The Survey on
Feasibility of Desalination Projects
in Sub-Saharan Africa

Final Report

June 2016

Japan International Cooperation Agency
(JICA)

Nippon Koei Co., Ltd.
Water Reuse Promotion Center

GE
JR
16-078

The Survey on
Feasibility of Desalination Projects
in Sub-Saharan Africa

Final Report

June 2016

Japan International Cooperation Agency
(JICA)

Nippon Koei Co., Ltd.
Water Reuse Promotion Center

Exchange Rates (as of May 2016)

USD 1 (U.S. Dollar)	= JPY 111.099
ZAR 1 (South African Rand)	= JPY 7.6975
MZN 1 (Mozambique Metical)	= JPY 2.0883
NAD 1 (Namibian Dollar)	= JPY 7.6975
AOA 1 (Angola Kwanza)	= JPY 0.67

The Survey on Feasibility of Desalination Projects
in Sub-Saharan Africa

Surveyed Countries

The Survey on Feasibility of Desalination Projects in Sub-Saharan Africa

Final Report

Table of Contents

Figures

Tables

Abbreviations

ADWEA	Abu Dhabi Water and Electricity Authority
ADWEC	Abu Dhabi Water and Electricity Company
AfDB	African Development Bank
AfDF	African Development Fund
ATP	Affordable to Pay
BOO	Build Operate Own
BOT	Build Operate Transfer
BOOT	Build Operate Own Transfer
BPD	Barrel per Day
BRIC	Brazil, Russia, India and China
Capex	Capital Expenditure
COMESA	Common Market for Eastern and Southern African States
COP21	The 21st Congress of the Parties for the United Nations Framework Convention on Climate Change
CRS	Creditor Reporting System
CTL	Coal-to-Liquid
^{o}C	Degrees Centigrade
DAF	Dissolved Air Flotation
DB	Design Build
DBB	Design Bid Build
DBO	Design Build Operate
DBOO	Design Build Operate Own
DBOOT	Design Build Operate Own Transfer
DBSA	Development Bank of South Africa
DRC	Democratic Republic of Congo
EAC	East Africa Community
ECOWAS	Economic Community of West African States
EIA	Environmental Impact Assessment
EOI	Expression of Interest
EOJ	Embassy of Japan
EPC	Engineering, Procurement and Construction
EPZ	Export Processing Zone
EU	European Union
F/S	Feasibility Study
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
GAMA	Greater Accra Metropolitan Area
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHS	Ghana Cedi
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GNI	Gross National Income
GRIPS	National Graduate Institute for Policy Studies
GTL	Gas-to-Liquid
GVA	Gross Value Added
GWh	Gigawatt Hours
GWI	Global Water Intelligence
ha	Hectares
ICD	Inland Container Depot
IDA	International Development Association
IDZ	Industrial Development Zone
IFRS	International Financial Reporting Standards
IMF	International Monetary Fund
IPP	Independent Power Producer
IT	Information Technology
ITCZ	Intertropical Convergence Zone
IWPP	Independent Water and Power Project
IWRM	Integrated Water Resources Management
JBIC	Japan Bank for International Cooperation
JETRO	Japan External Trade Organization

JICA	Japan International Cooperation Agency	
JPY	Japanese Yen	
KAHRAMAA	Qatar General Electricity & Water Corporation	
KfW	German Development Bank	
km	Kilometers	
km^2	Square Kilometers	
kV	Kilovolts	
kW	Kilowatts	
kWh	Kilowatt Hours	
L	Litters	
LNG	Liquefied Natural Gas	
lpcd	Litters per Capita per Day	
m	Meters	
mm	Millimeters	
m^2	Square Meters	
m^3	Cubic Meters	
M&A	Merger and Acquisition	
MCA	Millennium Challenge Account	
MCM	Million Cubic Meter	
MDGs	Millennium Development Goals	
MED	Multi-Effect Distillation	
MFEZ	Multi-Facility Economic Zone	
mg	Milligrams	
MSF	Multi-Stage Flash	
MW	Megawatts	
ND	Nominal Diameter in Millimeters	
NEDO	New Energy and Industrial Technology Development Organization	
NEPAD	New Partnership for Africa's Development	
NGO	Non-governmental Organization	
NOAA	National Oceanic and Atmospheric Administration	
NRW	Non-revenue Water	
O&M	Operation and Maintenance	
ODA	Official Development Assistance	
OECD	Organization for Economic Co-operation and Development	
ONEE	National Power and Drinking Water Office	Office National de l'Electricité et de l'Eau Potable
Opex	Operating Expense	
ppm	Parts per Million	
PPP	Public Private Partnership	
QEWC	Qatar Electricity and Water Company	
RECs	Regional Economic Communities	
RFP	Request for Proposal	
RO	Reverse Osmosis	
SACU	Southern African Customs Union	
SADC	Southern African Development Community	
SDI	Spatial Development Initiative	
SEZ	Special Economic Zone	
SPC	Special Purpose Company	
SWCC	Saline Water Conversion Corporation	
Tcf	Trillion Cubic Feet	
TDS	Total Dissolved Solid	
TEU	Twenty-foot Equivalent Unit	
TICAD V	The Fifth Tokyo International Conference on African Development	
UAE	United Arab Emirates	
UEMOA	Economic Community of West African States	Union Economique et Monétaire Ouest Africaine
UF	Ultra-filtration	
UK	United Kingdom	
UNDP	United Nations Development Programme	
UNICEF	United Nations Children's Fund	
USA	United States of America	
USAID	United States Agency for International Development	
USD	United States Dollar	
USGS	United States Geological Survey	
VGF	Viability Gap Funding	

WHO	World Health Organization	
WTI	West Texas Intermediate	
WTP	Water Treatment Plant	

Cote d’Ivoire

CNP-PPP	National Steering Committee for PPP	Comité National de Pilotage des Partenariats Public-Privé
DRE	Directorate of Water Resources	Direction des Ressources en Eau
FDE	Water Development Fund	Fonds de Développement de l’Eau
FNE	National Water Fund	Fonds National de l’Eau
HCH	High Commission on Water	Haut Commissariat à l’Hydraulique
MIE	Ministry of Economic Infrastructure	Ministère des Infrastructures Economique
MINEF	Ministry of Water and Forests	Ministère des Eaux et Forêts
ONEP	National Drinking Water Authority	Office National de l’Eau Potable
PLANGIRE	National Action Plan for Integrated Management of Water Resources	Plan d’Actions National de Gestion Intégrée de Ressources en Eau
PND	National Development Program	Programme National de Développement
SODECI	Cote d’Ivoire Water Distribution Company	Société de Distribution d’Eau de Côte d’Ivoire

Angola

AOA	Angolan Kwanza	
DNA	National Directorate of Water	Direcção Nacional de Águas
DPEA	Provincial Energy and Water Directorate	Direçcão Provinciais de Energia e Águas
EPAL	Luanda Water Supply Company	Empresa Pública de Águas de Luanda
INE	National Statistics Institute	Instituto Nacional de Estatística
INRH	National Water Resources Institute	Instituto Nacional de Recursos Hídricos
MINEA	Ministry of Energy and Water	Ministério da Energia e Águas
PLANAGEO	National Geology Plan	Plano Nacional de Geologia
PWSU	Provincial Water Supply and Sanitation Utility	
SWF	Sovereign Wealth Fund	

Namibia

DWRM	Directorate of Water resource Management
HKIA	Hosea Kutako International Airport
HPP	Harambee Prosperity Plan
IUSDF	Integrated Urban Spatial Development Framework
MAWF	Ministry of Agriculture, Water and Forestry
NAD	Namibian Dollar
NUST	Namibia University of Science and Technology
NamPort	Namibia Port Authority
NamPower	Namibia Power Corporation
NamWater	Namibia Water Corporation
REFIT	Renewable Energy Feed In Tariff
WBCG	Walvis Bay Corridor Group

South Africa

BEE	Broad-Based Black Economic Empowerment
BWSS	Bulk Water Supply System
CCT	City of Cape Town
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
MDS	Market Demand Strategy
MFMA	Municipal Finance Management Act
MSA	Municipal Systems Act
PFMA	Public Finance Management Act
PRASA	Passenger Rail Agency of South Africa
RWU	Regional Water Utility
TFR	Transnet Freight Rail
WC WSS	Western Cape Water Supply System
WDM	Water Demand Management
WSA	Water Services Authority
WSP	Water Service Provider

ZAR	South African Rand	

Madagascar

JIRAMA	Water Supply and Power Entity	Jiro Sy Rano Malagasy
OMNIS	National Mineral and Strategic Industries Agency	Office des Mines Nationales et des Industries Stratégiques

Mozambique

AdM	Mozambique Water	Águas de Moçambique
AdP	Portugal Water	Águas de Portugal
ADPP	Development Aid from People to People in Mozambique	Ajuda de Desenvolvimento de Povo para Povo
AIAS	Management Infrastructure for Water Supply and Sanitation	Administração de Infraestruturas de Abastecimento de Água e Saneamento
ARA	Regional Water Administrations	Administração Regional de Águas
BAGC	Beira Agricultural Growth Corridor	
CNA	National Water Council	Conselho Nacional de Águas
CRA	Water Regulatory Council	Conselho de Regulação do Abastecimento de Água
DNA	National Directorate of Water	Direcção Nacional de Águas
DPCA	Provincial Directorate for Co-ordination of Environmental Affairs	Direcção Provincial para a Coordenação da Acção Ambiental
EDM	Mozambique Electricity Company	Electricidade de Moçambique
EPDA	Environmental Pre-viability Report and Scope Definition	Estudo de Pre-viabilidade Ambiental e Definicao de Ambito
FIPAG	Investment Fund and Water Supply Asset Holder	Fundo de Investimento e Património de Abastecimento de Água
IGPP	Integrated Growth Poles Project	
MITADER	Ministry of Land, Environmental and Rural Development	Ministério da Terra, Ambiente e Desenvolvimento Rural
MOPH	Ministry of Public Works and Housing	Ministério de Obras Públicas e Habitação
MZN	Mozambique Metical	
GMMA	Greater Maputo Metropolitan Area	
GAZEDA	Special Economic Zones Office	Gabinete das Zonas Económicas de Desenvolvimento Acelerado
PEDEC-Nacala	Project for Nacala Corridor Economic Development Strategies	Projeto do Estratégias de Desenvolvimento Econômico do Corredor de Nacala
SER	Simplified Environmental Report	
TAC	Technical Assessment Commission	
WASIS	Water Services Institutional Support Project	

Tanzania

CWS	City Water Services
DAWASCO	Dar Es Salaam Water Supply and Sewerage Corporation
DAWASA	Dar Es Salaam Water Supply and Sewerage Authority
EWURA	Energy and Water Utilities Regulatory Authority
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
TANESCO	Tanzania Electric Supply Company Limited
TAZARA	Tanzania Zambia Railways
TIC	Tanzania Investment Centre
WSSA	Water Supply and Sanitation Authority

Mauritius

CEB	Central Electricity Board
CWA	Central Water Authority
PPO	Policy Procurement Office

Chapter 1 Introduction

1.1 Background

In Sub-Saharan Africa, the access rate to safe water, which is one of the Millennium Development Goals (MDGs), has improved from 34% in 1990 to 56% in 2015 in rural areas. However, the access rate to safe water in urban areas is 87% in 2015 and does not show a significant increase from 83% in 1990. There are several countries where the access rate is below 50% because urban areas cannot be covered adequately by water supply from conventional water resources, e.g., surface water and groundwater, as water demand rapidly increases with population growth and industrialization. Meanwhile, it should be noted that excessive water consumption would endanger the limited available conventional water resources. In order to avoid excessive reliance on the conventional water resources, a portfolio needs to be established with additional water resources.

Under the said circumstances, the Japan International Cooperation Agency (JICA) needs to contribute toward the accomplishment of MDGs as well as the Fifth Tokyo International Conference on African Development (TICAD V) including the access to safe water and sanitation improvement for 10 million people in Africa. In addition, African countries become eligible for the Japanese official development assistance (ODA) loan for large-scale developments. Therefore, the promotion of projects to be implemented with Japanese ODA loan is a crucial issue towards the achievements of TICAD V.

In seeking solutions to water scarcity, seawater desalination is expected to be one of the measures for ensuring water resources. Seawater desalination plants have been installed in the Middle East since the 1960s. As these were developed with the distillation method that needs heavy use of fossil fuels, it was not realistic for African countries to introduce seawater desalination. Afterwards in the 1980s, the reverse osmosis (RO) membrane was developed for application to seawater desalination plants with advantages of producing freshwater with lower cost and less site area requirement in comparison with the distillation method. The RO membrane has been further upgraded recently for increasing water production efficiency. As Japanese manufacturers keep a large market share of the RO membrane and associated technologies in the world, Japanese firms are expected to have more opportunities to develop seawater desalination.

For major cities having a large water demand, project preparation under Japanese ODA loan is expected for developing a seawater desalination plant with a scale of some tens of thousands m^3/day. In recent years, the seawater desalination projects are underway in Cape Verde and being considered in Tunisia and Senegal through Japanese ODA loan. Succeeding to these projects, JICA seeks to promote seawater desalination projects in Africa. Besides, small-scale seawater desalination plants are built with European aid at the coast near the island in Tanzania. Similar projects can be promoted by Japanese grant aid as well where operation and maintenance for seawater desalination plant are well organized.

On the other hand, seawater desalination requires high development costs causing financial impact on the water supply system. Therefore, there are many issues in the introduction of seawater desalination to the public water supply, such as the manner of connecting with the existing water distribution network, operation and maintenance, environmental impact, water tariff, and financial capability of the city undergoing industrialization, that require prior adjustment or confirmation. The international market of seawater desalination should also be analyzed in view of promoting opportunities for Japanese firms.

1.2 Objective of the Survey

With regard to the above-mentioned background, the present survey aims at clarifying the key issues on the seawater desalination project preparation, including lessons learned from previous experiences. In addition, further studies are carried out for locations where the need to provide safe water by seawater desalination is identified from the viewpoints of the rapid increase of water demand due to population growth and industrialization under the limitation of surface water and/or groundwater resources. The present survey is oriented toward a concrete and practical research to serve as a useful reference in future project preparation that will need to follow the formal procedures of the Japanese government.

1.3 Surveyed Countries

The surveyed countries are Cote d'Ivoire, Angola, Namibia, South Africa, Madagascar, Mozambique, Tanzania, and Mauritius.

1.4 Methodology of the Survey

1.4.1 First Stage Survey

The first stage survey aims at assessing the conditions that will increase the feasibility of seawater desalination project in the target countries through the compilation and analysis of the information extracted from the available literatures. Resulting from the first stage survey, the locations to be surveyed in the second stage survey are selected.

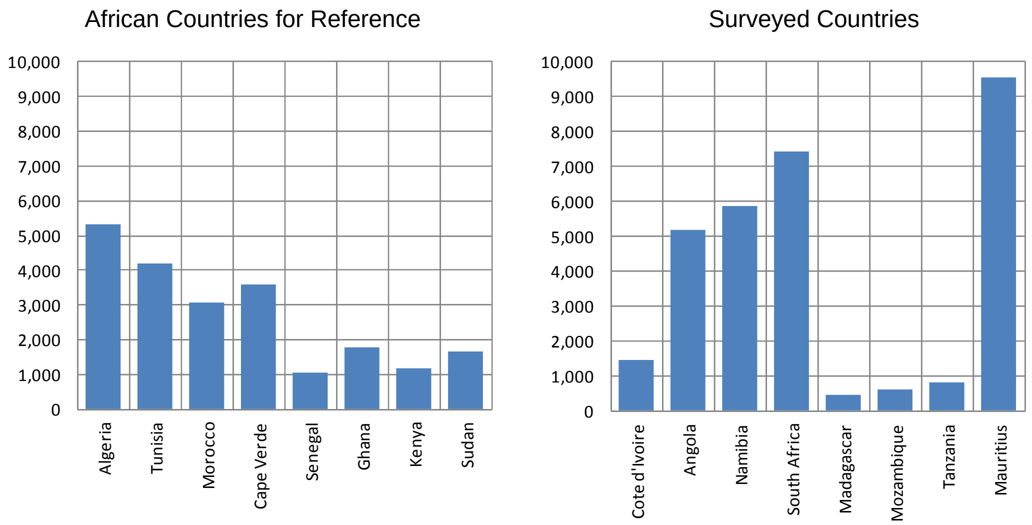
1.4.2 Second Stage Survey

The second stage survey envisages to confirm the need for seawater desalination project and the development environment for a possible introduction of seawater desalination through the site surveys in the selected locations. In addition, the main subjects toward the preparation of seawater desalination project are clarified in terms of conceptual facility planning, operation and maintenance system, cost estimate, and framework of project implementation in order to seek the possibility of a project to be financed by Japanese ODA loan.

1.5 Preliminary Assessment of Need for Seawater Desalination

As a preliminary assessment of the need for seawater desalination, two groups of countries are compared in terms of: 1) economy (gross national income (GNI) per capita), 2) water resources (renewable water resources per capita), 3) water supply (urban population with water service), and 4) access to electricity. The first group, serving as reference, are African countries with existing seawater desalination plants or with plants under implementation and/or consideration. The second group includes the surveyed countries under the present survey.

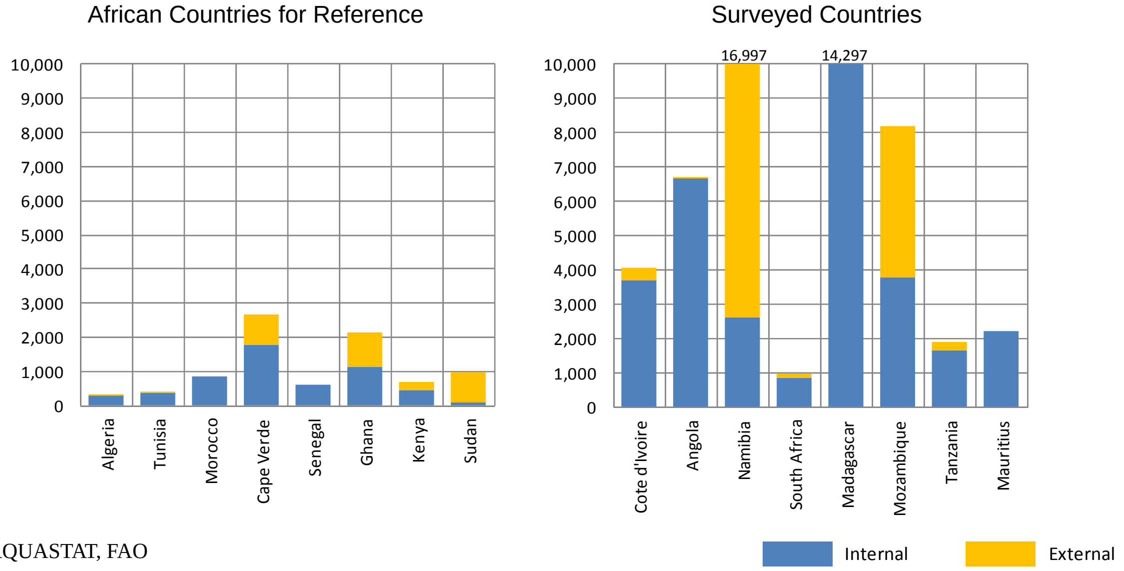
GNI per Capita (Figure 1.1): North African countries attain a relatively high GNI per capita. Of the surveyed countries, the countries rich in underground mining production indicate a higher GNI per capita than the North African countries; and Mauritius has achieved the highest. In countries which have already achieved relatively high economic development, the feasibility of seawater desalination project is expected. In the case of countries remaining at the lower bracket in terms of economic development at present, it is necessary to examine the future need of seawater desalination project in view of future economic growth prospects and existence of major growth centers.



Source: World Bank

Figure 1.1 GNI per Capita (Current USD, 2013)

Renewable Water Resources per Capita (Figure 1.2): African countries for reference are generally faced with water scarcity. Among the surveyed countries, South Africa, Tanzania, and Mauritius are in a similar situation. The remaining surveyed countries are better in terms of availability of water resources over their territory. In these countries, the feasibility of seawater desalination project is considered, identifying water demand and supply gap caused by uneven regional distribution of water resources.

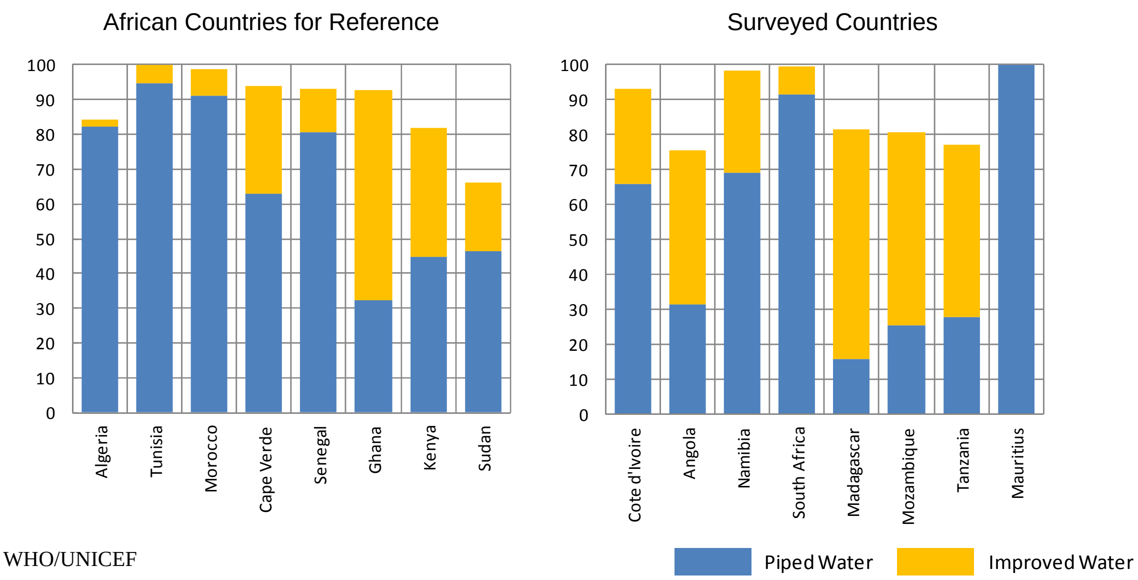


Source: AQUASTAT, FAO

Figure 1.2 Renewable Water Resources per Capita (m^3/inhabitant/year)

Urban Population Served with Water (Figure 1.3) : When a public water supply system attains a certain high level of performance in terms of infrastructure development and service, the feasibility of introducing seawater desalination project to such public water supply system is expected to increase.

