.6	35	10	10	1.5	1.5	45	45	45	45
	Sta. 8	-22.1	32.5	10	10	1.5	1	45	45	45	45
	Sta. 10	-21	30	10	10	1.5	1	45	45	45	45
bridge	Sta. 11	-20.9	27.5	10	10	1.5	1	45	45	45	45
gage	Sta. 12	-20.8	30	10	10	1.5	1	45	45	45	45
	Sta. 14	-17.5	29	10	10	1.5	1	45	45	45	45
	Sta. 16	-13.7	28	10	10	1.5	1	45	45	45	45
	Sta. 18	-13	27	10	10	1.5	1	45	45	45	45
	Sta. 20	-11.9	26	10	10	1.5	1	45	45	45	45
	Sta. 22	-10	25	10	10	1.5	1	45	45	45	45
	Sta. 24	-9.75	25	10	10	1.5	1	45	45	45	45
	Sta. 26	-8.9	25	10	10	1.5	1	45	45	45	45
	Sta. 28	-6.36	22.5	10	10	1.5	1	45	45	45	45
bridge	Sta. 30	-3.82	20	10	10	1.5	1	45	45	45	45
	Sta. 32	-1.28	20	10	10	1.5	1	45	45	45	45
	Sta. 34	1	17.5	10	10	1.5	1	45	45	45	45
	Sta. 36	3.7	17	10	10	1.5	1	45	45	45	45
	Sta. 38	6.4	17	7.5	7.5	1.5	1	45	45	45	45
	Sta. 40	9.1	17	7.5	7.5	1.5	1	45	45	45	45
bridge	Sta. 42	11.8	15	7.5	7.5	1.5	1	45	45	45	45
	Sta. 44	14.5	15	7.5	7.5	1.5	1	45	45	45	45
	Sta. 46	17.2	15	7.5	7.5	1.5	1	45	45	45	45
	Sta. 48	19.9	15	7.5	7.5	1.5	1	45	45	45	45
	Sta. 49	28.9	15	7.5	7.5	1.5	1	45	45	45	45
inflow	Sta. 50	37.9	15	7.5	7.5	1.5	1	45	45	45	45
	Sta. 52	42.9	12	7.5	7.5	1.5	1	45	45	45	45
	Sta. 54	46.1	12	7.5	7.5	1.5	1	45	45	45	45
	Sta. 56	52.5	12	7.5	7.5	1.5	1	45	45	45	45
	Sta. 58	58.9	12	7.5	7.5	1.5	1	45	45	45	45
	Sta. 59	65.3	12	7.5	7.5	1.5	1	45	45	45	45
gage	Sta. 60	69.3	12	7.5	7.5	1.5	1	45	45	45	45
	Sta. 62	73.3	12	7.5	7.5	1.5	1	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team

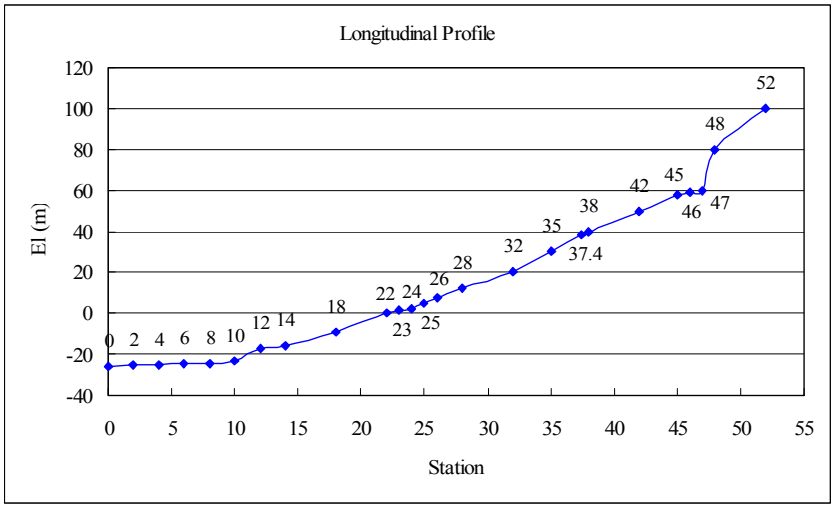
Table 5.2.10 Geometric Data for Sediment Transport Model (9 of 9)

River Name	Pirbazar	
Temp	20	Celcius
Temp	68	Farenheit
Num. X-sect.	25	

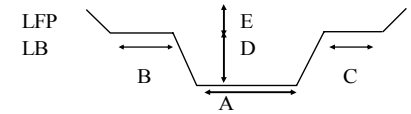
Sta.10

(meters) (degree)

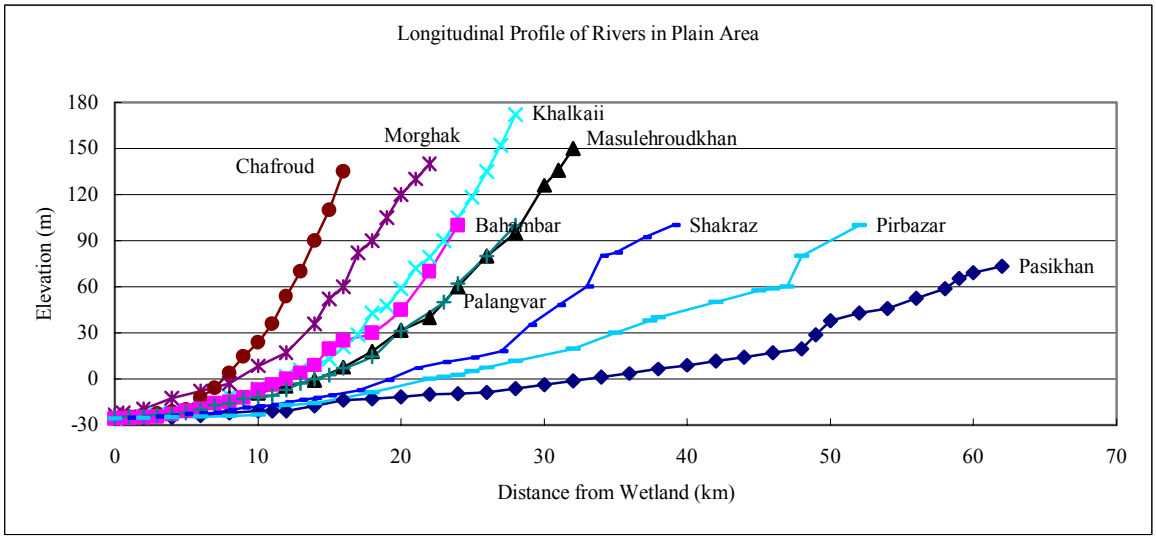
Feature	Station	Elevation (m)	Dimensions A	B	C	D	E	Side-Slopes LB	RB	LFP	RFP
	Sta. 0	-26	20	10	10	2.5	1	45	45	45	45
	Sta. 2	-25.6	20	10	10	2.5	1	45	45	45	45
	Sta. 4	-25	20	10	10	2.5	1	45	45	45	45
Gage	Sta. 6	-24.7	20	10	10	2.5	1	45	45	45	45
	Sta. 8	-24.3	20	10	10	2.5	1	45	45	45	45
Bridge	Sta. 10	-23.4	20	10	10	2.5	1	45	45	45	45
Goharoud	Sta. 12	-17.3	20	10	10	2	1	45	45	45	45
	Sta. 14	-15.7	17.5	10	10	2	1	45	45	45	45
	Sta. 18	-9	15	10	10	2	1	45	45	45	45
	Sta. 22	0	12.5	7.5	7.5	2	1	45	45	45	45
	Sta. 23	1.2	10	7.5	7.5	2	1	45	45	45	45
	Sta. 24	2.4	7.5	7.5	7.5	2	1	45	45	45	45
	Sta. 25	4.8	7.5	7.5	7.5	2	1	45	45	45	45
Gage	Sta. 26	7.2	7	7.5	7.5	2	1	45	45	45	45
	Sta. 28	12	7	7.5	7.5	1.5	1	45	45	45	45
	Sta. 32	20	6	7.5	7.5	1.5	1	45	45	45	45
	Sta. 35	30.1	6	7.5	7.5	1.5	1	45	45	45	45
Gage	Sta. 37.4	38.2	6	7.5	7.5	1.5	1	45	45	45	45
	Sta. 38	40	6	7.5	7.5	1.5	1	45	45	45	45
	Sta. 42	50	6	7.5	7.5	1.5	1	45	45	45	45
	Sta. 45	57.5	6	7.5	7.5	1.5	1	45	45	45	45
	Sta. 46	59	6	7.5	7.5	1.5	1	45	45	45	45
	Sta. 47	60	5	7.5	7.5	1.5	1	45	45	45	45
	Sta. 48	80	5	7.5	7.5	1.5	1	45	45	45	45
	Sta. 52	100	5	7.5	7.5	1.5	1	45	45	45	45



Legend
LFP - left flood plain
LB - left bank
RFP - right flood plain
RB - right flood bank



Source: JICA Study Team



Source: measured by JICA Study Team using 1:50,000 and 1:25,000 maps

Figure 5.2.1 Longitudinal Profiles of Rivers in Plain Area

Discharge data collected by MOE and was used for the model. The downstream discharge is used as the boundary condition to determine the velocity and water surface profiles for the upstream sections. The calculation uses the standard step method. This method solves the energy and continuity equations to determine the water profile and velocity of each section.

