(4) Estimation of Monthly Discharge

The monthly outflow was calculated for 30 years from 1975 to 2004 for major wadis as shown in Figure 4-20. In the figure, 'bottom-upper' in arranging graphs is respond to 'north-south' and the 'left-right' is similar to 'the west (Red Sea side)-east (inland side)' in basin's spatial configuration in the project area.

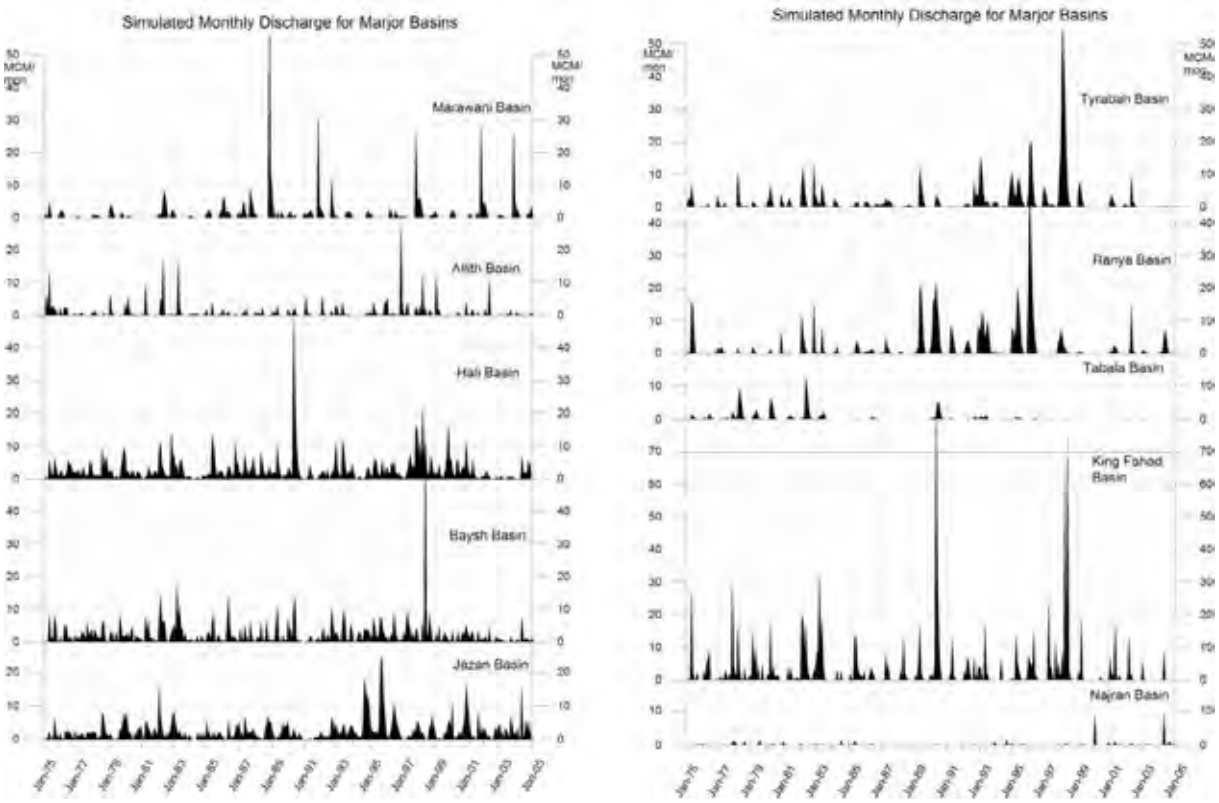


Figure 4-20 Monthly Discharge of Major Wadis

Moreover, the monthly discharge was obtained for each year, and non-exceedance probability was calculated by Iwai method for 30 years as shown in Figure 4-21.

When 1/10 probability (draught year) is designated from the figure, 34 MCM (an average of 82 MCM) was taken at Jizan Dam while 11MCM (an average of 95 MCM) at King Fahd Dam.

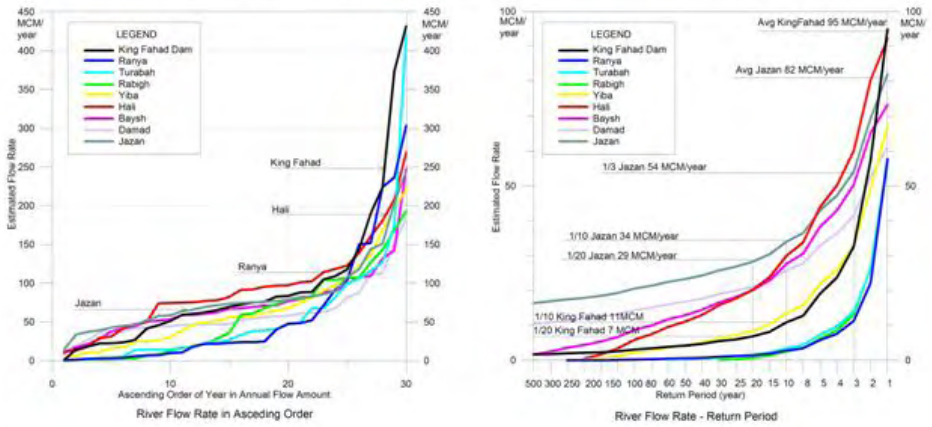
(5) Water Resources Potential between Major Wadis

In order to investigate the actual condition of discharge in the plain area and to examine the water balance of the fore-mountain which was not contained as the model area, water potential of inter-basins (between basins) was analyzed.

Inter-basins, a number of minor wadis between major wadis, are now developing by MOWE. Especially in fore-mountain area in Jazan and the southern part of Asir, small dams are being planned for utilizing flood water.

With setting 20 inter-basins along Red Sea coast as shown in Figure4-22, their flow rates were estimated by the specific discharge method.

Probability	Jazan	Damad	Baysh	Hali	Yiba	Rabigh	Turabah	Ranya	kingFahad
Average in 30yrs	82	61	73	92	67	57	56	58	95
1/2	69.4	52.8	65.2	80.4	49.1	26.4	26.1	22.2	57.4
1/3	54.1	41.5	50.3	60	32.9	13.1	14	11.3	32.6
1/4	47.2	36.3	42.9	50.1	25.9	8.6	9.7	7.6	23.7
1/5	43	33	38.3	44	21.9	6.3	7.4	5.8	19.1
1/8	36.5	27.8	30.6	33.8	15.7	3.4	4.4	3.5	12.8
1/10	34	25.8	27.6	29.9	13.5	2.5	3.5	2.8	10.9
1/15	30.4	22.9	22.9	23.8	10.3	1.3	2.2	1.9	8.2
1/20	28.3	21.1	20.1	20.2	8.4	0.7	1.6	1.4	6.9
1/25	26.9	19.9	18.1	17.7	7.2	0.3	1.2	1.2	6
1/30	25.8	19	16.6	15.8	6.3	0.1	0.9	1	5.5
1/40	24.3	17.7	14.5	13	5.1		0.5	0.7	4.7
1/50	23.3	16.8	12.9	11.1	4.3		0.3	0.6	4.2
1/60	22.5	16.1	11.8	9.6	3.7		0.1	0.5	3.9
1/80	21.4	15.1	10	7.5	2.8			0.3	3.4
1/100	20.6	14.4	8.8	5.9	2.2			0.2	3.1
1/150	19.3	13.2	6.7	3.4	1.2			0.1	2.6
1/200	18.5	12.5	5.4	1.7	0.6			0	2.3
1/250	17.9	12	4.4	0.5	0.2			0	2.2
1/300	17.5	11.5	3.6					0	2
1/400	16.9	10.9	2.5						1.8
1/500	16.4	10.5	1.7						1.7



Title: Probability Analysis for Estimated River Flow Rate (for major wadis)

LEGEND
- King Fahad Dam
- Ranya
- Turabah
- Rabigh
- Yiba
- Hali
- Baysh
- Damad
- Jazan

Date	Oct 2009
Drawn by	JICA REWARD
Data Source	MOWE, REWAED
Period Analysis	1975–2004

The Study on Master Plan on Renewable Water Resources Development in the Southwest Region in the Kingdom of Saudi Arabia

Figure 4-21 Non-exceedance Probability of Discharge in Major Wadis

The value of specific discharge was prepared based on the result of SWAT model for 20 inter-basins.

The total area of 20 inter-basins is 25,400 km^2, comprising 17,000 km^2 of Alluvial plain and 8,400 km^2 of the mountain area. With the calculation, as the most productive area, 91 MCM/year (as an average of 0.016 m^3/sec/m^2 of specific discharge) and 34 MCM/year (0.009 m^3/sec/m^2) were obtained from Jazan (5,600 km^2) and Asir (4,200 km^2) respectively. As well, 33 MCM (0.002 m^3/sec/m^2) was estimated for the northern part of Red Sea coast covering 15,600 km^2.

In the groundwater model applied in the Jazan area, amount of outflows, 91 MCM/year was also used as boundary condition.

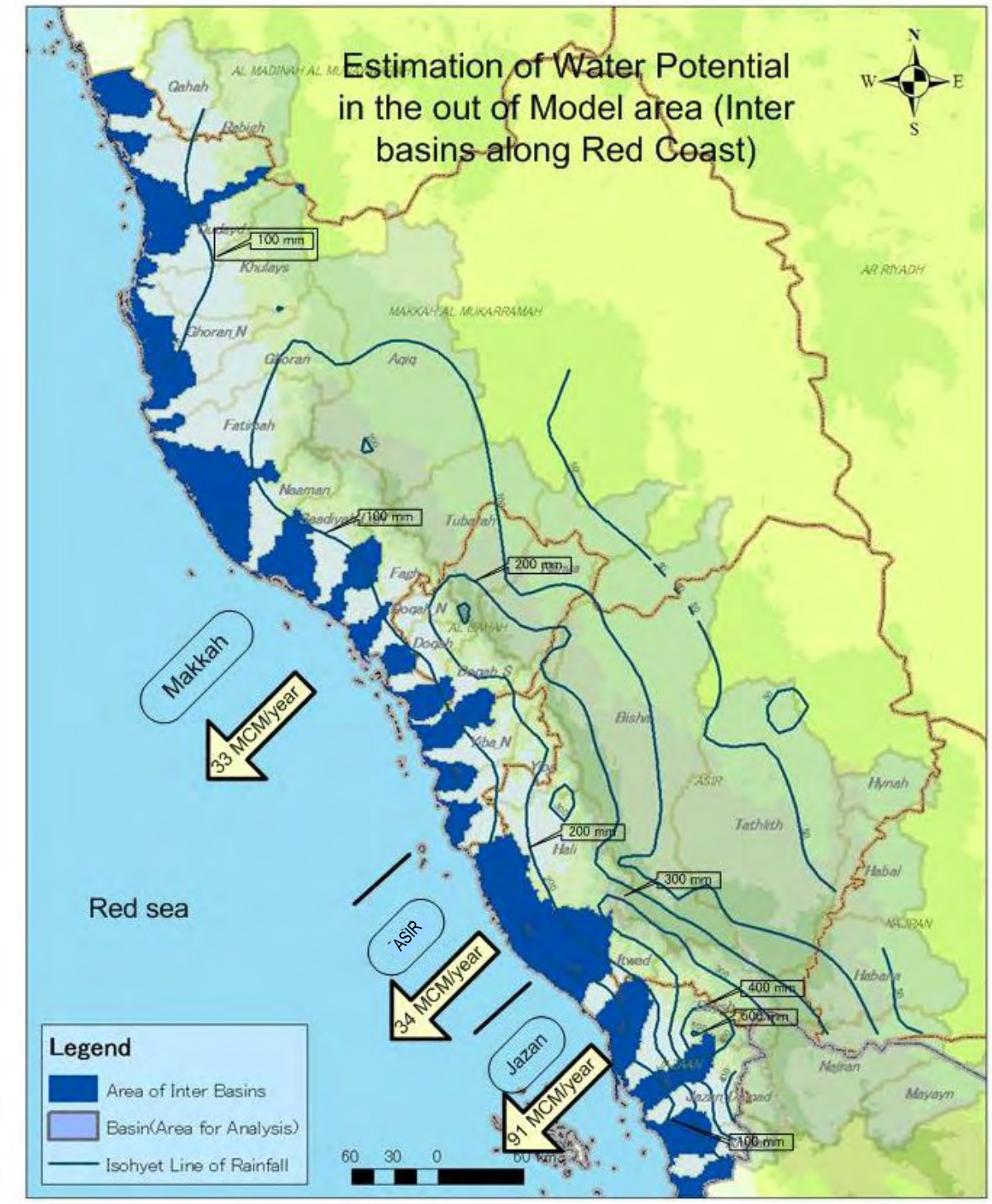


Figure 4-22 Water Resources Potential between Major Basins

(6) Water Balance in Regions

The water balance calculated in each basin was re-arranged and summed up based on their outlets position in each region. In Table 4-4 (1), the summary of water balance in the mountain area (mountain + inter-basin) is shown. As well, in Table 4-4 (2), the balance of the project area is summarized.

Moreover, the schematic diagram of IN/OUT of surface/groundwater resources are delineated in Figure 4-23. In the diagram, the inner side of bundling with 'light green' indicates the water balance of mountain area and the outside with 'yellow' shows that of whole project area.

Table 4-4 (1) Water Balance in Region - Mountain Area -

Basin					Water Potential (MCM/year)		
No	B_ID	Basin	Area (Sqkm)	Outlet Ptn. At	ER (Moutain)	Surface Runoff	Ground-water Runoff
1	J5	Khulab	1,160	jazan	40	37	3
2	J4	Jazan	1,438	jazan	86	82	3
3	J3	Damad	1,063	jazan	72	61	11
4	J2	Baysh	4,767	jazan	105	73	32
5	J1	Itwad	1,478	jazan	51	46	5
		interBasin			91	6	85
				Jazan	**444**	**306**	**139**
6	M12	Hali	4,850	makkah	123	92	31
7	M11	Yiba	2,812	makkah	81	67	14
8	M10	Yiba_N	1,640	makkah	45	32	13
9	M9	Doquah_S	1,496	makkah	52	45	7
10	M8	Doquah	1,080	makkah	25	18	7
11	M7	Doquah_N	960	makkah	31	28	3
12	M6	Fagh	1,706	makkah	44	38	6
13	M5	AlLith_Sadiyah	2,641	makkah	40	29	12
14	M4	Naaman	1,351	makkah	38	30	8
15	M3	Fatimah	2,756	makkah	42	32	10
16	M2	Ghoran	3,807	makkah	51	30	21
17	M1	Ghoran_N	1,016	makkah	15	10	5
18	M0	Khulays	4,390	makkah	100	67	33
19	M1	Qudayd	1,341	makkah	15	9	6
20	M2	Rabigh	4,433	makkah	99	72	27
21	M3	Qahah	2,842	makkah	5	2	3
		interBasin(via.Ashir)			34	9	25
		interBasin(via.Ashir)			33	3	30
				Makkah(red coast)	**872**	**613**	**259**
22	M1	Aqiq	6,448	makkah	18	10	9
23	M2	Turabah	4,816	makkah	133	90	43
23	M2	Mountain:Turabah Dam		makkah	(75.3)	(56.2)	(19.2)
23	M2	Mountain:kara Al Qawamah Dam		makkah	(57.4)	(33.4)	(24)
24	M2	Ranya	3,503	makkah	80	58	22
				Makkah(njed)	**230**	**157**	**73**
25	A1	Bisha	12,908	asir	111	107	4
25	A1	Mountain:King Fahad Dam		asir	(97.6)	(94.9)	(2.7)
25	A1	Mountain:Tabalah Dam		asir	(13.4)	(11.8)	(1.5)
26	A2	Tathlith	6,900	asir	15	1	15
				Asir	**126**	**107**	**19**
27	N1	Habana	2,613	Najran	8	2	6
28	N2	Najran	4,729	Najran	25	4	21
29	N2	Mayayn	3,128	Najran	5	1	4
30	N3	Hynah	2,262	Najran	5	0	4
31	N3	Habal	3,891	Najran	3	0	3
				Najran	**46**	**7**	**39**
		Ground Total	100,225		**1,718**	**1,189**	**529**

Table 4-4 (2) Water Balance in Region - Basin -

Moutain-Plain (Area 161,150 sqkm)+Inter Basins(Area 25,353 sqkm)							
Basin					Water Potential (MCM/year)		
No	B_ID	Basin	Area (Sqkm)	Outlet Ptn. at	ER (Mountain+ Plain)	Surface Runoff	Ground-water Runoff
1	J5	Khulab	1,568	Jazan	47	1	46
2	J4	Jazan	1,862	Jazan	100	14	85
3	J3	Damad	1,376	Jazan	77	12	65
4	J2	Baysh	6,367	Jazan	98	14	84
5	J1	Itwad	1,972	Jazan	25	1	24
				Jazan	**347**	**44**	**303**
6	M12	Hali	5,659	makkah	99	89	11
7	M11	Yiba	3,346	makkah	91	70	21
8	M10	Yiba_N	2,416	makkah	59	38	20
9	M9	Doquah_S	1,726	makkah	53	41	13
10	M8	Doquah	1,603	makkah	24	18	6
11	M7	Doquah_N	1,578	makkah	16	26	-10
12	M6	Fagh	2,362	makkah	15	36	-21
13	M5	AlLith_Sadiyah	3,338	makkah	17	7	9
14	M4	Naaman	2,513	makkah	8	26	-18
15	M3	Fatimah	4,306	makkah	46	28	18
16	M2	Ghoran	4,916	makkah	51	25	26
17	M1	Ghoran_N	2,355	makkah	16	9	7
18	M0	Khulays	5,462	makkah	100	57	43
19	M1	Qudayd	2,207	makkah	15	7	8
20	M2	Rabigh	6,699	makkah	116	65	52
21	M3	Qahah	3,356	makkah	5	1	4
				Makkah(red coast)	**731**	**542**	**188**
22	M1	Aqiq	15,485	makkah	47	17	30
23	M2	Turabah	7,786	makkah	154	106	48
24	M2	Ranya	7,885	makkah	144	90	54
				Makkah(njed)	**345**	**213**	**132**
25	A1	Bisha	22,303	asir	117	53	64
26	A2	Tathlith	17,237	asir	21	13	8
				Asir	**139**	**66**	**73**
27	N1	Habana	7,186	Najran	12	1	11
28	N2	Najran	6,999	Najran	28	3	25
29	N2	Mayayn	3,128	Najran	5	1	4
30	N3	Hynah	2,262	Najran	5	0	4
31	N3	Habal	3,891	Najran	3	0	3
				Najran	**53**	**5**	**48**
Total (on basins)			161,149		**1,614**	**870**	**744**
Total (Inter basins)			25,353	red coast	158	18	140
Ground Total			186,502		1,772	888	884

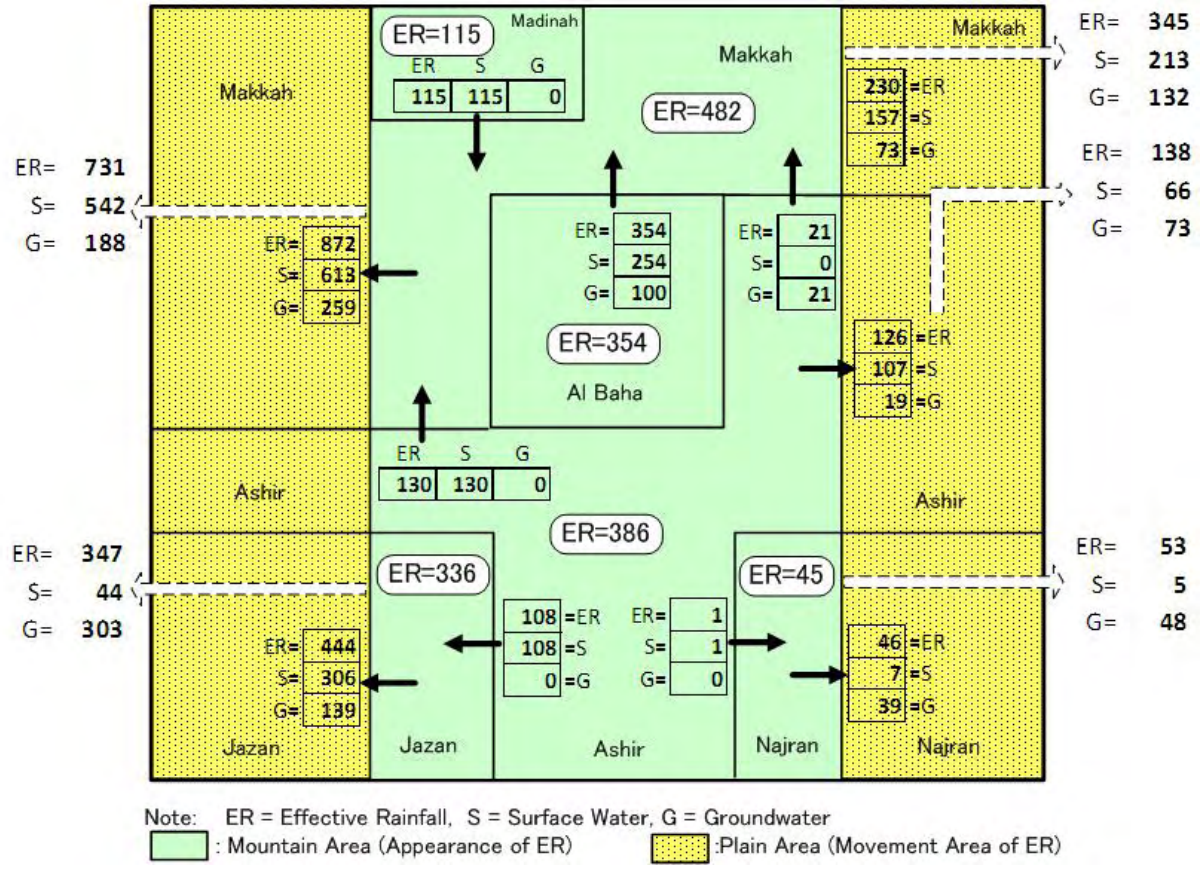


Figure 4-23 Schematic Diagram of Water Balance in Region

(7) Storage of Shallow Aquifer

The distribution of shallow aquifers which behaves as a storage basin for the replenishment resource was reviewed and their capacity was estimated. The replenishment water resource, calculated as 744MCM of recharge amount, was evaluated through a comparison between available storage capacity and rechargeable water amount as shown in Table 4-5.

The storage capacity of the shallow aquifer was obtained as 125 BCM with 50 meters (of marginal depth), and corresponds to 150 times of annual amount of groundwater recharge (0.8 BCM, refer to Table 4-5). In Figure 4-24, the extent (wadi deposit: blue, alluvium: yellowish green, diluvium: green, and a basalt + brown) of the shallow aquifer and their groundwater recharge (only vertical recharge) are shown.

Table 4-5 Storage Capacity of Shallow Aquifer

BASIN		RECHARGE (MCM/Year)			AQUIFER STORAGE FOR TYPES (MCM up to the depth of 50m)							
No.	Basins	① Apparent GW Recharge in Basin	② ET	③ GW Runoff (①-②) Recharge (MCM/Year)	Wadi Beds	Alluvial Plain	Coastal Plain	Sand Sheets and Dunes	Pleistocene Deposit	Volcanics	Total Aquifer Capacity	Ratio: Storage Capacity / A.GW Recharge
1	KHULAB	46	0	46	38	1,160	442	0	48	0	1,688	37
2	JAZAN DAMAD	150	-0	150	29	2,320	87	0	0	83	2,518	17
3	BAYSH	90	7	84	86	3,447	87	0	451	5	4,076	45
4	ITWAD	50	26	24	38	1,514	351	0	0	0	1,903	38
5	HALI	35	24	11	95	2,449	100	0	1,402	203	4,248	122
6	YIBA	21	0	21	190	1,869	37	0	354	28	2,478	118
7	YIBA N	20	-0	20	238	1,514	0	282	209	0	2,243	111
8	DAWQAH S	13	0	13	190	387	25	78	0	0	680	54
9	DAWQAH	7	1	6	238	1,224	62	889	0	0	2,414	360
10	DAWQAH N	5	15	-10	219	1,643	112	302	0	0	2,276	484
11	FAGH	8	29	-21	29	1,160	149	0	145	0	1,483	185
12	SAADIAH L	33	24	9	86	290	117	0	0	0	493	15
13	NAAMAN	12	30	-18	0	1,095	286	0	0	0	1,382	120
14	FATIMAH	18	0	18	447	3,673	75	0	773	14	4,982	272
15	GHORAN	26	-0	26	152	2,835	125	0	242	1,281	4,634	178
16	GHORAN N	7	0	7	152	1,289	40	0	983	774	3,237	469
17	LHULAYS	43	0	43	57	644	52	0	918	2,759	4,431	103
18	QUDAYD	8	0	8	76	1,385	40	0	338	806	2,646	315
19	RABIGH	52	0	52	124	1,611	411	129	435	4,371	7,081	137
20	QANUNAH	4	0	4	38	741	53	0	451	83	1,366	360
21	AQIQ	30	0	30	656	34,287	0	2,057	628	2,847	40,475	1,331
22	TURABAH	48	0	48	618	709	0	0	0	2,745	4,072	85
23	RANYA	58	4	54	86	1,772	0	0	0	2,054	3,912	68
24	BISHA	118	54	64	770	967	0	79	564	60	2,440	21
25	TATHLITH	2	-6	8	923	1,740	0	0	451	825	3,938	1,641
26	HABAWNAH	7	-4	11	400	1,768	0	64	467	0	2,699	391
27	NAJRAN	22	-3	25	276	1,247	0	64	226	0	1,812	82
28	MAYAYN	4	0	4	105	3,550	0	738	129	0	4,522	1,190
29	HYNAH	44	0	4	76	1,964	0	0	0	0	2,040	474
30	HABAL	3	-0	3	105	1,423	0	219	773	0	2,521	813
Total		943	199	744	6,535	81,678	2,651	4,900	9,988	18,937	124,689	132

①Apparent GW Recharge is a value of including direct recharge of rainfall, recharge from surface runoff and groundwater inflow. It does not include the value of evepo-transpiaration from Basin.
②ET is a value of evepo-transpiaration from Basin.
③GW Runoff is a specific recharging value, which reducts ①ET from ②Apparent GW Recharge and refers groundwater runoff from basin.

Figure 4-24 Distribution of Shallow Aquifer and Groundwater Recharge

The Kingdom of Saudi Arabia

The Ministry of Water and Electricity (MOWE)

THE STUDY ON MASTER PLAN

ON

RENEWABLE WATER RESOURCES DEVELOPMENT IN THE SOUTHWEST REGION

IN

THE KINGDOM OF SAUDI ARABIA

FINAL REPORT

(SUPPORTING REPORT)

D. AGRICULTURE AND IRRIGATION

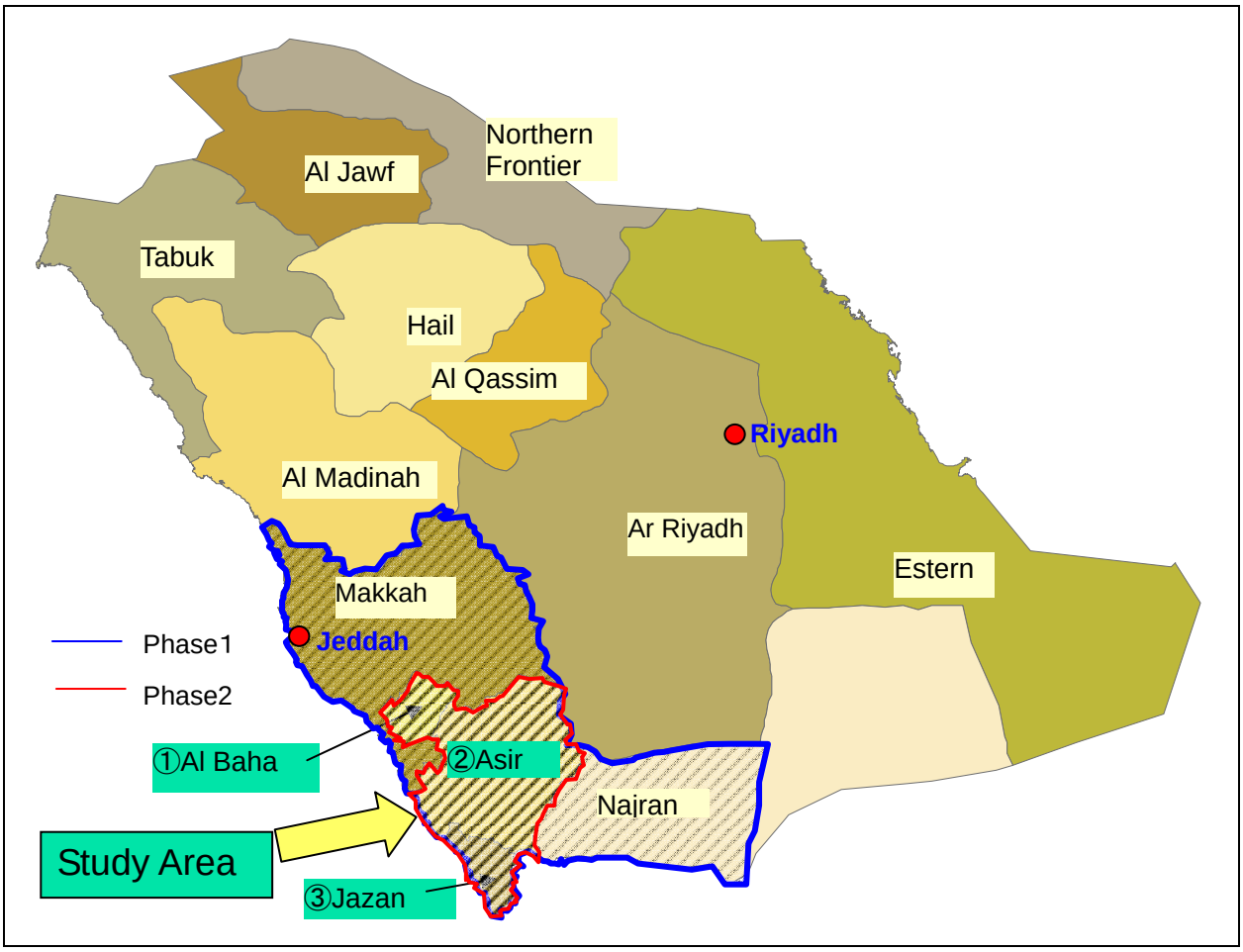
OCTOBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

SANYU CONSULTANTS INC.

The Kingdom of Saudi Arabia Location of Map



Final Report
Supporting Report (D)

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List of Abbreviations

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
BCM	Billion Cubic Meters	مليار متر مكعب	10 億立方メーター
CBD	Convention on Biological Diversity	اتفاقية التنوع البيولوجي	生物多様性保全条約
C/P	Counterpart	النظير	カウンターパート
EIA	Environment Impact Assessment	تقييم الأثر البيئي	環境アセスメント
ER	Effective Rainfall	الأمطار الفعالة	有効雨量
ET	Evapotranspiration	البخرنتح	蒸発散
FAO	Food and Agriculture Organization, United Nations	منظمة الأغذية والزراعة للأمم المتحدة	国連食料農業機関
GIS	Geographic Information System	نظام المعلومات الجغرافية	地理情報システム
GPS	Global Positioning System	نظام تحديد المواقع العالمي	グローバル・ポジショニング・システム
GDP	Gross Domestic Product	الانتاج المحلي الإجمالي	国内総生産
GDW	General Directorate of Water		地方水事務所
GNI	Gross National Income	الدخل القومي الإجمالي	国民総所得
GSMO	Grain Silos and Flour Mills Organization	صوامع الحبوب ومطاحن الدقيق	サイロ・製粉公団
GTZ	Deutsche Gesellschaft fur Technical Zusammenarbeit GmbH	الجمعية الألمانية للتعاون التقني المحدودة	ドイツ技術協力公社
IC/R	Inception Report	تقرير الإنشاء	インセプション・レポート
IEE	Initial Environmental Examination	الفحص البيئي الأولي	初期環境調査
IUCN	World Conversion Union	اتحاد التحويل العالمي	国際自然保護連合
IWPP	Independent Water and Power Project	المياه المستقلة وطاقة المشروع	独立水道・発電事業
IWRP	Integrated Water Resources Planning	التخطيط المتكامل للموارد المائية	総合水資源計画
JCCME	Japan Cooperation Center for Middle East	مركز التعاون الياباني للشرق الأوسط	財団法人中東協力センター
JICA	Japan International Cooperation Agency	الوكالة اليابانية للتعاون الدولي	独立行政法人国際協力機構
KSA	Kingdom of Saudi Arabia	المملكة العربية السعودية	サウジアラビア王国
LCD	Liter per Capita per Day	لتر للفرد يوميا	リッター/人/日
MAW	Ministry of Agriculture and Water	وزارة الزراعة والمياه	水・農業省
MEPA	Meteorology and Environment Protection Administration	ادارةالأرصاد الجوية و حماية البيئة	気象環境保護庁
MCM	Million Cubic Meters	مليون متر مكعب	100 万立方メーター
M/M	Minutes of Meeting	ملخص الاجتماع	会議の議事録
MMW	Million Megawatt	مليون ميغاوات	100 万メガワット
NAS	National Agriculture Strategy	استراتيجية الزراعة الوطنية	国家農業戦略
NGO	Non-Governmental Organization	المنظمات غير الحكومية	民間公益団体
NMS	National Mining Strategy	استراتيجية التعدين الوطنية	国家鉱業戦略
NSS	National Spatial Strategy	استراتيجية العمران الوطنية	国家特別戦略
NWC	National Water Company	شركة المياه الوطنية	国家水会社
MWS	National Water Strategy	الاستراتيجية الوطنية للمياه	国家水戦略
MOA	Ministry of Agriculture	وزارة الزراعة	農業省
MOEP	Ministry of Economy and Planning	وزارة الاقتصاد والتخطيط	国家経済計画省
MOF	Ministry of Finance	وزارة المالية	財務省
MOI	Ministry of Interior	وزارة الداخلية	内務省

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
MOMRA	Ministry of Municipal and Rural Affairs	وزارة الشؤون البلدية والقروية	地方自治省
MOWE	Ministry of Water and Electricity	وزارة المياه والكهرباء	水・電力省
M/P	Master Plan	الخطة الرئيسية	マスタープラン
MSR	Million Saudi Riyals	مليون ريال سعودي	100 万サウジリアル
NCWCD	National Commission for Wildlife Conservation and Development	اللجنة الوطنية لحماية و تطويرالحياة البرية	国立動物保護開発協会
NIA	National Irrigation Authority	السلطة الوطنية للري	国家灌漑局
PME	Presidency of Meteorology and Environment Protection	الرئاسة العامة للأرصاد وحماية البيئة	国家気象環境保護
P/O	Plan of Operation	خطة العمل	プラン オブ オペレーション
PPP	Public Private Partnership	شراكة القطاعين العام والخاص	官民連携
RWPC	Renewable Water Production Corporation	شركة إنتاج المياه المتجددة	再生可能水生産公社
REWLIP	Red Sea Water Lifeline Project	شريان الحياة للمياه البحر الأحمر المشروع	紅海水ライフライン事業
OJT	On the Job Training	التدريب المهني	研修
SAGIA	Governor Saudi Arabian General Investment Authority	محافظ الهيئة العامة للاستثمار العربي السعودي	サウジアラビア総合投資庁
SAMA	Saudi Arabian Monetary Agency	مؤسسة النقد العربي السعودي	サウジアラビア通貨庁
SAR	Saudi Arabian Riyal	الريال السعودي	サウジアラビアリアル
SCT	Supreme Council for Tourism	المجلس الأعلى للسياحة	最高観光委員会
SEA	Strategic Environment Assessment	التقييم البيئي الاستراتيجي	戦略的環境アセスメント
SGS	Saudi Geological Survey	هيئة المساحة الجيولوجية السعودية	サウジ地質調査
SOIETZ	Saudi Organization for Industrial Estates and Technology Zone	الهيئة السعودية للمدن الصناعية و للمنطقة التكنولوجية	サウジ産業国家技術団体
SR	Saudi Riyals	الريال السعودي	サウジリアル
STP	Strategic Transformation Plan	خطة التحول الاستراتيجي	戦略的転換計画
STP	Sewerage Treatment Plant	محطة معالجة الصرف الصحي	下水処理プラント
S/W	Scope of Works	العملنطاق	業務範囲
SWAT	Soil and Water Assessment Tool	أداة تقييم التربة والمياه	土壌水アセスメントツール
SWCC	Saline Water Conversion Corporation	المؤسسة العامة لتحلية المياه المالحة	海水淡水化公社
UFW	Unaccounted For Water	مياه غير محسوبة	無収水
UNDP	United Nations Development Programme	برنامج الأمم المتحدة للتنمية	国連開発計画
UN-ESCWA	United Nations Economic and Social Commission for Western Asia	اللجنة الاقتصادية والاجتماعية للأمم المتحدة لغربي آسيا	国連西アジア経済社会委員会
WB	The World Bank	البنك الدولي	世界銀行
WHO	World Health Organizations	منظمة الصحة العالمية للأمم المتحدة	世界保健機関
WMO	World Meteorological Organization	المنظمة العالمية للأرصاد الجوية	世界気象機関

D. AGRICALTURE AND IRRIGATION

1. Present Status of Agriculture in the Kingdom of Saudi Arabia (KSA) and Southwest Region

1.1 Agricultural Area in KSA

The average planted area of the whole country in 2002 to 2007 is about 1,140,000 ha. As shown in Figure 1-1, Table 1-1, the big 5 regions of planted area are Riyadh, Al Qasim, Jazan, Al Jawf and Hail in odder, and the Jazan of the biggest planted area in the South West region is the 3rd in KSA. In these regions except Jazan, large-scale mechanized farming is carried out and much fossil water is used as a head. In addition, the percentage of occupying the agricultural population in 2001 in whole Saudi Arabia to overall population by 1,930,000 people is 9.2%. Moreover, the percentage that a working population occupies to the total working population by 580,000 people is 9.1% (source: FAOSTAT).

Regarding wheat production, 100% of self support of 1.8 million ton was attained in 1985, and a part of surplus production was turned to export since 1986. Maximum production amounted 4.2 million ton in 1992. Then cutback in production policy implemented from 1993 to 1997 in order to prevent exhaustion of water resources.

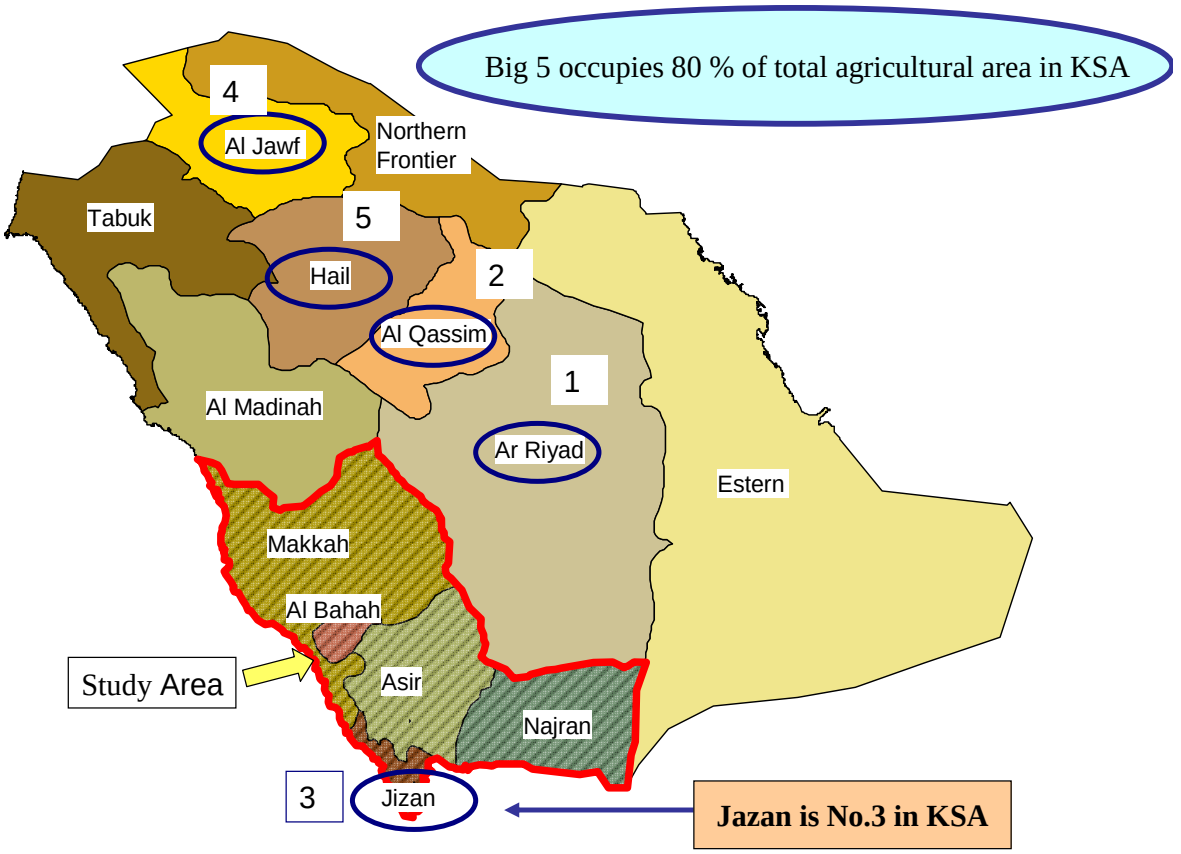


Figure 1-1 Agricultural Area in KSA

Table 1-1 Planted Area in KSA

(unit: ha)

Region(Ranking)	2002	2003	2004	2005	2006	2007	Average	%
Riyadh(1)	319,006	344,438	314,264	286,264	275,982	283,717	303,945	26.5
Makkah(8)	45,311	41,941	37,697	38,237	39,912	420,077	40,863	3.6
Madina(9)	28,505	28,490	28,838	29,551	29,842	30,670	29,316	2.6
Qaseem(2)	237,080	234,115	204,950	192,544	174,982	164,740	201,402	17.6
Eastern(6)	87,686	81,899	68,153	69,297	71,911	67,994	74,490	6.5
Asir(10)	22,508	22,695	22,038	21,023	20,368	21,054	21,614	1.9
Tabuk(7)	53,301	53,733	57,910	55,459	53,437	56,264	55,017	4.8
Hail(5)	87,477	92,641	110,962	120,889	115,443	118,545	107,660	9.4
Northern(13)	144	125	98	121	158	151	133	0.0
Jazan(3)	186,350	157,747	148,450	120,268	117,032	113,558	140,568	12.3
Najran(11)	13,212	12,286	12,185	13,107	11,747	11,430	12,328	1.1
Al Baha(12)	2,769	2,927	3,459	3,584	5,023	4,450	3,702	0.3
Jawf(4)	141,153	143,000	163,737	156,383	158,318	160,308	153,817	13.4
KingDom	1,224,502	1,216,038	1,172,742	1,106,728	1,074,155	1,074,958	1,144,854	100.0

Data : Agriculture Statistical Year Book Twenty Issue by MOA

1.2 Agriculture in Southwest Region

The crop planted area and production for the last five years are as shown in Table 1-2. Since the Makkah region is holding the big consuming city Jeddah, agriculture in suburban type cultivation is popular in this area. Moreover, mountainous Al Baha, Asir (Abha), and Najran regions are active in the fruit trees and vegetable cultivation based on the geographical feature and climate of high elevation. On the other hand, the cereals represented by the sorghum and wheat are grown on the flat plain of Asir and Jazan regions. In the South West Region, although modern irrigation systems, such as drip irrigation and micro jet irrigation, are adopted as for vegetables and fruit tree and irrigation efficiency is rather high, in cultivation of cereals, such as a sorghum and wheat, traditional irrigation systems, such as flood irrigation system, are generally adopted, and irrigation efficiency is rather low.

If the agricultural population of the South West region is estimated at the above rate of KSA, it's become about 178,000 and 53,000 people respectively.

Table 1-2 Planted Area and Production in the South West Region

(Production Unit : ton)

Region/Crops	2002		2003		2004		2005		2006		2007	
	ha	**Production**	ha	**Production**	ha	**Production**	ha	**Production**	ha	**Production**	ha	**Production**
Makkah	45,311	**377,845**	41,941	**389,345**	37,697	**396,010**	38,237	**399,221**	39,912	**404,417**	42,077	**408,982**
Cereal	12,588	19,212	10,467	21,365	8,128	18,513	7,608	16,392	7,708	17,085	8,386	18,998
Fodder	9,732	87,956	7,883	74,353	4,885	51,661	5,262	60,604	5,698	59,838	5,761	70,747
Fruits	11,396	108,282	11,343	102,567	12,005	130,079	13,201	115,532	13,930	106,484	15,447	109,270
Vegetable	11,595	162,395	12,249	191,060	12,680	195,757	12,166	206,693	12,576	221,010	12,483	209,967
Al Baha	2,769	**31,154**	2,927	**29,308**	3,459	**28,074**	3,584	**30,421**	5,023	**46,172**	4,450	**38,864**
Cereal	549	1,478	443	1,425	713	2,212	608	1,916	604	2,011	532	1,763
Fodder	168	2,272	139	2,091	136	2,285	94	1,585	147	2,255	185	2,982
Fruits	1,788	20,896	2,075	19,533	2,280	16,091	2,603	20,089	3,974	35,227	3,457	28,005
Vegetable	264	6,508	271	6,259	330	7,486	278	6,831	298	6,679	276	6,114
Asir	22,508	**221,898**	22,695	**203,806**	22,038	**203,205**	21,023	**178,885**	20,368	**209,778**	21,054	**206,243**
Cereal	6,477	14,192	7,318	16,731	8,159	24,027	7,550	20,497	6,780	20,573	7,744	23,587
Fodder	2,796	39,896	1,930	24,089	1,581	20,518	1,680	22,778	1,644	28,466	2,001	34,567
Fruits	10,159	102,679	10,644	103,088	9,633	92,610	9,220	74,156	9,334	73,584	8,579	65,252
Vegetable	3,076	65,131	2,803	59,898	2,664	66,050	2,572	61,454	2,610	87,155	2,730	82,837
Jazan	186,350	**557,840**	157,747	**455,250**	148,450	**513,797**	120,268	**449,714**	117,032	**503,187**	113,558	**504,303**
Cereal	159,461	229,467	136,609	225,736	128,551	275,667	101,302	197,261	97,484	230,382	92,204	217,924
Fodder	18,095	258,079	12,956	174,588	12,204	168,897	10,552	173,548	10,852	187,499	12,247	203,018
Fruits	4,151	19,451	3,843	18,292	4,322	23,646	4,786	30,783	5,049	28,252	5,525	32,365
Vegetable	4,643	50,843	4,339	36,634	3,373	45,587	3,629	48,122	3,647	57,054	3,582	50,996
Najran	13,212	**180,304**	12,286	**156,140**	12,185	**147,184**	13,107	**155,084**	11,747	**145,694**	11,430	**141,119**
Cereal	984	2,129	708	1,631	1,001	2,597	1,019	2,448	659	2,544	908	3,491
Fodder	3,237	35,718	2,520	26,421	2,479	36,690	2,879	44,838	2,435	37,266	2,287	35,916
Fruits	5,962	66,321	6,682	70,445	7,007	62,412	7,272	65,782	6,658	57,985	6,311	57,868
Vegetable	3,029	76,136	2,375	57,643	1,698	45,485	1,937	42,016	1,995	47,899	1,924	43,844
Total	270,150	**1,369,041**	237,596	**1,233,849**	223,829	**1,288,270**	196,219	**1,213,325**	194,082	**1,309,248**	**192,569**	**1,299,511**
Cereal	180,059	266,478	155,545	266,888	146,552	323,016	118,087	238,514	113,235	272,595	109,774	265,763
Fodder	34,028	423,921	25,428	301,542	21,285	280,051	20,467	303,353	20,776	315,324	22,481	347,230
Fruits	33,456	317,629	34,587	313,925	35,247	324,838	37,082	306,342	38,945	301,532	39,319	292,760
Vegetable	22,607	361,013	22,037	351,494	20,745	360,365	20,582	365,116	21,126	419,797	20,995	393,758

Data Source: Agriculture Statistical Year Book Twenty Issue by MOA

2. Current Status on Agricultural Water Use

2.1 Planted Area of All Crops

The total of average planted area for the last five years of South West Region is about 225,000 ha. Since the planted area of whole Saudi Arabia is 1,159,000 ha, the panted area of South West region occupies about 19% of whole Saudi Arabia. Moreover, in South West region, as shown in Figure 2-1, Table 2-1, Jazan region occupies 65% of South West regions with about 146,000 ha at the maximum.

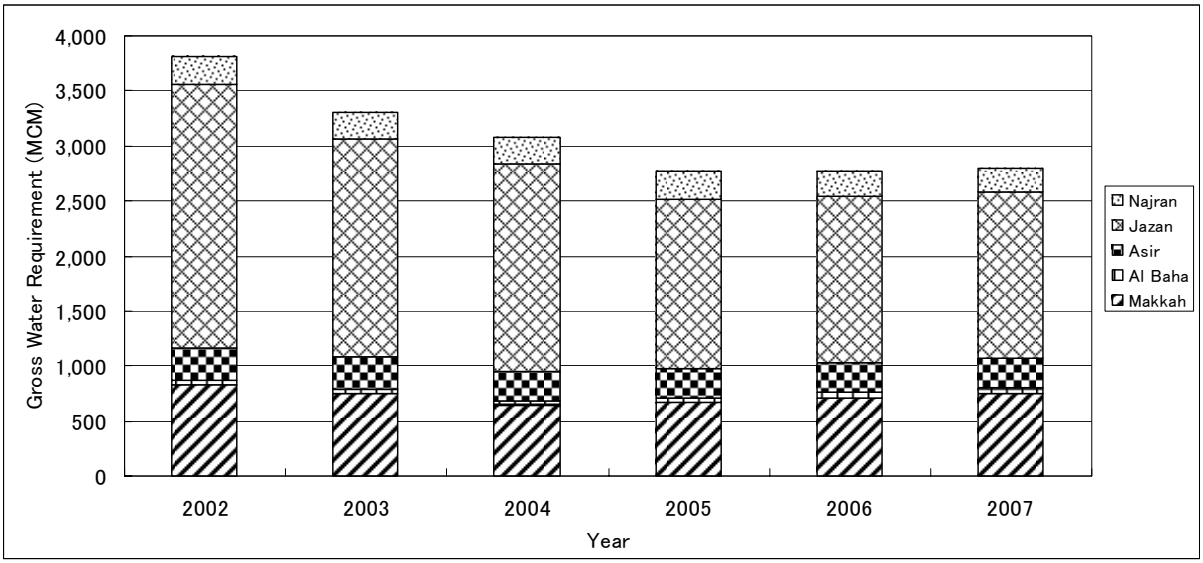


Figure 2-1 Planted Area in 5 Regions

Table 2-1 Planted Area in 5 Regions

Unit:ha

Region/Year	2002	2003	2004	2005	2006	2007	Average	%
Makkah	45,311	41,941	37,697	38,237	39,912	42,077	40,863	18.7%
Al Baha	2,769	2,927	3,459	3,584	5,023	11,430	4,865	2.2%
Asir	22,508	22,695	22,038	21,023	20,368	4,450	18,847	8.6%
Jazan	186,350	157,747	148,450	120,268	117,032	21,054	125,150	57.1%
Najran	13,212	12,286	12,185	13,107	11,747	113,558	29,349	13.4%
Total	270,150	237,596	223,829	196,219	194,082	192,569	219,074	100.0%

Source: Agriculture Statistical Year Book Twenty Issue (MOA)

2.2 Planted Area of Different Crops in the South West Region

(1) Makkah Region

Planted Area of different crops is shown in Figure 2-2, Table 2-2. Since the big consuming city Jeddah locates in Makkah region, cultivation of vegetables and fruits tree is popular. The cultivation of cereals and fodder crops, which use much water for irrigation are on the decline due to lack of water resources. The lowering of well water level and salt water intrusion problem occur especially in recent years.