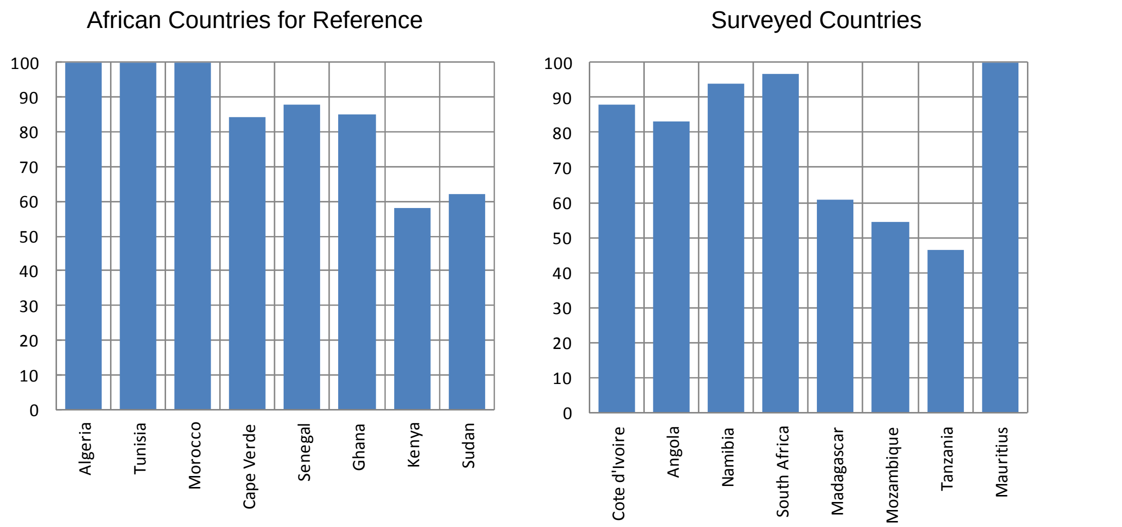
Among the African countries for reference, four out of eight have a high rate, i.e., above 80%, of urban population served with piped water supply. Among surveyed countries, South Africa and Mauritius attain a rate of above 80% of urban population served with piped water supply. Meanwhile, the rate is below 50% in four countries. Even though the rate is not high in the majority of the surveyed countries, it is necessary to examine them on the basis of understanding the water supply development status at the regional or city level.



Source: WHO/UNICEF

Figure 1.3 Proportion of Urban Population Served with Water (%, 2015)

Access to Electricity (Figure 1.4): Access to electricity (% of urban population) is an indicator of the infrastructure development level of the country. North African countries have achieved 100% and Cape Verde, Senegal and Ghana have more than 80%. Of eight surveyed countries, three countries have 60% or less. For countries with low rate, it is necessary to see the perspective of electricity infrastructure development at a major growth center, where seawater desalination project is expected to take place.



Source: World Bank

Figure 1.4 Access to Electricity (% of Urban Population, 2012)

First Stage Survey

Chapter 2 Global Trend of Seawater Desalination Market and Technology

2.1 Worldwide Trend

2.1.1 Installed Capacity

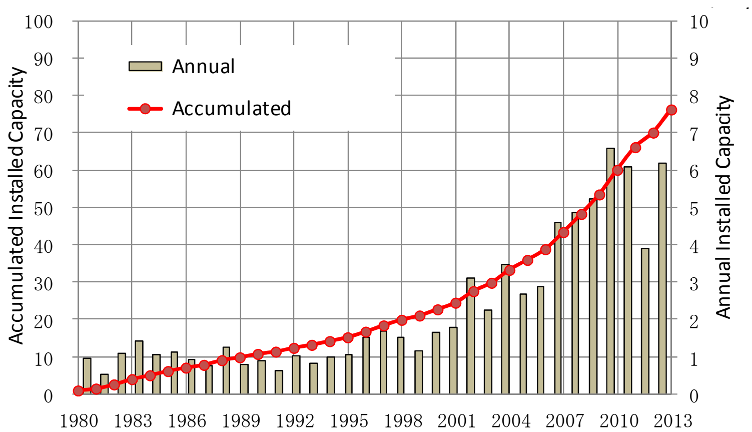
(1) All Desalination Plants

According to DesalData (Global Water Intelligence: GWI), the total installed capacity of desalination plants around the world, including those using raw water other than seawater, is about 80 million m^3/day accumulated for 69 years from 1945 to 2013. Assuming an operational life of plant of about 30 years, the total installed capacity of the corresponding plants is about 76 million m^3/day accumulated for 33 years from 1980 to 2013. In addition, the annual installed capacity in the last ten years varies from 3 to 6 million m^3/day (Figure 2.1).

The accumulated installed capacity of all desalination plants was 20 million m^3/day in 1998 and it doubled after ten years up to 40 million m^3/day in 2007. After three years in 2010, the accumulated installed capacity reached 60 million m^3/day, which is equivalent to three times of that in 1998. In 2014, it has exceeded 80 million m^3/day that is more than four times within 16 years since 1998.

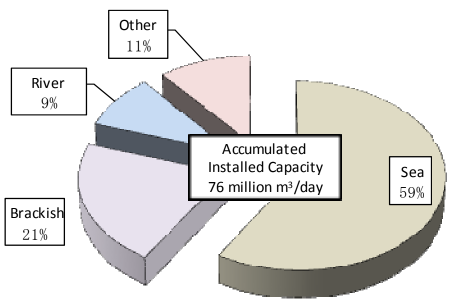
The raw water used for these desalination plants are seawater, brackish water, and river water[1] and the sum of seawater (59%) and brackish water (21%) accounts for 80% of the total volume (Figure 2.2).

The desalination plants are used for domestic water (61%) and industrial water (27%), which account for 88% of the total capacity (Figure 2.3).



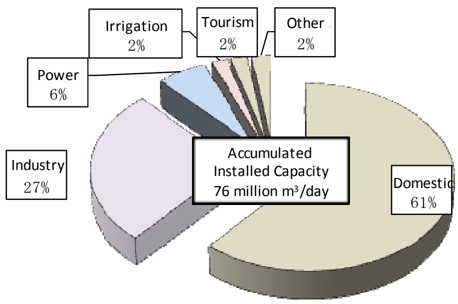
Source: Prepared by the Survey Team based on DesalData (GWI)

Figure 2.1 Historical Increase of Installed Capacity - All Desalination Plant



Source: Prepared by the Survey Team based on DesalData (GWI)

Figure 2.2 Desalination Plants by Raw Water Usage (as of December 2013)



Source: Prepared by the Survey Team based on DesalData (GWI)

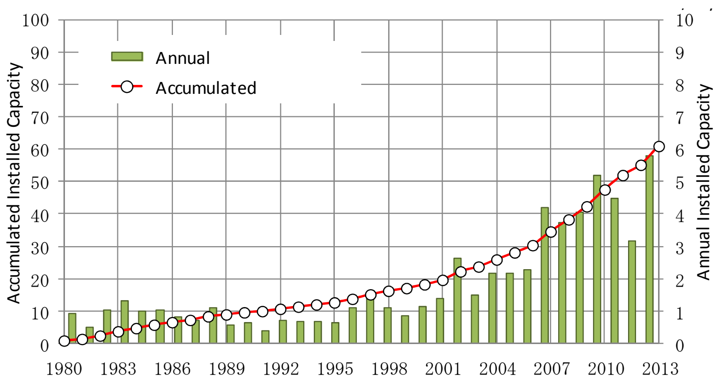
Figure 2.3 Desalination Plants by Purified Water Usage (as of December 2013)

---

[1] Desalination Market 2016 (GWI) categorizes the type of feed water used: Seawater (TDS 20,000-50,000 ppm), Brackish Water (TDS 3,000-20,000 ppm, and River Water (TDS 500-3,000 ppm).

(2) Seawater and Brackish Water Desalination Plants

The total installed capacity of seawater and brackish water desalination plants in the world is about 61 million m³/day for 33 years from 1980 to 2013. The accumulated installed capacity of seawater and brackish water desalination plants reached 10 million m³/day in 1992 and doubled to 20 million m³/day after ten years in 2001.



Source: Prepared by the Survey Team based on DesalData (GWI)

Figure 2.4 Historical Increase of Installed Capacity - Seawater and Brackish Water Desalination Plants

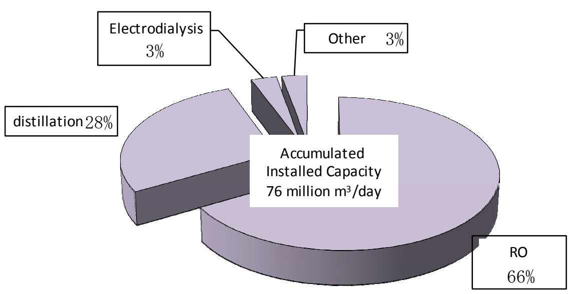
The accumulated installed capacity in 2009 amounted to 40 million m³/day which is equivalent to four times of that in 1992 and it reached 60 million m³/day in 2013. It has been increasing six times for 20 years since 1992 (Figure 2.4).

2.1.2 Desalination Method

(1) All Desalination Plants

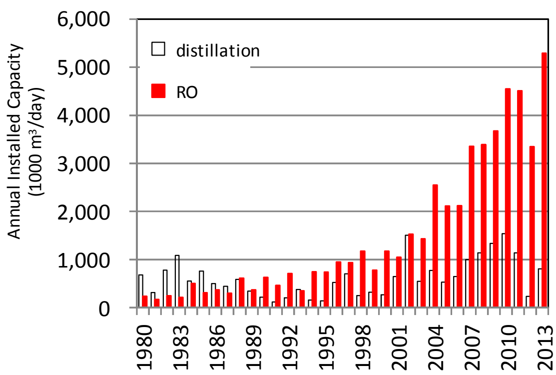
Of the desalination methods of all the plants installed for 33 years from 1980 to 2013, the reverse osmosis (RO) and distillation methods (MSF and MED)[2] account for 94% of the total installed capacity of 76 million m³/day, comprising 66% of reverse osmosis and 28% of distillation. Reverse osmosis is more dominant than the distillation method (see Figure 2.5).

Reverse osmosis exceeded distillation in terms of the installed capacity since 1990s and has been increasing remarkably since 2000s (see Figure 2.6).



Source: Prepared by the Survey Team based on DesalData (GWI)

Figure 2.5 Proportion of Desalination Method (as of October 2013)



Source: Prepared by the Survey Team based on DesalData (GWI)

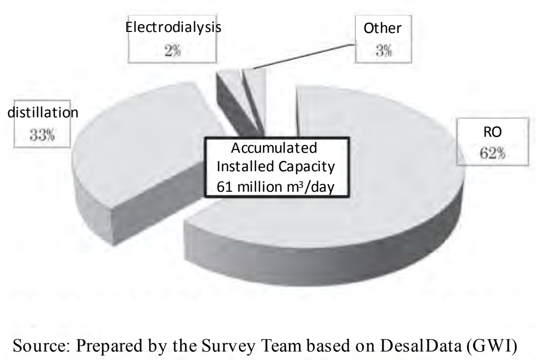
Figure 2.6 Annual Installation of Distillation and Reverse Osmosis (as of December 2013)

2 Multi-stage Flash and Multiple-effect Distillation

(2) Seawater and Brackish Water Desalination Plants

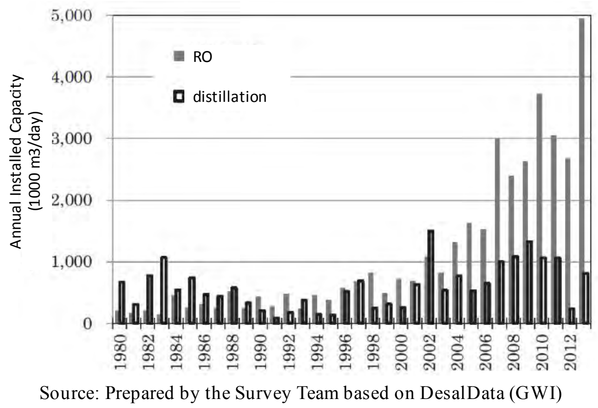
Of the desalination methods of the plants installed for 33 years from 1980 to 2013 for seawater and brackish water, the reverse osmosis and distillation methods account for 95% of the total installed capacity of 61 million m^3/day, comprising 62% of reverse osmosis, and 33% of distillation (MSF and MED). Reverse osmosis is more dominant than distillation (Figure 2.7).

Of the desalination methods for seawater and brackish water, distillation dominated until 1998 but reverse osmosis became dominant since 2003. The annual installation of reverse osmosis has been more than twice that of distillation since 2004 (Figure 2.8).



Source: Prepared by the Survey Team based on DesalData (GWI)

Figure 2.7 Proportion of Desalination Method for Seawater and Brackish Water (1980-2013)



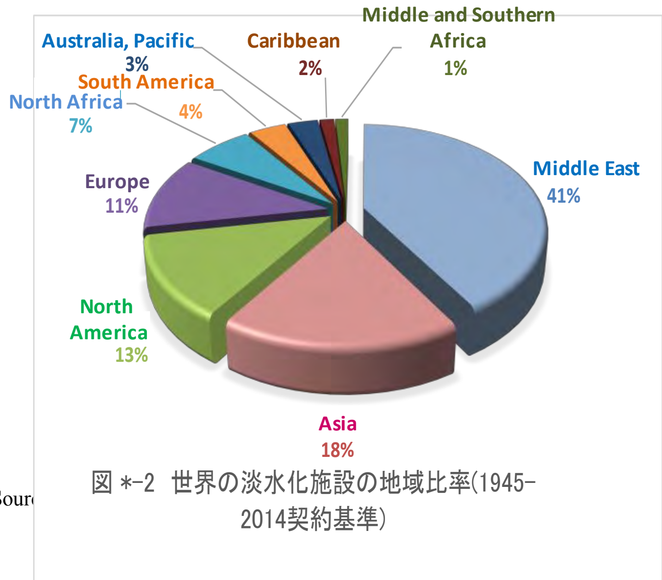
Source: Prepared by the Survey Team based on DesalData (GWI)

Figure 2.8 Annual Installation of Distillation and Reverse Osmosis for Seawater and Brackish Water (as of December 2013)

2.1.3 Regional Installation

Of the total installation of desalination plants for 33 years from 1980 to 2013, the regional installation in the Middle East accounts for 31.1 million m^3/day, which is 41% of the total installation. The regional installation accounts for 5.2 million m^3/day (7%) in the North Africa but only 0.9 million m^3/day (1%) in the Middle and South Africa (Figure 2.9 and Table 2.1).

The proportion of seawater desalination is 81% in the Middle East, 81% in the North Africa, 56% in the Europe, 42% in the Asia, Australia and Pacific, and 78% in the Middle and South Africa.



In North America, Caribbean, and South America, the total installation within the regions include 21% seawater water desalination and 47% brackish water desalination (Table 2.1).

Table 2.1 Installed Capacity of Desalination Plant by Region (1980-2013)

Unit: million m^3/day

Region	Capacity by Raw Water Source				Total
	Sea	Brackish	River	Other	
Middle East	25.1	4.3	0.5	1.1	31.1
North Africa	4.2	0.7	0.1	0.1	5.2
Middle and South Africa	0.7	0.1	0.0	0.1	0.9
Asia, Australia and Pacific	6.5	2.5	2.0	4.5	15.6
North America, Caribbean, and South America	2.9	6.6	3.1	1.4	14.0
Europe	5.4	2.0	1.2	1.0	9.6
Total	44.8	16.2	6.9	8.2	76.3

Source: Prepared by the Survey Team based on DesalData (GWI)

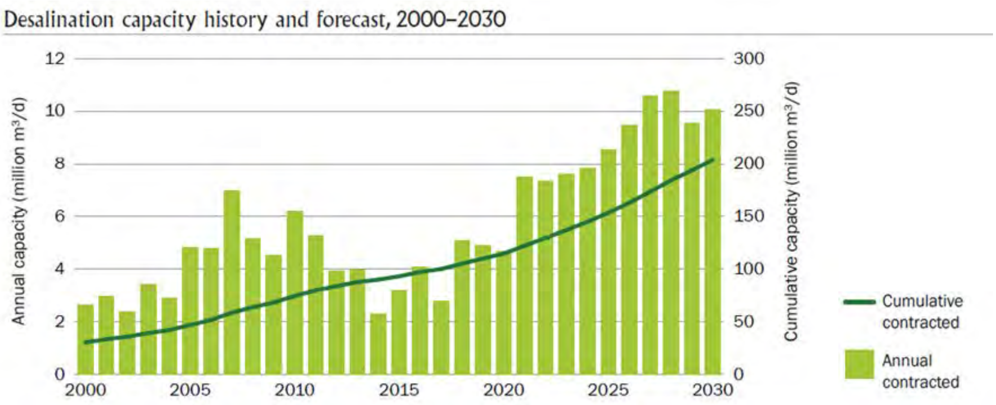
2.1.4 Market Trend

The past and forecasted installation of desalination from 2000 to 2030 is shown in Figure 2.10. The need for developing desalination plant is attributed to long-term and short-term factors. Long-term factors enlarging the market include the increase of water demand due to urbanization in coastal area, economic growth and natural resources development, increase of drought risks due to the climate change, and decrease and salinity of groundwater. Short-term factors causing fluctuations of the market include real estate markets, financial aspects, prices of natural resources, droughts, and political aspects.

The installation of desalination increased rapidly since early 2000s and peaked in 2007 but afterward declined due to the factors such as the collapse of Lehman Brothers in 2008, political unrests caused by the Arab Spring for 2010-2012, and drop of crude oil prices in 2014. The annual installation in 2014 resulted in less than half of the peak in 2007. As the annual installation in 2015 has turned to increase, the market is expected to expand continuously at least for ten years but will take time for the recovery to the same attained in 2007 until around 2021.

Although the market was stagnant in recent years, the long-term outlook of the market is still strong as desalination is one of the countermeasures to serve water for sustaining the life of the people, considering the forecast that 4.8 billion out of 9.7 billion people in 2050 over the world will be affected by water stress[3].

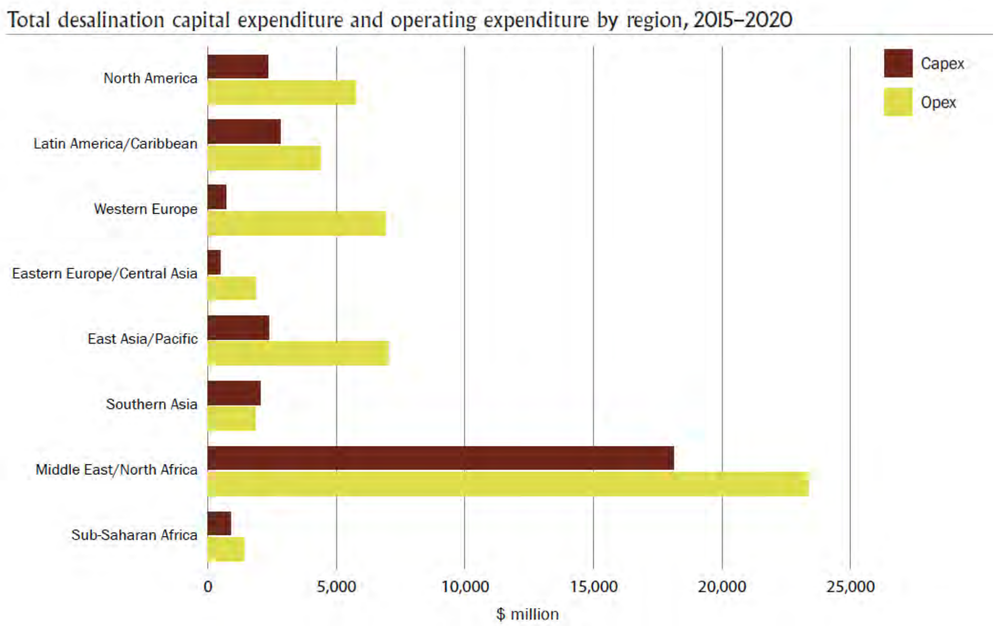
[3] The minimum requirement of water resources for life, agriculture, industry, energy and environment is defined as 1,700 m^3/person/year. 'Water Stress' is the condition that the water resources availability less than 1,700 m^3/person/year. When the water resources availability further decreases, such conditions are defied as 'Water Shortage' for 1,000 m^3/person/year or less and 'Absolute Water Shortage' for 500 m^3/person/year or less, respectively.
Source: Cause of Water Resources Problems, Ministry of Land, Transport, Infrastructure and Tourism, Japan, http://www.mlit.go.jp/mizukokudo/mizsei/mizukokudo_mizsei_tk2_000021.html



Source: Desalination Markets 2016 (GWI)

Figure 2.10 Past and Forecasted Installation of Desalination Capacity (2000-2030)

For the period from 2015 to 2020, the capital expenditure (Capex) will be the largest in the Middle East and North Africa markets, followed by the Latin America and Caribbean, North America, and East Asia and Pacific. The market in the Sub-Saharan Africa will be the smallest: less than one-tenth of the Middle East and North Africa, and one-fifth of East the Asia and Pacific. The operating expense (Opex) will also be the largest in the Middle East and North Africa markets, followed by the East Asia and Pacific, Western Europe, and North America (Figure 2.11).



Source: Desalination Markets 2016 (GWI)

Figure 2.11 Capex and Opex for Desalination by Region (2015-2020)

2.1.5 Desalination Technology

In the GCC[4] countries, the desalination technology tends to alternate gradually from distillation to reverse osmosis (RO) due to a concern about the use of fuel for water production. At present, there are some new technologies developed in order to counter the RO. But any of these are not expected to be

[4] The Gulf Cooperation Council established in May 1981 is political and economic alliance of six Middle Eastern countries: Kuwait, Saudi Arabia, Bahrain, Qatar, UAE and Oman.

the mainstream of desalination technology for the time being and the main issue on the desalination technology is to increase the efficiency of the RO.

