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

(MAIN REPORT)

OCTOBER 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

SANYU CONSULTANTS INC.

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Foreign Exchange Rate

1.00 US Dollar=3.74 Saudi Arabia Riyal=¥89.0

(WEB：1st March, 2010 US Dollar/Saudi Arabia Riyal)

PREFACE

In response to a request from the Kingdom of the Saudi Arabia, the Government of Japan decided to conduct a study concerning the Master Plan Study on Renewable Water Resources Development in the Southwest Region, and entrusted the study to the Japan International Cooperation Agency.

JICA selected and dispatched a study team headed by Mr. Masatomo WATANABE of Yachiyo Engineering Co., Ltd. to the Kingdom of Saudi Arabia between June 2007 and June 2010.

The team held a series of discussions with the officials concerned in the Government of Saudi Arabia and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of further friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned in the Government of the Kingdom of Saudi Arabia for their close cooperation extended to the study.

October 2010

Mr. Izumi Takashima
Vice President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

October, 2010

Mr. Izumi Takashima,
Vice President
Japan International Cooperation Agency

Dear Sir

We are pleased to submit to you the final report of the Master Plan Study on Renewable Water Resources Development in the Southwest Region in the Kingdom of Saudi Arabia (KSA).

The final report deals with the basic policy, strategy and action plan for sustainable water resources development, utilization and management in the five regions (Makkah, Al Baha, Asir, Jazan and Najran Region) located in the southwest region in KSA and the Water Master Plan on renewable water resources development targeting the year of 2035, focusing for only the three regions (Al Baha, Asir and Jazan Region). In elaboration of the final report, the Study Team has taken into account the advices and suggestions of your Agency and the comments on draft final report made by the Ministry of Water and Electricity (MOWE).

The Water Master Plan proposes the water resources development facilities such as dams and wells which meet the water demand to the year of 2035. In order to overcome hydrological handicaps (scarcity of rainfall, annual and regional large fluctuation gap of rainfall, large potential evaporation) in the study area belonging to arid and semi-arid areas, the Water Master Plan also proposes the renewable water resources development by combining operations between large dams and aquifers in Wadi. It finally proposes the extension and construction of desalination plant hence water demand cannot be obtainable by only developing the renewable water resources in the three regions.

Based on economic and technical aspects it was taken into consideration the development of different water resources such as renewable water resources as well as desalinated seawater in three regions in order to secure less expensive water and necessary water sufficiency. Therefore, the Study Team planned the Red Sea Water Lifeline Project (REWLIP) that widely connects water resources with pipelines and supplies water to the mentioned three regions' major cities. As part of the water demand management plan, the Study Team promoted the reuse of reclaimed waste water for municipal greening, industrial cooling and agricultural water.

The proposed project components in the master plan can be evaluated as feasible from the viewpoints of technology, economy, and finance, and socio-environment. By the implementation of these projects proposed in the Water Master Plan, we are convinced that it will contribute to the socio-economic development of three regions and will achieve comfortable life for people.

We wish to take this opportunity to express our sincere gratitude to your Agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the MOWE and the related organizations for their close cooperation and extended assistance to us during the study period.

Very truly yours,

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

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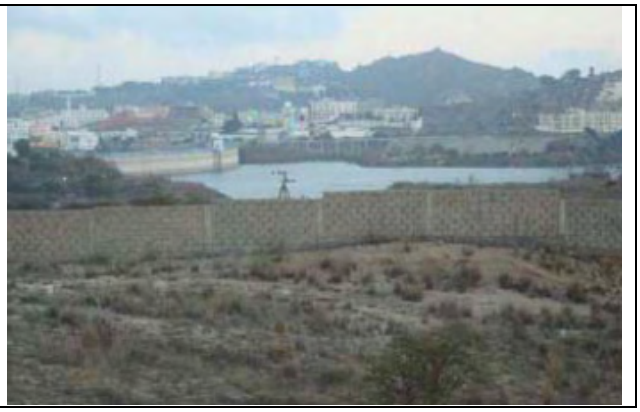

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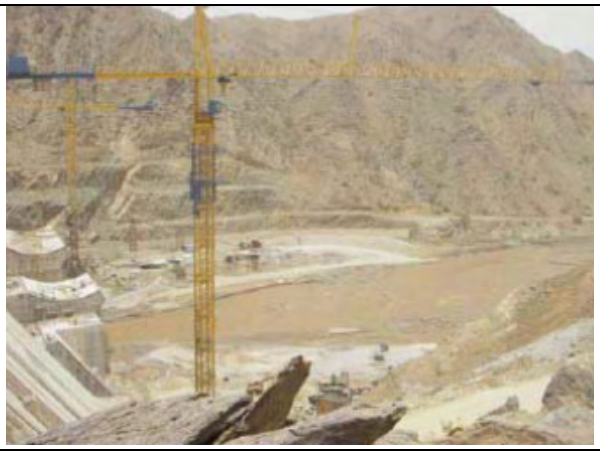

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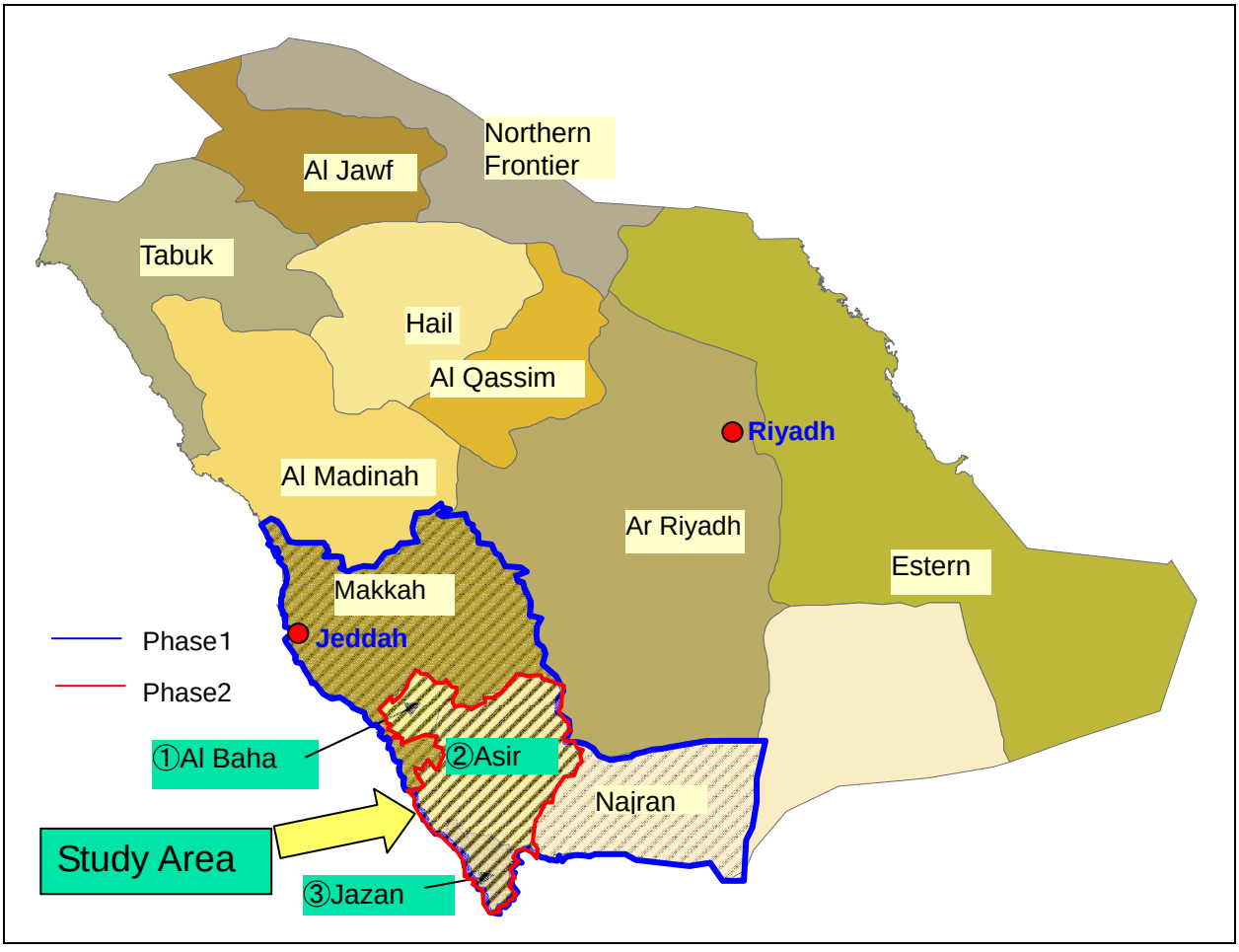

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List of Abbreviations

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
MOAW	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
NCWCD	National Commission for Wildlife Conservation and Development	اللجنة الوطنية لحماية و تطويرالحياة البرية	国立動物保護開発協会

Abbreviation and Acronym	English	Arabic（عربي）	Japanese（日本語）
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

SYNOPSIS

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

Study Period: June 2007 － July 2010
Recipient Agency: Ministry of Water and Electricity, the Kingdom of Saudi Arabia

1 Background of the Study

The desert or arid area extends throughout the entire land of the Kingdom of Saudi Arabia (KSA), and the acquisition of water resources is one of the top issues to sustain the people's life and domestic industries. The recent increase in population, urbanization and industrialization induces the rapid increase in water demand, and it requires that appropriate and prompt measures be taken against water scarcity.

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

The Government of KSA, accordingly, requested the Japanese Government in 2000 to formulate a master study plan on renewable water resources development and management mainly for renewable water resources of surface and groundwater in the Southwest Region of KSA based on her basic policy on the restriction of water use from non-renewable water (fossil water) and the increase of the water supply from the other water sources.

2 Objectives of the Study

The objectives of the Study are shown below.

1) To formulate a basic policy, strategy and action plan for sustainable water resources development, utilization and management in 5 Regions (Makkah, Al Baha, Asir, Jazan and Najran) located in the southwest region of KSA
2) To formulate a master plan (M/P) for sustainable water resources for the selected Regions based on the action plan
3) To transfer relevant skills and technologies mainly to personnel of the MOWE

3 Water Policy, Strategy and Action Plan of Five Regions

3.1 Issues on Water Sectors

Current condition and issues on water sectors for each Region are as follows. Refer to Table 1.

(1) Municipal Water (Domestic Water)

Coverage of domestic water network is low in Al Baha region, Asir region and Jazan region. Water supply amount, which is called LCD, in Al Baha region, Jazan region and Najran region is less than value used in planning for a small village whose population is not more than five thousand. These regions are classified as no desalinated seawater supplying area or small supplying area. There is a possibility of large scale seasonal change of water use in Makkah Region, Al Baha Region and Asir Region.

(2) Industrial Water

Total volume of industrial water use is rather small except Makkah region. Percentage of reuse of reclaimed waste water in Makkah region is rather high comparing to other regions. Other four regions

use no or a little amount of it.

(3) Agricultural Water

Agricultural water is said to account for high ratio to the total water use. Actual water use for agriculture is not monitored and there are developments of agricultural wells without proper license. Because agriculture uses a lot of amount of water, there is a possibility to produce large amount of water by water saving. Level of introduction of modern irrigation facilities is low. Percentage of reuse of reclaimed waste water in agriculture is very low.

Table 1 Basic Information and Issues on Water Sectors in 5 Regions

Items	Makkah	Al Baha	Asir	Jazan	Najran
[Population]Projection by MOWE (2009)					
• 2010 (x1000), Total: 10.680	6,468	411	1,895	1,404	502
• 2035 (x1000), Total: 16,302	9,785	627	2,914	2,190	786
[Renewable Water]	Reference points**:** points at river mouth + points in front of desert. Al Baha: Inter basin (All potentials flow into Makkah)				
• Surface Runoff (MCM/Y) Total: 870	755	(254)	66	44	5
• Groundwater (MCM/Y) Total: 744	320	(100)	73	303	48
• Total (MCM/Y) Total: 1,614	1,075	(354)	139	347	53
[Domestic Water]					
• Total volume of domestic water use	389	14	57	16	12
• Coverage of public potable water networks	96%	47%	43%	64%	79%
• Estimated water supply amount (LCD: Litter per capita per day)	183	149	192	55	93
• Percentage of desalinated seawater	High (88%)	Low (0%)	Middle (57%)	Low (4%)	Low (0%)
• Large scale seasonal change in water demand	(Haji Pilgrim)	(Jun-Aug)	(Jun-Aug)	No	No
[Industrial Water]					
• Total volume of industrial water	38	0	2	0	0
• Percentage of reuse of reclaimed waste water	Middle (59.8%)	-	Low (0%)	-	-
[Agricultural Water]					
• Total volume of agricultural water	768	54	283	1,527	229
• Ratio of agricultural water in total water use	Middle (64%)	High (79%)	High (83%)	High (99%)	High (95%)
• Percentage of reuse of reclaimed waste water	Low (2%)	-	Low (6%)	-	-
• Introduction of updated facilities	Low <50%	Low <50%	Low <50%	Low <50%	Low <50%
• Lowering of groundwater level & deterioration of water quality in agricultural wells	Yes : Middle	Yes : Low	Yes : Low	Yes : High	Yes : Low
• Development of agricultural wells without proper license	Yes	Yes	Yes	Yes	Yes
• Monitoring of yield and level on agricultural water	No	No	No	No	No

3.2 Balance on Water Supply and Demand

(1) Municipal Water

Table 2 shows the estimation of amount of water resources which should be developed by a planned target year 2035. The amount of water resources in 5 regions are estimated as 422 MCM/year (or 1.2 MCM/day). The ratio to the current water supply capacity of the future water demand in four regions other than the Makkah region is from 2 times to 4 times. The water resources should be developed and the water supply network should be expanded in the 4 regions.

Considering such water users after dam construction, 30% of renewable water resources developed by dams were allocated as available renewable water to municipal water which can be used as an assumption value in the municipal water plan. The remaining 70% shall be discharged to downstream, and shall be used by vested water users and recharged to a groundwater aquifer. As shown in Table 2, available renewable water in 5 regions is to be 340m^3/day. To meet the future water demand, the water development by water resources other than renewable water resources should be examined in the study area.

Table 2 Balance for Future Water Demand in 2035

Region	(1)Current Water Supply Capacity (MCM/Y)	(2)Future(2035) Water Demand (MCM/Y)	Balance (MCM/Y) (3)=(2)-(1)	(4) Balance (1000 m^3/d)	(5)Available Renewable water (1000 m^3/d)	(6)Balance (1000 m^3/d) (6)= -((4)+(5))
Makkah	748	845	-97	-266	161	105
Al Baha	10	38	-28	-77	16	61
Asir	44	208	-164	-449	60	389
Jazan	53	148	-95	-260	103	157
Najran	24	62	-38	-104	0	104
Total	879	1,301	-422	-1,156	340	816

*) 30% x Industrial Water and 5% x Municipal Water are to be supplied by Reclaimed Waste Water.

(2) Agricultural Water

Table 3 shows water balance on agricultural water and comparison of the planted area between 2007 and 2035. Planted area in 2035 was predicted based on the [Decision 335] and irrigation water potential consists of reclaimed waster water and new developed water. A part for a water supply for municipal water is first deducted from the renewable amount of water resources, and the remaining amounts of water resources is transferred to irrigation water.

New developed irrigation water consists of water saving, reclaimed waste water and return flow of irrigation water (estimated as 40% of irrigation water).

Planted area for the target year (2035) corresponding to the new irrigation water resources developed by renewable water resources and water saving will become 53% in the whole 5 regions as compared with the planted area in 2007. However, although three regions such as Makkah, Al Baha and Asir Region can secure the planted area at 2007 level mostly, two regions such as Jazan and Najran region can not secure. Planted area will be decreased as 75% from 2007 level in Jazan region, whereas as 29% in Najran Region.

Table 3 Water Balance on Agricultural Water and Comparison of Planted Area

Region	(1)Irrigation Demand 2007 (MCM/Y)	(2) Available for Agricultural Use(MCM/Y)	(3)New Water Resources (MCM/Y)	(4)Balance (MCM/Y) =(2)+(3)+(4)-(1)	(5)Planted Area in 2007 (ha)	(6)Planted Area in 2035 (ha)	(7)Ratio (%)
Makkah	751	674	513	436	42,077	39,293	93 %
Al Baha	54	83	14	43	4,450	4,425	99 %
Asir	268	360	109	201	21,054	20,759	99 %
Jazan	1,502	216	70	-1,216	113,558	28,559	25 %
Najran	217	328	88	200	11,430	8,134	71 %
Total	2,792	1,661	795	-336	192,569	101,170	53 %

*) New Water Resources = saving water＋reuse of reclaimed water＋return flow

*) Planted area in 2035 is based on the Decision335 and irrigation potential resources (reclaimed waste water + new resources)

3.3 Basic Policy for Water Resources Development, Utilization and Management

(1) Hydrological Handicaps in the Dry Area and Actions for Securing Water

Regarding the renewable water resources development in the Study Area (the area belongs to arid and semi-arid areas). Distinctive hydrological features (or Handicaps) are summarized as follows:

- ◆ Scarcity of Renewable Water (Rainfall, Surface Water and Groundwater)
- ◆ Annual and Seasonal Large Fluctuation of Rainfall and Renewable Water Resources
- ◆ Large Potential Evaporation

To overcome the above handicaps and to secure sufficient water for increasing demands, necessary actions should be taken and summarized as follows.