Sediment data consists of two types. They are suspended sediment data collected by MOE and particle size data taken from reports prepared by MOJA during their study in 1989[12]. Bed material in the rivers consisted mainly of sandy material with a small fraction of silts and clays. The model also specifies the depth of scour in the river bed. No data on bed elevation change was available. By site observation, it was assessed that the river beds are relatively stable and that they do not encounter scouring. Therefore, a minimal scouring depth was assumed for the analysis.

At each section, the amount of deposition and transport are computed by the software. Deposition of inflowing sediment is governed by the settling velocity of the particle while the sediment transport was calculated by the use of DuBoy's equation.

(3) Results

The degree of sediment deposition along the longitudinal profile of the rivers, starting from the entrance of the wetland, is shown in Table 5.2.11.

[12] MOJA 1989, Vol. 5 – Sediment

Table 5.2.11 Results of Sediment and Scour/Deposition Analysis

(tons/yr/section)

River: Chafroud

Sta.	Qs,pass	Qs,dep/scour
	14,696	
16	14,719	-18
15	14,766	-37
14	14,812	-37
13	14,859	-37
12	14,908	-39
11	14,957	-39
10	15,007	-39
9	15,056	-39
8	15,103	-38
7	15,152	-39
6	15,174	-17
5	15,142	25
4	15,118	19
3	15,056	58
2	15,061	-4
1	15,084	-15
0	15,090	-4

River: Bahambar

Sta.	Qs,pass	Qs,dep/scour
	4,399	
26	4,315	107
24	4,371	-45
22	4,428	-45
20	4,486	-47
18	4,551	-51
16	4,595	-36
14	4,628	-26
13	4,662	-28
12	4,683	-17
11	4,703	-16
10	4,724	-17
9	4,746	-17
8	4,772	-21
7	4,794	-18
6	4,813	-15
5	4,835	-17
4	4,852	-13
3	4,849	2
2	4,860	4
1	4,682	215
0	4,341	373

River: Morghak

Sta.	Qs,pass	Qs,dep/scour
	19,018	
22	19,027	-7
21	19,046	-15
20	19,064	-15
19	19,083	-15
18	19,101	-15
17	19,119	-15
16	19,138	-14
15	19,141	-3
14	19,144	-2
12	19,163	-15
10	19,174	-8
8	19,191	-14
6	19,224	-26
4	19,276	-41
2	19,324	-39
1	19,359	-28
0	19,351	7

River: Khakaii

Sta.	Qs,pass	Qs,dep/scour
	15,352	
28	15,356	-4
27	15,365	-7
26	15,374	-7
25	15,383	-7
24	15,391	-7
23	15,398	-5
22	15,407	-7
21	15,416	-7
20	15,430	-11
19	15,453	-19
18	15,466	-10
17	15,477	-9
16	15,488	-9
15	15,499	-9
14	15,511	-9
13	15,524	-11
12	15,542	-14
10	15,565	-19
8	15,589	-19
6	15,613	-19
4	15,634	-16
3	15,617	13

River: Palangvar

Sta.	Qs,pass	Qs,dep/scour
	19,727	
28	19,767	-32
26	19,848	-64
24	19,905	-45
22	19,975	-55
20	20,069	-75
18	20,217	-118
16	20,304	-70
15	20,385	-64
14	20,428	-34
13	20,470	-33
12	20,513	-35
11	20,563	-40
10	20,615	-41
9	20,662	-37
8	20,704	-34
7	20,750	-36
6	20,799	-39
5	20,850	-41
4	20,896	-37
3	20,857	31
2	20,706	121
1	20,475	183
0	20,622	-117

River: Masulehroudkhan

Sta.	Qs,pass	Qs,dep/scour
	25,832	
38	26,335	-401
36	26,824	-389
34	27,241	-331
32	27,571	-263
30	27,702	-104
28	27,741	-31
26	27,852	-89
24	28,000	-118
22	28,055	-44
20	28,275	-175
18	28,440	-131
16	28,572	-106
14	28,591	-15
12	28,605	-11
11	28,632	-22
10	28,604	23
8	28,617	-11
6	28,631	-11
4	28,501	103
2	28,392	87
0	28,305	126

River: Shakraz

Sta.	Qs,pass	Qs,dep/scour
	47,516	
39	47,532	-13
37	47,643	-88
35	47,733	-72
34	47,728	4
33	47,840	-89
31	48,098	-205
29	48,163	-52
27	48,182	-15
25	48,238	-45
23	48,297	-47
21	48,382	-68
19	48,482	-80
17	48,577	-75
15	48,637	-48
14	48,675	-30
13	48,714	-31
12	48,750	-29
11	48,788	-30
10	48,827	-31
9	48,867	-32
8	48,911	-35
7	48,447	370
6	48,042	322
5	47,671	296
4	47,382	230
3	47,289	74
2	47,511	-176
1	47,667	-125
0	47,599	55

River: Pasikhan

Sta.	Qs,pass	Qs,dep/scour
	137,912	
62	137,925	-10
60	137,925	0
59	137,840	67
58	137,842	-2
56	137,866	-19
54	137,886	-16
52	137,911	-20
50	137,947	-29
49	137,979	-25
48	138,007	-22
46	138,041	-27
44	138,078	-29
42	138,114	-29
40	138,150	-29
38	138,208	-46
36	138,286	-62
34	138,330	-35
32	138,376	-37
30	138,476	-80
28	138,248	182
26	138,292	-35
24	138,421	-102
22	138,379	33
20	138,356	18
18	138,369	-11
16	138,356	10
14	138,301	44
12	138,344	-34
11	138,146	359
10	138,194	-38
8	137,853	609
6	137,813	32
4	137,512	544
2	137,275	431
0	137,140	230

River: Pirbazar

Sta.	Qs,pass	Qs,dep/scour
	47,888	
52	48,003	-91
48	48,198	-155
47	48,245	-38
46	48,286	-32
45	48,398	-90
42	48,549	-120
38	48,632	-66
37.4	48,661	-23
35	48,727	-53
32	48,843	-93
28	48,957	-91
26	49,009	-42
25	49,049	-32
24	49,086	-29
23	49,132	-37
22	49,291	-127
18	49,532	-192
12	59,038	-123
10	59,145	-86
8	59,197	-41
6	59,350	-122
4	59,694	-275
2	59,795	-80
0	59,818	-18

Station also refers to distance from wetland
Soure: JICA Study Team

The simulation was run for one year in order to incorporate the rainy and dry season and calibrated to observed values where they are available. Positive/negative values in the table indicate the scouring/deposition of sediment for that section.

As is shown, the upper reaches of the rivers as they flow out of the mountain area and into the plain area, have the ability to scouring to some degree. These areas are characterized by coarse river beds in the site. The lower reaches appear to vary from west to east. Towards the west, the lower reaches tend to carry sediments which is due to their steeper slopes. Towards the east, the lower reaches have lower gradients and thus, are more prone to sediment deposit (ie. Pasikhan and Masulehroudkhan, and Khalkaii rivers show a very small percentage of sediment deposition within a few kilometers of the wetland).

At the bottom of the table, the overall sediment that reaches the wetland as a percentage of inflowing sediment is calculated. They show that over the course of a year, a minor increase in sediment of up to 3% can be expected for the rivers. This is relatively minor as the occurrence of floods are likely to balance out the river bed. This result appears to be reasonable, given the relatively stable riverbeds in the basin.