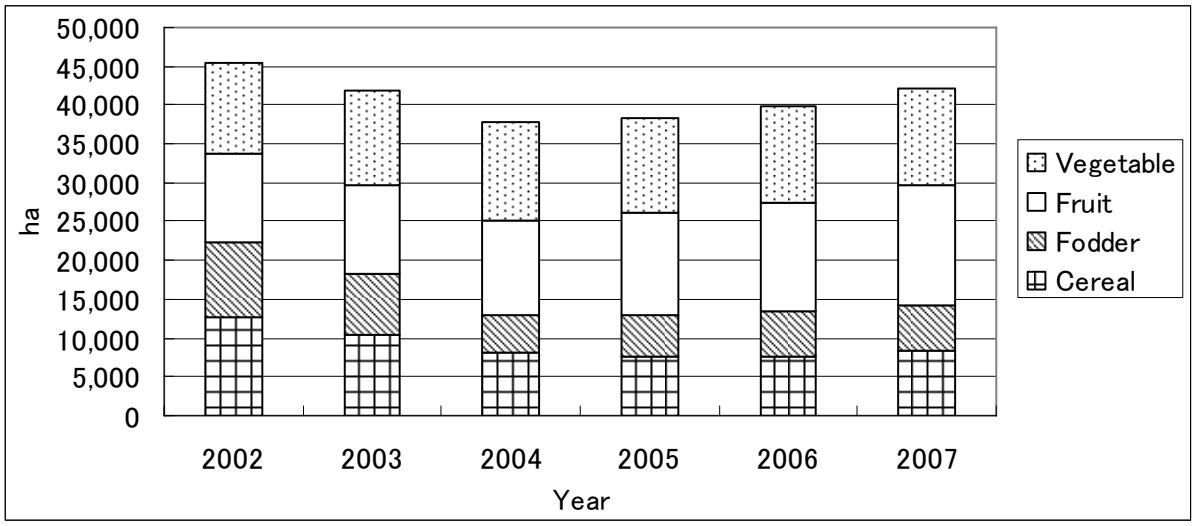


Figure 2-2 Planted Area of Different Crops in Makkah Region

Table 2-2 Planted Area of Different Crops in Makkah Region

	2002	2003	2004	2005	2006	2007
All Crops	45,311	41,941	37,697	38,237	39,912	42,077
Cereal	12,588	10,467	8,128	7,608	7,708	8,386
Wheat	231	329	296	132	266	263
Barley	231	262	611	575	344	218
Solgum	6,789	5,708	3,908	4,307	5,090	5,735
Maize	251	266	141	239	344	468
Millet	4,460	3,627	2,983	2,150	1,348	1,313
Sesame	615	259	182	187	294	382
Other Cereal	11	17	6	18	22	7
Fodder	9,732	7,883	4,885	5,262	5,698	5,761
Alfalfa	1,193	1,941	824	974	950	689
Other Fodder	8,539	5,942	4,060	4,288	4,748	5,072
Fruit	11,396	11,343	12,005	13,201	13,930	15,447
Dates	9,072	8,981	9,773	10,686	10,050	10,997
Citrus	563	533	605	826	1,149	1,510
Grapes	360	230	339	400	401	602
Other Fruits	1,401	1,599	1,288	1,290	2,330	2,338
Vegetable	11,595	12,249	12,680	12,166	12,576	12,483
Vegetable(OP:Open)	11,491	10,246	10,676	10,161	10,570	10,476
Vegetable(GH:GreenHouse)	104	112	155	164	208	195
Tomato(OP+GH)	2,695	2,550	2,069	2,028	1,760	1,893
Tomato(OP)	2,664	2,529	1,997	2,011	1,690	1,823
Tomato(GH)	31	21	72	76	70	70
Eggplant	1,294	1,266	1,408	1,478	1,305	1,187
Squash(OP+BH)	596	856	688	1,160	749	846
Squash(OP)	582	844	679	1,152	743	841
Squash(GH)	14	12	10	8	6	5
Cucumber(OP+GH)	271	252	245	288	338	335
Cucumber(OP)	218	176	176	213	213	225
Cucumber(GH)	53	76	69	75	125	110
Okra	891	1,107	968	745	1,310	1,116
Carrots	183	132	176	210	189	189
Potatoes	78	67	112	147	209	250
Onion(dry)	159	135	240	199	145	181
Melon	88	101	117	134	182	112
Watermelon	96	280	180	240	252	256
Other vegetables(OP+GH)	5,244	5,504	6,478	5,479	6,137	6,118
Other vegetables(OP)	5,238	5,501	6,474	5,474	6,130	6,108
Other vegetables(GH)	6	2	4	5	7	10

Source: Agriculture Statistical Year Book Twenty Issue by MOA

(2) Al Baha Region

Planted Area of different crops is shown in Figure 2-3, Table 2-3. A main vegetable is a tomato. It is grown in both the open field and the greenhouse in winter. Dates and citrus fruit cultivation are

popular using the geographical feature conditions of high elevation. Especially citrus fruit cultivation area is increasing twice in five years.

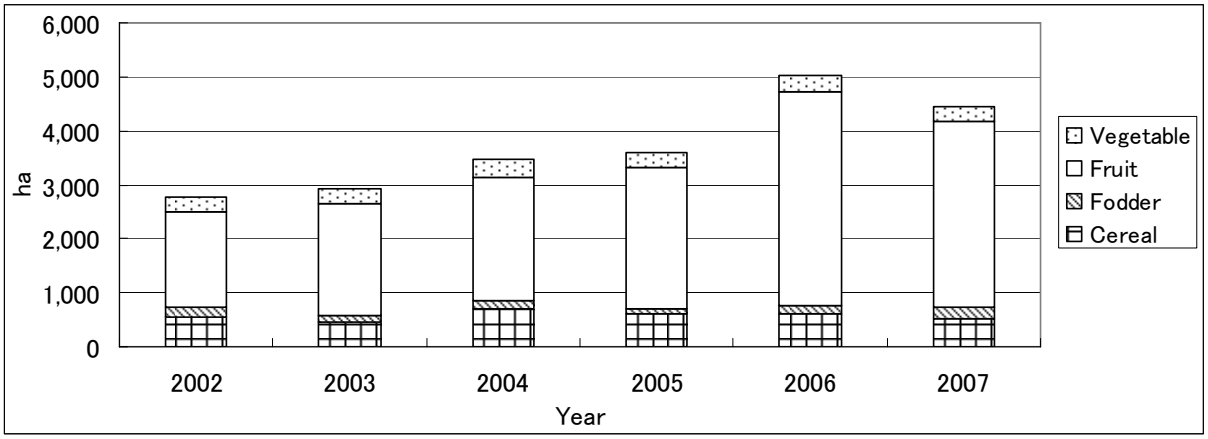


Figure 2-3 Planted Area of Different Crops in Al Baha Region

Table 2-3 Planted Area of Different Crops in Al Baha Region

	2002	2003	2004	2005	2006	2007
All Crops	2,769	2,927	3,459	3,584	5,023	4,450
Cereal	549	443	713	608	604	532
Wheat	160	136	438	344	271	225
Barley	84	100	69	69	55	44
Solgum	101	64	86	80	178	171
Maize	192	141	120	111	95	86
Millet	0	0	0	0	2	2
Sesame	0	0	0	0	0	0
Other Cereal	0	1	1	2	3	4
Fodder	168	139	136	94	147	185
Alfalfa	41	52	23	32	46	98
Other Fodder	127	87	114	62	101	87
Fruit	1,788	2,075	2,280	2,603	3,974	3,457
Dates	680	712	963	1,253	1,496	1,411
Citrus	13	11	19	22	28	35
Grapes	105	215	245	208	448	161
Other Fruits	990	1,137	1,051	1,120	2,002	1,850
Vegetable(Open+GH)	264	271	330	278	298	276
Vegetable(OP:Open)	219	232	301	262	278	251
Vegetable(GH:GreenHouse)	45	39	29	16	20	25
Tomato(OP+GH)	86	88	91	64	89	74
Tomato(OP)	59	65	72	54	74	55
Tomato(GH)	28	23	19	10	15	19
Eggplant	6	5	6	5	8	9
Squash(OP+BH)	15	15	15	13	21	20
Squash(OP)	15	15	15	13	20	18
Squash(GH)	0	1	0	0	1	2
Cucumber(OP+GH)	24	25	22	16	12	9
Cucumber(OP)	7	11	14	11	8	6
Cucumber(GH)	17	15	9	5	4	3
Okra	5	4	1	1	2	4
Carrots	5	5	4	3	3	3
Potatoes	15	13	11	10	9	8
Onion(dry)	0	1	0	0	1	1
Melon	0	1	0	2	3	4
Watermelon	5	4	3	3	3	3
Other vegetables(OP+GH)	103	109	177	161	147	141
Other vegetables(OP)	102	108	176	161	146	140
Other vegetables(GH)	0	0	0	0	0	1

Source: Agriculture Statistical Year Book Twenty Issue by MOA

(3) Asir Region

Planted Area of different crops is shown in Figure 2-4, Table 2-4. As the whole region, the planted area is decreasing by reduction of cereals and a fodder crop etc. However, cultivation of vegetables

and citrus fruit is increasing in Abha Governorate blessed with water resources and natural conditions.

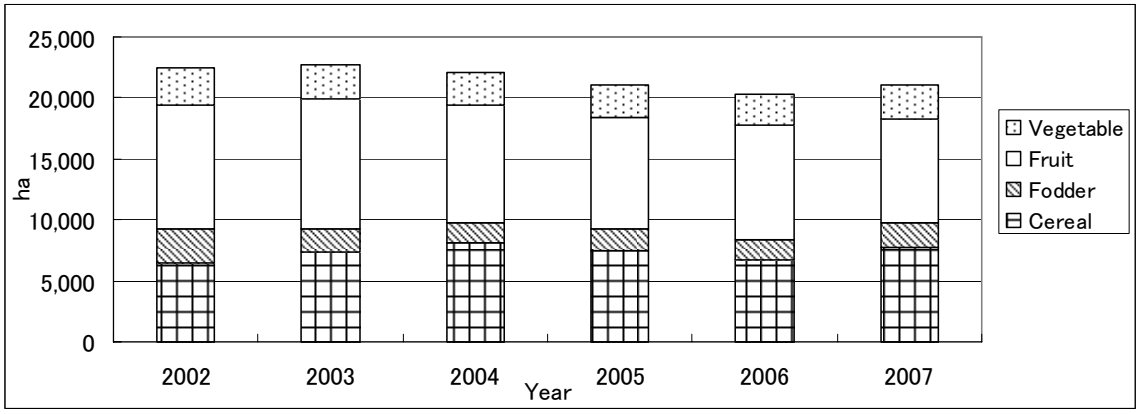


Figure 2-4 Planted Area of Different Crops in Asir Region

Table 2-4 Planted Area of Different Crops in Asir Region

	2002	2003	2004	2005	2006	2007
All Crops	22,508	22,695	22,038	21,023	20,368	21,054
Cereal	6,477	7,318	8,159	7,550	6,780	7,744
Wheat	2,498	2,319	4,531	3,800	2,977	3,808
Barley	519	446	510	530	630	675
Solgum	2,986	4,046	2,674	2,682	2,505	2,594
Maize	160	207	136	238	189	176
Millet	166	127	146	116	154	118
Sesame	142	172	151	169	308	362
Other Cereal	6	0	11	16	17	11
Fodder	2,796	1,930	1,581	1,680	1,644	2,001
Alfalfa	2,002	1,545	1,068	1,046	1,189	1,503
Other Fodder	794	385	513	634	455	498
Fruit	10,159	10,644	9,633	9,220	9,334	8,579
Dates	8,016	8,392	7,154	6,569	6,310	5,712
Citrus	79	95	114	237	217	249
Grapes	374	462	447	433	539	470
Other Fruits	1,690	1,696	1,919	1,981	2,268	2,148
Vegetable(Open+GH)	3,076	2,803	2,664	2,572	2,610	2,730
Vegetable(OP:Open)	2,640	2,444	2,242	2,186	1,946	2,183
Vegetable(GH:GreenHouse)	436	359	422	386	664	547
Tomato(OP+GH)	1,907	1,754	1,698	1,468	1,397	1,523
Tomato(OP)	1,717	1,605	1,461	1,251	1,024	1,256
Tomato(GH)	190	149	236	218	373	267
Eggplant	64	73	56	68	46	43
Squash(OP+BH)	231	154	139	175	163	167
Squash(OP)	229	151	136	172	160	163
Squash(GH)	2	3	3	2	3	4
Cucumber(OP+GH)	240	224	221	240	348	322
Cucumber(OP)	57	68	82	112	93	87
Cucumber(GH)	183	156	139	128	255	235
Okra	283	241	156	128	111	103
Carrots	19	19	28	24	34	49
Potatoes	35	40	50	83	64	49
Onion(dry)	12	14	21	12	8	8
Melon	3	2	2	2	3	4
Watermelon	0	1	0	0	1	1
Other vegetables(OP+GH)	282	282	294	370	435	461
Other vegetables(OP)	221	231	251	333	402	420
Other vegetables(GH)	61	52	44	37	33	41

Source: Agriculture Statistical Year Book Twenty Issue by MOA

(4) Jazan Region

Planted Area of different crops is shown in Figure 2-5, Table 2-5. The planted area of the whole region decreased about 40% by reduction of cereals and fodder crops in the last five years. On the other hand, tropical fruit growing active on a mango is increasing under Jazan Agriculture Research Center under Ministry of Agriculture (MOA). Moreover, in Jazan Governorate, Jazan Agricultural Development

Company is carrying out about 1,300 ha cultivation of the fruit trees, such as a banana, a mango, a papaya, and a fig, since 1992. The shrimp culture currently performed along the seashore is excellent condition in domestic market, and is exported also to South Korea in these years. Furthermore, there is Wadi Jazan Agriculture Development Project in Abou Areesh Governorate as a large-scale irrigation system, by the storage dam of available storage capacity 51MCM, and 52km length of irrigation canal, about 10,000 ha are irrigated. Although there are about 8,000 beneficiary farmers, there is no irrigation association and water service fee is not collected. In addition, the Ministry of Water and Electricity (MOWE) is carrying out control of maintenance of a dam and a waterway.

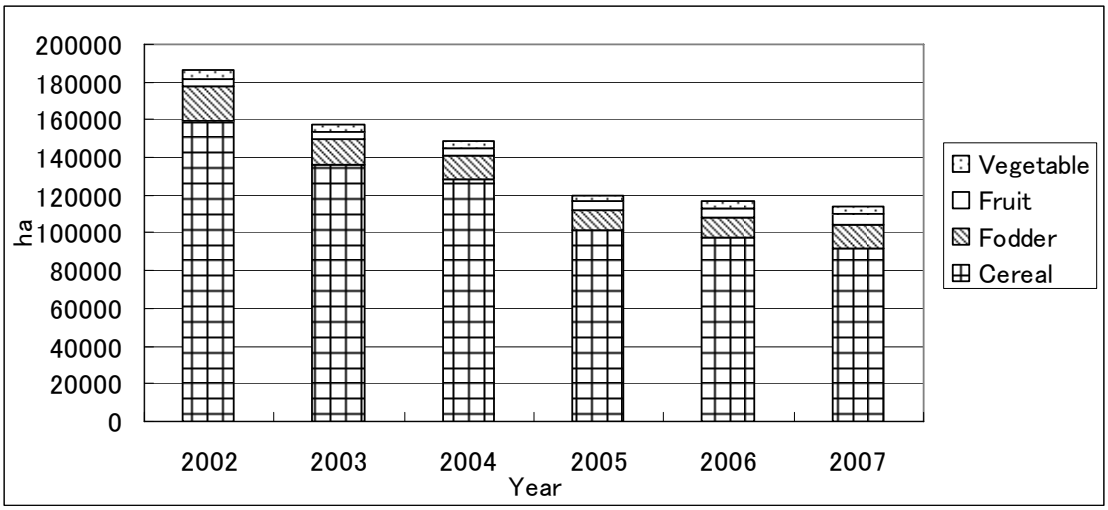


Figure 2-5 Planted Area of Different Crops in Jazan Region

Table 2-5 Planted Area of Different Crops in Jazan Region

	2002	2003	2004	2005	2006	2007
All Crops	186,350	157,747	148,450	120,268	117,032	113,558
Cereal	159,461	136,609	128,551	101,302	97,484	92,204
Wheat	42	33	68	60	49	44
Barley	16	15	8	10	12	13
Solgum	156,001	132,051	123,197	96,427	91,910	86,906
Maize	278	331	432	315	632	758
Millet	2,146	2,936	2,259	1,909	2,429	1,960
Sesame	978	1,244	2,587	2,577	2,447	2,517
Other Cereal	0	0	0	4	5	6
Fodder	18,095	12,956	12,204	10,552	10,852	12,247
Alfalfa	0	0	0	0	0	0
Other Fodder	18,095	12,956	12,204	10,552	10,852	12,247
Fruit	4,151	3,843	4,322	4,786	5,049	5,525
Dates	318	205	166	186	207	231
Citrus	8	0	327	385	301	235
Grapes	0	0	0	0	0	0
Other Fruits	3,825	3,638	3,830	4,215	4,541	5,059
Vegetable(Open+GH)	4,643	4,339	3,373	3,629	3,647	3,582
Vegetable(OP:Open)	4,643	4,339	3,373	3,629	3,647	3,582
Vegetable(GH:GreenHouse)	0	0	0	0	0	0
Tomato(OP+GH)	1,118	1,147	1,113	1,349	1,191	1,121
Tomato(OP)	1,118	1,147	1,113	1,349	1,191	1,121
Tomato(GH)	0	0	0	0	0	0
Eggplant	229	457	384	324	333	274
Squash(OP+BH)	109	217	228	208	184	185
Squash(OP)	109	217	228	208	184	185
Squash(GH)	0	0	0	0	0	0
Cucumber(OP+GH)	6	7	5	6	8	12
Cucumber(OP)	6	7	5	6	8	12
Cucumber(GH)	0	0	0	0	0	0
Okra	2,202	1,728	1,156	1,154	1,217	1,187
Carrots	3	3	2	4	4	5
Potatoes	0	0	0	0	0	0
Onion(dry)	2	2	2	2	2	3
Melon	122	58	49	43	38	33
Watermelon	194	93	79	144	125	108

	2002	2003	2004	2005	2006	2007
Other vegetables(OP+GH)	658	627	355	396	545	654
Other vegetables(OP)	658	627	355	396	545	654
Other vegetables(GH)	0	0	0	0	0	0

Source: Agriculture Statistical Year Book Twenty Issue by MOA

(5) Najran Region

The planted area of different crops is shown in Figure 2-6, Table 2-6. Cultivation of a citrus fruit tree is popular using the daily range of temperature. About 60 percent of planted area is a fruit tree in the region. There is Najran Horticulture Development Research Center under Ministry of Agriculture, and research of a tropical fruit tree and research of the irrigation method are made in the experimental farm. The experiment of micro irrigation called Bablar is conducted by especially irrigation of citrus fruits and dates. Furthermore, the experiment of automatic irrigation called "Water Mark Irrigation System" is also conducted by irrigation of Dates. Moreover, in the experiment cultivated land, lysimeter is installed and survey of the amount of crop water requirement is performed. In the Najran region, groundwater of 300MCM exceeding annual amount of rechargeable 100MCM is pumped up, and drying up of wells are at issue in the downstream part of a Najran dam.

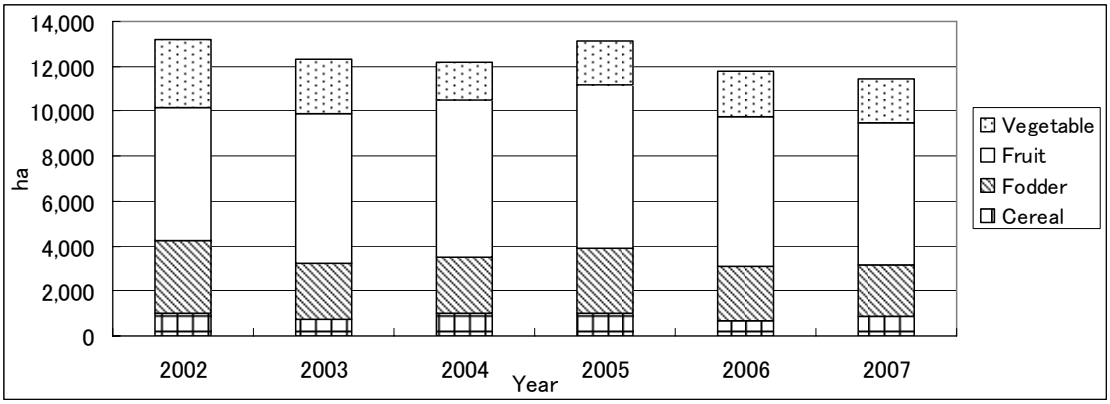


Figure 2-6 Planted Area of Different Crops in Najran Region

Table 2-6 Planted Area of Different Crops in Najran Region

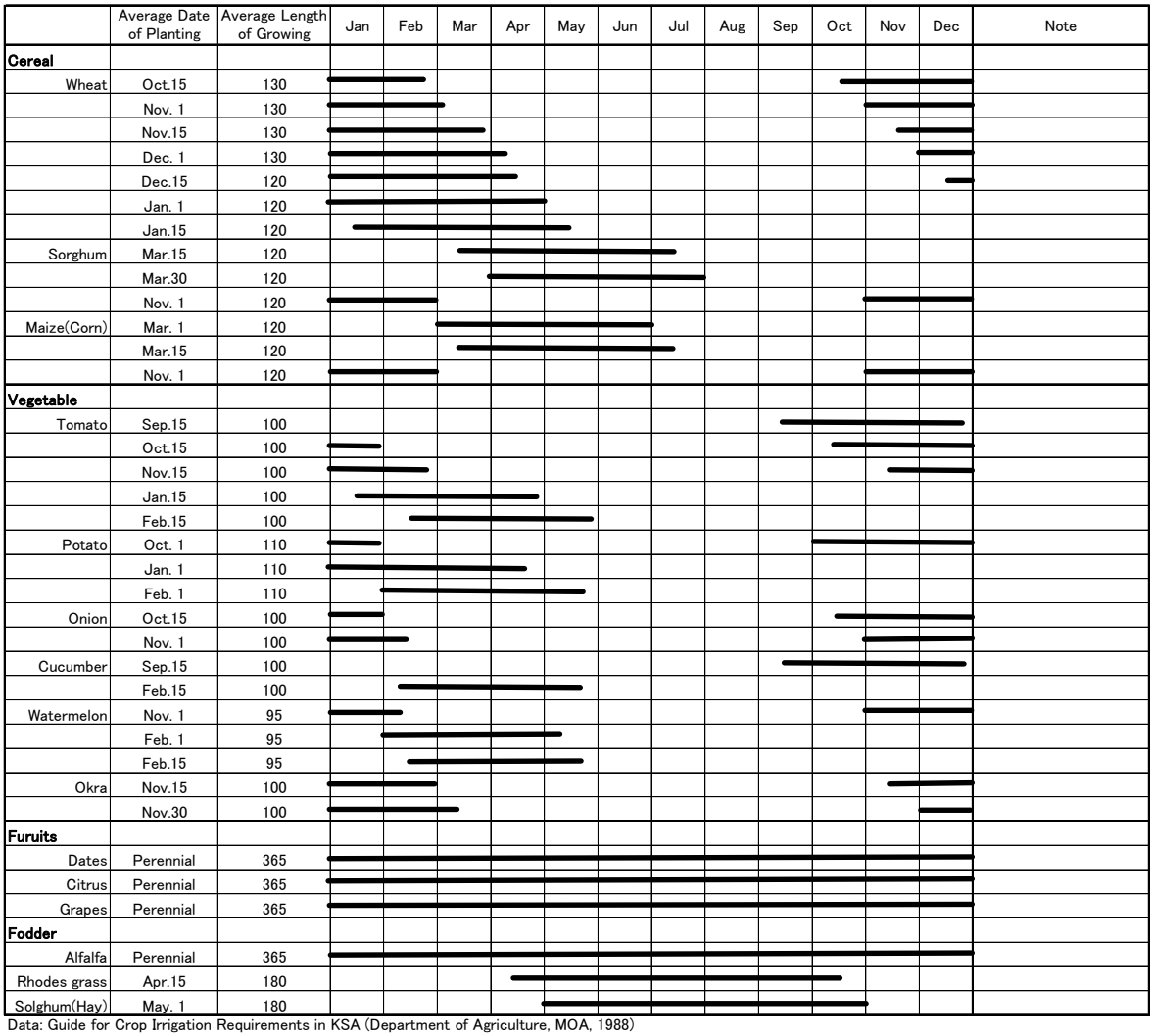
	2002	2003	2004	2005	2006	2007
All Crops	13,212	12,286	12,185	13,107	11,747	11,430
Cereal	984	708	1,001	1,019	659	908
Wheat	913	648	946	959	608	868
Barley	58	60	53	55	50	39
Solgum	0	0	0	0	0	0
Maize	13	0	0	4	0	0
Millet	0	0	0	0	0	0
Sesame	0	0	0	0	0	0
Other Cereal	0	0	2	1	1	1
Fodder	3,237	2,520	2,479	2,879	2,435	2,287
Alfalfa	2,270	2,025	1,697	2,054	1,635	1,515
Other Fodder	967	494	782	825	800	772
Fruit	5,962	6,682	7,007	7,272	6,658	6,311
Dates	3,045	3,438	3,390	3,146	3,143	3,124
Citrus	2,054	2,504	2,798	3,025	2,513	2,094
Grapes	117	106	87	61	94	69
Other Fruits	746	634	732	1,039	908	1,024
Vegetable(Open+GH)	3,029	2,375	1,698	1,937	1,995	1,924
Vegatable(OP:Open)	2,575	1,942	1,416	1,715	1,715	1,677
Vegetable(GH:GreenHouse)	454	433	282	222	280	247
Tomato(OP+GH)	1,357	1,197	961	1,085	917	932
Tomato(OP)	1,356	1,196	960	1,083	914	924
Tomato(GH)	1	1	1	1	3	3
Eggplant	216	154	114	156	247	263
Squash(OP+BH)	413	226	162	213	304	264
Squash(OP)	413	224	161	212	301	265
Squash(GH)	0	2	1	1	3	3
Cucumber(OP+GH)	472	448	292	237	288	253
Cucumber(OP)	19	18	13	18	15	13

	2002	2003	2004	2005	2006	2007
Cucumber(GH)	453	430	280	219	273	240
Okra	62	60	56	76	94	74
Carrots	17	18	16	25	21	18
Potatoes	75	14	11	21	23	21
Onion(dry)	9	14	11	13	18	25
Melon	0	0	0	0	0	0
Watermelon	0	1	0	1	1	1
Other vegetables(OP+GH)	408	243	75	111	82	69
Other vegetables(OP)	408	243	75	110	81	68
Other vegetables(GH)	0	0	0	0	1	1

Source: Agriculture Statistical Year Book Twenty Issue by MOA

2.3 Cropping Calendar

MOA with collaboration of FAO prepared "Guide for Crop Irrigation Requirements in The kingdom of Saudi Arabia" in 1988, the typical cropping calendar in the Saudi whole country has shown in the following Figure 2-7. According to the cropping calendar, crop cultivation is basically active in winter season and is not performed till September from June of summer due to sever weather conditions such as high temperature and no rainfall.



Data: Guide for Crop Irrigation Requirements in KSA (Department of Agriculture, MOA, 1988)

Figure 2-7 Cropping Calendar in KSA

2.4 Reference Evapotranspiration (ETo)

The amount of reference evapotranpiration in each meteorological observing station of the South West Region is calculated using the crop water requirements calculation program (CROPWAT: Pennman-Monteith Method offered by FAO 1992) and FAO climate database. The calculated result is

shown in Table 2-7.

Table 2-7 Reference Evapotranspiration (ETo) in the South West Region

(Unit: mm/day)

	Meteorological Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Total(mm/year)
1	MEDINA	4.41	6.30	7.44	9.03	9.94	11.84	11.68	10.69	9.11	7.55	6.11	4.52	8.22	3,002
2	JEDDAH	5.06	5.78	6.09	7.25	7.93	8.11	8.17	8.01	7.08	5.29	4.84	4.57	6.52	2,379
3	TAIF	3.74	4.92	6.00	7.02	7.79	9.52	10.30	9.92	8.38	5.98	4.35	3.38	6.78	2,476
4	BISHA	3.81	4.97	6.36	7.26	7.19	7.26	7.70	7.80	7.25	6.15	4.55	3.62	6.16	2,250
5	KWASH	3.51	4.36	5.42	6.69	7.02	7.32	7.16	6.53	6.14	5.36	4.33	3.59	5.62	2,053
6	ABHA	3.17	3.35	4.17	5.38	5.63	6.91	6.26	6.07	5.92	4.81	3.53	3.01	4.85	1,773
7	KHAMIS MUSHAIT	3.45	4.33	4.83	5.69	6.10	6.28	6.05	5.55	6.05	4.85	3.57	3.08	4.99	1,820
8	JAZAN	4.40	4.54	5.98	6.99	6.99	7.32	7.60	7.31	6.71	5.95	5.35	4.57	6.14	2,245
9	NAJRAN	4.17	5.09	6.30	6.83	7.55	8.62	7.62	7.57	7.95	4.91	4.91	3.88	6.28	2,294
10	SULAYEL	4.68	5.65	7.11	8.41	9.66	9.69	11.02	10.38	8.70	6.57	5.49	3.89	7.60	2,780

2.5 Crop Coefficient (Kc)

The crop coefficient (Kc) is related to the evapotranspiration of a disease-free crop grown in large field under optimum soil and water conditions and achieving full production potential under a given growing environment. The values of crop coefficients vary with the crop, time of planting or sowing, stage of crop growth, growing season and prevailing weather conditions. The crop coefficients and the stages of crop development for major crops grown in different areas in KSA are shown in Table 4.2.8. The four growth stages mentioned in Table 2-8 are explained as follows:

Stage 1. (Initial stage). Germination and early growth when the soil surface is not or is hardly covered by the crop (Ground cover less than 10%)

Stage 2, (Crop development stage). From end of initial stage to attainment of effective full ground cover (Ground cover 70~80%)

Stage 3. (Mid-season stage). From attainment of effective full groundcover to time of start of maturing as indicated by discoloring of leaves (Beans) or leaves falling off (cotton). For some crops this may extend to very near harvest (sugar beets) unless irrigation is not applied at late season and reduction in ET crop is induced to increase yield and / or quality (sugarcane, cotton, some grains); normally well past the flowering stage of annual crops

Stage 4. (Late season stage). From end of mid-season stage until full maturity or harvest.

Table 2-8 Crop Coefficient (Kc) in KSA

	Average Date of Planting	Average Length of Growing	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Note
Cereal															
Wheat	Oct.15	130	1.14	0.65								0.58	0.82	1.14	
	Nov. 1	130	1.15	0.95									0.64	1.04	
	Nov.15	130	1.14	1.14	0.65								0.58	0.82	
	Dec. 1	130	1.04	1.15	0.95	0.43								0.64	
	Dec.15	120	0.82	1.14	1.08	0.54								0.58	
	Jan. 1	120	0.64	1.04	1.15	0.80									
	Jan.15	120	0.58	0.82	1.14	1.08	0.54								
Sorghum	Mar.15	120			0.61	0.83	1.09	0.93	0.68						
	Mar.30	120				0.77	1.02	1.10	0.78						
	Nov. 1	120	1.10	0.78									0.77	1.02	
Maize(Corn)	Mar. 1	120			0.77	1.02	1.10	0.85							
	Mar.15	120			0.61	0.83	1.09	0.98	0.73						
	Nov. 1	120	1.10	0.85									0.77	1.02	
Vegetable															
Tomato	Sep.15	100									0.76	0.92	1.05	0.91	
	Oct.15	100	0.91									0.76	0.92	1.05	
	Nov.15	100	1.05	0.91									0.76	0.92	
	Jan.15	100	0.76	1.03	1.19	1.05									
	Feb.15	100		0.76	1.03	1.19	1.05								
Potato	Oct. 1	110	0.95									0.84	1.04	1.15	
	Jan. 1	110	0.84	1.04	1.15	0.95									
	Feb. 1	110		0.84	1.04	1.15	0.95								
Onion	Oct.15	100	0.93									0.76	0.92	1.05	
	Nov. 1	100	1.03	0.86									0.81	1.05	
Cucumber	Sep.15	100									0.64	0.80	1.00	0.92	
	Feb.15	100		0.64	0.80	1.00	0.92								
Watermelon	Nov. 1	95	0.97	0.79									0.68	0.88	
	Feb. 1	95		0.68	0.93	0.97	0.79								
	Feb.15	95		0.64	0.81	1.00	0.91								
Okra	Nov.15	100	1.00	0.90									0.68	0.88	
	Nov.30	100	0.97	0.98	0.85									0.78	
Furuits															
Dates	Perennial	365	0.55	0.55	0.55	0.70	0.70	0.75	0.75	0.75	0.75	0.70	0.65	0.65	
Citrus	Perennial	365	0.80	0.80	0.75	0.75	0.75	0.70	0.70	0.70	0.70	0.75	0.80	0.80	
Grapes	Perennial	365	0.25	0.25	0.35	0.45	0.67	0.75	0.80	0.75	0.60	0.45	0.35	0.25	
Fodder															
Alfalfa	Perennial	365	0.96	0.96	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.95	
Rhodes grass	Apr.15	180				0.70	1.02	0.85	0.94	0.87	0.86	1.08			
Solghum(Hay)	May. 1	180					0.84	0.89	0.90	0.88	0.86	1.00			

Data: Guide for Crop Irrigation Requirements in KSA (Department of Agriculture, MOA, 1988)

2.6 Net Water Requirement of Different Crops

The net water requirement of different crops is calculated by ETo x Kc, and the net water requirement of different crops in each region is shown in Table 2-9. The net water requirement in Al Baha region is small by good climate condition for farming, on the other hand, the net water requirement in Makkah is 2 times as much water as Al Baha region due to sever climate condition for farming. Moreover, a fodder crops need generally about 2.7 times as much water as cereals.

Table 2-9 Net Water Requirements of Different Crops in 5 Regions

(Unit : m3/ha)

Crops	Makkah	Al Baha	Asir	Jazan	Najran	Average	Note
Cereal	8,011	4,743	6,173	6,295	6,412	6,327	Wheat, Sorghum, Maize
Fodder	21,825	12,832	15,994	15,679	16,210	16,508	Alfalfa, Rhodes Grass, Sorghum
Fruit	19,826	11,669	14,720	14,633	15,023	15,174	Date, Citrus, Grapes, Fig
Vegetable	6,207	3,742	4,978	5,158	5,029	5,023	Tomato, Onion, Cucumber, Watermelon, Okra

2.7 Net Water Requirements in 5 Regions for last 6 years

Net water requirement multiplies the planted area of each year by the unit net water requirement of

different crops shown above is calculated and shown in Figure 2-8 and Table 2-10. In the whole 5 regions, when the planted area carried out about 78,000 ha reduction in six years, the net water requirement which was 2,220 million m^3 in 2002 decreases by 540 million m^3, and has become 1,680million m^3 in 2007 The reduction of net water requirement is caused by remarkable decreasing of cereal planted area in Jazan region. On the other hand, in Al Baha region, fruits tree planted area is increasing twice in these six years.

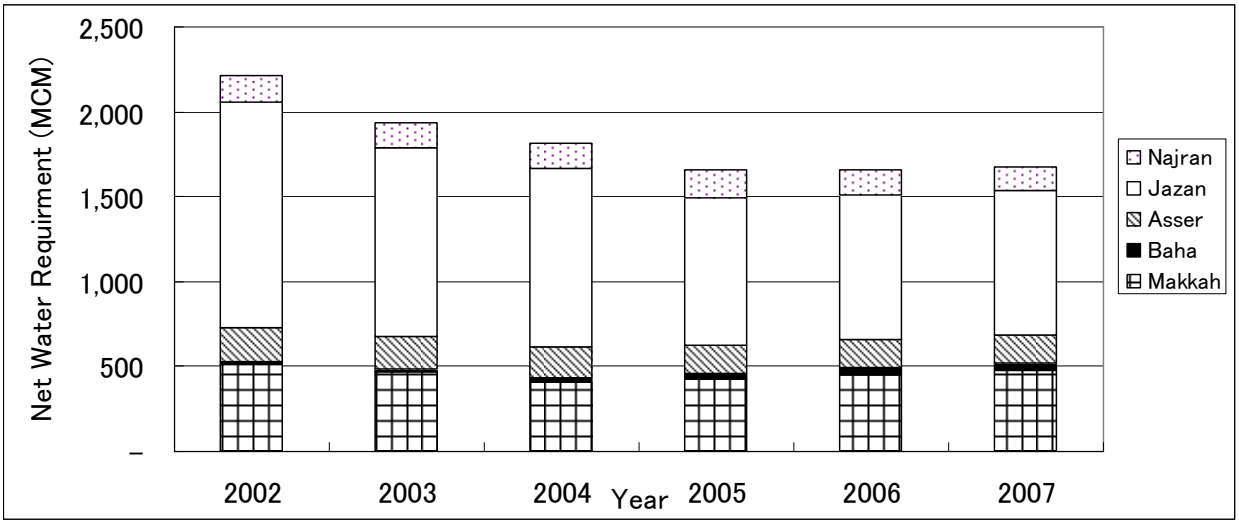


Figure 2-8 Net Water Requirements in 5 Regions for Last 6 Years

Table 2-10 Net Water Requirements in 5 Regions for Last 6 Years

Region/ Crops	Net Irrigation Water (m3/ha)	2002		2003		2004		2005		2006		2007	
		ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM
Makkah		45,311	**511**	41,942	**466**	37,698	**408**	38,237	**428**	39,912	**451**	42,077	**481**
Cereal	6,753	12,588	85	10,467	71	8,128	55	7,608	51	7,708	52	8,386	57
Fodder	18,420	9,732	179	7,883	145	4,885	90	5,262	97	5,698	105	5,761	106
Fruits	16,420	11,396	187	11,343	186	12,005	197	13,201	217	13,930	229	15,447	254
Vegetable	5,175	11,595	60	12,249	63	12,680	66	12,166	63	12,576	65	12,483	65
Al Baha		2,769	**21**	2,928	**23**	3,459	**26**	3,583	**28**	5,023	**41**	4,450	**37**
Cereal	3,637	549	2	443	2	713	3	608	2	604	2	532	2
Fodder	11,160	168	2	139	2	136	2	94	1	147	2	185	2
Fruits	9,223	1,788	16	2,075	19	2,280	21	2,603	24	3,974	37	3,457	32
Vegetable	2,863	264	1	271	1	330	1	278	1	298	1	276	1
Asir		22,508	**195**	22,695	**192**	22,037	**179**	21,022	**172**	20,368	**170**	21,054	**171**
Cereal	4,691	6,477	30	7,318	34	8,159	38	7,550	35	6,780	32	7,744	36
Fodder	13,259	2,796	37	1,930	26	1,581	21	1,680	22	1,644	22	2,001	27
Fruits	11,384	10,159	116	10,644	121	9,633	110	9,220	105	9,334	106	8,579	98
Vegetable	3,736	3,076	11	2,803	10	2,664	10	2,572	10	2,610	10	2,730	10
Jazan		186,350	**1,333**	157,747	**1,109**	148,450	**1,050**	120,269	**866**	117,032	**851**	113,558	**846**
Cereal	6,119	159,461	976	136,609	836	128,551	787	101,302	620	97,484	597	92,204	564
Fodder	15,276	18,095	276	12,956	198	12,204	186	10,552	161	10,852	166	12,247	187
Fruits	14,010	4,151	58	3,843	54	4,322	61	4,786	67	5,049	71	5,525	77
Vegetable	4,951	4,643	23	4,339	21	3,373	17	3,629	18	3,647	18	3,582	18
Najran		13,212	**156**	12,285	**150**	12,185	**153**	13,107	**164**	11,747	**146**	11,430	**140**
Cereal	6,077	984	6	708	4	1,001	6	1,019	6	659	4	908	6
Fodder	15,748	3,237	51	2,520	40	2,479	39	2,879	45	2,435	38	2,287	36
Fruits	14,197	5,962	85	6,682	95	7,007	99	7,272	103	6,658	95	6,311	90
Vegetable	4,725	3,029	14	2,375	11	1,698	8	1,937	9	1,995	9	1,924	9
Total		**270,150**	**2,216**	**237,597**	**1,939**	**223,829**	**1,815**	**196,218**	**1,658**	**194,082**	**1,659**	**192,569**	**1,675**

2.8 Gross Water Requirement

In the South West region, the irrigation system has a common case where water is pumped up from a well and delivered to a farm land with a pipe. When the irrigation method is surface irrigation, by the guideline of MOA, the irrigation efficiency is 55%, in sprinkler irrigation, 70%, in drip irrigation, it is indicated as 85%, and the required amount of gross water requirement also presumes using these

values. In order to raise accuracy further from now on, the work which survey the planted area according to irrigation system, and presumes gross water requirement based on net water requirement using the above-mentioned irrigation efficiency is required, but at present, all of cereals and a fodder crop presume gross water requirement, assuming 100% surface irrigation, a fruit tree and vegetables to be 50% of surface irrigation and 50% of drip irrigation. The future prediction of gross water requirement under the above-mentioned conditions is shown in Figure 2-9, Table 2-11. Gross water requirement becomes about 1.67 times to the net water requirement, and in the target year of 2035, it becomes 14 billion m^3 in Case-3. The gross water requirement shall decrease by rehabilitation of water-saving irrigation system progressing and improving use efficiency.

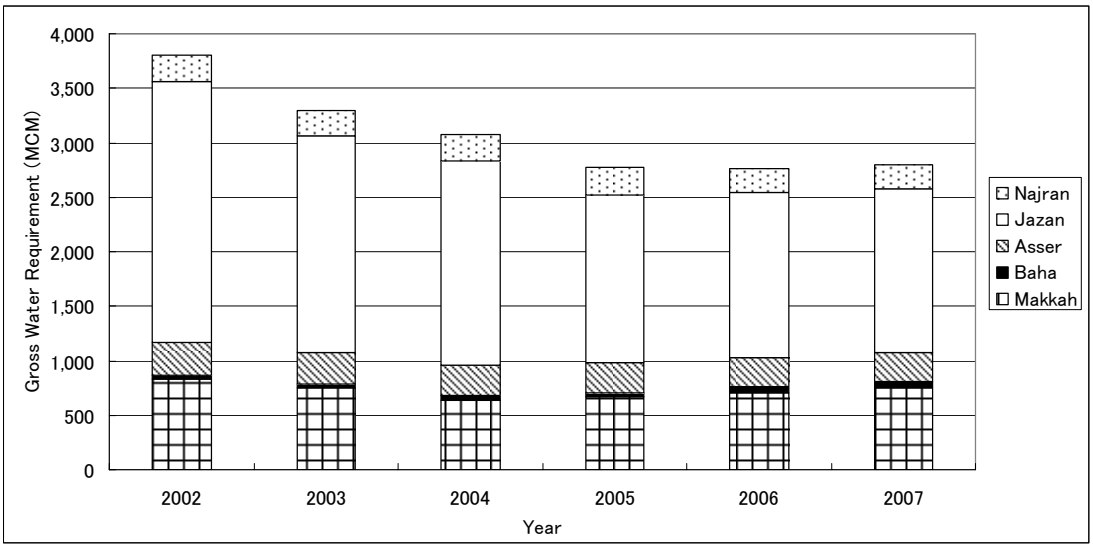


Figure 2-9 Gross Water Requirements in 5 Regions for Last 6 Years

Table 2-11 Gross Water Requirements in 5 Regions for Last 6 Years

Region/ Crops	Net Irrigation Water (m3/ha)	2002		2003		2004		2005		2006		2007	
		ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM
Makkah		45,311	**834**	41,941	**749**	37,697	**639**	38,237	**669**	39,912	**705**	42,077	**751**
Cereal	6,753	12,588	155	10,467	129	8,128	100	7,608	93	7,708	95	8,386	103
Fodder	18,420	9,732	326	7,883	264	4,885	164	5,262	176	5,698	191	5,761	193
Fruits	16,420	11,396	267	11,343	266	12,005	282	13,201	310	13,930	327	15,447	362
Vegetable	5,175	11,595	86	12,249	91	12,680	94	12,166	90	12,576	93	12,483	92
Al Baha		2,769	**32**	2,927	**34**	3,459	**39**	3,584	**41**	5,023	**61**	4,450	**54**
Cereal	3,637	549	4	443	3	713	5	608	4	604	4	532	4
Fodder	11,160	168	3	139	3	136	3	94	2	147	3	185	4
Fruits	9,223	1,788	24	2,075	27	2,280	30	2,603	34	3,974	52	3,457	46
Vegetable	2,863	264	1	271	1	330	1	278	1	298	1	276	1
Asir		22,508	**304**	22,695	**297**	22,038	**279**	21,023	**269**	20,368	**263**	21,054	**268**
Cereal	4,691	6,477	55	7,318	62	8,159	70	7,550	64	6,780	58	7,744	66
Fodder	13,259	2,796	67	1,930	47	1,581	38	1,680	41	1,644	40	2,001	48
Fruits	11,384	10,159	165	10,644	173	9,633	157	9,220	150	9,334	152	8,579	140
Vegetable	3,736	3,076	16	2,803	15	2,664	14	2,572	14	2,610	14	2,730	15
Jazan		186,350	**2,393**	157,747	**1,987**	148,450	**1,880**	120,268	**1,542**	117,032	**1,513**	113,558	**1,502**
Cereal	6,119	159,461	1,774	136,609	1,520	128,551	1,430	101,302	1,127	97,484	1,085	92,204	1,026
Fodder	15,276	18,095	503	12,956	360	12,204	339	10,552	293	10,852	301	12,247	340
Fruits	14,010	4,151	83	3,843	77	4,322	87	4,786	96	5,049	101	5,525	111
Vegetable	4,951	4,643	33	4,339	31	3,373	24	3,629	26	3,647	26	3,582	25
Najran		13,212	**245**	12,286	**232**	12,185	**236**	13,107	**254**	11,747	**226**	11,430	**217**
Cereal	6,077	984	11	708	8	1,001	11	1,019	11	659	7	908	10
Fodder	15,748	3,237	93	2,520	72	2,479	71	2,879	82	2,435	70	2,287	65
Fruits	14,197	5,962	121	6,682	136	7,007	142	7,272	147	6,658	135	6,311	128
Vegetable	4,725	3,029	20	2,375	16	1,698	11	1,937	13	1,995	13	1,924	13
Total		**270,150**	**3,807**	237,596	**3,299**	223,829	**3,071**	196,219	**2,775**	194,082	**2,767**	**192,569**	**2,791**

3. Agricultural Water Demands Prediction

3.1 Agricultural Policy

The Government has implemented various encouragement policies of an agricultural sector for agricultural promotion. Especially an important policy is having distributed uncultivated land to the farmer and the agricultural company gratuitously in it, it continues still now and this policy is performed. Moreover, the government has provided the farmer with loan and subsidy of a loan through the Agricultural Bank which established in 1962 over a long period of time. The Government paid 50% of the purchase expense of an agricultural machine and pump for irrigation untill 2005, and agricultural equipment, and also paid 45% of purchase expense of imported and domestic product of fertilizer. Moreover, the seed, the seedling, etc. are distributed at a very low price. Furthermore, service of agricultural technique is provided to the farmer through the Agriculture Office and the Agricultural Experiment Stations which are established in each region.

The old subsidy policy is revised in order to prevent superfluous pumping of groundwater in 2005. As for 50% of subsidy delivered until 2005 to the purchase of all the agricultural instrument / machines, and farmstead construction, well drilling, a pump, a house, the lodgings for laborers, and a track (except for the track with a cold-packed warehouse) were removed from the object, and the subsidy was cut to 25%. Although the maximum reason for reexamination was preventing superfluous pumping of groundwater and preserving water resources, the purchase of a water-saving irrigation system, an agricultural machine, etc. was reduced by 25% of what serves as a subsidy object as usual.
For example, as for a subsidy, in a well drilling and a pump purchase, in the case of 100% payment (subsidy 0%) for a well drilling and a pump purchase, and in a well drilling and a water-saving irrigation system, in the case of 75% payment (subsidy 25%) for of a water-saving irrigation system and 100% payment (Subsidy 0%) for a well drilling. However, there is no interest burden in every case.

The future development project in agriculture is not developing water resources and increasing farmland area, and in order that it may prevent exhaustion of water resources, it is how to reduce farmland area. With for this reason, in Decree No.3035 (Rules and Procedure for the Rationalization of Water Consumption and regulates its use in Agriculture Purpose in all cities and villages within KSA), the following policies are examined.

- To stop a subsidy to a well construction and a pump purchase,
- To stop a land distribution policy,
- To eliminate import tariffs on an agricultural-products,
- To promote import of a fodder crops,
- To stop an encouragement price of wheat and barley through the GSMO (Grain Silos and Flour Mills Organization)

Therefore, with future planning of agricultural project, in another way of saying, how many planted area is put after the above-mentioned policy was implemented?

Although it decided upon the future agriculture plan by 2020 in MOA in 2000 to 2004, as compared with the agricultural-statistics data in 2007, deviation with the actual planted area is seen in a Southwest area. Therefore, in order to raise accuracy in demand forecasting, the three following cases are examined in consideration of the future agriculture plan of MOA, and the both sides of agricultural-statistics data.

Case-1: Case which rectified the future agriculture plan by 2020 upon which MOA decided in 2000 to 2004 by the agricultural-statistics data in 2007.
Case-2: Case presumed in recent years using the agricultural-statistics data of 6 years (2002-2007).
Case-3: Case which the planted area in 2007 where change of the planted area settled down will continue.

3.2 Future Frame for Demand Prediction

How many farmland area will be decreased by 2035, it is prediction of the water demand in a planned

target year (2035), and it needs to discern and predict the implementation situation of the governmental agricultural measure classified by region. Here, in consideration of the above-mentioned policy, the amount demanded of the water for agricultural use of a region unit is provisionally calculated based on the following case.

- Case-1: Case which rectified the future agriculture plan by 2020 upon which MOA decided in 2000 to 2004 by the agricultural-statistics data in 2007.
- Case-2: Case presumed in recent years using the agricultural-statistics data of 6 years (2002-2007).
- Case-3: Case which the planted area in 2007 where change of the planted area settled down will continue.

(1) Case-1 (Modified MOA Plan)

MOA was entrusted to King Abdulla Institute for Research in 2002 to 2004, and decided upon the agricultural development plan by 2005 to 2020. This is the newest agricultural development plan of MOA in which the policy was made to reflect based on 1999. As shown in Figure 3-1, judging from the viewpoint of water-resources preservation, MOA has a plan to decrease the planted area of whole KSA from 1,100,000 ha in 2007 to 680,000 ha in 2020. However, the South West region blessed with water resources although the planted area is decreased in whole KSA, MOA has a plan to increase the planted area of South West region from 241,000 ha in 1999 to 284,000 ha in 2020.

Summary of MOA Plan

- Although cereals and fodder crop are scheduled to be decreased in the whole country, although fodder crops are decreased in all five regions, in the South West region, cereals are scheduled to be increased in Asir and Jazan regions.
- Although a fruit tree is scheduled to be decreased in the whole country, it is scheduled to make it increase about four regions except Jazan in the South West region.
- Vegetable is scheduled to be increased in the whole country, it is also scheduled to make it increase about five regions in the South West region.

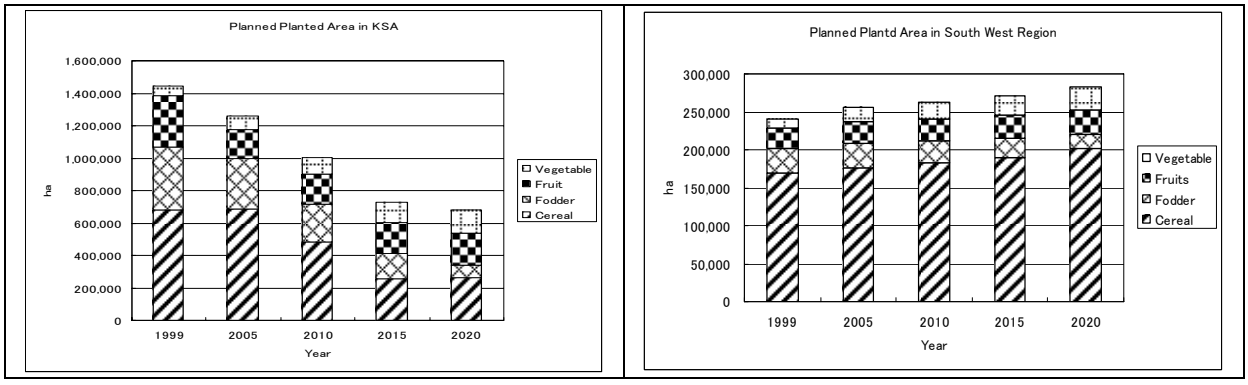


Figure 3-1 Future Agriculture Plan by MOA (KSA and South West Region)

However, change has arisen in the agriculture plan by concern of the further water-resources lack, reexamination of a subsidy, issue of Decree3035, etc. after plan decision. As compared with the agricultural –statistics data in 2007, there is more planted area of MOA about 66,000 ha in the South West region. Therefore, the plan of MOA needs to correct. Here, the change tendency of the planted area according to crops sets up provisionally what extended the plan area which left as it was and was adjusted by the difference of 2007 till 2035 as Case-1.