In the 1990-2005 period, the water production cost of seawater desalination by reverse osmosis had been reduced from USD 2.0/m^3 to USD 0.5/m^3 with the adoption of the effective membrane with the energy recovery system. Since 2005, any effective cost reduction technology has not been developed. The water production cost has increased again due to the rapid increase of material costs and requirements for environmental mitigation measures[5]. Countermeasures such as use of renewable energy and monitoring technology[6] are being studied for alleviating the increase of the cost.

2.1.6 Market Dynamics

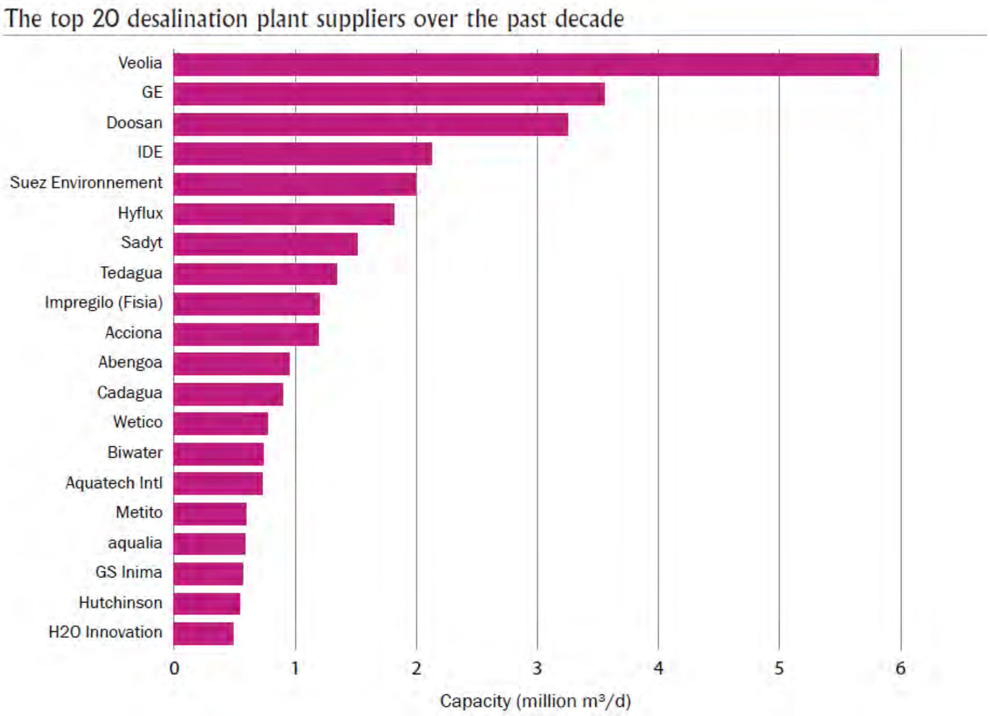
The top 20 firms in the market are shown in Figure 2.12. The Desalination Market 2016 (GWI) predicts the market dynamics and forecasts as described hereunder.

The competitions in the market were accelerated with the involvement of many firms through the rapid growth of the desalination market since early 2000s and have been further intensified due to the stagnation afterward. The firms are obliged to develop their survival strategy. The major firms such as Veolia (France), GE-water (USA), and Suez Environment (France) find a way out to keep their market share through the introduction of desalination plant to the industrial sector, oil and gas production in particular, due to the tough competitions in the public water supply sector. Others such as Hyflux (Singapore), IDE (Israel), and Abengoa (Spain) specialize in taking construction and operation orders in an integrated manner for ensuring their profits continuously. The major distillation plant suppliers such as Fisia (Italy) and Veolia Sidem (France) decrease their market share due to the emerging competitor of Doosan (South Korea). Because of price competitions and orders decreased, equipment suppliers are faced with critical difficulties. Meanwhile, membrane suppliers can keep growing with profits from the sales for the replacement taking place on the installed plants' basis.

The market growth will alleviate the intensified competitions but not be stabilized. New players will strengthen their competitiveness through merger and acquisition (M&A) of existing players to shift their business to more profitable sectors. In this context, the desalination plants invested by private sector will increase and pre-engineered plants, containerized plants and skid-mounted plants will be developed to facilitate economical manufacturing and shorten the time for delivery.

[5] Measures for mitigating impacts on the sea environment include: reducing the use of chemicals for high-efficiency operation, and reducing salt-concentration of post-treated water discharged to the sea by lowering collection rate of desalinated water.

[6] Measures include: solar power generation (including use of heat) or wind power generation for electricity supply to desalination plant, operating data acquisition and evaluation system for efficiency of plant, and real-time monitoring system for quality of post-treated water to the sea.



Source: Desalination Markets 2016 (GWI)

Figure 2.12 Top 20 Desalination Plant Suppliers for the Last Ten Years

2.2 Overview of Project Implementation in the World

2.2.1 Manners of Project Implementation

The total installation of desalination plants with a capacity of 5,000 m^3/day or more around the world amounts to 62.2 million m^3/day. The manners of project implementation for these plants are classified as shown in Table 2.2. Plant purchase, accounting for 70% of the total installation, is applicable for small and medium scale plants but tends to decrease while IWPP and BOT/BOO for large plants by private investment tend to increase.

Table 2.2 Manners of Project Implementation for Desalination Plants around the World

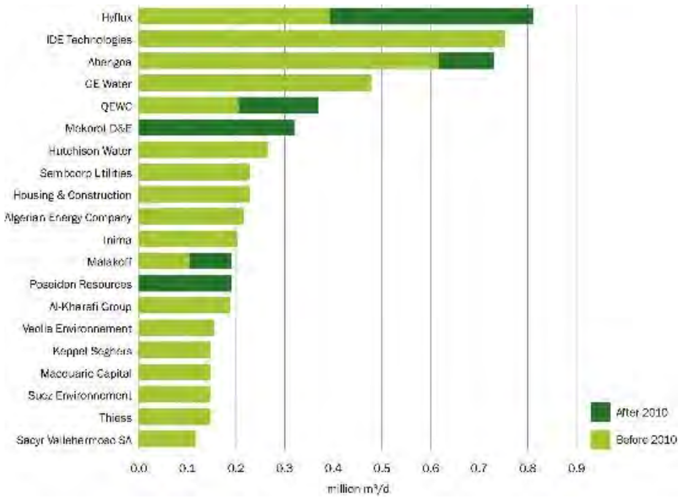
Manners of Project Implementation	Abbreviation	Characteristics	Percentage
Plant Purchase	EPC, DB, DBB	Design, construction, and equipment supply	70
Design-build-operate	DBO	Design, construction, and operation	3.6
Build-operate-transfer	BOT	Construction, operation, and transfer	8.3
Build-own-operate	BOO	Construction and operation	4.9
Independent water and power project	IWPP	BOT for supplying water and power	11

Source: Prepared by the Survey Team based on Desalination Markets 2016 (GWI)

2.2.2 Market Share of Firms

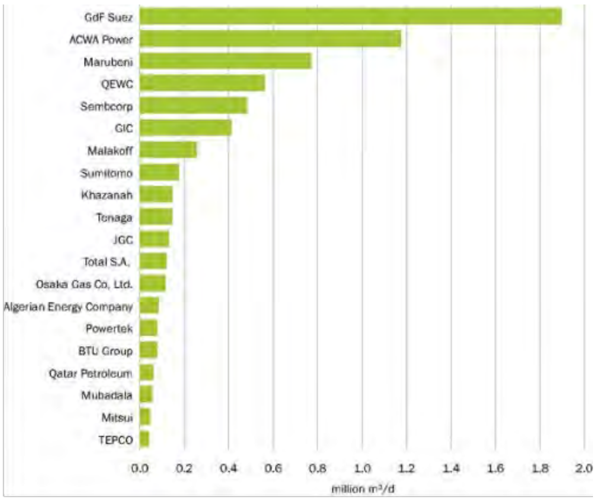
In the world water business market, the major firms are implementing the project throughout a series of stages: planning, design, manufacturing member and equipment, construction, maintenance and operation. They have strong competitiveness to win the concession of seawater desalination project. Hyflux, IDE, and Abengoa have marked BOO/BOT installations larger than those by Veolia and Suez. As Japanese firms have less experiences of the concession of seawater desalination project, no Japanese firm is ranked within the top 20 for BOO/BOT projects (Figure 2.13).

Meanwhile, the Japanese firms have the experiences of the concession of independent water and power project (IWPP) in the Middle East. Within the top 20 for IWPP, Japanese firms such as Marubeni (3rd), Sumitomo (8th), JGC (11th), Osaka Gas (13th), Mitsui (19th), and Tokyo Electric Power Corporation (TEPCO, 19th) are included (Figure 2.14).



Source: Desalination Markets 2016 (GWI)

Figure 2.13 Share of Desalination Plant Capacity by Firm (BOO/BOT)



Source: Desalination Markets 2016 (GWI)

Figure 2.14 Share of Desalination Plant Capacity by Firm (IWPP)

According the report on the water business market survey entrusted by the Ministry of Economy, Trade, Industry of Japan (March 2015), the global market share by Japanese firms was 0.7% in 2007 and 0.5% in 2013 for the whole water business. On the other hand, the share was 8.1% in 2007 and 5.2% in 2013 for desalination (Table 2.3) because of the orders received for large-scale plants. Even though Japanese products such as RO membrane, filtration membrane, and high-pressure pump are prevailing in the global market, the annual amount of desalination by Japanese firms is highly variable whether orders received for large-scale plants take place or not.

Table 2.3 Global Market Share of Desalination by Japanese Firms

		2007	2010	2013
Whole Water Business	Total Amount, Global Market (JPY Million)	29,536,124	(n/a)	48,815,079
	Total Amount, Japanese Firm (JPY Million)	206,788	175,746	246,343
	Share by Japanese Firm	0.7%	-	0.5%
Desalination	Total Amount, Global Market (JPY Million)	440,536	(n/a)	412,410
	Total Amount, Japanese Firm (JPY Million)	35,713	10,120	21,309
	Share by Japanese Firm	8.1%	-	5.2%

Source: The Report on the Water Business Market Survey, entrusted by the Ministry of Economy, Trade, Industry of Japan (March 2015)

Since 2010, RO membrane market shares by firm are: 38.3% by Dow Water & Process Solutions (USA), 28.3% by Toray (Japan), 20.1% by Nitto/Hydranautics[7] (Japan/USA), 7.6% by Toyobo (Japan), and 4.4% by NanoH2O (USA, acquired by South Korean LG Chem in 2014)[8]. The sum of the market shares by three Japanese firms accounts for 56% over the world.

The major manufacturers of high pressure pump are KSB (Germany), Torisima (Japan), Flowserve (USA), Sulzer (Swiss), etc. and Torishma has around 40% market share over the world.

7 Nitto acquired Hydranautics in 1987.

8 RO membrane market shares described in Desalination Market 2016 (GWI)

2.2.3 Recent Trend of Japanese Firms

The international water business by Japanese firms is divided into three domains: (i) business operations, maintenance, and management by general trading firms, (ii) equipment design, assembly, and construction by plant manufacturers, and (ii) members, parts, and equipment manufacturing by water treatment equipment manufacturers. Competitive bidding with foreign competitors is essential in any of the business domains in order to get concession contract for general trading firms, engineering-procurement-construction (EPC) contract for plant manufacturers, and equipment supply contract for water treatment equipment manufacturers.

Since the seawater desalination project requires technical knowledge for planning, design, and construction as well as operation and maintenance (O&M), the contractor is involved not only in EPC but also in O&M. For example, the EPC contractor conducts O&M for a few years after the construction of the plant in design-build-operate (DBO) and then transfers it to the project owner. In other cases, the major water business firms carry out a long-term concession throughout project proposal, planning, design, financing, EPC, and O&M.

Two French water business firms, Veolia Water and Suez Environment, are performing their business all over the world but their global market shares are declining in recent years. On the other hand, the emerging water business firms, such as Hyflux (Singapore) and Doosan (South Korea), are rapidly expanding their businesses. GE (USA) affiliated the professional firms by M&A in the 2000s and has been expanding its global market share significantly. In addition, a number of firms have been entering into the international water business. These water business firms enhance the competitiveness by business proposals to integrate the above-mentioned three domains.

The projects for the seawater desalination plant and succeeding O&M are implemented in the manner of EPC (DBO) or PPP (e.g., design-build-own-operate: DBOO, design-build-own-operate-transfer: DBOOT). In any of these, it is hard for Japanese firms to win the competitive bidding against the international water business firms. For the time being, Japanese firms have been participating in the international water business in such manners as joint investment by general trading firm, EPC subcontract by plant manufacturer, and equipment supply subcontract by water treatment equipment manufacturers, associated with the concession by international water business firm.

It is commonly recognized that the international water business including seawater desalination can be developed effectively in such manners as establishment of foreign branch for seeking opportunities continuously and alliance with local firm and/or firm specialized for foreign business. Japanese firms have been activating their business by means of not only conventional engineering but also establishment of joint enterprise and M&A.

2.2.4 Desalination Projects with Involvement of Japanese Firms

Japanese firms are involved in desalination project mainly through IWPP. The general trading firms and electric power firms invest in the IWPPs. Japanese plant suppliers receive orders of EPC under some of the IWPPs as shown in Table 2.4.

Table 2.4 Desalination Projects with Involvement of Japanese Firms

Project	Country	Start Year	Type	Japanese Firm Involved
1) Umm Al Nar Power and Water Project	UAE	2003	IWPP (BOO)	TEPCO, Mitsui, (Hitachi Zosen)
2) Taweelah Power and Water Project	UAE	2005	IWPP (BOO)	Marubeni, JGC
3) Rabigh IWSPP	Saudi Arabia	2005	IWSPP (BOOT)	Marubeni, JGC, Itochu, (Mitsubishi Heavy Industry)
4) Al Hidd Independent Water and Power Project	Bahrain	2006	IWPP (BOO)	Sumitomo
5) Shuqaiq IWPP	Saudi Arabia	2007	IWPP (BOO)	Mitsubishi, (Mitsubishi Heavy Industry)
6) Ras Laffan C Power and Desalination Project	Qatar	2008	IWPP (BOT)	Mitsui, Shikoku Electric Power, Chubu Electric Power
7) Shuweihat S2 IWPP	UAE	2009	IWPP (BOO)	Marubeni, Osaka Gas
8) Accra Seawater Desalination Project	Ghana	2012	BOOT	Sojitz
9) Ras Abu Fontas A2 Seawater Desalination Project	Qatar	2013	BOO	(Mitsubishi, Hitachi Zosen)
10) Az Zour North IWPP	Kuwait	2013	IWPP (BOOT)	Sumitomo
11) Al Ghubrah Desalination Project	Oman	2013	BOO	Sumitomo
12) Agadir Seawater Desalination Project	Morocco	2014	BOT	(Mitsui & Co. Plant Systems)
13) Basra Desalination Project	Iraq	2014	EPC	Hitachi
14) Project for Restoration of Al Jubail Seawater Desalination Plant	Saudi Arabia	2014	EPC	Sasakura, Itochu
15) Project for Expansion of Shuaiba (Phase 2) Seawater Desalination Plant	Saudi Arabia	2015	EPC	Sasakura, Itochu
16) Umm Al Houl IWPP	Qatar	2015	IWPP (BOOT)	Mitsubishi, TEOCO, (Hitachi Zosen)

Note: Name of firm in parenthesis denotes EPC subcontractor or equipment package supplier. Individual equipment supplier (membrane, pump, etc,) is not shown.
Source: Prepared by the Survey Team

1) Umm Al Nar Power and Water Project, UAE

Tokyo Electric Power Co., Ltd. (TEPCO, Japan), Mitsui & Co., Ltd. (Japan), and International Power (UK) won the bid for the project at Umm Al Nar in Abu Dhabi, consisting of the following: purchase of natural gas-fired combined cycle power plant (850 MW) and desalination plant (750,000 m^3/day), and construction of natural gas-fired combined cycle power plant (1,550 MW) and desalination plant (110,000 m^3/day).

- Project Type: IWPP (BOO) for 20 years
- Project Company: Arabian Power Company with 20% share by International Power, 14% by TEPCO, 6% by Mitsui, and 60% by Abu Dhabi Water and Electricity Authority (ADWEA)
- O&M Company: ITM O&M Company with 30% share by TEPCO and 70% by International Power
- Off-taker: Abu Dhabi Water and Electricity Company (ADWEC)
- Project Start Year: 2003
- Project Cost: USD 2.1 billion
- Power Plant Capacity: 850 MW (existing) and 1,550 MW (new)
- Desalination Plant Capacity: 750,000 m^3/day (existing) and 110,000 m^3/day (new)
- Desalination Method: MSF (for new plant)

- Desalination Plant Supplier: Hitachi Zosen Corporation (Japan)

2) Taweelah Power and Water Project, UAE

Taweelah B: Marubeni Corporation (Japan), JGC Corporation (Japan), BTU Power (USA), and Powertek Energy (Malaysia) won the bid for the project at Taweelah, 80 km northeast of Abu Dhabi, consisting of the following: purchase of natural gas-fired combined cycle power plant (1,000 MW) and desalination plant (450,000 m^3/day), and construction of natural gas-fired combined cycle power plant (1,000 MW) and desalination plant (300,000 m^3/day). Of the total project cost USD 3 billion, USD 2.2 billion was financed by the Japan Bank for International Cooperation (JBIC) and international commercial banks (15 banks from 8 countries).

- Project Type: IWPP (BOO) for 20 years
- Project Company: Taweelah Asia Power Company (TAPCO) with 40% share by Marubeni group and 60% by ADWEA
- O&M Company: Asia Gulf Power Service Company (AGPS) with 35% share by Marubeni, 15% by JGC, 25% by BTU, and 25% by Powertek
- Off-taker: Abu Dhabi Water and Electricity Company (ADWEC)
- Project Start Year: 2005
- Project Cost: USD 3 billion
- Power Plant Capacity: 1,000 MW (existing) and 1,000 MW (new)
- Desalination Plant Capacity: 450,000 m^3/day (existing) and 300,000 m^3/day (new)
- Desalination Method: MSF (for new plant)
- Desalination Plant Supplier: Fisia Italimpianti (Italy)

Taweelah A2: Marubeni acquired a 40% share of Taweelah A2 from Abu Dhabi National Energy PJSC (TAQA) in 2007. The project includes a 710 MW combined cycle power plant and 230,000 m^3/day desalination plant.

3) Rabigh IWSPP, Saudi Arabia

Marubeni Corporation (Japan), JGC Corporation (Japan), Itochu Corporation (Japan), and the local independent power producer ACWA Power got the concession. The project was planned to supply power, water, and steam for a period of 25 years for the world’s largest oil refining and petrochemical plants constructed by Saudi Aramco and Sumitomo Chemical. Power plant and desalination plant were built in Rabigh, 140 km north of Jeddah, at the Red Sea coast, consisting of the following: thermal power plants (360 MW), 9 units of heavy oil-fired boiler to generate 470 tons per hour of steam, five steam turbine generators (5×120 MW), and reverse osmosis desalination plant (192,000 m^3/day).

- Project Type: IWSPP (BOOT) for 25 years
- Project Company: Rabigh Arabian Water and Electricity Company (RAWEC) with 30% share by Marubeni, 25% by JGC, 20.1% by Itochu, 24.9% by ACWA Power and others
- Off-taker: Rabigh Refining and Petrochemical Company
- Project Start Year: 2005
- Project Cost: USD 1.1 billion
- Power Plant Capacity: 360 MW

- Desalination Plant Capacity: 192,000 m^3/day
- Steam Plant Capacity: 1,230 tons/hour
- Desalination Method: RO
- Desalination Plant Supplier: Mitsubishi Heavy Industries (Japan)

4) Al Hidd Independent Water and Power Project, Bahrain

Sumitomo Corporation (Japan), International Power (UK), and Suez-Tractebel S.A. (Belgium) won the concession for the project at Al Hidd, Bahrain, consisting of the following: purchase of natural gas-fired combined cycle power plant (1,000 MW), desalination plant (135,000 m^3/day), and construction of desalination plant (270,000 m^3/day). The project is co-financed by financial institutions including JBIC, Mizuho Corporate Bank, Ltd., and Sumitomo Mitsui Banking Corporation.

- Project Type: IWPP (BOO) for 20 years
- Project Company: Hidd Power Company B.S.C.(c) with 30% share by Sumitomo, 40% by International Power, and 30% by Suez-Tractebel
- Off-taker: Ministry of Electricity and Water
- Project Start Year: 2006
- Project Cost: USD 1.25 billion
- Power Plant Capacity: 1,000 MW
- Desalination Plant Capacity: 135,000 m^3/day (existing) and 270,000 m^3/day (new)
- Desalination Method: MSF
- Desalination Plant Supplier: Sidem (France: Veolia Group)

5) Shuqaiq IWPP, Saudi Arabia

Mitsubishi Corporation (Japan), Gulf Investment Corporation (GIC: Kuwait investment fund), ACWA Power (Saudi Arabia), and the government entities established Shuqaiq Water and Electricity Company (SqWEC) for the project at Shuqaiq near the border of Yemen in the Red Sea coast, consisting of power plant (850 MW) and seawater desalination plant (212,000 m^3/day).

- Project Type: IWPP (BOO) for 20 years
- Project Company: Shuqaiq Water and Electricity Company (SqWEC) with 6% share by Mitsubishi, 20% by GIC, 34% by ACWA Power, 32% by Public Investment Fund (PIF), and 8% by Saudi Electric Company
- O&M Company: First National Operation & Maintenance Co. Ltd. (NOMAC)
- Off-taker: Water and Electricity Company (WEC)
- Project Start Year: 2007
- Project Cost: USD 1.87 billion
- Power Plant Capacity: 850 MW
- Desalination Plant Capacity: 212,000 m^3/day
- Desalination Method: RO
- Desalination Plant Supplier: Mitsubishi Heavy Industries (Japan)

6) Ras Laffan C Power and Desalination Project, Qatar

Ras Girtas Power Company (RGPC), established by Mitsui & Co., Ltd. (Japan), Shikoku Electric Power Co., Inc (Japan), Chubu Electric Power Co., Inc (Japan), Suez-Tractebel S.A. (Belgium), Qatar Petroleum, and Qatar Electricity and Water Company Q.S.C. (QEWC), initiated the project consisting of natural gas-fired combined cycle power plant (2,730 MW) and desalination plant (290,000 m^3/day) in Ras Laffan Industrial City, located 80 km north of the capital Doha. RGPC sells electric power and freshwater to Qatar General Electricity & Water Corporation (KAHRAMAA) for 25 years. The project is co-financed by JBIC, the Bank of Tokyo-Mitsubishi UFJ, Sumitomo Mitsui Banking Corporation and Islamic financial institutions.