5.2.4 Sediment-Discharge Relationship

Sediment-discharge relationships were established for all gages in the watershed. The equation of the regression curves has the following form.

$$Q_s = aQ^b$$

Q_s : suspended sediment load (ton/day)

Q : discharge (m^3/s)

a,b : regression constants (-)

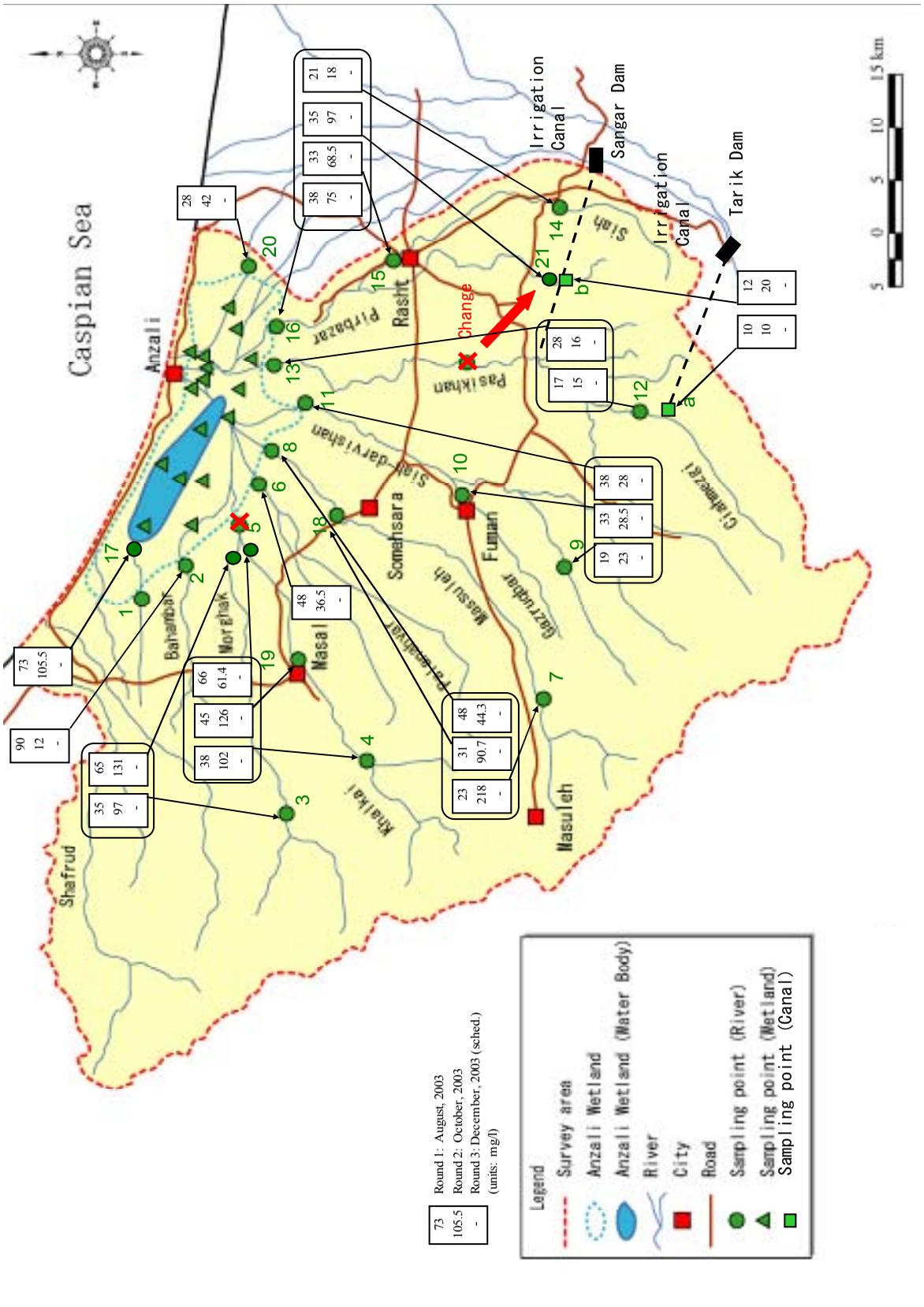
Sediment and flow data from MOE was used. The data was compared with the sediment measurements collected during the Study, shown in Figure 5.2.2, and were found to be reasonable in magnitude. Attempt was not made to create a broken curve for normal and flood situation, however measurements were divided into those within the last ten years and those more than ten years. Table 5.2.12 lists the *a*, *b* values for each of the stations, together with the number of suspended sediment measurements used. The number of samples is generally over 200. Figure 5.2.3 shows the sediment rating curves for each station.

The annual suspended sediment load was calculated using the above equation for each station by using the average daily discharge to compute the average daily suspended sediment load.

Table 5.2.12 Summary of Parameters for Suspended Sediment Equation

No.	River	Station	MOE Code	No of Samples	Qs=aQb >10yr		Qs=aQb last 10yr	
					a	b	a	b
1	Chafroud	Roudbarsara	18019	263	2.1969	2.1823	2.5857	1.4844
2	Bahmbar	Aghamahaleh	18095	241	4.5121	1.2351	3.448	1.2182
3	Morghak	Imamzadeh Shafee	18067	242	2.8136	1.4879	3.2014	1.4168
4	Morghak	Kotemjan	18093	239	4.218	1.6529	2.9591	1.3938
5	Khalkai	Taskooh	18065	291	1.8749	1.6002	1.2059	1.6153
6	Khalkai	Kotemjan	18091	269	3.6499	1.1394	3.5568	1.2048
7	Tanianroud	Mianbar	18921	91	2.5234	1.1394	2.5234	1.1394
8	Siavaroud	Siavaroud Alian	18923	105	2.1586	1.0326	2.1586	1.0326
9	Palangvar	Masjed Pish Alian	18920	92	2.2164	1.1986	2.2164	1.1986
10	Palangvar	Kalsar	18089	243	1.6067	1.6304	2.2067	1.3241
11	Masulehroudkhan	Kamadol	18063	300	3.4397	1.6454	2.1042	1.6212
12	Masulehroudkhan	Chomesghal	18087	263	2.6025	1.6085	2.4256	1.4984
13	Gashteroudkhan	Pirsara	18061	258	4.2631	1.1646	2.5288	1.1294
14	Nazaralat	Ghaleroudkhan	18059	262	2.2695	1.69	2.6787	1.2434
15	Ghaleroudkhan	Ghaleroudkhan	18030	136	2.353	1.117	2.353	1.117
16	Shakhazar	Laksar	18083	259	2.7715	1.4609	2.4117	1.5712
17	Imamzadeh Ibrahin	Mobarakabad	18106	136	1.9105	1.324	1.9105	1.324
18	Pasikhan	Nokhaleh	18081	277	1.1539	1.6595	1.7085	1.3639
19	Goharroud	Lakan	17967	234	6.8441	1.4352	4.672	1.1642
20	Siahroud	Behdan	17111	271	7.0312	1.0939	3.867	1.2011
21	Siahroud	Polesazeman	17053	306	2.4239	1.8065	2.4595	1.5192

Source: JICA Study Team



Source: JICA Study Team

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran

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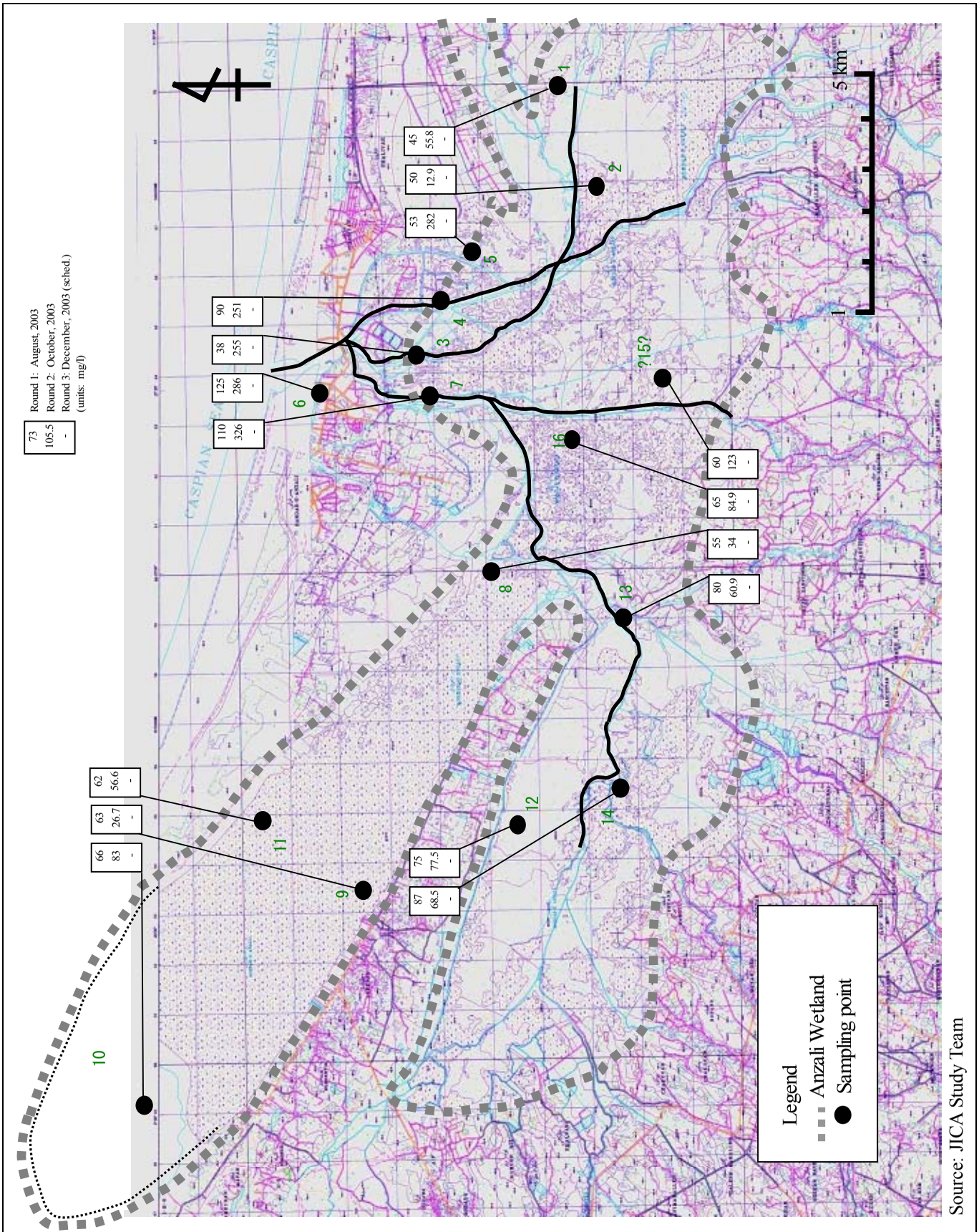
Figure 5.2.2 (1/2)
Suspended Sediment Measurements