- ◆ To respond the annual fluctuation and the seasonal variation of rain and renewable water resources, minimum amount of water required for maintenance of social economy is secured by desalinated seawater.

- Water resources development which stresses on the stock is taken to plan a dam with the larger storage-of-water capacity which stores a flood certainly, to use water for years and can absorb change is needed.
- The different area and basins are connected with a pipeline, and the mechanism in which water resources are accommodated is needed.
- It is one of the problems that the evaporation loss from the reservoir is very large in dry and semi dry area due to large potential evapotranspiration. To respond it, promotion of recharging groundwater and keep water as groundwater is thought to be advantageous. An Effective use of recharging facilities such as recharge dams and trenches to promote infiltration of water into aquifer is necessary to improve recharge efficiency.

(2) Basic Policy of Water Resources Development and Conservation

Intentional Development and Utilization of Renewable Water Resources (Surface Water)

- From examination of the analysis result of renewable water-resources potential, and the dam site for using it efficiently, it is presumed that about 30% of the developed renewable water resources is usable for municipal water supply.
- However, allocation of developed water is not clarified in the plan of the dam project until now in many cases. In particular on the flood control dam, the utilization plan of the water resources stored by the flood is not defined.
- The development unit price of renewable water resources is cheaper than desalinated seawater and renewable water could be sustainable resource if it is managed properly.
- Therefore, it is important to perform development and use of these renewable water resources intentionally.

Monitoring of Renewable Water Resources (Groundwater)

- The fall of the groundwater level and water quality degradation are reported in connection with the groundwater use.
- Such wells as MOWE uses as water resources for supplying municipal water are monitored amount of water, water quality, and a water level and controlled. However, with the agricultural sector which is the greatest user of groundwater, a use situation is not grasped but a possibility of being the cause of degradation of groundwater is pointed out.
- For this reason, it is necessary to perform management properly and to assure sustainable use. Therefore, while strengthening the recharge capability of groundwater, governing structures, such as monitoring of a pump discharge, need to be strengthened.

Combination of Renewable Water Resources and Desalinated Seawater in the Water Supply Plan

- Although the renewable water resources are precious water resources to supply municipal water, it is difficult for only renewable water to deal with the increase demand of future municipal water.
- For this reason, it is necessary to examine rational water resources development plan by combining desalinated seawater and fossil groundwater with renewable water.

Effective Development and Use of Reclaimed Waste Water

- Reclaimed waste water can be used as water resources supplied to some of water for agricultural use, tree planting city water, and industrial water.
- However, the coverage rate of a sewage system is low and, under the present circumstances, the capability of a processing institution does not enough, either.
- It is required to promote the spread of sewage networks, to install the processing institution for securing water quality required for use, and to use positively combining renewable water resources, desalinate seawater, etc.

(3) Basic Policy of Water Resources Utilization and Management

Necessity of Demand Management

- Available renewable water resources are restricted by natural conditions, and production of water by desalinization of seawater could be theoretically becomes huge, however, it cost much.
- For this reason, it is required for the sectors of domestic water, industrial water and agricultural water to put demand management into practice in exploitation of water resources, and to aim at curtailment of the amount of use.
- The agricultural water use sector which is the greatest user of renewable water resources needs to tackle curtailment of the amount used, such as raising use efficiency or converting into crops with little consumption amount of water.

Establishment of Effective Water Use System

- A water development institution has a situation where the mechanisms of it being managed independently or no effective managing system like groundwater for agriculture.
- The system such as legislation and organization is required for carrying out comprehensive water-resources management continuous and efficient exploitation of renewable water resources, water accommodation of water among agricultural use and municipal water use and inter-regional water use.

3.4 Water Policy and Strategy of Five Regions

In consideration of the current condition of water use and issues, the gap between renewable water resources potential and water demand in planned target year, water policy, which becomes common to five regions, and its strategy were adjusted as the following table. As a water policy, ten items were displayed in the following four classifications. The strategies to each water policy are shown in Table 4.

- Water Resources Development and utilization
- Water Resources Conservation
- Water Resources Management
- Legislation for Water Resources Development, Utilization and Management

Table 4 Water Policy and Strategy of Five Region

Items	Contents
	(1) Water Resources Development and utilization
Policy：WP1	To Use Renewable Surface Water Effectively
Strategy	◆ To make effective use of surface water stored in reservoir together with groundwater and desalinated seawater ◆ To be given priority to domestic use of water ◆ To establish coordination body for rational allocation of surface water
Policy：WP2	To Use Renewable Groundwater Sustainably
Strategy	◆ To improve with balance between water resource development and resource conservation ◆ To develop groundwater efficiently by making use of recharge dam and underground dam ◆ To establish coordination body for rational allocation of groundwater
Policy：WP3	To Use Desalinated Seawater properly
Strategy	◆ To make rational plan for using desalinated seawater as stable water resource to supplement renewable water ◆ To make plan for using desalinated seawater well balanced considering renewable water resources and reuse of reclaimed waste water
Policy：WP4	To Improve Reuse of Reclaimed Waste Water
Strategy	◆ To plan and construct sewerage and treatment plant to secure necessary water quality for reuse ◆ To be given priority to industrial and agricultural use so that load of renewable groundwater should be decreased ◆ To campaign for enlightenment for promoting reuse in agricultural use
	(2) Water Resources Conservation
Policy：WP5	To Conserve Groundwater
Strategy	◆ To observe and mange groundwater condition not to deplete groundwater level or degradation of water quality ◆ To strengthen monitoring system for groundwater conditions such as volume extracted and water level ◆ To strengthen inspection of registration system and its actual conditions of groundwater use
Policy：WP6	To Conserve Water Quality (surface water and groundwater)
Strategy	◆ To strengthen monitoring system for reservoir conditions such as stored volume and water quality ◆ To strengthen monitoring system for groundwater condition such as water quality

Items	Contents
	◆ To strengthen inspection not to dump garbage, waste water etc. illegally
	(3) Water Use and Management
Policy：WP7	To Promote Effective Use of Municipal Water
Strategy	◆ To strengthen activities to decrease unaccounted for water ◆ To improve consciousness for water saving and strengthen action for water saving
Policy：WP8	To improve consciousness for water saving and strengthen action for water saving
Strategy	◆ To improve collecting used water in factories and its reuse ◆ To promote water saving activities in factories and to take priority over introducing more non-water-consumptive industry
Policy：WP9	To Improve Appropriate Agricultural Water Use
Strategy	◆ To improve irrigation efficiency by introducing modern irrigation facility and rehabilitation of old irrigation facilities ◆ To disseminate knowledge about efficient water use to farmers and strengthen actions for saving water ◆ To place sustainable water use as a restriction for agriculture
	(4) Legislations for Water Resources Development, Utilization and Management
Policy：WP10	To Prepare Legislative and Institutional Framework for Effective Water Resources Development and Management
Strategy	◆ To prepare legislative and institutional framework for: 1) Sustainable water resources development, 2) Effective water resources conservation, 3) Smooth and efficient water use and management

3.5 Action Plan - Water Resources Development

(1) Water Resources Development

Action plan on water policy and strategy (WP1: Surface Water Use, WP2: Groundwater Use, WP3: Desalinated Seawater Use)

<REWLIP (Red-Seawater Lifeline Project)>

REWLIP is a project to produce and distribute municipal water to the main cities in the southwestern area (Makkah, Al Baha, Asir and Jazan Regions) of KSA. REWLIP are composed of 1) desalination plants (including new 2 plants), 2) 10 dams (constructed and under construction), and water pipelines (total length: around 1,300km). The Study Team proposes REWLIP based on the two important aspects: 1) Economic Aspect to Secure Less Expensive Water, and 2) Technical Aspect to Secure Necessary Water Sufficiently in Wide Area by Different Water Sources and Well Connected Water Conveyance Systems. Outline of REWLIP is as follows:

- ◆ The renewable water resource in the four regions (excluding Najran Region) is assumed to be developed by dams. There is no new dam plan in Najran Region.
- ◆ About desalinization plant, the Makkah Region extends a Shuaibah Plant, and the Asir Region corresponds by extension of a Shuqaiq Plant.
- ◆ New desalination plants are planned to be constructed to supply water to Al Baha Region and Jazan Region respectively. This plan is proposed by the Study Team.
- ◆ Water conveyance among regions is done by the pipelines proposed by the Study Team.

<Water Supply System of Five Regions in 2035>

Table 5 Water Demand and Supply Plan and Water Resources by percentage (%) Region according to Region in 2035

Region	Water Demand (1000m^3/day)	Water Supply (1000m^3/day)				Balance of Demand and Supply
		Total	Renewable Water	Desalinated Seawater	Fossil Groundwater	
Makkah	2,278	2,278	170	2,108	0	0
		(100%)	(7.5%)	(92.5%)		
Al Baha	135	135	35	100	0	0
		(100%)	(25.9%)	(74.1%)		
Asir	648	648	255	327	66	0
		(100%)	(39.4%)	(50.5%)	(10.1%)	
Jazan	436	436	219	217	0	0
		(100%)	(50.2%)	(49.8%)		
Najran	184	184	65	0	119	0
		(100%)	(35.3%)		(64.7%)	
Total	3,681	3,681	744	2,752	187	0

Action plan on water policy and strategy (WP4: Reuse of reclaimed waste water)

<Use of Reclaimed Waste Water>

When using sewage disposal water as a proportion of domestic water or industrial water, it is necessary to separate the water supply method completely from general water service for safe preservation. Processing of the concentration drainage generated in the processing procedure, sludge, etc. must be ensured, and secondary pollution generating must be prevented.

Within the agricultural sector, reuse of reclaimed waste water potential is considered to be very large. Under the present circumstances, farmers have resistance towards changing from groundwater use to reusing reclaimed waste water. However, it is required to promote the use of reclaimed waste water for agricultural purposes from the current situation where water supply and demand are tight.

(2) Water Resources Conservation

Action plan on water policy and strategy (WP5: Groundwater Conservation, WP6: Water Quality Conservation)

<Groundwater Conservation by Dam>

Groundwater is recharged into aquifer through wadi bed. Therefore, it is possible to conserve groundwater by controlling wadi discharge from recharge dam. Optimum dam operation method will be proposed to promote groundwater recharge by considering the items below:

- To reduce ineffective discharge into Red Sea in wadi basins of the west of Shield
- To reduce ineffective discharge into lower reaches of the area where groundwater is used in wadi basins of the east of Shield
- Amount of groundwater recharge can be maximized by controlling discharge through dam
- Optimum discharge should be decided for each dam site because of the differences from dam to dam

<Monitoring Plan>

- Rainfall
- Monitoring of Wadi Discharge and Water Quality
- Monitoring of Groundwater Level and Quality

(3) Water Use Management

Action plan on water policy and strategy (WP7: Effective Use of Municipal Water, WP8: Improvement of Water Saving, WP9: Appropriate Agricultural Water Use)

<Demand Management of Domestic Water Supply>

- Introduction of Pricing
- Educational Programs concerning Water Saving and Water Preservation

<Water Demand Management of Agricultural Water Use>

- Crop Conversion
- Water Saving

(4) Adjustment of Organization and Institution

Action plan on water policy and strategy (WP10: Institutional Framework for Effective Water Resources Development and Management)

- Introduction of Integrated Water Resources Management (IWRM)
- Information Sharing and Adjustment among Sectors
- Management of Water Resources Facilities and Organization
- Systematization of Agricultural Water Use Sectors
- Capability Building of MOWE

4 Master Plan for Three Regions

It is recommended for Al Baha, Asir and Jazan Region that development, utilization and management with focus on renewable water resources (surface water + ground water) will lead to benefits. These three regions are adjacent to each other, and collaborative and integrated water resources development including water transmission and supply beyond regional boundaries is also possible. The three regions (Al Baha, Asir and Jazan) were selected for regions on the M/P study on renewable water resources development, utilization and management.

4.1 Water Resources Development

(1) Renewable Water Resources

To overcome the hydrological handicaps such as little rainfall, quantitative fluctuations and much evapotranspiration, and to secure sufficient water for increasing demands, the following view points shall be taken into consideration on development of renewable water resources.

- Water resources development which stresses on the stock is taken to plan a dam with the larger storage-of-water capacity which stores floods certainly
- An Effective use of recharging facilities such as recharge dams and trenches to promote infiltration of water into aquifer is necessary to improve recharge efficiency.

Methods proposed below are applicable to develop renewable water resources (surface water and shallow groundwater) in the Study Area

Surface Water Development by Large Dam: For the purpose of water use, surface water is developed by the large scaled dam & reservoir with double or triple volume of annual average discharge volume. Reservoir is continuously stored and used throughout the year. Developed water is conveyed to the consumer areas.

Development of Surface Water and Groundwater by the Combination with Large Dam and Groundwater Aquifer: In case of small sized dams or limited annual flow regime at dam sites, surface water is recharged and stored in the groundwater aquifer to increase development volume. To increase recharge volume, recharge wells and trenches are employed.

Groundwater Development by the Recharge Dams: Recharge dams with facilities of natural discharge are constructed to increase recharge volume in the course of Wadi by changing the flow pattern.

Table 6 shows the development volume of dams and combination development with dams and aquifers. The Study Team estimated for the volume of annual 351MCM for surface water developed by large dams.

Table 6 Development by Dams and Combination Development with Dams and Aquifers

Name of Dam	Location of River	Annual Flow (MCM/Y)	Reservoir Volume (MCM)	Development Volume *1		Development Rate*2 (α)	Design Supply Volume*3 ($1000m^3/d$)	Dams & Aquifers *4	
				(MCM/Y)	($1000m^3/d$)			(MCM/Y).	Rate (%)
Aradah	East(Desert)	15.2	68.0	6.7	18	44%	5	6.7	100%
King Fahd	East(Desert)	69.1	325.0	55.3	152	80%	-	57.3	104%
Tabalah	East(Desert)	12.3	68.4	3.6	10	29%	10	4.7	131%
Ranyah	East(Desert)	99.6	219.8	32.9	90	33%	68	32.9	100%
Hirjab	East(Desert)	16.8	4.6	3.4	9	20%	9	7.4	218%
Jizan	West(Redsea)	78.9	51.0	23.7	65	30%	-	25.4	107%
Baysh	West(Redsea)	104.6	193.6	73.2	201	70%	58	95.2	130%
Damad	West(Redsea)	61.5	55.5	24.0	66	39%	36	25.2	105%
Hali	West(Redsea)	122.3	249.9	97.8	268	80%	70	106.4	109%
Qanunah	West(Redsea)	21.3	79.2	6.4	18	30%	10	13.2	206%
Yiba	West(Redsea)	81.3	80.9	24.4	67	30%	-	26.8	110%
Total		682.9	1,395.9	351.4	964	51%		401.2	114%
Total	East(Desert)	213.0	685.8	101.9	279	48%		109.0	107%
Total	West(Redsea)	469.9	710.1	249.5	685	53%		292.2	117%

[Note] *1: Development Safe97%=30% of development volume is insufficient once in 10 years、*2: Development Safe 95%=50% of development volume is insufficient once in 10 years、*3: Development Rate(α)=Development Volume/Annual Flow, *4: Development volume by the combination of dam and aquifer with two times volume of the dam reservoir

In such cases that there are users in downstream and new irrigations, although not all of such development quantities can be used for water supply, the supply volume by dams may be larger than the planned water supply volume which MOWE planned, and may be able to increase water supply volume more.

In case of combination development with dams and aquifers (development volume in aquifer is estimated as 2 times of dam development), development volume increases greatly. In particular, this tendency is shown on Tabalah dam, Hirjab dam, Baysh dam, and Qanunah dam.