(2) Case-2 (2002-2007 Trend)

Aiming at self-support of agricultural products, various agricultural policy was implemented, farmland is distributed gratuitously or the subsidy has so far been taken out with MOA from 1948 established to

irrigation institution construction through an agricultural bank. Furthermore, as a result of taking preferential treatment measures, such as acquisition at an encouragement price of wheat and barley, through the GSMO (Grain Silos and Flour Mills Organization), 100% of the self-sufficiency rate of wheat was attained in 1995, the output amounted to 4,200,000t in 1992, and Saudi Arabia became an exporting country of wheat.

As a result, exhaustion of water resources became an issue, a subsidy policy is improved repeatedly until now, or the agricultural output control policy has been taken by Decree.

As this has appeared in agricultural-statistics data and it is shown in Figure 3-2, for the year, whole KSA and South West region has been decreasing in number recently.

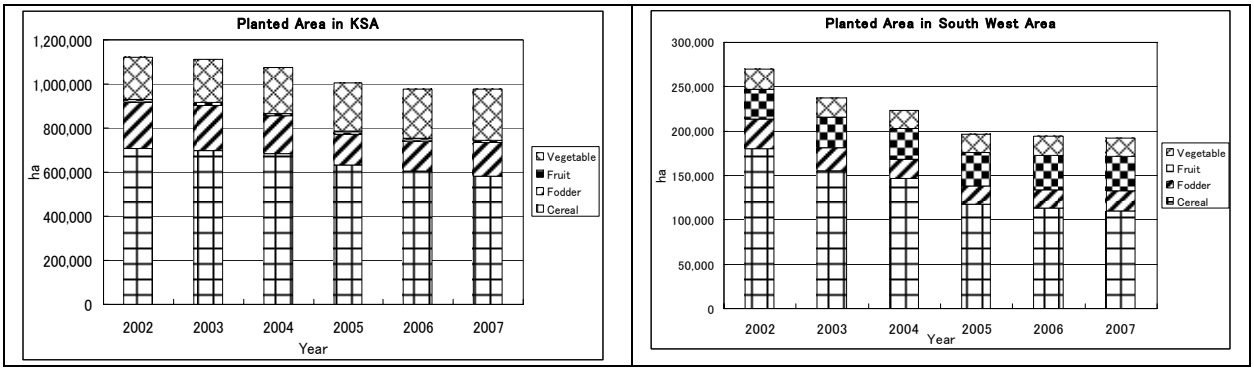


Figure 3-2 Tendency of the Planted Area in 2002 to 2007 by Agricultural-statistics Data

However, since the agricultural-statistical data shows that it is in the tendency of a lowering stop in recent years, this reduction sets up Case-2 as a case where 2035 which are a target planning year are presumed using this tendency.

(3) Case-3 (2007 Year Level)

As the Case-2 described, according to the agricultural-statistics data, it can see for converging the downward tendency of the planted area on the value in 2007 which is a line of constant. Although reexamination of agricultural policy also serves as a backdrop, it can observe approaching the planted area which agricultural activity was actually restricted by exhaustion of water resources as a major factor, and irrigation area decreased, and balanced the amount of water resources. Therefore, Case-3 is set up as a case it was presupposed that the planted area in 2007 continues also in 2035 which are a target planning year.

3.3 Water Demand Prediction

(1) Future Planted Area in South West Region

The result of having calculated the planted area according to whole South West region and 5 regions about the three following cases is shown in Figure 3-3 and Table 3-1.

Case-1; Case which rectified the future agriculture plan by 2020 upon which MOA decided in 2000 to 2004 by the agricultural-statistics data in 2007.
Case-2: Case presumed in recent years using the agricultural-statistics data of 6 years (2002-2007).
Case-3: Case which the planted area in 2007 where change of the planted area settled down will continue.

In addition, agricultural water demanded changes greatly with combination of crops. In Case-1 MOA plan was used, in Case-2 the regression curve according to the crops of 6 years (2002-2007) was used, and the value of the agricultural statistics in 2007 was used in Case-3.

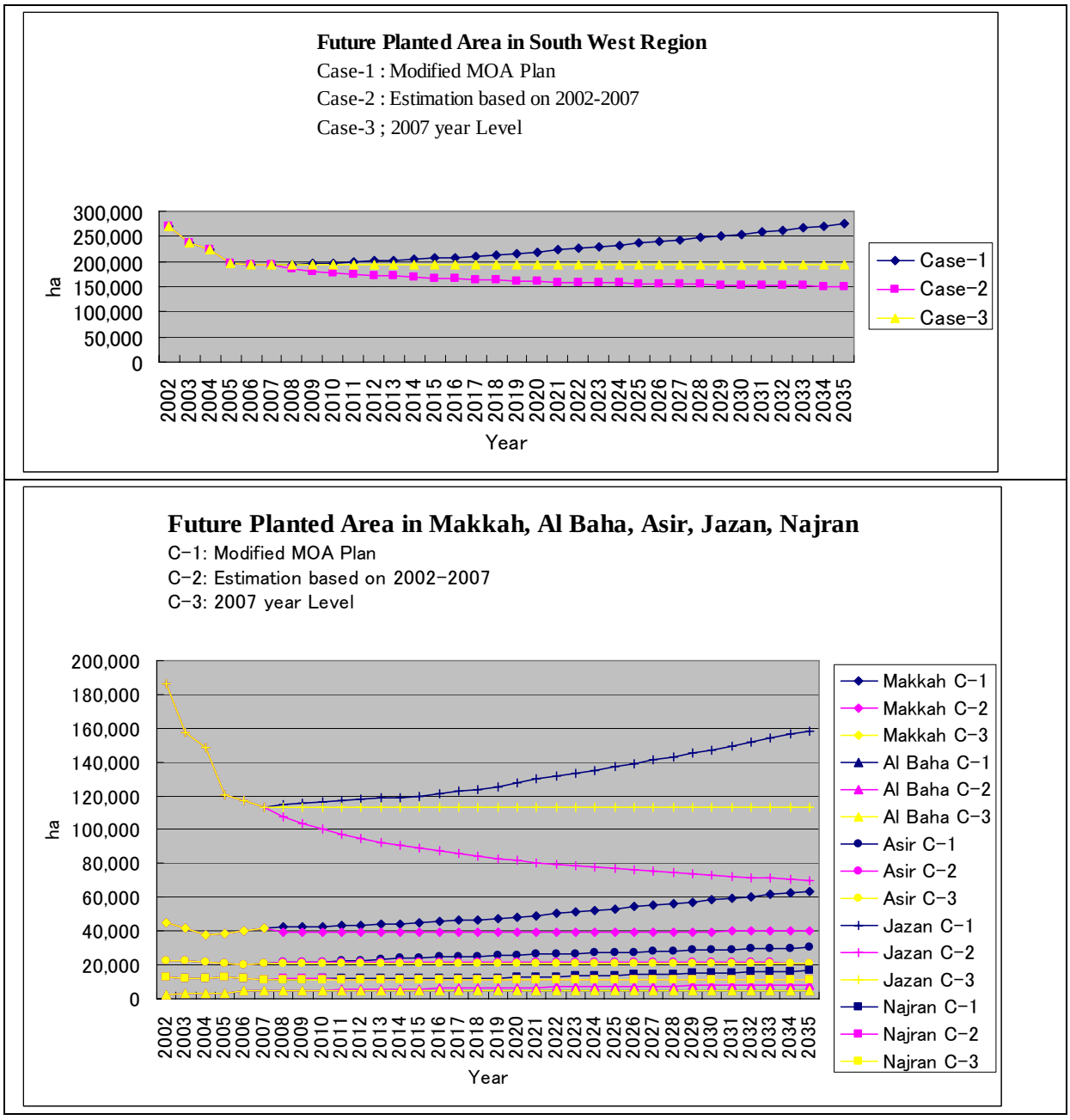


Figure 3-3 Future Planted Area of 5 Regions in 3 Cases

(2) Net Water Requirements of Different Crops in 5 Regions

The net water requirement of different crops is calculated by ETo x Kc, and the net water requirement of different crops in each region is shown in Table below. The net water requirement in Al Baha region is small by good climate condition for farming, on the other hand, the net water requirement in Makkah is 2 times as much water as Al Baha region due to sever climate condition for farming. Moreover, a fodder crops need generally about 2.7 times as much water as cereals.

Table 3-1 Net Water Requirements of Different Crops in 5 Regions

(Unit : m3/ha)

Crops	Makkah	Al Baha	Asir	Jazan	Najran	Average	Note
Cereal	6,753	3,637	4,691	6,119	6,077	5,455	Wheat, Sorghum, Maize
Fodder	18,420	11,160	13,259	15,276	15,748	14,773	Alfalfa, Rhodes Grass, Sorghum
Fruit	16,420	9,223	11,384	14,010	14,197	13,047	Date, Citrus, Grapes, Fig
Vegetable	5,175	2,863	3,736	4,951	4,725	4,290	Tomato, Onion, Cucumber, Watermelon, Okra

(3) Gross Water Requirements

In the South West region, the irrigation system has a common case where water is pumped up from a well and delivered to a farm land with a pipe. When the irrigation method is surface irrigation, by the guideline of MOA, the irrigation efficiency is 55%, in sprinkler irrigation, 70%, in drip irrigation, it is indicated as 85%, and the required amount of gross water requirement also presumes using these values. In order to raise accuracy further from now on, the work which survey the planted area according to irrigation system, and presumes gross water requirement based on net water requirement using the above-mentioned irrigation efficiency is required, but at present, all of cereals and a fodder crop presume gross water requirement, assuming 100% surface irrigation, a fruit tree and vegetables to be 50% of surface irrigation and 50% of drip irrigation.

(4) Future Agricultural Water Demand in South West Region

The result of having calculated the agricultural water demand according to whole South West region and 5 regions about the three following cases is shown in Figure 3-4 and Table 3-2(1) – Table 3-2(3).

Case-1; Case which rectified the future agriculture plan by 2020 upon which MOA decided in 2000 to 2004 by the agricultural-statistics data in 2007.
Case-2: Case presumed in recent years using the agricultural-statistics data of 6 years (2002-2007).
Case-3: Case which the planted area in 2007 where change of the planted area settled down will continue.

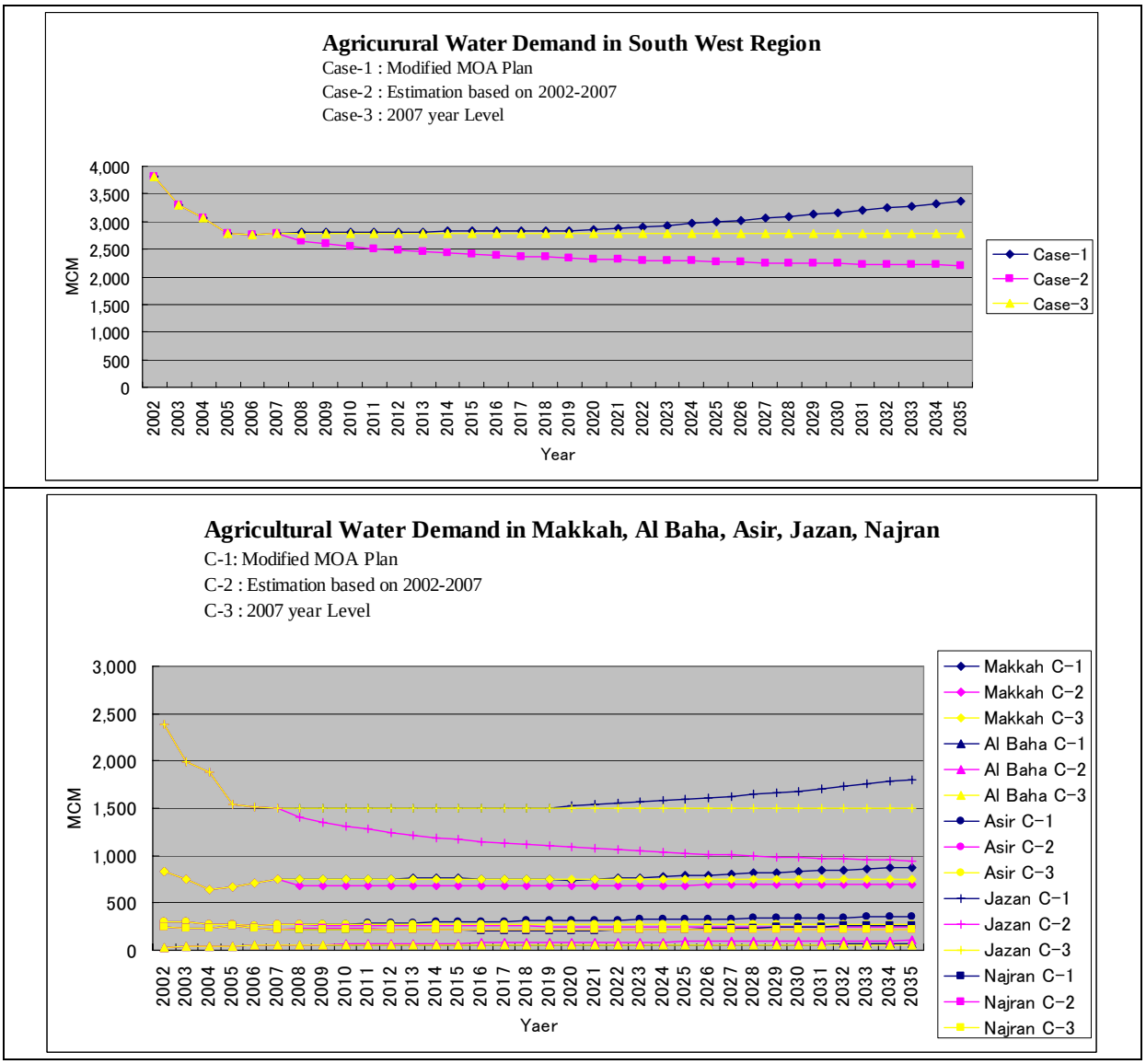


Figure 3-4 Future Water Demand of 5 Regions in 3 Cases

Table 3-2(1) Breakdown of Future Planted Area and Water Demanded (2010-2035)

Region/Crops	2010						2015					
	Case-1		Case-2		Case-3		Case-1		Case-2		Case-3	
	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM
Makkah	42,657	**756.2**	39,167	**682.7**	42,077	**750.5**	**44,964**	**757.7**	39,173	**681.7**	42,077	**750.5**
Cereal	7,350	90.2	6,631	81.4	8,386	103.0	7,641	93.8	5,869	72.1	8,386	103.0
Fodder	5,895	197.4	4,386	146.9	5,761	192.9	5,024	168.3	3,784	126.7	5,761	192.9
Fruits	15,631	366.6	15,329	359.6	15,447	362.3	15,989	375.1	16,478	386.5	15,447	362.3
Vegetable	13,782	101.9	12,821	94.8	12,483	92.3	16,309	120.6	13,042	96.4	12,483	92.3
Al Baha	4,468	**54.0**	5,150	**62.1**	4,450	**53.9**	4,577	**55.2**	6,003	**73.1**	4,450	**53.9**
Cereal	499	3.3	611	4.0	532	3.5	499	3.3	629	4.2	532	3.5
Fodder	122	2.5	135	2.7	185	3.8	95	1.9	133	2.7	185	3.8
Fruits	3,572	47.1	4,104	54.1	3,457	45.5	3,708	48.9	4,936	65.0	3,457	45.5
Vegetable	275	1.1	300	1.2	276	1.1	275	1.1	306	1.3	276	1.1
Asir	21,757	**275.2**	21,558	**262.1**	21,054	**268.4**	24,407	**299.3**	21,426	**255.6**	21,054	**268.4**
Cereal	8,177	69.7	7,861	67.1	7,744	66.1	10,302	87.9	8,091	69.0	7,744	66.1
Fodder	2,001	48.2	1,476	35.6	2,001	48.2	2,001	48.2	1,334	32.1	2,001	48.2
Fruits	8,730	142.0	8,625	140.3	8,579	139.5	9,024	146.8	8,272	134.5	8,579	139.5
Vegetable	2,849	15.2	3,596	19.2	2,730	14.6	3,080	16.4	3,730	19.9	2,730	14.6
Jazan	116,581	**1,503.0**	100,457	**1,312.4**	113,558	**1,501.9**	119,842	**1,499.7**	88,820	**1,170.8**	113,558	**1,501.9**
Cereal	96,784	1,076.8	82,173	914.2	92,204	1,025.8	101,880	1,133.5	71,336	793.6	92,204	1,025.8
Fodder	10,392	288.6	9,540	265.0	12,247	340.2	8,124	225.6	8,530	236.9	12,247	340.2
Fruits	5,489	109.9	5,516	110.4	5,525	110.6	5,489	109.9	5,944	119.0	5,525	110.6
Vegetable	3,916	27.7	3,228	22.8	3,582	25.3	4,349	30.8	3,009	21.3	3,582	25.3
Najran	11,692	**216.8**	11,652	**225.8**	11,430	**216.5**	12,122	**211.9**	11,476	**223.5**	11,430	**216.5**
Cereal	908	10.0	817	9.0	908	10.0	908	10.0	798	8.8	908	10.0
Fodder	2,127	60.9	2,232	63.9	2,287	65.5	1,409	40.4	2,092	59.9	2,287	65.5
Fruits	6,464	131.1	7,004	142.1	6,311	128.0	7,042	142.8	7,158	145.2	6,311	128.0
Vegetable	2,193	14.8	1,599	10.8	1,924	13.0	2,762	18.6	1,428	9.6	1,924	13.0
Total	**197,154**	**2,805.1**	**177,984**	**2,545.0**	**192,569**	**2,791.3**	**205,912**	**2,823.8**	**166,898**	**2,404.8**	**192,569**	**2,791.3**

Table 3-2(2) Breakdown of Future Planted Area and Water Demanded (2010-2035)

Region/Crops	2020						2025					
	Case-1		Case-2		Case-3		Case-1		Case-2		Case-3	
	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM
Makkah	**48,179**	**739.6**	39,330	**684.5**	42,077	**750.5**	**53,316**	**785.8**	39,530	**688.5**	42,077	**750.5**
Cereal	8,152	100.1	5,394	66.2	8,386	103.0	8,663	106.4	5,057	62.1	8,386	103.0
Fodder	3,103	103.9	3,417	114.4	5,761	192.9	3,103	103.9	3,160	105.8	5,761	192.9
Fruits	16,348	383.5	17,321	406.3	15,447	362.3	16,707	391.9	17,996	422.1	15,447	362.3
Vegetable	20,576	152.1	13,197	97.6	12,483	92.3	24,843	183.7	13,317	98.5	12,483	92.3
Al Baha	**4,704**	**56.7**	6,690	**82.1**	4,450	**53.9**	**4,856**	**58.7**	7,277	**89.7**	4,450	**53.9**
Cereal	499	3.3	642	4.2	532	3.5	499	3.3	652	4.3	532	3.5
Fodder	69	1.4	131	2.7	185	3.8	69	1.4	130	2.6	185	3.8
Fruits	3,861	50.9	5,607	73.9	3,457	45.5	4,013	52.9	6,182	81.5	3,457	45.5
Vegetable	275	1.1	310	1.3	276	1.1	275	1.1	313	1.3	276	1.1
Asir	**25,880**	**313.4**	21,359	**251.5**	21,054	**268.4**	**27,354**	**327.5**	21,320	**248.5**	21,054	**268.4**
Cereal	11,251	96.0	8,254	70.4	7,744	66.1	12,200	104.1	8,381	71.5	7,744	66.1
Fodder	2,001	48.2	1,243	30.0	2,001	48.2	2,001	48.2	1,178	28.4	2,001	48.2
Fruits	9,318	151.5	8,036	130.7	8,579	139.5	9,611	156.3	7,860	127.8	8,579	139.5
Vegetable	3,311	17.7	3,826	20.4	2,730	14.6	3,542	18.9	3,900	20.8	2,730	14.6
Jazan	**126,920**	**1,503.9**	81,715	**1,084.6**	113,558	**1,501.9**	**135,863**	**1,559.9**	76,748	**1,024.5**	113,558	**1,501.9**
Cereal	112,518	1,251.8	64,693	719.7	92,204	1,025.8	123,155	1,370.2	60,031	667.9	92,204	1,025.8
Fodder	3,827	106.3	7,895	219.3	12,247	340.2	1,394	38.7	7,442	206.7	12,247	340.2
Fruits	5,489	109.9	6,260	125.3	5,525	110.6	5,489	109.9	6,512	130.3	5,525	110.6
Vegetable	5,086	36.0	2,867	20.3	3,582	25.3	5,823	41.2	2,763	19.5	3,582	25.3
Najran	**12,523**	**204.6**	11,372	**222.2**	11,430	**216.5**	**13,876**	**224.6**	11,303	**221.4**	11,430	**216.5**
Cereal	908	10.0	785	8.7	908	10.0	908	10.0	775	8.6	908	10.0
Fodder	458	13.1	2,001	57.3	2,287	65.5	458	13.1	1,933	55.4	2,287	65.5
Fruits	7,845	159.1	7,266	147.4	6,311	128.0	8,649	175.4	7,350	149.1	6,311	128.0
Vegetable	3,312	22.4	1,321	8.9	1,924	13.0	3,861	26.1	1,244	8.4	1,924	13.0
Total	**218,206**	**2,818.3**	**160,465**	**2,324.9**	**192,569**	**2,791.3**	**235,264**	**2,956.6**	**156,177**	**2,272.6**	**192,569**	**2,791.3**

Table 3-2(3) Breakdown of Future Planted Area and Water Demanded (2010-2035)

Region/Crops	2030						2035					
	Case-1		Case-2		Case-3		Case-1		Case-2		Case-3	
	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM	ha	MCM
Makkah	**58,453**	**832**	39,742	**693**	42,077	**751**	63,589	**878**	39,954	**697**	42,077	**751**
Cereal	9,174	113	4,800	59	8,386	103	9,686	119	4,593	56	8,386	103
Fodder	3,103	104	2,967	99	5,761	193	3,103	104	2,813	94	5,761	193
Fruits	17,065	400	18,561	435	15,447	362	17,424	409	19,050	447	15,447	362
Vegetable	29,110	215	13,415	99	12,483	92	33,377	247	13,498	100	12,483	92
Al Baha	**5,009**	**61**	7,795	**96**	4,450	**54**	5,161	**63**	8,264	**103**	4,450	**54**
Cereal	499	3	660	4	532	4	499	3	667	4	532	4
Fodder	69	1	129	3	185	4	69	1	128	3	185	4
Fruits	4,166	55	6,691	88	3,457	46	4,319	57	7,151	94	3,457	46
Vegetable	275	1	316	1	276	1	275	1	318	1	276	1
Asir	**28,828**	**342**	21,295	**246**	21,054	**268**	30,302	**356**	21,281	**244**	21,054	**268**
Cereal	13,149	112	8,485	72	7,744	66	14,098	120	8,574	73	7,744	66
Fodder	2,001	48	1,128	27	2,001	48	2,001	48	1,088	26	2,001	48
Fruits	9,905	161	7,720	126	8,579	140	10,199	166	7,605	124	8,579	140
Vegetable	3,772	20	3,962	21	2,730	15	4,003	21	4,014	21	2,730	15
Jazan	**147,238**	**1,684**	73,002	**979**	113,558	**1,502**	158,613	**1,807**	70,033	**943**	113,558	**1,502**
Cereal	133,793	1,489	56,503	629	92,204	1,026	144,431	1,607	53,698	597	92,204	1,026
Fodder	1,394	39	7,094	197	12,247	340	1,394	39	6,814	189	12,247	340
Fruits	5,489	110	6,724	135	5,525	111	5,489	110	6,908	138	5,525	111
Vegetable	6,561	46	2,681	19	3,582	25	7,298	52	2,614	18	3,582	25
Najran	**15,228**	**245**	11,252	**221**	11,430	**217**	16,581	**265**	11,213	**220**	11,430	**217**
Cereal	908	10	767	8	908	10	908	10	761	8	908	10
Fodder	458	13	1,881	54	2,287	65	458	13	1,837	53	2,287	65
Fruits	9,452	192	7,419	150	6,311	128	10,255	208	7,477	152	6,311	128
Vegetable	4,410	30	1,185	8	1,924	13	4,959	33	1,138	8	1,924	13
Total	**254,755**	**3,163**	**153,087**	**2,236**	**192,569**	**2,791**	**274,246**	**3,368**	**150,745**	**2,208**	**192,569**	**2,791**

(5) Water Demand in each Governorate

(a) Data Conversion from Agricultural Branch Office Based to Governorate Units

The agricultural-statistics data of MOA is based on Agricultural Branch Office, and is not arranged in governorate. In order to follow and to calculate the water demand of Governorate unit, the work which changes the data which has become per agricultural branch office in governorate is required.

The relation of the governorate and agricultural branch office in each region is shown in Table 3-3. There are 2 cases. Case-1 is two or more agricultural branch offices are in one governorate, and case 2 is one agricultural branch office covers two or more governorates.

When two or more agricultural branch offices are in one governorate, the data of the agricultural branch office which corresponds simply will be totaled, but when one agricultural branch office is having two or more jurisdictions, it is necessary to distribute the data of one agricultural branch office to an applicable governorate.

However, since the management area of each agricultural branch office is not clear, and the location on a map is difficult, agricultural water demand of the governorate which refers to the hearing information in Directorate of Agricultural Office and based on the topographical map of 1/500,000 was estimated practically.

It is necessary to obtain the jurisdiction map of each Agricultural Branch Office from now on, to clarify Governorate and the relation of Agricultural Branch Office, and to scrutinize a fractional rate.

Table 3-3 Relations between Governorate and Agricultural Branch Office

Region	Directorates	Branch	Governorate	Branch→Governorate
Makkah	Makkah	(1)Jeddah	(0)Makkah Almukarramah	(9)Makkah
		(2)Al Qunfudah	(1)Jeddah	(1)Jeddah
		(3)Khelees	(2)Altaif	(1)Al Taif+(3)Bani malek
		(4)Al Lith	(3)Alqunfidhah	(2)Al Qunfudah+(7)Al Arthayat
		(5)Al Kamel	(4)Allith	(4)Al Lith+(8)Athame
		(6)Rabigh	(5)Rabigh	(6)Rabigh
		(7)Al Arthayat	(6)Aljumum	None
		(8)Athame	(7)Khulays	(3)Khelees
		(9)Makkah	(8)Alkamil	(5)Al Kamel
	Taif	(1)Al Taif	(9)Alkhurmah	(5)Alkuma
		(2)Terba	(10)Ranyah	(4)Ranya+(6)Almlah
		(3)Bani malek	(11)Turubah	(2)Terba
		(4)Ranya		
		(5)Alkuma		
		(6)Almlah		
Al Baha	Al Baha	(1)Al Baha	(0)Al Baha	(1)Al Baha
		(2)Baljurashi	(1)Biljurashi	(2)Baljurashi+(6)Benybabayem
		(3)Al Mandaq	(2)Almandaq	(3)Al Mandaq
		(4)Al Aqiq	(3)Almukwah	(7)Al Mekhwat
		(5)Qilwah	(4)Alaqiq	(4)Al Aqiq
		(6)Benybabayem	(5)Qilwah	(5)Qilwah
		(7)Al Mekhwat	(6)Alqari	(8)Baydah
		(8)Baydah		
Asir	Abha	(1)Abha	(0)Abha	(1)Abha+(5)+(12)+(17)
		(2)Al Namas	(1)Khamis Mushayt	(3)Kamis Mushayt+(13)
		(3)Kamis Mushayt	(2)Bishah	(1)Bisha
		(4)Rijal Almah	(3)Annamas	(2)Al Namas+(14)
		(5)Bl Alsamem Al Ahamar	(4)Muhayil	(7)Mahael
		(6)Gana Al Baher	(5)Sarat Abidah	(8)Serat Abeedah
		(7)Mahael	(6)Tathlith	(4)Tatlith
		(8)Serat Abeedah	(7)Rijal Alma	(4)Rijal Almah+(6)
		(9)Dahran Al Janub	(8)Ahad Rifaydah	(11)Tarieb+(15)+(16)
		(10)Al Majardha	(9)Zahran Aljanub	(9)Dahran Al Janub
		(11)Tarieb	(10)Balqarn	(2)Balqarn+(3)Al Basham
		(12)Al Mawin	(11)Almajardah	(10)Al Majardha
		(13)Beny nashble		
		(14)Beny Amare		
		(15)Al Mathah		
		(16)Al Anaine		
		(17)Fanuma		
	Bisha	(1)Bisha		
		(2)Balqarn		
		(3)Al Basham		
		(4)Tatlith		
Jazan	Jizan	(1)Jizan	(0)Jizan	(1)Jizan(5/6)
		(2)Sabya	(1)Sabya	(2)Sabya(6/7)
		(3)Baysh	(2)Abu Arish	(7)Abu Arish
		(4)Al Shaaguge	(3)Samtah	(6)Ahad Al masarba(10/21)
		(5)Ayaban	(4)Alharth	(6)Ahad Al masarba(3/21)
		(6)Ahad Al masarba	(5)Damad	(2)Sabya (1/7)
		(7)Abu Arish	(6)Arrayth	(3)Baysh (10/11)
		(8)Al Aradah	(7)Baysh	(3)Baysh (1/11)
			(8)Farasan	(1)Jizan(1/6)
			(9)Addair	(5)Ayaban(1/3)
			(10)Ahad Almusarihah	(6)Ahad Al masarba(8/21)
			(11)Alidabi	(5)Ayaban(2/3)
			(12)Alaridah	(8)Al Ardah
			(13)Addarb	(4)Al Shaaguge
Najran	Najran	(1)Najran	(0)Najran	(1)Najran*1.0
		(2)Habunah	(1)Sharurah	None
		(3)Yadmah	(2)Hubuna	(2)Habunah*0.5
		(4)Thar	(3)Badr Aljanub	(2)Habunah*0.5
			(4)Yadamah	(3)Yadmah
			(5)Thar	(4)Thar
			(6)Khubash	None
			(7)Alkharkhir	None

(b) Water Demand of Governorate Units

The water demand of the governorate units in each target year is shown in Table 3-5 (Case-1), Table 3-6 (Case-2), and Table 3-7 (Case-3) for every case, respectively. In addition, water demand of the major governorate in a Target year (2035) is as in Table 3-4, Figure 3-5, Figure 3-6, Figure 3-7, Figure 3-8 and Figure 3-9.

Table 3-4 Water Demand of Major Governorate in a Target Panned Year 2035

(Unit : MCM)

Region	1st				2nd				3rd			
	Governorate	C-1	C-2	C-3	Governorate	C-1	C-2	C-3	Governorate	C-1	C-2	C-3
Makkah	Alqunfidhah	204.3	162.3	174.6	Altaif	182.7	145.0	156.1	Khulays	100.3	79.7	85.7
Al Baha	Alquari	22.0	35.9	18.9	Alaqiq	14.4	23.5	12.4	Almandaq	8.3	13.6	7.1
Asir	Bisha	110.7	76.1	83.5	Abha	60.7	41.7	45.8	Balqarn	38.9	26.7	29.4
Jazan	Samtah	448.2	234.1	372.6	Sabya	362.4	189.3	301.3	Ahad al Musarihah	358.5	187.3	298.1
Najran	Najran	188.2	156.7	154.0	Hubuna	30.3	25.2	24.8	Badr al Janub	30.3	25.2	24.8

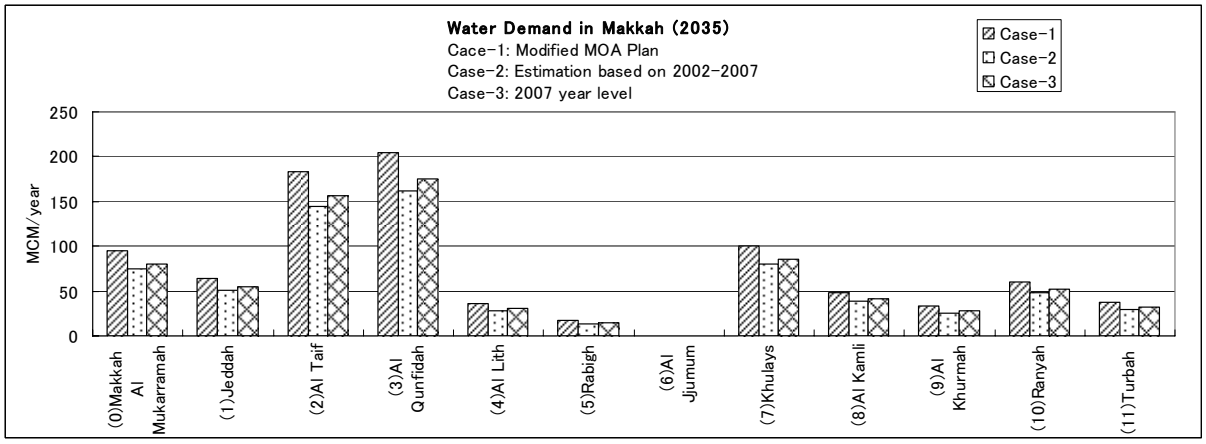


Figure 3-5 Water Demand Classified by Governorate in 2035 in Makkah Region

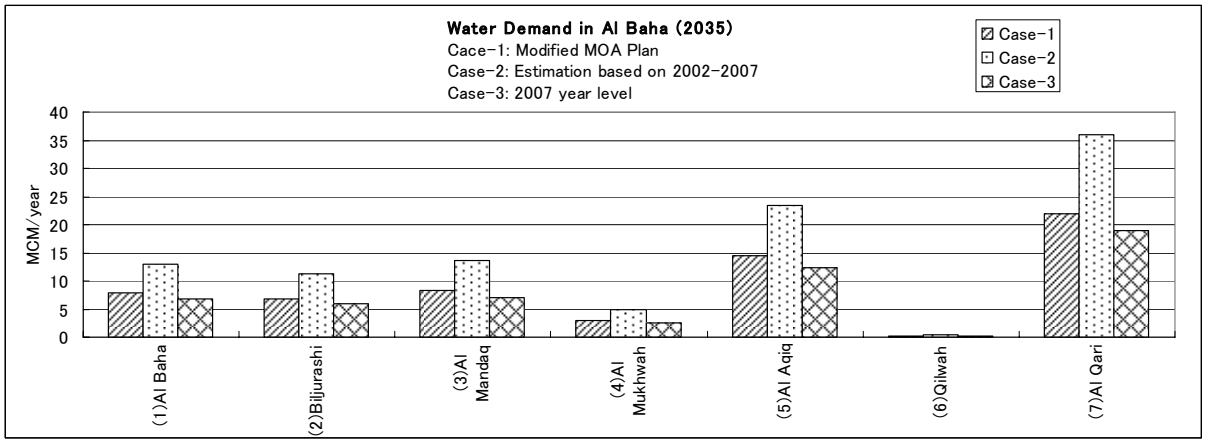


Figure 3-6 Water Demand Classified by Governorate in 2035 in Al Baha Region

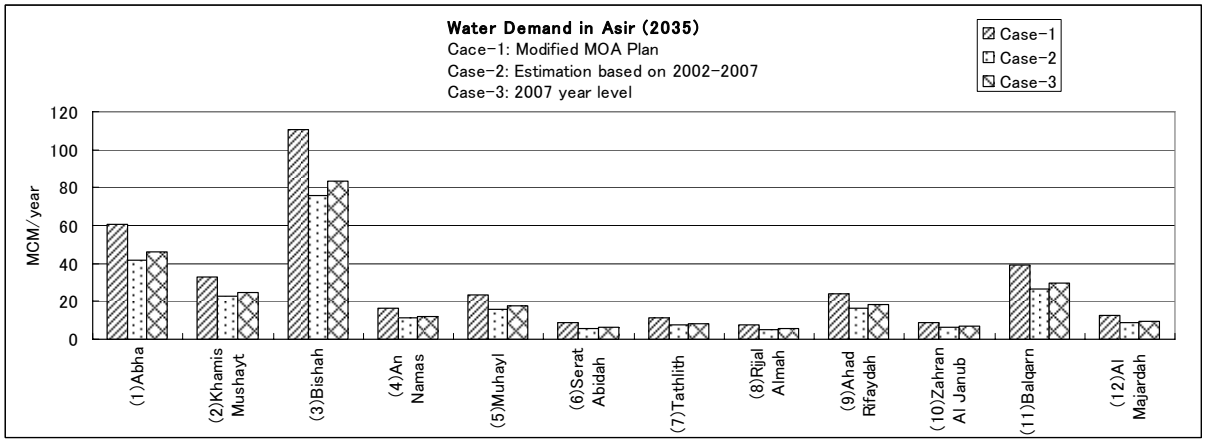


Figure 3-7 Water Demand Classified by Governorate in 2035 in Asir Region

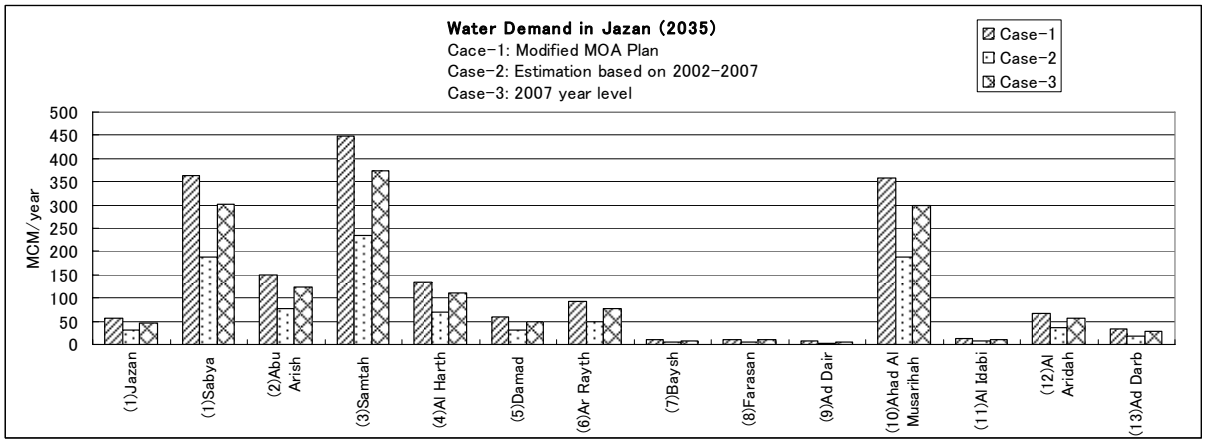


Figure 3-8 Water Demand Classified by Governorate in 2035 in Jazan Region

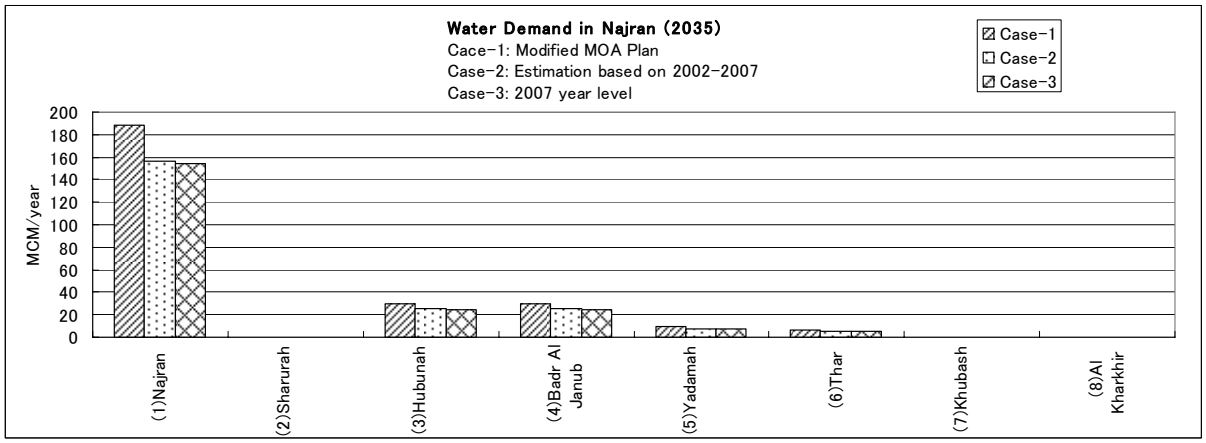


Figure 3-9 Water Demand Classified by Governorate in 2035 in Najran Region

Table 3-5 Governorate Basis Water Demand (Case-1)

Unit: (MCM)

Case-1	2010	2015	2020	2025	2030	2035
Makkah(12)	**756**	**758**	**740**	**786**	**832**	**878**
(0)Makkah Almukarramah	81.4	81.5	79.6	84.6	89.5	94.5
(1)Jeddah	54.9	55.0	53.7	57.1	60.4	63.8
(2)Altaif	157.3	157.6	153.9	163.5	173.1	182.7
(3)Alqunfidhah	175.9	176.3	172.1	182.8	193.6	204.3
(4)Allith	31.2	31.2	30.5	32.4	34.3	36.2
(5)Rabigh	14.8	14.9	14.5	15.4	16.3	17.2
(6)Aljumum	0.0	0.0	0.0	0.0	0.0	0.0
(7)Khulays	86.4	86.6	84.5	89.8	95.1	100.3
(8)Alkamil	41.4	41.5	40.5	43.1	45.6	48.1
(9)Alkhurmah	28.2	28.3	27.6	29.3	31.1	32.8
(10)Ranyah	52.0	52.1	50.9	54.1	57.2	60.4
(11)Turabah	32.6	32.6	31.9	33.8	35.8	37.8
Al Baha(7)	**54**	**55**	**57**	**59**	**61**	**63**
(0)Albaha	6.8	7.0	7.2	7.4	7.7	7.9
(1)Biljurashi	5.9	6.1	6.2	6.5	6.7	6.9
(2)Almandaq	7.1	7.3	7.5	7.8	8.0	8.3
(3)Almukwah	2.5	2.6	2.7	2.8	2.9	2.9
(4)Alaqiq	12.4	12.6	13.0	13.4	13.9	14.4
(5)Qilwah	0.3	0.3	0.3	0.3	0.3	0.3
(6)Alqari	18.9	19.4	19.9	20.6	21.3	22.0
Asir(12)	**275**	**299**	**313**	**328**	**342**	**356**
(0)Abha	46.9	51.1	53.5	55.9	58.3	60.7
(1)Khamis Mushayt	25.4	27.7	29.0	30.3	31.6	32.9
(2)Bisha	85.7	93.2	97.6	102.0	106.3	110.7
(3)Annamas	12.6	13.7	14.4	15.0	15.7	16.3
(4)Muhayil	17.9	19.4	20.3	21.3	22.2	23.1
(5)Sarat Abidah	6.8	7.4	7.8	8.1	8.5	8.8
(6)Tathlith	8.6	9.4	9.8	10.3	10.7	11.2
(7)Rijal Alma	5.7	6.2	6.5	6.8	7.1	7.4
(8)Ahad Rifaydah	18.8	20.5	21.4	22.4	23.4	24.3
(9)Zahran Aljanub	6.9	7.5	7.9	8.2	8.6	8.9
(10)Balqarn	30.1	32.7	34.3	35.8	37.4	38.9
(11)Almajardah	9.7	10.5	11.0	11.5	12.0	12.5
Jazan(14)	**1,503**	**1,500**	**1,533**	**1,593**	**1,683**	**1,806**
(0)Jizan	47.5	47.4	48.4	50.3	53.2	57.1
(1)Sabya	301.6	300.9	307.5	319.6	337.6	362.4
(2)Abu Arish	124.3	124.1	126.8	131.8	139.2	149.4
(3)Samtah	372.9	372.1	380.3	395.2	417.5	448.2
(4)Alharth	111.9	111.6	114.1	118.6	125.3	134.4
(5)Damad	50.3	50.2	51.3	53.3	56.3	60.4
(6)Arrayth	77.3	77.1	78.8	81.9	86.5	92.9
(7)Baysh	7.7	7.7	7.9	8.2	8.7	9.3
(8)Farasan	9.5	9.5	9.7	10.1	10.6	11.4
(9)Addair	5.4	5.4	5.5	5.7	6.0	6.5
(10)Ahad Almusarihah	298.3	297.7	304.2	316.2	334.0	358.5
(11)Alidabi	10.7	10.7	11.0	11.4	12.0	12.9
(12)Alaridah	56.8	56.7	57.9	60.2	63.6	68.2
(13)Addarb	28.8	28.7	29.4	30.5	32.2	34.6
Najran(8)	**217**	**212**	**205**	**225**	**245**	**265**
(0)Najran	154.2	150.7	145.5	159.8	174.0	188.2
(1)Sharurah	0.0	0.0	0.0	0.0	0.0	0.0
(2)Habawnah	24.8	24.3	23.4	25.7	28.0	30.3
(3)Badr Aljanub	24.8	24.3	23.4	25.7	28.0	30.3
(4)Yadamah	7.7	7.6	7.3	8.0	8.7	9.5
(5)Thar	5.2	5.1	4.9	5.4	5.9	6.3
(6)Khubash	0.0	0.0	0.0	0.0	0.0	0.0
(7)Alkharkhir	0.0	0.0	0.0	0.0	0.0	0.0

Table 3-6 Governorate Basis Water Demand (Case-2)

Unit: (MCM)

Case-2	2010	2015	2020	2025	2030	2035
Makkah(12)	**682.7**	**681.7**	**684.5**	**688.5**	**692.8**	**697.3**
(0)Makkah Almukarramah	73.5	73.4	73.7	74.1	74.6	75.0
(1)Jeddah	49.6	49.5	49.7	50.0	50.3	50.6
(2)Altaif	142.0	141.8	142.4	143.2	144.1	145.0
(3)Alqunfidhah	158.8	158.6	159.3	160.2	161.2	162.2
(4)Allith	28.1	28.1	28.2	28.4	28.6	28.7
(5)Rabigh	13.4	13.4	13.4	13.5	13.6	13.7
(6)Aljumum	0.0	0.0	0.0	0.0	0.0	0.0
(7)Khulays	78.0	77.9	78.2	78.7	79.2	79.7
(8)Alkamil	37.4	37.3	37.5	37.7	38.0	38.2
(9)Alkhurmah	25.5	25.5	25.6	25.7	25.9	26.0
(10)Ranyah	47.0	46.9	47.1	47.4	47.7	48.0
(11)Turubah	29.4	29.4	29.5	29.7	29.8	30.0
Al Baha(7)	**62.1**	**73.1**	**82.1**	**89.7**	**96.4**	**102.5**
(0)Albaha	7.8	9.2	10.4	11.3	12.2	13.0
(1)Biljurashi	6.8	8.1	9.0	9.9	10.6	11.3
(2)Almandaq	8.2	9.7	10.9	11.9	12.8	13.6
(3)Almukwah	2.9	3.4	3.9	4.2	4.5	4.8
(4)Alaqiq	14.2	16.8	18.8	20.5	22.1	23.5
(5)Qilwah	0.3	0.3	0.4	0.4	0.5	0.5
(6)Alqari	21.8	25.6	28.8	31.4	33.8	35.9
Asir(12)	**262.1**	**255.6**	**251.5**	**248.5**	**246.3**	**244.5**
(0)Abha	44.7	43.6	42.9	42.4	42.0	41.7
(1)Khamis Mushayt	24.2	23.6	23.3	23.0	22.8	22.6
(2)Bisha	81.6	79.6	78.3	77.4	76.7	76.1
(3)Annamas	12.0	11.7	11.5	11.4	11.3	11.2
(4)Muhayil	17.0	16.6	16.3	16.1	16.0	15.9
(5)Sarat Abidah	6.5	6.3	6.2	6.1	6.1	6.0
(6)Tathlith	8.2	8.0	7.9	7.8	7.7	7.7
(7)Rijal Alma	5.4	5.3	5.2	5.1	5.1	5.1
(8)Ahad Rifaydah	17.9	17.5	17.2	17.0	16.9	16.7
(9)Zahran Aljanub	6.6	6.4	6.3	6.3	6.2	6.1
(10)Balqarn	28.7	28.0	27.5	27.2	26.9	26.7
(11)Almajardah	9.2	9.0	8.8	8.7	8.7	8.6
Jazan(14)	**1,312.4**	**1,170.8**	**1,084.6**	**1,024.5**	**317.2**	**943.4**
(0)Jizan	41.5	37.0	34.3	32.4	10.0	29.8
(1)Sabya	263.3	234.9	217.6	205.6	63.7	189.3
(2)Abu Arish	108.6	96.9	89.7	84.8	26.2	78.1
(3)Samtah	325.6	290.5	269.1	254.2	78.7	234.1
(4)Alharth	97.7	87.1	80.7	76.3	23.6	70.2
(5)Damad	43.9	39.2	36.3	34.3	10.6	31.5
(6)Arrayth	67.5	60.2	55.8	52.7	16.3	48.5
(7)Baysh	6.7	6.0	5.6	5.3	1.6	4.9
(8)Farasan	8.3	7.4	6.9	6.5	2.0	6.0
(9)Addair	4.7	4.2	3.9	3.7	1.1	3.4
(10)Ahad Almusarihah	260.5	232.4	215.3	203.3	63.0	187.3
(11)Alidabi	9.4	8.4	7.8	7.3	2.3	6.7
(12)Alaridah	49.6	44.2	41.0	38.7	12.0	35.6
(13)Addarb	25.2	22.4	20.8	19.6	6.1	18.1
Najran(8)	**225.8**	**223.5**	**222.2**	**221.4**	**220.8**	**220.3**
(0)Najran	160.6	159.0	158.1	157.5	157.0	156.7
(1)Sharurah	0.0	0.0	0.0	0.0	0.0	0.0
(2)Habawnah	25.9	25.6	25.5	25.4	25.3	25.2
(3)Badr Aljanub	25.9	25.6	25.5	25.4	25.3	25.2
(4)Yadamah	8.1	8.0	7.9	7.9	7.9	7.9
(5)Thar	5.4	5.4	5.3	5.3	5.3	5.3
(6)Khubash	0.0	0.0	0.0	0.0	0.0	0.0
(7)Alkharkhir	0.0	0.0	0.0	0.0	0.0	0.0

Table 3-7 Governorate Basis Water Demand (Case-3)

Unit: (MCM)

Case-3	2010	2015	2020	2025	2030	2035
Makkah(12)	750.5	750.5	750.5	750.5	750.5	750.5
(0)Makkah Almukarramah	80.8	80.8	80.8	80.8	80.8	80.8
(1)Jeddah	54.5	54.5	54.5	54.5	54.5	54.5
(2)Altaif	156.1	156.1	156.1	156.1	156.1	156.1
(3)Alqunfidhah	174.6	174.6	174.6	174.6	174.6	174.6
(4)Allith	30.9	30.9	30.9	30.9	30.9	30.9
(5)Rabigh	14.7	14.7	14.7	14.7	14.7	14.7
(6)Aljumum	0.0	0.0	0.0	0.0	0.0	0.0
(7)Khulays	85.7	85.7	85.7	85.7	85.7	85.7
(8)Alkamil	41.1	41.1	41.1	41.1	41.1	41.1
(9)Alkhurmah	28.0	28.0	28.0	28.0	28.0	28.0
(10)Ranyah	51.6	51.6	51.6	51.6	51.6	51.6
(11)Turubah	32.3	32.3	32.3	32.3	32.3	32.3
Al Baha(7)	53.9	53.9	53.9	53.9	53.9	53.9
(0)Albaha	6.8	6.8	6.8	6.8	6.8	6.8
(1)Biljurashi	5.9	5.9	5.9	5.9	5.9	5.9
(2)Almandaq	7.1	7.1	7.1	7.1	7.1	7.1
(3)Almukwah	2.5	2.5	2.5	2.5	2.5	2.5
(4)Alaqiq	12.4	12.4	12.4	12.4	12.4	12.4
(5)Qilwah	0.3	0.3	0.3	0.3	0.3	0.3
(6)Alqari	18.9	18.9	18.9	18.9	18.9	18.9
Asir(12)	268.4	268.4	268.4	268.4	268.4	268.4
(0)Abha	45.8	45.8	45.8	45.8	45.8	45.8
(1)Khamis Mushayt	24.8	24.8	24.8	24.8	24.8	24.8
(2)Bisha	83.5	83.5	83.5	83.5	83.5	76.2
(3)Annamas	12.3	12.3	12.3	12.3	12.3	8.2
(4)Muhayil	17.4	17.4	17.4	17.4	17.4	17.4
(5)Sarat Abidah	6.6	6.6	6.6	6.6	6.6	6.6
(6)Tathlith	8.4	8.4	8.4	8.4	8.4	8.4
(7)Rijal Alma	5.5	5.5	5.5	5.5	5.5	5.5
(8)Ahad Rifaydah	18.4	18.4	18.4	18.4	18.4	16.8
(9)Zahran Aljanub	6.8	6.8	6.8	6.8	6.8	6.8
(10)Balqarn	29.4	29.4	29.4	29.4	29.4	29.4
(11)Almajardah	9.4	9.4	9.4	9.4	9.4	9.4
Jazan(14)	1,501.9	1,501.9	1,501.9	1,501.9	1,501.9	1,501.9
(0)Jizan	47.5	47.5	47.5	47.5	47.5	47.5
(1)Sabya	301.3	301.3	301.3	301.3	301.3	301.3
(2)Abu Arish	124.3	124.3	124.3	124.3	124.3	124.3
(3)Samtah	372.6	372.6	372.6	372.6	372.6	372.6
(4)Alharth	111.8	111.8	111.8	111.8	111.8	111.8
(5)Damad	50.2	50.2	50.2	50.2	50.2	50.2
(6)Arrayth	77.2	77.2	77.2	77.2	77.2	77.2
(7)Baysh	7.7	7.7	7.7	7.7	7.7	7.7
(8)Farasan	9.5	9.5	9.5	9.5	9.5	9.5
(9)Addair	5.4	5.4	5.4	5.4	5.4	5.4
(10)Ahad Almusarihah	298.1	298.1	298.1	298.1	298.1	298.1
(11)Alidabi	10.7	10.7	10.7	10.7	10.7	10.7
(12)Alaridah	56.7	56.7	56.7	56.7	56.7	56.7
(13)Addarb	28.8	28.8	28.8	28.8	28.8	28.8
Najran(8)	216.5	216.5	216.5	216.5	216.5	216.5
(0)Najran	154.0	154.0	154.0	154.0	154.0	154.0
(1)Sharurah	0.0	0.0	0.0	0.0	0.0	0.0
(2)Habawnah	24.8	24.8	24.8	24.8	24.8	24.8
(3)Badr Aljanub	24.8	24.8	24.8	24.8	24.8	24.8
(4)Yadamah	7.7	7.7	7.7	7.7	7.7	7.7
(5)Thar	5.2	5.2	5.2	5.2	5.2	5.2
(6)Khubash	0.0	0.0	0.0	0.0	0.0	0.0
(7)Alkharkhir	0.0	0.0	0.0	0.0	0.0	0.0

4. Sensitivity Analysis on Water Supply and Demand

Since the absolute quantity of renewable water resources is insufficient while a supply-demand gap is large about water for agricultural use, reduction of the planted area serves as pressing need. The government issued Decision 335 in 2008 and is carrying out the policy shift from the 100% self-support policy of agricultural product to the sustainable agriculture development by rational use of water for agriculture.