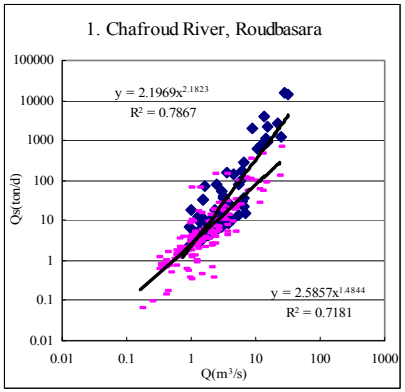


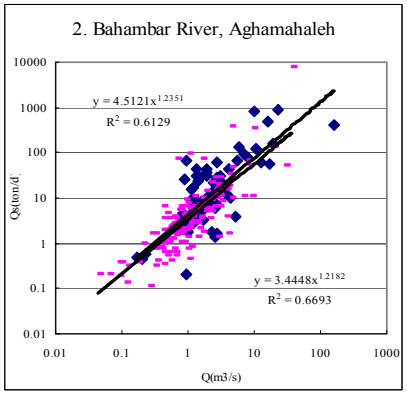
The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran

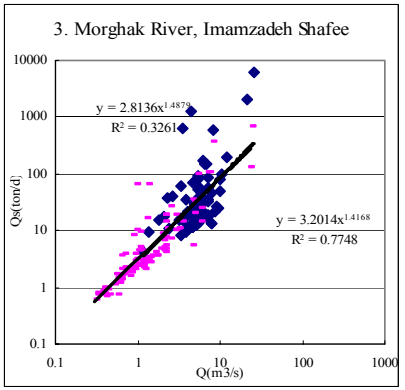
JAPAN INTERNATIONAL COOPERATION AGENCY

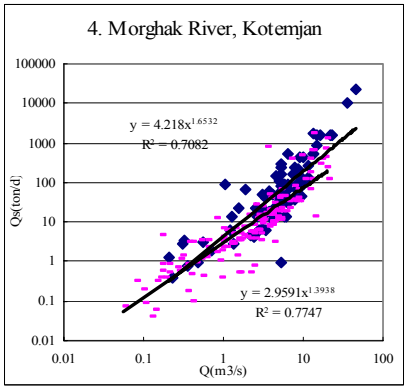
Figure 5.2.2 (2/2)

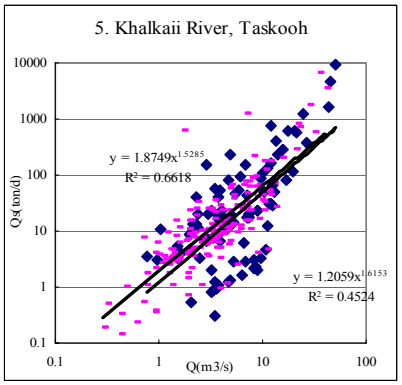
Suspended Sediment Measurements

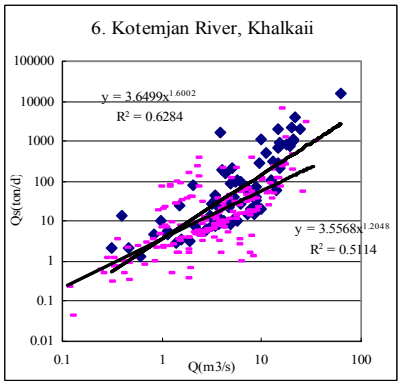


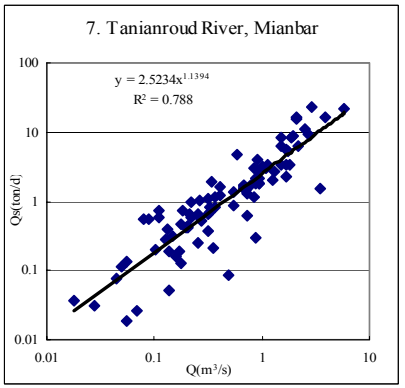


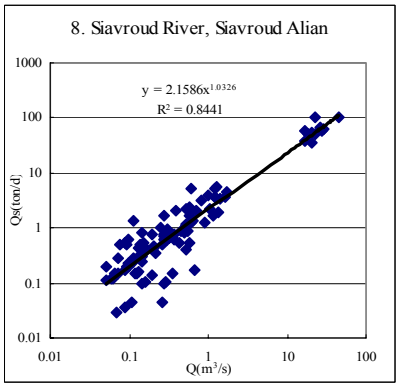


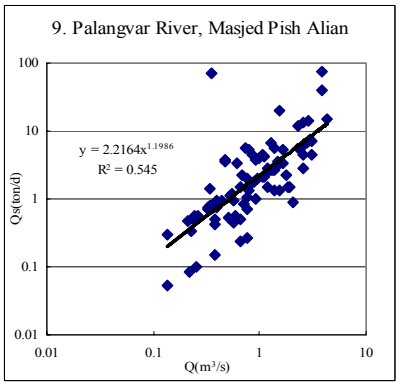


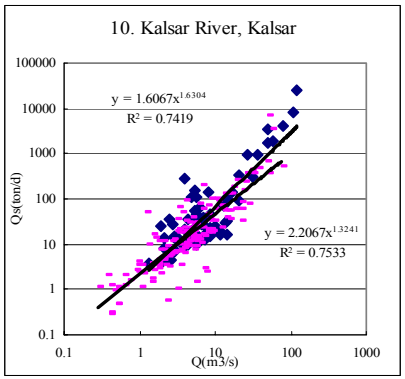


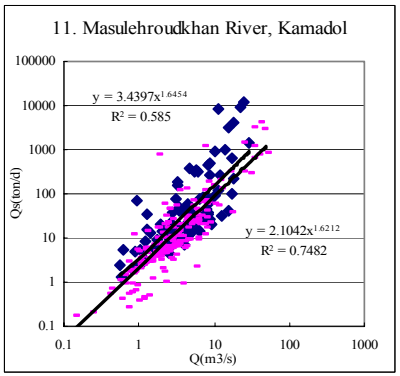












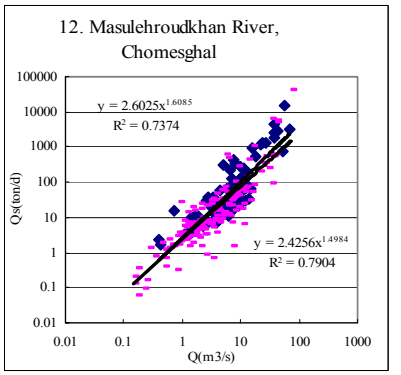


Figure 5.2.3 (1/2)
Sediment Rating Curves

diamonds: prior to 1993

lines: 1992-2002

Source: MOE Anzali and JICA Study Team

diamonds: prior to 1993

lines: 1992-2002

Source: MOE Anzali and JICA Study Team

Figure 5.2.3 (2/2)
Sediment Rating Curves

Next, bed load was incorporated by assuming that 15% of the total sediment yield is bed load. Based on interviews with MOJA staff, and based on MOJA '89, it is generally accepted that the bed load is 15% of the total yield. The annual sediment load from each station is given in Table 5.2.13.

Based on measurement data, the amount of sediment is tabulated to be 158,300 ton/yr from the mountain area and 393,500 ton/yr from the lowland rivers into the wetlands, as summarized in Table 5.2.14.

It is pointed out that the mountain sediment load calculated is much smaller than the average of the EPM and PSIAC methods (ie. 158,300 ton/yr vs 326,000 ton/yr). This discrepancy can be explained by the following errors.

1) Bed load assumption: Bed load was assumed to be 15% in the mountain area. The USBR[13] mentions that bed load can be as low as 25 % of the suspended load to as high as 150% of the sediment load. The Delft Hydraulic Laboratory[14] in the Netherlands mentions by a graph that the ratio of suspended sediment to bed load sediment can be as high as 1.0. Since bed load is not measured by MOE at present, large errors due to bed load are conceivable.
2) Difficulty to measure mountain area sediment during high flow: While MOE is diligent in obtaining suspended sediment discharge data, it is extremely difficult to obtain accurate data during times of high flow. This is even more difficult in the mountain areas. Thus, due to this difficulty, the overall sediment from the mountain area may be underestimated than as compared to estimates in the lowland area gages.