- Project Type: IWPP (BOT) for 25 years
- Project Company: Ras Girtas Power Company (RGPC) with 45% share by QEWC, 15% by Qatar Petroleum, 20% by Suez-Tractebel, 10% by Mitsui, 5% by Shikoku Electric Power, and 5% by Chubu Electric Power
- Off-taker: Qatar General Electricity & Water Corporation (KAHRAMAA)
- Project Start Year: 2008
- Project Cost: USD 3.9 billion
- Power Plant Capacity: 2,730 MW
- Desalination Plant Capacity: 290,000 m^3/day
- Desalination Method: MED
- Desalination Plant Supplier: Veolia (France)

7) Shuweihat S2 IWPP, Abu Dhabi, UAE

Marubeni Corporation (Japan), Osaka Gas Co., Ltd. (Japan), and International Power GDF Suez (France) are implementing the project consisting of natural gas-fired combined cycle power plant (1,500 MW) and seawater desalination plant (454,000 m^3/day), located 250 km southwest of the city of Abu Dhabi, to supply electric power and freshwater to Abu Dhabi Water and Electricity Company (ADWEC) for the period of 25 years. The project is co-financed by JBIC and commercial banks including Sumitomo Mitsui Banking Corporation, The Bank of Tokyo-Mitsubishi UFJ Ltd., Mizuho Corporate Bank, Ltd. and The Sumitomo Trust and Banking Co., Ltd.

- Project Type: IWPP (BOO) for 25 years
- Project Company: Ruwais Power Company with 10% share by Marubeni, 10% by Osaka Gas, 20% by International Power GDF Suez, and 60% by Abu Dhabi Water and Electricity Authority (ADWEA)
- O&M Company: S2 Operation and Maintenance Company (25% share by Marubeni, 25% by Osaka Gas, and 50% by International Power GDF Suez)
- Off-taker: Abu Dhabi Water and Electricity Company (ADWEC)
- Project Start Year: 2009
- Project Cost: USD 2.7 billion
- Power Plant Capacity: 1,500 MW
- Desalination Plant Capacity: 454,000 m^3/day
- Desalination Method: MSF
- Desalination Plant Supplier: Doosan Heavy Industries and Construction (South Korea)

8) Accra Seawater Desalination Project, Ghana

Abengoa Water (Spain), Sojitz Corporation (Japan), and Hydrocol (Ghana) constructed the seawater desalination plant (60,000 m^3/day) in Nungua, Accra and have started its commercial operation from 2015 to sell freshwater to Ghana Water Company Limited.

- Project Type: BOOT for 25 years
- Project Company: Befesa Desalination Developments Ghana Ltd. with 51% share by Abengoa, 44% by Sojitz, and 5% by Hydrocol
- Off-taker: Ghana Water Company Limited
- Project Start Year: 2012
- Project Cost: USD 126 million
- Desalination Plant Capacity: 60,000 m^3/day
- Desalination Method: RO
- Desalination Plant Supplier: Abeima (Spain: Abengoa Group)

9) Ras Abu Fontas A2 Seawater Desalination Project, Qatar

A consortium of Mitsubishi Corporation (Japan) and Toyo Thai Corporation Public Company (Thailand) has completed the Abu Fontas A2 Seawater Desalination Plant, located about 10 km south of Doha under a turnkey contract with Qatar Electricity & Water Company (QEWC).

- Project Type: BOO for 25 years
- Project Company: Qatar Electricity & Water Company (QEWC)
- Off-taker: Qatar General Electricity & Water Corporation (KAHRAMAA)
- Project Start Year: 2013
- Project Cost: USD 500 million
- Desalination Plant Capacity: 164,000 m^3/day
- Desalination Method: MSF
- Desalination Plant Supplier: Hitachi Zosen Corporation (Japan)

10) Az Zour North IWPP, Kuwait

This is the first IWPP in Kuwait. AZN1 established by Sumitomo Corporation (Japan), Electrabel S.A. (Belgium), Abdullah Hamad Al-Sager and Brothers (Kuwait), and Kuwaiti Government entities, implements the project to install a 1,500 MW natural gas-fired combined cycle power plant and a 480,000 m^3/day seawater desalination plant at Az-Zour North, located about 100 km south of Kuwait City, and sell electric power and freshwater to the Ministry of Electricity and Water for 40 years in the manner of BOOT. The project is co-financed by JBIC, The Bank of Tokyo-Mitsubishi UFJ, Ltd., Sumitomo Mitsui Banking Corporation, Standard Chartered Bank (Tokyo branch), National Bank of Kuwait S.A.K., and other financial institutions.

- Project Type: IWPP (BOOT) for 40 years
- Project Company: SHAMAL AZ-ZOUR AL-OULA FOR THE BUILDING, EXECUTION, OPERATION, MANAGEMENT AND MAINTENANCE OF THE FIRST PHASE OF AZ-ZOUR POWER PLANT K.S.C. (AZN1), with 17.5% share by Sumitomo, 17.5% by GDF Suez, 5% by Abdullah Hamad Al-Sager and Brothers, and 60% by Kuwaiti Government entities

- O&M Company: to be carried out by Sumitomo and GDF Suez
- Off-taker: Kuwait Ministry of Electricity and Water
- Project Start Year: 2013
- Project Cost: USD 1.43 billion
- Power Plant Capacity: 1,500 MW
- Desalination Plant Capacity: 480,000 m^3/day
- Desalination Method: MSF
- Desalination Plant Supplier: Sidem (France: Veolia Group)

11) Al Ghubrah Desalination Project, Oman

This is the first case for JBIC to finance the project for sole seawater desalination rather than IWPP. Muscat City Desalination Company S.A.O.C. (MCDC) was jointly established by Sumitomo Corporation (Japan), Malakoff Corporation Berhad (Malaysia) and Cadagua S.A. (Spain) to implement this project. MCDC implements the project to install a 191,000 m^3/day seawater desalination plant at Al Ghubrah located in the capital Muscat and sell freshwater to Oman Power and Water Procurement Company S.A.O.C. for 20 years in the manner of BOO. The project is co-financed by JBIC, Sumitomo Mitsui Banking Corporation, and The Bank of Tokyo-Mitsubishi UFJ Ltd.

- Project Type: BOO for 20 years
- Project Company: Muscat City Desalination Company S.A.O.C. with 45% share by Sumitomo, 45% by Malakoff, and 10% by Cadagua
- Off-taker: Oman Power and Water Procurement Company S.A.O.C.
- Project Start Year: 2013
- Project Cost: USD 370 million
- Desalination Plant Capacity: 191,000 m^3/day
- Desalination Method: RO
- Desalination Plant Supplier: Ferrovial (Spain), VA Tech Wabag Ltd. (India)

12) Agadir Seawater Desalination Project, Morocco

Abengoa S.A. received an order for construction and 20 years O&M of the seawater desalination plant with a capacity of 100,000 m^3/day from the National Power and Drinking Water Office (*Office National de l'Electricité et de l'Eau Potable*: ONEE). In March 2015, UTE Abeima Agadir I, a subsidiary of Abengoa, signed a contract with Mitsui & Co. Plant Systems, Ltd. to export a package of major equipment for the project, including reverse osmosis membranes manufactured by Toray, high pressure pumps manufactured by Torishima, and others by different manufacturers. For the total contract price about JPY 3 billion, JBIC and Crédit Agricole Corporate & Investment Bank Tokyo Branch (CACIB) provides Buyer's Credit loan for this export contract. Nippon Export and Investment Insurance (NEXI) provides Buyer's Credit Insurance covering the loan provided by CACIB.

- Project Formation: BOT for 20 years
- Project Company: Société d'Eau Dessalée d'Agadir with 51% share by Abengoa and 49% by InfraMaroc
- Off-taker: National Power and Drinking Water Office (ONEE)

- Project Start Year: 2014
- Project Cost: EUR 82 million
- Desalination Plant Capacity: 100,000 m^3/day
- Desalination Method: RO
- Plant Supplier: UTE Abeima Agadir I (Spain: Abengoa Group)

13) Basra Desalination Project, Iraq

Basra City is the second largest city and the center of the southern region in Iraq. The water demand in Basra City is 900,000 m^3/day that is far larger than the present water supply capacity of 400,000 m^3/day. To increase the water supply capacity, the project for developing a 199,000 m^3/day desalination plant with RO facility is being implemented for using the saline raw water to be taken from the river mouth.

Hitachi, Ltd. (Japan), OTV (France: a subsidiary of Veolia), and Arab Contractors (Egypt) received the orders from the Iraqi Ministry of Municipalities and Public Works: EPC and 5-year O&M for the desalination plant as well as EPC for river water intake, conveyance and pre-treatment facilities.

- Project Owner: Ministry of Municipalities and Public Works
- Contractor: Hitachi, OTV, and Arab Contractors
- Project Start Year: 2014
- Contract Amount: JPY 25 billion for EPC and 5-year O&M for the desalination plant (financed by the Government of Iraq) and JPY 24 billion for EPC for river water intake, conveyance and pre-treatment facilities (financed by Japanese ODA loan)
- Desalination Plant Capacity: 199,000 m^3/day
- Desalination Method: RO

14) Project for Restoration of Al Jubail Seawater Desalination Plant, Saudi Arabia

Sasakura Engineering Co., Ltd. and Itochu Corporation received an order for the restoration of Al Jubail (Phase 2) C4 seawater desalination plant (constructed in 1984) from Saline Water Conversion Corporation (SWCC) through Arabian Company and Sasakura for Water and Power (APS), a joint venture with local capital in Saudi Arabia.

- Project Owner: Saline Water Conversion Corporation (SWCC)
- Contractor: Arabian Company and Sasakura for Water and Power (APS: 50% share by ACWA Holding, 35.1% by Sasakura and 14.9% by Itochu）
- Project Start Year: 2014
- Contract Amount: SAR 142 million (equivalent JPY 3.8 billion)
- Desalination Plant Capacity: 23,500 m^3/day×10 nos.
- Desalination Method: MSF

15) Project for Expansion of Shuaiba (Phase 2) Seawater Desalination Plant, Saudi Arabia

Sasakura Engineering Co., Ltd. and Itochu Corporation received an order for the expansion of existing Shuaiba (phase 2) seawater desalination plant a full-turnkey basis from Saline Water Conversion Corporation (SWCC) through Arabian Company and Sasakura for Water and Power

(APS), a joint venture with local capital in Saudi Arabia.

- Project Owner: Saline Water Conversion Corporation (SWCC)
- Contractor: Arabian Company and Sasakura for Water and Power (APS) with 50% share by ACWA Holding, 35.1% by Sasakura and 14.9% by Itochu
- Project Start Year: 2015
- Contract Amount: USD 120 million
- Desalination Plant Capacity: 91,200 m^3/day
- Desalination Method: MED

16) Umm Al Houl IWPP, Qatar

K1 Energy (established by Mitsubishi Corporation and TEPCO) and Qatar investors established Umm Al Houl Power to construct a 2,400 MW natural gas-fired combined cycle power plant and a 590,000 m^3/day seawater desalination plant located 20 km south of the capital Doha and sell electric power and freshwater to Qatar General Electricity & Water Corporation (KAHRAMAA). The project is co-financed by JBIC, The Bank of Tokyo-Mitsubishi UFJ, Ltd., Mizuho Bank, Ltd., Sumitomo Mitsui Banking Corporation, Mitsubishi UFJ Trust and Banking Corporation, Sumitomo Mitsui Trust Bank, Limited, the Norinchukin Bank, Qatar National Bank, and KfW IPEX-Bank.

- Project Type: IWPP (BOOT) for 25 years
- Project Company: Umm Al Houl Power with 30% share by K1 Energy, 5% by Qatar Petroleum, 5% by Qatar Foundation, and 60% by Qatar Electricity & Water Company (QEWC)
- Off-taker: Qatar General Electricity & Water Corporation (KAHRAMAA)
- Project Start Year: 2015
- Project Cost: USD 3.15 billion
- Power Plant Capacity: 2,400 MW
- Desalination Plant Capacity: 590,000 m^3/day
- Desalination Method: RO
- Plant Supplier: Hitachi Zosen Corporation (Japan)

2.3 Desalination Plants in Africa

2.3.1 Desalination Plants in Whole Africa

In Africa, the introduction of seawater desalination was initiated in the northern part of the continent. In 1990, a seawater desalination plant having a production capacity of 5,000 m^3/day by reverse osmosis became operational at Hurghada in Egypt. To date, the total installed capacity of the existing desalination plants is 7.2 million m^3/day and the total number of the plants is 1,643. The top three of Algeria, Libya and Egypt have 74% in terms of both capacity and number (Table 2.5).

Except the areas along the Nile River and Mediterranean coast, the countries in the North Africa (Egypt, Libya, Tunisia, Algeria and Morocco) are faced with the scarcity of water resources because of their territories belonging to the arid region. Algeria and Libya are exporting oil and gas and Egypt is also exporting gas. With the financial capacity by the revenue from oil and gas, these countries are ready for the early introduction of the seawater desalination plants. All of five countries have GNI per capita over USD 3,000 and well-developed basic infrastructure[9]. The socio-economic conditions in these countries are also ready for accept the seawater desalination.

In Sub-Saharan Africa, the seawater desalination plants are increasing gradually in Angola, South Africa and Ghana.

Table 2.5 Desalination Plants in Africa

Installed Capacity and No. of Plant

Country	Capacity m³/day	No. of Plant
Algeria	2,728,720	187
Libya	1,452,627	323
Egypt	1,144,231	704
Angola	557,254	34
South Africa	334,210	73
Morocco	267,549	45
Tunisia	199,764	96
Ghana	150,314	10
Kenya	58,114	17
Namibia	56,720	5
Sudan	45,695	20
Equatorial Guinea	44,901	6
Cape Verde	41,803	29
Nigeria	40,890	9
Seychelles	21,672	14
Botsw ana	18,082	8
Congo, Republic	10,738	2
Mozambique	9,840	2
Mauritania	6,894	5
Zambia	5,146	2
Guinea	4,286	3
St. Helena	4,130	11
Ethiopia	3,896	4
Tanzania	3,744	6
Djibouti	3,096	8
Congo, DR	1,568	4
Eritrea	1,152	2
Senegal	1,107	5
Zimbabw e	1,079	1
Chad	545	1
Somalia	408	2
Gabon	300	1
South Sudan	300	1
Comoro	268	1
Sierra Leone	160	1
Madagascar	16	1
Total	7,221,219	1,643

No. of Plant by Desalination Method

Country	RO	Distillation		Other	Total
		MED	MSF		
Egypt	610	38	16	40	704
Libya	136	36	58	93	323
Algeria	111	26	24	26	187
Tunisia	60	11	2	23	96
South Africa	50	13		10	73
Morocco	31	7	3	4	45
Angola	19	1		14	34
Cape Verde	16	8	5		29
Sudan	14	4	2		20
Kenya	16	1			17
Seychelles	14				14
St. Helena	2	2	7		11
Ghana	9			1	10
Nigeria	6	3			9
Djibouti	6	2			8
Botsw ana	8				8
Tanzania	6				6
Equatorial Guinea	1	1		4	6
Senegal	4		1		5
Namibia	3	1	1		5
Mauritania	2	2	1		5
Ethiopia	4				4
Congo, DR	1	3			4
Guinea	2	1			3
Zambia	2				2
Somalia	1	1			2
Mozambique	2				2
Eritrea	2				2
Congo, Republic	1			1	2
Zimbabw e	1				1
South Sudan	1				1
Sierra Leone	1				1
Madagascar	1				1
Gabon	1				1
Comoro	1				1
Chad	1				1
Total	1,146	161	120	216	1,643

Source: Prepared by the Survey Team based on DesalData (GWI)

Algeria has ten plants with a capacity of 100,000 m³/day or more. The plants with capacity of more than 50,000 m³/day are installed in Morocco, Ghana, and Namibia (Table 2.6).

Seven out of the eight countries surveyed, except Cote d'Ivoire, have seawater desalination plants. Many of these are owned by private firms doing natural resources development and industrial production. The plants used for water supply services for citizens exist in South Africa. Such plants in other countries are small units only.

9 All of five countries accomplish 100% electrification.

Table 2.6 Existing Seawater Desalination Plants with 15,000 m^3/day or More (RO, on Land)

Country	Location	Project	Capacity (m3/day)	Year Commissioned	Plant Supplier	Procurement
Algeria	Or Ain	Magtaa	500,000	2014	Hyflux	BOT
Algeria	El Hamma	El Hamma	200,000	2005	Besix	BOO
Algeria	Mostaganem	Mostaganem	200,000	2011	GS Engineeing & Construction	IWP
Algeria	Tenes	Tenes	200,000	2015	Abengoa	DBOOT
Algeria	Beni Saf	Beni Saf	200,000	2010	Sacyr Vallehermoso SA	BOO
Algeria	Tlemcen	Tlemcen-Honaine	200,000	2012	Sacyr Vallehermoso SA	BOO
Algeria	Tlemcen	Tlemcen Souk Tleta	199,848	2010	Hyflux	BOOT
Algeria	Tipasa	Fouka	120,000	2011	Acciona SA	BOO
Algeria	Skikda	Skikda	100,000	2008	Sacyr Vallehermoso SA	BOO
Algeria	Cap Djinet	Cap Djinet	100,000	2012	GS Engineeing & Construction	BOO
Egypt	Ain Sokhna	Tahrir Petrochemicals Complex SWRO	91,200		General Electric Group (GE)	
Morocco	Jorf Lasfar	Jorf Lasfar	75,800	2015	Ferroval	EPC
Ghana	Accra	Teshie Nungua	60,000	2015	Abengoa	BOOT
Namibia	Wlotzkasbaken	Uramin Wlotzkasbaken	55,000	2010	Aveng Group	EPC
Kenya	Kenya	Kensalt	48,000	2008	Central Salt & Marine Chemicals Reseach Institute	EPC
Ghana	Ghana	Power Plant Ghana	43,000	2008	Enersave Water Systems	EPC
Algeria	Sete	Sete	30,000	2004	GdF Suez	EPC
Egypt	Red Sea Coast	Ridgewood Egypt	27,252	2008	Xylem Inc.	EPC
Egypt	Marsa Alam	Marsa Alam	27,048	2014	Metito	EPC
Lydia	Soussa	Soussa	26,000	2010	Veolia	EPC
Egypt	Marsa Alam	Oriental-4k	24,000	2011	International Hydro Systems	EPC
Egypt	Marsa Matrouh	Baghoush Desalination Plant	24,000	2013	Desalia	EPC
Sudan	Port Sudan	Port Sudan	20,000	2003	EBD Water	EPC
Egypt	Montazah	Montazah	18,000	2011	TAM Environmental	EPC
Egypt	Sinai Peninsula	Sinai	17,500	2006	Intech	EPC
Egypt	Egypt	SWRO-Egypt	15,000	2014	Metito	EPC
South Africa	Mosell Bay	Mosell Bay Desalination Plant	15,000	2011	Veolia	EPC

Source: Prepared by the Survey Team based on Desaldata (GWI)

2.3.2 Suppliers in Africa

Most of the desalination plant suppliers in Africa are European and American. There are two Japanese firms involved, namely, Sasakura Engineering and Itochu Corporation (Table 2.7). Before 2000, Sasakura Engineering supplied plants mostly using distillation except for two small RO plants. Itochu Corporation supplied only one plant using distillation.

Table 2.7 Desalination Plant Suppliers in Africa

	Plant Supplier	No. of Plant
1	Metito	209
2	Ionics, Inc.	191
3	Veolia Sidem (Societe Internationale De Dessalement.)	68
4	Culligan International Company	56
5	GE Water & Process Technologies	51
6	Entropie S.A.S.	43
7	Desalia	43
8	Ridgewood Egypt for Infrastructure Projects, Ltd.	32
9	Veolia Iberica (Bekox)	31
10	Krupp Uhde	31
11	Grupo SETA, S.L.	25
12	Osmo Sistemi	21
13	Universal Aqua Technologies, Inc.	21
14	ITT Water Equipment Technologies	20
15	Weir Westgarth Ltd.	19
16	Aquatech International Corporation	18
17	Seven Trent Services	17
18	Preussag Wassertechnik (PWT)	17
19	International Hydro Systems	17
20	TAM Environmental	17
21	Christ Water Technology Group	16
22	IDE Technologies Ltd.	16
23	Waterlink, Inc.	16
24	Sasakura Engineering Co., Ltd.	15

	Plant Supplier	Capacity (m^3/day)
1	Hyflux	699,848
2	Veolia Sidem (Societe Internationale De Dessalement)	509,558
3	Sociedad Anonima Depuracion Y Tratamientos	300,000
4	Befesa Agua	276,788
5	Societe Internationale De Dessalement (SIDEM)	250,000
6	Metito	222,591
7	VWS Westgarth	220,797
8	Besix / Orascom Construction Industries	200,000
9	Sacyr Vallehermoso SA / Befesa Agua	200,000
10	Inima (ex-OHL) / Aqualia	200,000
11	Degremont	165,739
12	Ionics, Inc.	161,708
13	NATCO	138,210
14	Pridesa / SNC Lavallin	120,000
15	GE Water & Process Technoligies	112,306
16	Cadagua	105,800
17	US Filter	105,727
18	Desalia	104,650
19	Inima (ex-OHL) / Servicios y Procesos Ambientales	100,000
20	Weir Westgarth Ltd.	99,511
21	Itochu Corporation	88,888
22	Entropie S.A.S.	87,085
23	Krupp Uhde	79,616
24	Veolia Sidem / ENKA Construction & Industry Co., Inc.	66,000
25	Keyplan	65,000
26	Aker Solutions	58,500
27	Christ Water Technology Group	57,555
28	Sasakura Engineering Co., Ltd.	55,537
29	Aqua Engineering GmbH	52,625

Source: Prepared by the Survey Team based on Desaldata (GWI)

2.3.3 Desalination Plants in Surveyed Countries

The desalination plants in the surveyed countries except Cote d'Ivoire are summarized in Table 2.8. Angola has the total installed capacity of 536,662 m^3/day and the most of desalination plants are installed with off-shore oil production facilities. The total capacity of the plants installed on land is only 4,510 m^3/day, which is less than 1% of the total installed capacity in the whole country. In other countries, all desalination plants are located on land and there is no off-shore plant. South Africa and Namibia have 334,210 m^3/day and 56,720 m^3/day, respectively. The installed capacity is less than ten thousands m^3/day in the remaining countries.