The basic agricultural policy is as follows.

- Renewable water (groundwater and surface water) and re-use of waste water is main water resources for agricultural use.
- By considering the various usages about re-use of reclaimed waste water, improvement in use is aimed at and decreases the dependence to renewable water resources.
- Decision 335 aim at the agricultural policy converted into sustainable agricultural development from the 100% self-support policy of agricultural products by the KSA government. It is premised on observing this in future agricultural development.
- Continue the agriculture within the limits of the potential of renewable water resources in consideration of the present condition.
- Agricultural rational uses are aimed at and consider it as the measure to which don't make agricultural output increase.

The following action plan can be considered as a policy for carrying out these basic policies.

- Introduction of saved-water type modern irrigation technology
- Positive use in the agricultural field of reclaimed waste water.
- Reduction of the planted area in consideration of renewable water-resources potential.
- Promote cultivation of the vegetables and fruit trees in the city suburbs from a viewpoint of reservation of a food self-sufficiency ratio.

Therefore, the planted area which can be irrigated is calculated based on the sensitivity analysis which took the above-mentioned action plan into consideration in examination of the demand-and-supply balance. In addition, the items taken into consideration by a sensitivity analysis are as follows.

- Calculation of the renewable water-resources potential according to governorate
- Priority is given to water supply.
- Water saving by modern irrigation institution introduction.
- Re-use of reclaimed waste water.

4.1 Basic Frame Work for Sensitivity Analysis

So far, although 3 cases of water demand was examined such as a modified MOA plan (Case-1), 2002 to 2007 trend (Case-2), and 2007-year level (Case-3), the Case 1 which added correction to prediction of MOA can be taken for reality having deviated clearly as compared with agricultural-statistics data. On the other hand, since it can observe converging the increase and decrease of a tendency of the planted area on the value in 2007 from agricultural-statistics data, it is simple to perform examination of a demand restraint measure on a "Case-3:2007-year level", and it is intelligible (Case-3 is with the statistical data itself). Since it is judged for not processing regressive prediction etc., examination after this (water balance) is performed about a Case-3 (2007 level).

(1) Procedure of Water Demand and Supply Balance

The following procedures perform examination of the demand-and-supply balance of water for agricultural use. Water supply is renewable water resources, and is divided into surface water and groundwater. There are also the amount of water saving, the reclaimed waste water reuse, and the return flow from irrigation water which are shown below as what is otherwise added to water resources. Since the above is all the things considered as water resources, even if it uses these, when a water shortage occurs, it is necessary to take into consideration control of water for irrigation itself. Moreover, since it is water supply priority, a part for a water supply is first deducted from the

renewable amount of water resources, and the remaining amounts of water resources examine the area which can be irrigated.

(2) Renewable Water Resources (Surface Water and Groundwater)

The water resources potential according to each governorate is calculated based on the catchment area of 31 Wadi (21 Wadi: Red Sea side, 10 Wadi: Inland side)

(3) Crop Diversification

The planted area shall not be increased, although rational use of water for agricultural use is aimed at on the basis of Decision335 about an agricultural development plan and crop diversification is performed. In addition, crop diversification should specialize in vegetables and fruit growing centering on the city suburbs from a viewpoint of reservation of food self-sufficiency, and small-scale farmhouse protection, and vegetables shall double the planted area in 2007, and fruit trees shall maintain the planted area in 2007. Therefore, a part for the planted area of vegetables to have increased is taken as a plan to decrease the planted area of cereals and a feed crop. Therefore, the part which increased the planted area of vegetables shall be decreased from the planted area of cereals and fodder crops.

(4) Water Saving by Modern Irrigation

The irrigation method of a fruit tree and vegetables has main traditional method such as furrow irrigation, and its irrigation efficiency is low in a southwest area. However, water can be saved by introducing modernistic irrigation systems, such as a sprinkler and a drip, in the future. Although the maintenance rate (the traditional irrigation method and the modernistic irrigation method) of present condition is assumed to be 50% by the result of hearing from the agriculture office and irrigation efficiency is made into 70% (= (55% +85%) *50%), future plan considers promoting the modern irrigation method and raising irrigation efficiency to 85%.

(5) Reuse of Reclaimed Waste Water

In the KSA, National Irrigation Authority (NIA) built the large-scale irrigation institution which reused reclaimed waste water in the suburb of Riyadh, and reuse of the reclaimed waste water is performed from 1982. However, although the reuse of reclaimed waste water is limited to the cereals crop, a fruit tree and a fodder crop part by the standard of a country and application to vegetables is not performed, it is necessary to aim at use expansion to the water for irrigation of reuse of reclaimed waste water positively for effective use of water resources. Since ITAL CONSULT has established upon the development plan[1] in the whole KSA about the reuse plan of reclaimed waste water in 2009, this report is referred to the study.

(6) Return Flow of Irrigation Water

Although parts for a net water requirement is absorbed by the plant among water for irrigation (gross water requirement), since it is thought that a part for an irrigation loss returns into the ground, and recharge the groundwater, this is counted to a head indirect as return flow. The net water requirement in the southwest area in 2007 is 1,675MCM, and the gross water requirement is 2,791MCM. Therefore, 40% (= (2,791-1675) /2791)) of gross water requirement can be reused to irrigation as return flow.

4.2 Water Balance in 5 Regions

Water balance result when the above-mentioned water balance computational procedure uses the renewable water resources in five states is shown in Table 4-1. In a planned target year, whole balances are plus in four regions except Jazan. However, since water-resources potential, sewage water reuse, and agricultural area are unevenly distributed in the region, it is necessary to check them according to governorates and Wadi basin classified.

[1] Investigation and Engineering Design for Treated Wastewater Reuse in the Kingdom of Saudi Arabia

Table 4-1 Water Balance in 5 Regions

(Unit: MCM)

Region	Renewable Water Resource	Water Supply	Available Water	Agriculture Demand	Balance ①	Crop Conversion	Water Saving	Reuse of Treated Water	Return Flow	Balance ②
Makkah	782.0	108.2	673.8	750.5	-148.7	168.8	96.5	247.4	300.2	664.2
Al Baha	99.4	16.4	83.0	53.9	29.1	1.7	8.4	4.2	21.6	65.0
Asir	380.5	20.4	360.1	268.4	91.7	17.4	29.8	62.1	107.4	308.4
Jazan	322.9	106.9	216.0	1,501.9	-1,285.9	21.5	28.5	20.3	600.8	-614.8
Najran	401.1	72.7	328.4	216.5	111.9	32.5	27.2	28.4	86.6	286.6
Total	1,985.9	396.6	1,661.3	2,791.2	-1,201.9	241.9	190.4	362.4	1,116.5	781.3

Balance① : Renewable Water – (Water Supply ; Agriculture Demand)

Balance② : ①+(Crop Conversion +Water Saving + Reuse of Treated Water + Return Flow)

4.3 Water Demand Control Measures in 5 Regions

Although the planted area of the Southwest Region in 2007 is 192,569ha, it is necessary to decrease it from the standpoint of preservation of renewal water resources potential to 101,150 ha of the half in 2007. When water resources potential after deducting water supply is made into a maximum, it calculates the possible planted area in each region and governorate as follows.

(1) Makkah Region

When the maximum amount of renewable water is set to 782.0 MCM, possible planted area in target year, 2035 becomes 39,293 ha, which is 93% of the 2007 level (42,077 ha). Figure 4-1 shows the calculated result.

Almost the same planted area is supposed to be possible to use. Because drawdown of groundwater level and deterioration of groundwater quality is observed already, monitoring of planted area and groundwater to analyze relationships is recommended to control the proper planted area.

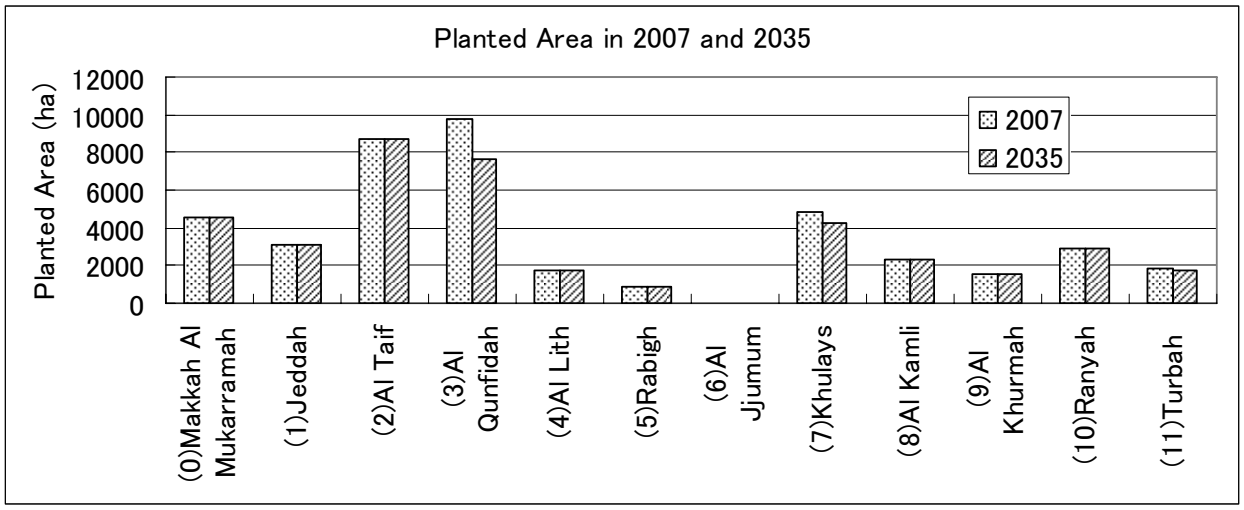


Figure 4-1 Planted Area in 2007 and 2035 in Makkah Region

(2) Al Baha Region

When the maximum amount of renewable water is set to 99.4 MCM, possible planted area in target year, 2035 becomes 4,425 ha, which is 99% of the 2007 level (4,450 ha). Figure 4-2 shows the calculated result.

Almost the same planted area is supposed to be possible to use. Because drawdown of groundwater level and deterioration of groundwater quality is observed already, monitoring of planted area and groundwater to analyze relationships is recommended to control the proper planted area.

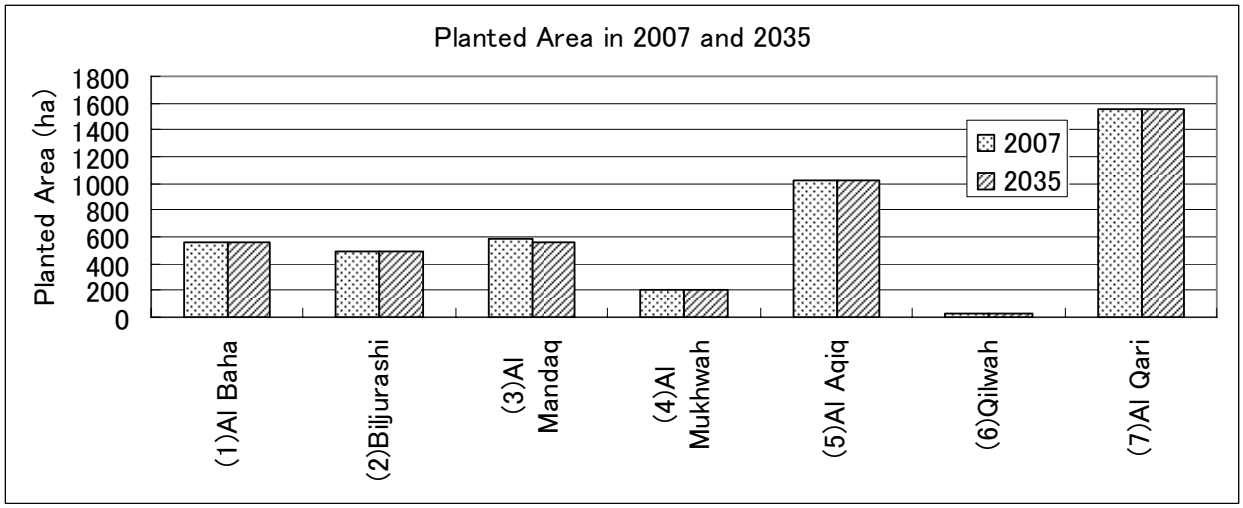


Figure 4-2 Planted Area in 2007 and 2035 in Al Baha Region

(3) Asir Region

When the maximum amount of renewable water is set to 329.4 MCM, it is necessary to reduce by 20,759 ha, which is 99% of the 2007 level (21,054 ha). Figure 4-3 shows the calculated result.

Almost the same planted area is supposed to be possible to use. Because drawdown of groundwater level and deterioration of groundwater quality is observed already, monitoring of planted area and groundwater to analyze relationships is recommended to control the proper planted area.

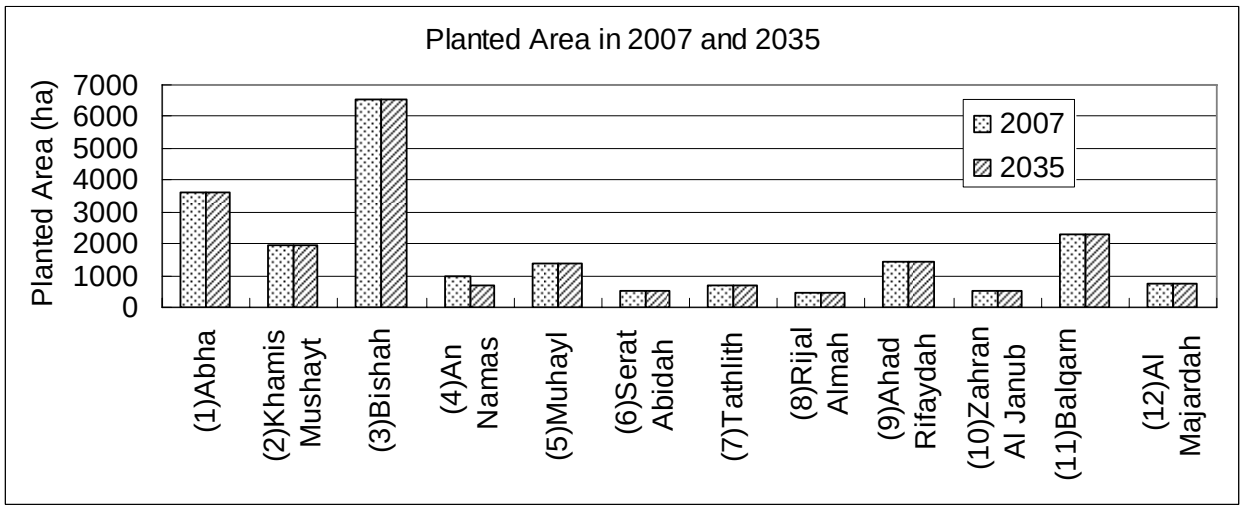


Figure 4-3 Planted Area in 2007 and 2035 in Asir Region

(4) Jazan Region

When the maximum amount of renewable water is set to 322.9 MCM, possible planted area in target year, 2035 becomes 28,540 ha, which is 25% of the 2007 level (113,558 ha). Figure 4-4 shows the calculated result.

It seems very severe to keep present level of planted area from the point of view of availability of renewable water resources. However, it is important to carry out monitoring of groundwater and planted area, analyzing and grasping relations and managing proper planted area before decreasing planted areas in the Region. As many conditions are assumed to analyze renewable water resources potential and to estimate amount of irrigation water which is calculated based on planning standard, it is important to monitor the situation and verify the assumptions.

Following governorates have large gaps between present planted area and projected future possible

planted area. It is recommended to monitor and evaluate the result carefully in these governorates to grasp relations between planted area and groundwater.

Table 4-2 Planted Area in 2007 and 2035

Governorate	Present Planted Area in 2007 (ha)	Estimation of Planted Area in 2035 (ha)
Sabya	22.785	6,348
Abu Arith	9,395	2,292
Samtah	28,175	1,393.
Alrth	8,452	171
Damad	3,797	1,457
Arrayth	5,839	3,784
Ad Almusarih	22,540	2,561
Alaridah	4,290	2,465
Addarb	2,176	1,960

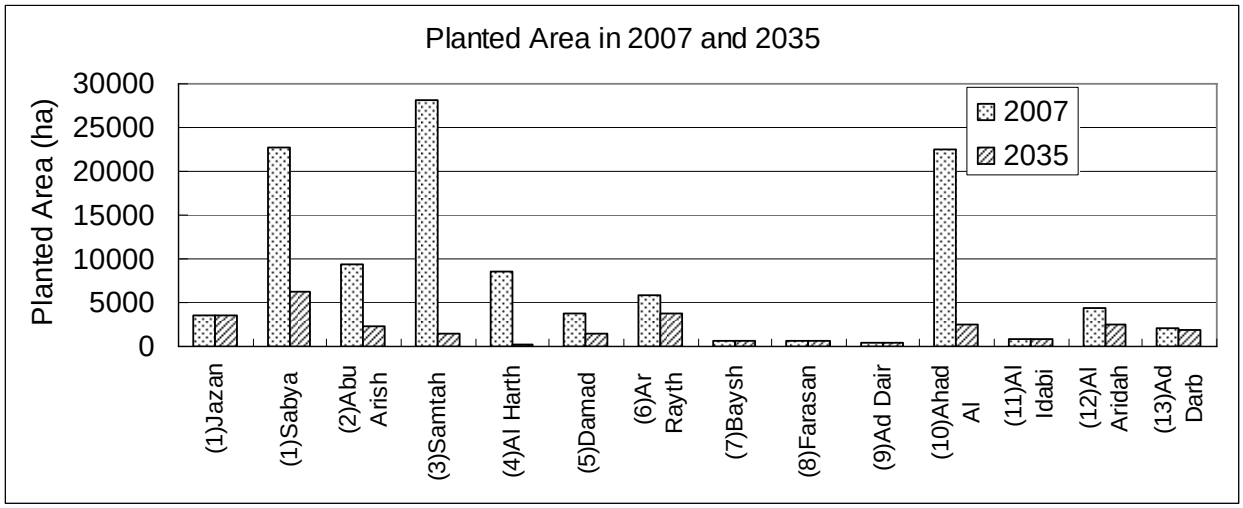


Figure 4-4 Planted Area in 2007 and 2035 in Jazan Region

(5) Najran Region

When the maximum amount of renewable water is set to 401.1 MCM, possible planted area in target year, 2035 becomes 8,134 ha, which is 71% of the 2007 level (11,430 ha). Figure 4-5 shows the calculated result.

It seems very severe to keep present level of planted area from the point of view of availability of renewable water resources. However, it is important to carry out monitoring of groundwater and planted area, analyzing and grasping relations and managing proper planted area before decreasing planted areas in the Region. As many conditions are assumed to analyze renewable water resources potential and to estimate amount of irrigation water which is calculated based on planning standard, it is important to monitor the situation and verify the assumptions.

Some governorates have large gaps between present planted area and projected future possible planted area. It is recommended to monitor and evaluate the result carefully in these governorates to grasp relations between planted area and groundwater.

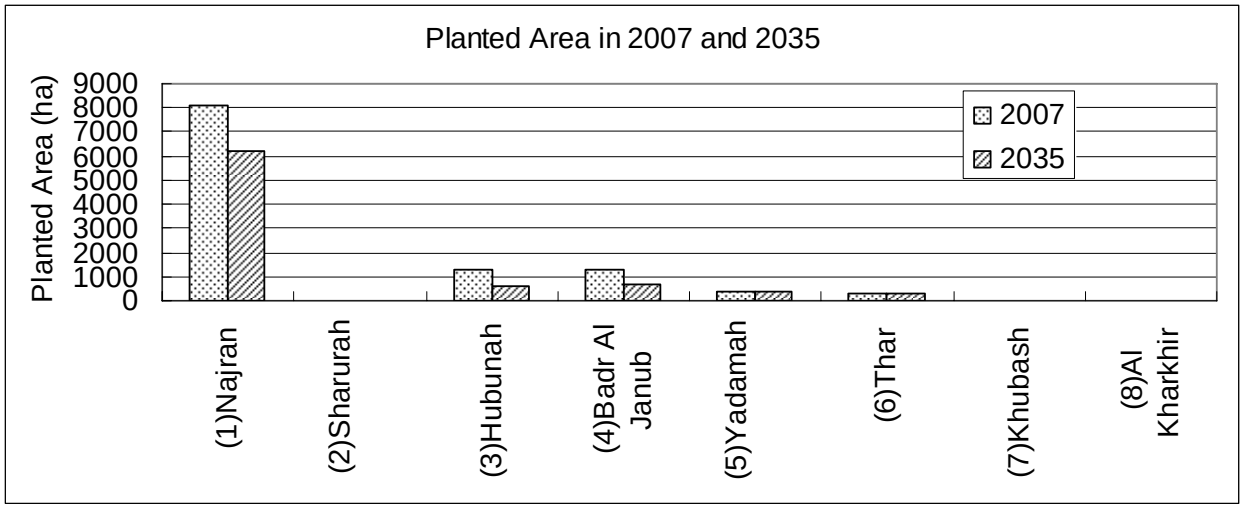


Figure 4-5 Planted Area in 2007 and 2035 in Najran Region

As mentioned above, the reduction of the planted area in five regions corresponding to renewable water resources is summarized in Table 4-3. As compared with the planted area in 2007, the reduction area especially in the State of Jazan is large, and it is necessary to formulate a radical reduction plan about Jazan region. (Refer to Chapter 5)

Table 4-3 Planted Area in 2007 and Calculated Planted Area in 2035 in five Regions

Name of Region	Planted Area in 2007 (ha)	Planted Area in 2035 (ha)	Reduced Area for 2007 percentage (%)
Makkah	42,077	39,293	93
Al Baha	4,450	4,425	99
Asir	21,054	20,759	99
Jazan	113,558	28,559	25
Najran	11,430	8,134	71

5. Proposal to Agricultural Sector

5.1 Future Planting Plan for Water Demand Control

The water development of surface water for agriculture use is not expectable except new water development at the Baysh dam and Damad dam under construction in Jazan region. The water resource development in the future can be considered about reuse of treated sewage water, and the groundwater development by the well group with a central focus on the underground dam.

Although the reuse rate of treated sewage water with 2% of agricultural demand in Jazan region as of 2020 is too small, but in the Al Baha region and Asir region, 20% or more is used and these are promising water resources. On the other hand, the development of the groundwater by an underground dam is planned in Jazan region, it does not serve as promising water resources judging from the present condition of a lowering groundwater level, and a viewpoint of the water-resources potential. Therefore, in future the water development for agriculture use is considered that reuse of a treated sewage water will become main measures.

Since water development can not be expected, the demand management plays important roles in the future. The issues on the water management are summarized as follows.

- Popularization of modern irrigation system is behind.
- Since measurement of irrigation water is inaccurate, superfluous irrigation has occurred.
- The technical assistance on water management to the farmers is insufficient.
- Farmer's water-saving awareness is too low.

Specially, support of the water management technology to the farmers is required by popularizing

water-saving irrigation method and the water-saving awareness to the farmers needs to be popularized. Furthermore, from a viewpoint of demand management, crop conversion to vegetables with small water requirement and fruit tree which can expect increased demand from a fodder crop and other crops with large water requirement is considered to be the most realistic measure according to Decision 335 by MOA.

As mentioned above, regarding the water resources for agriculture, reuse of a treated sewage water and groundwater development by a renewable well group shall be performed, and crop conversion consisting mainly of vegetables and fruit trees from cereals and fodder crop is proposed judging from a viewpoint of demand management.

The water balance simulation at the time of enforcing the water-saving irrigation as demand management and reuse of the treated sewage water as new water resources, and conversion of the planted area as agricultural policy, etc. are examined, and the result of the possible planted area according to the region in 2035 is shown below.

Table 5-1 Water Balance Simulation and Planted Area in Al Baha Region

Governorate			Albaha	Biljurashi	Almandaq	Almukwah	Alaqiq	Qilwah	Alqari	Total
(1)	Planted Area (ha)	2007	562.5	489.8	588.7	209.0	1019.2	21.1	1559.7	4450.0
		2035	562.5	489.8	563.7	209.0	1019.2	21.1	1559.7	4425.0
(2)	Agricultural Water Demand (MCM)	2007	6.8	5.9	7.1	2.5	12.3	0.3	18.9	53.9
		2035	6.8	5.9	6.8	2.5	12.3	0.3	18.9	53.6
(3)	Water Supply Demand (MCM)	MCM	1.4	0.7	0.4	5.7	3.0	4.9	0.3	16.4
(4)	Water-resources Potential	MCM	2.6	10.0	3.5	14.4	35.4	21.9	11.6	99.4
(5)	Water-resources after water supply	MCM	1.2	9.3	3.1	8.7	32.4	17.0	11.3	83.0
(6)	Water Balance in 2035 (5)-(2)	MCM	-5.6	3.4	-3.7	6.2	20.0	16.7	-7.6	29.4
(7)	Water Saving	MCM	1.1	0.9	1.1	0.4	1.9	0.0	2.9	8.4
(8)	Waste Water Re-use	MCM	2.2	0.8	0.0	0.4	0.3	0.2	0.2	4.2
(9)	Return Flow	MCM	2.7	2.4	2.7	1.0	4.9	0.1	7.6	21.4
(10)	Water Balance (6)+(7)+(8)+(9)	MCM	0.4	7.5	0.1	8.0	27.2	17.1	3.1	63.4
(11)	(-)Reduction/ (+)Increse of cultivation in 2035 compared with 2007	ha	0.0	0.0	-25.0	0.0	0.0	0.0	0.0	-25.0
		MCM	0.0	0.0	-0.3	0.0	0.0	0.0	0.0	-0.3
Name of Basin (water resources)			Ranyah	Ranyah	Turubah	Dawqah S	Ranyah	Ranyah	Dawqah N +Dawqah	

Note;
(7): Development of Modern irrigation system
(8): Waste water re-use (Data source: By ITAL CONSULT)
(9): Return flow (Irrigation losses) =Demand*(1-1/1.67)=Demand*0.4

Table 5-2 Water Balance Simulation and Planted Area in Asir Region

Governorate			Abha	Khamis Mushayt	Bisha	Annamas	Muhayil	Sarat Abidah	Tathlith	Rijal Alma	Ahad Rifaydah	Zahran Aljanub	Balqarn	Almajardah	Total
(1)	Irrigation Area (ha)	2007	3591.2	1946.7	6554.2	964.7	1366.1	520.9	661.0	435.2	1440.6	529.6	2303.0	740.8	21054.0
		2035	3591.2	1946.7	6554.2	709.8	1366.1	520.9	661.0	435.2	1400.4	529.6	2303.0	740.8	20758.9
(2)	Agricultural Water Demand (MCM)	2007	45.8	24.8	83.6	12.3	17.4	6.6	8.4	5.5	18.4	6.8	29.4	9.4	268.4
		2035	45.8	24.8	83.6	8.4	17.4	6.6	8.4	5.5	16.7	6.8	29.4	9.4	262.8
(3)	Water Supply Demand (MCM)	MCM	3.9	3.3	4.9	0.3	2.8	0.7	1.0	0.4	1.7	0.4	0.2	0.8	20.4
(4)	Water-resources Potential	MCM	65.5	10.2	47.0	2.5	39.9	92.7	56.3	16.1	5.6	5.4	18.1	21.2	380.5
(5)	Water-resources after water supply	MCM	61.6	6.9	42.1	2.2	37.1	92.0	55.3	15.7	3.9	5.0	17.9	20.4	360.1
(6)	Water Balance in 2035 (5)-(2)	MCM	15.8	-17.9	-41.4	-6.3	19.7	85.4	46.9	10.2	-12.7	-1.8	-11.5	11.0	97.3
(7)	Water Saving	MCM	5.1	2.8	9.3	1.4	1.9	0.7	0.9	0.6	2.0	0.7	3.3	1.0	29.8
(8)	Waste Water Re-use	MCM	13.8	25.5	6.2	1.5	5.1	0.8	1.4	0.0	4.0	1.3	1.6	0.9	62.1
(9)	Return Flow	MCM	18.3	9.9	33.4	3.4	7.0	2.7	3.4	2.2	6.7	2.7	11.7	3.8	105.1
(10)	Water Balance (6)+(7)+(8)+(9)	MCM	53.0	20.2	7.5	0.0	33.7	89.6	52.6	13.0	0.0	3.0	5.1	16.7	294.3
(11)	(-)Reduction/ (+)Increse of cultivation in 2035 compared with 2007	ha	0.0	0.0	0.0	-254.9	0.0	0.0	0.0	0.0	-40.2	0.0	0.0	0.0	-295.1
		MCM	0.0	0.0	0.0	-3.9	0.0	0.0	0.0	0.0	-1.7	0.0	0.0	0.0	-5.6
Name of Basin (water resources)			Baysh+Itwad +Hail+Bisha	Tatlith+Bisha	Bisha	Bisha	Hali	Baysh	Tatlith	Hali	Tatlith	Tatlith	Hali	Hali+Yiba	

Table 5-3 Water Balance Simulation and Planed Area in Jazan Region

Governorate			Jizan	Sabya	Abu Arish	Samtah	Alharth	Damad	Arrayth	Baysh	Farasan	Addair	Ahad Almusarihah	Alidabi	Alaridah	Addarb	Total
(1)	Irrigation Area (ha)	2007	3589.4	22784.7	9395.1	28174.6	8452.4	3797.4	5839.3	583.9	717.9	405.7	22539.7	811.5	4289.9	2176.3	113558.0
		2035	902.1	5726.2	2361.2	7080.8	2124.2	954.4	1467.5	146.8	180.4	102.0	5664.7	203.9	1078.1	547.0	28539.3
(2)	Agricultural Water Demand (MCM)	2007	47.5	301.3	124.3	372.6	111.8	50.2	77.2	7.7	9.5	5.4	298.1	10.7	56.7	28.8	1501.9
		2035	47.5	77.7	27.8	11.9	0.3	18.2	48.0	7.7	9.5	5.4	28.4	10.7	31.2	25.1	349.3
(3)	Water Supply Demand (MCM)	MCM	28.0	15.6	11.4	9.1	4.8	3.2	1.3	5.9	0.0	4.9	9.0	5.3	6.2	2.3	106.9
(4)	Water-resources Potential	MCM	61.2	50.9	21.9	6.4	2.9	10.9	28.6	25.5		26.9	19.1	28.4	23.8	16.4	322.9
(5)	Water-resources after water supply	MCM	33.2	35.3	10.5	-2.7	-1.9	7.7	27.3	19.6		22.0	10.1	23.1	17.6	14.1	216.0
(6)	Water Balance in 2035 (5)-(2)	MCM	-14.2	-42.3	-17.3	-14.6	-2.3	-10.5	-20.7	11.9		16.6	-18.2	12.3	-13.6	-11.0	-123.8
(7)	Water Saving	MCM	0.9	5.7	2.4	7.1	2.1	1.0	1.5	0.1		0.1	5.7	0.2	1.1	0.5	24.0
(8)	Waste Water Re-use	MCM	3.5	5.5	3.8	2.7	0.0	2.3	0.0	0.6		0.4	1.2	0.0	0.0	0.4	20.3
(9)	Return Flow	MCM	19.0	31.1	11.1	4.8	0.1	7.3	19.2	3.1		2.1	11.3	4.3	12.5	10.0	135.9
(10)	Water Balance (6)+(7)+(8)+(9)	MCM	9.1	0.0	0.0	0.0	0.0	0.0	0.0	15.7		19.2	0.0	16.8	0.0	0.0	60.7
(11)	(-)Reduction/ (+)Increase of cultivation in 2035 compared with 2007	ha	-2687.3	-17058.5	-7033.9	-21093.8	-6328.1	-2843.1	-4371.8	-437.2		-303.8	-16875.1	-607.5	-3211.8	-1629.4	-84481.2
		MCM	0.0	-223.7	-96.5	-360.7	-111.4	-32.1	-29.2	0.0		0.0	-269.7	0.0	-25.6	-3.7	-1152.6
Name of Basin (water resources)			Jizan+Damad	Jizan+Damad +Baysh	Jiza+Damad	Khulab	Khulab	Jiza+Damad	Baysh	Baysh	Island	Jazan+Damad	Jazan+Damad	Jazan+Damad +Baysh	Jizan+Damad	Itwad	

Based on the calculation table in the above, the results are summarized as follows.

1) Al Baha Region

- Comparison of the agricultural water demand and the renewable water resources in 2007 will generate a water shortage in Al Baha, Al Mandaq, and Al Qari governorate.
- The planted area of the 2007 level is securable in gross by the reuse of treated sewage water and the water-saving irrigation in the planned target 2035 year.
- Regarding Mandaq governorate, 25ha of planted area needs to be reduced in 2035. (25ha reduction of the planted area of cereals/fodder crops will be carried out from the 2007 level)

2) Asir Region

- Comparison of the agricultural water demanded and the renewable water resources in 2007 will generate a water shortage in Khamis Mushayt, Bisha, An Namas, Ahad Rifaydah, Zahran Aljanub, and Balqarn governorate.
- By the reuse of treated sewage water and the water-saving irrigation in the planned target 2035 year, the planted area of the 2007 level is securable in gross except for two governorates.
- Regarding An Namas and Ahad Rifaydah governorate, the planted area of 255 ha and 40 ha still

need to be reduced respectively.

3) Jazan Region

- A water shortage occurs in almost all the governorate, and the water balance simulation serves as 1,200 MCM minus.
- Although the amount of water resources newly securable by the reuse of sewage water and the water-saving irrigation by the planned target 2035 year serves as about 44 MCM, when this is converted into vegetable cultivation, it is only about 6,200 ha.

Based on the result of water balance simulation with the 3 regions mentioned above, in the Al Baha region and Asir region, it is possible to maintain agriculture by the crop conversion. However, in Jazan region the water demand for agricultural use is large, and the shortage of water resources is inevitable. As a measure against future, a method only has reducing the planted area until it balances renewable water-resources potential. Accordingly, following agricultural measures are proposed in order to reduce the planted area.

From a viewpoint of fresh-vegetables self-supply, vegetable cultivation will be promoted and the planted area in the planned target 2035 year will set to 7,164 ha of the twice in 2007 (3,582ha).

Regarding fruit trees, Jazan region has Tropical Fruit Research Center (Jazan Agriculture Research Center) of MOA, moreover, since the fruit trees which mainly continue to be concerned with the mango has consumption in the region, reduction shall not be performed but 5,525ha of the 2007 level shall be maintained.

According to Decision No.335, planting of a fodder crop with much water consumption does not carry out.

The amount of water resources produced by reducing the planted area of cereals and fodder crops are preferentially converted to vegetables and fruit farming, and the remainder is taken as a plan to assign the sorghum cultivation which is typical crops of Jazan region.

The planted area and the water demand at the time of implementing the above-mentioned measures become as follows, the fruit tree can maintain the 2007 level, and the vegetable can secure the planted area of the twice in 2007.

Table 5-4 Reduction Plan of Planted Area in Jazan Region

Crops	Current Status(2007)		Target Year（2035）		Compared to 2007
	Planted Area (ha)	Water Demand (MCM)	Planted Area (ha)	Water Demand (MCM)	
Cereal	92,200	1,030	15,900	190	93% Reduction
Fodder	12,200	340	0	0	Stop
Fruit	5,500	110	5,500	110	2007 Maintain
Vegetable	3,600	30	7,100	50	2007 Doubling
Total	113,600	1,510	28,500	350	75% Reduction

5.2 Preconditions in Examination

In the estimate for agricultural water use and demand prediction, as information is insufficient and examination of long-term water demand and supply balance are not completed, data and the plan for water supplies which are collected in the statistical yearbook prepared by MOA and the MOA regional office, MOWE, and the MOWE regional office are adopted as assumption conditions. The main things are as follows;

The amount of the present water use for agriculture (Calculation of Gross Water Requirement: B. Chapter 1)

Based on the data such as the planted area, a crop coefficient and etc., the net water requirement is computed and then the gross water requirement is computed in consideration of the conveyance loss and the irrigation application loss.

The prediction conditions for future agricultural water demand (B. Chapter 3)

Planted area is constant from 2007 to 2035.

Since the planted area is constant, the planted area according to region and the period of the above are constant.

Although irrigation efficiency is set up for every crop, the above-mentioned period is constant.

The setting conditions of estimate for the agricultural water use in the water demand-and-supply balance simulation of a sensitivity analysis etc. (B. Chapter 5)

The target water resource is renewable water, and the result of the water resources potential calculation by SWAT model is used as basic data.

Surface water in the water demand-and-supply balance simulation gives priority to the water supply to a city, and supplies 30% of total water, and then assigns the remaining of 70% to water use in the down stream and agricultural water use.

Irrigation efficiency is set 85% in target year from 70% of present condition, supposing a sprinkler, drip irrigation and etc. popularizing further in the future, and irrigation efficiency increasing about vegetables and fruit trees.

The reuse of the sewage water for every region sets up based on the data prepared by Ital Consult.

Regarding the planting crops, the demand of fruit and vegetable will be increased in the future, and these planting are performed in the farming land outside a city focusing on vegetables with less water requirement and fruit trees, and assign renewal water with the priority to these crops.

Since it is water balance simulation in case the absolute quantity of water resources is insufficient, all the amounts of losses assume that repetitive use is carried out in order to understand a sever water shortage condition.

Although the demand for agricultural water use is calculated based on many assumptions explained in the above, many problems in each region such as water level decline and dry up of the well for agriculture use are occurring. Since the phenomena such as salty water intrusion are also seen in the observation wells along the coastal line of Jazan region, accordingly it is obvious that the potential of the water resources for agricultural use is limited.

5.3 Proposal to Future Agriculture Development

The proposal to the agricultural development in each region is summarized as follows based on the plan of the above-mentioned planting conversion, a reduction plan and etc.

(1) Al Baha Region

Although in the Al Baha region, small-scale wheat cultivation has been maintained by the traditional agricultural technique using the climate blessed till the first half of the 1980s, by having developed the large machinery agriculture using fossil water in Riyadh and Quassim (Buraidah) regions with many flatlands by the free distribution policy of farmland which aims at 100% of a grain self-sufficiency rate, the subsidy policy on well drilling and etc., cereals cultivation in the hilly and mountainous area where is small farmland and where a production cost is high was obliged to decline. As the result, 70% of farmland is converted into the fruit tree now. In the case of the Al Baha region, since the renewable water resources which covers the planted area of the 2007 level are secured, it is possible to develop the agriculture consisting mainly of fresh vegetables and fruit cultivation also in the future taking advantage of high elevation.

(2) Asir Region

Asir region is divided roughly into the hilly and mountainous agricultural area centering on Abha Governorate, and the flat-ground agriculture area centering on Bisha Governorate. Since it is expected that the outskirts of Abha are blessed with water resources, fruit growing consisting mainly of the vegetables centering on a open field cultivated tomato and a grape cultivation are prosperous, and consumption of vegetables and fruit trees increases in connection with population increase, the

agriculture consisting mainly of vegetables and fruit trees can be continued in the future.

The water resources around Bisha which locates in the North of the region are not enough. It is necessary to perform the planting conversion in future, and the water-saving irrigation needs to perform reuse of treated sewage water etc.

Moreover, the diligent farmer who is practicing the organic farming is located in Abha Governorate and the organic farming is getting popularity from the safety of a food in Saudi Arabia. Accordingly by popularizing the organic farming through this farmer, differentiation with other regions is attained, and the policy which promotes the agriculture of Asir region can be considered.

(3) Jazan Region

Although the planted area aiming at 2035 can secure planting of the scale in 2007 about fruit trees and vegetables, it stops planting of fodder crop, and 93% reduction of planted area about cereals is required.

The agriculture in the region will cooperate with "Jazan Agriculture Research Center" which FAO is carrying out technical assistance in the region. If the fruit tree which suited the climate of the region, and the agriculture in suburban areas which specialized in vegetables are promoted and water resources have a margin, it is possible to survive in the intensive agriculture of performing cash crop cultivation such as maize, millet, sesame and etc.

According to a hearing at the MOA regional office, it is pointed out that a farmer's aging and luck of successor are becoming big issues in the region. It is also a problem that the Agriculture of Saudi Arabia is performed by Saudi peoples as a manager and foreigner as a farmer, therefore MOA does not like to advice to foreigners positively.

If the present condition mentioned above and insufficient water resources are taken into consideration, it will be judged that the agriculture in Jazan region is obliged to a decline. Therefore, other industries which accept agricultural population need to be introduced.

Fortunately, the Jazan Economic City project is progressing near Sabya which locates in 60km northwest of Jazan, and the number of the labor force of this project will be needed about 300,000. On the other hand, the number of the agricultural labor force in Jazan is about 30,000; accordingly acceptance by this project is possible enough.

Therefore, if the issues mentioned above are not solved, industrial structure should be transformed and the surplus farmer should be assigned to the labor force of the Jazan Economic City. In addition, when carrying out industrial structure conversion, necessity has the political to the small-scale farmer which has made its living by traditional agriculture.

The Kingdom of Saudi Arabia

The Ministry of Water and Electricity (MOWE)

THE STUDY ON MASTER PLAN

ON

RENEWABLE WATER RESOURCES DEVELOPMENT IN THE SOUTHWEST REGION

IN

THE KINGDOM OF SAUDI ARABIA

FINAL REPORT

(SUPPORTING REPORT)

E. WATER SUPPLY

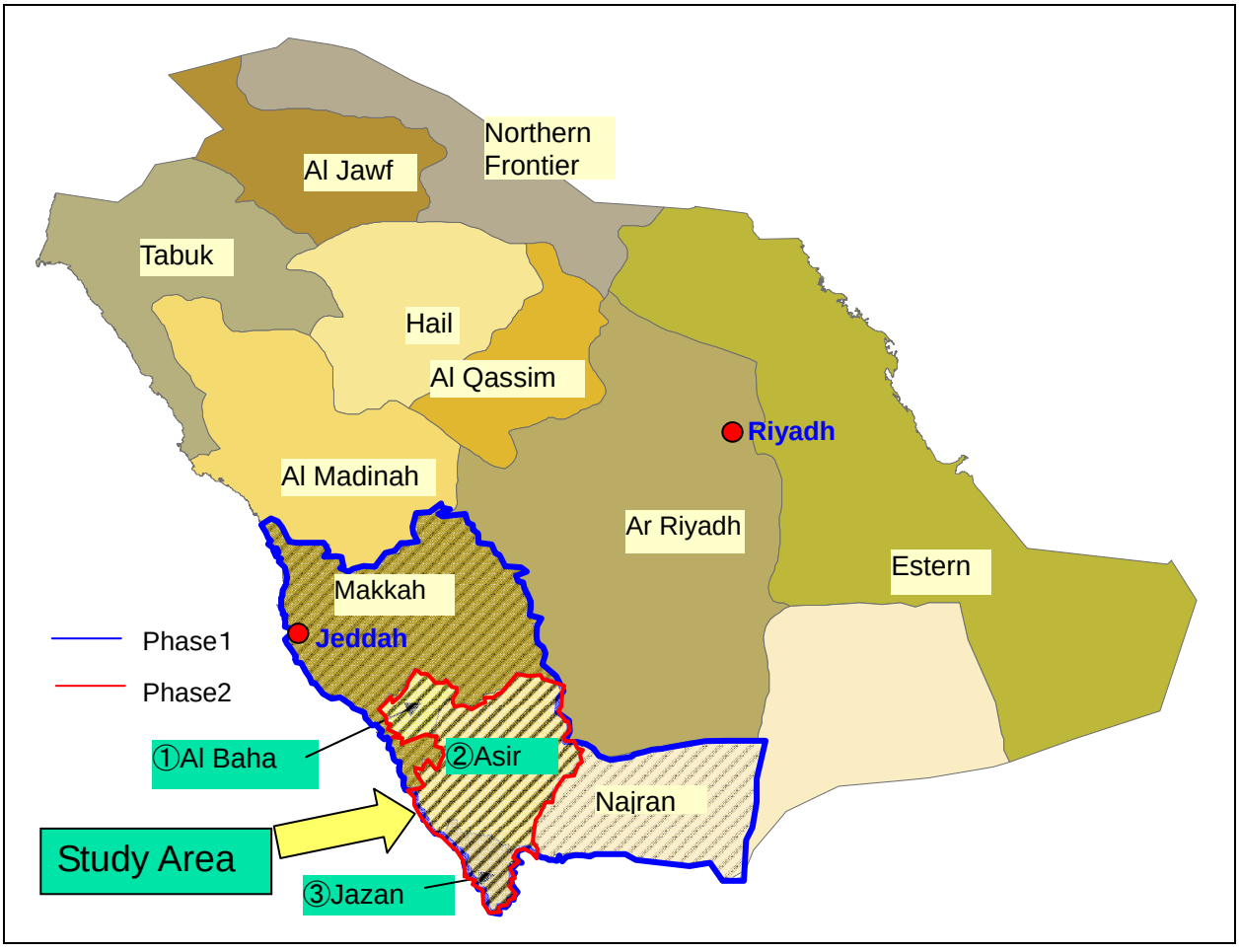
OCTOBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

SANYU CONSULTANTS INC.

The Kingdom of Saudi Arabia Location of Map



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List of Abbreviations

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
BCM	Billion Cubic Meters	مليار متر مكعب	10 億立方メーター
CBD	Convention on Biological Diversity	اتفاقية التنوع البيولوجي	生物多様性保全条約
C/P	Counterpart	النظير	カウンターパート
EIA	Environment Impact Assessment	تقييم الأثر البيئي	環境アセスメント
ER	Effective Rainfall	الأمطار الفعالة	有効雨量
ET	Evapotranspiration	البخرنتح	蒸発散
FAO	Food and Agriculture Organization, United Nations	منظمة الأغذية والزراعة للأمم المتحدة	国連食料農業機関
GIS	Geographic Information System	نظام المعلومات الجغرافية	地理情報システム
GPS	Global Positioning System	نظام تحديد المواقع العالمي	グローバル・ポジショニング・システム
GDP	Gross Domestic Product	الانتاج المحلي الإجمالي	国内総生産
GDW	General Directorate of Water		地方水事務所
GNI	Gross National Income	الدخل القومي الإجمالي	国民総所得
GSMO	Grain Silos and Flour Mills Organization	صوامع الحبوب ومطاحن الدقيق	サイロ・製粉公団
GTZ	Deutsche Gesellschaft fur Technical Zusammenarbeit GmbH	الجمعية الألمانية للتعاون التقني المحدودة	ドイツ技術協力公社
IC/R	Inception Report	تقرير الإنشاء	インセプション・レポート
IEE	Initial Environmental Examination	الفحص البيئي الأولي	初期環境調査
IUCN	World Conversion Union	اتحاد التحويل العالمي	国際自然保護連合
IWPP	Independent Water and Power Project	المياه المستقلة وطاقة المشروع	独立水道・発電事業
IWRP	Integrated Water Resources Planning	التخطيط المتكامل للموارد المائية	総合水資源計画
JCCME	Japan Cooperation Center for Middle East	مركز التعاون الياباني للشرق الأوسط	財団法人中東協力センター
JICA	Japan International Cooperation Agency	الوكالة اليابانية للتعاون الدولي	独立行政法人国際協力機構
KSA	Kingdom of Saudi Arabia	المملكة العربية السعودية	サウジアラビア王国
LCD	Liter per Capita per Day	لتر للفرد يوميا	リッター/人/日
MAW	Ministry of Agriculture and Water	وزارة الزراعة والمياه	水・農業省
MEPA	Meteorology and Environment Protection Administration	ادارةالأرصاد الجوية و حماية البيئة	気象環境保護庁
MCM	Million Cubic Meters	مليون متر مكعب	100 万立方メーター
M/M	Minutes of Meeting	ملخص الاجتماع	会議の議事録
MMW	Million Megawatt	مليون ميغاوات	100 万メガワット
NAS	National Agriculture Strategy	استراتيجية الزراعة الوطنية	国家農業戦略
NGO	Non-Governmental Organization	المنظمات غير الحكومية	民間公益団体
NMS	National Mining Strategy	استراتيجية التعدين الوطنية	国家鉱業戦略
NSS	National Spatial Strategy	استراتيجية العمران الوطنية	国家特別戦略
NWC	National Water Company	شركة المياه الوطنية	国家水会社
MWS	National Water Strategy	الاستراتيجية الوطنية للمياه	国家水戦略
MOA	Ministry of Agriculture	وزارة الزراعة	農業省
MOEP	Ministry of Economy and Planning	وزارة الاقتصاد والتخطيط	国家経済計画省
MOF	Ministry of Finance	وزارة المالية	財務省
MOI	Ministry of Interior	وزارة الداخلية	内務省
MOMRA	Ministry of Municipal and Rural Affairs	وزارة الشؤون البلدية والقروية	地方自治省
MOWE	Ministry of Water and Electricity	وزارة المياه والكهرباء	水・電力省
M/P	Master Plan	الخطة الرئيسية	マスタープラン
MSR	Million Saudi Riyals	مليون ريال سعودي	100 万サウジリアル

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
NCWCD	National Commission for Wildlife Conservation and Development	اللجنة الوطنية لحماية و تطويرالحياة البرية	国立動物保護開発協会
NIA	National Irrigation Authority	السلطة الوطنية للري	国家灌漑局
PME	Presidency of Meteorology and Environment Protection	الرئاسة العامة للأرصاد وحماية البيئة	国家気象環境保護
P/O	Plan of Operation	خطة العمل	プラン オブ オペレーション
PPP	Public Private Partnership	شراكة القطاعين العام والخاص	官民連携
RWPC	Renewable Water Production Corporation	شركة إنتاج المياه المتجددة	再生可能水生産公社
REWLIP	Red Sea Water Lifeline Project	شريان الحياة للمياه البحر الأحمر المشروع	紅海水ライフライン事業
OJT	On the Job Training	التدريب المهني	研修
SAGIA	Governor Saudi Arabian General Investment Authority	محافظ الهيئة العامة للاستثمار العربي السعودي	サウジアラビア総合投資庁
SAMA	Saudi Arabian Monetary Agency	مؤسسة النقد العربي السعودي	サウジアラビア通貨庁
SAR	Saudi Arabian Riyal	الريال السعودي	サウジアラビアリアル
SCT	Supreme Council for Tourism	المجلس الأعلى للسياحة	最高観光委員会
SEA	Strategic Environment Assessment	التقييم البيئي الاستراتيجي	戦略的環境アセスメント
SGS	Saudi Geological Survey	هيئة المساحة الجيولوجية السعودية	サウジ地質調査
SOIETZ	Saudi Organization for Industrial Estates and Technology Zone	الهيئة السعودية للمدن الصناعية و للمنطقة التكنولوجية	サウジ産業国家技術団体
SR	Saudi Riyals	الريال السعودي	サウジリアル
STP	Strategic Transformation Plan	خطة التحول الاستراتيجي	戦略的転換計画
STP	Sewerage Treatment Plant	محطة معالجة الصرف الصحي	下水処理プラント
S/W	Scope of Works	العملنطاق	業務範囲
SWAT	Soil and Water Assessment Tool	أداة تقييم التربة والمياه	土壌水アセスメントツール
SWCC	Saline Water Conversion Corporation	المؤسسة العامة لتحلية المياه المالحة	海水淡水化公社
UFW	Unaccounted For Water	مياه غير محسوبة	無収水
UNDP	United Nations Development Programme	برنامج الأمم المتحدة للتنمية	国連開発計画
UN-ESCWA	United Nations Economic and Social Commission for Western Asia	اللجنة الاقتصادية والاجتماعية للأمم المتحدة لغربي آسيا	国連西アジア経済社会委員会
WB	The World Bank	البنك الدولي	世界銀行
WHO	World Health Organizations	منظمة الصحة العالمية للأمم المتحدة	世界保健機関
WMO	World Meteorological Organization	المنظمة العالمية للأرصاد الجوية	世界気象機関

E. WATER SUPPLY

1. Water Demand

1.1 Amount of Reclaimed Water to be Used for Industry

The JICA study team proposed that reclaimed waste water should concretely be utilized for industrial purpose as well as landscaping purpose. According to the regulation of reclaimed use, reclaimed waste water can be utilized for industrial purpose with exception of beverage and food processing factory.