The total quantity of sediment entering the wetland is similar in value to the value in the sediment balance earlier, although discrepancies in magnitude for individual rivers are apparent. The major reason for this discrepancy is due to the approach to calculation. The sediment in the mountain was calculated with land area as the main factor, thus reflecting aerial parameters of the basin. On the other hand, the sediment using suspended sediment data was calculated with discharge being the main factor, thus reflecting climatological and hydrological factors of the basin.

[13] "Design of Small Dams", Appendix A, pg 539, USBR, 1987
[14] "Methods for Measurement of Sediment Transport", Section 2.1, Delft Hydraulics Laboratory, 1986

Table 5.2.13 Annual Suspended Sediment (tons) (1/2)

River Station	1. Chafroud Roudbarsara	2. Bahmbar Aghamahaleh	3. Morghak Imamzadeh Shafee	4. Morghak Kotemjan	5. Khalkai Taskooh	6. Khalkai Kotemjan	7. Tanianroud Mianbar	8. Siavaroud Siavaroud Alian	9. Palangvar Masjed Pish Alian	10. Palangvar Kalsar	11.Masulehroudkhan Kamadol	12.Masulehroudkhan Chomesghal
Location	(US)	(DS)	(US)	(DS)	(US)	(DS)	(US)	(US)	(US)	(DS)	(US)	(DS)
Area(km2)	131.7	150.6	235.7	328.4	215.9	310.8	39.8	12.5	48.3	227.0	223.7	406.8
Year												
1974	incomplete											
1975	25,826											
1976	8,509											
1977	39,382											
1978	9,003											
1979	788											
1980	4,040											
1981	8,242											
1982	40,114				incomplete							
1983	13,584				8,718							
1984	18,876		incomplete		11,330						incomplete	
1985	24,570		16,347		12,613					incomplete	22,747	
1986	15,277	incomplete	incomplete	incomplete	9,345	incomplete				32,426	21,060	11,954
1987	41,037	4,384	incomplete	27,390	11,132	31,481				no data	21,178	29,626
1988	9,614	4,593	13,460	19,983	10,043	24,402				no data	24,973	22,660
1989	incomplete	3,609	13,126	29,810	8,714	18,767				no data	23,178	18,856
1990	incomplete	4,414	12,370	19,471	10,226	20,805				22,709	21,962	27,103
1991	7,731	3,155	6,815	13,945	6,530	14,919				18,552	13,979	20,677
1992	19,995	6,239	17,816	40,746	13,232	40,219				45,952	29,649	45,529
1993	17,944	7,138	17,774	48,819	14,216	46,747				47,847	30,548	51,891
1994	4,204	2,632	14,495	11,545	9,605	13,814				9,470	18,060	24,580
1995	1,717	1,651	4,978	5,107	3,292	5,534				7,858	6,718	6,750
1996	12,174	3,584	11,806	8,202	9,464	9,813				12,886	16,616	24,849
1997	3,328	3,757	10,465	8,347	6,791	8,423				15,175	13,202	19,544
1998	3,628	4,779	12,133	9,164	9,069	9,325	incomplete	incomplete		13,192	16,709	27,167
1999	2,100	2,795	7,654	2,463	3,904	3,659	681	304	incomplete	7,893	5,978	10,618
2000	3,785	3,779	16,165	5,220	6,132	6,849	722	290	incomplete	9,893	incomplete	12,446
2001	2,780	1,962	8,220	6,174	6,890	6,564	604	225	incomplete	10,605	4,026	incomplete
Suspended	13,530	3,898	12,242	17,092	9,013	17,421				19,574	18,161	23,617
Yield*	15,918	4,586	14,402	20,109	10,604	20,496				23,028	21,366	27,784
Conversion												
ton/km2	121	30	61	61	49	66				101	96	68
mm/yr	0.093	0.023	0.047	0.047	0.038	0.051				0.078	0.073	0.053

Note: * Yield refers to suspended and bed sediment load; bed sediment load taken at 15% of total as suggested by MOJA staff.
Source: JICA Study Team

Table 5.2.13 Annual Suspended Sediment (tons) (2/2)

River	13.Gashteroudkhan	14.Nazaralat	15.Ghaleroudkhan	16.Shakhazar	17.Imamzadeh Ibrahim	18.Pasikhan	19.Goharroud	20. Siahroud	21. Siahroud
Station	Pirsara	Ghaleroudkhan	Ghaleroudkhan	Laksar	Mobarakabad	Nokhaleh	Lakan	Behdan	Polesazeman
Location	(US)	(US)	(US)	(DS)	(US)	(DS)	(US)	(US)	(DS)
Area(km2)	72.5	83.8	112.0	429.3	118.8	751.2	29.2	93.1	147.2
Year									
1974									incomplete
1975									46,428
1976									80,588
1977									47,754
1978									67,029
1979									50,463
1980									44,600
1981									36,502
1982									56,704
1983									27,654
1984	2,385	3,504		incomplete					no data
1985	5,120	5,298		incomplete					no data
1986	4,382	6,758		incomplete		incomplete			30,873
1987	4,525	9,278		55,091		incomplete			36,178
1988	3,951	4,492		40,923		139,066		4,975	27,030
1989	4,058	7,136		45,417		92,752		6,066	40,858
1990	4,702	6,305		51,830		156,019	incomplete	5,165	45,218
1991	4,088	6,150		31,078		152,890	1,736	3,768	15,928
1992	5,250	10,182		73,971		66,319	5,166	incomplete	38,921
1993	6,598	incomplete		79,377		198,647	7,609	incomplete	66,597
1994	2,518	incomplete		28,962	incomplete	277,932	1,779	incomplete	20,791
1995	1,420	1,858		15,042	3,537	65,980	888	incomplete	12,954
1996	5,372	6,497		incomplete	6,945	37,610	1,483	incomplete	16,718
1997	2,837	3,874	1,191	incomplete	6,185	57,721	1,961	3,884	21,209
1998	3,123	5,096	incomplete	31,784	incomplete	68,193	3,207	5,225	24,654
1999	2,364	2,921	incomplete	16,711	incomplete	78,429	2,632	2,682	14,182
2000	3,346	3,855	incomplete	28,948	8,737	40,321	1,521	7,616	18,915
2001	2,088	2,276	incomplete	incomplete	5,242	79,671	1,209	4,297	16,036
Suspended	3,785	5,343	1,191	41,595	6,129	107,968	2,654	4,853	36,191
Yield*	4,453	6,285	1,401	48,935	7,211	127,021	3,122	5,709	42,578
Conversion									
ton/km2	61	75	13	114	61	169	107	61	289
mm/yr	0.047	0.058	0.010	0.088	0.047	0.130	0.082	0.047	0.223

Note: * Yield refers to suspended and bed sediment load; bed sediment load taken at 15% of total as suggested by MOJA staff.
Source: JICA Study Team

Table 5.2.14 Sediment Load from Mountain Area and Plain Area

No.	River	River Length (m)	Mountainous Area								
			Gage data		Adjusted to EL 100m.						
			Area (km^2)	Q_s Load (ton)	Area (km^2)	Q_s Adjust (ton)	Q_b 15% of tot.(ton)	Q_y (ton)	Denudation Rate (mm/yr)	Unit Total Load (ton/km^2)	Reference
1	Chafroud	44.6	132	13,530	132	13,530	2,388	15,918	0.093	121	Roudbasara Sta
2	Bahmbar	27.1	30	3,031 *	30	3,031 *	535	3,565	0.093	121	Roudbasara Sta
3	Morghak	47.4	236	12,200	256	13,271	2,342	15,613	0.047	61	Imamzadeh Sta.
4	Khalkai	49	216	9,000	245	10,217	1,803	12,020	0.038	49	Taskooh Sta.
5	Palangvar	36.2	115	9,373 *	115	9,373 *	1,654	11,027	0.074	96	Komadol Sta
6	Masulehroudkhan	58.1	224	18,200	300	24,440	4,313	28,753	0.074	96	Komadol Sta
7	Shakhazar	56.7	272	22,154 *	272	22,154 *	3,910	26,064	0.074	96	Komadol Sta
8	Pasikhan	85.8	412	33,528 *	412	33,528 *	5,917	39,445	0.074	96	Komadol Sta
9	Pirbazar	60.2	122	7,600	80	4,984	879	5,863	0.056	73	Behdan+Lakan Sta
10	Remaining Catchment										
	Total		1,758		1,843			158,268	0.066		

Note: * - no data; estimated from adjoining river using areal weight

No.	River		Plain Area								
			Area (km^2)	Q_s Load (ton)	Q_b 15% of tot. (ton)	Q_y (ton)	Ratio of Lowland to Mountain	Denudation Rate (mm/yr)	Unit Total Load all	Unit Total Load, lowland only (ton/km^2)	Reference
1	Chafroud		180	14,883	2,626	17,509	110%	0.064	97	25	110% Roudbasara
2	Bahmbar		151	3,900	688	4,588	129%	0.020	30	6	Aghamahaleh Sta
3	Morghak		328	17,100	3,018	20,118	129%	0.040	61	37	Kotemjan Sta
4	Khalkai		311	17,400	3,071	20,471	170%	0.043	66	68	Kotemjan Sta
5	Palangvar		227	19,600	3,459	23,059	209%	0.066	102	83	Kalsar Sta
6	Masulehroudkhan		407	23,600	4,165	27,765	97%	0.045	68	-4	Chomesghal Sta
7	Shakhazar		429	41,600	7,341	48,941	188%	0.075	114	112	Laksar Sta
8	Pasikhan		751	108,000	19,059	127,059	322%	0.111	169	199	Nokhaleh Sta
9	Pirbazar		340	66,000 **	11,647	77,647	1324%	0.149	228	254	Mahomabad Sta
10	Remaining Catchment		486	22,400 **	3,953	26,353					
	Total		3,610	334,483		393,509		0.084			

Note: ** - no data: taken from MOJA '89
Source: JICA Study Team

5.3 Sedimentation in the Wetland

(1) Methodology

In the previous sections the mechanism of sediment in the watershed was described. In this section, the mechanism of sediment within the wetland is analyzed (the wetland characteristics is outlined in Section 3.3).