The major RO desalination plants installed in the surveyed countries are shown in Table 2.9.

Table 2.8 Summary of Desalination Plants Installed in the Surveyed Countries

Country	Angola	Namibia	Mozambique	Madagascar	Tanzania	South Africa	Mauritius
Total No. of Plant	32	5	2	1	6	73	9
No. of Plant on Land	9	5	2	1	6	73	9
Capacity of Plant on Land	4,510	56,720	9,840	16	3,744	334,210	7,499
Capacity of Plant Off-shore	532,152	0	0	0	0	0	0
Total Capacity of Plant	536,662	56,720	9,840	16	3,744	334,210	7,499
Total Capacity, Seawater and Brackish Water	536,662	56,720	5,400	16	3,408	178,108	7,499
Capacity of Plan on Land, Seawater and Brackish Water	4,510	56,720	5,400	16	3,408	178,108	7,499
Capacity of RO Plant on Land, Seawater and Brackish Water	4,010	55,945	5,400	16	3,408	155,861	7,499
Capacity of Other Plant on Land, Seawater and Brackish Water	500	775	0	0	0	64,870	0

Source: Prepared by the Survey Team based on DesalData (GWI)

Table 2.9 Major RO Desalination Plants in the Surveyed Countries

Country	Angola	Namibia	Mozambique	Madagascar	Tanzania	South Africa	Mauritius
Project		Uramin Wlotzkasbaken	SAB Miller	Beheloke Brackish Solar			
Location		Wlotzkasbaken		Beheloke Toliara		Richards Bay	Rodrigues
Installed Capacity	2,592	55,000	5,400	16	600	100,000	4,000
Desalination Method	RO	RO	RO	RO	RO	RO	RO
Raw Water	Seawater	Seawater	Brackish	Brackish	Seawater	Seawater	Seawater
Award Date	2011	2007	2007	2012	1998	2010	2004
Online Data	2013	2010	2007	2012	1999	2012	2005
Plant Supplier	Culligan International Company	Keyplan	Veolia Water S&T	Trunz Water Systems AG	ProMaqua GmbH		
Usage		Industry	Industry	Municipalities as Drinking Water	Municipalities as Drinking Water	Power Stations	Municipalities as Drinking Water
Detailed User Category		Mining					
Holding Company		Avera Group		Trunz Water Systems AG	ProMinent		
Customer		Uramin Inc.		World Wildlife Fund			Government
Project							
Location						Mossel Bay	
Installed Capacity			4,440		1,440	15,000	800
Desalination Method			RO		RO	RO	RO
Raw Water			River		Brackish	Seawater	Seawater
Award Date			2013		2010	2010	2011
Online Data			2014		2010	2011	2011
Plant Supplier			GE Water & Process Technology			Veolia Water S&T	ProMaqua GmbH
Usage			Industry		Industry	Municipalities as Drinking Water	Tourist Facilities as Drinking Water
Detailed User Category			Mining				
Holding Company			General Electric Group			Veolia	ProMinent
Customer						Petro SA	

Source: Prepared by the Survey Team based on DesalData (GWI)

The existing and planned desalination plants for public water supply in the surveyed countries are listed in Table 2.10.

Table 2.10 Desalination Plants for Public Water Supply in the Surveyed Countries (Including Planned)

No.	Country Name	Output Water (m^3/day)	Technology	Raw Water Type	Award Date	Online Date	Plant Suppliers	User Category	Customer
16	Namibia	10,977	RO	Seawater				Municipal (Drinking)	NamWater
18	Namibia	60,000	RO	Seawater				Municipal (Drinking)	NamWater /MAW
83	South Africa	750	RO	Seawater	2009	2009	Veolia	Municipal (Drinking)	Ndlambe Municipality
84	South Africa	2,000	RO	Seawater	2010	2010	Veolia Water Solutions and Technologies	Municipal (Drinking)	Knysna Municipality
85	South Africa	2,000	RO	Seawater	2010	2010	Veolia Water Solutions and Technologies	Municipal (Drinking)	Bitou Municipality
98	South Africa	1,700	RO	Seawater	2013	2013	Veolia Water Solutions and Technologies South Africa (Pty) Ltd	Municipal (Drinking)	Cederberg Municipality
102	South Africa	13,000	RO	Seawater				Municipal (Drinking)	Nelson Mandela Bay Municipality
103	South Africa	17,750	RO	Brackish				Municipal (Drinking)	Amatola Water
105	South Africa	25,500	RO	Seawater				Municipal (Drinking)	West Coast District Municipality
106	South Africa	100,000	RO	Seawater				Municipal (Drinking)	City of Cape Town
108	South Africa	300,000	RO	Seawater				Municipal (Drinking)	Durban Water
111	Mauritius	4,000	RO	Seawater	2004	2005		Municipal (Drinking)	Government

Source: Prepared by the Survey Team based on DesalData (GWI)

Chapter 3 Socioeconomy

3.1 Introduction

The main subject of the first stage survey is to seek the conditions to increase the feasibility of seawater desalination project. It is presumed that the increase of demands for water infrastructure along with population and economic growth in the major coastal cities would be considered as one of the conditions. From the said viewpoint, this chapter summarizes the socioeconomic aspects of the surveyed countries through the compilation of the information extracted from the available literatures. The socioeconomic aspects recognized in this chapter are utilized in the process of selecting the locations to be surveyed as discussed later in Chapter 5 of this report.

1) Population

The population in Sub-Saharan Africa is growing remarkably and concentrating into the urban areas. Along with the population growth, the demands of the basic infrastructure including transportation, energy and water will increase largely in the future. When the water demand increases rapidly and exceeds the exploitable water volume taken from existing water resources, the seawater desalination is expected to be a possible solution for the water shortage. This chapter describes the trends and projections of the population growth and concentration into the urban areas.

2) Macroeconomy

The major coastal cities are pulling the economic growth of the surveyed countries respectively. Through the activation of the economic corridors, the other growth centers will also be developed in the future. It is presumed that the need for seawater desalination would take place in such growth centers characterized with the regional development potentials. For the assessment of the economic development in the growth centers, this charter compiles firstly the information about the macroeconomy, such as industrial structure, economic growth in recent years and issues on further economic growth, for recognizing the general characteristics of the economy by country.

3) Infrastructure Development

The urban development and growth requires the essential infrastructure such as transportation, energy and water. For recognizing the development and growth of the major coastal cities, this chapter describes the information about the transportation network to link the seaport and inland regions. In addition, the country-wide development of energy infrastructure is also outlined as the seawater desalination requires a high voltage of electricity for its operation. The development of water infrastructure is described in Chapter 4 later.

4) Development of Coastal Regions

The major cities in Sub-Saharan Africa have the seaport and are functioning as the international logistics hub of the corresponding economic corridor to/from the domestic inland regions and neighboring landlocked countries. In addition, intensive industrial developments are also expected in the hinterland of the seaport. This chapter summarizes the available information about the economic corridors, associated development status and perspectives in the major coastal cities where the need for seawater desalination may take place in the future. In addition, the information about the oil, gas and mineral resources exploitation is described briefly in view of the contribution to the development of the economic corridor and coastal city.

5) Assistance by Donor

The statistics by the Organization for Economic Co-operation and Development (OECD) for 2010-2014 are summarized for recognizing the amount of the official development assistance (ODA) received: grand total, by sector, by donor and by major infrastructure such as (i) water and sanitation, (ii) transportation, (iii) energy, and (iv) industry, mining and construction for the surveyed countries respectively. The summarized information gives ideas about the major focus of the infrastructure sectors by country or donor.

3.2 Population

The population in Africa will increase from 1.186 billion in 2015 to 2.478 billion in 2050[1]. The population growth rate towards 2050 is different by country, i.e.: 134% in South Africa, 157% in Namibia, almost stabilized in Mauritius, and double or more in Cote d'Ivoire, Angola, Madagascar, Mozambique, and Tanzania. Table 3.1 shows the population projection in each surveyed country.

Table 3.1 Population Projection in Surveyed Countries

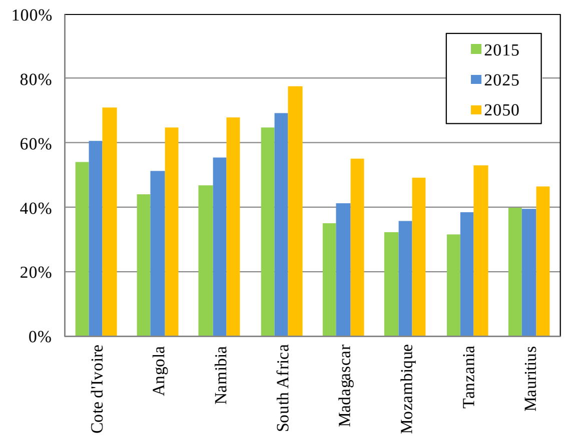
Unit: million

Country	2010	2011	2012	2013	2014	2015	2025	2050	2025/2015	2050/2015
Cote d'Ivoire	18.98	19.39	19.84	20.32	20.80	21.30	26.41	42.34	124%	199%
Angola	19.55	20.18	20.82	21.47	22.14	22.82	30.45	54.32	133%	238%
Namibia	2.18	2.22	2.26	2.30	2.35	2.39	2.83	3.74	118%	157%
South Africa	50.79	51.55	52.34	53.16	54.00	54.95	61.41	73.63	112%	134%
Madagascar	23.97	24.58	25.20	25.83	26.47	24.24	31.74	55.50	131%	229%
Mozambique	21.08	21.68	22.29	22.92	23.57	27.12	34.46	59.93	127%	221%
Tanzania	44.97	46.35	47.78	49.25	50.76	52.29	69.33	129.42	133%	247%
Mauritius	1.25	1.25	1.26	1.26	1.26	1.27	1.30	1.25	103%	99%

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.1 shows the urbanization ratio of each surveyed country.

In African countries, the concentration of population in urban areas is forecasted. The population growth corresponds to the increase of labor forces as resources for economic growth. For the sustainability of economic growth, infrastructure including water supply should be provided along with the population growth.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.1 Urbanization Ratio of Surveyed Countries

[1] World Population Prospects, Key Findings and Advance Tables, 2015 Revision, United Nations

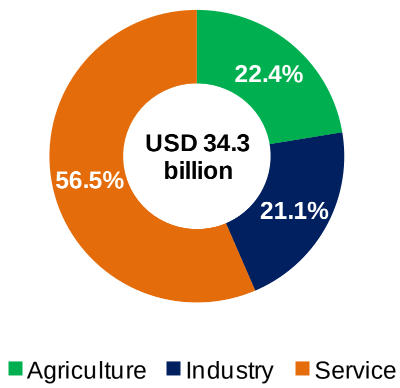
3.3 Macroeconomy

3.3.1 Cote d'Ivoire[2]

Figure 3.2 shows the GDP by economic sector of Cote d'Ivoire in 2014. Table 3.2 shows the macroeconomic indicators of Cote d'Ivoire. An average GDP growth rate from 2012 to 2014 was 9.2%/year.

Cote d'Ivoire leads the regional economic growth in West Africa and has one-third of the total gross domestic product (GDP) within the Economic Community of West African States (*Union Economique et Monétaire Ouest Africaine*: UEMOA) comprising eight countries. The country's economy is strengthened by a variety of export products, close relationship with the former colonial powers of France, and increase in foreign direct investment. The major export products are cocoa beans, cocoa preparations, crude oil, and petroleum products. The country started oil production in 1993 and petroleum products have become the major export products in recent years along with the traditional ones such as cocoa beans and coffee. Meanwhile, the country's economy is highly dependent on the international prices of these export products.

The GDP growth rate remained at 2% to 4% from 2004 to 2010 and fell into negative growth in 2011. Since the end of 2012 when the civil war ended, GDP has been growing at a high rate. As an overall economic trend, export-related sectors were weak under the influence of the civil war but are getting better with the stabilized political situation. Other sectors are growing continuously along with domestic demands.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.2 GDP by Economic Sector of Cote d'Ivoire (2014)

Table 3.2 Macroeconomic Indicators of Cote d'Ivoire

Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	2.0	-4.4	10.7	9.2	9.0
Inflation, GDP deflator (annual %)	5.4	1.6	4.1	2.5	0.5
Revenue, excluding grants (% of GDP)	15.8	12.5	16.3		
Current account balance (% of GDP)	1.9	10.5	-1.2	-1.4	
Total reserves in months of imports	3.7	4.9	3.6	3.9	
Total debt service (% of exports of goods, services, and primary income)	5.8	5.2	5.8	9.5	11.6

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

3.3.2 Angola[3]

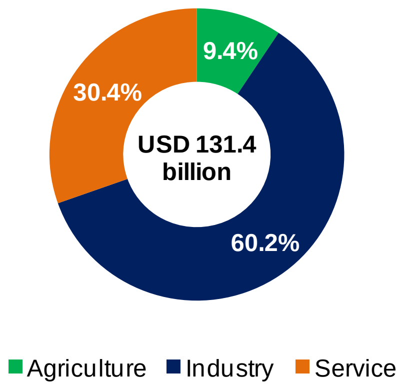
Figure 3.3 shows the GDP by economic sector of Angola in 2014. Table 3.3 shows the macroeconomic indicators of Angola. An average GDP growth rate from 2010 to 2014 was 4.6%/year.

---

2 Survey Project Report on Support in Development of Overseas Markets for Japanese Food Products and Food Industry (2014)

3 Macro-economy in Emerging Country 'WATCH', Angola Updates (2014)

Since the end of the civil war in 2002, Angola has been rapidly expanding its petroleum production and is known as an emerging oil-producing country which has attained a strong economic growth. However, the balance of payments has deteriorated significantly due to the decline of oil price after the collapse of Lehman Brothers. Therefore, Angola was forced to take the financial support of the International Monetary Fund (IMF). After the completion of the IMF program, the macroeconomy of Angola has regained stability with the recovery of the oil prices.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.3 GDP by Economic Sector of Angola (2014)

In 2013, oil sector accounted for 78% of the fiscal revenue, 97% of exports, and 42% of the GDP. Angola's economy is highly dependent on the oil sector and was significantly affected by the oil price fall in 2009.

Since the oil sector is capital intensive, its effect on employment creation is limited. Creation of job opportunity is a high priority issue under the rapid increase of the labor population towards the future. The Government of Angola is making efforts for having an economic structure less susceptible to oil price fluctuations, for the development of non-oil sectors, and for the effective use and inheritance of petroleum resources to future generations.

Table 3.3 Macroeconomic Indicators of Angola

Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	3.4	3.9	5.2	6.8	3.9
Inflation, GDP deflator (annual %)	22.4	24.2	7.1	1.9	3.7
Revenue, excluding grants (% of GDP)	35.6	47.9	40.2		
Current account balance % of GDP)	9.0	11.8	11.0	6.0	
Total reserves in months of imports	5.4	6.4	7.1	6.6	
Total debt service (% of exports of goods, services, and primary income)	4.5	4.2	5.8	7.0	10.7

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

3.3.3 Namibia[4]

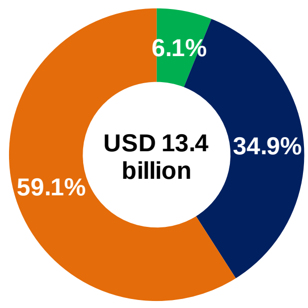
Figure 3.4 shows the GDP by economic sector of Namibia in 2014. Table 3.4 shows the macroeconomic indicators of Namibia. An average GDP growth rate from 2010 to 2014 was 5.2%/year.

The economy of Namibia is relatively stabilized with the development of mineral resources including diamonds and uranium as well as services. Principal industries are mining (uranium, zinc, and rare stones), agricultural and animal husbandry, fisheries (fishing and seafood processing industry), and tourism.

4 Present Conditions of Logistics in Namibia (2012)

As Namibia has a relatively well-equipped transportation infrastructure, the worldwide products coming from the border of South Africa and the port of Walvis Bay are transported to Angola, Botswana, Zambia, and the Democratic Republic of Congo (DRC) through domestic transportation routes. Therefore, the service industry related to logistics is developing rapidly.

Meanwhile, the international competitiveness of the domestic manufacturing industry is low. The country imports nearly all of the industrial products and about half of the grain for domestic consumption. In addition, Namibia is faced with a very high unemployment rate[5]. Job creation through the development of the manufacturing and service industries is a crucial issue.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.4 GDP by Economic Sector of Namibia (2014)

Table 3.4 Macroeconomic Indicators of Namibia

Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	6.0	5.2	5.2	5.1	4.5
Inflation, GDP deflator (annual %)	3.6	3.8	12.8	11.1	11.7
Revenue, excluding grants (% of GDP)	23.8	25.9			
Current account balance (% of GDP)	-3.5	-3.0	-5.8	-4.2	
Total reserves in months of imports	3.1	3.1	2.6	2.3	
Total debt service (% of exports of goods, services, and primary income)					

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

3.3.4 South Africa[6]

Figure 3.5 shows the GDP by economic sector of South Africa in 2014. Table 3.5 shows the macroeconomic indicators of South Africa. An average GDP growth rate from 2010 to 2014 was 2.4%/year.

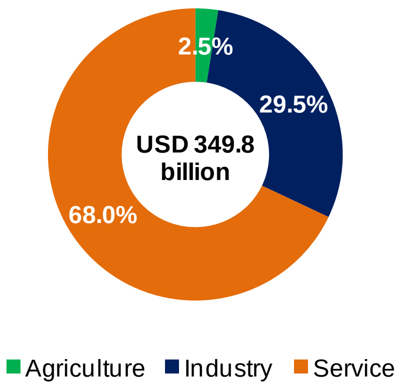
The GDP of South Africa accounted for 26.9% of the total GDP of Sub-Saharan Africa (2013: IMF) and the country is driving the African economy. Its largest trading partner is China. Trade relations with EU, USA, and Japan are also active. In recent years, South Africa is strengthening economic ties with Brazil, Russia, India, and China (BRIC) and the southern African countries.

The ratio of GDP from mining, which was the mainstay industry, decreased from its peak of 23.7% in 1981 to 9.3% in 2012. On the other hand, the GDP from financial and insurance expanded greatly from 14.6% in 1991 to 21.5% in 2012 since industrial structure has been changing. In 2012, the GDP comprised agriculture (2.6%), industry (21.7%), and services (75.7%). Similar to developed countries, South Africa's economy has increased the proportion of its tertiary industry. However, the trade is still highly dependent on mineral resources export.

5 African Economic Outlook (AfDB, 2015) indicates that unemployment rate in Namibia was 29.2% in 2013.
6 Basic Data, The Republic of South Africa, Ministry of Foreign Affair of Japan

The economic growth rate fell into negative in 2009 but recovered to an upward trend after 2010. However, due to domestic factors such as labor strikes and power supply problem in recent years, the economic growth indicates a sign of slowdown again. The inflation rate tends to rise and stays between 3% and 6% since April 2014. It is higher than the target inflation range set by the government.

In recent years, the labor strikes' negative impact on the economy has been a major concern. In June 2014, the Standard and Poor's (S&P) downgraded South Africa's long-term credit rating to BBB-. The rating outlook by Fitch has also been reduced. In addition, unemployment is still a major social problem. It was 21% in 1996 and remains at high level exceeding 20%[7].



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.5 GDP by Economic Sector of South Africa (2014)

Table 3.5 Macroeconomic Indicators of South Africa

Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	3.0	3.2	2.2	2.2	1.5
Inflation, GDP deflator (annual %)	6.4	6.7	5.5	6.0	5.8
Revenue, excluding grants (% of GDP)	28.1	28.5	28.3		
Current account balance (% of GDP)	-1.5	-2.2	-5.0	-5.8	-5.5
Total reserves in months of imports	4.5	4.2	4.3	4.3	4.4
Total debt service (% of exports of goods, services, and primary income)	5.6	4.8	7.8	7.5	8.6

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

3.3.5 Madagascar[8]

Figure 3.6 shows the GDP by economic sector of Madagascar in 2014. Table 3.6 shows the macroeconomic indicators of Madagascar. An average GDP growth rate from 2010 to 2014 was 2.0%/year.

The major industries of Madagascar are agriculture and livestock farming (rice, coffee, vanilla, sugar, and cattle), fisheries (shrimp and tuna), mining (nickel), and tourism. Agriculture accounts for 80% of the working population. The GDP is composed of agriculture (26.4%), industrial (16.1%), and services (57.5%) in 2014. In the past, the garment industry that produces clothing exported to USA and Europe was the major income source. After the political crisis in 2009, Madagascar faced the withdrawal of foreign firms due to the exclusion of preference by USA and decline of orders from Europe.

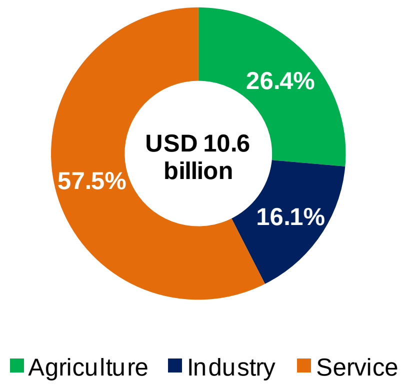
Since the political crisis in 2009, foreign aid was frozen with the exception of humanitarian aid and the application of preferential duty for the country was stopped. Since half of the country's national budget had been covered by foreign aid, the financial status deteriorated with the economic downturn coupled with high inflation. The people's life was more distressed. The poverty ratio was 75.3% (World Bank, 2010) with a per capita GDP of USD 450, which is ranked 180th among 185 countries as per IMF

7 African Economic Outlook (AfDB, 2015) indicates that unemployment rate in South Africa was 24.3% in 2014.

8 e-NEXI, May 2014

statistics. Despite its economic potentials such as mineral resources, agriculture and tourism, political unrest has been the major obstacle to the economic development of Madagascar.