30% of total industrial water demand in five (5) regions is applied for estimating reclaimed waste water. The basis of 30% was examined based on the following criteria.

- Utilize for coolant and temperature control use
- It is envisaged that about 50% of the served water is utilized for coolant and temperature control for the future because water might be recycled.
- Reclaimed waste water is not utilized for beverage and food processing factory.
- Based on Japanese Industrial Statistics (2007), rates of coolant and temperature control water which was made up in industrial water are as follows:
  - ✓ Chemical industries and plastic products: 88.5%
  - ✓ Building materials, glass, ceramic and metal basic industries: 78.9%
  - ✓ Manufactured metals, machines and equipment: 68.3%

As results of estimation, rate of reclaimed waste water which is utilized for industrial water in five (5) regions is to be 60% as shown in Table 1-1.

However, considering the progress of facility development for utilizing reclaimed waste water and recycled water improvement, the rate of reclaimed waste water is less than 60%. Accordingly, it is proposed that the rate of reclaimed waste water is 30% (a half of 60%) on the safe side.

Amount of reclaimed water to be used for industry is shown in Table 1-1.

Table 1-1 Rate of Utilized Reclaimed Waste Water

Industrial Sector	Labor Ratio by Sector [1]	Daily Per-labor Water Consumption (m^3/day/labor) [2]	% of Total Industrial Water [3]=[1]x[2]/Total [2]	% of Coolant and Temperature Control [4]	% of Reclaimed Waste Water utilized [5]=[3]x[4]
Makkah Region					
Food and Beverages	20.8%	1.00	15.0%		
Textiles, readymade clothes and leather	6.0%	0.43	1.9%		
Wood, wooden products and furniture	3.1%	0.46	1.0%		
Paper, printing and publication	7.5%	0.27	1.5%		
Chemical industries and plastic products	21.1%	2.30	34.9%	88.5%	30.9%
Building materials, glass, ceramic and metal basic industries	12.2%	2.50	21.9%	78.9%	17.3%
Basic Metallic	15.2%	0.54	5.9%		
Manufactured metals, machines and equipment	11.8%	2.10	17.8%	68.3%	12.2%
Transportation	0.2%	0.05	0.0%		
Others	2.0%	0.05	0.1%		
Total	**99.9%**	**1.39**	**100.0%**		**60.3%**
Al Baha Region					
Food and Beverages	26.7%	1.00	18.5%		
Textiles, readymade clothes and leather	10.9%	0.43	3.3%		
Wood, wooden products and furniture	0.0%	0.46	0.0%		
Paper, printing and	17.5%	0.27	3.3%		

Industrial Sector	Labor Ratio by Sector [1]	Daily Per-labor Water Consumption (m^3/day/labor) [2]	% of Total Industrial Water [3]=[1]x[2]/Total [2]	% of Coolant and Temperature Control [4]	% of Reclaimed Waste Water utilized [5]=[3]x[4]
publication					
Chemical industries and plastic products	21.9%	2.30	35.0%	88.5%	31.0%
Building materials, glass, ceramic and metal basic industries	23.0%	2.50	39.9%	78.9%	31.5%
Basic Metallic	0.0%	0.54	0.0%		
Manufactured metals, machines and equipment	0.0%	2.10	0.0%		
Transportation	0.0%	0.05	0.0%		
Others	0.0%	0.05	0.0%		
Total	**100.0%**	**1.44**	**100.0%**		**62.5%**
Asir Region					
Food and Beverages	17.1%	1.00	9.7%		
Textiles, readymade clothes and leather	1.1%	0.43	0.3%		
Wood, wooden products and furniture	0.7%	0.46	0.2%		
Paper, printing and publication	9.4%	0.27	1.4%		
Chemical industries and plastic products	18.8%	2.30	24.6%	88.5%	21.8%
Building materials, glass, ceramic and metal basic industries	42.3%	2.50	60.1%	78.9%	47.4%
Basic Metallic	9.6%	0.54	2.9%		
Manufactured metals, machines and equipment	0.6%	2.10	0.7%		
Transportation	0.0%	0.05	0.0%		
Others	0.4%	0.05	0.0%		
Total	**100.0%**	**1.76**	**100.0%**		**69.2%**
Jazan Region					
Food and Beverages	22.6%	1.00	11.3%		
Textiles, readymade clothes and leather	1.6%	0.43	0.3%		
Wood, wooden products and furniture	0.0%	0.46	0.0%		
Paper, printing and publication	0.6%	0.27	0.1%		
Chemical industries and plastic products	6.3%	2.30	7.2%	88.5%	6.4%
Building materials, glass, ceramic and metal basic industries	64.4%	2.50	80.4%	78.9%	63.4%
Basic Metallic	2.3%	0.54	0.6%		
Manufactured metals, machines and equipment	0.0%	2.10	0.0%		
Transportation	2.3%	0.05	0.1%		
Others	0.0%	0.05	0.0%		
Total	**100.1%**	**2.00**	**100.0%**		**69.8%**
Najran Region					
Food and Beverages	26.9%	1.00	15.0%		
Textiles, readymade clothes and leather	0.0%	0.43	0.0%		
Wood, wooden products and furniture	0.0%	0.46	0.0%		
Paper, printing and publication	0.0%	0.27	0.0%		
Chemical industries and plastic products	24.1%	2.30	30.9%	88.5%	27.3%
Building materials, glass, ceramic and metal	35.9%	2.50	50.1%	78.9%	39.5%

Industrial Sector	Labor Ratio by Sector [1]	Daily Per-labor Water Consumption (m^3/day/labor) [2]	% of Total Industrial Water [3]=[1]x[2]/Total [2]	% of Coolant and Temperature Control [4]	% of Reclaimed Waste Water utilized [5]=[3]x[4]
basic industries					
Basic Metallic	13.1%	0.54	3.9%		
Manufactured metals, machines and equipment	0.0%	2.10	0.0%		
Transportation	0.0%	0.05	0.0%		
Others	0.0%	0.05	0.0%		
Total	**100.0%**	**1.79**	**100.0%**		**66.9%**

Source: JICA Study Team

1.2 Municipal Water Demand (Domestic, Commerce and Institution)

Tables 1-2 – 1-6 summarize municipal water excepting industry by governorate.

Table 1-2 Estimated Water Demand (Makkah Region)

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Option-0						
Makkah Al Mukarramah	370,704	407,512	443,729	479,117	517,617	558,953
Jeddah	799,723	878,566	960,082	1,035,929	1,117,823	1,206,252
Al Taif	236,363	260,652	285,085	308,894	334,702	362,946
Al Qunfidah	53,645	59,220	64,869	70,369	76,589	83,086
Al Lith	23,595	26,842	29,407	31,905	34,868	37,831
Rabigh	15,066	16,608	18,417	19,947	21,605	23,402
Al Jjumum	16,354	18,037	19,988	21,662	23,733	25,722
Khulays	10,439	11,783	13,152	14,262	15,466	16,771
Al Kamli	3,759	4,150	4,545	4,930	5,347	5,800
Al Khurmah	8,614	9,504	10,400	11,274	12,222	13,249
Ranyah	9,558	10,550	11,553	12,530	13,590	14,740
Turbah	8,958	10,151	11,111	12,046	13,320	14,442
Total	**1,556,777**	**1,713,575**	**1,872,339**	**2,022,866**	**2,186,883**	**2,363,194**
Option-1						
Makkah Al Mukarramah	330,803	384,420	441,202	477,290	516,616	558,953
Jeddah	713,267	828,382	959,383	1,035,424	1,117,549	1,206,252
Al Taif	197,006	232,457	270,877	298,619	329,128	362,946
Al Qunfidah	26,769	35,485	45,369	56,267	68,930	83,086
Al Lith	11,474	16,009	20,506	25,467	31,365	37,831
Rabigh	7,433	9,877	12,867	15,940	19,435	23,402
Al Jjumum	7,992	10,659	13,903	17,265	21,341	25,722
Khulays	5,003	6,943	9,147	11,367	13,896	16,771
Al Kamli	1,765	2,388	3,098	3,884	4,780	5,800
Al Khurmah	4,275	5,674	7,257	9,002	10,990	13,249
Ranyah	4,680	6,242	8,015	9,972	12,203	14,740
Turbah	4,298	5,995	7,699	9,580	11,973	14,442
Total	**1,314,764**	**1,544,530**	**1,799,322**	**1,970,076**	**2,158,206**	**2,363,194**
Option-2						
Makkah Al Mukarramah	330,803	383,946	440,165	475,604	514,285	555,792
Jeddah	713,267	827,488	959,149	1,035,045	1,117,002	1,205,512
Al Taif	197,006	230,173	265,872	290,475	317,348	347,105
Al Qunfidah	26,769	32,495	38,818	45,607	53,613	62,314
Al Lith	11,474	14,607	17,433	20,467	24,232	28,156
Rabigh	7,433	8,991	10,983	12,879	15,015	17,418
Al Jjumum	7,992	9,655	11,757	13,777	16,402	19,031
Khulays	5,003	6,274	7,732	9,066	10,569	12,262
Al Kamli	1,765	2,117	2,504	2,918	3,383	3,907
Al Khurmah	4,275	5,181	6,178	7,248	8,454	9,812
Ranyah	4,680	5,659	6,739	7,896	9,200	10,669
Turbah	4,298	5,427	6,457	7,559	9,156	10,624
Total	**1,314,764**	**1,532,013**	**1,773,788**	**1,928,540**	**2,098,660**	**2,282,602**
Option-3						
Makkah Al Mukarramah	297,723	345,978	397,081	429,561	464,955	503,058
Jeddah	641,940	745,544	863,444	931,881	1,005,795	1,085,627
Al Taif	177,306	209,211	243,789	268,757	296,215	326,652
Al Qunfidah	24,092	31,937	40,833	50,640	62,037	74,777
Al Lith	10,326	14,408	18,455	22,920	28,228	34,047
Rabigh	6,690	8,889	11,580	14,346	17,492	21,062
Al Jjumum	7,193	9,593	12,513	15,539	19,207	23,150
Khulays	4,503	6,249	8,232	10,230	12,506	15,094

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Al Kamli	1,588	2,149	2,788	3,496	4,302	5,220
Al Khurmah	3,847	5,106	6,531	8,102	9,891	11,924
Ranyah	4,212	5,618	7,213	8,975	10,982	13,266
Turbah	3,868	5,395	6,929	8,622	10,776	12,998
Total	**1,183,288**	**1,390,077**	**1,619,389**	**1,773,068**	**1,942,386**	**2,126,874**
Option-4						
Makkah Al Mukarramah	314,263	365,199	419,141	453,425	490,785	531,005
Jeddah	677,604	786,963	911,414	983,653	1,061,672	1,145,940
Al Taif	187,156	220,834	257,333	283,688	312,672	344,799
Al Qunfidah	25,430	33,711	43,101	53,454	65,484	78,932
Al Lith	10,900	15,208	19,481	24,194	29,797	35,939
Rabigh	7,062	9,383	12,223	15,143	18,463	22,232
Al Jjumum	7,592	10,126	13,208	16,402	20,274	24,436
Khulays	4,753	6,596	8,689	10,798	13,201	15,933
Al Kamli	1,676	2,269	2,943	3,690	4,541	5,510
Al Khurmah	4,061	5,390	6,894	8,552	10,441	12,586
Ranyah	4,446	5,930	7,614	9,473	11,593	14,003
Turbah	4,083	5,695	7,314	9,101	11,374	13,720
Total	**1,249,026**	**1,467,303**	**1,709,356**	**1,871,572**	**2,050,296**	**2,245,034**
Option-5						
Makkah Al Mukarramah	281,182	326,757	375,021	405,696	439,124	475,110
Jeddah	606,277	704,125	815,475	880,110	949,917	1,025,315
Al Taif	167,455	197,588	230,245	253,826	279,759	308,504
Al Qunfidah	22,754	30,162	38,564	47,827	58,591	70,623
Al Lith	9,753	13,607	17,430	21,647	26,660	32,156
Rabigh	6,318	8,395	10,937	13,549	16,520	19,892
Al Jjumum	6,793	9,060	11,818	14,676	18,140	21,863
Khulays	4,253	5,901	7,775	9,662	11,811	14,256
Al Kamli	1,500	2,030	2,633	3,301	4,063	4,930
Al Khurmah	3,634	4,823	6,168	7,652	9,342	11,261
Ranyah	3,978	5,306	6,813	8,476	10,372	12,529
Turbah	3,653	5,096	6,544	8,143	10,177	12,276
Total	**1,117,549**	**1,312,850**	**1,529,423**	**1,674,565**	**1,834,475**	**2,008,715**
Option-6						
Makkah Al Mukarramah	330,803	384,420	441,202	477,290	516,616	558,953
Jeddah	713,267	828,382	959,383	1,035,424	1,117,549	1,206,252
Al Taif	197,006	232,457	270,877	298,619	329,128	362,946
Al Qunfidah	26,769	35,485	45,369	56,267	68,930	83,086
Al Lith	11,474	16,009	20,506	25,467	31,365	37,831
Rabigh	7,433	9,877	12,867	15,940	19,435	23,402
Al Jjumum	7,992	10,659	13,903	17,265	21,341	25,722
Khulays	5,003	6,943	9,147	11,367	13,896	16,771
Al Kamli	1,765	2,388	3,098	3,884	4,780	5,800
Al Khurmah	4,275	5,674	7,257	9,002	10,990	13,249
Ranyah	4,680	6,242	8,015	9,972	12,203	14,740
Turbah	4,298	5,995	7,699	9,580	11,973	14,442
Total	**1,314,764**	**1,544,530**	**1,799,322**	**1,970,076**	**2,158,206**	**2,363,194**

Source: JICA Study Team

Table 1-3 Estimated Water Demand (Al Baha Region)

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Option-0						
Al Baha	24,905	27,201	29,741	32,217	34,900	37,808
Biljurashi	13,104	14,323	15,670	16,983	18,405	20,211
Al Mandaq	9,733	10,651	11,666	12,654	13,993	15,179
Al Mukhwah	13,258	15,043	16,481	17,882	19,665	21,335
Al Aqiq	5,854	6,406	7,015	7,608	8,763	9,505
Qilwah	11,414	13,022	14,271	15,487	16,807	18,491
Al Qari	6,190	6,770	7,413	8,039	8,717	9,453
Total	**84,458**	**93,415**	**102,257**	**110,869**	**121,251**	**131,983**
Option-1						
Al Baha	21,727	25,182	29,122	31,769	34,657	37,808
Biljurashi	6,480	8,530	10,917	13,548	16,544	20,211
Al Mandaq	4,809	6,341	8,125	10,094	12,594	15,179
Al Mukhwah	6,412	8,963	11,485	14,268	17,694	21,335
Al Aqiq	2,819	3,748	4,832	6,030	7,887	9,505
Qilwah	5,514	7,770	9,954	12,364	15,112	18,491
Al Qari	3,054	4,026	5,159	6,409	7,833	9,453

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Total	**50,815**	**64,560**	**79,595**	**94,482**	**112,322**	**131,983**
Option-2						
Al Baha	21,727	25,088	28,916	31,433	34,171	37,148
Biljurashi	6,480	7,775	9,263	10,860	12,659	15,079
Al Mandaq	4,809	5,777	6,890	8,084	9,795	11,384
Al Mukhwah	6,412	8,171	9,751	11,445	13,715	15,939
Al Aqiq	2,819	3,368	4,000	4,676	6,134	7,129
Qilwah	5,514	7,092	8,468	9,945	11,611	13,869
Al Qari	3,054	3,665	4,368	5,123	5,974	6,932
Total	**50,815**	**60,936**	**71,656**	**81,566**	**94,060**	**107,480**
Option-3						
Al Baha	19,554	22,664	26,210	28,592	31,191	34,027
Biljurashi	5,832	7,677	9,825	12,194	14,890	18,190
Al Mandaq	4,328	5,707	7,313	9,084	11,335	13,661
Al Mukhwah	5,771	8,067	10,337	12,841	15,924	19,202
Al Aqiq	2,537	3,373	4,349	5,427	7,098	8,555
Qilwah	4,963	6,993	8,959	11,128	13,601	16,642
Al Qari	2,748	3,624	4,643	5,768	7,050	8,507
Total	**45,734**	**58,104**	**71,635**	**85,034**	**101,090**	**118,785**
Option-4						
Al Baha	20,641	23,923	27,666	30,181	32,924	35,917
Biljurashi	6,156	8,104	10,371	12,871	15,717	19,201
Al Mandaq	4,569	6,024	7,719	9,589	11,964	14,420
Al Mukhwah	6,091	8,515	10,911	13,554	16,809	20,268
Al Aqiq	2,678	3,561	4,591	5,728	7,493	9,030
Qilwah	5,239	7,381	9,456	11,746	14,357	17,567
Al Qari	2,901	3,825	4,901	6,089	7,442	8,980
Total	**48,274**	**61,332**	**75,615**	**89,758**	**106,706**	**125,384**
Option-5						
Al Baha	18,468	21,405	24,754	27,004	29,459	32,137
Biljurashi	5,508	7,251	9,279	11,516	14,063	17,180
Al Mandaq	4,088	5,390	6,906	8,580	10,705	12,902
Al Mukhwah	5,450	7,619	9,762	12,128	15,040	18,135
Al Aqiq	2,396	3,186	4,108	5,125	6,704	8,080
Qilwah	4,687	6,604	8,461	10,509	12,845	15,718
Al Qari	2,596	3,422	4,385	5,448	6,658	8,035
Total	**43,193**	**54,876**	**67,655**	**80,310**	**95,474**	**112,185**
Option-6						
Al Baha	21,727	25,182	29,122	31,769	34,657	37,808
Biljurashi	6,480	8,530	10,917	13,548	16,544	20,211
Al Mandaq	4,809	6,341	8,125	10,094	12,594	15,179
Al Mukhwah	6,412	8,963	11,485	14,268	17,694	21,335
Al Aqiq	2,819	3,748	4,832	6,030	7,887	9,505
Qilwah	5,514	7,770	9,954	12,364	15,112	18,491
Al Qari	3,054	4,026	5,159	6,409	7,833	9,453
Total	**50,815**	**64,560**	**79,595**	**94,482**	**112,322**	**131,983**

Source: JICA Study Team

Table 1-4 Estimated Water Demand (Asir Region)

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Option-0						
Abha	90,669	99,971	109,613	119,030	128,974	139,753
Khamis Mushayt	121,217	133,632	146,136	158,323	171,531	185,846
Bisha	47,150	52,279	57,210	62,013	67,222	72,871
An Namas	10,730	11,831	12,940	14,020	15,191	16,460
Muhayl	45,334	50,058	54,823	59,464	64,498	70,218
Sarat Abidah	12,913	14,257	16,151	17,518	19,000	20,608
Tathlith	10,204	11,525	12,627	14,241	15,451	16,765
Rijal Almah	13,221	14,602	15,995	17,350	18,823	20,421
Ahad Rifaydah	22,134	24,438	26,762	29,025	35,943	38,984
Zahran Al Janub	12,344	13,629	14,925	16,187	17,556	19,041
Balqarn	14,788	16,319	17,863	19,366	20,997	22,765
Al Majardah	19,935	22,014	24,111	26,154	28,369	30,773
Total	**420,640**	**464,554**	**509,155**	**552,690**	**603,554**	**654,504**
Option-1						
Abha	70,014	83,788	99,095	111,403	124,838	139,753
Khamis Mushayt	102,562	120,638	140,211	154,038	169,206	185,846
Bisha	33,786	41,285	49,344	56,324	64,136	72,871

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
An Namas	5,365	7,099	9,058	11,216	13,672	16,460
Muhayl	34,499	41,465	49,106	55,327	62,253	70,218
Sarat Abidah	6,323	8,436	11,306	14,014	17,100	20,608
Tathlith	4,883	6,782	8,729	11,378	13,898	16,765
Rijal Almah	6,610	8,761	11,196	13,880	16,941	20,421
Ahad Rifaydah	11,028	14,628	18,705	23,199	34,568	38,984
Zahran Al Janub	6,139	8,148	10,423	12,932	15,791	19,041
Balqarn	7,342	9,745	12,466	15,465	18,882	22,765
Al Majardah	9,916	13,162	16,840	20,896	25,517	30,773
Total	**298,465**	**363,936**	**436,479**	**500,073**	**576,803**	**654,504**
Option-2						
Abha	70,014	82,127	95,512	105,654	116,523	128,480
Khamis Mushayt	102,562	119,732	138,227	150,810	164,537	179,515
Bisha	33,786	40,073	46,689	52,003	57,885	64,393
An Namas	5,365	6,507	7,764	9,113	10,634	12,345
Muhayl	34,499	40,573	47,152	52,146	57,649	64,101
Sarat Abidah	6,323	7,649	9,691	11,387	13,300	15,456
Tathlith	4,883	6,122	7,284	9,188	10,730	12,468
Rijal Almah	6,610	8,031	9,597	11,278	13,176	15,316
Ahad Rifaydah	11,028	13,384	15,981	18,768	31,729	35,135
Zahran Al Janub	6,139	7,448	8,890	10,439	12,185	14,153
Balqarn	7,342	8,901	10,616	12,457	14,534	16,871
Al Majardah	9,916	12,033	14,366	16,870	19,695	22,878
Total	**298,465**	**352,581**	**411,768**	**460,111**	**522,577**	**581,110**
Option-3						
Abha	63,012	75,409	89,185	100,263	112,354	125,778
Khamis Mushayt	92,306	108,574	126,190	138,634	152,286	167,261
Bisha	30,407	37,156	44,409	50,692	57,722	65,584
An Namas	4,829	6,389	8,152	10,094	12,305	14,814
Muhayl	31,049	37,318	44,196	49,794	56,028	63,196
Sarat Abidah	5,691	7,592	10,175	12,613	15,390	18,547
Tathlith	4,395	6,103	7,856	10,240	12,508	15,088
Rijal Almah	5,949	7,885	10,077	12,492	15,247	18,379
Ahad Rifaydah	9,925	13,165	16,834	20,879	31,111	35,085
Zahran Al Janub	5,525	7,333	9,381	11,639	14,212	17,137
Balqarn	6,608	8,771	11,219	13,919	16,994	20,489
Al Majardah	8,924	11,846	15,156	18,806	22,965	27,695
Total	**268,619**	**327,542**	**392,831**	**450,066**	**519,122**	**589,054**
Option-4						
Abha	66,513	79,598	94,140	105,833	118,596	132,766
Khamis Mushayt	97,434	114,606	133,200	146,336	160,746	176,554
Bisha	32,097	39,221	46,877	53,508	60,929	69,227
An Namas	5,097	6,744	8,605	10,655	12,988	15,637
Muhayl	32,774	39,391	46,651	52,561	59,141	66,707
Sarat Abidah	6,007	8,014	10,740	13,314	16,245	19,577
Tathlith	4,639	6,443	8,293	10,809	13,203	15,927
Rijal Almah	6,280	8,323	10,637	13,186	16,094	19,400
Ahad Rifaydah	10,476	13,897	17,770	22,039	32,840	37,034
Zahran Al Janub	5,832	7,741	9,902	12,286	15,002	18,089
Balqarn	6,975	9,258	11,843	14,692	17,938	21,627
Al Majardah	9,420	12,504	15,998	19,851	24,241	29,234
Total	**283,542**	**345,739**	**414,655**	**475,070**	**547,962**	**621,779**
Option-5						
Abha	59,511	71,219	84,231	94,693	106,112	118,790
Khamis Mushayt	87,177	102,542	119,179	130,932	143,825	157,969
Bisha	28,718	35,092	41,942	47,875	54,516	61,940
An Namas	4,560	6,034	7,699	9,534	11,621	13,991
Muhayl	29,324	35,245	41,740	47,028	52,915	59,685
Sarat Abidah	5,375	7,171	9,610	11,912	14,535	17,517
Tathlith	4,150	5,764	7,420	9,672	11,813	14,250
Rijal Almah	5,619	7,447	9,517	11,798	14,400	17,358
Ahad Rifaydah	9,373	12,434	15,899	19,719	29,383	33,136
Zahran Al Janub	5,218	6,926	8,860	10,992	13,422	16,185
Balqarn	6,241	8,284	10,596	13,146	16,050	19,351
Al Majardah	8,428	11,188	14,314	17,761	21,689	26,157
Total	**253,696**	**309,345**	**371,007**	**425,062**	**490,282**	**556,329**
Option-6						
Abha	70,014	83,788	99,095	111,403	124,838	139,753
Khamis Mushayt	102,562	120,638	140,211	154,038	169,206	185,846
Bisha	33,786	41,285	49,344	56,324	64,136	72,871

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
An Namas	5,365	7,099	9,058	11,216	13,672	16,460
Muhayl	34,499	41,465	49,106	55,327	62,253	70,218
Sarat Abidah	6,323	8,436	11,306	14,014	17,100	20,608
Tathlith	4,883	6,782	8,729	11,378	13,898	16,765
Rijal Almah	6,610	8,761	11,196	13,880	16,941	20,421
Ahad Rifaydah	11,028	14,628	18,705	23,199	34,568	38,984
Zahran Al Janub	6,139	8,148	10,423	12,932	15,791	19,041
Balqarn	7,342	9,745	12,466	15,465	18,882	22,765
Al Majardah	9,916	13,162	16,840	20,896	25,517	30,773
Total	**298,465**	**363,936**	**436,479**	**500,073**	**576,803**	**654,504**

Source: JICA Study Team

Table 1-5 Estimated Water Demand (Jazan Region)

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Option-0						
Jizan	65,761	73,652	80,550	87,272	94,559	106,910
Sabya	55,345	61,972	67,744	73,372	79,468	86,074
Abu Arish	36,620	41,026	44,895	48,666	52,754	57,187
Samtah	35,668	39,945	43,679	47,319	51,263	55,538
Al Harth	11,313	12,672	13,863	15,024	16,282	17,646
Damad	14,812	16,584	18,124	19,626	21,253	23,016
Ar Rayth	3,063	3,434	3,766	4,088	4,439	4,819
Baysh	13,805	15,464	16,919	18,336	19,872	21,538
Farasan	3,304	3,702	4,052	4,394	4,764	5,166
Ad Dair	11,434	12,817	14,044	15,239	16,537	18,197
Ahad Al Musarihah	16,552	23,180	25,371	27,505	29,819	32,329
Al Idabi	13,316	15,185	16,906	18,341	19,899	21,591
Al Aridah	14,738	16,517	18,091	19,623	21,286	23,090
Ad Darb	12,228	13,698	14,987	16,243	17,605	19,082
Total	**307,960**	**349,847**	**382,992**	**415,047**	**449,798**	**492,181**
Option-1						
Jizan	44,848	55,908	67,344	77,721	89,377	106,910
Sabya	44,505	53,671	62,859	69,838	77,551	86,074
Abu Arish	32,958	38,974	44,895	48,666	52,754	57,187
Samtah	28,105	34,029	40,000	44,659	49,820	55,538
Al Harth	5,656	7,603	9,704	12,019	14,654	17,646
Damad	7,406	9,950	12,687	15,700	19,128	23,016
Ar Rayth	1,502	2,034	2,614	3,255	3,986	4,819
Baysh	6,903	9,279	11,843	14,668	17,885	21,538
Farasan	1,652	2,221	2,837	3,515	4,288	5,166
Ad Dair	5,658	7,637	9,787	12,160	14,866	18,197
Ahad Al Musarihah	8,276	22,021	25,371	27,505	29,819	32,329
Al Idabi	6,512	9,047	11,831	14,670	17,908	21,591
Al Aridah	7,330	9,875	12,635	15,677	19,146	23,090
Ad Darb	6,092	8,199	10,475	12,983	15,838	19,082
Total	**207,404**	**270,448**	**324,882**	**373,036**	**427,018**	**492,181**
Option-2						
Jizan	44,848	53,899	62,943	70,557	79,013	97,308
Sabya	44,505	52,927	61,230	67,187	73,717	80,875
Abu Arish	32,958	38,974	44,895	48,666	52,754	57,187
Samtah	28,105	33,469	38,774	42,663	46,935	51,625
Al Harth	5,656	6,970	8,318	9,765	11,397	13,235
Damad	7,406	9,121	10,874	12,757	14,877	17,262
Ar Rayth	1,502	1,846	2,201	2,582	3,013	3,497
Baysh	6,903	8,505	10,151	11,918	13,910	16,154
Farasan	1,652	2,036	2,431	2,856	3,335	3,874
Ad Dair	5,658	6,963	8,310	9,756	11,388	13,606
Ahad Al Musarihah	8,276	22,021	25,371	27,505	29,819	32,329
Al Idabi	6,512	8,248	10,134	11,909	13,914	16,173
Al Aridah	7,330	9,027	10,777	12,656	14,775	17,163
Ad Darb	6,092	7,502	8,949	10,502	12,254	14,225
Total	**207,404**	**261,509**	**305,360**	**341,279**	**381,099**	**434,512**
Option-3						
Jizan	40,364	50,317	60,610	69,949	80,439	96,219
Sabya	40,055	48,304	56,573	62,854	69,796	77,467
Abu Arish	29,663	35,077	40,406	43,799	47,478	51,468
Samtah	25,295	30,626	36,000	40,193	44,838	49,984
Al Harth	5,091	6,843	8,734	10,817	13,188	15,881

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Damad	6,665	8,955	11,418	14,130	17,215	20,714
Ar Rayth	1,352	1,831	2,353	2,929	3,588	4,337
Baysh	6,212	8,351	10,659	13,202	16,096	19,385
Farasan	1,487	1,999	2,553	3,164	3,859	4,649
Ad Dair	5,092	6,873	8,809	10,944	13,379	16,378
Ahad Al Musarihah	7,448	19,819	22,834	24,754	26,837	29,096
Al Idabi	5,861	8,142	10,647	13,203	16,117	19,432
Al Aridah	6,597	8,888	11,371	14,110	17,231	20,781
Ad Darb	5,483	7,379	9,427	11,684	14,254	17,173
Total	**186,663**	**243,403**	**292,394**	**335,732**	**384,316**	**442,963**
Option-4						
Jizan	42,606	53,112	63,977	73,835	84,908	101,565
Sabya	42,280	50,987	59,716	66,346	73,674	81,770
Abu Arish	31,310	37,026	42,651	46,232	50,116	54,327
Samtah	26,700	32,327	38,000	42,426	47,329	52,761
Al Harth	5,374	7,223	9,219	11,418	13,921	16,764
Damad	7,036	9,453	12,052	14,915	18,171	21,865
Ar Rayth	1,427	1,932	2,483	3,092	3,787	4,578
Baysh	6,558	8,815	11,251	13,935	16,991	20,461
Farasan	1,569	2,110	2,695	3,339	4,073	4,907
Ad Dair	5,375	7,255	9,298	11,552	14,122	17,288
Ahad Al Musarihah	7,862	20,920	24,102	26,130	28,328	30,712
Al Idabi	6,187	8,595	11,239	13,937	17,013	20,511
Al Aridah	6,963	9,382	12,003	14,894	18,189	21,935
Ad Darb	5,788	7,789	9,951	12,334	15,046	18,127
Total	**197,034**	**256,926**	**308,638**	**354,384**	**405,667**	**467,572**
Option-5						
Jizan	38,121	47,521	57,243	66,063	75,970	90,874
Sabya	37,830	45,620	53,430	59,362	65,918	73,163
Abu Arish	28,015	33,128	38,161	41,366	44,840	48,609
Samtah	23,889	28,925	34,000	37,960	42,347	47,207
Al Harth	4,808	6,463	8,249	10,216	12,456	14,999
Damad	6,295	8,458	10,784	13,345	16,258	19,563
Ar Rayth	1,276	1,729	2,222	2,767	3,388	4,096
Baysh	5,867	7,887	10,067	12,468	15,202	18,308
Farasan	1,404	1,888	2,411	2,988	3,645	4,391
Ad Dair	4,809	6,491	8,319	10,336	12,636	15,468
Ahad Al Musarihah	7,034	18,718	21,565	23,379	25,346	27,479
Al Idabi	5,535	7,690	10,056	12,470	15,222	18,352
Al Aridah	6,230	8,394	10,739	13,326	16,274	19,626
Ad Darb	5,178	6,969	8,904	11,035	13,462	16,219
Total	**176,293**	**229,881**	**276,150**	**317,080**	**362,965**	**418,354**
Option-6						
Jizan	44,848	55,908	67,344	77,721	89,377	106,910
Sabya	44,505	53,671	62,859	69,838	77,551	86,074
Abu Arish	32,958	38,974	44,895	48,666	52,754	57,187
Samtah	28,105	34,029	40,000	44,659	49,820	55,538
Al Harth	5,656	7,603	9,704	12,019	14,654	17,646
Damad	7,406	9,950	12,687	15,700	19,128	23,016
Ar Rayth	1,502	2,034	2,614	3,255	3,986	4,819
Baysh	6,903	9,279	11,843	14,668	17,885	21,538
Farasan	1,652	2,221	2,837	3,515	4,288	5,166
Ad Dair	5,658	7,637	9,787	12,160	14,866	18,197
Ahad Al Musarihah	8,276	22,021	25,371	27,505	29,819	32,329
Al Idabi	6,512	9,047	11,831	14,670	17,908	21,591
Al Aridah	7,330	9,875	12,635	15,677	19,146	23,090
Ad Darb	6,092	8,199	10,475	12,983	15,838	19,082
Total	**207,404**	**270,448**	**324,882**	**373,036**	**427,018**	**492,181**

Source: JICA Study Team

Table 1-6 Estimated Water Demand (Najran Region)

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Option-0						
Najran	77,360	86,683	94,813	102,987	111,596	120,928
Sharurah	17,279	23,748	26,002	28,195	30,574	33,155
Habawnah	5,483	6,165	6,751	7,322	7,940	9,128
Badr Al Janub	1,724	2,208	2,420	2,626	3,103	3,368
Yadamah	3,282	3,697	4,051	4,397	4,772	5,178
Thar	2,679	3,022	3,313	3,597	3,904	4,238

m^3/day

Governorate	2010	2015	2020	2025	2030	2035
Khubash	4,233	5,034	5,518	5,988	6,498	7,051
Al Kharkhir	681	1,017	1,113	1,206	1,307	1,416
Total	**112,722**	**131,574**	**143,981**	**156,317**	**169,694**	**184,461**
Option-1						
Najran	68,062	80,823	93,392	101,941	111,029	120,928
Sharurah	8,576	21,766	25,263	27,661	30,285	33,155
Habawnah	2,640	3,607	4,650	5,803	7,117	9,128
Badr Al Janub	690	1,233	1,618	2,046	2,778	3,368
Yadamah	1,621	2,200	2,821	3,507	4,289	5,178
Thar	1,206	1,693	2,220	2,805	3,475	4,238
Khubash	2,024	3,001	3,846	4,779	5,841	7,051
Al Kharkhir	272	610	779	965	1,176	1,416
Total	**85,091**	**114,933**	**134,590**	**149,506**	**165,990**	**184,461**
Option-2						
Najran	68,062	80,561	92,819	101,083	109,789	119,248
Sharurah	8,576	21,625	24,954	27,159	29,560	32,174
Habawnah	2,640	3,242	3,850	4,500	5,233	6,832
Badr Al Janub	690	1,065	1,251	1,447	2,013	2,330
Yadamah	1,621	2,004	2,391	2,807	3,276	3,804
Thar	1,206	1,466	1,723	1,997	2,304	2,649
Khubash	2,024	2,736	3,267	3,836	4,478	5,203
Al Kharkhir	272	559	668	784	915	1,062
Total	**85,091**	**113,259**	**130,922**	**143,614**	**157,569**	**173,302**
Option-3						
Najran	61,256	72,741	84,053	91,747	99,926	108,835
Sharurah	7,718	19,589	22,737	24,895	27,256	29,839
Habawnah	2,376	3,247	4,185	5,222	6,405	8,216
Badr Al Janub	621	1,110	1,457	1,841	2,500	3,031
Yadamah	1,459	1,980	2,539	3,156	3,860	4,660
Thar	1,085	1,523	1,998	2,525	3,127	3,814
Khubash	1,821	2,701	3,461	4,301	5,257	6,346
Al Kharkhir	245	549	701	868	1,059	1,275
Total	**76,582**	**103,440**	**121,131**	**134,556**	**149,391**	**166,015**
Option-4						
Najran	64,659	76,782	88,723	96,844	105,478	114,881
Sharurah	8,147	20,677	24,000	26,278	28,770	31,497
Habawnah	2,508	3,427	4,418	5,513	6,761	8,672
Badr Al Janub	655	1,171	1,538	1,944	2,639	3,199
Yadamah	1,540	2,090	2,680	3,331	4,074	4,919
Thar	1,146	1,608	2,109	2,665	3,301	4,026
Khubash	1,922	2,851	3,654	4,540	5,549	6,699
Al Kharkhir	259	580	740	917	1,117	1,346
Total	**80,836**	**109,186**	**127,861**	**142,031**	**157,690**	**175,238**
Option-5						
Najran	57,853	68,700	79,384	86,650	94,375	102,788
Sharurah	7,290	18,501	21,473	23,512	25,742	28,181
Habawnah	2,244	3,066	3,953	4,932	6,049	7,759
Badr Al Janub	586	1,048	1,376	1,739	2,362	2,862
Yadamah	1,378	1,870	2,398	2,981	3,645	4,401
Thar	1,025	1,439	1,887	2,385	2,954	3,602
Khubash	1,720	2,551	3,269	4,062	4,965	5,993
Al Kharkhir	231	519	662	820	1,000	1,204
Total	**72,327**	**97,693**	**114,402**	**127,080**	**141,091**	**156,792**
Option-6						
Najran	68,062	80,823	93,392	101,941	111,029	120,928
Sharurah	8,576	21,766	25,263	27,661	30,285	33,155
Habawnah	2,640	3,607	4,650	5,803	7,117	9,128
Badr Al Janub	690	1,233	1,618	2,046	2,778	3,368
Yadamah	1,621	2,200	2,821	3,507	4,289	5,178
Thar	1,206	1,693	2,220	2,805	3,475	4,238
Khubash	2,024	3,001	3,846	4,779	5,841	7,051
Al Kharkhir	272	610	779	965	1,176	1,416
Total	**85,091**	**114,933**	**134,590**	**149,506**	**165,990**	**184,461**

Source: JICA Study Team

1.3 Breakdown of Water Demand Estimates in Municipal Water Supply

Total water demand such as domestic water demand including commercial and institutional purpose, and industry water demand as estimated in '3.1' of Main Report is summarized by option in Table 1-7 - 1-11. Of the total water demand, part of industrial water and gardening water can be covered by reclaimed waste water. As the reclaimed waste water which can be utilized for their water use is estimated and total water demand as municipal water supply system is re-calculated as shown in the following Tables.

Table 1-7 (1) Water Demand Prediction of Makkah Region (Option-0)

Makkah Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 0 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	371	408	444	479	518	559	7	8	9	9	10	11	378	416	452	489	528	570	378	416	452	489	528	570	0	0	0	0	0	0
Jeddah	800	879	960	1,036	1,118	1,206	139	152	166	180	193	207	938	1,031	1,126	1,215	1,311	1,413	938	1,031	1,126	1,215	1,311	1,413	0	0	0	0	0	0
Al Taif	236	261	285	309	335	363							236	261	285	309	335	363	236	261	285	309	335	363	0	0	0	0	0	0
Al Qunfidah	54	59	65	70	77	83							54	59	65	70	77	83	54	59	65	70	77	83	0	0	0	0	0	0
Al Lith	24	27	29	32	35	38							24	27	29	32	35	38	24	27	29	32	35	38	0	0	0	0	0	0
Rabigh	15	17	18	20	22	23							15	17	18	20	22	23	15	17	18	20	22	23	0	0	0	0	0	0
Al Jjumum	16	18	20	22	24	26							16	18	20	22	24	26	16	18	20	22	24	26	0	0	0	0	0	0
Khulays	10	12	13	14	15	17							10	12	13	14	15	17	10	12	13	14	15	17	0	0	0	0	0	0
Al Kamli	4	4	5	5	5	6							4	4	5	5	5	6	4	4	5	5	5	6	0	0	0	0	0	0
Al Khurmah	9	10	10	11	12	13							9	10	10	11	12	13	9	10	10	11	12	13	0	0	0	0	0	0
Ranyah	10	11	12	13	14	15							10	11	12	13	14	15	10	11	12	13	14	15	0	0	0	0	0	0
Turbah	9	10	11	12	13	14							9	10	11	12	13	14	9	10	11	12	13	14	0	0	0	0	0	0
Total	1,557	1,714	1,872	2,023	2,187	2,363	146	160	175	189	203	218	1,703	1,874	2,047	2,212	2,390	2,581	1,703	1,874	2,047	2,212	2,390	2,581	0	0	0	0	0	0

Table 1-7 (2) Water Demand Prediction of Makkah Region (Option-1)

Makkah Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 1 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	331	384	441	477	517	559	7	8	9	9	10	11	338	392	450	487	527	570	240	279	318	344	373	404	98	114	132	143	154	166
Jeddah	713	828	959	1,035	1,118	1,206	139	152	166	180	193	207	852	980	1,126	1,215	1,310	1,413	775	894	1,028	1,109	1,197	1,291	77	86	98	106	114	122
Al Taif	197	232	271	299	329	363							197	232	271	299	329	363	188	222	259	286	315	348	9	10	12	13	14	15
Al Qunfidah	27	35	45	56	69	83							27	35	45	56	69	83	27	35	45	56	69	83	0	0	0	0	0	0
Al Lith	11	16	21	25	31	38							11	16	21	25	31	38	11	16	21	25	31	38	0	0	0	0	0	0
Rabigh	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Al Jjumum	8	11	14	17	21	26							8	11	14	17	21	26	8	11	14	17	21	26	0	0	0	0	0	0
Khulays	5	7	9	11	14	17							5	7	9	11	14	17	5	7	9	11	14	17	0	0	0	0	0	0
Al Kamli	2	2	3	4	5	6							2	2	3	4	5	6	2	2	3	4	5	6	0	0	0	0	0	0
Al Khurmah	4	6	7	9	11	13							4	6	7	9	11	13	4	6	7	9	11	13	0	0	0	0	0	0
Ranyah	5	6	8	10	12	15							5	6	8	10	12	15	5	6	8	10	12	15	0	0	0	0	0	0
Turbah	4	6	8	10	12	14							4	6	8	10	12	14	4	6	8	10	12	14	0	0	0	0	0	0
Total	1,315	1,545	1,799	1,970	2,158	2,363	146	160	175	189	203	218	1,461	1,705	1,974	2,159	2,361	2,581	1,277	1,494	1,733	1,898	2,080	2,278	184	210	242	261	282	304

Table 1-7 (3) Water Demand Prediction of Makkah Region (Option-2)

Makkah Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 2

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	331	384	440	476	514	556	7	8	9	9	10	11	338	392	449	485	524	567	240	278	317	342	370	401	98	114	132	143	154	166
Jeddah	713	827	959	1,035	1,117	1,206	139	152	166	180	193	207	852	979	1,125	1,215	1,310	1,413	775	893	1,028	1,109	1,196	1,290	77	86	98	106	114	122
Al Taif	197	230	266	290	317	347							197	230	266	290	317	347	188	220	254	278	303	332	9	10	12	13	14	15
Al Qunfidah	27	32	39	46	54	62							27	32	39	46	54	62	27	32	39	46	54	62	0	0	0	0	0	0
Al Lith	11	15	17	20	24	28							11	15	17	20	24	28	11	15	17	20	24	28	0	0	0	0	0	0
Rabigh	7	9	11	13	15	17							7	9	11	13	15	17	7	9	11	13	15	17	0	0	0	0	0	0
Al Jjumum	8	10	12	14	16	19							8	10	12	14	16	19	8	10	12	14	16	19	0	0	0	0	0	0
Khulays	5	6	8	9	11	12							5	6	8	9	11	12	5	6	8	9	11	12	0	0	0	0	0	0
Al Kamli	2	2	3	3	3	4							2	2	3	3	3	4	2	2	3	3	3	4	0	0	0	0	0	0
Al Khurmah	4	5	6	7	8	10							4	5	6	7	8	10	4	5	6	7	8	10	0	0	0	0	0	0
Ranyah	5	6	7	8	9	11							5	6	7	8	9	11	5	6	7	8	9	11	0	0	0	0	0	0
Turbah	4	5	6	8	9	11							4	5	6	8	9	11	4	5	6	8	9	11	0	0	0	0	0	0
Total	1,315	1,532	1,774	1,929	2,099	2,283	146	160	175	189	203	218	1,461	1,692	1,949	2,118	2,302	2,501	1,277	1,482	1,707	1,856	2,020	2,197	184	210	242	261	282	304

Table 1-7 (4) Water Demand Prediction of Makkah Region (Option-3)

Makkah Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 3

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	298	346	397	430	465	503	7	8	9	9	10	11	305	354	406	439	475	514	217	252	287	310	336	364	88	102	119	129	139	150
Jeddah	642	746	863	932	1,006	1,086	139	152	166	180	193	207	781	898	1,030	1,111	1,199	1,293	707	815	937	1,011	1,091	1,176	73	82	93	100	108	116
Al Taif	177	209	244	269	296	327							177	209	244	269	296	327	169	200	233	257	284	313	8	9	11	12	13	14
Al Qunfidah	24	32	41	51	62	75							24	32	41	51	62	75	24	32	41	51	62	75	0	0	0	0	0	0
Al Lith	10	14	18	23	28	34							10	14	18	23	28	34	10	14	18	23	28	34	0	0	0	0	0	0
Rabigh	7	9	12	14	17	21							7	9	12	14	17	21	7	9	12	14	17	21	0	0	0	0	0	0
Al Jjumum	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Khulays	5	6	8	10	13	15							5	6	8	10	13	15	5	6	8	10	13	15	0	0	0	0	0	0
Al Kamli	2	2	3	3	4	5							2	2	3	3	4	5	2	2	3	3	4	5	0	0	0	0	0	0
Al Khurmah	4	5	7	8	10	12							4	5	7	8	10	12	4	5	7	8	10	12	0	0	0	0	0	0
Ranyah	4	6	7	9	11	13							4	6	7	9	11	13	4	6	7	9	11	13	0	0	0	0	0	0
Turbah	4	5	7	9	11	13							4	5	7	9	11	13	4	5	7	9	11	13	0	0	0	0	0	0
Total	1,183	1,390	1,619	1,773	1,942	2,127	146	160	175	189	203	218	1,329	1,550	1,794	1,962	2,145	2,345	1,160	1,356	1,572	1,721	1,886	2,065	170	194	223	241	259	280

Table 1-7 (5) Water Demand Prediction of Makkah Region (Option-4)

Makkah Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 4 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	314	365	419	453	491	531	7	8	9	9	10	11	322	373	428	463	501	542	228	265	302	327	355	384	93	108	126	136	146	158
Jeddah	678	787	911	984	1,062	1,146	139	152	166	180	193	207	816	939	1,078	1,163	1,255	1,353	741	855	982	1,060	1,144	1,234	75	84	95	103	111	119
Al Taif	187	221	257	284	313	345							187	221	257	284	313	345	179	211	246	271	299	330	8	10	11	12	13	14
Al Qunfidah	25	34	43	53	65	79							25	34	43	53	65	79	25	34	43	53	65	79	0	0	0	0	0	0
Al Lith	11	15	19	24	30	36							11	15	19	24	30	36	11	15	19	24	30	36	0	0	0	0	0	0
Rabigh	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Al Jjumum	8	10	13	16	20	24							8	10	13	16	20	24	8	10	13	16	20	24	0	0	0	0	0	0
Khulays	5	7	9	11	13	16							5	7	9	11	13	16	5	7	9	11	13	16	0	0	0	0	0	0
Al Kamli	2	2	3	4	5	6							2	2	3	4	5	6	2	2	3	4	5	6	0	0	0	0	0	0
Al Khurmah	4	5	7	9	10	13							4	5	7	9	10	13	4	5	7	9	10	13	0	0	0	0	0	0
Ranyah	4	6	8	9	12	14							4	6	8	9	12	14	4	6	8	9	12	14	0	0	0	0	0	0
Turbah	4	6	7	9	11	14							4	6	7	9	11	14	4	6	7	9	11	14	0	0	0	0	0	0
Total	1,249	1,467	1,709	1,872	2,050	2,245	146	160	175	189	203	218	1,395	1,627	1,884	2,061	2,253	2,463	1,218	1,425	1,652	1,810	1,983	2,171	177	202	232	251	271	292

Table 1-7 (6) Water Demand Prediction of Makkah Region (Option-5)

Makkah Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 5 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	281	327	375	406	439	475	7	8	9	9	10	11	288	335	384	415	449	486	205	238	271	294	318	344	84	97	113	122	131	142
Jeddah	606	704	815	880	950	1,025	139	152	166	180	193	207	745	856	982	1,060	1,143	1,232	673	776	891	962	1,038	1,119	72	80	91	98	105	113
Al Taif	167	198	230	254	280	309							167	198	230	254	280	309	160	189	220	243	268	296	8	9	10	11	12	13
Al Qunfidah	23	30	39	48	59	71							23	30	39	48	59	71	23	30	39	48	59	71	0	0	0	0	0	0
Al Lith	10	14	17	22	27	32							10	14	17	22	27	32	10	14	17	22	27	32	0	0	0	0	0	0
Rabigh	6	8	11	14	17	20							6	8	11	14	17	20	6	8	11	14	17	20	0	0	0	0	0	0
Al Jjumum	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Khulays	4	6	8	10	12	14							4	6	8	10	12	14	4	6	8	10	12	14	0	0	0	0	0	0
Al Kamli	1	2	3	3	4	5							1	2	3	3	4	5	1	2	3	3	4	5	0	0	0	0	0	0
Al Khurmah	4	5	6	8	9	11							4	5	6	8	9	11	4	5	6	8	9	11	0	0	0	0	0	0
Ranyah	4	5	7	8	10	13							4	5	7	8	10	13	4	5	7	8	10	13	0	0	0	0	0	0
Turbah	4	5	7	8	10	12							4	5	7	8	10	12	4	5	7	8	10	12	0	0	0	0	0	0
Total	1,118	1,313	1,529	1,675	1,834	2,009	146	160	175	189	203	218	1,264	1,473	1,704	1,864	2,037	2,227	1,101	1,287	1,491	1,633	1,789	1,959	163	186	213	230	248	268

Table 1-7 (7) Water Demand Prediction of Makkah Region (Option-6)

Makkah Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 6 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Makkah Al Mukarramah	331	384	441	477	517	559	7	8	9	9	10	11	338	392	450	487	527	570	338	392	450	487	527	570	0	0	0	0	0	0
Jeddah	713	828	959	1,035	1,118	1,206	139	152	166	180	193	207	852	980	1,126	1,215	1,310	1,413	852	980	1,126	1,215	1,310	1,413	0	0	0	0	0	0
Al Taif	197	232	271	299	329	363							197	232	271	299	329	363	197	232	271	299	329	363	0	0	0	0	0	0
Al Qunfidah	27	35	45	56	69	83							27	35	45	56	69	83	27	35	45	56	69	83	0	0	0	0	0	0
Al Lith	11	16	21	25	31	38							11	16	21	25	31	38	11	16	21	25	31	38	0	0	0	0	0	0
Rabigh	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Al Jjumum	8	11	14	17	21	26							8	11	14	17	21	26	8	11	14	17	21	26	0	0	0	0	0	0
Khulays	5	7	9	11	14	17							5	7	9	11	14	17	5	7	9	11	14	17	0	0	0	0	0	0
Al Kamli	2	2	3	4	5	6							2	2	3	4	5	6	2	2	3	4	5	6	0	0	0	0	0	0
Al Khurmah	4	6	7	9	11	13							4	6	7	9	11	13	4	6	7	9	11	13	0	0	0	0	0	0
Ranyah	5	6	8	10	12	15							5	6	8	10	12	15	5	6	8	10	12	15	0	0	0	0	0	0
Turbah	4	6	8	10	12	14							4	6	8	10	12	14	4	6	8	10	12	14	0	0	0	0	0	0
Total	1,315	1,545	1,799	1,970	2,158	2,363	146	160	175	189	203	218	1,461	1,705	1,974	2,159	2,361	2,581	1,461	1,705	1,974	2,159	2,361	2,581	0	0	0	0	0	0