All rivers in the watershed flow through the wetland before exiting to the Caspian Sea, transporting the sediment discussed in the previous section. Once the sediment enters the wetland, it either deposits or remains in suspension. The other end of the wetland is the Anzali Port, which is the only exit to the wetland. In the port area, the Anzali Port authority dredges approximately 200,000 tons of sediment annually on average to maintain the shipping lanes. Given these conditions, it would be beneficial to know 1) what percentage of sediment exits the wetland at the Anzali Port and 2) the locations where the sediment tends to deposit.

Due to the complexity of the hydraulics in the wetland system, a two dimensional finite element computer model was used in order to simulate the slow moving sediment within the wetland. The software used for analysis was the Surface-water Modeling System (SMS) software developed by the Environmental Modeling System Inc. in the US. This software was selected because of its capability to model hydraulic conditions in shallow marshy areas, including sediment transport in such areas.

(2) Data Inputs

Data requirements for the model are categorized into geometric, hydraulic and sediment.

Geometry consists of geographical and topographical data which are the most important for the model. The present 1:25,000 maps were used to create the layout of the wetland. Supplement from the 1982 aerial photos (published from NCC) was used to determine the extent of the wetted surface.

Some topographic data was contained on the 1:25,000 maps, but not sufficient for modeling purposes. Due to the lack of topographical data, a bathymetric survey was carried out by the Study Team. The resulting scatter set covers most of the central waterways, a portion of Siakeshim and the lagoon area. Due to the extremely large area and limited time, the survey could not cover the entire wetland and thus, site observation was made to supplement the bathymetry. The geographical data was incorporated into the program to form a mesh of the wetland. Triangle-shaped elements were used to form the mesh and the topographic data was interpolated to the nodes of each element.

Hydraulic data consisted of inflows from the river. These flows act as the incoming boundary conditions of the model. Monthly average discharge of the rivers were used (refer to Data Book). The downstream boundary condition was also specified by using Anzali Port water levels. It is noted that since the wetland water levels are not measured regularly, the relationship between the wetland water level and Caspian Sea water level could not be determined (limited measurements by the Study Team taken for purposes of bathymetric survey reveals a direct relationship). Other hydraulic data included the roughness coefficient and dispersion coefficients. For the Manning's roughness coefficient, typical values for marshy areas (between 0.03 and 0.04) were used, while representative values for eddy viscosity that were suggested by the model developers were used.

Sediment data consisting of suspended sediment inflow was also required. The data collected from the MOE discussed in Section 5.2.1 4) was used.

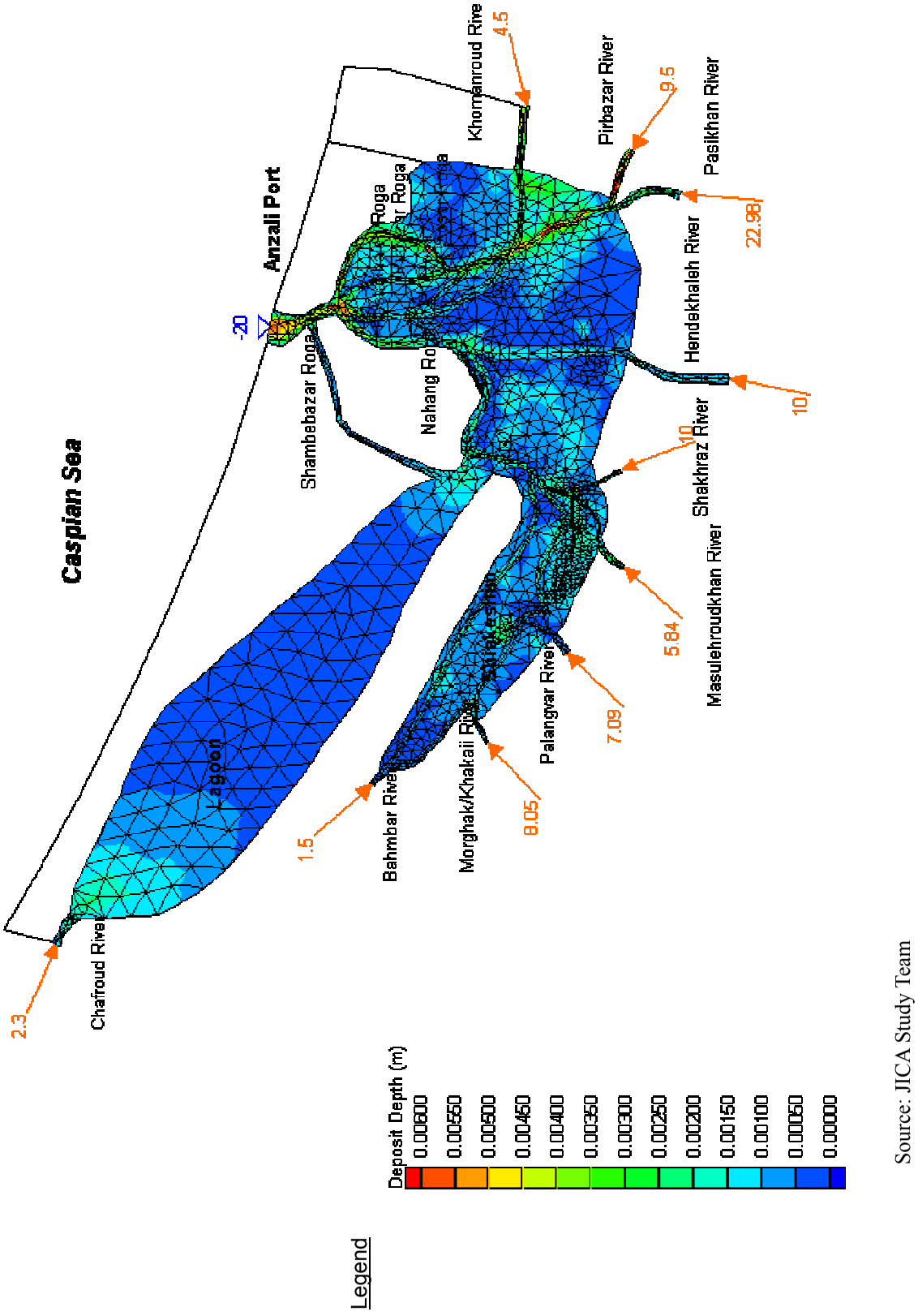
(3) Results

The above data was incorporated into the model and simulation was conducted over one year. Figure 3.3.1 shows the locations where sediment tends to accumulate in the wetland. The simulation was run for one year using annual sediment inflows (note that in order to determine the movement of the inflowing sediment, background concentration of the wetland is set to zero). Observations of the simulation are as follows.

1) Location of Deposition

The degree of sediment deposition after one year of simulation shows that settlement is not even throughout the wetland, varying from 0 mm to 6 mm per year. For example, the Anzali port area undergoes considerable sedimentation, mainly from the Pirbazar and Pasikhan Rivers. Also, deposits are seen at major junctions of the channels due to expansion losses. The Siakeshim area also has a tendency to deposit sediments, due to the pond-like bathymetry which lowers the velocity allowing for more settlement.

Conversely, the simulation shows there are areas which are not affected significantly by sediment. For example, the western lagoon undergoes limited settlement except where Chafroud River flows in from the west, and a certain degree from the central channels to the east.



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 5.3.1** **Sediment Deposit Distribution in the Wetland**
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2) Sediment Outflow

The amount of sediment that exits the wetland was calculated by taking the difference between the total potential sediment (inflow from watershed plus background sediment) and the sediment deposits. Using this method, the deposited sediments were found to be about 28% (110,000ton/y), resulting in an outflow of about 72% (290,000 ton/yr). The overall sediment balance is shown below and details are shown in Table 5.3.1. It is emphasized that the following balance is only indicative of the trends while the quantities shown are rough estimates.

Table 5.3.1 Sediment Balance in the Anzali Wetland

Source		Quantity	Percent
A)	Suspended in Wetland	30,000	-
B)	Inflow from River	400,000	-
C)	Settled in Wetland	110,000	25%
D)	Exit to Caspian	290,000	75%
Balance		30,000	-

Source: JICA Study Team

5.4 Conceivable Measures for Sediment Reduction

The recommendations mentioned here are presented for the plain area only. Measures in the wetland and in the mountain area are outlined in a separate report.