(2) Desalinated Seawater

It is indispensable for desalinated seawater project to continue and expand in order to suffice the demand of municipal water and industrial water, judging from the water demand projection and water resources potential analyzed in this Study. Saline Water Conversion Corporation (SWCC) projects implemented under supervision of MOWE shall be implemented considering the following matters:

- Stable and Reliable Water Source: Desalinated seawater is a stable and reliable water source to secure the expected water supply quantity comparing with renewable water resources which are affected by the annual fluctuation, the most prominent characteristics in the semi-arid areas.
- High Production Cost: Although the production cost of desalinated seawater falls by technical progress, 3 times - 4 times are still high (SWCC Annual Report 2008, 2.40SR/m^3) in comparison with the renewable water production cost by the dam. An investment capital interest rate of the dam construction is assured to be 8% a year.
- Minimum Water Transmission: As the desalinated seawater is produced near the sea, the cost of water transmission increases so that the consumption location is too far from the sea. For example, in concert with the above report, transmission cost from Shuqaiq Plan to Abha is 5.18 SR/m3. It is self-evident to plan the construction of new plants as near as possible to the consuming area to reduce transportation cost.

(3) Use of Reclaimed Waste Water

Regarding the recycle use of the reclaimed waste water, utilization for municipal water and industrial water is limited and relatively small, but utilization for agricultural water is large. In Al Baha Region and Asir Region, the rates of agricultural use (Available Reclaimed Waste Water for Agricultural Use / Total Agricultural Demand in Region) are 21% in Al Baha and 25% in Asir Region. This means that the reclaimed waste water will eventually become promising water resources for agricultural use in the regions of Al Baha and Asir.

<Utilization Merritt for Municipal and Industrial Uses>

If 5% of the municipal water is replaced with the reclaimed waste water, consequently the municipal water demand will decrease by 5%. According to SWCC Annual Report 2008, the water unit price (production cost and a transportation cost) of the desalinated seawater is 8.0 SR/m^3 from 3.5 SR/m^3. In particular, as Transportation costs increase, the water supply to the plateau city rises as well. For example, the decrease of the government subsidy for one year reaches SR67.8 Million if 5% (25,800m^3/day) on city water demand 516,000m^3/day at 2020 in Al Baha Region and Asir Region, and government subsidy supposes with 90% (8.0SR/m^3 x 90% = 7.2SR/m^3).

<Recycle Use of Treated Waste Water for Agricultural Use>

Recycle rate of reclaimed waste water for agricultural use (more than 20%) is high in Al Baha Region and Asir Region. Therefore, to promote agricultural use of reclaimed waste water, “Distributed System of Sewage Treatment and Recycle Use“ is recommended over an “Intensive System” in Al Baha Region and Asir Region.

<Proposal of Implementation of Artificial Recharge by Treated Sewage>

For countermeasures against seawater intrusion, rising of groundwater level by artificial recharge is effective. It is recommended to use treated sewage for water source of artificial recharge. This method can be applied by using treated sewage discharge from Jizan city. The southern part of Jizan city, where seawater intrusion is taking place, should be target for this method. Feasibility Study (F/S) on the reuse of treated sewage discharge is recommended.

4.2 Water Supply

(1) Al Baha Region

Table 7 Water Production Plan in Al Baha Region

Water Resource	-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035
1.Existing (m^3/day)	**29,000**	**59,000**	**19,000**	**19,000**	**19,000**	**19,000**
1.1 Renewable Water	**19,000**	**19,000**	**19,000**	**19,000**	**19,000**	**19,000**
Aradah Dam (B)	5,000	14,000	14,000	14,000	14,000	14,000
Al Aqiq Dam (B)	4,000					
Wadi Thrad Dam (B)	5,000					
Qilwah Well (B)	2,000	5,000	5,000	5,000	5,000	5,000
Mukwah Well (B)	1,000					
Al Aqiq Well (B)	1,000					
Others Wells (B)	1,000					
1.2 Desalination	**10,000**	**40,000**	**0**	**0**	**0**	**0**
Shuaiba D.P (M)	10,000	40,000	0	0	0	0
2.New (m^3/day)	**-**	**51,000**	**91,000**	**91,000**	**116,000**	**116,000**
2.1 Renewable Water		**51,000**	**16,000**	**16,000**	**16,000**	**16,000**
Nilah Dam (B)	-	11,000	11,000	11,000	11,000	11,000
Qilwah Dam (B)	-					
Al Janabin Dam (B)	-	5,000	5,000	5,000	5,000	5,000
Hali Dam (M)	-	35,000	0	0	0	0
2.2 Desalination		**0**	**75,000**	**75,000**	**100,000**	**100,000**
Dawqah D.P (M)	-	-	75,000	75,000	100,000	100,000
Total (m^3/day)	**29,000**	**110,000**	**110,000**	**110,000**	**135,000**	**135,000**
Water Demand(m^3/day)	**50,000**	**64,000**	**79,000**	**94,000**	**111,000**	**131,000**

[Note] (B):Al Baha Region, (M):Makkah Region

(2) Asir Region

Table 8 Water Production Plan in Asir Region

Water Resource	-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035
1.Existing (m^3/day)	**122,000**	**122,000**	**122,000**	**122,000**	**122,000**	**122,000**
1.1 Renewable Water	40,000	40,000	40,000	40,000	40,000	40,000
Existing Wells	40,000	40,000	40,000	40,000	40,000	40,000
1.2 Desalination	82,000	82,000	82,000	82,000	82,000	82,000
Shuqaiq D.P (J)	82,000	82,000	82,000	82,000	82,000	82,000
2.New (m^3/day)		**245,000**	**375,000**	**482,000**	**557,000**	**557,000**
2.1 Renewable Water		70,000	200,000	200,000	200,000	200,000
Baysh Dam (J)	-	25,000	25,000	25,000	25,000	25,000
Hali Dam (M)	-	35,000	70,000	70,000	70,000	70,000
Tabalah Dam	-	10,000	10,000	10,000	10,000	10,000
Hirjab	-		9,000	9,000	9,000	9,000
Ranya Dam	-		68,000	68,000	68,000	68,000
Qanunah Dam (M)	-		18,000	18,000	18,000	18,000
2.2 Desalination		146,000	146,000	221,000	296,000	296,000
Shuqaiq D.P (J)	-	146,000	146,000	221,000	296,000	296,000
2.3 Desalination		29,000	29,000	61,000	61,000	61,000
Wajid Fossil Water	-	29,000	29,000	61,000	61,000	61,000
3.Total (m^3/day)	**122,000**	**367,000**	**497,000**	**604,000**	**679,000**	**679,000**
4.Water Demand(m^3/day)	**295,000**	**361,000**	**432,000**	**495,000**	**571,000**	**648,000**

Note) (J):Jazan Region, (M):Makkah Region

(3) Jazan Region

Table 9 Water Production Plan in Jazan Region

Water Resource	-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035
1.Existing (m^3/day)	**140,000**	**140,000**	**140,000**	**137,000**	**137,000**	**137,000**
1.1 Renewable Water	**136,000**	**136,000**	**136,000**	**136,000**	**136,000**	**136,000**
Existing Wells	136,000	136,000	136,000	136,000	136,000	136,000
1.2 Desalination	**4,000**	**4,000**	**4,000**	**1,000**	**1,000**	**1,000**
Shuqaiq D.P	3,000	3,000	3,000	0	0	0
Farasan D.P	1,000	1,000	1,000	1,000	1,000	1,000
2.New (m^3/day)	**-**	**149,000**	**193,000**	**246,000**	**246,000**	**301,000**
2.1 Renewable Water	**-**	**69,000**	**78,000**	**78,000**	**78,000**	**78,000**
Bayash Dam	-	33,000	33,000	33,000	33,000	33,000
Damad Dam	-	36,000	36,000	36,000	36,000	36,000
Qissi Dam	-	-	9,000	9,000	9,000	9,000

Water Resource	-2010	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035
2.2 Desalination	**-**	**80,000**	**115,000**	**168,000**	**168,000**	**223,000**
Shuqaiq D.P	-	72,000	72,000	0	0	0
Farasan D.P	-	8,000	8,000	8,000	8,000	8,000
Sabya D.P	-	-	35,000	160,000	160,000	215,000
3.Total (m^3/day)	**140,000**	**289,000**	**333,000**	**383,000**	**383,000**	**438,000**
4.Water Demand(m^3/day)	**203,000**	**238,000**	**286,000**	**329,000**	**379,000**	**436,000**

[Note)] (J):Jazan Region, (M):Makkah Region, (N): Najran Region

4.3 Management of Water Demand

(1) Urban Water Supply - Proposal for Reduction of LCD

- Promote introduction of the water saving type apparatus according to updating time (a washing machine, a dishwasher, a flush lavatory, etc.).
- Promotion of renewal of an institution for the improvement in a recycling rate of the water in a factory
- Water rates and the water-saving motivation
- Promoting recognition of importance of water saving by education and enlightenment

(2) Urban Water Supply - Proposal for Improvement of Leakage Ratio

- Planned renewal of a decrepit pipeline
- Checking and verifying the amount of supply by a flow meter and actual amount of water supply to users
- Introduction of leakage-of-water diagnostic technology

(3) Agricultural Water Use - Future Planting Plan for Water Demand Control

- Support of the water management technology to the farmers
- Water-saving awareness to farming communities
- 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

4.4 Operation and Management

(1) Integrated Water Management System

The system that deliberately manages renewable water (surface water, groundwater) had not actively been managed as proposed years before. Conventionally, surface water and groundwater have been managed and used almost individually except the dams and wells which the MOWE regional office has managed for domestic water supply. For this reason, the existing agencies which are bearing managing and supplying renewable water are only MOWE regional offices.

In this M/P, governorate responsibilities are overlapped and the water management plan is proposed. A new RWPC (Renewable Water Production Corporation) is proposed as an organization to take a central role in renewable water activities. In addition, a Water Authority is proposed as a committee that carries out adjustments with the MOWE and the MOA (Ministry of Agriculture).

(2) Groundwater Recharge by Dams

Surface Water Development in Combination with Dam and Groundwater Aquifer

The development volume of each dam is decided based on the annual flow regime and scale of reservoir volume. Therefore, the surface water development in combination with dam and groundwater aquifer is necessary.

Increase of Groundwater Recharge by Facilities

Generally, groundwater is recharged by surface water through wadi bed in the Study Area. To increase groundwater recharge from surface water, construction of groundwater recharge dam along wadi is effective. It is possible to increase groundwater recharge by controlling discharge from recharge dam. In planning of recharge dam, characteristics of groundwater recharge from wadi should be examined.

(3) Organization Structure and Management System

<Proposal of Organization Improvement>

Water Authority and Water Council

This organization is established for strengthening policy and decision-making levels. The water authority consist of the minister, and secretary of each ministry and agency related to water, and the director general, who determines the national water policy and basic strategy of water and adjustments between relevant ministries and agencies. Moreover, the organization agrees on the water resources development and management plan of the broad-based areas like two or more provinces with related or important state capital. The water council constitutes the deputy minister, vice-president official, and academic expert of relevant ministries and agencies as a consultative body of water policy. The water council deliberates and consults with the water authority and proposes draft doctrine, etc.

Renewable Water Production Corporation (RWPC)

This organization is established to enforce projects concerning development and management of renewable water. Based on the broad-based and relevant water development administrative plan agreed on by the national policy, water authority, and water council, required projects are undertaken and supervised by the commission through the ministries and agencies. This public corporation makes MOWE relevant authorities and undertakes projects based on the supervision and instruction of MOWE.

The operation and maintenance of dams for integrated control and other large-scale vital dams, the operation and maintenance of main groundwater basins which perform joint operations, the control of intake or withdrawal of main natural water resources and water supply networks are specially managed. This public corporation achieves the following functions and roles.

- ◆ Production of renewable water and supply of the producing water to water service enterprise etc
- ◆ Control and maintenance of large-scale dams and middle-scale dams (flood control, intake control, control and maintenance of facilities)
- ◆ Control and maintenance of main groundwater basins (aquifer management, withdrawal management, water quality monitoring and supervision, control and maintenance of facilities)
- ◆ Main pipeline transportation (transportation control, control and maintenance of facilities) and sale of the producing water
- ◆ The planning, investigation, design, and construction management of large-scale dams and middle-scale dams, and groundwater withdrawal facilities by commission from MOWE
- ◆ Promotion of dissemination of rain water harvesting facilities

<System Improvement of Existing Organizations>

MOWE Head Office

MOWE head office, based on the broad direction of the water policy by the water authority and the water council, carries out planning of water management, management of subordinate organizations, instruction of waterworks and sewage enterprise enforcement, and planning of construction management of large-scale facilities. Moreover, MOWE makes adjustments between organizations related to broad-based, important projects over provinces concerning the exploitation of water resources.

General Directorate of Water in Region

Each general directorate of water in region carries out operation and maintenance of intake facilities, water transfer and water supply network in the jurisdiction territory except for big cities managed by RWPC and facilities controlled by NWC, execution of water supply and sewage enterprise of province, planning /investigation /design and construction management of small- scale facilities. Moreover, the General Directorate of Water makes adjustments concerning project in the province concerning the exploitation of water resources as well.

Saline Water Conversion Corporation (SWCC)

SWCC is a corporation responsible for undertaking desalination water production, supply enterprise and the power generation enterprise under the supervisor of MOWE. SWCC continues to support

these enterprises and ensure their successful development.

National Water Company (NWC)

NWC is the execution organization of the water supply enterprise and sewer enterprise of the waterworks of big cities, which has operated since 2008. For the moment, NWC maintains oversight of the city zone of Makkah and Jeddah. Although it seems the management of the water supply enterprise is undertaking by the local office of MOWE is transferred to NWC, even in the other major cities in the future; at present, the concrete plan in the target region of this M/P project is not relinquished. Although the water resources development enterprise is mainly concerned with groundwater, it is proposed that part of the management of water resources development is transferred to RWPC, and NWC exists as a specialty company of the water supply enterprise and sewage enterprise in large cities.

<Proposal of New Institutions for Agricultural Water Management>

Agricultural Water Management Division and Agricultural Cooperative Association

Although the farmhouse is using the private well individually until now, the time and the labor for negotiation and adjustment for water supply condition become huge in case of selection of individual farmhouse as target for adjustment. Therefore, adjustment and the regulating function as an agricultural sector is given to the new organization representing farmhouse.

The agricultural water management division (Inner Organization in General Directorate of Agriculture in Region) is the organization for execution of agricultural water use management and adjustment between the farmers and other water basin users.

The agricultural cooperative association is an enterprise enforcement organization of agricultural sector. The organization is established for the purpose of a farmhouse performing production of agricultural products, sale, circulation, development and introduction of agricultural technology. Through these activities, agricultural water demand will be managed.

Government Support System

As governmental support, the system where government organizations carry out priority grants of support and government preferential subsidies is introduced into the joint enterprise and joint activities of farmers to promote the following enterprises.

- The joint enterprise for promoting agricultural activity activation (Establishment of the Agricultural Cooperative Association is included)
- The enterprise of decrease water use (the conversion enterprise to water-saving crops, the water-saving facilities construction enterprise, etc.)
- The enterprise for shift to joint agricultural water management

4.5 Cost Estimate and Implementation Plan

(1) Cost Estimate for Water Supply Facilities

As for the facilities proposed in the M/P, construction costs were calculated based on the construction quantity and a unit cost. Regarding construction cost for dams, except for Ranyah Dam and Hirjab Dam, cost estimate were excluded from construction cost.

Table 10 Construction Cost for each Implementation Period (Million SR)

Regions	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035	Total
Al Baha	1,247	105	0	29	0	1,381
Asir	1,528	1,284	387	0	0	3,199
Jazan	710	49	175	113	0	1,048
Total	3,485	1,438	562	143	0	5,628

Table 8 shows operation and maintenance cost, which is the highest during Year of 2010 to Year of 2035. The operation and maintenance cost by 2015 serves as SR130Million per every year, hereafter, increases every year and serves as per every year and SR298Milion for the targeted Year of 2035.