In the mining sector, firms from Japan, Canada, and South Korea initiated the world's largest nickel mine, i.e., Ambatovy Project, in 2007 and attained the first shipment of nickel in November 2012. In January 2014, full-fledged commercial production commenced with an operating rate of over 70%. The production of mineral resources such as nickel and cobalt is expected to continue to push up the export of the country.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.6 GDP by Economic Sector of Madagascar (2014)

Table 3.6 Macroeconomic Indicators of Madagascar

Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	0.3	1.5	3.0	2.4	3.0
Inflation, GDP deflator (annual %)	8.8	8.2	5.5	5.0	6.1
Revenue, excluding grants (% of GDP)	11.2	10.3			
Current account balance (% of GDP)	-10.2	-7.0	-7.6	-5.9	
Total reserves in months of imports	3.4	3.4	3.0	2.1	
Total debt service (% of exports of goods, services, and primary income)	2.7	1.8	2.5	2.5	

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

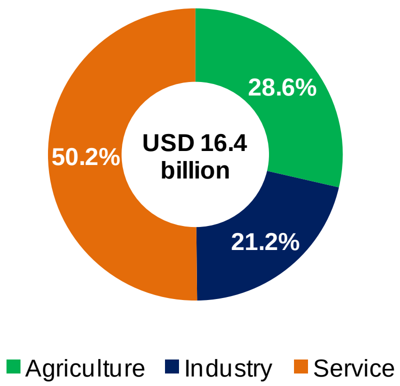
3.3.6 Mozambique[9]

Figure 3.7 shows the GDP by economic sector of Mozambique in 2014. Table 3.7 shows the macroeconomic indicators of Mozambique. An average GDP growth rate from 2010 to 2014 was 7.2%/year.

Mozambique is one of the fastest growing countries in Africa. In addition, domestic and overseas direct investments amounted to USD 20 billion. Foreign direct investment (FDI) has been flowing to industries, such as agriculture, fisheries, industry, transport and communications, and tourism, and has become a cornerstone of rapid economic growth.

9 Mozambique Investment Guide (2015)

In recent years, exports have been increasing gradually but the balance in trade has become a significant deficit that is primarily related to the rapid increase of the imports of capital goods and special services associated with the increase of FDI in the natural resources sector. In addition, machinery, transportation equipment, and other durable consumer goods tend to depend on imports. On the other hand, exports of coal, natural gas, titanium, and aluminum are strong because of the inflow of FDI.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.7 GDP by Economic Sector of Mozambique (2014)

Table 3.7 Macroeconomic Indicators of Mozambique

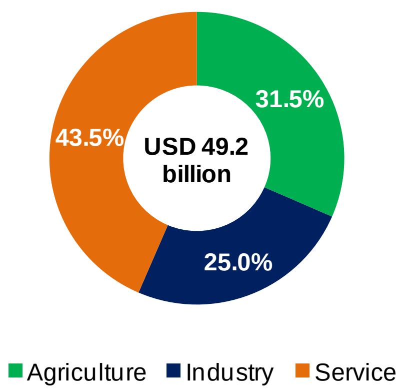
Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	6.8	7.4	7.1	7.3	7.4
Inflation, GDP deflator (annual %)	9.1	3.9	3.2	2.3	2.8
Revenue, excluding grants (% of GDP)	18.0	20.7	22.9		
Current account balance (% of GDP)	-14.3	-22.6	-43.8	-36.8	
Total reserves in months of imports	5.2	3.9	2.9	3.2	
Total debt service (% of exports of goods, services, and primary income)	2.8	1.5	1.4	2.6	

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

3.3.7 Tanzania[10]

Figure 3.8 shows the GDP by economic sector of Tanzania in 2014. Table 3.8 shows the macroeconomic indicators of Tanzania. An average GDP growth rate from 2010 to 2014 was 6.7%/year.

According to the IMF, the real GDP growth rate of Tanzania in 2013 was 7.0%, which was higher than the average of 5.1% among Sub-Saharan African countries. Tanzania is further characterized by a continuous economic growth of 6% to 7% since 2004. Transportation and communication, manufacturing, and construction industry are growing strongly. The primary industry reduces its share and the shares of the secondary and tertiary industries increase year by year.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.8 GDP by Economic Sector of Tanzania (2014)

On the other hand, Doing Business 2012, published by the World Bank, describes that Tanzania is positioned at 127th among 183 countries in the world in terms of business environment. Tanzania needs improvement of its business environment by strengthening the foundations for foreign

[10] Macro-economy in Emerging Country 'WATCH', Tanzania: Its Potential and Future (2015)

investment expansion in the natural resources such as natural gas. In addition, Tanzania faces problems on macroeconomic structure such as trade deficit, inflation, foreign exchange reserves shortage, and fiscal deficit although these have been improved in the short term[11].

Table 3.8 Macroeconomic Indicators of Tanzania

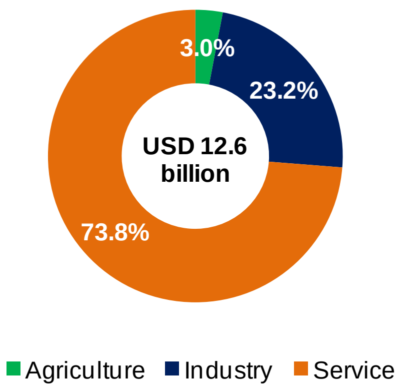
Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	6.4	7.9	5.1	7.3	7.0
Inflation, GDP deflator (annual %)	9.2	11.5	10.7	7.7	4.7
Revenue, excluding grants (% of GDP)	12.7	13.3	12.6		
Current account balance (% of GDP)	-6.2	-11.8	-9.6	-10.6	
Total reserves in months of imports	4.9	3.6	3.6	4.0	
Total debt service (% of exports of goods, services, and primary income)	3.0	1.9	1.9	1.9	

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

3.3.8 Mauritius[12]

Figure 3.10 shows the GDP by economic sector of Mauritius in 2014. Table 3.9 shows the macroeconomic indicators of Mauritius. An average GDP growth rate from 2010 to 2014 was 3.6%/year.

Mauritius has promoted economic structural reforms since 2006 by investing in IT industry and international financial center in order to break away from an economy that relies on conventional industries such as sugar production, textile, and tourism. Mauritius has been actively attracting foreign direct investments through the development of its investment environment. In recent years, Mauritius maintained its first place rank in Africa in Doing Business, published by the World Bank. The country aims at establishing its key position for investments to Africa through the promotion of the investment agreement with African countries.



Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

Figure 3.9 GDP by Economic Sector of Mauritius (2014)

Table 3.9 Macroeconomic Indicators of Mauritius

Indicator	2010	2011	2012	2013	2014
GDP growth (annual %)	4.1	3.9	3.2	3.2	3.6
Inflation, GDP deflator (annual %)	1.8	3.9	3.1	3.2	1.8
Revenue, excluding grants (% of GDP)	22.8	22.4	23.0		
Current account balance (% of GDP)	-10.3	-13.9	-7.2	-9.9	-10.2
Total reserves in months of imports	2.8	3.8	4.1	4.5	4.9
Total debt service (% of exports of goods, services, and primary income)	1.5	49.3	39.1	27.7	26.8

Source: Prepared by the Survey Team based on the data extracted from World Bank Open Data

[11] Ex-Ante Evaluation, Tenth Poverty Reduction Support Credit (2013)
[12] Basic Data, The Republic of Mauritius, Ministry of Foreign Affair of Japan

3.4 Infrastructure Development

3.4.1 Cote d'Ivoire

(1) Transportation[13]

The transportation infrastructure of road, railway, and aviation is undeveloped as a whole. The road network to the neighboring cities and countries spreads over the southern region around Abidjan and the surrounding areas but is underdeveloped in the northern region. The main railway passes through Abidjan, Yamoussoukro, and Bouaké.

Ports are relatively well developed like the commercial ports in Abidjan and San Pedro. The Abidjan Port is a West African hub which functions as a key logistics hub to inland countries such as Mali and Burkina Faso. San Pedro Port handles less cargo volume as compared to Abidjan Port, but the shipment demand of the mineral resources is expected from the nearby mining areas of iron ore and manganese.

(2) Electricity[14]

Cote d'Ivoire has stable power generation to achieve power self-sufficiency and enable the sale of electricity to other countries. The country plays an important role as a power supplier for the entire West African region. The main customers are Burkina Faso, Benin, Mali, and Togo. Domestic power supply has also been developed and 71% of the population lives in electrified regions.

3.4.2 Angola

(1) Transportation[15]

In Angola, domestic infrastructure deteriorated during the long-lasting civil war. Reconstruction of infrastructure is a comprehensive issue. Since 2002, the Government of Angola has been promoting infrastructure development with public and external funds.

Aviation routes spread over the regions in the country. International direct flights are operated to/from the Cuatro de Febereiro International Airport in the capital Luanda. The road network comprises a total length of 51,429 km. The prioritized road rehabilitation projects are implemented in Luanda and its suburbs as well as in the major city centers. Highways link the capital of Luanda and inland areas to the east.

There are three railway trunk lines, namely: Luanda Railway, Benguela Railway, and Moçâmedes Railway. These railways previously connected the provinces in Angola and provided access to the neighboring countries such as Namibia, Congo, and Zambia. But these railways deteriorated and had not been operational due to the civil war. Restoration of these railways has been underway.

There are four major ports in Angola, namely: Luanda Port at the capital, Lobito Port, Namibe Port, and Cabinda Port. About 70% of the total cargo handling volume is concentrated in Luanda Port. Lobito Port handles about 20%.

---

[13] Fiscal 2013 Survey Project Report on Support in Development of Overseas Markets for Japanese Food Products and Food Industry (2014)

[14] Cote d'Ivoire, Infrastructure Map (2014)

[15] The Survey on Investment Environment in Angola (2012)

(2) Electricity[16]

Angola has large rivers with hydroelectric power potential. Three-fourths of the country's electricity is generated by hydroelectric power. Present electricity supply does not keep pace with the growth of the demand due to the deterioration of existing power generation and supply facilities during the civil war. Power supply services are mostly limited to urban areas.

3.4.3 Namibia

(1) Transportation[17]

Namibia has a well-established road infrastructure network of about 46,376 km. The country is linked by all-weather bitumen roads to Angola, Zambia, Zimbabwe, Botswana, and South Africa. Major roads provide a fast and comfortable road link between Namibia's Port of Walvis Bay on the Atlantic coast and landlocked neighboring countries. The major highways are the Trans-Kalahari Highway towards Botswana and South Africa, the Trans-Caprivi Highway towards Zambia and Zimbabwe, and the Trans-Cunene Highway towards Angola. These highways are paved but the remaining local roads are mostly unpaved.

The railway network comprises 2,382 km of narrow gauge track (1,067 mm). The main line runs from the South African border at Ariamsvlei via Keetmanshoop to Windhoek, Okahandja, Swakopmund, and Walvis Bay. Northern section links up with Omaruru, Otjiwarongo, Otavi, Tsumeb, and Oshikango. The east is linked from Windhoek to Gobabis. The south is linked from Windhoek-Keetmanshoop to Lüderitz.

The major airports in Namibia are Hosea Kutako International Airport (HKIA), Walvis Bay Airport, and Keetmanshoop Airport. The small airports include Rundu, Mpacha, Ondangwa, Oranjemund, Swakopmund, and Lüderitz.

Namibia has two main ports which are operated by the Namibian Ports Authority (Namport), namely, Walvis Bay and Lüderitz. The Port of Walvis Bay is one of the preferred entries to the Southern African Development Community (SADC) region due to its accessibility. Lüderitz Port added a new cargo and container quay in 2000.

(2) Electricity[18]

The main sources of power are the coal-fired Van Eck Power Station (3%), the hydroelectric plant at Ruacana (35%), and the standby diesel-fired Paratus Power Station. Additional electricity is sourced through imports from South Africa (19%), Zambia (30%), Angola (1%), and Zimbabwe (12%) in 2012/2013.

[16] The Preparatory Survey on Rural Electrification Development Works in the Republic of Angola, Final Report (2011)
[17] Infrastructure Financing in Namibia (2014)
[18] -ditto-

3.4.4 South Africa

(1) Transportation[19]

South Africa’s road network links the major cities through national roads and motorways. The majority of the highways are passable free of charge except those part of the toll road sections. The national highways are well developed and maintained with a speed limit as high as 80 km/hour to 100 km/hour. Road improvement works such as widening and linear improvements are underway in some places.

The total length of the railway is approximately 23,000 km. The railway of South Africa uses a cape gauge of 1,067 mm. The railway governing body of South Africa is divided into Transnet Freight Rail (TFR) that handles freight transport and the Passenger Rail Agency of South Africa (PRASA) that handles passenger transport.

Airline routes are formed to link Johannesburg and the other major cities. The Johannesburg-Durban and Johannesburg-Cape Town routes are trunk routes of domestic flight. Flights for Johannesburg-Durban are scheduled with 15 to 30 minute intervals during the period of most frequent departures in a day.

The Richards Bay Port is the world’s largest port for coal shipping. The Saldanha Port handles the shipment of iron ore. These ports are linked with the mines located inlands through the railways. The large-scale ports that handle containers are Durban and Cape Town. The Durban Port is the largest for containers in South Africa and has strong ties with Johannesburg, the center of the economy in the country.

(2) Electricity[20]

Eskom is the state-owned power supply company. Its installed capacity is 41,194 MW corresponding to 95% of the power supply in South Africa and equivalent to about 45% of the electricity used in Africa. Its power generation consists of coal-fired (86%), gas turbine (5%), nuclear (4%), pumped-storage (3%), hydropower (1%), and wind (less than 1%). Electricity consumer categories are municipal (42.2%), industry (23.8%), mining (14.6%), commercial and agriculture (6.8%), export (6.4%), other domestic (4.7%), and railway (1.4%).

The power demand increased along with the economic growth during the post-apartheid period. Eskom was faced with the lack of power generation capacity and announced force majeure due to the large-scale power outage in January 2008. Afterwards, Eskom has been taking measures for strengthening the power supply capacity such as restart of suspended power plants, expansion of existing power plants, and construction of new power plants. In addition, Eskom has been requesting large energy consumers to cooperate by saving electricity consumption.

---

[19] Study on High Speed Railway Project between Johannesburg and Durban in the Republic of South Africa, Final Report, February (2012)

[20] Impact on Chromium and Manganese Production due to Power Shortage and Labor Disputes in the Republic of South Africa (2013)

3.4.5 Madagascar

(1) Transportation[21]

It was reported that the total length of roads in Madagascar is 31,612 km. Of these, 5,855 km were evaluated as good or fair in terms of road conditions. The remaining lengths were found to require rehabilitation. The length of paved roads is 4,074 km in total, equivalent to 34% of the total length of the national roads. On the other hand, Africa Development Indicator 2008/09 by the World Bank states the total length of 49,827 km, of which 11.6% are paved. There are a lot of season road sections which are passable during the dry season only. From the populated capital region, only three ports are accessible throughout a year, namely: Toamasina, Mahajanga, and Toliara.

There are two railways in Madagascar, namely, Northern Railway and Southern Railway. The Northern Railway has a total length of 732 km and links Toamasina Port with Antananarivo and Antsirabe. This railway was privatized in 2003. Madagascar Railways (MADARAIL) operates this railway in accordance with the concession agreement with the government. The Southern Railway has a total length of 163 km that links Fianarantsoa and Manakara Port.

There are eight major airports in Madagascar. Under the open sky policy by the government, ten international airline companies have their scheduled flights opened or under preparation. Air Madagascar is the only airline company to manage domestic flights.

The Government of Madagascar manages 16 ports. Of these, four ports, namely: Toamasina, Antsiranana, Mahajanga, and Toliara handle international cargos. Other ports handle domestic feeder cargos. The Toamasina Port is the largest and handles the majority of international cargos[22].

(2) Electricity[23]

There are a number of renewable energy sources such as hydropower in Madagascar. But the development of renewable energy sources is limited in scale at present and does not keep pace with the increase of power demand. In the meantime, the deterioration of existing power plants and transmission and distribution lines is also a major problem. In recent years, thermal power plants account for more than half of the total of the power supply capacity in the country. The existing transmission network consists of three systems, namely: Antananarivo, Toamasina, and Fianarantsoa.

3.4.6 Mozambique

(1) Transportation[24]

In Mozambique, the development of port and railway has been carried out for linking the Indian Ocean and the landlocked countries in Southern Africa. There are five international ports being operated, namely: Maputo, Beira, Nacala, Quelimane, and Pemba. The renovation and expansion project for Nacala Port is being implemented with the support of Japan. There are also other plans such as construction of a new terminal in Beira Port and construction of new ports in Macuse (Zambezia Province) and Techobanine (Maputo Province).

[21] The Feasibility Study on Toamasina Port Development in the Republic of Madagascar, Final Report (2009)
[22] Request for Proposal, Toamasina Port Expansion Project Implementation Support (2014) describes around 90%.
[23] Preliminary Study for Expansion of Manandona Hydroelectric Power Station in Madagascar, Study Report (2009)
[24] Mozambique Investment Guide (2015)

Each provincial capital has an airport. The major cities such as Maputo, Beira, Nampula, Tete, and Pemba operate international airports. Nacala Airport was rehabilitated and operational as an international airport since December 2014. It is expected to play an important role in the future economic development of the northern region.

(2) Electricity[25]

The Cahora Bassa Hydroelectric Power Plant (2,075 MW, 15,000 GWh/year) contributed to most of the installed capacity in Mozambique. Of the total power generation by the Cahora Bassa, 95% is exported to South Africa (60%) and Zimbabwe (35%) and 5% is used for domestic consumption. Even though the power network was expanded all over the provinces, the electrification rate remained at a low level of 23% as of 2012. As the power supply is increasing every year by 10%, Mozambique Electric Power Corporation (*Electricidade de Moçambique*: EDM) needs to take immediate action for the increase of domestic power demand. According to the government energy policy, the power and energy demands are expected to be up to 1,350 MW and 8,200 GWh/year in 2030.

3.4.7 Tanzania

(1) Transportation[26]

In East Africa, a large part of Kenya, Uganda, and Tanzania sections of the Northern Corridor and Central Corridor has been rehabilitated in recent years through donor supports such as the World Bank, EU, and AfDB. The Central Corridor starts from Dar es Salaam Port and extends to Burundi, Rwanda, and Uganda. The rehabilitation of the Central Corridor was initiated later than the Northern Corridor. At present, the conditions in the Tanzanian section have been improved. JICA is assisting the infrastructure development and logistics for the Central Corridor.

Tanzania-Zambia Railway Authority (TAZARA), which is owned by the governments of Tanzania and Zambia, has jurisdiction over the railway on the Tazara Corridor connecting Tanzania with Zambia (Tanzanian section). The railway is connected with the Zambia Railway at the Tunduma-Nakonde border and is further indirectly connected with the railways of Zimbabwe and South Africa.

There are five international trading ports in Tanzania, namely: Dar es Salaam, Tanga, Mtwara, Zanzibar and Kigoma. Dar es Salaam Port is the base of the Central Corridor and handles the largest cargo volume. The port is the main entrance of international trade not only for Tanzania but also for Zambia, Burundi, and Rwanda. Kigoma Port is located on the eastern shore of the Lake Tanganyika and functions as an international hub for the logistics with Brundi, Congo (DRC) and Zambia on the other side of the Lake.

(2) Electricity[27]

As the power demand in Tanzania is expanding at a pace of more than 10% every year, the power supply system stays at chronic overload in order to cope with the demand. In addition, power outage occurs frequently (26.3 hours/month) and has caused the major failure of the activities of the social economy. Moreover, in order to compensate for the decrease of power generation by hydroelectric

---

[25] The Feasibility Study on Smart-AHAT Gas Power Plant in Mozambique (2014)
[26] The Research on the Cross-Border Transport Infrastructure: Phase 3, Final Report (2009)
[27] Ex-Ante Evaluation (Technical Cooperation for Development Planning), Project for Formulation of Power System Master Plan In Dar es Salaam and Review of the Power System Master Plan (2012)

power plants due to drought in recent years, Tanzania Energy Supply Company (TANESCO) has increased the purchase of electric power from independent power producers (IPPs). As a result, TANESCO's operating loss has become serious due the difference between lower electricity prices and higher power supply costs. In order to improve this situation, the Tanzanian government has established the Power System Master Plan (PSMP) on the basis of the forecast for the 25-year period from 2008 in order to develop trunk transmission lines and power generation facilities. The PSMP was already updated to its 2012 edition.

3.4.8 Mauritius

(1) Transportation[28]

The total length of roads in Mauritius was 2,356 km in 2014, comprising 99 km of motorways, 1,131 km of main roads, 673 km of secondary roads, and 453 km of other roads.

Port Louis is a major maritime logistics hub connecting Asia, Australia, and Africa with Europe. Sir Seewoosagur Ramgoolam International Airport is located 48 km southeast from Port Louis.

(2) Electricity[29]

The installed power capacities were 768.5 MW in Mauritius Island and 13.7 MW in Rodrigues Island in 2014. The peak power demands were 446.2 MW and 7.2 MW for Mauritius and Rodrigues Island, respectively. The total power generation is 2,937 GWh, including about 20% of renewable energy, and consisting of 40% from the electricity authority (Central Electricity Board: CEB) and 60% from IPPs. About 86% of primary energy is generated from imported fossil fuels (55% of oil and 31% of coal).