(1) Recommendation on Data Collection

Data was extremely limited prior to the Study and therefore had to be collected from various sources by the Study Team. The data collected however, was the bare minimum in order develop the master plan. To better understand the intricate functions of the wetland, supplemental data should be collected. Topographic/bathymetric data should be collected in the difficult to access areas such as Siakeshim in order to improve the geometric accuracy of the model. Also, since the rate at which sediment is unknown in the wetland at the moment, sediment deposition data in the wetland should be collected. This entails the use of sedimentation dishes which are measured every six months. This will aid in determining the effectiveness of countermeasures and can assist in prediction of future sedimentation.

(2) Sediment Trapping

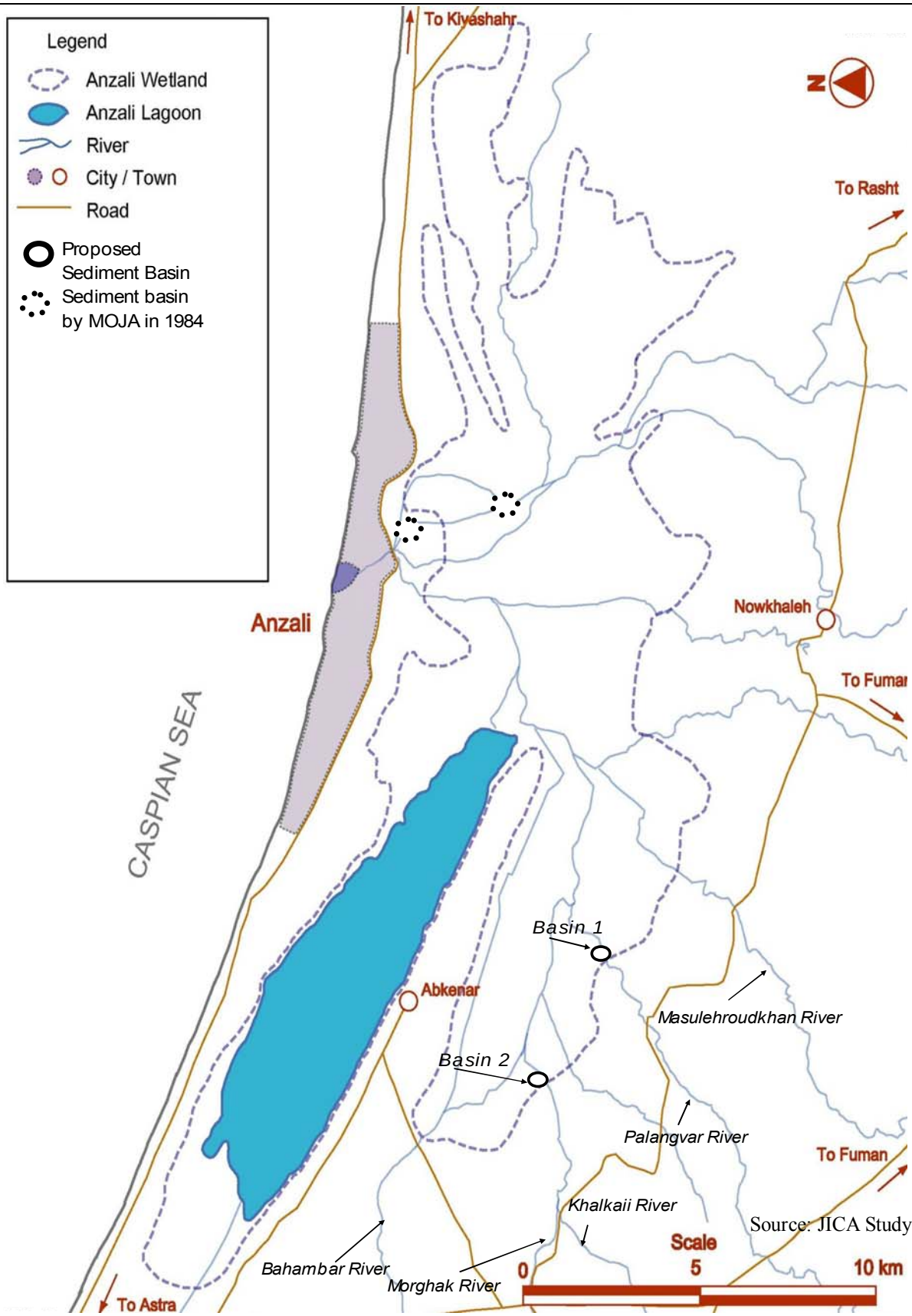
Sediment trapping activities include construction of sediment basins, channel dredging, check dams and flood detention ponds. Selection of these countermeasures should consider the following: 1) they catch sediment from the mountain and plain area so it does not enter the wetland, 2) they do not cause negative impacts, 3) they can be readily implemented and 4)

have reasonable cost.

Channel dredging is not recommended as it will cause the river channel to become unstable. While check dams are effective to trap sediment, they are not recommended as they cause scouring to the river bed, as evidenced by the check dam structures on the Pasikhan and Masulehroudkhan rivers. Sediment basins would satisfy the above conditions if they are constructed near the wetland.

At present, the Siakeshim area is under pressure as a result of sediment inflow, and given the availability of land near the border of the wetland, two sediment basins as shown in Figure 5.4.1 are proposed. From an environmental view, it would be preferential to construct the sediment basins outside the wetland core zone, but this would entail land acquisition. Therefore the traps are proposed for inside the core zone.

The surface area is the key design factor of the basin, using the inflow, sediment size and sediment quantity as inputs. No information on inflowing sediment particle size was available so particle size distribution curves from the bed of Siakeshim were used. Subsequently, the settling velocity and quantity of sediment was calculated as shown in Table 5.4.1. Figure 5.4.2 shows plots of basin surface area against sediment quantity. The figure shows that both basins should be approximately 10,000 m^2; constructing them any larger would not be effective in trapping additional sediment.



The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran	**Figure 5.4.1** **Location of Proposed Sediment Basin**
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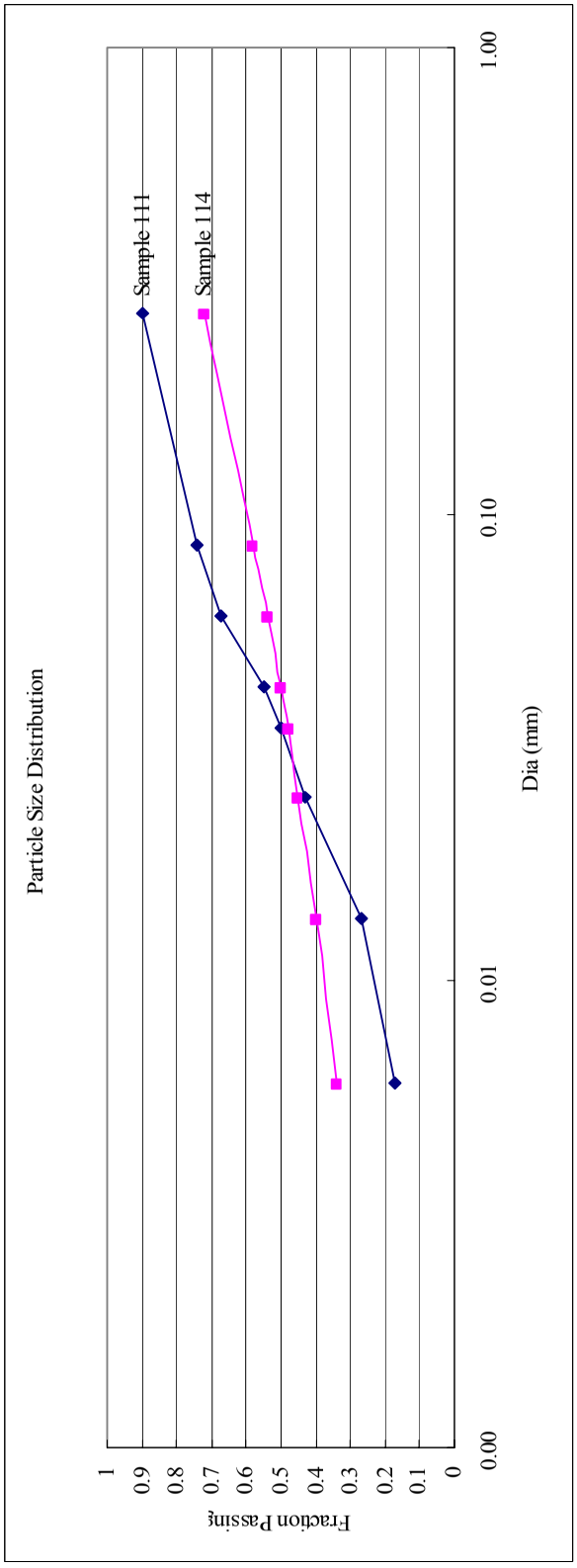