Table 11 Operation and Maintenance Cost (Million SR/Year)

Region	2011-2015	2016-2020	2021-2025	2026-2030	2031-2035
Al Baha	17	43	43	43	43
Asir	81	120	131	138	138
Jazan	102	114	158	187	187
Total	130	207	262	298	298

(2) Implementation Program

Table 12 Implementation Plan for the Major Facilities in the Water M/P

Facility	Section or Location Name	Construction Period (Water volume 10^3m^3)	2006-10	2011-15	2016-20	2021-25	2026-30	2031-35	Remarks
AL Baha									
Transmission line	Dawqah – Al Baha	2011-2030 (135)		70	135	135	135		
	Hali-Dawqah	2011-2015 (75)		75					
	Al Baha - Al Alayah	2016-2020 (65)			65				
Desalination	Shuaibah	2006-2010 (40)	40	0					Return to Makkah
	Dawqa Plant	2016-2030 (100)			75	75	100		
Renewable Water	Existing	2011-2015 (19)		19					
	Hali Dam	2011-2015 (35)		35	0				Return to Makkah
	Qanunah Dam	2011-2015 (30)		30	0				Return to Makkah
	Yiba Dam	2011-2015 (38)		38	0				Return to Makkah
	Al Janabin Dam	2011-2015 (5)		5					
	Niala& Qilwah Dam	2011-2015 (11)		11					
Asir									
Transmission line	Shuqaiq - Abha	2006-2025 (313)	82	238	238	313			
	Shuqaiq - Al Birk	2016-2020 (10)			10				
	Abha -Al Alayan	2016-2020 (40)			40				
	Abha -Al Janabin	2021-2025 (19)				19			
	Al Baha - Al Alayan	2016-2020 (65)			65				
	Al Alayan - Bishah	2016-2020 (65)			65				
Desalination	Shuqaiq	2006-2025 (313)	82	238	238	313			
Fossil water		2011-2025 (32)		29	29	61			
Dam	Existing	2006-2010 (57)	57						
	Baysh	2011-2015 (25)		25					
	Hali	2011-2015 (35)		35					
	Tabalah	2011-2015 (16)		16					
	Hirjab	2016-2020 (9)			9				
	Ranyah	2016-2020 (68)			68				
Jazan									
Transmission line	UKAD-Samtah	2011-2015 (75)		75					
Dam	Baysh	2011-2015 (33)		33					
	Damad	2016-2020 (36)		36					
	Qissi	2011-2015 (9)			9				
Desalination	Shoqaiq	2006-2020 (75)	3	75	75	0			No use in 2025
	Sabya	2016-2030 (215)			35	160	215		

Note) 1.Implementation period is shown by pattern coloring.
2. Number in a pattern shows the sum total water supply (quantity of production) for the target within the implementation period..

4.6 Evaluation for Water M/P

(1) Technical Evaluation

The M/P for water in the three regions proposed by the Study Team is drawn up according to technical data, standards and judgments, and suitable decision procedures described below. Therefore, this M/P can be technically evaluated as feasible.

(2) Economic and Financial Evaluation

Result of the Financial Analysis

The financial analysis was carried out, applying the financial value of water to the benefit of the water

supply plan. The B/C ratio discounted by 6.5% is 0.10. This result is caused by the low establishment of the water tariff as a matter of course. The water tariff should be raised about ten times of the current price level if it covers the whole cost in the current tariff structure.

Result of the Economic Analysis

The Internal Rate of Return (IRR) was calculated at 6.8%. The standard of the discount rate in the sector of water development is considered between 6 and 7%, approximately. Hence the proposed water supply plan could be evaluated feasible from the economic aspect. This result means that the proposed water supply plan is one of the mixed models of desalinated, surface and ground water, which can be feasible even if the standard discount ratio is applied to them.

(3) Evaluation from Socio-Environmental Aspect

Impact on the Natural Environment and Mitigation Program

In the M/P, the Study Team newly proposed construction of some facilities including dams, pipelines and desalination plants. Under this Study, the socio-environmental consideration survey was conducted at the magnitude of Initial Environmental Examination.

There are several uncertainties embraced in this socio-environmental consideration survey since the precise locations, layout and capacity have not been defined. However, it is anticipated that the newly proposed facilities including dams, pipelines and desalination plants, potentially cause some adverse impacts including temporary water pollution, noise and vibration, flora and fauna, etc. By considering and executing these mitigating measures, the minimum magnitude of adverse impact will be undertaken.

Consideration of Alternative Scenarios

Based on the concept of the Strategic Environmental Assessment (SEA), the following three (3) scenarios were examined.

Case A: Zero Option Scenario (Without implementation of the M/P)
Case B: M/P Scenario (With implementation of the M/P)
Case C: Alternative Scenario (Increase the water supply by desalination plant only)

Under the zero option scenario (Case A), nevertheless the natural environment would be reserved as present, deterioration of some social environments were projected due to shortage of water supply. Execution of the alternative scenario (Case C) may cause local pollution such as air pollution and adverse impacts on global warming due to complex and multiple effects of the facilities.

EIA at F/S Study Stage

In accordance with Environmental Law and Rules for Implementation (2001), Environmental Impact Assessment (EIA) is required for dams, pipelines and desalination plants at F/S Study Stage. It is recommended that the Kingdom shall conduct EIA and prepare social and environmental considerations not only limited to but particularly for the items that adverse impacts are possibly projected.

4.7 Recommendation

(1) Implementation of Projects Proposed in the Water M/P

The proposed Water M/P is prepared on the basis of the upper plans and programs such as the National Five-Years Development Plan and the National Water Strategy etc to develop proper conventional water resources and non-conventional water resources. This is to supply municipal water and agricultural water for the areas of Al Baha, Asir and Jazan Regions so that the prosperous socio-economy and ensure the comfort level of the populaces' lives are achieved in the three Regions.

The Water M/P proposes the reasonable plans of water demand and supply targeting the year of 2035 for three Regions based on the socio-economic framework by sector. To prepare the Water M/P, the opinions collected at the Stakeholder Meetings are taken into consideration.

The M/P prepared in this process proposes to solve or minimize negative water issues at present and in

future. That is why the M/P is useful and important for the people in the study regions. It is recommendable that the projects proposed in the M/P are implemented in accordance with the implementation schedule.

(2) Re-confirmation of Design Water Supply Volume from Dam

The Study team examined the new dam-projects in five Wadis (Ghoran, Naaman, Hirjam, Yiba, Khulab) based on the water balance study done in this Study. But the Study Team and MOWE concluded that these projects are not suitable for new projects judging from hydrologic, hydro-geologic and topographic conditions. Therefore, all the dams included in the M/P are the dams planned and under-construction by MOWE.

The M/P uses the design water supply volume developed at each dam that is planned by MOWE. Before the operation of each dam, MOWE must confirm whether the design development volume covers the design volumes for municipal water supply, irrigation and consumption water of current users. Also MOWE must prepare the operation rule and manual for the new dams.

For MOWE's confirmation and preparation mentioned above, the Study Team recommends the 3-Dimensional Computer Simulator to evaluate 1) sustainable water development volume and 2) effectiveness of joint operation (dam reservoir and aquifer).

(3) Promotion of Reclaimed Waste Water Reuse

At the main cities in the target regions covered by the M/P, the reclaimed waste water projects are being implemented by MOWE. The M/P proposed municipal greening water, industrial cooling water and irrigation water as a target of reuse of reclaimed waste water. Irrigation is the largest user for the reclaimed waste water. In Al Baha Region and Asir Region, each region's coverage of reclaimed waste water is respectively 20% and 25% of total irrigation water volume.

In these highland mountainous areas, the Study Team recommends the Distributed Waste Water Treatment System suitable for this kind of topography for targeting the promotion of reuse of reclaimed waste water. Also protection project of the seawater intrusion by recharging reclaimed waste water is recommendable in Jazan Region. Before starting the project operation of waste water treatment, a Feasibility Study (F/S) on reuse of reclaimed waste water is recommended.

(4) Further Study on Two New Desalination Plant in Water Supply Plan

The water supply plan proposed in the M/P targets municipal water use and industrial water use. The water resources of the water supply are surface water, renewable groundwater, fossil groundwater and desalinated seawater.

Desalinated seawater becomes the most useful water resources at the time of severe drought. Currently SWCC is supplying desalinated seawater for the areas of 3 Regions, and expanding the capacities of production and distribution.

The M/P Study clarified the renewable water resources potential and projected future water demand, and concluded that the renewable water resources potential is not sufficient to cover all the demand. It is indispensable for SWCC to continue and expand the desalination project to meet future water demand of municipal water and industrial water. However production cost of desalinated seawater is still 3 – 4 times higher than that of renewable water. As the cost of water conveyance is also high, new desalination plants should be constructed near the consumer areas to minimize water conveyance distance and cost.

The M/P proposes two new desalination plants at Dawqah in Makkah Region and Sabya in Jazan Region. The Implementation of F/S Study on these projects is recommended.

(5) Demand Management for Municipal Water

For the demand management of municipal water supply, the M/P proposes the promotion of measures to decrease LCD (or daily water consumption per capita), such as 1) Introduction of Water Saving Type Apparatus, 2) Review of Proper Water Charge and Its Collecting System, 3) Renewal of Institution for Improvement in Water Recycling Rate of Factories, and 4) Recognition of the

Importance of Water Saving by Education and Enlightenment. Also the M/P proposes such promotion measures to decrease leakage ratio of pipelines, such as 1) Planned Renewal of Decrepit Pipelines 2) Improvement of Flow Measurement, and 3) Introduction of Diagnostic Technology for Water Leakage.

Although the measures mentioned above requires some amount of financial investment, the investment is effective considering the financial aspect where the same amount of investment would save several dam constructions for water supply. Therefore, it is recommendable for water related organizations to implement demand control measures to decrease LCD.

(6) Demand Management for Irrigation Water

The water sources for irrigation water are renewable water resources and reclaimed waste water. The examination done in the M/P shows that the agriculture of year 2007 levels in Al Baha and Asir Region will be sustainable until 2035 by using renewable water and reclaimed waste water in each region. However, the agriculture in Jazan (National Top-3 Agricultural Region) will not be sustainable even in 2035 by using renewable water and reclaimed waste water in this region.

The demand management of irrigation water is especially recommended in the Jazan Region including 1) Popularization of Modern Irrigation System, 2) Conversion to Crops with Small Water Requirement Based on MOA-Decision335, and 3) Promotion of Utilization of Reclaimed Waste Water. Therefore, if the agricultural issues are not solved, industrial structure should be transformed and the surplus farming should be assigned to the other industries such as Jazan Economic City - Project. In addition, when carrying out industrial structure conversion, political consideration is necessary to compensate the small-scale farmers who have made a living by traditional agriculture methods.

(7) F/S Study on Establishment of RWPC

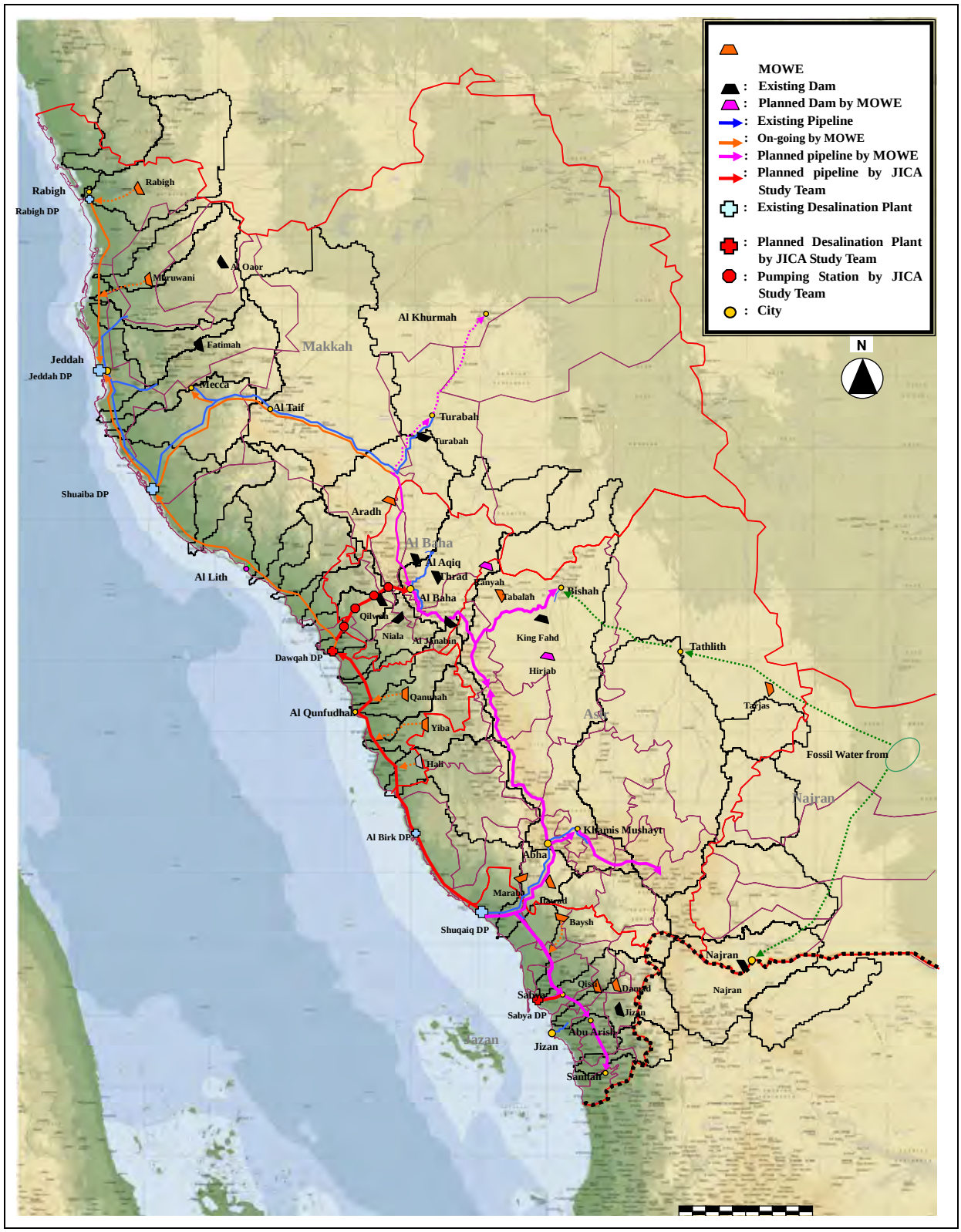
The Water M/P proposes several basic total water service management recommendations: 1) To perform efficient and economical management while combining different water resources; such as, renewable water resources, desalinated seawater, reclaimed waste water, and fossil groundwater, 2) In principle, each state usually manages the water resources assumed for every state at the current time, and 3) Water accommodation across a state should be carried out when water shortage is unusually tight due to the water supply and demand of a specific area arises (due to the local mal-distribution of rain, yearly fluctuation, and a seasonal variation).

The M/P proposes a new organization of RWPC (Renewable Water Production Corporation) as a core of the total water service management. The objectives of RWPC are to implement development, operation & maintenance of renewable water resources, and coordination with organizations concerned.

Also the M/P clarifies the mandates and activities on water resources management for water related organizations such as MOWE and MOWE Regional Office (GDW), other ministries, SWCC, NWC and so on. Further study (F/S) on the establishment of RWPC is highly recommended to realize good water management in the projected areas.

(8) F/S Study on Establishment of REWLIP (Red-Sea Water Lifeline Project)

The Study Team proposes REWLIP based on the following two important aspects: *1) Economic Aspect to Secure Less Expensive Water, and 2) Technical Aspect to Secure Necessary Water Sufficiently in a Wider Area by Different Water Sources and Well Connected Water Conveyance Systems*. This large project (which produces desalinated seawater, renewable water and distributes water in the 4 Regions) is the first and very important project for the area and for the KSA. The Study Team recommends the F/S Study on this very important project to be realized soon for the study regions and the KSA as a whole.



Red-Sea Water Lifeline Project

PART-A Study Operational

CHAPTER 1 OUTLINE OF THE STUDY

1.1 Background

The desert or arid area extends to the whole land of the Kingdom of Saudi Arabia (KSA), and the acquisition of water resources is one of the top issues to sustain the people's life and domestic industries. The recent increase in population, urbanization and industrialization induces the rapid increase of water demand, and it requires that appropriate and prompt measures against water scarcity be taken.

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 Government of the KSA, accordingly, requested the Japanese Government in 2000 to formulate a master plan (M/P) study on renewable water resources development and management mainly for the renewable water resources of surface and groundwater in the Southwest Region of KSA based on her basic policy on the restriction of water use from non-renewable water (fossil water) and the increase of the water supply from the other water sources. The Government of KSA expressed the request for the corporation in water resources sector to the Japanese Government in November, 1999. In response to the requests, JICA sent a Study Mission on the background of the request in April, 2000 and also sent a Mission for Project Formulation Study in October 2000 in order to conduct a project formulation on "The Renewable Water Resources Development in the Southwest Region of the Kingdom of Saudi Arabia".

As for the captioned study, the preliminary study was carried out in December, 2006 in order to reconfirm the details of the requests and the organization structure for above implementation and followed by the dispatch of the Preliminary Study Team from January 12th to February 8th, 2007. At the Preliminary Study, the discussion was carried out for confirming the scope of the full-scale study and the organization structure for above implementation between the Government of KSA and the Government of Japan. The team leader of JICA Preliminary Study Team and Deputy Minister of Ministry of Water and Electricity (MOWE) concluded an agreement and signed the S/W (Scope of Works) and M/M (Minutes of Meetings) on above full-scale study in January 21st 2007.

The JICA Study commenced in Riyadh in July, 2007, and submitted a progress report (1) based on field reconnaissance, new findings on water use and water resources, updated information was submitted on February, 2008. The interim report compiling the formulation on the basic strategy and policy for integrated water resources development and management, and selection of regions such as Al Baha, Asir and Jazan Region for the M/P study based on the water balance analysis including desalinated seawater as well as reclaimed wastewater and demand projection to the Targeted Year 2035 on municipal, industrial and agricultural water was also prepared in June, 2009.