3.5 Development in Coastal Regions

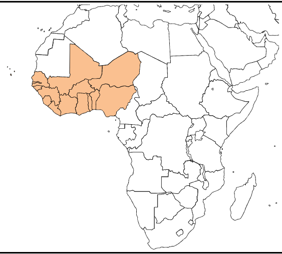
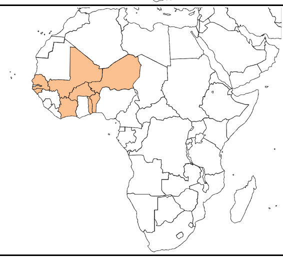
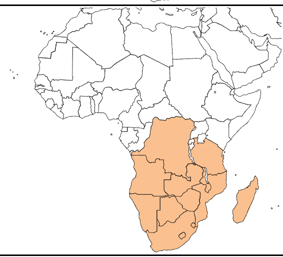
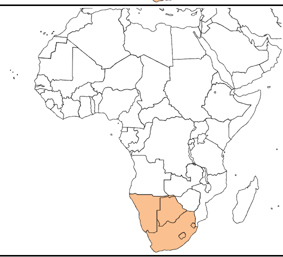
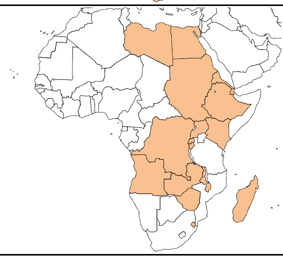
3.5.1 Regional Economic Communities (RECs)

Due to the borders set by the colonial policy in the past, African countries are small as a whole in terms of both economic scale and population and they have been seeking inter-regional cooperation and integration as a longstanding issue. There are Regional Economic Communities (RECs) in Africa for the purpose of economic integration between neighboring countries, establishment of customs union, introduction of common currency, cross-border trade promotion, and common market establishment. Some of the RECs perform investigation of wide-area corridor, adjustment of corridor development among the countries concerned, and promotion of agreements relating to intra-regional and cross-border traffic[30]. Table 3.10 shows the RECs in Sub-Saharan Africa.

---

28 Digest of Road Transport and Road Accident Statistics 2014
29 Digest of Road Energy and Water Statistics 2014
30 The Research on the Cross-Border Transport Infrastructure: Phase 3, Final Report (2009)

Table 3.10 Regional Economic Communities in Sub-Saharan Africa

Name	Members	
Economic Community of West African States (ECOWAS)	Nigeria, Gambia, Burkina Faso, Senegal, Benin, Mali, Niger, Togo, Cote d'Ivoire, Guinea-Bissau, Ghana, Guinea, Liberia, Sierra Leone, Cape Verde	
Union Economique et Monetaire Ouest-Africaine (UEMOA)	Burkina Faso, Senegal, Benin, Mali, Niger, Togo, Cote d'Ivoire, Guinea-Bissau	
Southern African Development Community (SADC)	Tanzania, Mozambique, Congo, Angola, Zambia, Zimbabwe, Malawi, Mauritius, Madagascar, Swaziland, Botswana, South Africa, Lesotho, Namibia	
Southern African Customs Union (SACU)	Swaziland, Botswana, South Africa, Lesotho, Namibia	
Common Market for Eastern and Southern Africa (COMESA)	Egypt, Libya, Djibouti, Sudan, Eritrea, Ethiopia, Kenya, Uganda, Burundi, Rwanda, Congo, Angola, Zambia, Zimbabwe, Malawi, Mauritius, Madagascar, Swaziland, Seychelles, Comoros	
East Africa Community (EAC)	Kenya, Uganda, Tanzania, Rwanda, Burundi	

Source: The Research on the Cross-Border Transport Infrastructure: Phase 3, Final Report (2009)

3.5.2 Economic Corridors

The African Development Corridors Initiatives: Cases in East and Southern Africa (April 2009) by the National Graduate Institute for Policy Studies (GRIPS) indicates 27 economic corridors and growth poles. Table 3.11 shows the economic corridors and growth poles in Sub-Saharan Africa. In addition, the Japan International Cooperation Agency (JICA) proposed eight priority economic corridors as described in the Preparatory Survey for Southern Africa Integrated Regional Transport Program, Final Report (March 2010). Table 3.12 shows the development potential of the eight economic corridors (shown in Figure 3.10) surveyed by JICA.

Afterwards, JICA further surveyed the eight economic corridors through the Data Collection Survey for Economic and Industrial Development along Economic Corridors in Southern Africa. The survey's Final Report (May 2013) describes the research and analysis for the possible supports to the infrastructure development in the eight economic corridors and presents a long list of projects suitable for technical and financial cooperation (loan and grant aid). At present, JICA is carrying out the Project for Strategic Master Plan of West Africa Growth Ring Corridors, which focuses on linking the coastal countries of Cote d'Ivoire, Ghana, and Togo with the landlocked country of Burkina Faso through three corridors and coastal highway.

Table 3.11 Economic Corridors and Growth Poles in Sub-Saharan Africa

Economic Corridor / Growth Pole	Countries Concerned	Description	Infrastructure Development
1. Maputo Corridor	South Africa Mozambique	Trade route connecting Maputo Port with the northern region of South Africa	Road, port, railway, customs, electricity, and telecommunication
2. Gariep Spatial Development Initiative (SDI)	Namibia South Africa	North Cape and Kalahari regional development utilizing the Orange River system	Agriculture
3. Coast 2 Coast (C2C) Corridor	Namibia Botswana South Africa Mozambique	Tourism route connecting Walvis Bay with Maputo	Road, port, railway, and electricity
4. Limpopo Valley SDI	Mozambique South Africa Zimbabwe	Development of tourism, agriculture, and mining sector by private investment	Road, railway, electricity, and agriculture
5. Walvis Bay Corridor	Namibia Botswana South Africa	Development of Walvis Bay Port as a major trading hub of Southern Africa	Port, road, and railway
6. Beira Corridor	Mozambique Zimbabwe	Export of inland natural resources through Beira Port	Road, port, railway, and electricity
7. Zambezi Valley SDI	Mozambique Zambia	Routes from Beira Port to Moatize coal mine	Railway, road, bridge, airport, and, mine
8. Nacara Corridor	Malawi Zambia Mozambique	Transport and communication route connecting Nacala Port with Malawi and eastern Zambia	Road, port, railway, and electricity
9. Mtwara Corridor	Tanzania Malawi Zambia Mozambique	Poverty reduction by production and expansion of exports	Port, airport, bridge, road, and railway
10. Central Corridor	Burundi Rwanda Tanzania	Mainly for securing of Rwandan export route	Railway, road, port, and export processing zone (EPZ)
11. Malange Corridor	Angola DRC	Multi-modal corridor development connecting Luanda and northeastern Angola	Road, railway, and port
12. Lobito Corridor	Angola DRC Zambia	Connecting the copper-cobalt belt of DRC and Zambia with Lobito Port	Port, railway, bridge, and road
13. Namibe Corridor	Angola Namibia		Port and road
14. Bas-Congo SDI	Angola Congo DRC	A variety of industrial development based on Inga Hydroelectric Power Plant	Electricity, road, railway, bridge, and port

Economic Corridor / Growth Pole	Countries Concerned	Description	Infrastructure Development
15. Lagos-Mombasa Corridor	Nigeria Cameroon Central Africa DRC Uganda Kenya	Connecting Central Africa, DRC, and Uganda with the core countries of East and West Africa	Road, bridge, port, railway, and electricity
16. Madagascar Growth Poles	Madagascar	Business environment in Nosy Be, Antananarivo, and Tolagnaro	Road, port, and EPZ
17. Northern Corridor	Burundi Rwanda Uganda Kenya	Activation of regional economy, agriculture, and tourism	Railway, waterway, and road
18. West Coast Corridor	Senegal Guinea-Bissau Gambia	Corridor along the west coast	Road and port
19. Tazara Corridor	Tanzania Zambia	Export route of coal and iron ore	Railway and inland container depot (ICD)
20. Niger River SDI	Senegal Gambia Mali Niger Nigeria	Economic corridor of the Niger River basin	Railway, port, road, electricity, and bridge
21. Conakry-Buchanan SDI	Guinea Liberia Cote d'Ivoire	Corridor connecting Guinea with Liberia	Road and railway
22. Sekondi/Takoradi-Ougadougou SDI / Tema-Ouagadougou-Mali Transport and Trade Facilitation	Ghana Burkina Faso Mali		
23. Gulf of Guinea SDI	Liberia Cote d'Ivoire Ghana Togo Benin Nigeria	Economic corridor linking the major cities along the coast of the Gulf of Guinea	Gas, electricity, port, and road
24. Douala-N'djamena SDI	Cameroon Chad	Economic development and regional integration through trade and investment promotion in Chad	Railway and road
25. Libreville-Lomie SDI	Gabon Congo Cameroon	Promotion of integrating economy in the region with mineral resources development	Railway and road
26. Mombasa SDI	Kenya Uganda DRC Sudan	Promotion of the products in the countries concerned (mineral resources, mining products, and agricultural products) and export of the products from Mombasa Port	Railway, gas pipeline, electricity distribution, port, and road
27. Djibouti SDI	Djibouti Ethiopia	Promotion of trade and investment through integration of economy in the region.	Electricity

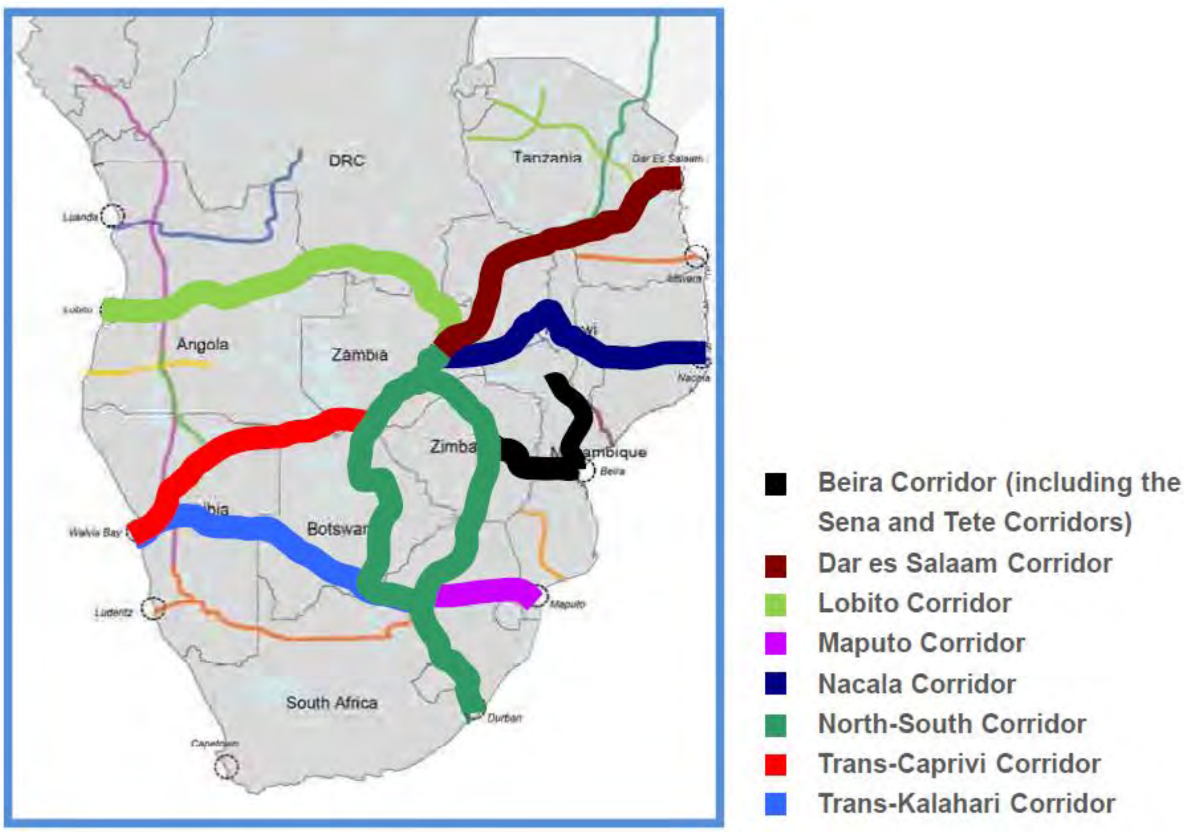
Source: The African Development Corridors Initiatives: Cases in East and Southern Africa (2009)

Table 3.12 Development Potential of the Eight Economic Corridors Surveyed by JICA

Beira Corridor	Nacala Corridor
● Agriculture and agro-industry along the Beira Agricultural Growth Corridor (BAGC) in Mozambique, and in Zimbabwe ● Offshore natural gas in Pande/Temane and downstream industries in Beira, Mozambique ● Coal and coal-fired power generation in Tete Province, Mozambique ● Various kinds of mineral extraction and downstream industries in Zimbabwe	● Agriculture and agro-industry along the corridor in Mozambique, central and southern Malawi, and Zambia ● Natural gas in the Rovuma offshore area and downstream industries ● Coal in Tete Province, Mozambique ● Various kinds of minerals and downstream industries in Malawi ● Copper, iron ore, coal, and downstream industries in Zambia

Dar es Salaam Corridor ● Agriculture and agro-industry along the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) and along the corridor in Zambia ● Offshore natural gas in southern Tanzania and downstream industries in the coastal area ● Coal, iron ore, and downstream industries in Iringa Province, Tanzania	**North-South Corridor** ● Agriculture and agro-industry along the corridor in Zambia, Zimbabwe, northeastern Botswana, and eastern South Africa ● Various kinds of minerals along the corridor that traverse the countries with high potentials for mining such as eastern Botswana, South Africa, Zambia, and Zimbabwe (e.g., copper, iron ore, nickel, coal, platinum, chrome, manganese, ferrochrome), and downstream industries in these countries
Lobito Corridor ● Agriculture along the corridor particularly in Angola ● Copper and iron ore and downstream industries in multi-facility economic zones and industrial parks in Zambia as well as in the Democratic Republic of Congo	**Trans-Caprivi Corridor** ● Agro-processing in the Walvis Bay Export Processing Zone, Namibia ● Uranium in the mid-eastern part of Namibia ● Copper processing and smelting in northern Namibia ● Coal and energy development in southern Zambia
Maputo Corridor ● Production of high-value commercial crops in Limpopo Province, South Africa ● Platinum group metals, coal, iron ore, and diamonds in South Africa ● Chemical industries, and iron and steel production along the corridor ● Offshore natural gas and associated fuel production (e.g., naphtha, kerosene, and light oil) in Maputo, Mozambique	**Trans-Kalahari Corridor** ● Agro-processing in Windhoek and the Walvis Bay Export Processing Zone, Namibia ● Uranium in the mid-western part of Namibia ● Copper fabrication in the vicinity of production areas along the corridor

Source: Southern Africa Growth Belt Initiatives Phase II, Corridor Development for Economic Growth (2013)



Source: Data Collection Survey for Economic and Industrial Development along Economic Corridors in Southern Africa (2013)

Figure 3.10 Eight Economic Corridors Surveyed by JICA

3.5.3 Development of Natural Resources

(1) Cote d'Ivoire

Oil and Natural Gas[31]

Oil proved reserves of Cote d'Ivoire is estimated to be 100 million barrels. Petroleum production was 37,650 barrels per day (BPD) in 2013[32]. A refinery of 60,000 BPD in Abidjan processes the imported crude oil from Nigeria for compensating the domestic consumption. In addition, natural gas proved reserves are estimated to be 28.3 billion m^3.

Mineral Resources[33]

Gold is the main product of the mining development in Cote d'Ivoire. In recent years, the productions of iron, nickel, manganese, and bauxite have also been notable. The mining sector has a high potential with estimated reserves of 3 billion tons of iron, 390 million tons of nickel, 1.2 billion tons of bauxite, 3 million tons of manganese, and 100,000 carats of diamonds. On the other hand, the mining sector is faced with the following issues: 1) geological maps for reference in carrying out the operations in the sector have not been created, 2) investments from overseas for development remain at a low level due to the lack of infrastructure for the access to the mines, and 3) public and private investments within the country are not active since mining is not regarded as traditional industry.

(2) Angola

Oil and Natural Gas[34]

The oil proved reserves of Angola are 9 billion barrels, making it the fourth largest in Africa, following Libya, Nigeria, and Algeria, and ranking 17th in the world. The majority are produced in the Lower Congo and the Kwanza deposition layers located offshore of the northern coast. In 2014, oil production was 1.75 million BPD. Since Angola's oil refining capacity is small, most of the oil produced is exported. Oil export amounted to 1.65 million BPD in 2014. About half of the volume was exported to China.

In Angola, Sonangol is the state-owned company operating Luanda Refinery (39,000 BPD) built in 1955. In December 2012, Sonangol initiated the construction of Sonaref Refinery (120,000 BPD) in Lobito. The new refinery is scheduled to start its operation in 2017 or 2018 and plans to expand its capacity to 200,000 BPD in the future. The new refinery is expected to purify Angola's crude oil and to sell the petroleum products in the domestic and international markets.

The proved reserve of natural gas in Angola is 274.5 billion m^3, which is the sixth largest in Africa following Nigeria, Algeria, Mozambique, Egypt, and Libya. All natural gas production is associated with oil production. In 2013, the total natural gas production in the country was 10.8 billion m^3. Of the total production, 7 billion m^3 was released into the atmosphere or flared and 2.6 billion m^3 was re-injected into the oil field. The remaining 1.2 billion m^3 was sold commercially. Since the

---

[31] Oil and Natural Gas Developments in West African Countries (2015)

[32] Oil proved reserves and petroleum production in Nigeria are far larger than those in the surrounding countries. These are 37.07 billion barrels and 2,371,510 BPD, respectively.

[33] The Report on Data Collection Survey for Resuming ODA (2010)

[34] Oil and Natural Gas Developments in Equatorial South African Countries (2015)

infrastructure required for the commercialization of natural gas is not sufficiently developed, large volume is released into the atmosphere and flared.

Angola LNG built a liquefied natural gas (LNG) plant with a production capacity of 5.2 million tons/year, utilizing natural gas associated from the deep sea oil fields offshore of Soyo in the north of the country. Angola LNG is a consortium of Sonangol, Chevron, Total, BP, and Eni. In 2013, its LNG export volume total was 500 million m^3. Its main export destinations are Brazil, Japan, and China.

Mineral Resources[35]

In Angola, mining of diamond, copper, iron, and manganese is carried out. The exploration of other mineral resources was also active before the civil war. Afterwards, due to the civil war, extensive survey of mineral resources using modern exploration techniques and methods was not implemented. The government has prepared the national geological plan (*Plano Nacional Geológico de Angola*: PLANAGEO) in 2009 and has been implementing the investigation of mineral resources, including creation of geological maps. At present, some projects for mining iron ore are in the development stage. It is also expected to mine gold, platinum, iron ore, manganese, copper, nickel, chromium, tin, tungsten, and other minerals for industrial materials.

Angola has both kimberlite and placer deposits of diamond. Full-scale development has been carried out after the termination of the civil war[36].

The transportation infrastructure is gradually developed with the support of China but has not been expanded over the country. The 505 km railway from the southern inland region of Cassinga to Namibe Port is being developed with the investment of a Chinese firm. In addition, the Benguela Railway was extended from Lobito Port to Luan in DRC in August 2014 through Chinese investment. When the railway is extended to Katanga Province in DRC, the production of copper ore in the copper-belt region will be transported to the Atlantic coast for shipment.

(3) Namibia

Oil and Natural Gas[37]

There are reserves of oil and natural gas around the offshore of the southwest coast in the vicinity of the territorial sea line between South Africa. The national oil company of Namibia and the subsidiary of a Japanese company carried out the exploration project. However, it was reported that the Japanese company withdrew from the project due to the difficulty in ensuring the economic efficiency for commercial production (as of August 2015).

Mineral Resources[38]

Mining is the major industry that produces about half of exports in Namibia. In particular, the government established a company in collaboration with De Beers for high value-added production and processing of diamond. Moreover, there are other major products such as uranium, zinc, copper, fluorite, gold, and silver. Uranium exploration was initiated in the late 1950s and became large scale since the late 1960s. As a result, it was found that there were a number of uranium deposits and

35 The Survey on Investment Environment in the Republic of Angola (2012)
36 Trend of Mining Industry in the World, 2014, Angola
37 JOGMEC News Release
38 Trend of Mining Industry in the World, 2015, Namibia

anomalous ore areas in the country. Namibia is one of the uranium-rich countries in the world. According to the World Nuclear Association, Namibian uranium resources amount to 261 thousand tons accounting for 5% of the known resources all over the world and Namibia is ranked 8th among the uranium-producing countries. In 2012, uranium production was 4,495 tons, which made Namibia the fifth largest producer in the world following Kazakhstan, Canada, Australia, and Niger.

(4) South Africa

Oil and Natural Gas[39]

Proved reserves of oil in South Africa are only 15 million barrels and all exist in the southern offshore of the Bredasdorp basin and in the western offshore around the territorial water line with Namibia. In the Orange basin located near Namibia, it is believed that a significant amount of oil and natural gas would be buried but exploration activities in this area have not been initiated.

Oil consumption (including synthetic liquid fuel) in South Africa is the second largest in Africa next to Egypt and comprises petroleum products by refinery as well as synthetic liquid fuels such as coal-to-liquid (CTL) and gas-to-liquid (GTL). The consumption in 2014 was 655,000 BPD, which is covered by the domestic production and imports mainly from Asian countries.

Natural gas reserves of South Africa are as small as 16 billion m^3. Meanwhile, potential reserves of shale gas are large. Natural gas is produced from the offshore of Mossel Bay and is served to the GTL refinery plant of Petro SA. In addition, the natural gas imported via pipeline from Mozambique is supplied to the Secunda Plant of Sasol and gas turbine power plants. Shale gas exists in the semi-desert area of the Karoo basin spreading over the south of the territory. Exploitable reserves are estimated to be 1,101 billion m^3, which is the eighth largest all over the world.

Mineral Resources[40]

South Africa produces a lot of mineral resources. The country has the largest production of platinum and chromium and the second largest production of manganese and titanium all over the world. In addition, nickel, coal, iron ore, uranium, gold, and antimony are also produced. The mining sector is a major industry which accounts for 60% of total exports.

In South Africa, Transnet is the state-owned enterprise in charge of the railway and port infrastructure. Since an increase in cargo demand is expected in the future, Transnet is investing on infrastructure development envisaged by the Market Demand Strategy (MDS) in 2013. Oil and gas pipelines will be expanded; and port and railway infrastructure will be modernized by 2019 for the transportation of coal, iron ore, and manganese.