Table 1-8 (1) Water Demand Prediction of Al Baha Region (Option-0)

Al Baha Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 0 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	25	27	30	32	35	38							25	27	30	32	35	38	25	27	30	32	35	38	0.0	0.0	0.0	0.0	0.0	0.0
Biljurashi	13	14	16	17	18	20	0.3	0.3	0.3	0.3	0.3	0.3	13	15	16	17	19	21	13	15	16	17	19	21	0.0	0.0	0.0	0.0	0.0	0.0
Al Mandaq	10	11	12	13	14	15							10	11	12	13	14	15	10	11	12	13	14	15	0.0	0.0	0.0	0.0	0.0	0.0
Al Mukhwah	13	15	16	18	20	21							13	15	16	18	20	21	13	15	16	18	20	21	0.0	0.0	0.0	0.0	0.0	0.0
Al Aqiq	6	6	7	8	9	10	0.7	0.7	0.7	0.7	0.7	0.7	7	7	8	8	9	10	7	7	8	8	9	10	0.0	0.0	0.0	0.0	0.0	0.0
Qilwah	11	13	14	15	17	18							11	13	14	15	17	18	11	13	14	15	17	18	0.0	0.0	0.0	0.0	0.0	0.0
Al Qari	6	7	7	8	9	9							6	7	7	8	9	9	6	7	7	8	9	9	0.0	0.0	0.0	0.0	0.0	0.0
Total	84	93	102	111	121	132	1	1	1	1	1	1	85	94	103	112	122	133	85	94	103	112	122	133	0.0	0.0	0.0	0.0	0.0	0.0

Table 1-8 (2) Water Demand Predicti on of Al Baha Region (Option-1)

Al Baha Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 1 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	22	25	29	32	35	38							22	25	29	32	35	38	21	24	28	30	33	36	1.0	1.2	1.4	1.5	1.6	1.8
Biljurashi	6	9	11	14	17	20	0.3	0.3	0.3	0.3	0.3	0.3	7	9	11	14	17	21	7	9	11	14	17	20	0.1	0.1	0.1	0.1	0.1	0.1
Al Mandaq	5	6	8	10	13	15							5	6	8	10	13	15	5	6	8	10	13	15	0.0	0.0	0.0	0.0	0.0	0.0
Al Mukhwah	6	9	11	14	18	21							6	9	11	14	18	21	6	9	11	14	18	21	0.0	0.0	0.0	0.0	0.0	0.0
Al Aqiq	3	4	5	6	8	10	0.7	0.7	0.7	0.7	0.7	0.7	4	4	6	7	9	10	3	4	5	7	8	10	0.2	0.2	0.2	0.2	0.2	0.2
Qilwah	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0.0	0.0	0.0	0.0	0.0	0.0
Al Qari	3	4	5	6	8	9							3	4	5	6	8	9	3	4	5	6	8	9	0.0	0.0	0.0	0.0	0.0	0.0
Total	51	65	80	94	112	132	1	1	1	1	1	1	52	66	81	95	113	133	50	64	79	94	111	131	1.3	1.5	1.7	1.8	1.9	2.1

Table 1-8 (3) Water Demand Prediction of Al Baha Region (Option-2)

Al Baha Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 2 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	22	25	29	31	34	37							22	25	29	31	34	37	21	24	28	30	33	35	1.0	1.2	1.4	1.5	1.6	1.8
Biljurashi	6	8	9	11	13	15	0.3	0.3	0.3	0.3	0.3	0.3	7	8	10	11	13	15	7	8	9	11	13	15	0.1	0.1	0.1	0.1	0.1	0.1
Al Mandaq	5	6	7	8	10	11							5	6	7	8	10	11	5	6	7	8	10	11	0.0	0.0	0.0	0.0	0.0	0.0
Al Mukhwah	6	8	10	11	14	16							6	8	10	11	14	16	6	8	10	11	14	16	0.0	0.0	0.0	0.0	0.0	0.0
Al Aqiq	3	3	4	5	6	7	0.7	0.7	0.7	0.7	0.7	0.7	4	4	5	5	7	8	3	4	4	5	7	8	0.2	0.2	0.2	0.2	0.2	0.2
Qilwah	6	7	8	10	12	14							6	7	8	10	12	14	6	7	8	10	12	14	0.0	0.0	0.0	0.0	0.0	0.0
Al Qari	3	4	4	5	6	7							3	4	4	5	6	7	3	4	4	5	6	7	0.0	0.0	0.0	0.0	0.0	0.0
Total	51	61	72	82	94	107	1	1	1	1	1	1	52	62	73	83	95	108	50	60	71	81	93	106	1.3	1.5	1.7	1.8	1.9	2.1

Table 1-8 (4) Water Demand Prediction of Al Baha Region (Option-3)

Al Baha Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 3 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Public Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	20	23	26	29	31	34							20	23	26	29	31	34	19	22	25	27	30	32	0.9	1	1	1	1	2
Biljurashi	6	8	10	12	15	18	0.3	0.3	0.3	0.3	0.3	0.3	6	8	10	12	15	18	6	8	10	12	15	18	0.1	0	0	0	0	0
Al Mandaq	4	6	7	9	11	14							4	6	7	9	11	14	4	6	7	9	11	14	0.0	0	0	0	0	0
Al Mukhwah	6	8	10	13	16	19							6	8	10	13	16	19	6	8	10	13	16	19	0.0	0	0	0	0	0
Al Aqiq	3	3	4	5	7	9	0.7	0.7	0.7	0.7	0.7	0.7	3	4	5	6	8	9	3	4	5	6	8	9	0.2	0	0	0	0	0
Qilwah	5	7	9	11	14	17							5	7	9	11	14	17	5	7	9	11	14	17	0.0	0	0	0	0	0
Al Qari	3	4	5	6	7	9							3	4	5	6	7	9	3	4	5	6	7	9	0.0	0	0	0	0	0
Total	46	58	72	85	101	119	1	1	1	1	1	1	47	59	73	86	102	120	45	58	71	84	100	118	1.2	1.4	1.5	1.6	1.8	1.9

Table 1-8 (5) Water Demand Prediction of Al Baha Region (Option-4)

Al Baha Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 4 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	21	24	28	30	33	36							21	24	28	30	33	36	20	23	26	29	31	34	1.0	1.1	1.3	1.4	1.5	1.7
Biljurashi	6	8	10	13	16	19	0.3	0.3	0.3	0.3	0.3	0.3	6	8	11	13	16	20	6	8	11	13	16	19	0.1	0.1	0.1	0.1	0.1	0.1
Al Mandaq	5	6	8	10	12	14							5	6	8	10	12	14	5	6	8	10	12	14	0.0	0.0	0.0	0.0	0.0	0.0
Al Mukhwah	6	9	11	14	17	20							6	9	11	14	17	20	6	9	11	14	17	20	0.0	0.0	0.0	0.0	0.0	0.0
Al Aqiq	3	4	5	6	7	9	0.7	0.7	0.7	0.7	0.7	0.7	3	4	5	6	8	10	3	4	5	6	8	10	0.2	0.2	0.2	0.2	0.2	0.2
Qilwah	5	7	9	12	14	18							5	7	9	12	14	18	5	7	9	12	14	18	0.0	0.0	0.0	0.0	0.0	0.0
Al Qari	3	4	5	6	7	9							3	4	5	6	7	9	3	4	5	6	7	9	0.0	0.0	0.0	0.0	0.0	0.0
Total	48	61	76	90	107	125	1	1	1	1	1	1	49	62	77	91	108	126	48	61	75	89	106	124	1.3	1.4	1.6	1.7	1.8	2.0

Table 1-8 (6) Water Demand Prediction of Al Baha Region (Option-5)

Al Baha Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 5 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	18	21	25	27	29	32							18	21	25	27	29	32	18	20	24	26	28	31	0.9	1.0	1.2	1.3	1.4	1.5
Biljurashi	6	7	9	12	14	17	0.3	0.3	0.3	0.3	0.3	0.3	6	8	10	12	14	17	6	7	9	12	14	17	0.1	0.1	0.1	0.1	0.1	0.1
Al Mandaq	4	5	7	9	11	13							4	5	7	9	11	13	4	5	7	9	11	13	0.0	0.0	0.0	0.0	0.0	0.0
Al Mukhwah	5	8	10	12	15	18							5	8	10	12	15	18	5	8	10	12	15	18	0.0	0.0	0.0	0.0	0.0	0.0
Al Aqiq	2	3	4	5	7	8	0.7	0.7	0.7	0.7	0.7	0.7	3	4	5	6	7	9	3	4	5	6	7	9	0.2	0.2	0.2	0.2	0.2	0.2
Qilwah	5	7	8	11	13	16							5	7	8	11	13	16	5	7	8	11	13	16	0.0	0.0	0.0	0.0	0.0	0.0
Al Qari	3	3	4	5	7	8							3	3	4	5	7	8	3	3	4	5	7	8	0.0	0.0	0.0	0.0	0.0	0.0
Total	43	55	68	80	95	112	1	1	1	1	1	1	44	56	69	81	96	113	43	55	67	80	95	111	1.2	1.3	1.5	1.6	1.7	1.8

Table 1-8 (7) Water Demand Prediction of Al Baha Region (Option-6)

Al Baha Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 6 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Al Baha	22	25	29	32	35	38							22	25	29	32	35	38	22	25	29	32	35	38	0.0	0.0	0.0	0.0	0.0	0.0
Biljurashi	6	9	11	14	17	20	0.3	0.3	0.3	0.3	0.3	0.3	7	9	11	14	17	21	7	9	11	14	17	21	0.0	0.0	0.0	0.0	0.0	0.0
Al Mandaq	5	6	8	10	13	15							5	6	8	10	13	15	5	6	8	10	13	15	0.0	0.0	0.0	0.0	0.0	0.0
Al Mukhwah	6	9	11	14	18	21							6	9	11	14	18	21	6	9	11	14	18	21	0.0	0.0	0.0	0.0	0.0	0.0
Al Aqiq	3	4	5	6	8	10	0.7	0.7	0.7	0.7	0.7	0.7	4	4	6	7	9	10	4	4	6	7	9	10	0.0	0.0	0.0	0.0	0.0	0.0
Qilwah	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0.0	0.0	0.0	0.0	0.0	0.0
Al Qari	3	4	5	6	8	9							3	4	5	6	8	9	3	4	5	6	8	9	0.0	0.0	0.0	0.0	0.0	0.0
Total	51	65	80	94	112	132	1	1	1	1	1	1	52	66	81	95	113	133	52	66	81	95	113	133	0.0	0.0	0.0	0.0	0.0	0.0

Table 1-9 (1) Water Demand Prediction of Asir Region (Option-0)

Asir Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 0

Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	91	100	110	119	129	140							91	100	110	119	129	140	91	100	110	119	129	140	0	0	0	0	0	0
Khamis Mushayt	121	134	146	158	172	186	10	12	13	14	16	17	131	146	159	172	188	203	131	146	159	172	188	203	0	0	0	0	0	0
Bishah	47	52	57	62	67	73							47	52	57	62	67	73	47	52	57	62	67	73	0	0	0	0	0	0
An Namas	11	12	13	14	15	16							11	12	13	14	15	16	11	12	13	14	15	16	0	0	0	0	0	0
Muhayl	45	50	55	59	64	70							45	50	55	59	64	70	45	50	55	59	64	70	0	0	0	0	0	0
Sarat Abidah	13	14	16	18	19	21							13	14	16	18	19	21	13	14	16	18	19	21	0	0	0	0	0	0
Tathlith	10	12	13	14	15	17							10	12	13	14	15	17	10	12	13	14	15	17	0	0	0	0	0	0
Rijal Almah	13	15	16	17	19	20							13	15	16	17	19	20	13	15	16	17	19	20	0	0	0	0	0	0
Ahad Rifaydah	22	24	27	29	36	39							22	24	27	29	36	39	22	24	27	29	36	39	0	0	0	0	0	0
Zahran Al Janub	12	14	15	16	18	19							12	14	15	16	18	19	12	14	15	16	18	19	0	0	0	0	0	0
Balqarn	15	16	18	19	21	23							15	16	18	19	21	23	15	16	18	19	21	23	0	0	0	0	0	0
Al Majardah	20	22	24	26	28	31							20	22	24	26	28	31	20	22	24	26	28	31	0	0	0	0	0	0
Total	421	465	509	553	604	655	10	12	13	14	16	17	431	477	522	567	620	672	431	477	522	567	620	672	0	0	0	0	0	0

Table 1-9 (2) Water Demand Prediction of Asir Region (Option-1)

Asir Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 1

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	70	84	99	111	125	140							70	84	99	111	125	140	67	81	95	107	120	135	3	3	4	4	4	5
Khamis Mushayt	103	121	140	154	169	186	10	12	13	14	16	17	113	133	153	168	185	203	105	124	143	157	173	190	8	9	10	11	12	13
Bishah	34	41	49	56	64	73							34	41	49	56	64	73	33	40	48	55	62	71	1	1	2	2	2	2
An Namas	5	7	9	11	14	16							5	7	9	11	14	16	5	7	9	11	14	16	0	0	0	0	0	0
Muhayl	34	41	49	55	62	70							34	41	49	55	62	70	33	40	47	53	60	68	1	2	2	2	2	2
Sarat Abidah	6	8	11	14	17	21							6	8	11	14	17	21	6	8	11	14	17	21	0	0	0	0	0	0
Tathlith	5	7	9	11	14	17							5	7	9	11	14	17	5	7	9	11	14	17	0	0	0	0	0	0
Rijal Almah	7	9	11	14	17	20							7	9	11	14	17	20	7	9	11	14	17	20	0	0	0	0	0	0
Ahad Rifaydah	11	15	19	23	35	39							11	15	19	23	35	39	11	15	19	23	33	38	0	0	0	0	1	1
Zahran Al Janub	6	8	10	13	16	19							6	8	10	13	16	19	6	8	10	13	16	19	0	0	0	0	0	0
Balqarn	7	10	12	15	19	23							7	10	12	15	19	23	7	10	12	15	19	23	0	0	0	0	0	0
Al Majardah	10	13	17	21	26	31							10	13	17	21	26	31	10	13	17	21	26	31	0	0	0	0	0	0
Total	298	364	436	500	577	655	10	12	13	14	16	17	308	376	449	514	593	672	295	361	432	495	571	648	13	15	17	19	22	23

Table 1-9 (3) Water Demand Prediction of Asir Region (Option-2)

Asir Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 2

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewate					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	70	82	96	106	117	128							70	82	96	106	117	128	67	79	92	102	112	124	3	3	4	4	4	5
Khamis Mushayt	103	120	138	151	165	180	10	12	13	14	16	17	113	132	151	165	181	197	105	123	141	154	168	183	8	9	10	11	12	13
Bishah	34	40	47	52	58	64							34	40	47	52	58	64	33	39	45	50	56	62	1	1	2	2	2	2
An Namas	5	7	8	9	11	12							5	7	8	9	11	12	5	7	8	9	11	12	0	0	0	0	0	0
Muhayl	34	41	47	52	58	64							34	41	47	52	58	64	33	39	45	50	56	62	1	2	2	2	2	2
Sarat Abidah	6	8	10	11	13	15							6	8	10	11	13	15	6	8	10	11	13	15	0	0	0	0	0	0
Tathlith	5	6	7	9	11	12							5	6	7	9	11	12	5	6	7	9	11	12	0	0	0	0	0	0
Rijal Almah	7	8	10	11	13	15							7	8	10	11	13	15	7	8	10	11	13	15	0	0	0	0	0	0
Ahad Rifaydah	11	13	16	19	32	35							11	13	16	19	32	35	11	13	16	19	31	34	0	0	0	0	1	1
Zahran Al Janub	6	7	9	10	12	14							6	7	9	10	12	14	6	7	9	10	12	14	0	0	0	0	0	0
Balqarn	7	9	11	12	15	17							7	9	11	12	15	17	7	9	11	12	15	17	0	0	0	0	0	0
Al Majardah	10	12	14	17	20	23							10	12	14	17	20	23	10	12	14	17	20	23	0	0	0	0	0	0
Total	298	353	412	460	523	581	10	12	13	14	16	17	308	365	425	474	539	598	295	349	407	455	517	575	13	15	17	19	22	23

Table 1-9 (4) Water Demand Prediction of Asir Region (Option-3)

Asir Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 3

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewate					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	63	75	89	100	112	126							63	75	89	100	112	126	60	72	86	97	108	122	3	3	3	4	4	4
Khamis Mushayt	92	109	126	139	152	167	10	12	13	14	16	17	102	121	139	153	168	184	95	112	130	142	157	172	7	9	10	10	11	12
Bishah	30	37	44	51	58	66							30	37	44	51	58	66	29	36	43	49	56	64	1	1	1	2	2	2
An Namas	5	6	8	10	12	15							5	6	8	10	12	15	5	6	8	10	12	15	0	0	0	0	0	0
Muhayl	31	37	44	50	56	63							31	37	44	50	56	63	30	36	43	48	54	61	1	1	2	2	2	2
Sarat Abidah	6	8	10	13	15	19							6	8	10	13	15	19	6	8	10	13	15	19	0	0	0	0	0	0
Tathlith	4	6	8	10	13	15							4	6	8	10	13	15	4	6	8	10	13	15	0	0	0	0	0	0
Rijal Almah	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Ahad Rifaydah	10	13	17	21	31	35							10	13	17	21	31	35	10	13	17	21	30	34	0	0	0	0	1	1
Zahran Al Janub	6	7	9	12	14	17							6	7	9	12	14	17	6	7	9	12	14	17	0	0	0	0	0	0
Balqarn	7	9	11	14	17	20							7	9	11	14	17	20	7	9	11	14	17	20	0	0	0	0	0	0
Al Majardah	9	12	15	19	23	28							9	12	15	19	23	28	9	12	15	19	23	28	0	0	0	0	0	0
Total	269	328	393	450	519	589	10	12	13	14	16	17	279	340	406	464	535	606	267	325	390	447	515	585	12	14	16	17	20	22

Table 1-9 (5) Water Demand Prediction of Asir Region (Option-4)

Asir Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 4

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	67	80	94	106	119	133							67	80	94	106	119	133	64	77	91	102	114	128	3	3	4	4	4	5
Khamis Mushayt	97	115	133	146	161	177	10	12	13	14	16	17	107	127	146	160	177	194	100	118	136	150	165	181	7	9	10	11	12	13
Bishah	32	39	47	54	61	69							32	39	47	54	61	69	31	38	45	52	59	67	1	1	1	2	2	2
An Namas	5	7	9	11	13	16							5	7	9	11	13	16	5	7	9	11	13	16	0	0	0	0	0	0
Muhayl	33	39	47	53	59	67							33	39	47	53	59	67	32	38	45	51	57	65	1	1	2	2	2	2
Sarat Abidah	6	8	11	13	16	20							6	8	11	13	16	20	6	8	11	13	16	20	0	0	0	0	0	0
Tathlith	5	6	8	11	13	16							5	6	8	11	13	16	5	6	8	11	13	16	0	0	0	0	0	0
Rijal Almah	6	8	11	13	16	19							6	8	11	13	16	19	6	8	11	13	16	19	0	0	0	0	0	0
Ahad Rifaydah	10	14	18	22	33	37							10	14	18	22	33	37	10	14	18	22	32	36	0	0	0	0	1	1
Zahran Al Janub	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Balqarn	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Al Majardah	9	13	16	20	24	29							9	13	16	20	24	29	9	13	16	20	24	29	0	0	0	0	0	0
Total	284	346	415	475	548	622	10	12	13	14	16	17	294	358	428	489	564	639	281	343	411	471	543	616	13	15	17	18	21	22

Table 1-9 (6) Water Demand Prediction of Asir Region (Option-5)

Asir Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 5

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	60	71	84	95	106	119							60	71	84	95	106	119	57	68	81	91	102	115	2	3	3	3	4	4
Khamis Mushayt	87	103	119	131	144	158	10	12	13	14	16	17	97	115	132	145	160	175	90	106	123	135	149	163	7	8	9	10	11	12
Bishah	29	35	42	48	55	62							29	35	42	48	55	62	28	34	41	46	53	60	1	1	1	1	2	2
An Namas	5	6	8	10	12	14							5	6	8	10	12	14	5	6	8	10	12	14	0	0	0	0	0	0
Muhayl	29	35	42	47	53	60							29	35	42	47	53	60	28	34	40	45	51	58	1	1	2	2	2	2
Sarat Abidah	5	7	10	12	15	18							5	7	10	12	15	18	5	7	10	12	15	18	0	0	0	0	0	0
Tathlith	4	6	7	10	12	14							4	6	7	10	12	14	4	6	7	10	12	14	0	0	0	0	0	0
Rijal Almah	6	7	10	12	14	17							6	7	10	12	14	17	6	7	10	12	14	17	0	0	0	0	0	0
Ahad Rifaydah	9	12	16	20	29	33							9	12	16	20	29	33	9	12	16	20	28	32	0	0	0	0	1	1
Zahran Al Janub	5	7	9	11	13	16							5	7	9	11	13	16	5	7	9	11	13	16	0	0	0	0	0	0
Balqarn	6	8	11	13	16	19							6	8	11	13	16	19	6	8	11	13	16	19	0	0	0	0	0	0
Al Majardah	8	11	14	18	22	26							8	11	14	18	22	26	8	11	14	18	22	26	0	0	0	0	0	0
Total	254	309	371	425	490	556	10	12	13	14	16	17	264	321	384	439	506	573	252	308	369	423	487	553	12	14	15	17	19	21

Table 1-9 (7) Water Demand Prediction of Asir Region (Option-6)

Asir Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 6 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Abha	70	84	99	111	125	140							70	84	99	111	125	140	70	84	99	111	125	140	0	0	0	0	0	0
Khamis Mushayt	103	121	140	154	169	186	10	12	13	14	16	17	113	133	153	168	185	203	113	133	153	168	185	203	0	0	0	0	0	0
Bishah	34	41	49	56	64	73							34	41	49	56	64	73	34	41	49	56	64	73	0	0	0	0	0	0
An Namas	5	7	9	11	14	16							5	7	9	11	14	16	5	7	9	11	14	16	0	0	0	0	0	0
Muhayl	34	41	49	55	62	70							34	41	49	55	62	70	34	41	49	55	62	70	0	0	0	0	0	0
Sarat Abidah	6	8	11	14	17	21							6	8	11	14	17	21	6	8	11	14	17	21	0	0	0	0	0	0
Tathlith	5	7	9	11	14	17							5	7	9	11	14	17	5	7	9	11	14	17	0	0	0	0	0	0
Rijal Almah	7	9	11	14	17	20							7	9	11	14	17	20	7	9	11	14	17	20	0	0	0	0	0	0
Ahad Rifaydah	11	15	19	23	35	39							11	15	19	23	35	39	11	15	19	23	35	39	0	0	0	0	0	0
Zahran Al Janub	6	8	10	13	16	19							6	8	10	13	16	19	6	8	10	13	16	19	0	0	0	0	0	0
Balqarn	7	10	12	15	19	23							7	10	12	15	19	23	7	10	12	15	19	23	0	0	0	0	0	0
Al Majardah	10	13	17	21	26	31							10	13	17	21	26	31	10	13	17	21	26	31	0	0	0	0	0	0
Total	298	364	436	500	577	655	10	12	13	14	16	17	308	376	449	514	593	672	308	376	449	514	593	672	0	0	0	0	0	0

Table 1-10 (1) Water Demand Prediction of Jazan Region (Option-0)

Jazan Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 0 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	66	74	81	87	95	107	3	3	3	3	4	4	69	77	84	90	99	111	69	77	84	90	99	111	0	0	0	0	0	0
Sabya	55	62	68	73	79	86							55	62	68	73	79	86	55	62	68	73	79	86	0	0	0	0	0	0
Abu Arish	37	41	45	49	53	57							37	41	45	49	53	57	37	41	45	49	53	57	0	0	0	0	0	0
Samtah	36	40	44	47	51	56							36	40	44	47	51	56	36	40	44	47	51	56	0	0	0	0	0	0
Al Harth	11	13	14	15	16	18							11	13	14	15	16	18	11	13	14	15	16	18	0	0	0	0	0	0
Damad	15	17	18	20	21	23							15	17	18	20	21	23	15	17	18	20	21	23	0	0	0	0	0	0
Ar Rayth	3	3	4	4	4	5							3	3	4	4	4	5	3	3	4	4	4	5	0	0	0	0	0	0
Baysh	14	15	17	18	20	22							14	15	17	18	20	22	14	15	17	18	20	22	0	0	0	0	0	0
Farasan	3	4	4	4	5	5							3	4	4	4	5	5	3	4	4	4	5	5	0	0	0	0	0	0
Ad Dair	11	13	14	15	17	18							11	13	14	15	17	18	11	13	14	15	17	18	0	0	0	0	0	0
Ahad Al Musarihah	17	23	25	28	30	32							17	23	25	28	30	32	17	23	25	28	30	32	0	0	0	0	0	0
Al Idabi	13	15	17	18	20	22							13	15	17	18	20	22	13	15	17	18	20	22	0	0	0	0	0	0
Al Aridah	15	17	18	20	21	23							15	17	18	20	21	23	15	17	18	20	21	23	0	0	0	0	0	0
Ad Darb	12	14	15	16	18	19							12	14	15	16	18	19	12	14	15	16	18	19	0	0	0	0	0	0
Total	308	314	344	372	403	442	3	3	3	3	4	4	283	317	347	375	407	446	283	317	347	375	407	446	0	0	0	0	0	0

Table 1-10 (2) Water Demand Prediction of Jazan Region (Option-1)

Jazan Region

Option - 1

Municipal Water 5% <-- Reclaimed Wastewater

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	45	56	67	78	89	107	3	3	3	3	4	4	48	59	70	81	93	111	46	56	68	78	90	106	2	2	3	3	3	5
Sabya	45	54	63	70	78	86							45	54	63	70	78	86	43	54	63	70	78	86	2	0	0	0	0	0
Abu Arish	33	39	45	49	53	57							33	39	45	49	53	57	31	37	43	46	50	54	2	2	2	2	3	3
Samtah	28	34	40	45	50	56							28	34	40	45	50	56	27	33	38	43	48	54	1	1	2	2	2	2
Al Harth	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Damad	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Ar Rayth	2	2	3	3	4	5							2	2	3	3	4	5	2	2	3	3	4	5	0	0	0	0	0	0
Baysh	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Farasan	2	2	3	4	4	5							2	2	3	4	4	5	2	2	3	4	4	5	0	0	0	0	0	0
Ad Dair	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Ahad Al Musarihah	8	22	25	28	30	32							8	22	25	28	30	32	8	21	24	26	28	31	0	1	1	1	1	2
Al Idabi	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Al Aridah	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Ad Darb	6	8	10	13	16	19							6	8	10	13	16	19	6	8	10	13	16	19	0	0	0	0	0	0
Total	207	241	290	333	382	442	3	3	3	3	4	4	196	244	293	336	386	446	190	238	286	329	379	436	7	6	7	7	8	9

Table 1-10 (3) Water Demand Prediction of Jazan Region (Option-2)

Jazan Region

Option - 2

Municipal Water 5% <-- Reclaimed Wastewater

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	45	54	63	71	79	97	3	3	3	3	4	4	48	57	66	74	83	101	46	54	63	71	80	97	2	2	3	3	3	5
Sabya	45	53	61	67	74	81							45	53	61	67	74	81	43	51	59	64	71	78	2	2	3	3	3	3
Abu Arish	33	39	45	49	53	57							33	39	45	49	53	57	31	37	43	46	50	54	2	2	2	2	3	3
Samtah	28	33	39	43	47	52							28	33	39	43	47	52	27	32	37	41	45	50	1	1	2	2	2	2
Al Harth	6	7	8	10	11	13							6	7	8	10	11	13	6	7	8	10	11	13	0	0	0	0	0	0
Damad	7	9	11	13	15	17							7	9	11	13	15	17	7	9	11	13	15	17	0	0	0	0	0	0
Ar Rayth	2	2	2	3	3	3							2	2	2	3	3	3	2	2	2	3	3	3	0	0	0	0	0	0
Baysh	7	9	10	12	14	16							7	9	10	12	14	16	7	9	10	12	14	16	0	0	0	0	0	0
Farasan	2	2	2	3	3	4							2	2	2	3	3	4	2	2	2	3	3	4	0	0	0	0	0	0
Ad Dair	6	7	8	10	11	14							6	7	8	10	11	14	6	7	8	10	11	14	0	0	0	0	0	0
Ahad Al Musarihah	8	22	25	28	30	32							8	22	25	28	30	32	8	21	24	26	28	31	0	1	1	1	1	2
Al Idabi	7	8	10	12	14	16							7	8	10	12	14	16	7	8	10	12	14	16	0	0	0	0	0	0
Al Aridah	7	9	11	13	15	17							7	9	11	13	15	17	7	9	11	13	15	17	0	0	0	0	0	0
Ad Darb	6	8	9	11	12	14							6	8	9	11	12	14	6	8	9	11	12	14	0	0	0	0	0	0
Total	207	233	272	304	340	389	3	3	3	3	4	4	196	236	275	307	344	393	190	227	266	297	333	380	7	8	9	10	11	13

Table 1-10 (4) Water Demand Prediction of Jazan Region (Option-3)

Jazan Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 3

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	40	50	61	70	80	96	3	3	3	3	4	4	43	53	64	73	84	100	41	51	61	70	81	96	2	2	3	3	3	5
Sabya	40	48	57	63	70	77							40	48	57	63	70	77	38	46	54	60	67	74	2	2	3	3	3	3
Abu Arish	30	35	40	44	47	51							30	35	40	44	47	51	28	33	38	41	45	49	2	2	2	2	3	3
Samtah	25	31	36	40	45	50							25	31	36	40	45	50	24	29	34	38	43	48	1	1	2	2	2	2
Al Harth	5	7	9	11	13	16							5	7	9	11	13	16	5	7	9	11	13	16	0	0	0	0	0	0
Damad	7	9	11	14	17	21							7	9	11	14	17	21	7	9	11	14	17	21	0	0	0	0	0	0
Ar Rayth	1	2	2	3	4	4							1	2	2	3	4	4	1	2	2	3	4	4	0	0	0	0	0	0
Baysh	6	8	11	13	16	19							6	8	11	13	16	19	6	8	11	13	16	19	0	0	0	0	0	0
Farasan	1	2	3	3	4	5							1	2	3	3	4	5	1	2	3	3	4	5	0	0	0	0	0	0
Ad Dair	5	7	9	11	13	16							5	7	9	11	13	16	5	7	9	11	13	16	0	0	0	0	0	0
Ahad Al Musarihah	7	20	23	25	27	29							7	20	23	25	27	29	7	19	22	23	25	27	0	1	1	1	1	2
Al Idabi	6	8	11	13	16	19							6	8	11	13	16	19	6	8	11	13	16	19	0	0	0	0	0	0
Al Aridah	7	9	11	14	17	21							7	9	11	14	17	21	7	9	11	14	17	21	0	0	0	0	0	0
Ad Darb	5	7	9	12	14	17							5	7	9	12	14	17	5	7	9	12	14	17	0	0	0	0	0	0
Total	187	217	261	300	344	397	3	3	3	3	4	4	177	220	264	303	348	401	170	212	255	293	337	389	7	8	9	10	11	13

Table 1-10 (5) Water Demand Prediction of Jazan Region (Option-4)

Jazan Region

Municipal Water 5% <-- Reclaimed Wastewater

Option - 4

Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	43	53	64	74	85	102	3	3	3	3	4	4	46	56	67	77	89	106	43	54	64	74	86	101	2	2	3	3	3	4
Sabya	42	51	60	66	74	82							42	51	60	66	74	82	40	49	57	64	71	79	2	2	2	3	3	3
Abu Arish	31	37	43	46	50	54							31	37	43	46	50	54	30	35	41	44	48	52	2	2	2	2	3	3
Samtah	27	32	38	42	47	53							27	32	38	42	47	53	26	31	37	41	46	51	1	1	1	2	2	2
Al Harth	5	7	9	11	14	17							5	7	9	11	14	17	5	7	9	11	14	17	0	0	0	0	0	0
Damad	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Ar Rayth	1	2	2	3	4	5							1	2	2	3	4	5	1	2	2	3	4	5	0	0	0	0	0	0
Baysh	7	9	11	14	17	20							7	9	11	14	17	20	7	9	11	14	17	20	0	0	0	0	0	0
Farasan	2	2	3	3	4	5							2	2	3	3	4	5	2	2	3	3	4	5	0	0	0	0	0	0
Ad Dair	5	7	9	12	14	17							5	7	9	12	14	17	5	7	9	12	14	17	0	0	0	0	0	0
Ahad Al Musarihah	8	21	24	26	28	31							8	21	24	26	28	31	8	20	23	25	27	29	0	1	1	1	1	2
Al Idabi	6	9	11	14	17	21							6	9	11	14	17	21	6	9	11	14	17	21	0	0	0	0	0	0
Al Aridah	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Ad Darb	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Total	197	229	275	317	363	420	3	3	3	3	4	4	187	232	278	320	367	424	180	224	270	310	357	411	7	8	9	9	10	12

Table 1-10 (6) Water Demand Prediction of Jazan Region (Option-5)

Jazan Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 5 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	38	48	57	66	76	91	3	3	3	3	4	4	41	51	60	69	80	95	39	48	58	66	77	90	2	2	3	3	3	4
Sabya	38	46	53	59	66	73							38	46	53	59	66	73	36	43	51	57	63	70	2	2	2	3	3	3
Abu Arish	28	33	38	41	45	49							28	33	38	41	45	49	26	31	36	39	42	46	2	2	2	2	3	3
Samtah	24	29	34	38	42	47							24	29	34	38	42	47	23	28	33	36	41	45	1	1	1	2	2	2
Al Harth	5	6	8	10	12	15							5	6	8	10	12	15	5	6	8	10	12	15	0	0	0	0	0	0
Damad	6	8	11	13	16	20							6	8	11	13	16	20	6	8	11	13	16	20	0	0	0	0	0	0
Ar Rayth	1	2	2	3	3	4							1	2	2	3	3	4	1	2	2	3	3	4	0	0	0	0	0	0
Baysh	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Farasan	1	2	2	3	4	4							1	2	2	3	4	4	1	2	2	3	4	4	0	0	0	0	0	0
Ad Dair	5	6	8	10	13	15							5	6	8	10	13	15	5	6	8	10	13	15	0	0	0	0	0	0
Ahad Al Musarihah	7	19	22	23	25	27							7	19	22	23	25	27	7	18	20	22	24	26	0	1	1	1	1	2
Al Idabi	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Al Aridah	6	8	11	13	16	20							6	8	11	13	16	20	6	8	11	13	16	20	0	0	0	0	0	0
Ad Darb	5	7	9	11	13	16							5	7	9	11	13	16	5	7	9	11	13	16	0	0	0	0	0	0
Total	176	205	246	283	325	375	3	3	3	3	4	4	167	208	249	286	329	379	161	200	241	277	319	367	7	8	9	9	10	12

Table 1-10 (7) Water Demand Prediction of Jazan Region (Option-6)

Jazan Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 6 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Jazan	45	56	67	78	89	107	3	3	3	3	4	4	48	59	70	81	93	111	48	59	70	81	93	111	0	0	0	0	0	0
Sabya	45	54	63	70	78	86							45	54	63	70	78	86	45	54	63	70	78	86	0	0	0	0	0	0
Abu Arish	33	39	45	49	53	57							33	39	45	49	53	57	33	39	45	49	53	57	0	0	0	0	0	0
Samtah	28	34	40	45	50	56							28	34	40	45	50	56	28	34	40	45	50	56	0	0	0	0	0	0
Al Harth	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Damad	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Ar Rayth	2	2	3	3	4	5							2	2	3	3	4	5	2	2	3	3	4	5	0	0	0	0	0	0
Baysh	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Farasan	2	2	3	4	4	5							2	2	3	4	4	5	2	2	3	4	4	5	0	0	0	0	0	0
Ad Dair	6	8	10	12	15	18							6	8	10	12	15	18	6	8	10	12	15	18	0	0	0	0	0	0
Ahad Al Musarihah	8	22	25	28	30	32							8	22	25	28	30	32	8	22	25	28	30	32	0	0	0	0	0	0
Al Idabi	7	9	12	15	18	22							7	9	12	15	18	22	7	9	12	15	18	22	0	0	0	0	0	0
Al Aridah	7	10	13	16	19	23							7	10	13	16	19	23	7	10	13	16	19	23	0	0	0	0	0	0
Ad Darb	6	8	10	13	16	19							6	8	10	13	16	19	6	8	10	13	16	19	0	0	0	0	0	0
Total	207	241	290	333	382	442	3	3	3	3	4	4	196	244	293	336	386	446	196	244	293	336	386	446	0	0	0	0	0	0

Table 1-11 (1) Water Demand Prediction of Najran Region (Option-0)

Najran Region Municipal Water 0% <-- Reclaimed Wastewater

Option - 0 Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	77	87	95	103	112	121	1	1	1	1	1	1	78	88	96	104	113	122	78	88	96	104	113	122	0.0	0.0	0.0	0.0	0.0	0.0
Sharurah	17	24	26	28	31	33							17	24	26	28	31	33	17	24	26	28	31	33	0	0.0	0.0	0.0	0.0	0.0
Hubunah	5	6	7	7	8	9							5	6	7	7	8	9	5	6	7	7	8	9	0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	2	2	2	3	3	3							2	2	2	3	3	3	2	2	2	3	3	3	0	0.0	0.0	0.0	0.0	0.0
Yadamah	3	4	4	4	5	5							3	4	4	4	5	5	3	4	4	4	5	5	0	0.0	0.0	0.0	0.0	0.0
Thar	3	3	3	4	4	4							3	3	3	4	4	4	3	3	3	4	4	4	0	0.0	0.0	0.0	0.0	0.0
Khubash	4	5	6	6	6	7							4	5	6	6	6	7	4	5	6	6	6	7	0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	1	1	1	1	1	1							1	1	1	1	1	1	1	1	1	1	1	1	0	0.0	0.0	0.0	0.0	0.0
Total	113	132	144	156	170	184	1	1	1	1	1	1	114	133	145	157	171	185	114	133	145	157	171	185	0	0	0	0	0	0

Table 1-11 (2) Water Demand Prediction of Najran Region (Option-1)

Najran Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 1 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	68	81	93	102	111	121	1	1	1	1	1	1	69	82	94	103	112	122	65	78	90	98	106	116	3.6	4.2	4.8	5.2	5.6	6.0
Sharurah	9	22	25	28	30	33							9	22	25	28	30	33	9	21	24	26	29	32	0.0	1.0	1.2	1.3	1.4	1.5
Hubunah	3	4	5	6	7	9							3	4	5	6	7	9	3	4	5	6	7	9	0.0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	1	1	2	2	3	3							1	1	2	2	3	3	1	1	2	2	3	3	0.0	0.0	0.0	0.0	0.0	0.0
Yadamah	2	2	3	4	4	5							2	2	3	4	4	5	2	2	3	4	4	5	0.0	0.0	0.0	0.0	0.0	0.0
Thar	1	2	2	3	3	4							1	2	2	3	3	4	1	2	2	3	3	4	0.0	0.0	0.0	0.0	0.0	0.0
Khubash	2	3	4	5	6	7							2	3	4	5	6	7	2	3	4	5	6	7	0.0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	0	1	1	1	1	1							0	1	1	1	1	1	0	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0
Total	85	115	135	150	166	184	1	1	1	1	1	1	86	116	136	151	167	185	82	111	130	144	160	178	4	5	6	6	7	8

Table 1-11 (3) Water Demand Prediction of Najran Region (Option-2)

Najran Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 2 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	68	81	93	101	110	119	1	1	1	1	1	1	69	82	94	102	111	120	65	77	89	97	105	114	3.6	4.2	4.8	5.2	5.6	6.0
Sharurah	9	22	25	27	30	32							9	22	25	27	30	32	9	21	24	26	28	31	0.0	1.0	1.2	1.3	1.4	1.5
Hubunah	3	3	4	5	5	7							3	3	4	5	5	7	3	3	4	5	5	7	0.0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	1	1	1	1	2	2							1	1	1	1	2	2	1	1	1	1	2	2	0.0	0.0	0.0	0.0	0.0	0.0
Yadamah	2	2	2	3	3	4							2	2	2	3	3	4	2	2	2	3	3	4	0.0	0.0	0.0	0.0	0.0	0.0
Thar	1	1	2	2	2	3							1	1	2	2	2	3	1	1	2	2	2	3	0.0	0.0	0.0	0.0	0.0	0.0
Khubash	2	3	3	4	4	5							2	3	3	4	4	5	2	3	3	4	4	5	0.0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	0	1	1	1	1	1							0	1	1	1	1	1	0	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0
Total	85	113	131	144	158	173	1	1	1	1	1	1	86	114	132	145	159	174	82	109	126	138	152	167	4	5	6	6	7	8

Table 1-11 (4) Water Demand Prediction of Najran Region (Option-3)

Najran Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 3 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	61	73	84	92	100	109	1	1	1	1	1	1	62	74	85	93	101	110	59	70	81	88	96	104	3.3	3.8	4.4	4.7	5.1	5.5
Sharurah	8	20	23	25	27	30							8	20	23	25	27	30	8	19	22	24	26	28	0.0	0.9	1.1	1.2	1.3	1.4
Hubunah	2	3	4	5	6	8							2	3	4	5	6	8	2	3	4	5	6	8	0.0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	1	1	1	2	3	3							1	1	1	2	3	3	1	1	1	2	3	3	0.0	0.0	0.0	0.0	0.0	0.0
Yadamah	1	2	3	3	4	5							1	2	3	3	4	5	1	2	3	3	4	5	0.0	0.0	0.0	0.0	0.0	0.0
Thar	1	2	2	3	3	4							1	2	2	3	3	4	1	2	2	3	3	4	0.0	0.0	0.0	0.0	0.0	0.0
Khubash	2	3	3	4	5	6							2	3	3	4	5	6	2	3	3	4	5	6	0.0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	0	1	1	1	1	1							0	1	1	1	1	1	0	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0
Total	77	103	121	135	149	166	1	1	1	1	1	1	78	104	122	136	150	167	74	100	117	130	144	160	3	5	5	6	6	7

Table 1-11 (5) Water Demand Prediction of Najran Region (Option-4)

Najran Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 4 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	65	77	89	97	105	115	1	1	1	1	1	1	66	78	90	98	106	116	62	74	85	93	101	110	3.5	4.0	4.6	4.9	5.3	5.8
Sharurah	8	21	24	26	29	31							8	21	24	26	29	31	8	20	23	25	27	30	0.0	1.0	1.1	1.2	1.3	1.4
Hubunah	3	3	4	6	7	9							3	3	4	6	7	9	3	3	4	6	7	9	0.0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	1	1	2	2	3	3							1	1	2	2	3	3	1	1	2	2	3	3	0.0	0.0	0.0	0.0	0.0	0.0
Yadamah	2	2	3	3	4	5							2	2	3	3	4	5	2	2	3	3	4	5	0.0	0.0	0.0	0.0	0.0	0.0
Thar	1	2	2	3	3	4							1	2	2	3	3	4	1	2	2	3	3	4	0.0	0.0	0.0	0.0	0.0	0.0
Khubash	2	3	4	5	6	7							2	3	4	5	6	7	2	3	4	5	6	7	0.0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	0	1	1	1	1	1							0	1	1	1	1	1	0	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0
Total	81	109	128	142	158	175	1	1	1	1	1	1	82	110	129	143	159	176	78	105	123	137	152	169	3	5	6	6	7	7

Table 1-11 (6) Water Demand Prediction of Najran Region (Option-5)

Najran Region Municipal Water 5% <-- Reclaimed Wastewater

Option - 5 Industrial Water 30% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	58	69	79	87	94	103	1	1	1	1	1	1	59	70	80	88	95	104	56	66	76	83	91	99	3.1	3.6	4.1	4.5	4.8	5.2
Sharurah	7	19	21	24	26	28							7	19	21	24	26	28	7	18	20	22	25	27	0.0	0.9	1.0	1.1	1.2	1.3
Hubunah	2	3	4	5	6	8							2	3	4	5	6	8	2	3	4	5	6	8	0.0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	1	1	1	2	2	3							1	1	1	2	2	3	1	1	1	2	2	3	0.0	0.0	0.0	0.0	0.0	0.0
Yadamah	1	2	2	3	4	4							1	2	2	3	4	4	1	2	2	3	4	4	0.0	0.0	0.0	0.0	0.0	0.0
Thar	1	1	2	2	3	4							1	1	2	2	3	4	1	1	2	2	3	4	0.0	0.0	0.0	0.0	0.0	0.0
Khubash	2	3	3	4	5	6							2	3	3	4	5	6	2	3	3	4	5	6	0.0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	0	1	1	1	1	1							0	1	1	1	1	1	0	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0
Total	72	98	114	127	141	157	1	1	1	1	1	1	73	99	115	128	142	158	70	94	110	123	136	151	3	5	5	6	6	6

Table 1-11 (7) Water Demand Prediction of Najran Region (Option-6)

Najran Region

Option - 6

Municipal Water 0% <-- Reclaimed Wastewater

Industrial Water 0% <-- Reclaimed Wastewater

Cities /Town	Municipal Water Demand						Industrial Water Demand						Total Water Demand (Mun.+Ind.)						Municipal Water Supply System						Water Supply from Reclaimed Wastewater					
	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035	2010	2015	2020	2025	2030	2035
Najran	68	81	93	102	111	121	1	1	1	1	1	1	69	82	94	103	112	122	69	82	94	103	112	122	0.0	0.0	0.0	0.0	0.0	0.0
Sharurah	9	22	25	28	30	33							9	22	25	28	30	33	9	22	25	28	30	33	0.0	0.0	0.0	0.0	0.0	0.0
Hubunah	3	4	5	6	7	9							3	4	5	6	7	9	3	4	5	6	7	9	0.0	0.0	0.0	0.0	0.0	0.0
Badr Al Janub	1	1	2	2	3	3							1	1	2	2	3	3	1	1	2	2	3	3	0.0	0.0	0.0	0.0	0.0	0.0
Yadamah	2	2	3	4	4	5							2	2	3	4	4	5	2	2	3	4	4	5	0.0	0.0	0.0	0.0	0.0	0.0
Thar	1	2	2	3	3	4							1	2	2	3	3	4	1	2	2	3	3	4	0.0	0.0	0.0	0.0	0.0	0.0
Khubash	2	3	4	5	6	7							2	3	4	5	6	7	2	3	4	5	6	7	0.0	0.0	0.0	0.0	0.0	0.0
Al Kharkhir	0	1	1	1	1	1							0	1	1	1	1	1	0	1	1	1	1	1	0.0	0.0	0.0	0.0	0.0	0.0
Total	85	115	135	150	166	184	1	1	1	1	1	1	86	116	136	151	167	185	86	116	136	151	167	185	0	0	0	0	0	0

2. Future Water Demand

The predicted water demand as municipal water supply system regarding all of the options is shown in Figure 2-1 - Figure 2-5.

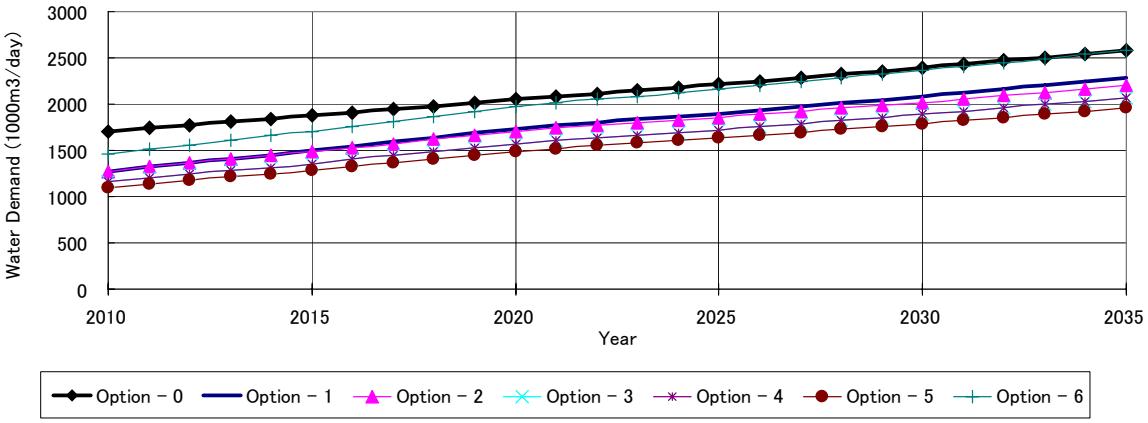


Figure 2-1 Trends of Future Water Demand (Makkah Region)

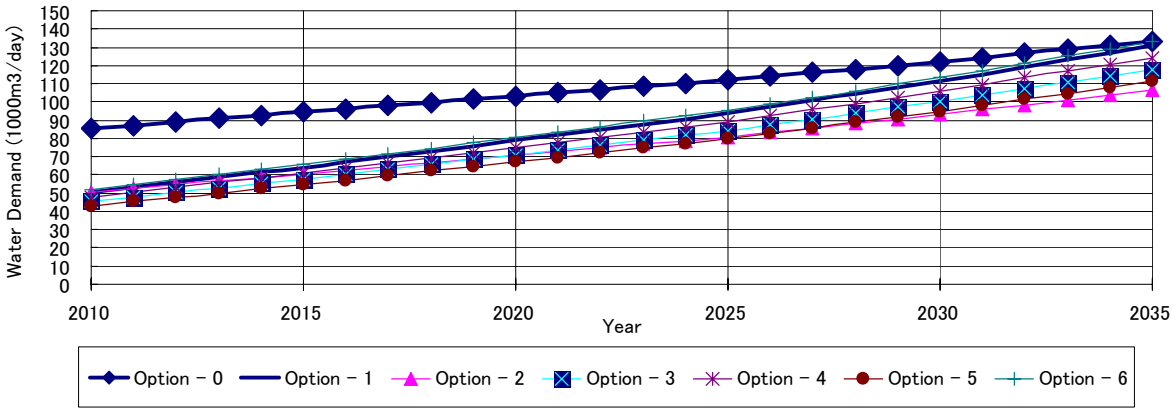


Figure 2-2 Trends of Future Water Demand (Al Baha Region)

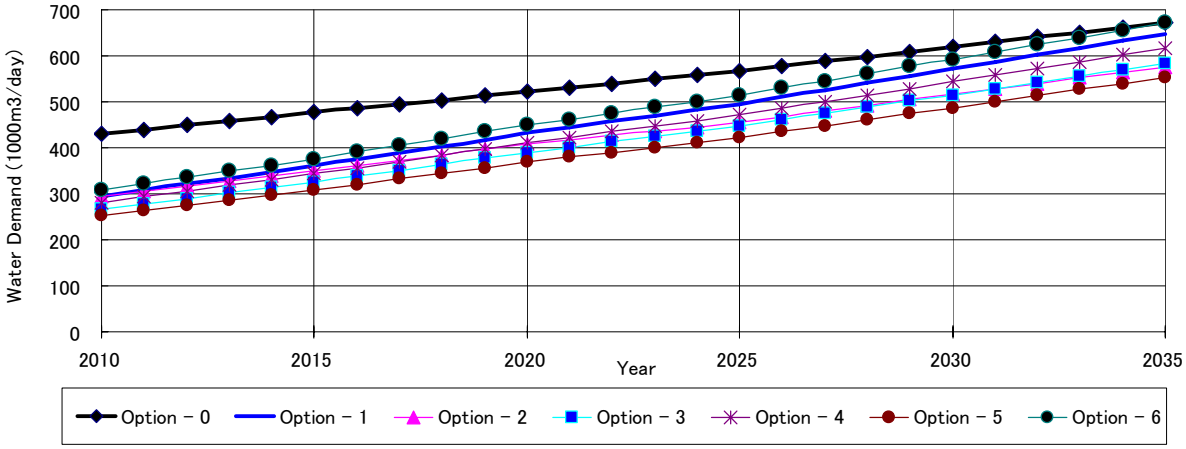


Figure 2-3 Trends of Future Water Demand (Asir Region)

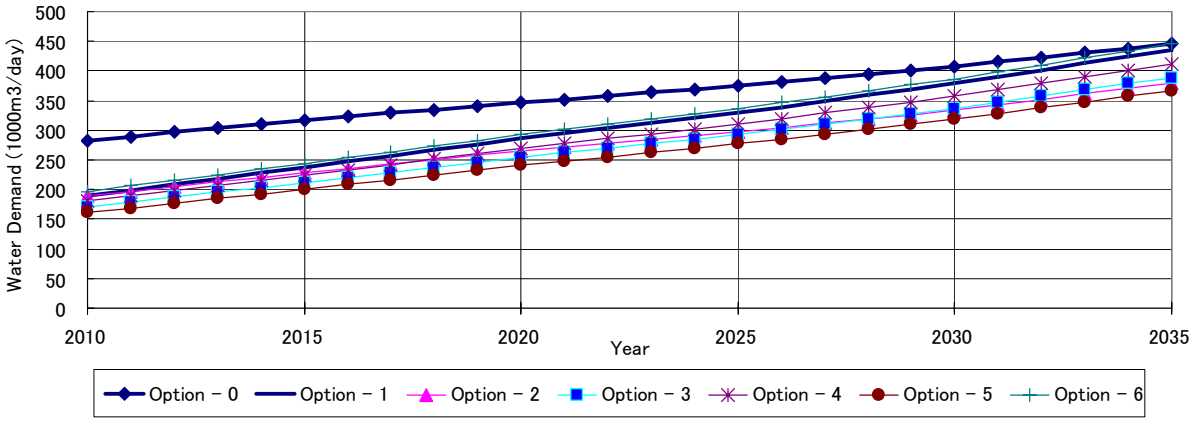


Figure 2-4 Trends of Future Water Demand (Jazan Region)

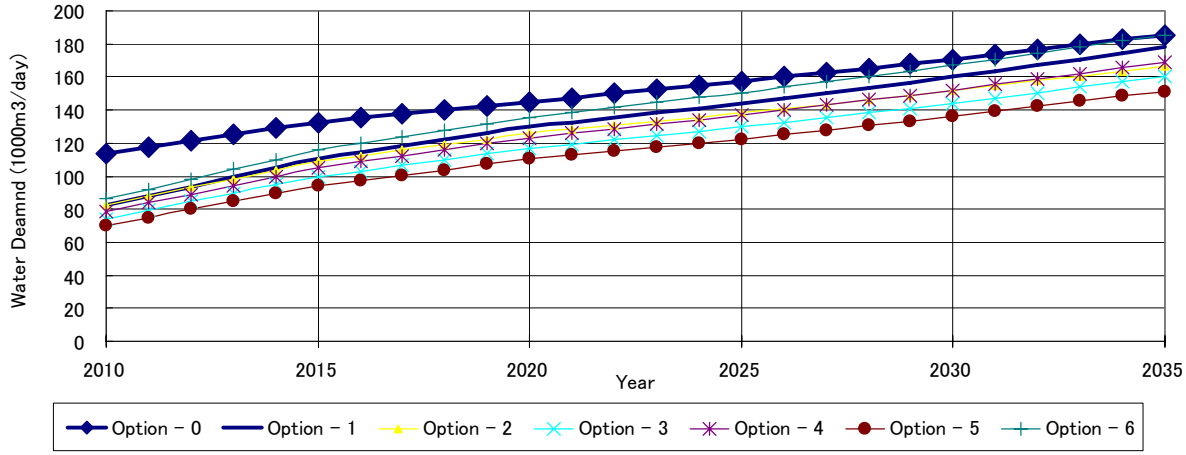


Figure 2-5 Trends of Future Water Demand (Najran Region)

Below is the predicted water demand regarding Option-1. It is applied for water supply facility plan to represent water demand as shown in Figures 2-6 – 2-10. Industrial water demand is allocated in each governorate based on the existing factory location and tentative plan.