The progress report (2) describing water resources development plan for renewable water, desalinated seawater and reclaimed water including operational plan, implementation plan and cost estimate as well as economic and financial evaluation for the water M/P was submitted to MOWE, and a discussion was held in January, 2010. The draft final report dealing with the strategy and action plans for water resources development and management plan in the 5 Regions and water M/P in the 3 Regions was prepared, and discussed in the steering committee in May, 2010.

1.2 Objectives of the Study

The objectives of the Study are shown below.

1) To formulate a basic policy, strategy and action plan for sustainable water resources development, utilization and management in the southwest region of KSA
2) To formulate a M/P for sustainable water resources for the selected Regions based on the action plan
3) To transfer relevant skills and technologies mainly to personnel of the MOWE

1.3 Study Area

The study area for the phase 1 covered the following five (5) Regions, Makkah, Al Baha, Asir, Jazan and Najran located in the southwest area of the KSA. The study area for phase 2 focuses on Al Baha, Asir and Jazan Region.

Figure A.1-1 Study Area

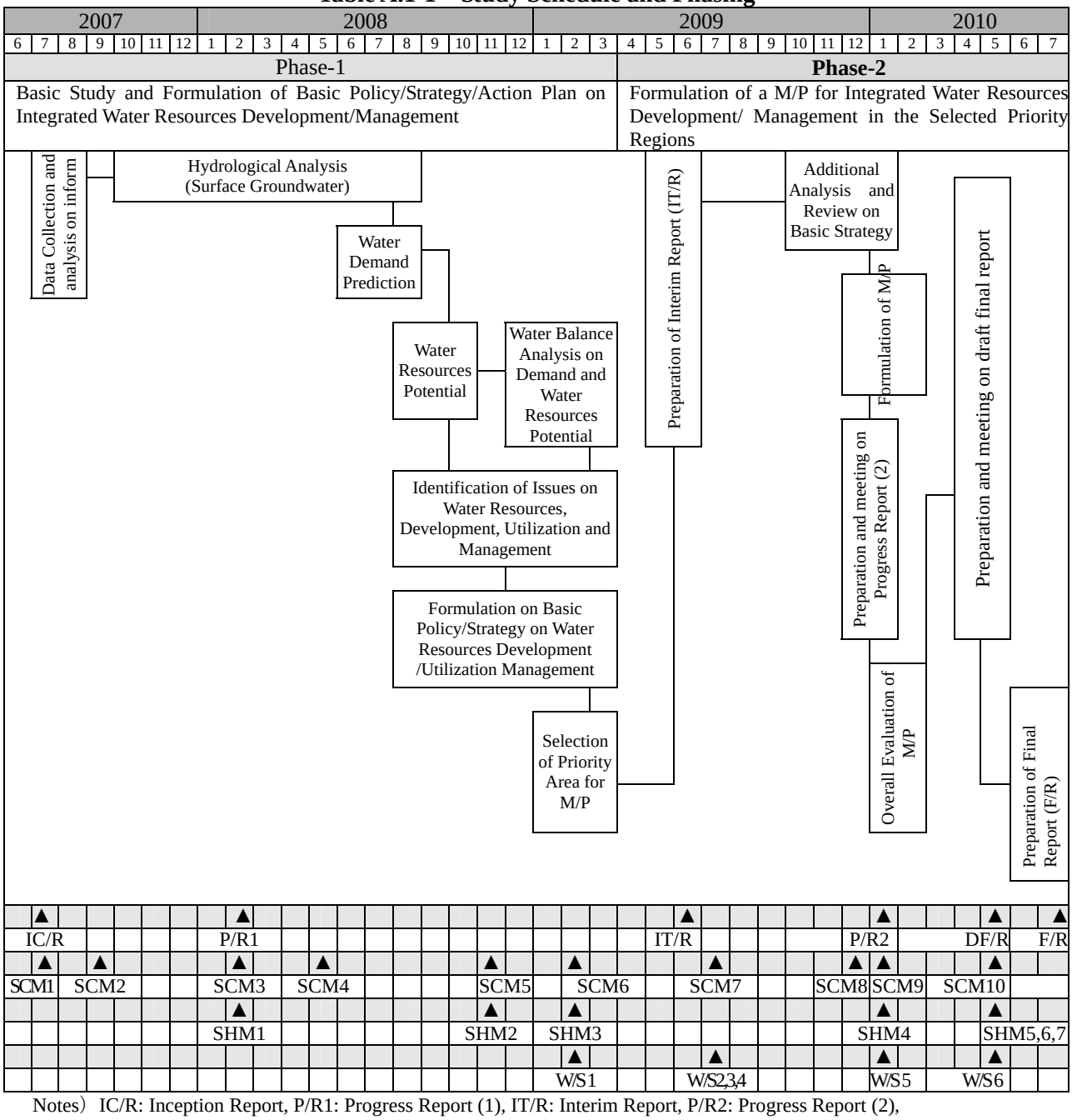
1.4 Study Schedule and Study Flow

The study consists of two (2) phases as shown below which will be allocated in the total study period of approximately 37 months.

Phase 1 : Basic study and formulation of basic policy, strategy and action plan on integrated water resources development and management

Phase 2 : Formulation of a M/P for integrated water resources development and management in the Selected Priority Regions

Table A.1-1 Study Schedule and Phasing



Notes) IC/R: Inception Report, P/R1: Progress Report (1), IT/R: Interim Report, P/R2: Progress Report (2), DF/R: Draft Final Report, SCM: Stirring Committee Meeting, W/S: Workshop, SHM: Stakeholder Meeting

Study flow is shown as follows.

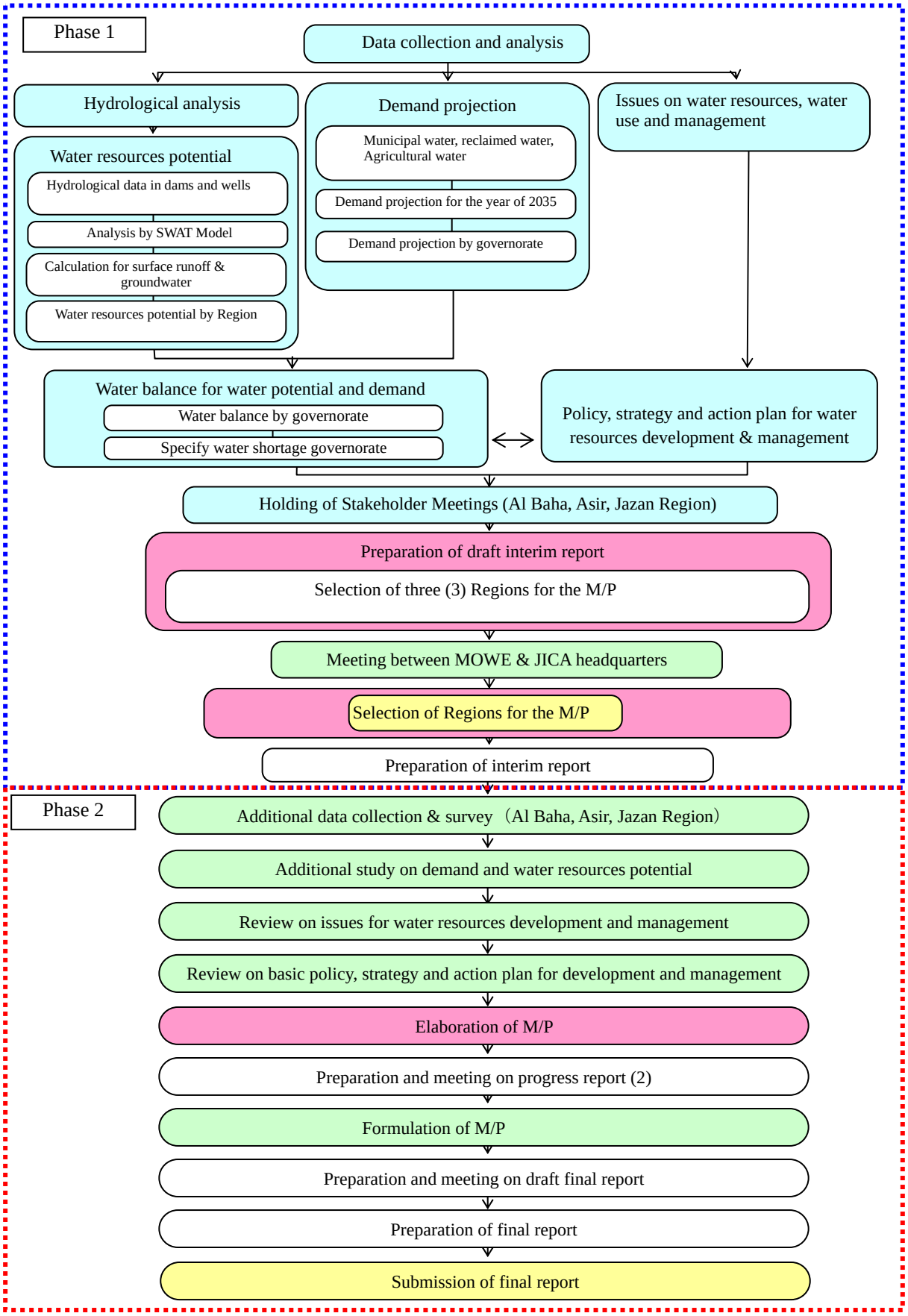


Figure A.1-2　Study Flow for the Study

CHAPTER 2 STUDY ORGANIZATION AND OPERATION

2.1 Study Organization

The operational organization of the study will be collaborated, finalized and decided through the discussion with MOWE and the details are shown in Figure A.2-1.

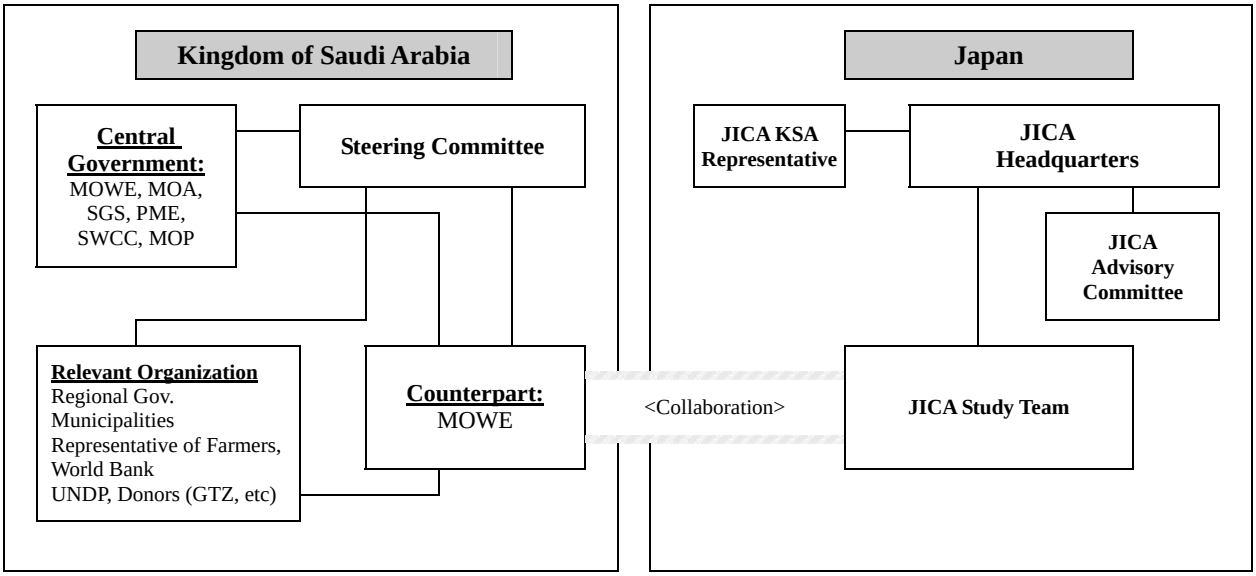


Figure A.2-1 Organization of the Study

2.2 Member of Steering Committee, Counterpart Personnel and JICA Study Team

The members of the steering committee and counterpart team of MOWE and JICA Study Team are shown in Table A.2-1, Table A.2-2 and Table A.2-3, respectively. Table A.2-4 shows the main topics discussed in the steering committee meetings.

Table A.2-1 Member of the Steering Committee (Ministry of Water and Electricity)

Position	Name	Position or Job Title
Chairman	Dr. A Mohammed I.Al Saud	Deputy Minister of Water Affairs, MOWE (Phase II)
Chairman	Dr. Ali Saad Al-Tokhais	Deputy Minister of Water Affairs, MOWE (Phase I)
Member	Mr. Said Ali Al Duair	Director General for Water Resources Development Department, MOWE (Phase II)
Member	Mr.Ahmed bin Abdullah Al-Ghamdi	Director General for Water Resources Development Department, MOWE (Phase I)
Member	Mr. Abdulaziz Al-Kahlan	Director of Hydrology Division, MOWE
Member	Mr. Helal Ayedh Al-Harthi	Director of Water Research & Studies Division, MOWE
Member	Mr. Ahmed Al-Khalifa	Assistant Director of Water Research & Studies Division, MOWE
Member	Mr. Fahad Ahmed Al-Beajan	Senior Geologist, MOWE
Member	Mr. Metib Al-Khatany	Senior Geologist, MOWE
Member	Mr. Abdulaziz bin Saleh Al-Hassan	Senior Hydrogeologist, MOWE
Member	Mr.Hatim Sarin H. Ratah	Senior hydrologist
Member	Mr. Ghanem Abdulaziz Al-Ghanem	Hydrologist, MOWE
Member	Mr. Saleh Al Meeman	Engineer of Project Execution Department, MOWE

Table A.2-2 Member of the Counterpart Personnel for each Region

Position	Name	Position or Job Title	Region
Member	Mr. Habib Mohammed Khayat	Senior Geologist	Makkah
Member	Mr. Hani Othman Kemrin	Senior Geologist	
Member	Mr. Jaber Al-Fifi	Senior Geologist	Al Baha
Member	Mr. Awadh Mahdi Al-Gharni	Senior Geologist	
Member	Mr. Ahmed bin Siraj	Senior Geologist	Asir
Member	Mr. Abdullah bin Ali Al-Shihri	Senior Geologist	
Member	Mr. Ahmad Hassan Nejmi	Senior Geologist	Jazan
Member	Mr. Ibrahim Souwaidi	Observer	
Member	Mr. Faris bin Mohammed Dakhil	Senior Geologist	Najran
Member	Mr. Abdullah bin Rashid Debis	Senior Geologist	

Table A.2-3 Member of the JICA Study Team

Name	Position in the Study Team or Job Title
Mr. WATANABE Masatomo	Team leader
Mr. NAKAGAWA Yoshio	Project Director
Mr. TAKAHASHI Toru	Deputy Team Leader / Water Resources
Mr. SHIRAISHI Masayuki	Deputy Team Leader / Water Resources Development Management(Phase I)
Mr. OCHII Yasuhiro	Deputy Team Leader / Water Resources Development Management(Phase I & II)
Mr. KANAMURA Hidetoshi	River/Hydrology (Phase I)
Mr. NAKAMURA Hiroshi	River/Hydrology (Phase II)
Mr. KATO Izumi	Geology/Hydrogeology
Mr. NAKANO Toshinobu	Agriculture /Irrigation
Mr. FUJIYAMA Taketoshi	Water Supply (Desalination, Waste Water Reuse)
Mr. SHINGU Tamotsu	Facility Design / Cost Estimate
Mr. Pirran D. DRIVER	Environmental and Social Consideration (Phase I)
Mr. HARA Takashi	Environmental and Social Consideration (Phase II)
Mr. NAKANISHi Sampei	Social / Organization /Institution (Phase I)
Mr. OURA Hisashi	Social / Organization /Institution (Phase II)
Mr. NATSUDA Shohei	Economic and Financial Analysis
Mr. ONO Shigeru	GIS Expert
Dr. EIBO Ahmad	Interpreter（Phase II）
Mr. KATO Atsushi	Coordinator (Computer specialist)

Table A.2-4 Main Topics of the Steering Committee Meetings

Time	Date	Main Topics or Report to be submitted for the Meeting
1st	July. 8, 2007	Inception report, Study schedule of the JICA Study Team
2nd	Aug.25, 2007	Plan of operation, Study schedule of the JICA Study Team
3rd	Feb.27, 2008	Progress report (1), Current situation of the study area
4th	May.12,.2008	Study Schedule
5th	Nov.13, 2008	Basic policy, strategy on water resources development, Future water supply in 5 Regions
6th	Feb.23, 2009	Draft interim report, Selection of Regions for the master plans study
7th	Jun.16, 2009	Interim report, Basic policy and strategy for water resources management in 5 Regions
8th	Nov.16, 2009	Water resources development for renewable water, desalinated seawater and reclaimed water
9th	Jan.26, 2010	Progress report (2)、Water resources development and management plan for renewable water
10th	May 26, 2010	Draft final report

2.3 Stakeholder Meetings

During phase 1 study, stakeholder meetings were held 3 times for the purpose of explanation of the study outline and obtaining information on water issues in Region. Outline of the water master plan for each Region was explained and discussed among stakeholders in the meeting during phase 2 study. Table A.2-5 shows an outline of the held stakeholder meeting.