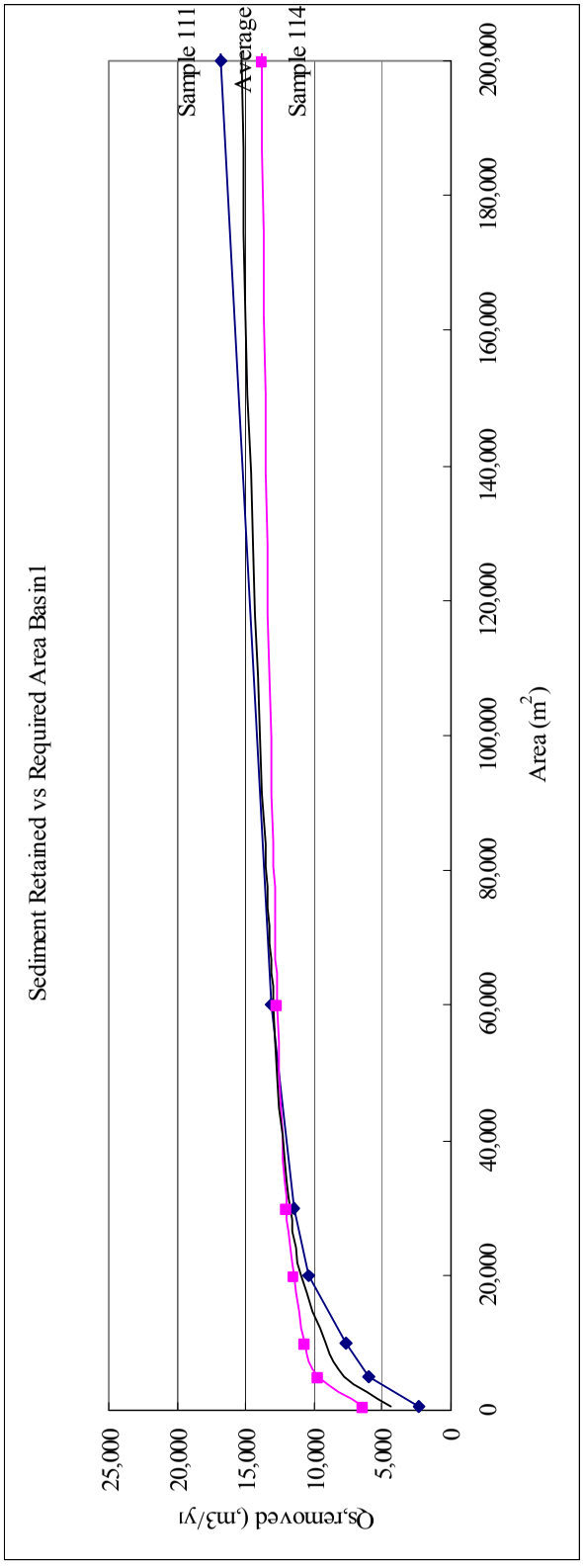

Source: JICA Study Team

The Study on Integrated Management for Ecosystem Conservation of the Anzali Wetland in the Islamic Republic of Iran

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Figure 5.4.2
Sediment Basin Surface Area Requirements

Table 5.4.1 Calculation of Area Requirement for Sediment Basin

	Basin 1	Basin 2	
Qs,total	23,059	40,589	ton/yr
Q	7.09	8.17	m3/s
part. den.	1.3	1.3	ton/m3
width	50	50	m

Basin 1

Area Surface	Dimension	Diameter	Calculation using MOJA '89, sample #111					Calculation using MOJA '89, sample #114					Average	
			Fraction		Qs,remove		Annual	Fraction		Qs,remove		Annual	Qs,remove	Removal
			Greater	Less	(per fract)	(cumul)	Depth	Greater	Less	(per fract)	(cumul)	Depth		
m2	m	mm			ton/yr	ton/yr	(m)			ton/yr	ton/yr	(m)*	ton/yr	(%)
500	10	0.27	0.1	0.9	2,306	2,306	3.5	0.28	0.72	6,457	6,457	9.9	4,381	19%
5,000	100	0.086	0.26	0.74	3,689	5,995	0.9	0.42	0.58	3,228	9,685	1.5	7,840	34%
10,000	200	0.061	0.33	0.67	1,614	7,609	0.6	0.46	0.54	922	10,607	0.8	9,108	40%
20,000	400	0.043	0.45	0.55	2,767	10,377	0.4	0.5	0.5	922	11,530	0.4	10,953	48%
30,000	600	0.035	0.5	0.5	1,153	11,530	0.3	0.52	0.48	461	11,991	0.3	11,760	51%
60,000	1,200	0.025	0.57	0.43	1,614	13,144	0.2	0.55	0.45	692	12,682	0.2	12,913	56%
200,000	4,000	0.014	0.73	0.27	3,689	16,833	0.1	0.6	0.4	1,153	13,835	0.1	15,334	67%
1,000,000	20,000	0.006	0.83	0.17	2,306	19,139	0.0	0.66	0.34	1,384	15,219	0.0	17,179	75%

Basin 2

Area Surface	Dimension	Diameter	Calculation using MOJA '89, sample #111					Calculation using MOJA '89, sample #114					Average	
			Fraction		Qs,remove		Annual	Fraction		Qs,remove		Annual	Qs,remove	Removal
			Greater	Less	(per fract)	(cumul)	Depth	Greater	Less	(per fract)	(cumul)	Depth		
m2	m	mm			ton/yr	ton/yr	(m)			ton/yr	ton/yr	(m)*	ton/yr	(%)
500	10	0.29	0.1	0.9	4,059	4,059	6.2	0.28	0.72	11,365	11,365	17.5	7,712	19%
5,000	100	0.092	0.26	0.74	6,494	10,553	1.6	0.42	0.58	5,682	17,047	2.6	13,800	34%
10,000	200	0.065	0.33	0.67	2,841	13,394	1.0	0.46	0.54	1,624	18,671	1.4	16,033	40%
20,000	400	0.046	0.45	0.55	4,871	18,265	0.7	0.5	0.5	1,624	20,295	0.8	19,280	48%
30,000	600	0.038	0.5	0.5	2,029	20,295	0.5	0.52	0.48	812	21,106	0.5	20,700	51%
60,000	1,200	0.027	0.57	0.43	2,841	23,136	0.3	0.55	0.45	1,218	22,324	0.3	22,730	56%
200,000	4,000	0.015	0.73	0.27	6,494	29,630	0.1	0.6	0.4	2,029	24,353	0.1	26,992	67%
1,000,000	20,000	0.007	0.83	0.17	4,059	33,689	0.0	0.66	0.34	2,435	26,789	0.0	30,239	75%

Source: JICA Study Team

The basins selected have features as shown in Table 5.4.2.

Table 5.4.2 Dimensions for Sediment Basin

Item	Area (m^2)	Dimension (L X W, m)	Q_{in},(ton/y)	$Q_{trapped}$,(ton/y)	Trap Rate (%)
Basin 1	10,000	200x50	23,000	9,000	40
Basin 2	10,000	200x50	41,000	16,000	

Source: JICA Study Team

The sketch below shows a typical section of the basin envisaged is shown below in Figure 5.4.3.

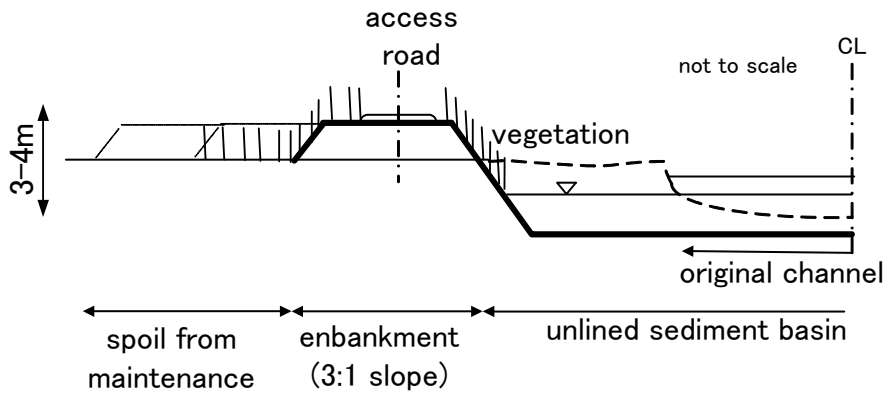

Figure 5.4.3 Typical Section of Sediment Basin

As the purpose of the basin is to trap the sediment only, the basin will be unlined and graded to very gentle side slopes (say 3:1). The slopes would require compaction and lining of vegetation for additional retardance and scour prevention. An access road around the embankment perimeter is also required for maintenance.

Along with the two basins, construction of access roads to the basins will be necessary. Maintenance requirements would consist of removing the deposits about once every year. As the implementation of the mountain area countermeasures begin to take effect (ie. biological controls, rangeland farmer resettlement), these maintenance requirements should reduce in the future. The spoil material could be placed on the outside of the basin in a location which will not affect the Siakeshim area. Additional soil testing could be performed to determine its usefulness for recycle.