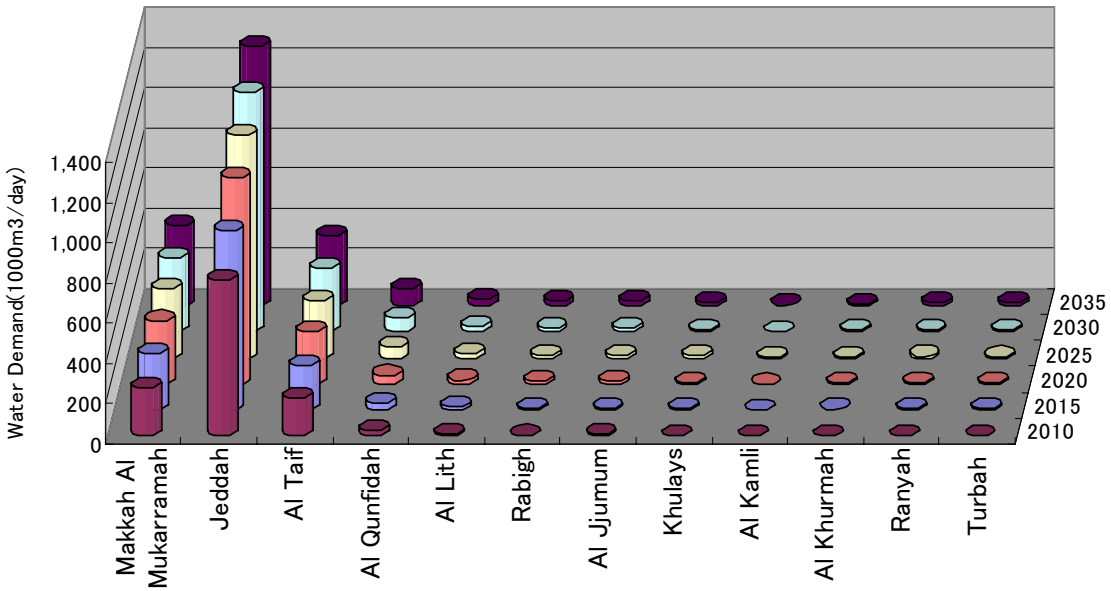


Figure 2-6 Municipal Water Demand by Governorate in Makkah Region (Option-1)

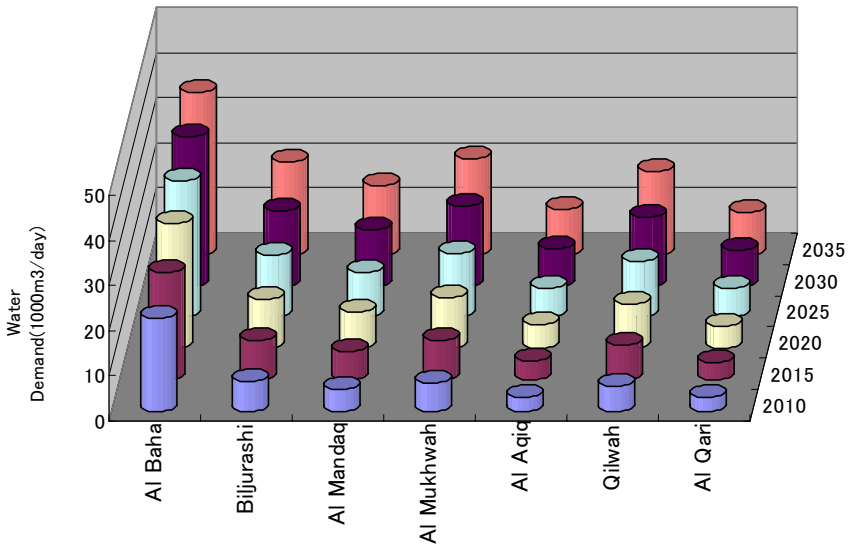


Figure 2-7 Municipal Water Demand by Governorate in Al Baha Region (Option-1)

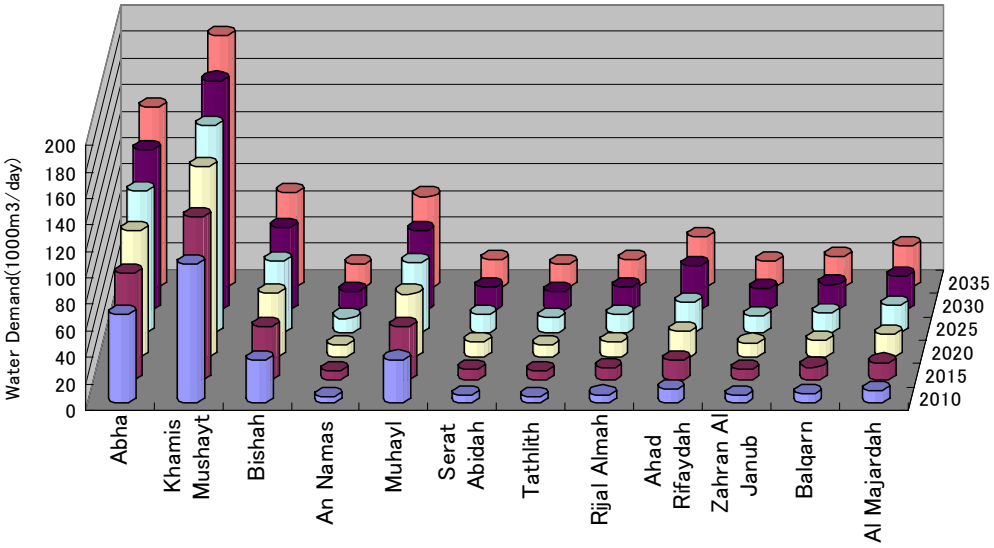


Figure 2-8 Municipal Water Demand by Governorate in Asir Region (Option-1)

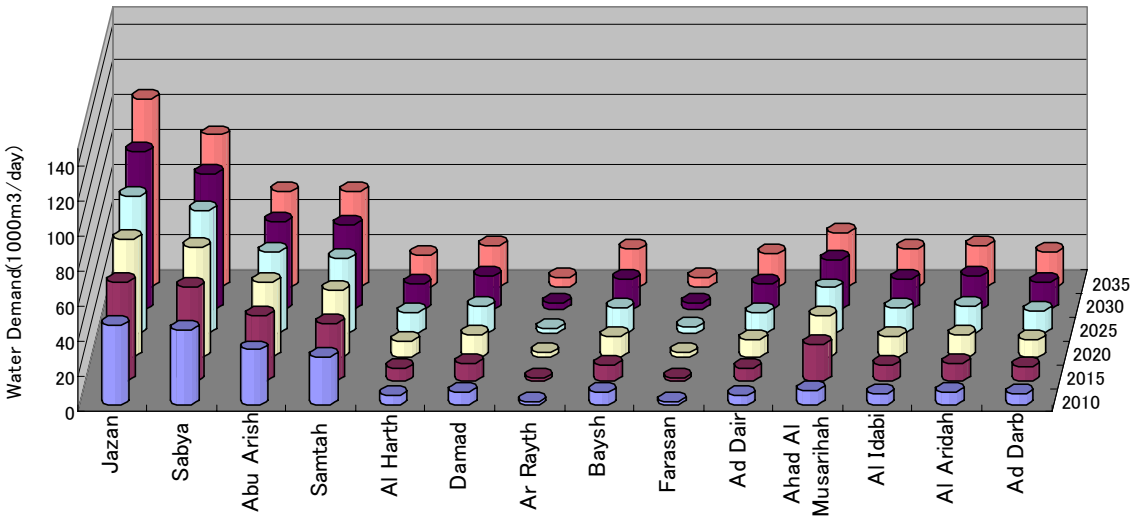


Figure 2-9 Municipal Water Demand by Governorate in Jazan Region (Option-1)

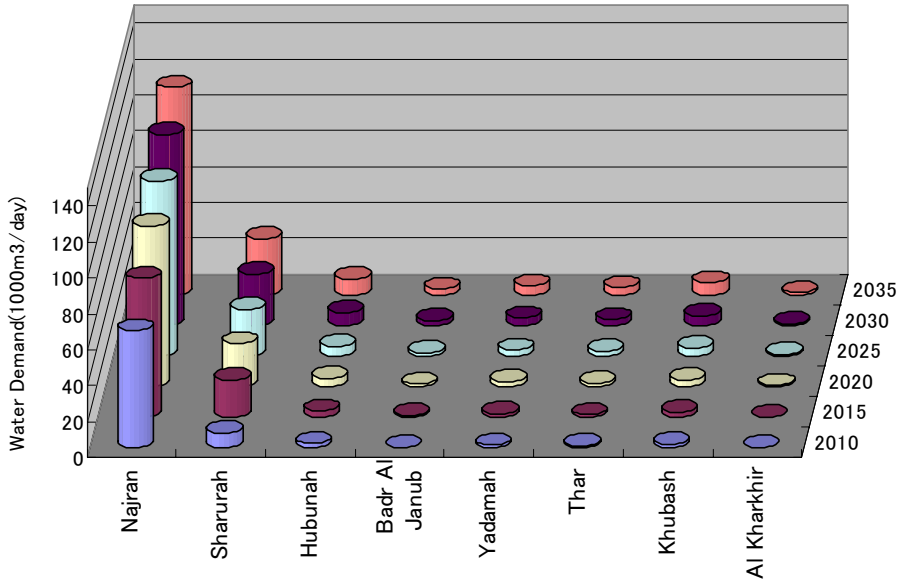


Figure 2-10 Municipal Water Demand by Governorate in Najran Region (Option-1)

The Kingdom of Saudi Arabia

The Ministry of Water and Electricity (MOWE)

THE STUDY ON MASTER PLAN

ON

RENEWABLE WATER RESOURCES DEVELOPMENT IN THE SOUTHWEST REGION

IN

THE KINGDOM OF SAUDI ARABIA

FINAL REPORT

(SUPPORTING REPORT)

F. GROUNDWATER SIMULATION

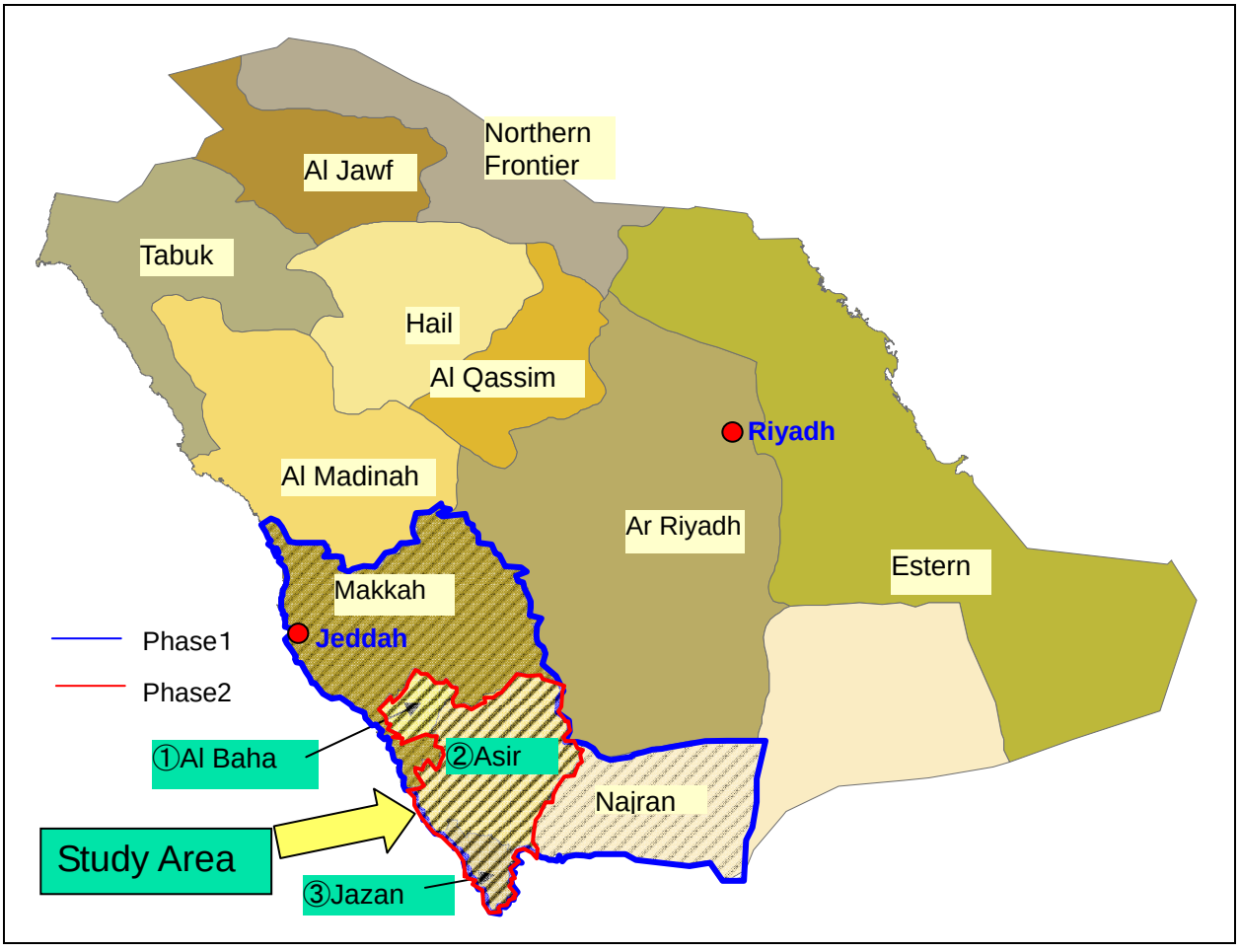
OCTOBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

SANYU CONSULTANTS INC.

The Kingdom of Saudi Arabia Location of Map



Final Report
Supporting Report (F)

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List of Abbreviations

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
BCM	Billion Cubic Meters	مليار متر مكعب	10 億立方メーター
CBD	Convention on Biological Diversity	اتفاقية التنوع البيولوجي	生物多様性保全条約
C/P	Counterpart	النظير	カウンターパート
EIA	Environment Impact Assessment	تقييم الأثر البيئي	環境アセスメント
ER	Effective Rainfall	الأمطار الفعالة	有効雨量
ET	Evapotranspiration	البخرنتح	蒸発散
FAO	Food and Agriculture Organization, United Nations	منظمة الأغذية والزراعة للأمم المتحدة	国連食料農業機関
GIS	Geographic Information System	نظام المعلومات الجغرافية	地理情報システム
GPS	Global Positioning System	نظام تحديد المواقع العالمي	グローバル・ポジショニング・システム
GDP	Gross Domestic Product	الانتاج المحلي الإجمالي	国内総生産
GDW	General Directorate of Water		地方水事務所
GNI	Gross National Income	الدخل القومي الإجمالي	国民総所得
GSMO	Grain Silos and Flour Mills Organization	صوامع الحبوب ومطاحن الدقيق	サイロ・製粉公団
GTZ	Deutsche Gesellschaft fur Technical Zusammenarbeit GmbH	الجمعية الألمانية للتعاون التقني المحدودة	ドイツ技術協力公社
IC/R	Inception Report	تقرير الإنشاء	インセプション・レポート
IEE	Initial Environmental Examination	الفحص البيئي الأولي	初期環境調査
IUCN	World Conversion Union	اتحاد التحويل العالمي	国際自然保護連合
IWPP	Independent Water and Power Project	المياه المستقلة وطاقة المشروع	独立水道・発電事業
IWRP	Integrated Water Resources Planning	التخطيط المتكامل للموارد المائية	総合水資源計画
JCCME	Japan Cooperation Center for Middle East	مركز التعاون الياباني للشرق الأوسط	財団法人中東協力センター
JICA	Japan International Cooperation Agency	الوكالة اليابانية للتعاون الدولي	独立行政法人国際協力機構
KSA	Kingdom of Saudi Arabia	المملكة العربية السعودية	サウジアラビア王国
LCD	Liter per Capita per Day	لتر للفرد يوميا	リッター/人/日
MAW	Ministry of Agriculture and Water	وزارة الزراعة والمياه	水・農業省
MEPA	Meteorology and Environment Protection Administration	ادارةالأرصاد الجوية و حماية البيئة	気象環境保護庁
MCM	Million Cubic Meters	مليون متر مكعب	100 万立方メーター
M/M	Minutes of Meeting	ملخص الاجتماع	会議の議事録
MMW	Million Megawatt	مليون ميغاوات	100 万メガワット
NAS	National Agriculture Strategy	استراتيجية الزراعة الوطنية	国家農業戦略
NGO	Non-Governmental Organization	المنظمات غير الحكومية	民間公益団体
NMS	National Mining Strategy	استراتيجية التعدين الوطنية	国家鉱業戦略
NSS	National Spatial Strategy	استراتيجية العمران الوطنية	国家特別戦略
NWC	National Water Company	شركة المياه الوطنية	国家水会社
MWS	National Water Strategy	الاستراتيجية الوطنية للمياه	国家水戦略
MOA	Ministry of Agriculture	وزارة الزراعة	農業省
MOEP	Ministry of Economy and Planning	وزارة الاقتصاد والتخطيط	国家経済計画省
MOF	Ministry of Finance	وزارة المالية	財務省
MOI	Ministry of Interior	وزارة الداخلية	内務省
MOMRA	Ministry of Municipal and Rural Affairs	وزارة الشؤون البلدية والقروية	地方自治省
MOWE	Ministry of Water and Electricity	وزارة المياه والكهرباء	水・電力省
M/P	Master Plan	الخطة الرئيسية	マスタープラン
MSR	Million Saudi Riyals	مليون ريال سعودي	100 万サウジリアル

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
NCWCD	National Commission for Wildlife Conservation and Development	اللجنة الوطنية لحماية و تطويرالحياة البرية	国立動物保護開発協会
NIA	National Irrigation Authority	السلطة الوطنية للري	国家灌漑局
PME	Presidency of Meteorology and Environment Protection	الرئاسة العامة للأرصاد وحماية البيئة	国家気象環境保護
P/O	Plan of Operation	خطة العمل	プラン オブ オペレーション
PPP	Public Private Partnership	شراكة القطاعين العام والخاص	官民連携
RWPC	Renewable Water Production Corporation	شركة إنتاج المياه المتجددة	再生可能水生産公社
REWLIP	Red Sea Water Lifeline Project	شريان الحياة للمياه البحر الأحمر المشروع	紅海水ライフライン事業
OJT	On the Job Training	التدريب المهني	研修
SAGIA	Governor Saudi Arabian General Investment Authority	محافظ الهيئة العامة للاستثمار العربي السعودي	サウジアラビア総合投資庁
SAMA	Saudi Arabian Monetary Agency	مؤسسة النقد العربي السعودي	サウジアラビア通貨庁
SAR	Saudi Arabian Riyal	الريال السعودي	サウジアラビアリアル
SCT	Supreme Council for Tourism	المجلس الأعلى للسياحة	最高観光委員会
SEA	Strategic Environment Assessment	التقييم البيئي الاستراتيجي	戦略的環境アセスメント
SGS	Saudi Geological Survey	هيئة المساحة الجيولوجية السعودية	サウジ地質調査
SOIETZ	Saudi Organization for Industrial Estates and Technology Zone	الهيئة السعودية للمدن الصناعية و للمنطقة التكنولوجية	サウジ産業国家技術団体
SR	Saudi Riyals	الريال السعودي	サウジリアル
STP	Strategic Transformation Plan	خطة التحول الاستراتيجي	戦略的転換計画
STP	Sewerage Treatment Plant	محطة معالجة الصرف الصحي	下水処理プラント
S/W	Scope of Works	العملنطاق	業務範囲
SWAT	Soil and Water Assessment Tool	أداة تقييم التربة والمياه	土壌水アセスメントツール
SWCC	Saline Water Conversion Corporation	المؤسسة العامة لتحلية المياه المالحة	海水淡水化公社
UFW	Unaccounted For Water	مياه غير محسوبة	無収水
UNDP	United Nations Development Programme	برنامج الأمم المتحدة للتنمية	国連開発計画
UN-ESCWA	United Nations Economic and Social Commission for Western Asia	اللجنة الاقتصادية والاجتماعية للأمم المتحدة لغربي آسيا	国連西アジア経済社会委員会
WB	The World Bank	البنك الدولي	世界銀行
WHO	World Health Organizations	منظمة الصحة العالمية للأمم المتحدة	世界保健機関
WMO	World Meteorological Organization	المنظمة العالمية للأرصاد الجوية	世界気象機関

F. GROUNDWATER SIMULATION

1. Impact Analysis by Groundwater Extraction

1.1 Analysis for Lowering of Groundwater Level

Alluvial plain is widely distributed in Jazan Region. Alluvial plan consists of sand and gravel with high permeability, forming excellent aquifer. Large amount of groundwater is pumped up from the aquifer and used for agriculture and water supply. However in recent years, groundwater level is going down, and seawater is advancing toward inland due to over pumping, causing negative impact to groundwater use. If the groundwater extraction is continued by the same amount, groundwater environment will become worse in the future. This Study predicted the future groundwater environment of Jazan Region.

(1) History of Groundwater Environment of Jazan Region

Groundwater environment of Jazan Region has been changed as shown in Figure 1-1 with groundwater development. Groundwater analysis of this Study simulated such history and predicted the future groundwater environment.

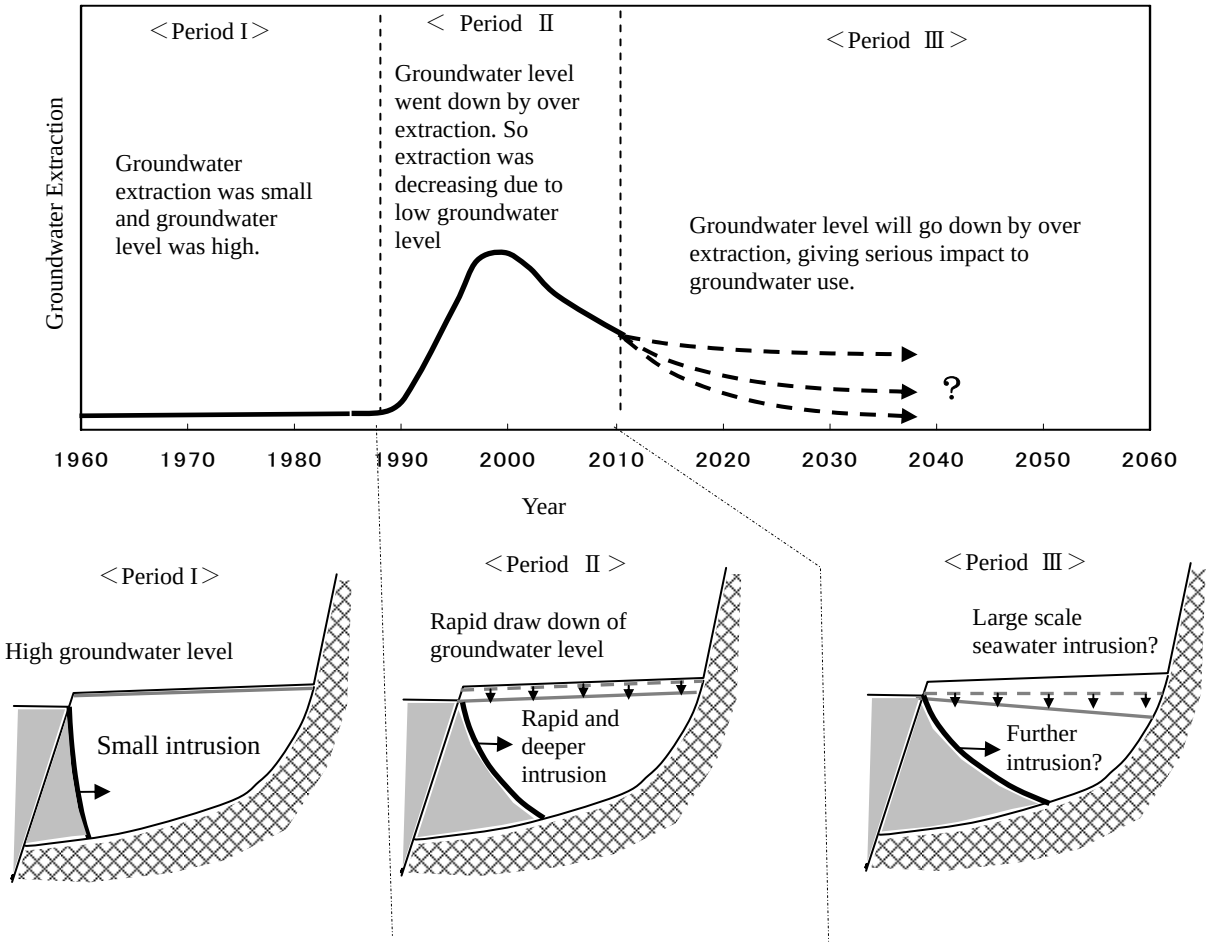


Figure 1-1 History of Groundwater Environment and Future Prediction

(2) Groundwater Simulation Model

Groundwater simulation was conducted for the area of Quaternary distribution in Jazan Region as shown in Figure 1-2. The simulation model is explained below:

Figure 1-2 Area for Simulation

Table 1-1 Outline of Simulation Model

Item	Content
Simulation program	MODFLOW（USGS, 1990）
Size of cell	1km×1km
Number of cell	5832cells×3 layers

(a) Aquifer Model

Quaternary formation of Jazan Region shows horizontal structure of almost constant layer thickness with similar aquifer parameters. Based on such hydrogeological characteristics, aquifer model was constructed by 3-larers structure.

Table 1-2 Aquifer Model

Aquifer	Geological formation	Thickness (m)	Mote
1st aquifer	Alluvium and Pleistocene	50m	Alluvium is classified into i) wadi sediments, ii) coastal sediments, iii) sand dune sediment and iv) flood plain sediments. Pleistocene sediments consist of sand and gravel.
2nd aquifer	Pleistocene	250m	2nd aquifer consists of Pleistocene formation with sand sediments, which is distributed in the entire Jazan Region.
3rd aquifer	Older than Tertiary	More than 200m	3rd aquifer consists of many formation of various age, forming basement of Quaternary aquifer. 3rd aquifer, however, is treated as single aquifer with low permeability.

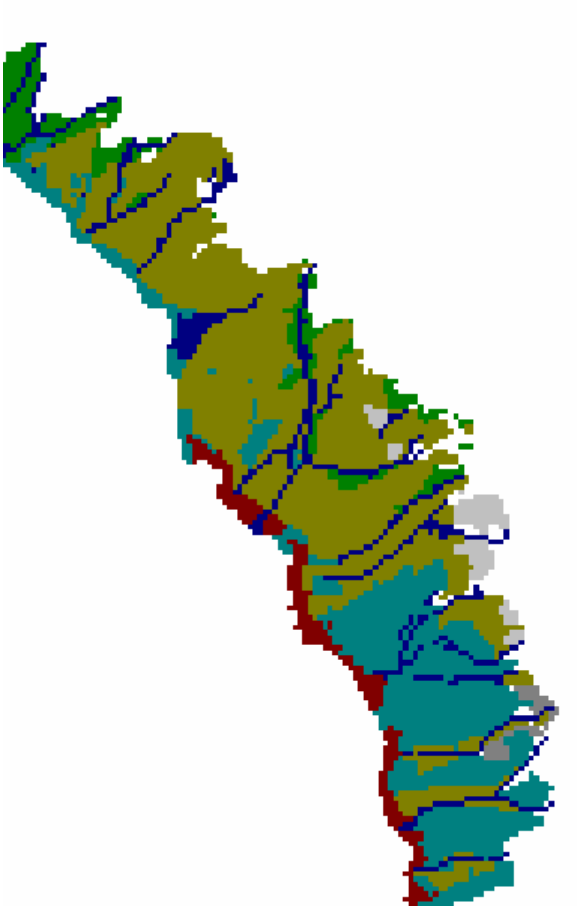


Table 1-3 Parameter of Aquifer

Mark	Classification	Permeability (m/day)	Storativity (1/m)	Effective porosity
	Wadi	50	10^{-3}	0.20
	Coastal sand	10	10^{-3}	0.10
	Flood plain	20	10^{-4}	0.15
	Late Pleistocene	10	10^{-5}	0.10
	Early Pleistocene	10	10^{-5}	0.10
	Basalt	20	10^{-4}	0.15
	Flood Plain	20	10^{-4}	0.15
	Tertiary	0.1	10^{-5}	0.02

Figure 1-3 Aquifer Model (Geological Unit of 1st Layer)

(b) Boundary Condition

Boundary condition of the simulation model for Quaternary aquifer is shown in Figure 1-4.

Table 1-4 Boundary Condition of Model

Type of Boundary Condition		Content
(1) Recharge	Groundwater recharge from main wadis	Groundwater recharge was given to model along boundary between plain and mountain of 4 main wadi basins. Groundwater recharge from the remaining basins also was given.
	Groundwater charge from wadi beds	Groundwater recharge from wadis beds was given to model in middle to up-stream reaches of wadi. Wadi discharge from the remaining basins was also given to model as groundwater recharge.
(2) Constant groundwater level		Groundwater level is set constant (=0m) along coastal line.
(3) Groundwater extraction		Groundwater extraction was given by governorate.

Table 1-5 Groundwater Extraction by Governorate

Mark	Extraction (MCM/year)	
	Year of 1990-2009	Year of 2010-
	9.8	17.2
	2.7	4.6
	102.9	180.4
	16.2	28.4
	17.1	30.1
	42.4	74.4
	101.8	178.5
	127.2	223.1
Total	420.1	736.7

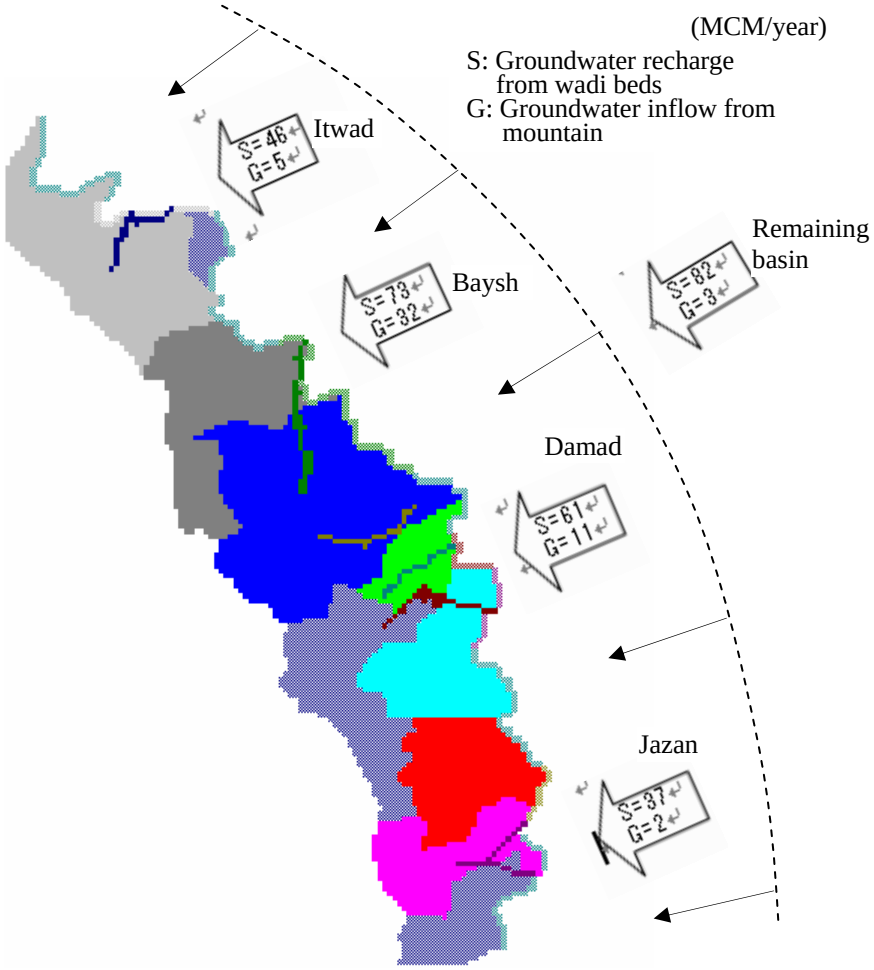


Figure 1-4 Boundary Condition of Simulation

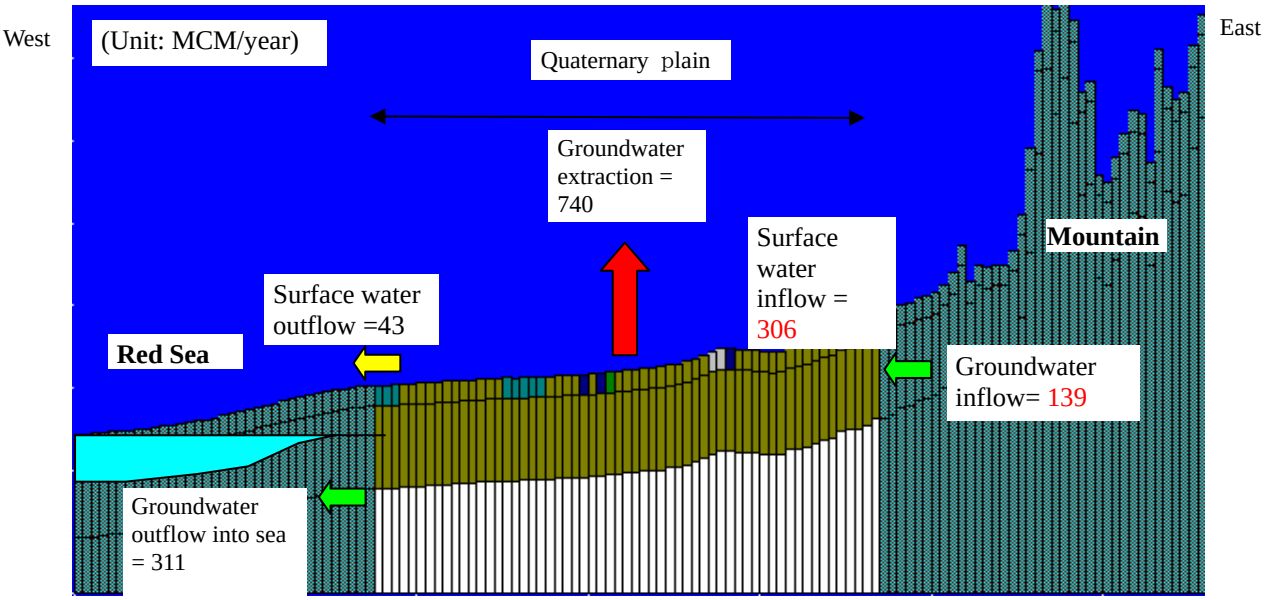


Figure 1-5 Water Balance Given to Model

Water balance given to the model (see Figure 1-5) was based on result of water balance analysis of this Study. Water balance of Jazan Region was as summarized as follows:

Groundwater recharge

= Surface water inflow + Groundwater inflow - Surface water outflow to Red Sea
= 306 + 139 - 43 (MCM/year)
= 402 (MCM/year)

Groundwater extraction

- Year of 1990-2009 : 420 (MCM/year)
- Year of after 2010 : 740 (MCM/year)

Most of groundwater in Jazan Region is used for agriculture. Amount of groundwater extraction was evaluated based on groundwater consumption of agriculture. Water leakage between wells and crop fields was assumed to infiltrate into aquifer. Therefore, only water consumption by evapo-transpiration from crops was given to the model as groundwater extraction. Relation below was used for estimation of groundwater extraction from crops.

Evapo-transpiration from crops = Amount of water conveyance from wells to crop fields /1.67

Water balance of Quaternary Plain

= Groundwater Recharge - Groundwater Extraction
= 402 - 740 (MCM/year)
= - 338 (MCM/year)

As seen above, groundwater extraction exceeds groundwater recharge by 338MCM/year in Jazan Region. Such over-extraction situation currently continues in Jazan Region.

(c) Procedure of Simulation

Future draw-down of groundwater level was predicted by groundwater simulation. Simulation was conducted by 2 steps as explained in Table 1-6. Both steps were done by non-equilibrium analysis.

Table 1-6 Procedure of Groundwater Simulation

Step	Simulation period	Content
1st Step	Year of 1990-2009	It was assumed that groundwater extraction was started in large scale after year of 1990 in Jazan Region (see Figure1-1). Based on this assumption, groundwater extraction of 420MCM/year was given to model. Initial groundwater level was given to model as same as ground elevation (m), because amount of groundwater extraction was small and groundwater level was high before year of 1990.
2nd step	Year of 2010-2060	Calculated groundwater level of year 2009 of the 1st simulation result was given to model as initial groundwater level. Groundwater extraction of 740MCM/year was given to model.

(d) Result of simulation

The predicted groundwater level in Jazan Region is shown in Figure-6 and Figure 1-7. As seen in those figures, large draw-down of groundwater level was predicted in the southern part of Jazan Region. Groundwater level will be lower than sea level in wide area. This is because groundwater extraction extremely exceeds groundwater recharge as shown below:

(A) Groundwater recharges 402MCM/year

(B) Groundwater extraction 740MCM/year

(A) - (B) -338MCM/year

Deficit in water balance, -338MCM/year, is compensated by consuming groundwater storage of aquifer. This causes regional groundwater level draw-down. Draw-down of groundwater level will cause i) seawater intrusion in the coastal area and ii) rising of salty groundwater from deep aquifer in the entire Jazan Region (see Figure 1-8). Above condition was also predicted by simulation as explained below:

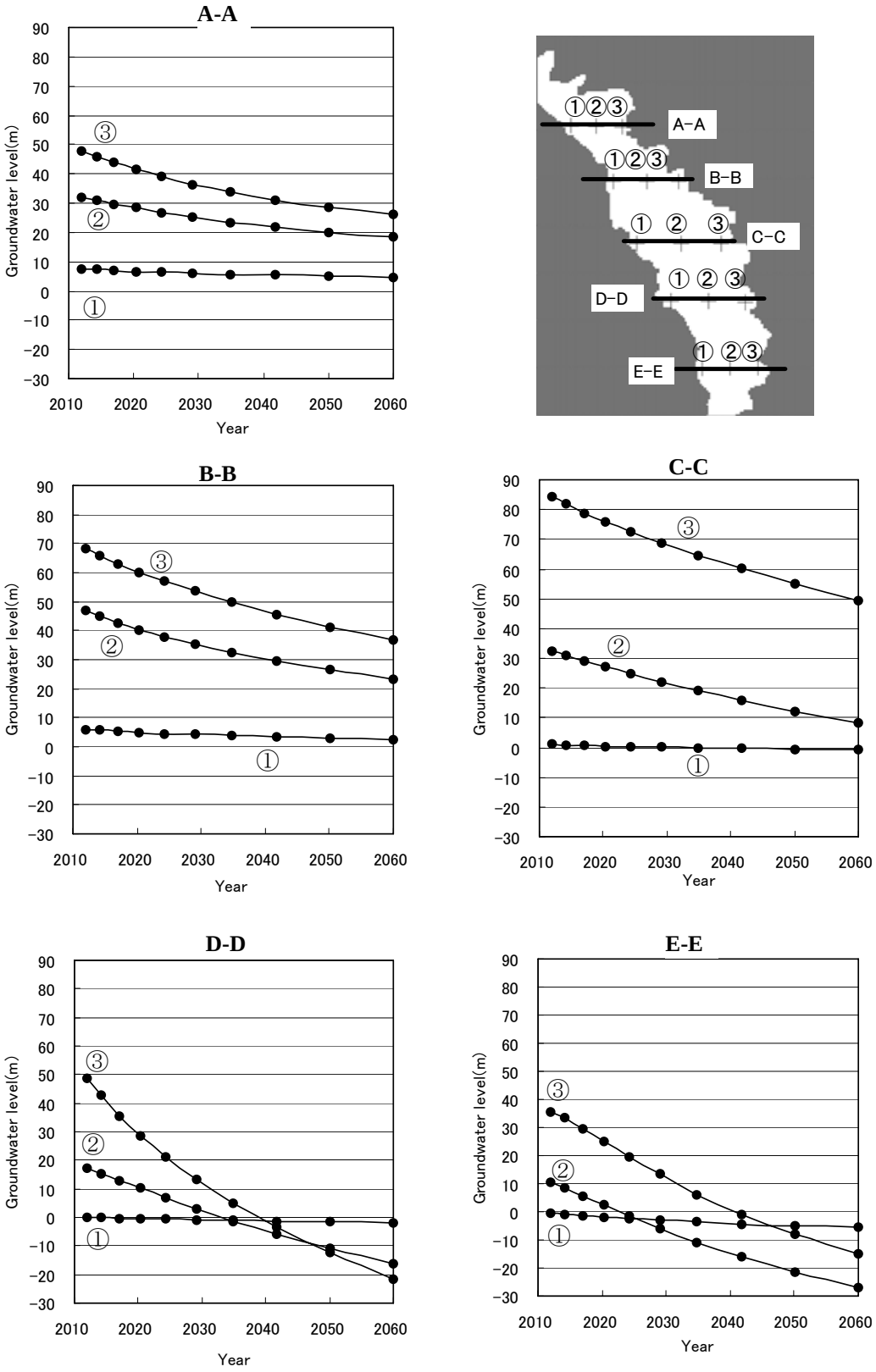


Figure 1-6 Predicted Groundwater Level (Groundwater Extraction: 740MCM/year)

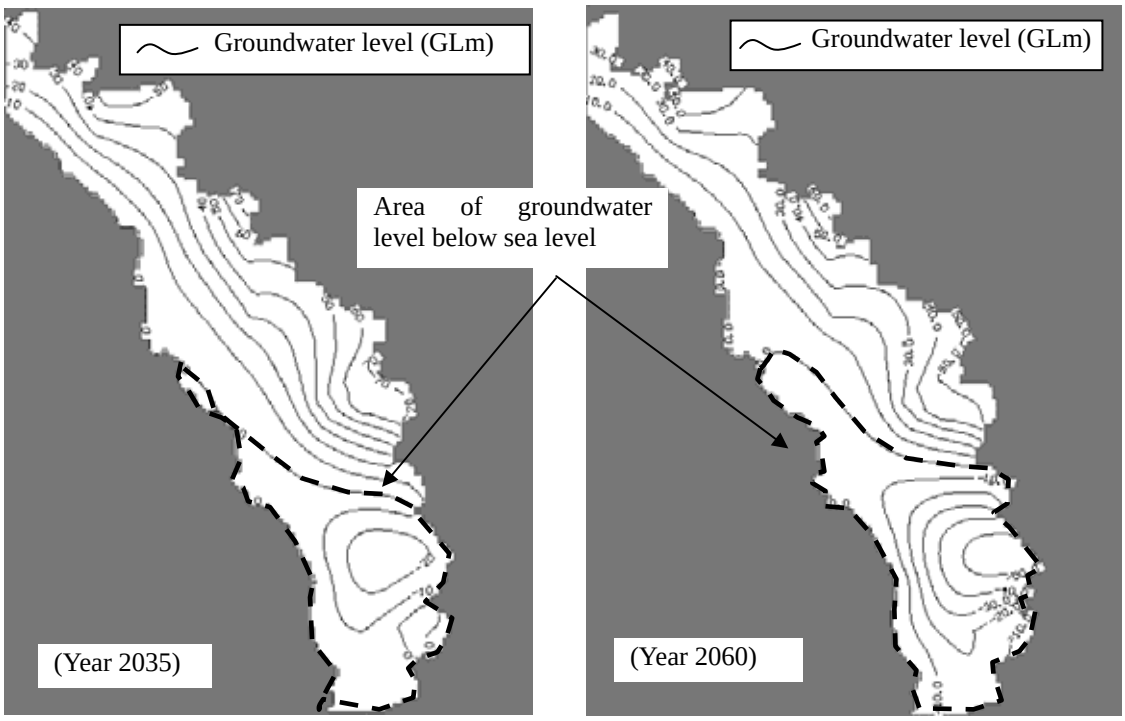


Figure 1-7 Predicted Area under Seawater Level

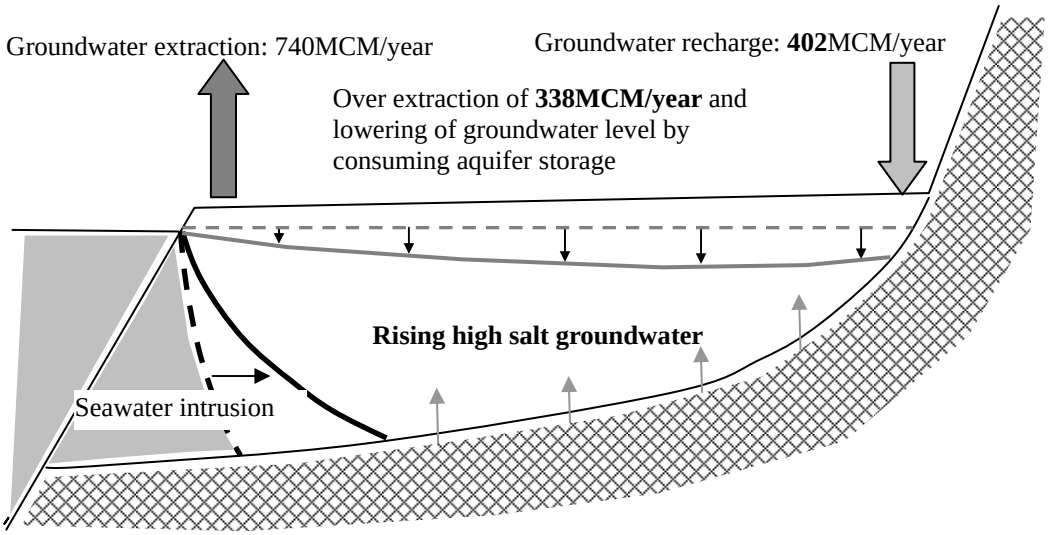


Figure 1-8 Groundwater Problem by Over-extraction of Groundwater

1.2 Simulation of Seawater Intrusion

In the coastal area, seawater will intrude into aquifer by draw-down of groundwater level. Interface between fresh water and seawater will move following amount of groundwater which flows toward sea (see Figure 1-9). Decreasing groundwater flow will make the interface move toward inland. Seawater intrusion by the current groundwater extraction was predicted by simulation.

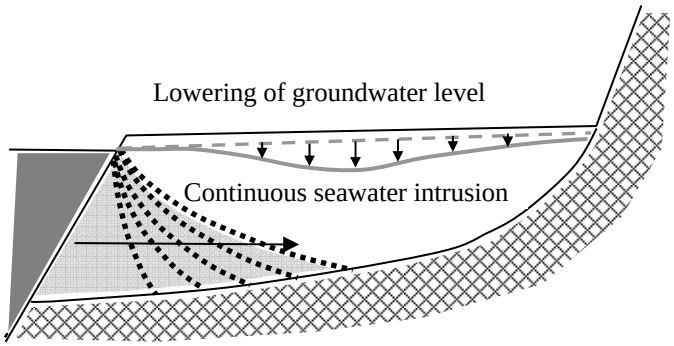


Figure 1-9 Continuous Seawater Intrusion

Aquifer model and boundary condition

Aquifer model and boundary condition is same as those above explained (see 3.6.1).

Method of Simulation

Density analysis is necessary for seawater intrusion because gravity effect, which is caused by difference in density between fresh/seawater, is dominant in this phenomenon. The program "SHARP" (USGS, 1990) are commonly used for analysis of seawater intrusion and used for this Study. Analysis of SHARP is based on assumption that fresh water and seawater is divided by sharp interface without being mixed. This simulation was performed by non-equilibrium analysis.

Result of analysis

Result of analysis is shown in Figure 1-11 and Figure 1-12. These results shows the situation of seawater intrusion by groundwater extraction of 740MCM/year. According to the result, interface between fresh /seawater will continuously move toward inland in the southern part of Jazan. It should be noticed that the analyzed result shows average location of the interface. Actually, interface will be locally going up as shown in Figure 1-10. In interpretation of the simulation result, matters below should be considered.

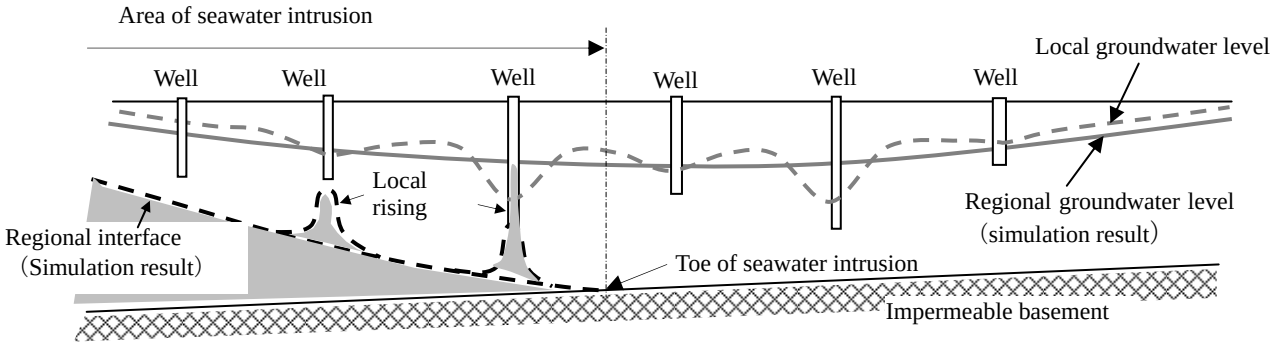


Figure 1-10 Local Rising of Interface (Upconing)

- Scale of seawater intrusion depends on the total amount of groundwater extracted from Quaternary aquifer by area. Speed of moving interface is highest in the southern part of Jazan, which was predicted 80m/year.
- Seawater will locally go up by pumping and infiltrate into wells. Such phenomenon is called as "Upconing" (see Figure 1-10). Due to upcoming, salt concentration of groundwater is different well by well in the area of seawater intrusion.
- Seawater intrusion will not stop even in year of 2060. Groundwater of the most of wells will be finally polluted by seawater in the area of seawater intrusion. It is very dangerous situation.