Table A.2-5 Outline of the Stakeholder Meetings

Time	Date	Agenda, Venue, Attendance
1st	Feb.14, 2008	JICA Study, Issues on water, Abha, Asir Region, 51 participants
2nd	Oct.10, 2008	Ditto, Al Baha, Al Baha Region, 80 persons
3rd	Mar.10, 2009	Ditto, Jizan, Jazan Region, 60 persons
4th	Jan. 19, 2010.	Basic policy, strategy and action plan for 5 Regions, water supply plan for municipal water Abha, Asir Region 38 participants
5th	May. 9, 2010.	Water master plan in Al Baha Region, 45 participants
6th	May.12, 2010	Water master plan in Asir Region
7th	May. 19,2010	Water master plan in Jazan Region

2.4 Workshop

Workshops were carried out 6 times for the exchange of information on water resources development and water demand, opinions for the JICA study and for seminar on monitoring method of surface runoff and sub-surface water in Wadis Table A.2-5 shows an outline of the held workshops.

Table A.2-6 Outline of the Workshop and Main Agenda

Time	Date	Venue, Region	Main Agenda
1st	Mar.28,2009	Wadi Hirjab, Bisha, Asir Region	Monitoring on surface runoff and sub-surface water in Wadis and arrangement of monitoring data
2nd	Jun 8, 2009	Abha, Asir Region	Water resources potential, Demand projection, Selection of Regions for the master plan study
3rd	Jun13,2009	Al Baha, Al Baha Region	Current water supply, Water resources development by dam construction, Water supply by desalination seawater
4th	Jun13, 2009	Jizan, Jazan Region	Hydrological water balance, SWAT model, Agricultural demand in the Region
5th	Jan. 12 2010	Abha, Asir Region	Basic policy, strategy and action plan for water resources development, Water master plan
6th	May 26 2010	Riyadh, Riyadh Region	Water master plan for each Region

2.5 Survey by Sub-contract

To grasp the hydrological condition on surface runoff and sub-surface water in Wadi and groundwater level, hydrological surveys were done in the study area. The initial environmental examination (IEE) was also conducted during the phase 2 study to recognize the richness and current conditions of the fauna, flora and water quality in the targeted areas as shown in Table A.2-7.

Table A.2-7 Outline of Survey by Sub-contract

Study Items	Consultant	Survey Area	Survey Description
Discharge in Wadi	Thobaity Office	Wadi Hirjab、Wadi Tabalah, Wadi Habawnah	Hydrological survey for discharge in three Wadis (Wadi Tabalah, Wadi Hirjab, Wadi Habawnah) for one year.
Sub-surface flow	Thobaity Office	Wadi Hirjab、Wadi Tabalah, Wadi Habawnah	Hydrological survey for groundwater level in three Wadis (Wadi Tabalah、Hirjab、Habawnah) for one year.
Groundwater in wells	Saudi Geo -physical	Selected 200 wells	Monitoring of groundwater level in selected 200 wells.
Initial Environmental Examination	Thobaity Office	Targeted study area or water resources development facilities	1) Recognize the richness and current conditions of the species of fauna and flora 2) Recognize the current water quality in selected water sources

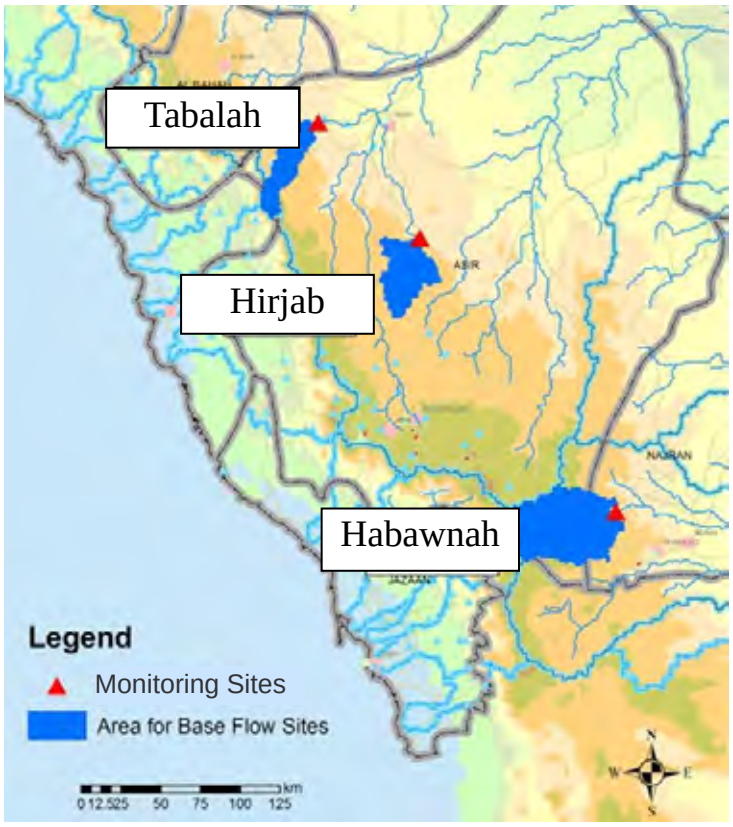


Figure A.2-2 Location Map of Survey by Sub-contract (1)

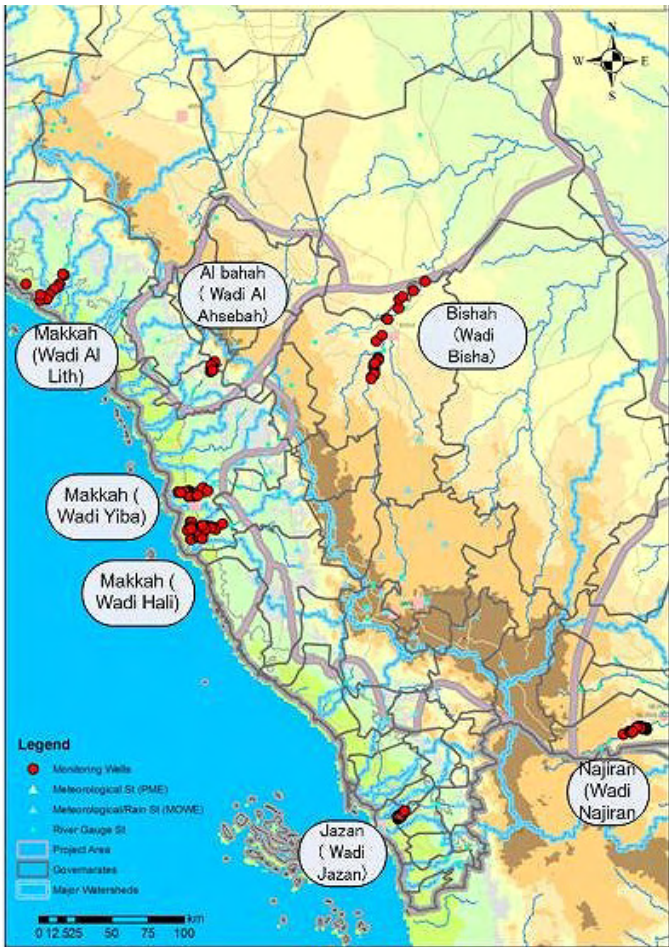


Figure A.2-2 Location Map of Survey by Sub-contract (2)

2.6 Counterpart Training in Japan

Counterpart training in Japan was carried out 2 times, in 2008 and 2009, for the purpose of introduction to the water development plan in Japan, the management and operation for water resources development facilities such as dams and barrages through the lectures and study tours. Semi High-level official training in Japan was carried out from June to July 2009, for the purpose of introducing of the technology of the future water field, and discussing the possibility of technical cooperation. Discussion on the master plan in the JICA Study was conducted at the headquarters of JICA, and a discussion with the executives of the Ministry of Land, Infrastructure and Transport, the Ministry of Agriculture, Forestry, and Fisheries (MAFF) and Japan Water Agency (JBA). An outline of training is shown in Table A.2-8.

Table A.2-8 Outline of Training in Japan

Duration	Number of Trainees	Venue or Site	Training Program
From July 10, 2008 to July 29, 2008	10 persons, MOWE	1)JICA Tokyo 2)Yachiyo Engineering Co., Ltd. 3)Kizugawa integrated dam operation office 4)Kawaji Dam operation office	1) Water resources development in Japan 2) Municipal water supply plan 3) Environmental issues on dams and reservoirs 4) Apply GIS for water resources development 5) Evaluation on groundwater potential 6) Apply remote censing for water resources development 7) Study tour (Hinachi Dam, Lake Biwa, Kawaji Dam, Arakawa retarding pond)
From June 29, 2009 to July 3, 2009	4 persons, MOWE	1)JICA Tokyo 2)Yachiyo Engineering Co., Ltd. 3)Japan Water Agency 4)Japan Sewage Work Association	1) Discussion for the Study on Master Plan on Renewable Water Resources Development in the Southwest Region 2) Administrative of water resources in Japan, Control facilities of water resources 3) Administrative of water supply in Japan, water treatment technology and administrative of sewerage 4) Water resources management facilities, Sewerage reclamation facilities of current state 5) Intro of Sewerage technology, New technology for recycled water
From July 9, 2009 to July 28, 2009	10 persons, MOWE	1)JICA Tokyo 2)Yachiyo Engineering Co., Ltd. 3)Kizugawa integrated dam operation office 4)Kawaji Dam operation office 5)Akigase Barrage	1) Water resources development in Japan 2) Municipal water supply plan 3) Environmental issues on dams and reservoirs 4) Apply GIS for water resources development 5) Evaluation on groundwater potential 6) Apply remote censing for water resources development 7) Study tour (Hinachi Dam, Lake Biwa, Kawaji Dam, Arakawa retarding pond, Akigase Barrage)

The counterpart training session was done for understanding the policy of water resources development method, technology, and Japan, while evaluating these situations through actually inspecting dam facilities, river operation and maintenance facilities. The technology of control management of a dam, floodgate and the water quality improvement method could be applied to Saudi Arabia, and the JICA Study Team followed up after training.

Semi high level official training deepened understanding and information concerning the administrative and technology of water resources development management in Japan, and purposely showed the interest in continuous discussions in the area of sewerage treatment technology and water reuse technology.

Trainees in 2008 and 2009 including semi high level official trainee are listed below.

Table A.2-9 List of Trainee for Semi High Level Official Training in Japan (2009)

Position	Name	Position or Job Title
Leader	Dr. A Mohammed I.Al Saud	Deputy Minister of Water Affairs, MOWE (Phase II)
Member	Mr. Said Ali Al Duair	Director General for Water Resources Development Department, MOWE
Member	Mr. Helal Ayedh Al-Harthi	Director of Water Research & Studies Division, MOWE
Member	Mr. Ahmed Al-Khalifa	Assistant Director of Water Research & Studies Division, MOWE

Table A.2-10 List of Trainee for Counterpart Training in Japan (2008)

Position	Name	Position or Job Title	MOWE (H.Q or Region)
Leader	Mr. Fahad Ahmed Al-Beajan	Senior Geologist	MOWE H.Q
Member	Mr. Ghanem Abdulaziz Al-Ghanem	Hydrologist	
Member	Mr. Fahad Miftah S. Al-Zahrani	Geologist	
Member	Mr. Hassan Moustafa Al-Shrime	Geologist	
Member	Mr. Fahad Yahia M. Al-Faifa	Geologist	
Member	Mr. Mohammed Sulaiman H. Al-Fahami	Geologist	
Member	Mr. Abudullah Ali A. Al-Zahrani	Electrical Engineer, Assistant Manager of O&M	General Directorate of Water (GDW) , Al -Baha
Member	Mr. Ahmed Siraj Y. Al-Zahrani	Hydrogeologist, Manager	GDW, Asir
Member	Mr. Ahmed Najimi H. Humadi	Senior Geologist, Manager	GDW, Jazan
Member	Mr. Hassan Salem H. Al Yami	Geologist	GDW, Najran

Table A.2-11 List of Trainee for Counterpart Training in Japan (2009)

Position	Name	Position or Job Title	MOWE (H.Q or Region)
Leader	Mr. Mohammed A. Al-Shamrani	Hydrogeologist, Manager	GDW, Asir
Member	Mr. Habib Mohammed A. Khayat	Hydrologeologist, Manager	GDW, Jiddah
Member	Mr. Jaber Mesfer S.	Hydrogeologist, Manager	GDW, Al Baha
Member	Mr. Ibrahim Ali Suwaydi	Section Manager	GDW, Jazan
Member	Mr. Absullah Belal Al Sabhi	Geophysist	MOWE, H.Q
Member	Mr. Awad Owaydh D. Al Solani	Geophysist	
Member	Mr. Majed Marui A. Al Asseiri	Geologist	
Member	Mr. Ahmed Ali M. Al Ghamdi	Hydrologist	
Member	Mr. Ahmed Saeed Saleh A.	Geologist	
Member	Mr. Faris Mohammed A.	Geologist	GDW, Najran

PART-B Basic Study and Basic Strategy of Water Resources Development Management

CHAPTER 1 CURRENT SITUATION OF THE STUDY AREA

1.1 Socio-economy

1.1.1 Sub-division and Population

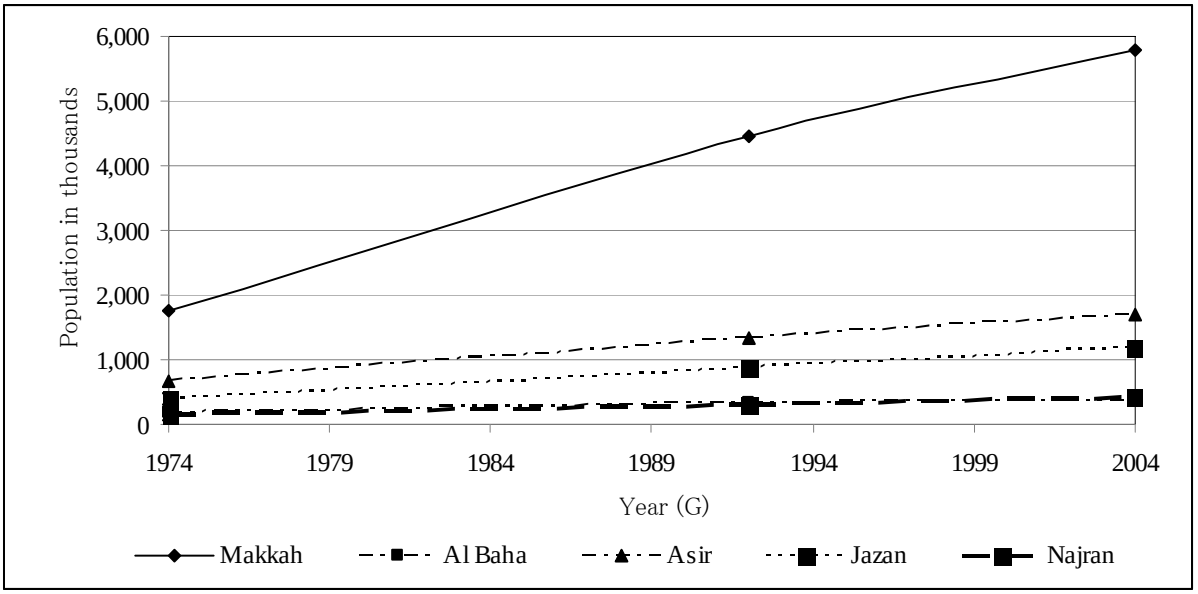
Table B.1-1 shows population trends in the five regions and all 13 regions in the KSA from 1974 to 2004 (see Figure B.1-1). The population of the five regions made up about 40% of the KSA's population in 2004 and increased three-fold in the 30 years from 1974 to 2004. In addition, the annual population growth rate was 6.9% from 1974 to 1992 and decreased to 2.3% from 1992 to 2004.