As method for prevention of seawater intrusion, regulation of groundwater pumping in the coastal area is proposed. However, it is more effective to reduce total amount of groundwater extraction of Jasan Province. This method can make the interface to retreat toward sea.

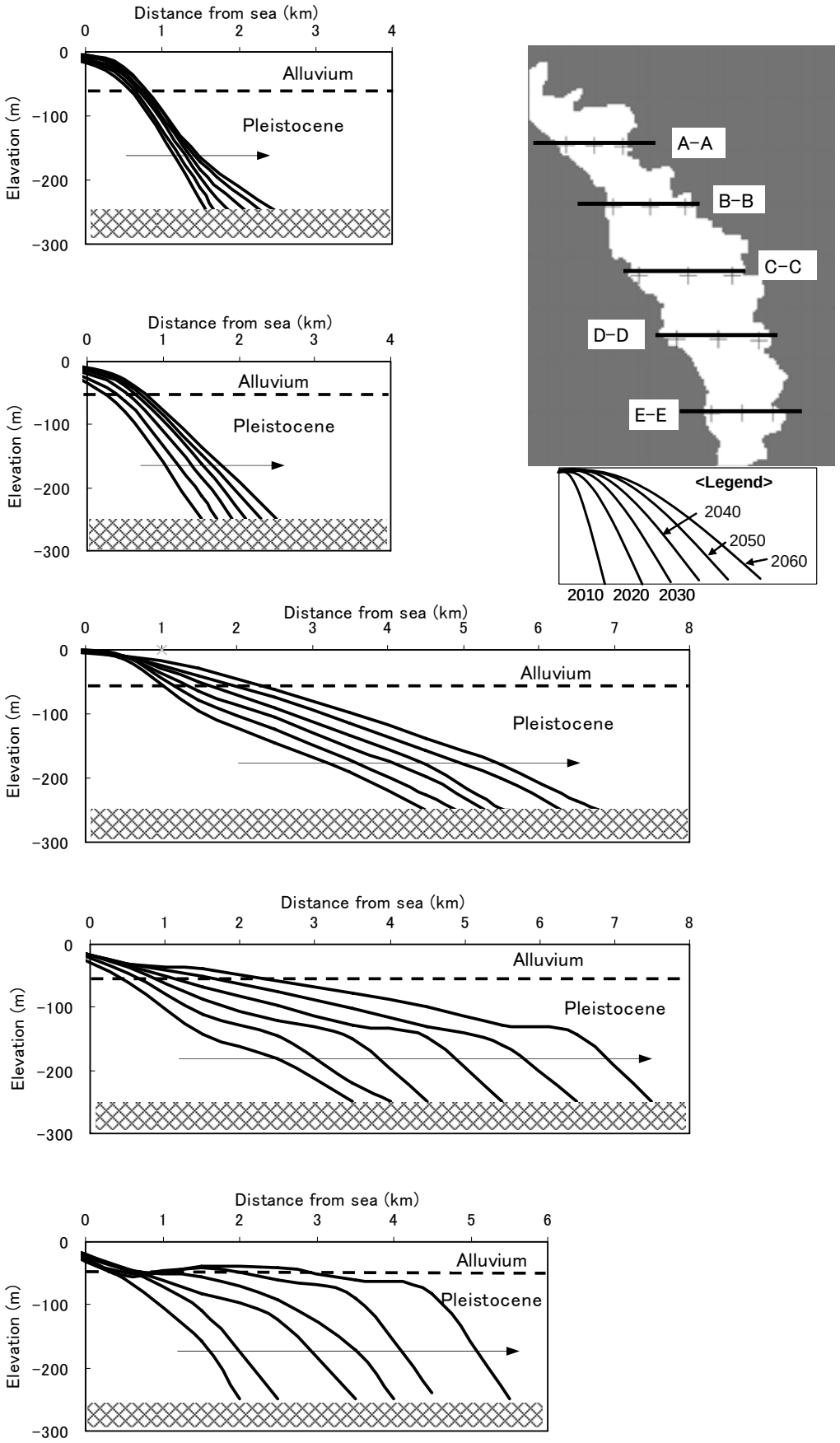


Figure 1-11 Predicted Location of Interface between Fresh /Seawater (2010-2060)

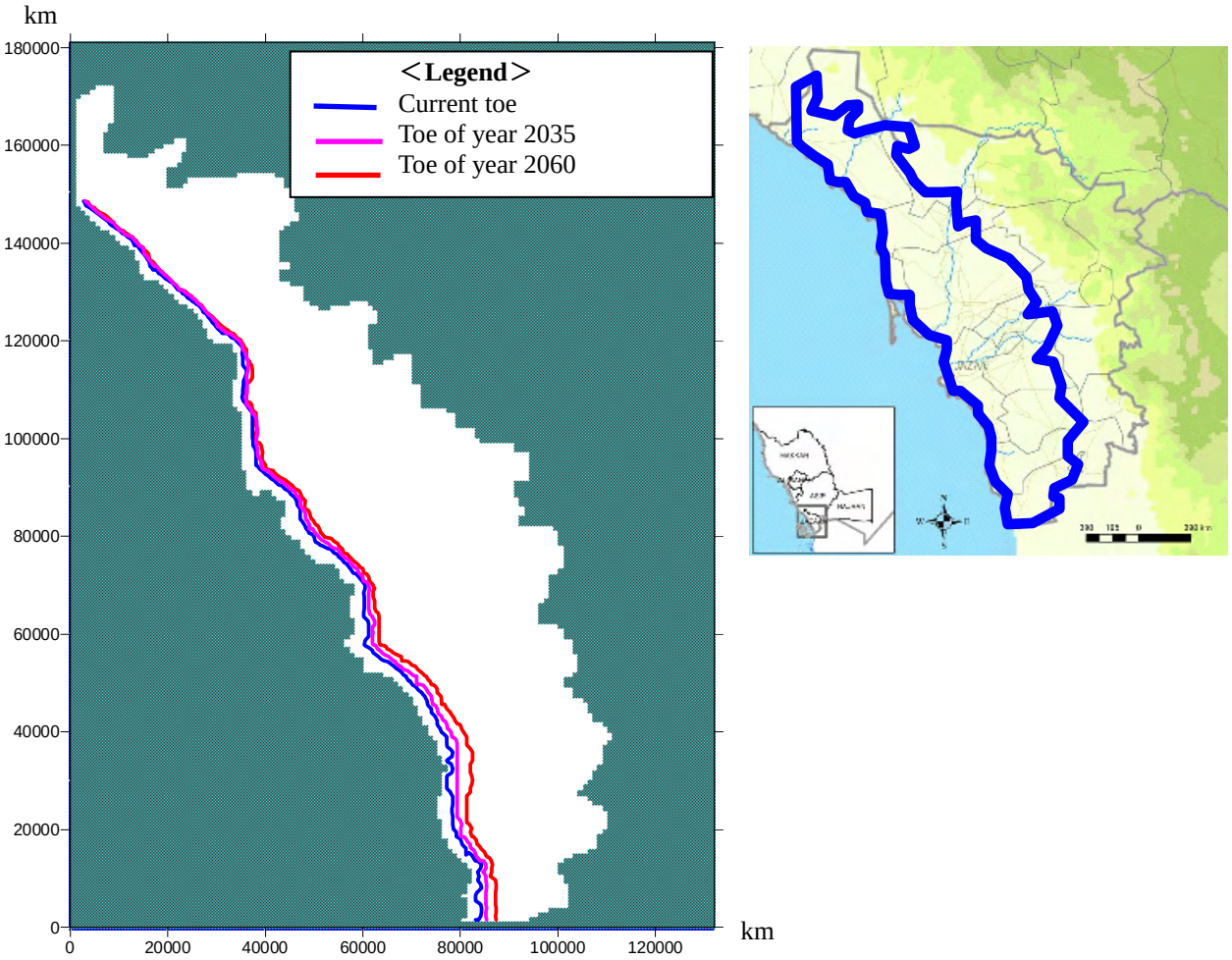


Figure 1-12 Predicted Area of Seawater Intrusion

1.3 Simulation of Rising Salty Groundwater from Deep Aquifer

Apart from seawater intrusion in the coastal area, it was confirmed in this Study that salty groundwater is stored in deep aquifer in the entire Study Area. Salt has been accumulated on the ground under dray climate condition, and it was dissolved and transported by groundwater, and gradually stored in deep aquifer for long period of time. Salty groundwater in deep aquifer will go up by over-extraction of groundwater from Quaternary aquifer.

Aquifer model and boundary condition

Aquifer model and boundary condition is same as those of the simulation model explained in the previous section (see 3.6.1).

Method of Analysis

Salt concentration of groundwater of deep aquifer is much lower than that of seawater. Therefore, advection-dispersion analysis without density consideration can be employed for this analysis. MT3D (USGS, 1993), which is one of package programs for MODFLOW and is commonly used together with MODFLOW, was used for this Study. This simulation was performed by non-equilibrium analysis.

Method of Analysis

Based on the result of water quality analysis by the Study Team (see Table 1-7), the current salt concentration of groundwater was given to model as shown in Figure 1-13. Total dissolved solid (TDS: ppm) was used in this simulation to represent salt concentration of groundwater.

Purpose of this simulation is to know how much salt concentration of groundwater will increase by

rinsing groundwater from the deep aquifer under the current groundwater extraction. Initial and boundary concentration condition was simplified (see Table1-7) and given to the model

Table 1-7 Hydrogeological Interpretation on Result of Water Quality Analysis for Quaternary Groundwater in Jazan Region

TDS concentration		Interpretation for simulation
Average	960ppm	This value was given to model as average salt concentration of groundwater of Quaternary aquifer
Maximum	2,600ppm	This value was given to model as salt concentration of groundwater of deep aquifer.

Note) 45 samples were analyzed

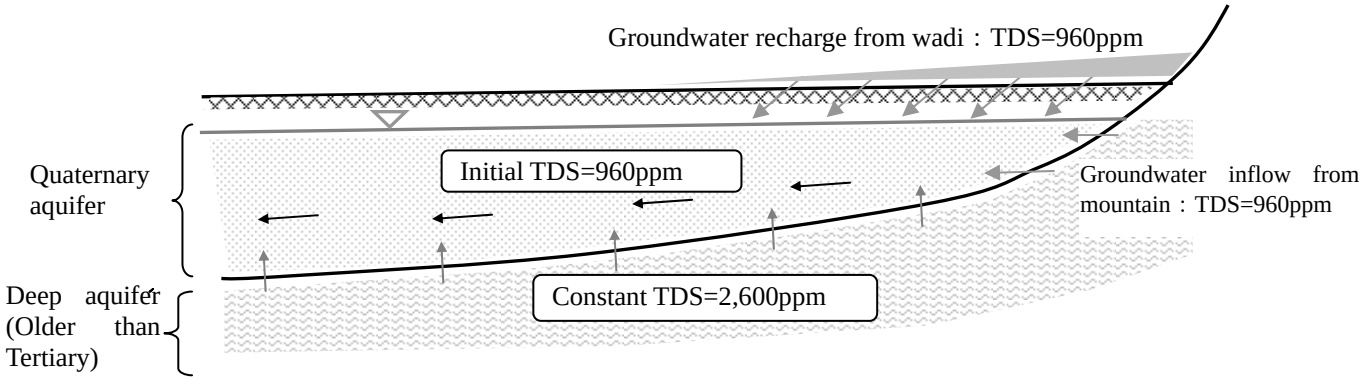


Figure 1-13 Initial and Constant TDS Concentration of Simulation

Table 1-8 Parameter and the other Condition for Simulation

Item	Note
TDS Concentration	• TDS concentration of groundwater is fixed to 2,600pm for deep aquifer. • TDS concentration of groundwater recharged from wadi bed and mountain is fixed to 960ppm.
Dispersion length of aquifer = 50m	Most important parameter dominating dispersion of groundwater flow is dispersion length of aquifer. In case when analyzing area is large, macroscopic dispersion length (MDL) should be used for analysis. MDL depends on observation length of groundwater flow. Length of groundwater flow of Quaternary aquifer of Jazan Region is 30km, which can be considered as observation length. Corresponding MDS was set as 50m to the model based on Beims'relation (Beims, 1983).
Numerical Method	Finite difference method, which is standard method of MT3D.

Result of Analysis

Result of analysis is shown in Figure 1-14. This result shows predicted TDS concentration in case where groundwater extraction is continued by the current extraction rate of 740MCM/year. As shown in this result, TDS concentration will increase up-to 1,300-1,500ppm from the initial concentration of 960ppm. It can be said that concentration of TDS will become 1.3 to 1.6 times as high as the current level. Relationship between TDS (ppm) and electric conductivity (EC) in the Study Area is expressed as below:

EC (μS/cm) = 1.34×TDS (ppm) + 191

According to above relation, TDS of 1,300-1,500ppm corresponds to EC of 1,300-1,500ppm. It is commonly said that groundwater with EC of less than 2,000 (μS/cm) can be potable and available for live stock and irrigation. Therefore, impact by rising salty groundwater from deep aquifer will not be so serious in groundwater use. However, simulation result shows average TDS concentration. TDS concentration will be much higher where high TSD groundwater is locally stored in deep aquifer.

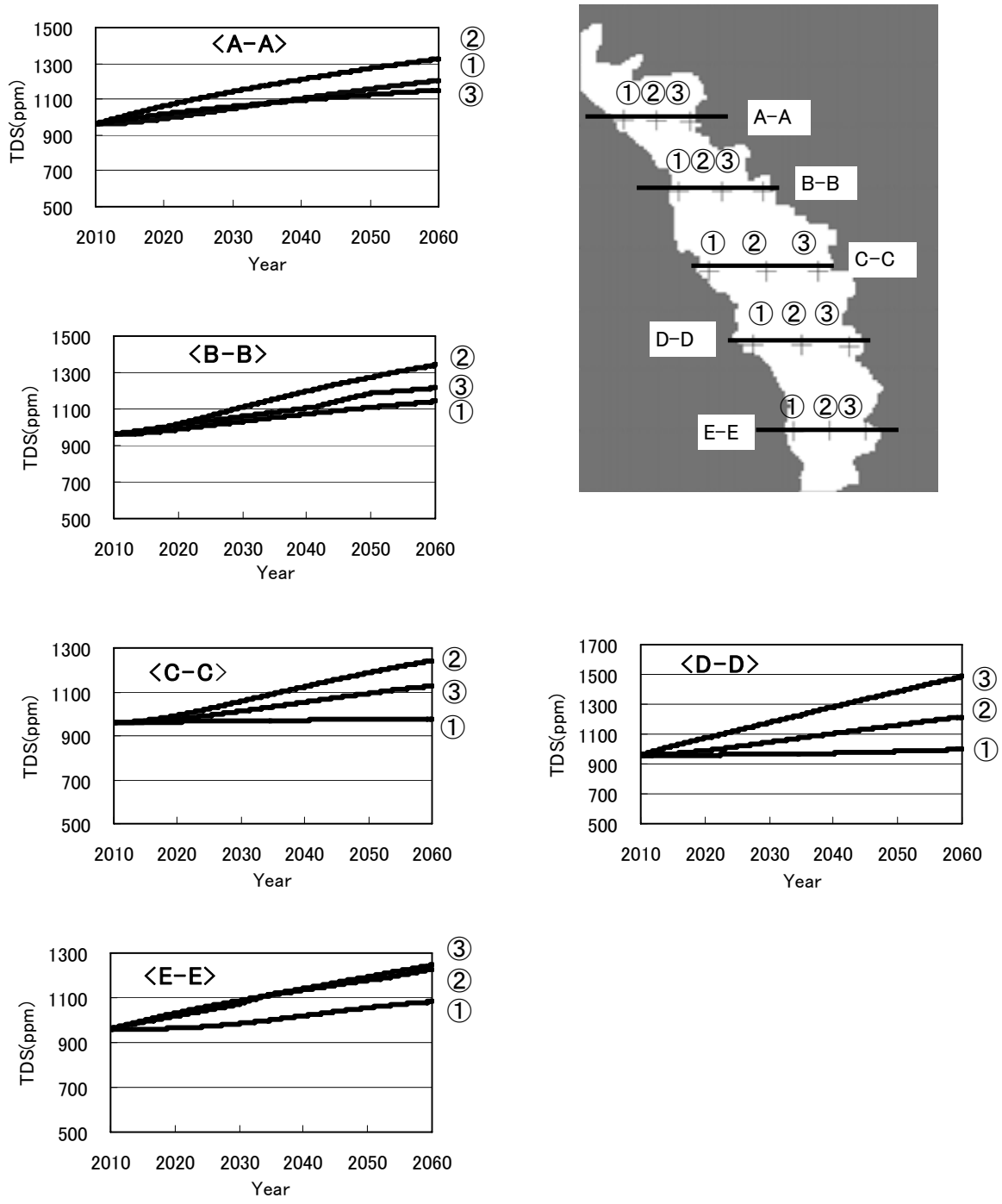


Figure 1-14 Predicted TDS Concentration of Groundwater by Rising Groundwater from Deep Aquifer

1.4 Reduction of Groundwater Extraction

Lowering of groundwater level will be mitigated by reduction of groundwater extraction. Effect of the reduction was analyzed by simulation. The result is shown in Figure 1-15. According to the result, reduction of groundwater extraction of 50% will considerably mitigate groundwater level lowering, and 70% of reduction will stop groundwater lowering. Matters below should be noticed in interpretation of simulation result.

Extremely large amount of groundwater is extracted in the central to the southern part of Jazan Region. Therefore, reduction of groundwater extraction in above area is effective.

Groundwater level will continue to go-down in the northern part of Jazan even after reduction of

groundwater extraction. This is because groundwater level is so low in southern part of Jazan that groundwater is flowing from north to south during recovery of groundwater level. Lowering of groundwater level will continue in northern area until groundwater level of the north and the south become same.

2. Recommendation of Reduction of Groundwater

Lowering of groundwater level will cause both drying-up of wells and reduction of yield form wells. Moreover, it will cause seawater intrusion and rising of salty groundwater from deep aquifer. Especially, seawater intrusion will give serious impact to groundwater use. Therefore, seawater intrusion must be prevented for sustainable groundwater use in Jazan Region. For this purpose, reduction of groundwater extraction is most effective. Matter bellow should be noticed in reduction of groundwater extraction.

Groundwater level should be kept above sea level

If groundwater level becomes lower than sea level, sea water intrusion will occur in large scale. Salt injury will happen in area of sea water intrusion, and it will take long time to recover polluted aquifer. To prevent such disaster, groundwater level must be kept higher than sea level.

Reduction of groundwater extraction in southern part of Jazan

Over-extraction of groundwater is taking place in the central to southern part of Jazan, in 4 governorates of Samtah, Ahad al Musarihah, Sabya and Jazan. Groundwater extraction of those 4 governorates occupies almost 70% of total extraction of Jazan Region. Groundwater extraction should be reduced in above 4 governorates.

According to Figure 2-2, the area of groundwater level below sea level will reduce with reduction of groundwater extraction. Groundwater level will become higher than sea level in the entire Jazan Region in case of reduction of 70%.

Seawater intrusion of the other Region

Based on the example of seawater intrusion in Jazan Region, it can be said that groundwater development potential of the coastal plan along Red Sea will be decided considering how to prevent seawater intrusion. Groundwater development potential of those areas may be around 55% of the total groundwater recharge, according to the example of Jazan Region.

Land subsidence

Land subsidence usually becomes problem in case of groundwater over-extraction of Quaternary area. However, land subsidence will not be problem in Jazan Region. The reason is that i) alluvial formation consists of mainly sands and gravels. Soft clay that causes large land subsidence is not so common in the alluvial, ii) there are few high wave and high tide phenomena in the Study Area, which will escalate damage by land subsidence, iii) there are few buildings apt to suffer damage by land subsidence, such as those with pile foundation.

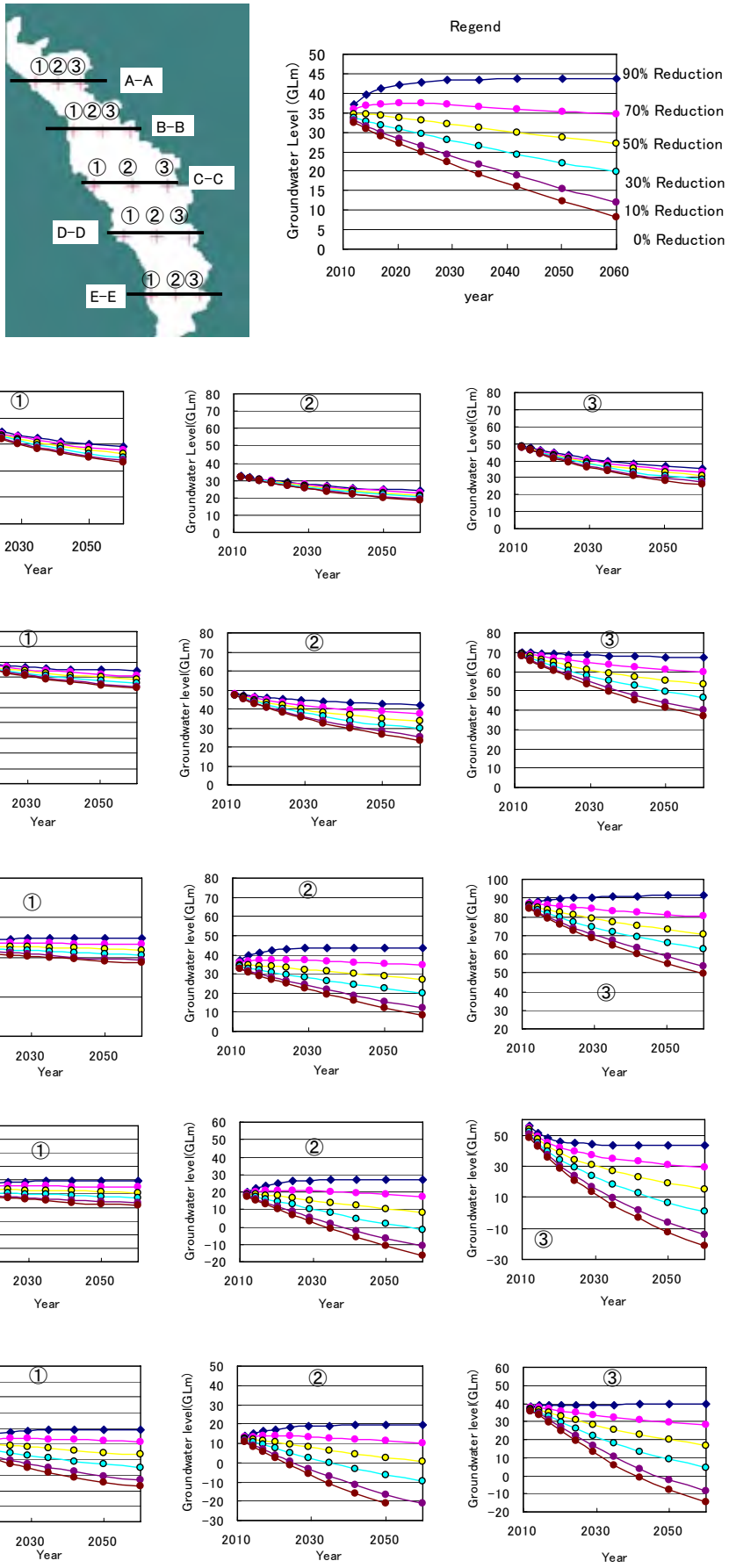


Figure 2-1 Reduction of Groundwater Extraction and Groundwater Level

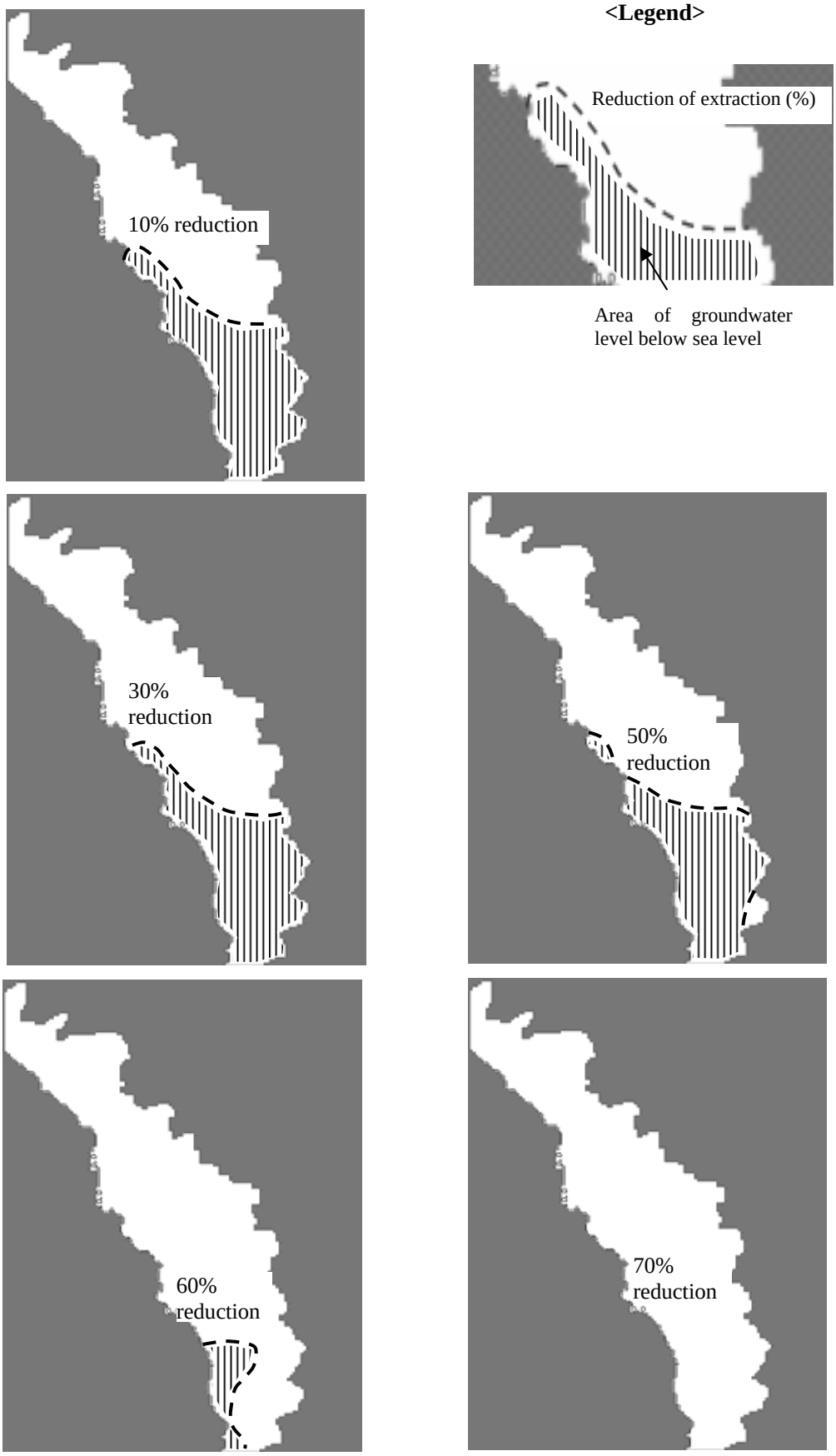


Figure 2-2 Reduction of Groundwater Extraction and Area under Sea Level (year of 2060)

2.1 Groundwater Monitoring

Accuracy of the result of groundwater simulation depends on accuracy of input data to the simulation model, such as result of water balance analysis, water demand analysis and hydrogeological analysis. Of course, there is limit in accuracy of above data.

For the best use of result of groundwater simulation, implementation of groundwater monitoring is effective. Simulation result should be examined by monitoring result. If there is considerable difference between them, its reason must be made clear and simulation result must be modified. Groundwater monitoring plan was proposed in Table 2-1, and monitoring points were proposed in Figure 2-3.

Table 2-1 Groundwater Monitoring Plan

Item	Monitoring well	Frequency of monitoring	Purpose of monitoring
Groundwater level	See Figure 2-3	Once/month	Groundwater level should be observed in area where simulation result indicated big draw-down of groundwater level.
Water quality (Electric conductivity)			Salt concentration of groundwater should be observed in area where simulation result indicated deep sea intrusion/

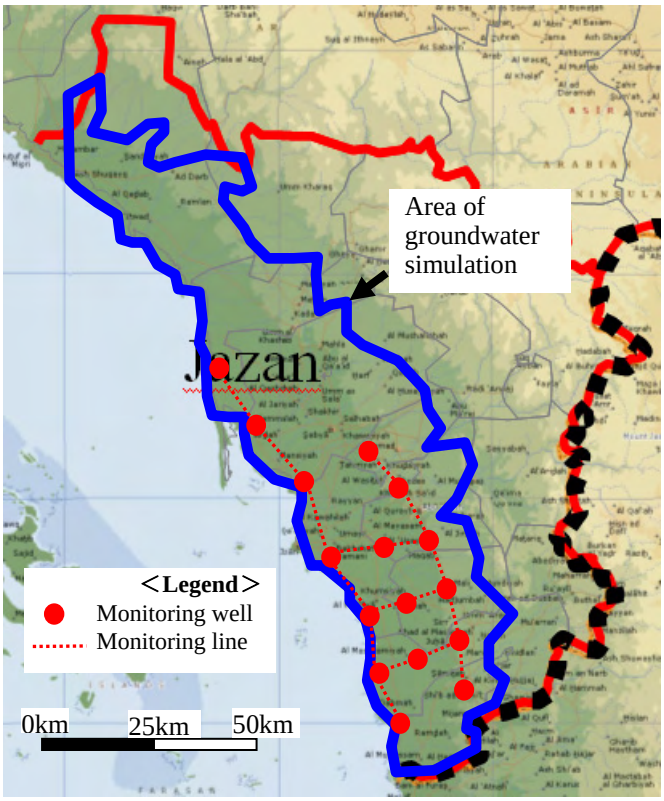


Figure 2-3 Proposed Groundwater Monitoring Location

The Kingdom of Saudi Arabia

The Ministry of Water and Electricity (MOWE)

THE STUDY ON MASTER PLAN

ON

RENEWABLE WATER RESOURCES DEVELOPMENT IN THE SOUTHWEST REGION

IN

THE KINGDOM OF SAUDI ARABIA

FINAL REPORT

(SUPPORTING REPORT)

G. ENVIRONMENTAL AND SOCIAL CONSIDERATION

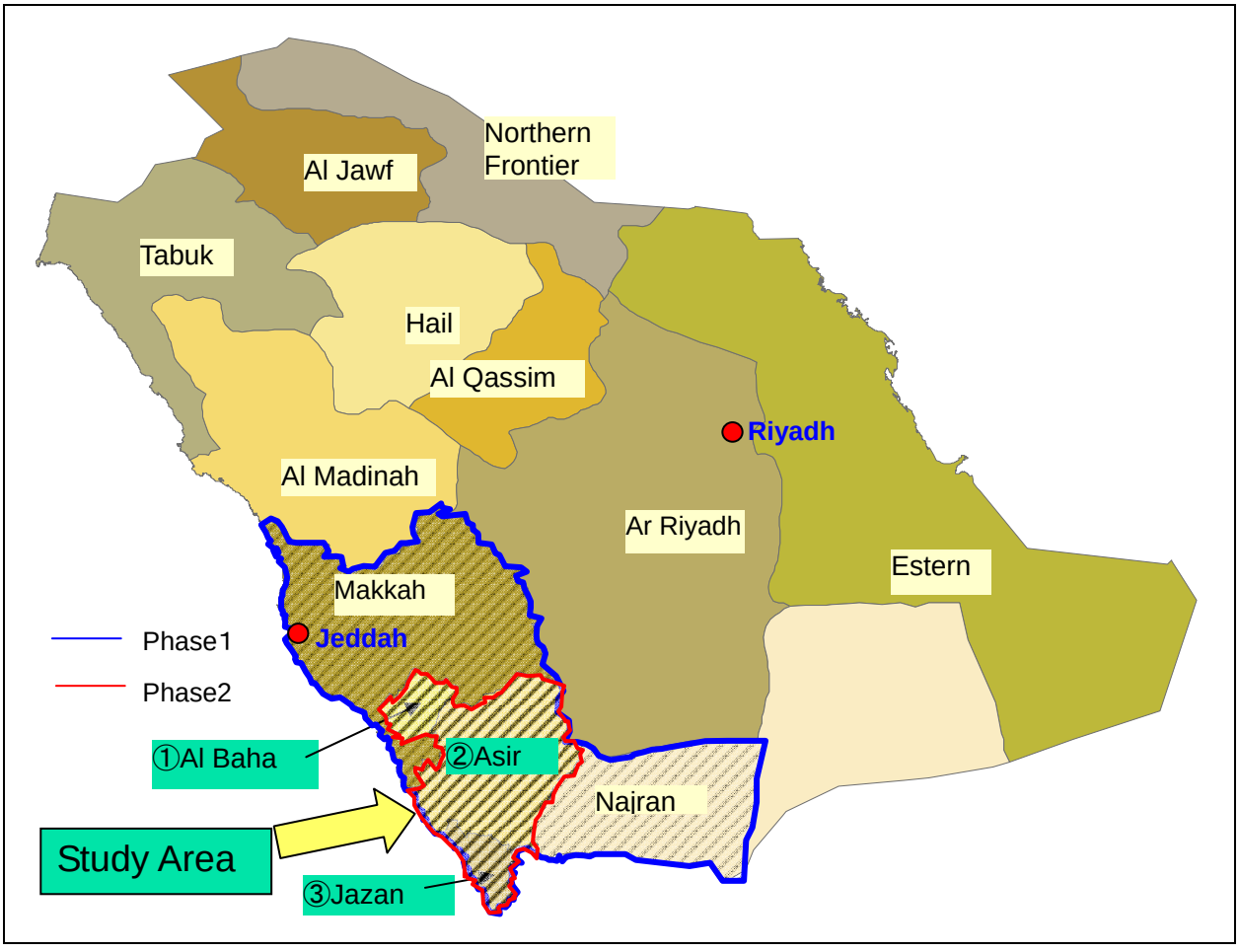
OCTOBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

SANYU CONSULTANTS INC.

The Kingdom of Saudi Arabia Location of Map



Final Report
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List of Abbreviations

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
BCM	Billion Cubic Meters	مليار متر مكعب	10 億立方メーター
CBD	Convention on Biological Diversity	اتفاقية التنوع البيولوجي	生物多様性保全条約
C/P	Counterpart	النظير	カウンターパート
EIA	Environment Impact Assessment	تقييم الأثر البيئي	環境アセスメント
ER	Effective Rainfall	الأمطار الفعالة	有効雨量
ET	Evapotranspiration	البخرنتح	蒸発散
FAO	Food and Agriculture Organization, United Nations	منظمة الأغذية والزراعة للأمم المتحدة	国連食料農業機関
GIS	Geographic Information System	نظام المعلومات الجغرافية	地理情報システム
GPS	Global Positioning System	نظام تحديد المواقع العالمي	グローバル・ポジショニング・システム
GDP	Gross Domestic Product	الانتاج المحلي الإجمالي	国内総生産
GDW	General Directorate of Water		地方水事務所
GNI	Gross National Income	الدخل القومي الإجمالي	国民総所得
GSMO	Grain Silos and Flour Mills Organization	صوامع الحبوب ومطاحن الدقيق	サイロ・製粉公団
GTZ	Deutsche Gesellschaft fur Technical Zusammenarbeit GmbH	الجمعية الألمانية للتعاون التقني المحدودة	ドイツ技術協力公社
IC/R	Inception Report	تقرير الإنشاء	インセプション・レポート
IEE	Initial Environmental Examination	الفحص البيئي الأولي	初期環境調査
IUCN	World Conversion Union	اتحاد التحويل العالمي	国際自然保護連合
IWPP	Independent Water and Power Project	المياه المستقلة وطاقة المشروع	独立水道・発電事業
IWRP	Integrated Water Resources Planning	التخطيط المتكامل للموارد المائية	総合水資源計画
JCCME	Japan Cooperation Center for Middle East	مركز التعاون الياباني للشرق الأوسط	財団法人中東協力センター
JICA	Japan International Cooperation Agency	الوكالة اليابانية للتعاون الدولي	独立行政法人国際協力機構
KSA	Kingdom of Saudi Arabia	المملكة العربية السعودية	サウジアラビア王国
LCD	Liter per Capita per Day	لتر للفرد يوميا	リッター/人/日
MAW	Ministry of Agriculture and Water	وزارة الزراعة والمياه	水・農業省
MEPA	Meteorology and Environment Protection Administration	ادارةالأرصاد الجوية و حماية البيئة	気象環境保護庁
MCM	Million Cubic Meters	مليون متر مكعب	100 万立方メーター
M/M	Minutes of Meeting	ملخص الاجتماع	会議の議事録
MMW	Million Megawatt	مليون ميغاوات	100 万メガワット
NAS	National Agriculture Strategy	استراتيجية الزراعة الوطنية	国家農業戦略
NGO	Non-Governmental Organization	المنظمات غير الحكومية	民間公益団体
NMS	National Mining Strategy	استراتيجية التعدين الوطنية	国家鉱業戦略
NSS	National Spatial Strategy	استراتيجية العمران الوطنية	国家特別戦略
NWC	National Water Company	شركة المياه الوطنية	国家水会社
MWS	National Water Strategy	الاستراتيجية الوطنية للمياه	国家水戦略
MOA	Ministry of Agriculture	وزارة الزراعة	農業省
MOEP	Ministry of Economy and Planning	وزارة الاقتصاد والتخطيط	国家経済計画省
MOF	Ministry of Finance	وزارة المالية	財務省
MOI	Ministry of Interior	وزارة الداخلية	内務省
MOMRA	Ministry of Municipal and Rural Affairs	وزارة الشؤون البلدية والقروية	地方自治省
MOWE	Ministry of Water and Electricity	وزارة المياه والكهرباء	水・電力省
M/P	Master Plan	الخطة الرئيسية	マスタープラン
MSR	Million Saudi Riyals	مليون ريال سعودي	100 万サウジリアル

Abbreviation and Acronym	English	Arabic (عربي)	Japanese (日本語)
NCWCD	National Commission for Wildlife Conservation and Development	اللجنة الوطنية لحماية و تطويرالحياة البرية	国立動物保護開発協会
NIA	National Irrigation Authority	السلطة الوطنية للري	国家灌漑局
PME	Presidency of Meteorology and Environment Protection	الرئاسة العامة للأرصاد وحماية البيئة	国家気象環境保護
P/O	Plan of Operation	خطة العمل	プラン オブ オペレーション
PPP	Public Private Partnership	شراكة القطاعين العام والخاص	官民連携
RWPC	Renewable Water Production Corporation	شركة إنتاج المياه المتجددة	再生可能水生産公社
REWLIP	Red Sea Water Lifeline Project	شريان الحياة للمياه البحر الأحمر المشروع	紅海水ライフライン事業
OJT	On the Job Training	التدريب المهني	研修
SAGIA	Governor Saudi Arabian General Investment Authority	محافظ الهيئة العامة للاستثمار العربي السعودي	サウジアラビア総合投資庁
SAMA	Saudi Arabian Monetary Agency	مؤسسة النقد العربي السعودي	サウジアラビア通貨庁
SAR	Saudi Arabian Riyal	الريال السعودي	サウジアラビアリアル
SCT	Supreme Council for Tourism	المجلس الأعلى للسياحة	最高観光委員会
SEA	Strategic Environment Assessment	التقييم البيئي الاستراتيجي	戦略的環境アセスメント
SGS	Saudi Geological Survey	هيئة المساحة الجيولوجية السعودية	サウジ地質調査
SOIETZ	Saudi Organization for Industrial Estates and Technology Zone	الهيئة السعودية للمدن الصناعية و للمنطقة التكنولوجية	サウジ産業国家技術団体
SR	Saudi Riyals	الريال السعودي	サウジリアル
STP	Strategic Transformation Plan	خطة التحول الاستراتيجي	戦略的転換計画
STP	Sewerage Treatment Plant	محطة معالجة الصرف الصحي	下水処理プラント
S/W	Scope of Works	العملنطاق	業務範囲
SWAT	Soil and Water Assessment Tool	أداة تقييم التربة والمياه	土壌水アセスメントツール
SWCC	Saline Water Conversion Corporation	المؤسسة العامة لتحلية المياه المالحة	海水淡水化公社
UFW	Unaccounted For Water	مياه غير محسوبة	無収水
UNDP	United Nations Development Programme	برنامج الأمم المتحدة للتنمية	国連開発計画
UN-ESCWA	United Nations Economic and Social Commission for Western Asia	اللجنة الاقتصادية والاجتماعية للأمم المتحدة لغربي آسيا	国連西アジア経済社会委員会
WB	The World Bank	البنك الدولي	世界銀行
WHO	World Health Organizations	منظمة الصحة العالمية للأمم المتحدة	世界保健機関
WMO	World Meteorological Organization	المنظمة العالمية للأرصاد الجوية	世界気象機関

G. ENVIRONMENTAL AND SOCIAL CONSIDERATION

1. Background, Objectives and Outline of the Environmental and Social Consideration

1.1 Background

The main objectives of the JICA Study is to assist the Ministry of Water and Electricity (hereinafter referred as to "MOWE") to formulate and elaborate a master plan (M/P) on renewable water resources development in the three (3) regions (Jazan, Najran and Al Baha Regions) in the Kingdom of Saudi Arabia (KSA).

Based on the draft M/P prepared by the JICA Study Team, this environmental and social consideration is taken place with the following subjects;

- Integrated Water Resources Management of the existing, under construction, under planned facilities including construction of 2 new Dams (Ranya Dam and Hirjab Dam), new Pipelines and new Desalination Plants.

1.2 EIA Requirements and IEE in the JICA Study

Referring to the Article five (5) of the General Environmental Law and Rules for Implementation (2001) and Appendix-2 of its associated regulation on the Environmental Standard, environmental study is not necessary at the phase of M/P study whereas it is required for implementation of a feasibility study. Therefore, environmental study is not compulsory subject in the Kingdom's legal frameworks.

On the other hand, environmental and social consideration level of this JICA Study was classified into category B in accordance to the Article 2.5 of the Japan International Cooperation Agency Environmental and Social Guidelines (2004) (hereinafter referred as to the "JICA Guidelines") since the M/P is composed of some physical structures such as construction of dams, pipelines and desalination plant. Therefore, this Study is required to conduct an Initial Environmental Examination (IEE) following the articles stipulated in the JICA Guidelines.

Therefore, an IEE by the JICA Study Team with Saudi side was needed for the draft M/P. Since an Environmental Impact Assessment (EIA) is required for conduction of feasibility study on the facilities such as dams, pipelines with the total length more than 50 km and desalination plant in accordance to the Article five (5) of the General Environmental Law and Rules for Implementation (2001), it is expected that the Kingdom will conduct a full scale environmental study for preparation of an EIA based on this IEE.

1.3 Outline of the M/P

The southwest region is comparatively rich in rainfall (with annual average amount ranging from 200 to 500mm) on a national basis in KSA where other regions have less than 100mm. The valuable water resources originating rainfall has not been fully utilized so far because of its direct drain-out into the sea (the Red Sea) and the underground infiltration. However, the water resources development projects in the region have been implemented in recent years to keep up with the rapid increase of population and actual progress of industrialization.

The M/P was prepared and formulated by the JICA Study Team and MOWE. The objectives of the Study are as in the followings;

- To formulate a Basic Policy, Strategy and Action Plan for sustainable water resources development, utilization and management in the southwest region of KSA
- To formulate a M/P for sustainable water resources for the selected Regions based on the Action Plan
- To transfer relevant skills and technologies mainly to personnel of the Ministry of Water and Electricity (MOWE or Executing Agency)

The M/P elaborated in this Study consists of the following components;

- Integrated Water Resources Management (Surface Water, Groundwater, Reclaimed Water and Desalinated Water)
- Utilization of the existing, under construction and newly developing dams.
- Construction of Water Conveyance Pipelines

The outline of the M/P is summarized in Figure 1-1.

Figure 1-1 Outline of the Newly Proposed Facilities

2. Legal Environmental Frameworks

The following shows the main environmental laws and regulations of the Kingdom.

- Agricultural and Veterinary Quarantine Regulations (1975) : To regulate the introduction of plant and animal species into Saudi Arabia and the issuing of health certificates for any importation.
- Uncultivated Land Act (1978) : The act restricts the random development of uncultivated lands and preparation of spatial planning.
- Forests and Rangelands Act (1979) : To ensure the conservation and rational exploitation of the forests and rangelands.
- Water Resources Conservation Act (1980) : To control and regulate the use of water resources.
- National Commission for Wildlife Conservation and Development Act (1986) : To establish the National Commission for Wildlife Conservation and Development (NCWCD).
- Fishing Exploitation and Protection of Live Aquatic Resources in the Territorial Waters of Saudi Arabia Act (1987) : To ensure the rational utilization of the live aquatic resources in the territorial waters of Saudi Arabia.
- Wildlife Protected Areas Act (1995) : To conserve and develop wildlife in the Kingdom of Saudi Arabia.
- Wild Animals and Birds Hunting Act (1999) : To regulate hunting of wild animals and birds; and to ensure the preservation of the nation's fauna by providing opportunities for wild animals and birds to breed.
- Act on Trade on Endangered Wildlife Species and Their Products (2000) : To regulate the trade in wildlife and wildlife products by the system of import/export permits according to the rules of the Convention on International Trade of Species (CITES).
- General Environmental Law and Rules for Implementation (2001) : To protect the environment and conserve biodiversity in the Kingdom.

(1) Environmental Impact Assessment (EIA)

Meteorology and Environmental protection Administration (MEPA) is the competent agency which shall examine and approve the environmental studies submitted by the executing agencies or project owners. Environmental studies or associated environmental surveys shall be conducted at the stage of feasibility study. Based on the environmental document submitted by the executing agencies or project owners, the MEPA may fully approve, conditionally approve or reject. The agency is also authorized to request the executing agencies or project owners to submit further detail explanation on the environmental information associated with the project and conduction of additional environmental studies/surveys. Figure 2-1 shows the flow chart of the process of environmental studies (or environmental impact assessment) in the Kingdom.

Required studies, surveys and application forms depend on the characteristics and impact of the project as shown in Table 2-1. The project proposed in this M/P is composed of construction of dams, pipelines more than 50 km and desalination plant. Therefore, the proposed projects are categorized as Category 3. A full scale EIA and approval from MEPA are required.

Table 2-1 Category of Environmental Impact Assessment

Category	Impact on the Environment (Sample Facilities)	Required Documents/Studies
1	Small（Factories inside industrial zone, Small extension of roads, etc）	Initial environmental assessment form prepared by environmental specialist
2	Middle（Factories outside industrial zone, Small scale power plants, etc）	Initial environmental assessment form prepared by qualified consulting firm, Environmental technical report, the project design drawings, equipment and instrumentation catalogues
3	Large（Large scale factories & projects, Oil relating facilities, dams, etc）	Environmental Impact Assessment study prepared by a qualified consulting firm

Note: The above table is prepared by the Study Team by summarizing the laws. Further details of the categorization are described in the attachment at the end of this report.

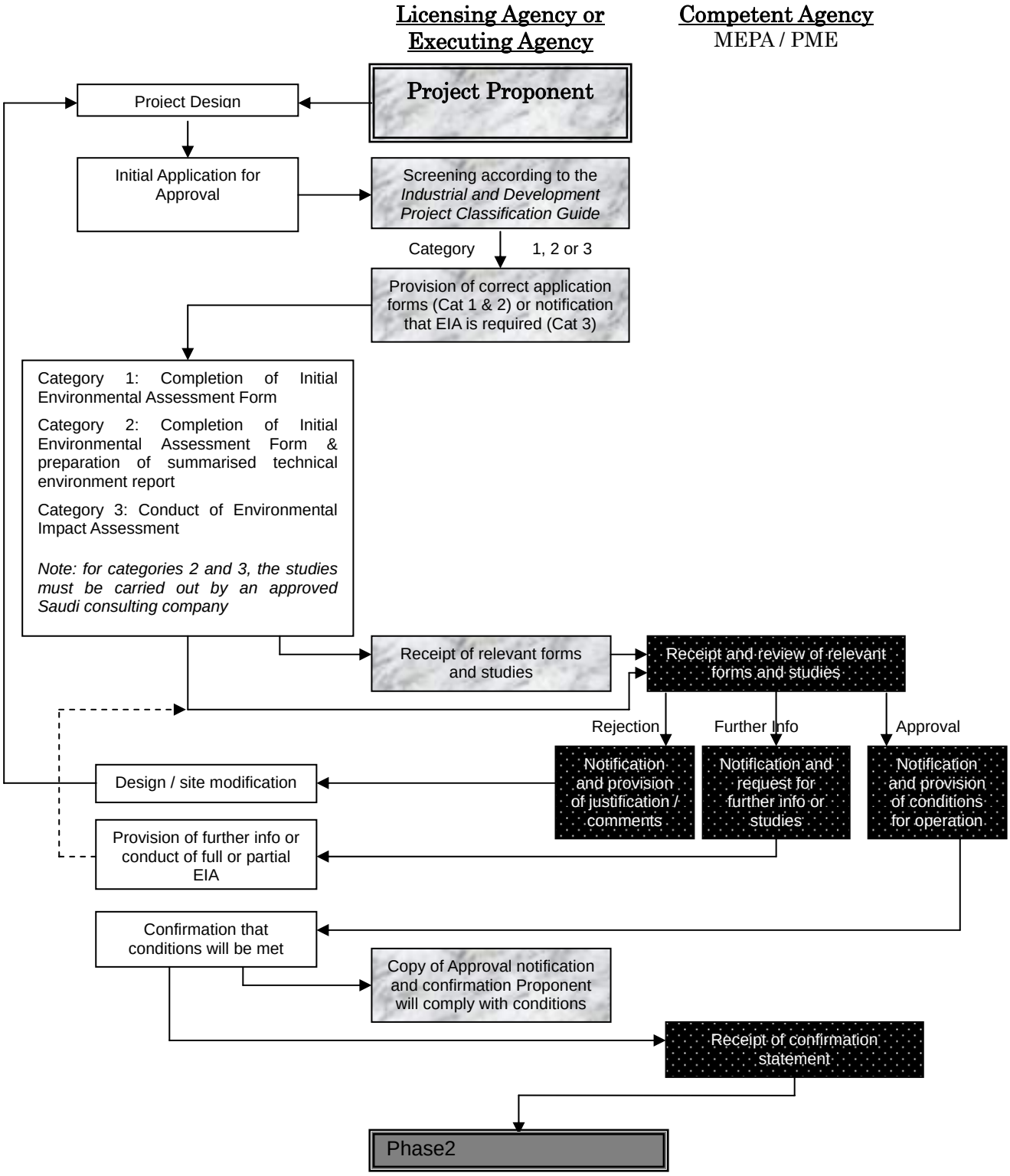

Figure 2-1 EIA Flow Chart in the Kingdom of Saudi Arabia

(2) Protected Area

In accordance to the National Commission for Wildlife Conservation and Development Act (1986), the National Commission for Wildlife Conservation and Development (NCWCD) is in charge of implementing plans to sustain terrestrial and marine wildlife and rehabilitation of rare and threatened species and their habitats as well as management of protected areas. There have been 16 protected areas nominated as of 2010 and two (2) exist inside the Study Area. Figure 2-2 shows the locations of the protected area. Table 2-2 shows the summary of the project areas in the Study Area.

These areas have high precipitation in comparison to the national average of the Kingdom. Thus, the fauna and flora inhabiting in the areas is comparatively rich. According to the information published by NCWCD on their homepage, there are some endangered species such as Arabian Leopard (Panthera pardus nimr), caracal (Caracal caracal), Arabian Oryx (Oryx leucoryx), Genet (Genetta genetta) and Baboon (Papio) inhabiting in the protected areas. Some protected areas are nominated to reintroduction of endangered species.

Among the proposed project in the M/P, a pipeline, extending from Ras Mouhesan to Al Baha city may pass through a part of the Jabal Shada protected area.

Table 2-2 Summary of the Protected Area in the M/P Area

Name	Established Year	Region	Area (km^2)	Overview
Raydah	1989	Asir	9	It is one the smallest protected area in the Kingdom. Dense Juniper forest extends in the area. A number of fauna including various birds, Baboon (*Papio*) and wild cat (*Felis silvestris*) inhabit in the area.
Jabal Shada	2002	Baha	67	The protected area extends from 490 ~ 2,222m in altitude. Reflecting rich precipitation, more than 500 floras exist in the area. Baboon (*papio*), fox (*wulpes*), stripe hyena (*hyaenidae*) and wild cat (*felis silvestris*) inhabit in the area. Reportedly Arabian Leopard (*Panthera pardus nimr*) is observed.

Figure 2-2 Locations of Protected Area and the Facilities