Table B.1-1 Population Growth in the Five Regions from 1974 to 2004

Regions	1974	1992	2004	Growth Rate per Year in 1974-1992 (%)	Growth Rate per Year in 1992-2004 (%)
Makkah	1,754,108	4,467,670	5,797,971	8.1	2.3
Al Baha	185,905	332,157	377,739	4.1	1.1
Asir	681,361	1,340,168	1,688,368	5.1	2.0
Jazan	403,106	865,961	1,186,139	6.0	2.8
Najran	147,970	300,994	419,457	5.4	3.0
5 Regions total	**3,172,450**	**7,306,950**	**9,469,674**	**6.9**	**2.3**
13 Regions total	**6,729,642**	**16,948,388**	**22,673,556**	**8.0**	**2.6**

Source: The Eighth Development Plan

Note: Population growth rates were re-calculated.



Source: The Eighth Development Plan

Figure B.1-1 Population Growth of the Five Regions from 1974 to 2004

The five regions of the study area are further divided into sub-divisions (Governorates) as shown in Table B.1-2. 73 cities are designated for urbanization (Population of at least 5,000) in the 53 governorates as shown in Table B.1-3. About 73% of the population in the five regions lives in urban areas.

Table B.1-2 Census Population of the Five Regions in 2004

Governorate	Households	Total	Rate of Governorate Pop.	Average size of household	Governorate	Households	Total	Rate of Governorate Pop.	Average size of household
Makkah Region									
Makkah	257,054	1,338,341	23.1%	5.21	Dahran Al janub	7,986	55,528	3.3%	6.95
Jeddah	635,001	2,883,169	49.7%	4.54	Balqarn	11,573	66,675	3.9%	5.76
Al taif	155,042	885,474	15.3%	5.71	Al majardah	16,028	89,655	5.3%	5.59
Al qunfudah	46,385	240,938	4.2%	5.19	**12 Governorates Total**	**287,853**	**1,688,368**	**100%**	**5.87**
Al lith	17,386	110,449	1.9%	6.35	**Jazan Region**				
Rabigh	14,605	68,966	1.2%	4.72	Jizan	38,940	252,488	21.3%	6.48
Al jamoom	15,365	75,993	1.3%	4.95	Sabya	32,000	198,029	16.7%	6.19
Khulays	10,448	49,955	0.9%	4.78	Abu Arish	19,096	123,823	10.4%	6.48
Al Kamel	4,053	18,547	0.3%	4.58	Samtah	18,643	128,906	10.9%	6.91
Al Khurmah	6,860	39,053	0.7%	5.69	Al harth	5,665	47,791	4.0%	8.44
Ranyah	7,118	44,276	0.8%	6.22	Damad	9,818	62,465	5.3%	6.36
Turaba	8,140	42,810	0.7%	5.26	Al rith	1,405	13,406	1.1%	9.54
12 Governorates Total	**1,177,457**	**5,797,971**	**100%**	**4.92**	Baysh	8,883	58,326	4.9%	6.57
Al Baha Region					Farasan	2,346	13,972	1.2%	5.96
Al baha	17,317	93,128	24.7%	5.38	Bany malik (al daeer)	6,887	49,265	4.2%	7.15
Baljurashi	11,586	61,354	16.2%	5.30	Ahad Al masarha	10,243	69,976	5.9%	6.83
Al mandaq	7,505	45,666	12.1%	6.08	Al edabi	6,931	52,783	4.4%	7.62
Al mekhwat	10,607	64,365	17.0%	6.07	Al aradah	7,484	62,934	5.3%	8.41
Al Oqiq	4,727	28,606	7.6%	6.05	Al darb	8,625	51,975	4.4%	6.03
Qilwah	7,989	55,511	14.7%	6.95	**14 Governorates Total**	**176,966**	**1,186,139**	**100%**	**6.70**
Al qurah	5,254	29,109	7.7%	5.54	**Najran Region**				
7 Governorates Total	**64,985**	**377,739**	**100%**	**5.81**	Najran	45,171	263,537	62.8%	5.83
Asir Region					Sharorah	10,794	72,804	17.4%	6.74
Abha	63,390	350,694	20.8%	5.53	Habawnah	4,352	24,204	5.8%	5.56
Khamis Mushayt	75,290	446,467	26.4%	5.93	Bader al janub	1,632	9,521	2.3%	5.83
Bisha	32,185	188,668	11.2%	5.86	Yadamah	2,382	13,879	3.3%	5.83
Al namas	9,114	47,783	2.8%	5.24	Thar	2,037	12,912	3.1%	6.34
Mahael	28,305	176,377	10.4%	6.23	Khibash	2,995	18,805	4.5%	6.28
Serat Abeedah	9,215	59,546	3.5%	6.46	Al kharkher	409	3,795	0.9%	9.28
Tathlith	7,500	48,765	2.9%	6.50	**8 Governorates Total**	**69,772**	**419,457**	**100%**	**6.01**
Rijal Almah	10,020	58,952	3.5%	5.88					
Ahad rifidah	17,247	99,258	5.9%	5.76	**53 Gov. Grand Total**	**1,777,033**	**9,469,674**		**5.33**

Source: 2004G Population Census

Table B.1-3 Population of the Five Regions by Urban (Cities) and Rural in 2004

Regions	Entire population of region (A)	Number of cities	City (Urban) population of region (B)		Other (Rural) population (C)=(B)-(A)	
Makkah	5,797,971	23	5,077,777	87.6%	720,194	12.4%
Al Baha	377,739	6	177,186	46.9%	200,553	53.1%
Asir	1,688,368	16	886,617	52.5%	801,751	47.5%
Jazan	1,186,139	23	403,756	34.0%	782,383	66.0%
Najran	419,457	5	331,966	79.1%	87,491	20.9%
Total	**9,469,674**	**73**	**6,877,302**	**72.6%**	**2,592,372**	**27.4%**

Source: 2004G Population Census

1.1.2 Economy

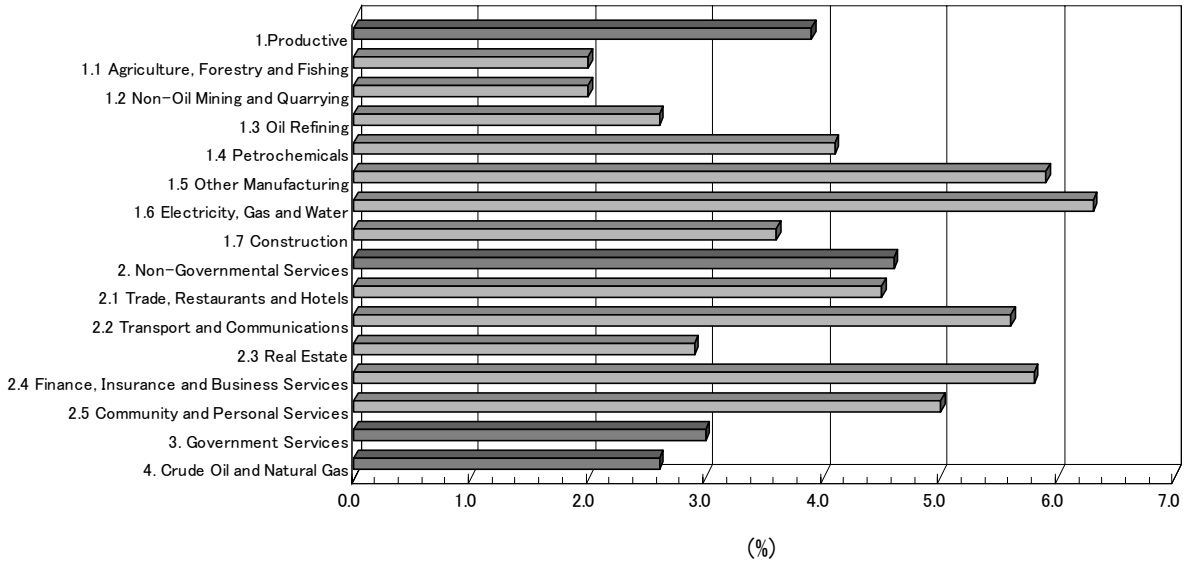
Table B.1-4 represents value added changes from 1999 to 2004. The average annual growth rate of the GDP in the period is 3.4%. The growth rate of the non-governmental services sector and the productive sector are higher than the average growth rate of GDP. In 2004, the share of non-governmental services sector was about 30%, the crude oil and natural gas sector was about 28%, and the productive sector was about 25% of the GDP.

Table B.1-4 GDP by Sector, Constant 1999 Prices

Sector	Value Added		Average Annual Growth Rate (%)	Shara in GDP	
	1999 (SR Million)	2004 (SR Million)		1999 (%)	2004 (%)
1.Productive	147,318	178,250	3.9	24.4	24.9
1.1 Agriculture, Forestry and Fishing	34,443	38005	2.0	5.7	5.3
1.2 Non-Oil Mining and Quarrying	2,464	2,723	2.0	0.4	0.4
1.3 Oil Refining	18,021	20,508	2.6	3.0	2.9
1.4 Petrochemicals	6,000	7,352	4.1	1.0	1.0
1.5 Other Manufacturing	38,779	51,616	5.9	6.4	7.2
1.6 Electricity, Gas and Water	8,174	11,085	6.3	1.4	1.6
1.7 Construction	39,437	46,961	3.6	6.5	6.6
2. Non-Governmental Services	169,086	211,953	4.6	28.0	29.6
2.1 Trade, Restaurants and Hotels	45,992	57,299	4.5	7.6	8.0
2.2 Transport and Communications	27,893	36,674	5.6	4.6	5.1
2.3 Real Estate	42,221	48,822	2.9	7.0	6.8
2.4 Finance, Insurance and Business Services	31,603	41,902	5.8	5.2	5.9
2.5 Community and Personal Services	21,377	27,256	5.0	3.5	3.8
3. Government Services	116,789	135,064	3.0	19.3	18.9
4. Crude Oil and Natural Gas	173,102	196,696	2.6	28.7	27.5
5. Other Items	-2,706	-7,063	21.2	-0.4	-1.0
GDP	603,589	714,900	3.4	100	100

Source: The Eighth Development Plan

Note: "Other Items" is import duties less imputed bank service charges.

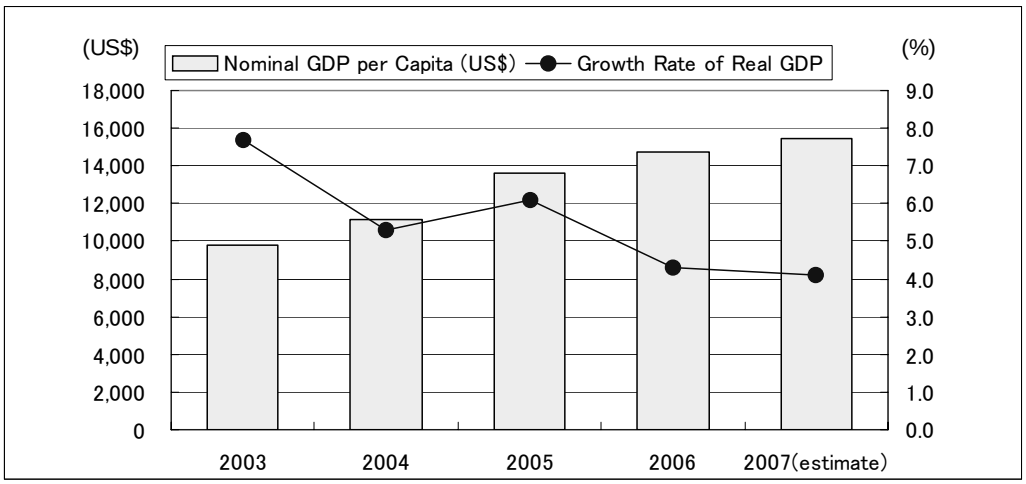


Source: The Eighth Development Plan

Figure B.1-2 Average Annual Growth Rate of GDP 1999 - 2004

The productive sector and non-governmental services sectors are divided into sub-sectors as shown in the above table. Trade, Restaurants and Hotels, Other manufacturing, Real estate, and Construction occupy more than 6.0% of the GDP. The sub-sectors whose average annual growth rates are over 5.0% are Electricity, Gas and Water (6.3%), Other Manufacturing (5.9%), Finance, insurance and business services (5.8%), and Transport and Communications (5.6%). These figures show that the manufacturing sector and non-governmental services sector are leading the growth of the national economy.

In these years, GDP per capita is increasing steadily year by year. The value is seemed to be over US$ 15,000 in 2007. The growth rate is decreasing in these five years. It came down between five and six percent in 2004 though it was nearly eight percent in 2003 in particular. However, the trend of decreasing has been eased, gradually. It is estimated that the growth rate in 2007 will maintain between four and five percent.



Source: IMF, "World Economic Outlook Database"

Figure B.1-3 GDP per Capita and the Growth Rate 2003 - 2007

1.1.3 Agriculture

(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 B.1-6, Table B.1-5, the big 5 regions of planted area are Riyadh, Al Qasim, Jazan, Al Jawf and Hail in order, and the Jazan of the biggest planted area in the South West Area 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%. (source: FAOSTAT).

Table B.1-5 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

(2) Agriculture in South West Region

The crop planted area and production for the last five years are as shown in Table B.1-6. 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 fruit trees and vegetable cultivation because of the geographical features and high elevation climate. Jazan Region shows the biggest planted area, especially cultivation of cereals occupies many, and has become percentage of 80% or more. 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 exist, such as drip irrigation and micro jet irrigation, the adopted irrigation efficiency is rather high for vegetables and fruit trees. In cultivation of cereals, such as a sorghum and wheat, traditional irrigation systems, such as flood irrigation systems, are generally adopted and irrigation efficiency is rather low.

Table B.1-6 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

1.1.4 Industry

(1) Current Status of Industries in Overall KSA

The ten main industries operating factories in the KSA are shown in Table B.1-7. The total number of factories remarkably increased eight-fold in the 35 years from 1971. Currently the main industries are chemical and plastic products, building materials, glass and basic metallic. There were 1,176 factories in the five regions in 2006, making up around 30% of the national total, and its rate has almost unchanged from 1999.

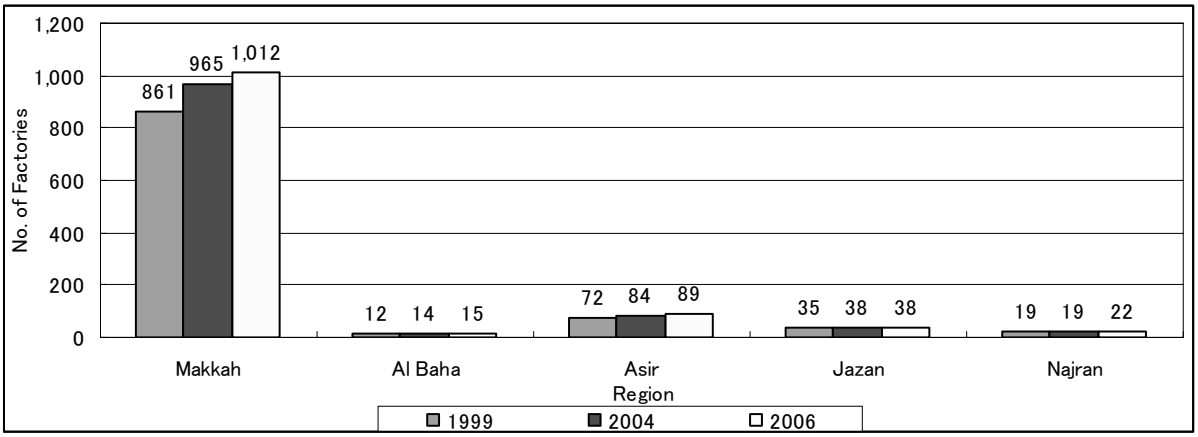
Table B.1-7 Number of Operating Factories in the KSA

Sectors	1971	1999	2004	2005	2006
Food and Beverages	73	504	577	597	603
Textiles, readymade clothes and leather	12	141	174	190	191
Wood, wooden products and furniture	25	145	190	189	189
Paper, printing and publication	46	195	226	227	227
Chemical industries and plastic products	63	630	795	855	869
Building materials, glass, ceramic and metal basic industries	91	545	585	808	611
Basic Metallic		11	16		610
Manufactured metals, machines and equipment	159	893	993	847	453
Other industries	3	78	80	79	79
Transportation & Warehouse		21	16		16
Total	**472**	**3,163**	**3,652**	**3,792**	**3,848**
5 regions	**-**	**999**	**1,120**	**-**	**1,176**
% in 13 regions	**-**	**31.6%**	**30.7%**	**-**	**30.6%**

Sources: Saudi Organization for Industrial States & Technology Zone, and the Eighth Development Plan

(2) Number of Industries in Five Regions

Figure B.1-7 shows trends of industry numbers in 1999, 2004 and 2006. The numbers of all industries in the five regions have increased. The region with the highest rate (about 3.6%) of increase is Al Baha region and the second highest rate (about 3.4%) is Asir region. On the other hand, the region with the lowest rate (about 1.2%) of increase is Jazan region.



Sources: Saudi Organization for Industrial States & Technology Zone, and the Eighth Development Plan

Figure B.1-4 Trend of Number of Industries

The following table shows the breakdown of the number of operating factories classified by industrial sectors in the five regions in 2006. Food processing, chemical products, building material and base metal processing in all five regions are the main sectors, and these four sectors make up more than 70% of the total (Figure B.1-8).

Table B.1-8 Numbers of Operating Factories of Five Regions in 2006

Sector	Makkah		Al Baha		Asir		Jazan		Najran		Total	
Food and Beverages	172	17.0%	4	26.7%	12	13.5%	9	23.7%	4	18.2%	201	17.1%
Textiles, readymade clothes and leather	62	6.1%	1	6.7%	1	1.1%	1	2.6%	0	0.0%	65	5.5%
Wood, wooden products and furniture	44	4.3%	0	0.0%	1	1.1%	0	0.0%	0	0.0%	45	3.8%
Paper, printing and publication	69	6.8%	3	20.0%	2	2.2%	1	2.6%	0	0.0%	75	6.4%
Chemical industries and plastic products	240	23.7%	3	20.0%	15	16.9%	2	5.3%	5	22.7%	265	22.5%
Building materials, glass, ceramic and metal basic industries	121	12.0%	4	26.7%	41	46.1%	22	57.9%	10	45.5%	198	16.8%
Basic Metallic	156	15.4%	0	0.0%	14	15.7%	2	5.3%	3	13.6%	175	14.9%
Manufactured metals, machines and equipment	118	11.7%	0	0.0%	2	2.2%	0	0.0%	0	0.0%	120	10.2%
Transportation & Warehouse	5	0.5%	0	0.0%	0	0.0%	1	2.6%	0	0.0%	6	0.5%
Other industries	25	2.5%	0	0.0%	1	1.1%	0	0.0%	0	0.0%	26	2.2%
Total	1,012	100.0%	15	100.0%	89	100.0%	38	100.0%	22	100.0%	1,176	100.0%

Source: Saudi Organization for Industrial States & Technology Zone (SOIETZ) and the Eighth Development Plan

(3) Number of Industrial Laborers in the Five Regions

Numbers of laborers by sector in each region are shown in Table B.1-9. Laborers for food processing, and chemical and plastic products represent the majority in the five regions overall. In Makkah Region, laborers for food processing, and chemical and plastic products are the majority as well. In Al Baha, Jazan, Najran Regions, the number of laborers for food processing, building materials and glass, etc are more than that for all other sectors combined.

Table B.1-9 Number of Laborers by Sector in Five Regions (2006)

Sector	Makkah		Al Baha		Asir		Jazan		Najran		Total	
Food and Beverages	22,022	20.8%	117	26.7%	801	17.1%	409	22.6%	173	26.9%	23,522	20.8%
Textiles, readymade clothes and leather	6,387	6.0%	48	10.9%	50	1.1%	29	1.6%	0	0.0%	6,514	5.7%
Wood, wooden products and furniture	3,312	3.1%	0	0.0%	33	0.7%	0	0.0%	0	0.0%	3,345	3.0%
Paper, printing and publication	7,917	7.5%	77	17.5%	439	9.4%	11	0.6%	0	0.0%	8,444	7.5%
Chemical industries and plastic products	22,297	21.1%	96	21.9%	883	18.8%	114	6.3%	155	24.1%	23,545	20.8%
Building materials, glass, ceramic and metal basic industries	12,942	12.2%	101	23.0%	1,982	42.3%	1,165	64.4%	231	35.9%	16,421	14.5%
Basic Metallic	16,051	15.2%	0	0.0%	451	9.6%	41	2.3%	84	13.1%	16,627	14.7%
Manufactured metals, machines and equipment	12,461	11.8%	0	0.0%	28	0.6%	0	0.0%	0	0.0%	12,489	11.0%
Transportation & Warehouse	217	0.2%	0	0.0%	0	0.0%	41	2.3%	0	0.0%	258	0.2%
Other industries	2,107	2.0%	0	0.0%	18	0.4%	0	0.0%	0	0.0%	2,125	1.9%
Total	105,713	100%	439	100%	4,685	100%	1,810	100%	643	100%	113,290	100%

Source: Saudi Organization for Industrial States & Technology Zone (SOIETZ)

(4) Number of Labors per factory by Sector in Five Regions

Table B.1-10 shows the number of laborers per factory in 2006. The average number of laborers per factory is between 30 and 100. Of the five regions, there are the largest scale factories in the Makkah Region with the laborers per factory of about 100. The next largest scale factories are located in the Asir Region with the laborers per factory of 60. In terms of sectors in the five Regions, the average number of laborers per factory is between 40 and 60 with the exception of paper, printing and publication sector.

Table B.1-10 Numbers of Laborers per Factory by Sector (2006)

Sector	Makkah	Al Baha	Asir	Jazan	Najran	**Average**
Food and Beverages	128	29	67	45	43	**62**
Textiles, readymade clothes and leather	103	48	50	29	-	**58**
Wood, wooden products and furniture	75	-	33	-	-	**54**
Paper, printing and publication	115	26	220	11	-	**93**
Chemical industries and plastic products	93	32	59	57	31	**54**
Building materials, glass, ceramic and metal basic industries	107	25	48	53	23	**51**
Basic Metallic	103	-	32	21	28	**46**
Manufactured metals, machines and equipment	106	-	14	-	-	**60**
Transportation & Warehouse	43	-	-	41	-	**42**
Other industries	84	-	18	-	-	**51**
Average	**96**	**32**	**60**	**37**	**31**	

Source: JICA Study Team

1.1.5 Infrastructure

(1) Roads

Table B.1-11 shows the length of roads by region in 2003. The road length of the targeted five regions make up about 38% of the KSA's total road network, with 80% unpaved and 20% paved, while the KSA national average is 73% unpaved and 27% paved. Asir, Riyadh, and Makkah have the highest proportions of the road network, and the proportion of road network in Najran, and Jazan is low.

Table B.1-11 Road Network by Region in 2003

Region	Type of Paved Roads								Unpaved Roads		Total	
	Total		Main		Secondary		Feeder					
	d=a+b+c (km)	d/f (%)	a (km)	a/d (%)	b (km)	b/d (%)	c (km)	c/d (%)	e (km)	e/f (%)	f=d+e (km)	f/∑f (%)
Riyadh	11,040	52	2,247	20	2,113	19	6,680	61	10,214	48	21,254	13.3
Madina	3,250	17	1,032	32	810	25	1,408	43	15,681	83	18,931	11.8
Qassi,	4,276	23	450	11	873	20	2,953	69	14,692	77	18,968	11.8
Eastern	5,081	61	2,218	44	1,133	22	1,730	34	3,210	39	8,291	5.2
Tabuk	2,062	19	1,405	68	156	8	501	24	8,525	81	10,587	6.6
Hail	2,631	20	410	16	372	14	1,849	70	10,710	80	13,341	8.3
Northern	1,326	59	896	68	-	-	430	32	903	41	2,229	1.4
Jawf	1,175	21	713	61	-	-	462	39	4,353	79	5,528	3.5
Makkah	**4,740**	**23**	**1,635**	**34**	**990**	**21**	**2,115**	**45**	**15,969**	**77**	**20,709**	**12.9**
Al Baha	**1,162**	**17**	**119**	**10**	**280**	**24**	**763**	**66**	**5,772**	**83**	**6,934**	**4.3**
Asir	**3,770**	**16**	**905**	**24**	**880**	**23**	**1,985**	**53**	**20,133**	**84**	**23,903**	**14.9**
Jazan	**949**	**18**	**205**	**22**	**130**	**14**	**614**	**65**	**4,207**	**82**	**5,156**	**3.2**
Najran	**1,478**	**34**	**455**	**31**	**525**	**36**	**498**	**34**	**2,868**	**66**	**4,346**	**2.7**
5 Regions Total	12,099	20	3,319	27	2,805	23	5,975	49	48,949	80	61,048	38.1
Total	42,940	27	12,690	30	8,262	19	21,988	51	117,237	73	160,177	100.0

Source: The Eighth Development Plan

(2) Electricity

The rate of electrical service coverage in 2003 was 90%, and the annual growth rate of the service coverage from 1999 to 2003 was 3.3%, with an annual growth rate of per capita consumption for electricity was 1.7%, which indicates the electricity sector is growing constantly (See Table B.1-12). About 83% of customers of the electrical service were residential, with an annual increase in customer numbers of 5.8%. According to The Eighth Development Plan, the estimation of electricity service coverage in 2004 was 92% and there are plans to achieve 100% coverage by 2009. In addition, no data of the existence of a power failure etc. is obtained.

Table B.1-12 Indicators in the Electrical Sector

Items	Unit	1999	2003	Average Annual Growth Rate(%)
Per Capita Consumption	KWH	5,444	5,833	1.7
Number of Customers	000	3,372	4,232	5.8
Number of Residential Customers	000	2,792	3,497	5.8
Service Coverage	%	79.1	90	3.3
Electricity Consumption	Billion KWH	106	142	7.6
Peak Load	MW	21,101	26,272	5.6
Actual Generation Capacity	MW	20,647	27,018	7.0
Generation Capacity of Desalination Plants	MW	2,675	2,866	1.7
Total Number of Employees	Person	28,785	29,189	0.3
Share of Saudis	%	69.1	79.4	3.5
Average Number of Customers per Employees	Customer	117	145	5.5
Average Sold Electricity per Employee	MWH	3,669	4,48	7.2

Source: The Eighth Development Plan

1.1.6 Employment

In 2003 about 33% of the total labor force in the private sector were Saudi nationals and 67% were foreigners. The productive sectors made up 52% of the entire labor force in the private sector and the ratio of the services sectors was 46%, as shown in Table B.1-13. The Saudi labor force in the services sectors was more than the Saudi labor force in the productive sectors while the non-Saudi labor force in the productive sectors was more than the non-Saudi labor force in the services sectors.

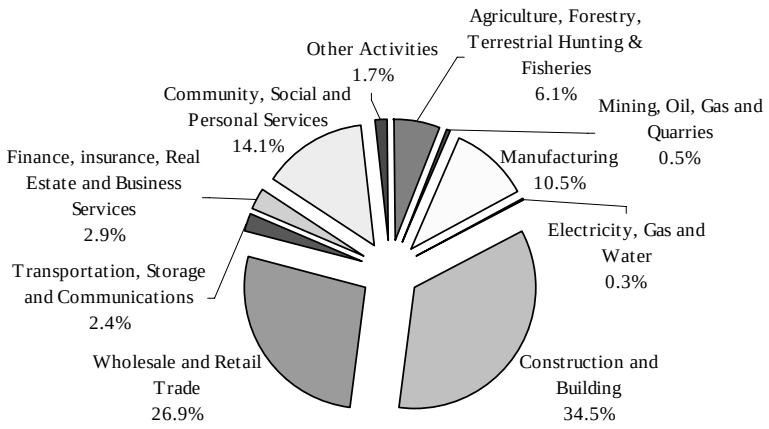
In the private productive sectors, the sub-sectors that occupied more than five percent of the general total were construction and building (35%), manufacturing (11%), and agriculture, forestry, terrestrial hunting & fisheries (6%). In these three sub-sectors, the ratio of non-Saudi workforce was higher than the ratio of Saudi workforce; especially non-Saudi workers in agriculture, forestry, terrestrial hunting & fisheries where it was nine-times as many Saudi workers in this sector. In the services sectors, the

sub-sectors that occupied more than five percent of the general total were wholesale and retail trade (27%) and community, social and personal services (14%). In these two sectors, the ratio of the non-Saudi labor force was higher than the ratio of the Saudi labor force but the ratios of non-Saudi labor were not as high as in comparison with the productive sectors.

Table B.1-13 Distribution of Labor in the Private Sector by Economic Activity and Nationality, 2003

Economic Activity	Saudi		Non-Saudi		Total	
	000	%	000	%	000	%
Agriculture Forestry, Terrestrial Hunting & Fisheries	46	10	393	90	438	6.1
Mining, Oil, Gas and Qusrries	21	54	18	46	39	0.5
Manufacturing	256	34	500	66	756	10.5
Electricity, Gas and Water	13	51	12	49	25	0.3
Construction and Building	686	28	1,800	72	2,487	34.5
Total Productive Sectors	1,022	27	2,723	73	3,744	52.0
Wholesale and Retail Trade	676	35	1,264	65	1,939	26.9
Transportation, Storage and Communications	71	41	100	59	171	2.4
Finance, Insurance, Real Estate and Business Services	140	68	66	32	206	2.9
Community, Social and Personal Services	436	43	583	57	1,019	14.1
Total Services Sectors	1,322	40	2,013	60	3,335	46.3
Other Activities	45	36	81	64	126	1.7
Total	2,389	33	4,817	67	7,205	100.0

Source: The Eighth Development Plan



Source: The Eighth Development Plan

Figure B.1-5 Proportion of Labor in the Private Sector by Economic Activity, 2003

The unemployment rates of the five target regions are arranged in the next table. Even in Makkah, that includes Jeddah, the unemployment rate is 18 %, which is higher than the average rate of 16% in the whole country. The remarkable regions whose unemployment rate is over 30 % include Al Baha (32 %) and Jazan (31 %). The unemployment rates among women in all regions are higher than that of men all over the country. The unemployment rates among women in Al Baha and Jazan are 64 % and 52 %, respectively, which means that women who can get job are less than the half of applicants for jobs.

Table B.1-14 Estimated Unemployment Rates in the Five Regions in 2006

Regions	Men (%)	Women (%)	Whole (%)
Makkah	13	37	18
Al Baha	18	64	32
Asir	18	49	27
Jazan	23	52	31
Najran	10	44	20
KSA	-	-	16

Source: "Economic Report 2007", SAGIA

1.1.7 Public Health

Saudi Arabia has achieved substantial improvements to its healthcare system in the past 20 years from 1984 to 2003, with infant mortality rates dropping from 85 per 1000 births to 22 per 1000 births, and average life expectancy increasing from 61 years to 72 years. Access to healthcare of pregnant women increased from 86.8% in 1999 to 98% in 2003.

Table B.1-15 shows the number of hospital beds and physicians available in each of the 5 regions in the study area, and compares these with the national figures. The average figures for the entire study area show that overall it has a higher number of beds per capita and a higher number of physicians per capita than the national average.

Table B.1-15 Healthcare Data for the Study Area

Items	No. of hospital beds	No of people per bed	No. of physicians	No of people per physician
Makkah	7,270	798	3,784	1,533
Al Baha	1,039	366	485	784
Asir	2,430	700	1,392	1,221
Jazan	1,338	897	762	1,575
Najran	638	658	404	1,040
Study area average	*N/A*	*684*	*N/A*	*1,230*
National Total	28,522	792	16,120	1,402

Source: Created using information in the Eighth Development Plan

1.1.8 Economic Value of Water

(1) Water Tariff

The eighth development plan mentions that the average water consumption for a family of six is estimated to be around 41 m^3/month. Such consumption falls under the first segment of the tariff structure (See Table B.1-16). Consequently the price paid by most consumers is SR 0.10 per cubic meter[1].

Table B.1-16 Structure of Water Tariff for Municipal Purposes

Segment	Volume (m^3)	Tariff (SR/m^3)
First	0-50	0.10
Second	51-100	0.15
Third	102-200	2.00
Fourth	201-300	4.00
Fifth	301 and Over	6.00

Source: The Eighth Development Plan

(2) Water Cost

Household water and sanitation services in Saudi Arabia: an analysis of economic, political and ecological issues[2] made a trial calculation of cost comparison between desalinated water and groundwater. It said that the cost of one cubic meter of domestic water from the New Riyadh Wells Project might be estimated at some US$ 0.36. With the addition of the opportunity cost of capital of US$ 0.18 per cubic meter the total cost becomes US$ 0.54 per cubic meter.

The production cost of desalinated water produced in recently built desalination plants in Eastern Region could be estimated at about US$ 1.84 per cubic meter, which consisted of the cost of desalinated water (US$ 0.52/m^3) and the pipeline transmission cost of the desalinated water from the Gulf Coast to Riyadh (US$ 1.32/m^3). The weighted average accounting cost of water from the 30 existing Saudi plants could be calculated at US$ 0.67 per cubic meter. When the opportunity cost of capital and the pipeline transmission cost is added to the accounting cost, the grand total is US$ 2.37 per cubic meter though the calculated cost included the cost of the electricity that was produced in

[1] 23.2.7 Water Cost (p. 476), The Eighth Development Plan

[2] Elie Elhadj, SOAS Water Research Group, Occasional Paper 56, SOAS/KCL Water Research Group, School of Oriental & African Studies and King's College London, University of London, May 2004