(5) Madagascar

Oil and Natural Gas[41]

There is no large-scale production in Madagascar at present. Test production of heavy oil is performed to a limited extent in parallel with some exploration activities. The Ministry of Energy and Mineral Resources establishes the policies on oil and natural gas. The National Mineral and Strategic Industries

[39] Oil and Natural Gas Developments in Equatorial South African Countries (2015)
[40] Trend of Mining Industry in the World, 2015, South Africa
[41] Analysis, East African Oil-producing Countries: Research for State-owned Company (2015)

Agency (*Office des Mines Nationales et des Industries Stratégiques*: OMNIS) is a state-owned institution that carries out exploration activities and supervision of oil development projects. It was expected in September 2015 that the Government of Madagascar would make an announcement for bidding on the public mining area of the Morondava sedimentary basin located west of the island of Madagascar.

Mineral Resources[42]

Even though a high production potential of mining had been expected in Madagascar, mining development is not activated. In 2002, the Government of Madagascar with the support of the World Bank established a large-scale mining investment law for natural resources development to drive economic growth using foreign investments. As a result, the first shipment of the ilmenite concentrate (a raw material of titanium) was made in 2009 and commercial production of the Ambatovy nickel mine was initiated in 2014. The major minerals are nickel, titanium, and chromium. Titanium accounted for 7% of the world production and the country was the fifth largest producer in the world in 2013. In addition, nickel became the country's most important export product after the commencement of commercial production at the Ambatovy nickel mine. There are a variety of mineral resources such as gold, cobalt, copper, lead, zinc, platinum, and bauxite, as well as energy resources such as uranium, coal, and oil but these have not been developed yet due to the lack of infrastructure.

(6) Mozambique

Oil and Natural Gas[43]

Since 2010, there are discoveries of natural gas in the Rovuma basin, which lies off the northeastern coast of Mozambique (Mozambique Channel). Proved reserves of natural gas are 2,830 billion m^3, which makes Mozambique third largest in Africa next to Nigeria and Algeria and 14th in the world.

Natural gas production volume in Mozambique is not much yet. In 2012, the country produced 4.4 billion m^3 mainly from two of the inland gas fields (Pande and Temae) in the southern and western shore region. The country considers South Africa as a promising market of natural gas. The majority of the produced natural gas (3.5 billion m^3) is exported to South Africa through Sasol Petroleum International gas pipeline (total length of about 860 km). The remaining 0.8 billion m^3 is supplied for domestic consumption. The export to South Africa started in 2005. The pipeline is co-owned by Sasol, the South African government, and the Mozambique government.

In addition, both governments of Mozambique and South Africa together with SacOil are considering a possibility to construct a new pipeline from the province of Cabo Delgado to South Africa after the discovery of the large-scale gas fields in the Rovuma basin in northern Mozambique.

Anadarko is working on the development of the world's largest LNG project. In addition, Anadarko is also promoting the development of LNG sales market with its partners. In December 2012, Anadarko agreed with Eni to jointly build a land-based LNG plant (20 million tons/year) at Afungi Park in northern Mozambique. Anadarko plans to start the LNG sales by 2018 and will fully operate the plant around 2030 to 2032. Eni considers installing a floating LNG production facility (2.5 million tons/year) in the same region.

[42] Trend of Mining Industry in the World, 2014, Madagascar
[43] Oil and Natural Gas Developments in Equatorial South African Countries (2015)

Mineral Resources[44]

The main mining products in Mozambique are coal, titanium, zirconium, tantalum, and gold. The country produces 8% of titanium, 5% of zirconium, and 8% of tantalum in the world. In Africa, the country's production of aluminum ingots is the second largest following South Africa and accounts for about 30% of the exports from the country.

In the northwestern part of Tete Province, there is the world's largest coal reserve of 23 billion tons. Transport infrastructure was underdeveloped. Since 2011, Vale and Rio Tinto[45] operate Moatize coal mine and Benga coal mine, respectively. In particular, Vale has made its largest investment in Moatize coal mine as well as in the railway and port construction. The 912 km railway enables coal transportation at 18 million tons/year from the mine to the port at Nacala. The railway and port are already operated as of February 2016. Besides copper, zinc metal, phosphorus ore for fertilizer, uranium, and lantern are also exploited.

(7) Tanzania

Oil and Natural Gas[46]

In the offshore deep sea of Tanzania, Rovuma - Tanzania coastal basin around the south of the border near Mozambique, natural gas field has been discovered and its reserve is estimated to be 20 trillion ft^3 (Tcf) or about 566.3 billion m^3. In the south of Tanzania, Songo Songo gas fields and Mnazi Bay gas field are in production. The production volume in 2011 was 860 million m^3 which was totally used for domestic consumption. Meanwhile, there is a plan to build an LNG plant for exporting purposes.

Mineral Resources[47]

A variety of mineral resources are found in Tanzania such as gold, iron ore, nickel, copper, platinum, tin, cobalt, silver, limestone, salt, phosphorus, coal, and uranium. Tanzania is the fourth largest gold producer in Africa, following South Africa, Ghana, and Mali (18th place in the whole world). According to the US Geological Survey (USGS), the ratio of the mining sector as a percentage of Tanzania's GDP was 2.2% in 2011 and increased up to 7.8% in 2012. Tanzania Minerals and Energy Association forecasted that the ratio would rise continuously with an average growth rate of 7.7% in the 2011-2015 period. Exploration of gold by foreign capitalists is active. In addition, explorations for uranium, nickel, as well as rare earth are also carried out.

(8) Mauritius

In August 2013, it was reported that Mauritius and the Seychelles were planning to carry out joint exploration of oil and natural gas in the Indian Ocean[48]. In the vicinity of the Seychelles, it is believed that a petroleum system exists because of the geological similarity with the petroleum system in East Africa[49].

---

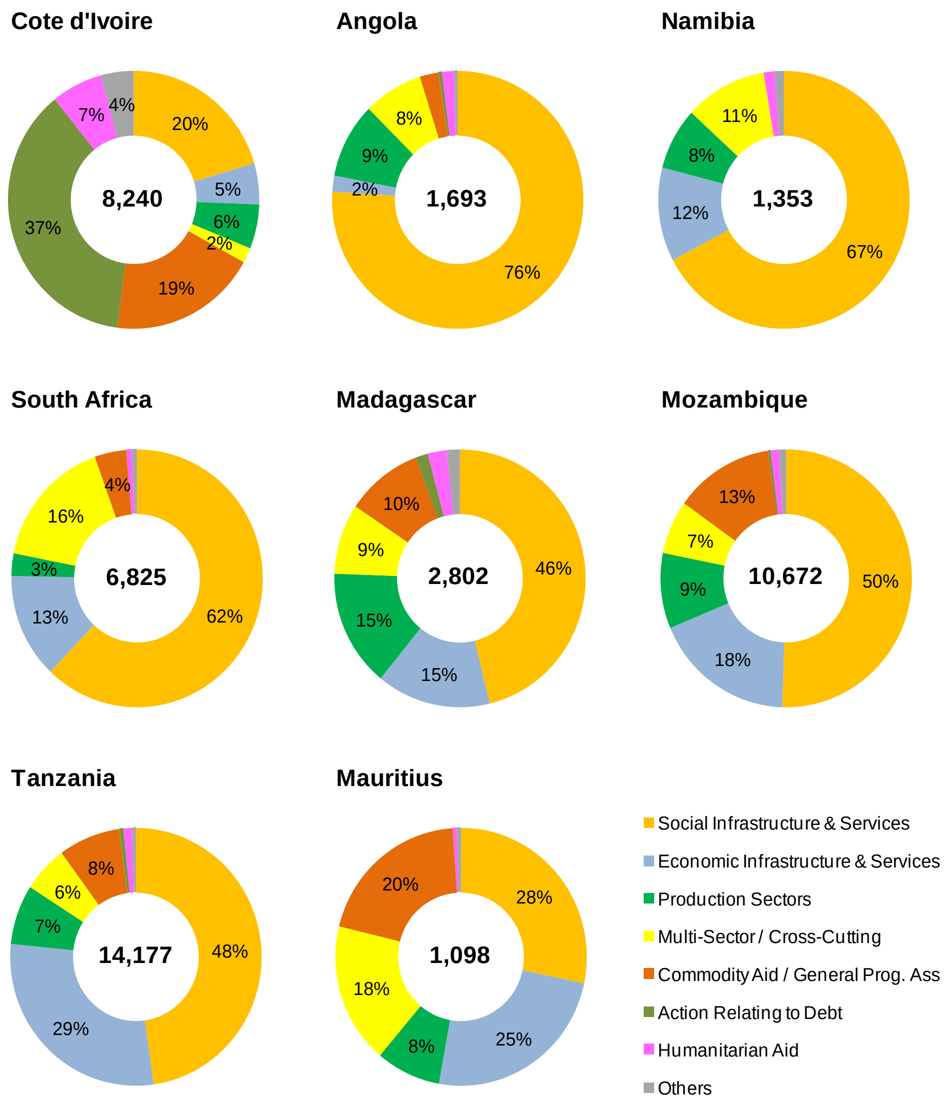
[44] Trend of Mining Industry in the World, 2014, Mozambique
[45] Rio Tinto sold the Benga coal mine and relevant projects in Tete Province to the Indian firm in 2014.
[46] Current Status of Deep Sea Exploration and Development in East Africa (Mozambique, Tanzania and Kenya) (2013)
[47] Trend of Mining Industry in the World, 2015, Tanzania
[48] Reuters, https://www.google.co.jp/?gws_rd=ssl#q=mauritius+statistics+oil
[49] Analysis, Prospects for Potential Countries in Exporting Oil and Natural Gas in East and Southern Africa (2015)

3.6 Assistance by Donor

Based on the data extracted from the Creditor Reporting System (CRS) of the Organisation for Economic Co-operation and Development (OECD)[50], the amount of official development assistance (ODA) for the surveyed countries is summarized below.

1) ODA by Sector (Figure 3.11)

Tanzania received the largest of USD 14,177 million for the period of 2010-2014, followed by Mozambique having its amount of USD 10,672 million. Cote d'Ivoire received the third largest of USD 8,240 million including USD 3,056 million of debt relief assistance; and the majority of debt relief assistance amounting USD 2,054 million took place in 2011. Every country received its largest ODA for social infrastructure sector (e.g., education, health, water and sanitation) and second largest for economic infrastructure (e.g., transportation, telecommunication, energy).



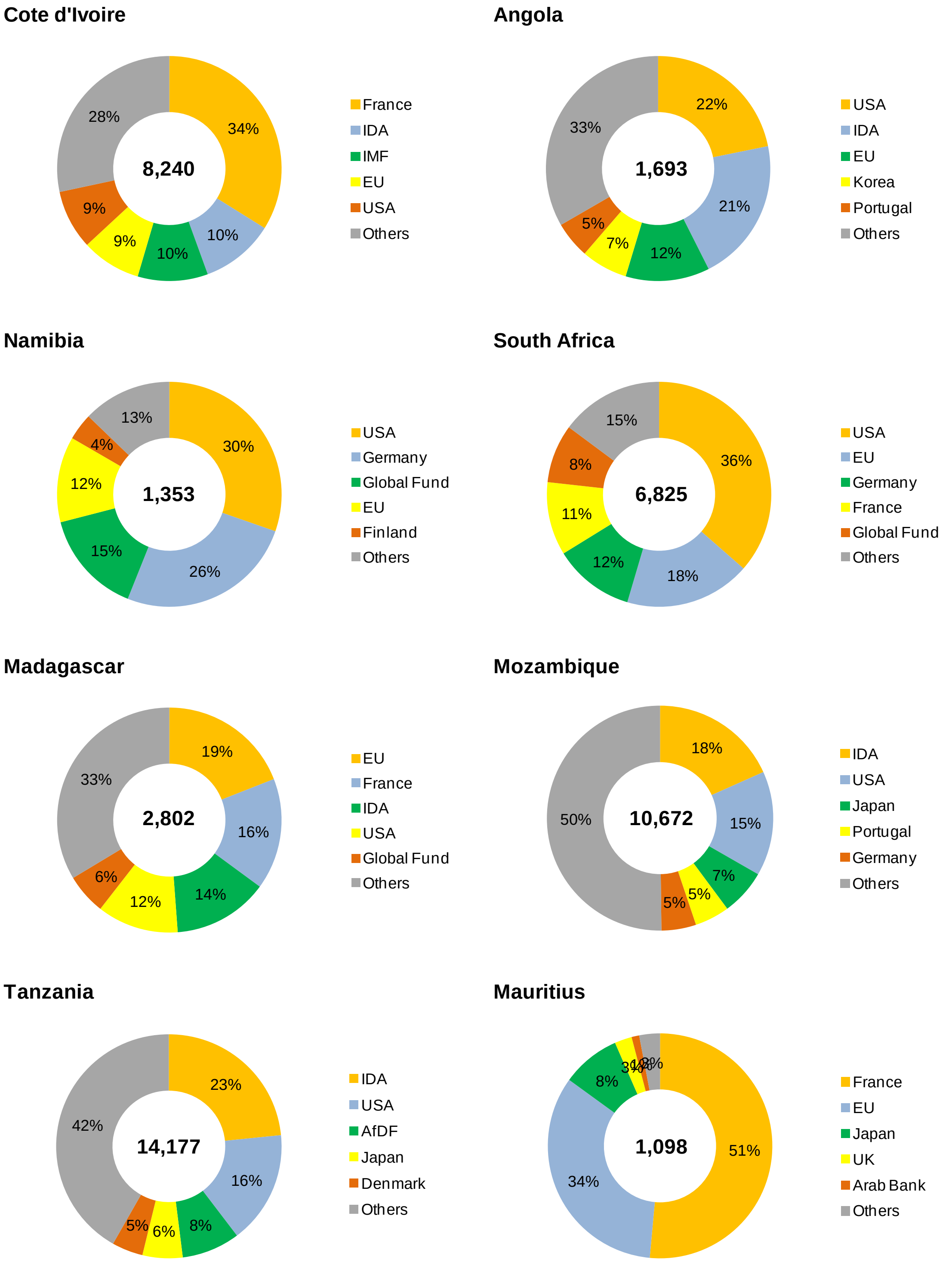
Source: OECD.Stat, Creditor Reporting System (CRS)

Figure 3.11 ODA by Sector for Surveyed Countries (Amount for 2010-2014, million USD)

[50] OECD.Stat, Creditor Reporting System (CRS), https://stats.oecd.org/Index.aspx?DataSetCode=CRS1

2) ODA by Donor (Figure 3.12)

The IDA and USA were top 2 donors for both Tanzania and Mozambique. Japanese ODA shared 6% for Tanzania and 7% for Mozambique. Top 5 donors shared 58% for Tanzania and 50% for Mozambique. Both Tanzania and Mozambique received ODA from a number of donors accordingly. USA shared the largest in South Africa, Namibia and Angola. France shared the largest in Cote d'Ivoire.



Source: OECD.Stat, Creditor Reporting System (CRS)

Figure 3.12 ODA by Donor for Surveyed Countries (Amount for 2010-2014, million USD)

3) ODA by Major Infrastructure Sector (Table 3.13 thru Table 3.17)

Both Tanzania and Mozambique received the largest for transportation followed by energy and water and sanitation. The amounts received for industry, mining and construction by Tanzania and Mozambique are also comparatively large among the surveyed countries.

Table 3.13 ODA by Major Infrastructure Sector for Surveyed Countries
(Amount for 2010-2014, million USD)

Country	Water Supply and Sanitation	Transport & Storage	Energy	Industry, Mining, Construction
Cote d'Ivoire	196.90	251.96	72.05	48.83
Angola	137.51	5.63	8.60	37.53
Namibia	78.43	62.74	53.27	5.66
South Africa	157.87	5.51	683.36	61.42
Madagascar	59.38	348.20	26.78	37.73
Mozambique	711.23	892.21	758.28	276.63
Tanzania	804.47	2,166.14	1,403.27	141.34
Mauritius	208.80	55.35	133.39	70.63

Source: OECD.Stat, Creditor Reporting System (CRS)

France shared the largest for water supply and sanitation in five (Cote d'Ivoire, South Africa, Tanzania, Madagascar, and Mauritius) out of eight countries and third largest in Mozambique. In Tanzania, Germany and African Development Fund (AfDF) shared the second and third largest respectively. The IDA shared the largest for water supply and sanitation in Angola and Mozambique.

Table 3.14 ODA by Donor for Surveyed Countries - Water Supply and Sanitation
(Amount for 2010-2014, million USD)

Water Supply and Sanitation

Cote d'Ivoire	
France	41.46
AfDF	35.71
EU	33.62
IDA	32.37
Kuwait	24.42
Others	29.33
Total	196.90

Angola	
IDA	117.97
USA	8.15
EU	7.97
Germany	0.62
Portugal	0.57
Others	2.23
Total	137.51

Namibia	
EU	48.97
Germany	13.05
Luxembourg	9.83
Spain	4.29
Finland	0.99
Others	1.30
Total	78.43

South Africa	
France	68.28
EU	68.11
Germany	6.80
Ireland	3.41
Netherlands	3.03
Others	8.25
Total	157.87

Madagascar	
France	16.26
EU	12.65
USA	10.86
IDA	6.96
UNICEF	4.42
Others	8.23
Total	59.38

Mozambique	
IDA	329.55
Netherlands	76.70
France	54.13
Korea	49.27
USA	41.78
Others	159.80
Total	711.23

Tanzania	
France	154.51
Germany	126.33
AfDF	112.88
UK	75.56
EU	69.27
Others	265.93
Total	804.47

Mauritius	
France	83.63
Japan	70.85
EU	53.84
AfDB	0.45
UNDP	0.03
Others	0.00
Total	208.80

Source: OECD.Stat, Creditor Reporting System (CRS)

Table 3.15 ODA by Donor for Surveyed Countries - Transport and Storage
(Amount for 2010-2014, million USD)

Transport and Storage

Cote d'Ivoire	
IDA	99.46
EU	95.35
Kuwait	32.55
Arab Bank	12.00
OFID	12.00
Others	0.60
Total	251.96

Angola	
AfDF	4.37
Japan	1.07
Portugal	0.09
USA	0.08
Korea	0.01
Others	0.00
Total	5.63

Namibia	
Germany	56.36
AfDB	2.44
EU	2.15
Japan	1.43
Finland	0.30
Others	0.06
Total	62.74

South Africa	
USA	2.32
Japan	1.47
GEF	1.36
Norway	0.19
Belgium	0.10
Others	0.07
Total	5.51

Madagascar	
EU	126.76
IDA	72.89
AfDF	70.40
UAE	29.82
OFID	18.10
Others	30.23
Total	348.20

Mozambique	
Japan	298.52
EU	141.16
IDA	138.49
AfDF	110.97
Korea	75.47
Others	127.61
Total	892.21

Tanzania	
IDA	959.40
AfDF	578.88
Japan	287.75
EU	117.98
Korea	117.72
Others	104.42
Total	2166.14

Mauritius	
France	43.21
Arab Bank	12.06
Korea	0.07
Total	55.35

Source: OECD.Stat, Creditor Reporting System (CRS)

Table 3.16 ODA by Donor for Surveyed Countries - Energy
(Amount for 2010-2014, million USD)

Energy

Cote d'Ivoire	
IDA	41.90
UK	26.89
GEF	1.90
USA	0.76
Italy	0.30
Others	0.30
Total	72.05

Angola	
Norway	4.23
USA	2.14
Japan	1.70
Germany	0.25
Italy	0.22
Others	0.05
Total	8.60

Namibia	
Germany	48.92
GEF	1.85
USA	0.91
Finland	0.85
Sweden	0.63
Others	0.13
Total	53.27

South Africa	
Germany	294.58
France	132.77
EU	131.49
UK	72.18
Norway	20.83
Others	31.51
Total	683.36

Madagascar	
OFID	14.91
IDA	7.51
GEF	2.94
UNDP	0.61
Italy	0.27
Others	0.54
Total	26.78

Mozambique	
Japan	180.36
France	133.49
IDA	100.50
Sweden	59.24
Denmark	56.39
Others	228.29
Total	758.28

Tanzania	
IDA	547.33
Norway	176.84
Japan	173.53
EU	142.87
AfDF	104.21
Others	258.49
Total	1403.27

Mauritius	
France	130.74
GEF	2.18
USA	0.44
UNDP	0.03
Total	133.39

Source: OECD.Stat, Creditor Reporting System (CRS)

Table 3.17 ODA by Donor for Surveyed Countries - Industry, Mining, Construction
(Amount for 2010-2014, million USD)

Industry, Mining, Construction

Cote d'Ivoire	
EU	27.62
IDA	16.22
Canada	2.19
UK	1.39
France	0.64
Others	0.76
Total	48.83

Angola	
UK	14.79
Spain	10.96
IDA	8.53
Norway	1.63
USA	0.70
Others	0.93
Total	37.53

Namibia	
Finland	2.41
Sweden	1.49
Japan	1.12
Germany	0.33
Spain	0.17
Others	0.14
Total	5.66

South Africa	
UK	20.29
Denmark	8.11
Norway	6.78
GEF	6.28
Belgium	4.49
Others	15.46
Total	61.42

Madagascar	
EU	16.95
IFAD	9.31
IDA	6.96
Japan	2.34
France	1.86
Others	0.31
Total	37.73

Mozambique	
Denmark	108.09
IDA	107.80
Sweden	19.53
Norway	19.48
USA	12.60
Others	9.13
Total	276.63

Tanzania	
IDA	61.25
Norway	23.54
Canada	18.53
EU	16.03
Denmark	8.59
Others	13.41
Total	141.34

Mauritius	
France	57.01
UK	13.61
Japan	0.02
Total	70.63

Source: OECD.Stat, Creditor Reporting System (CRS)

Chapter 4 Water Resources and Water Supply

4.1 Introduction

In the surveyed countries, the feasibility of seawater desalination project is dependent on the water demand and supply gap due to the uneven distribution of water resources over the country. In addition, the public water supply to attain a high standard of service level is a condition required for the introduction of seawater desalination project. Based on these considerations, the available data of the surveyed countries are compiled from the following viewpoints. The findings in this chapter are utilized for selecting the locations to be surveyed as discussed in Chapter 5.

1) Geography and Climate

The uneven distribution of water resources over the country is assessed broadly from the geographical distribution of annual rainfall and climate divisions.

2) Water Resources

The available statistics are utilized for understanding an overview of the water resources and water uses by country. In addition, the available data are compiled regarding the characteristics of surface water and groundwater as well as assessments of water resources and water demand in the coastal regions.

3) Water Supply

The administrative framework for water supply is outlined by country together with the available information about the development of water supply.

4) Introduction of PPP

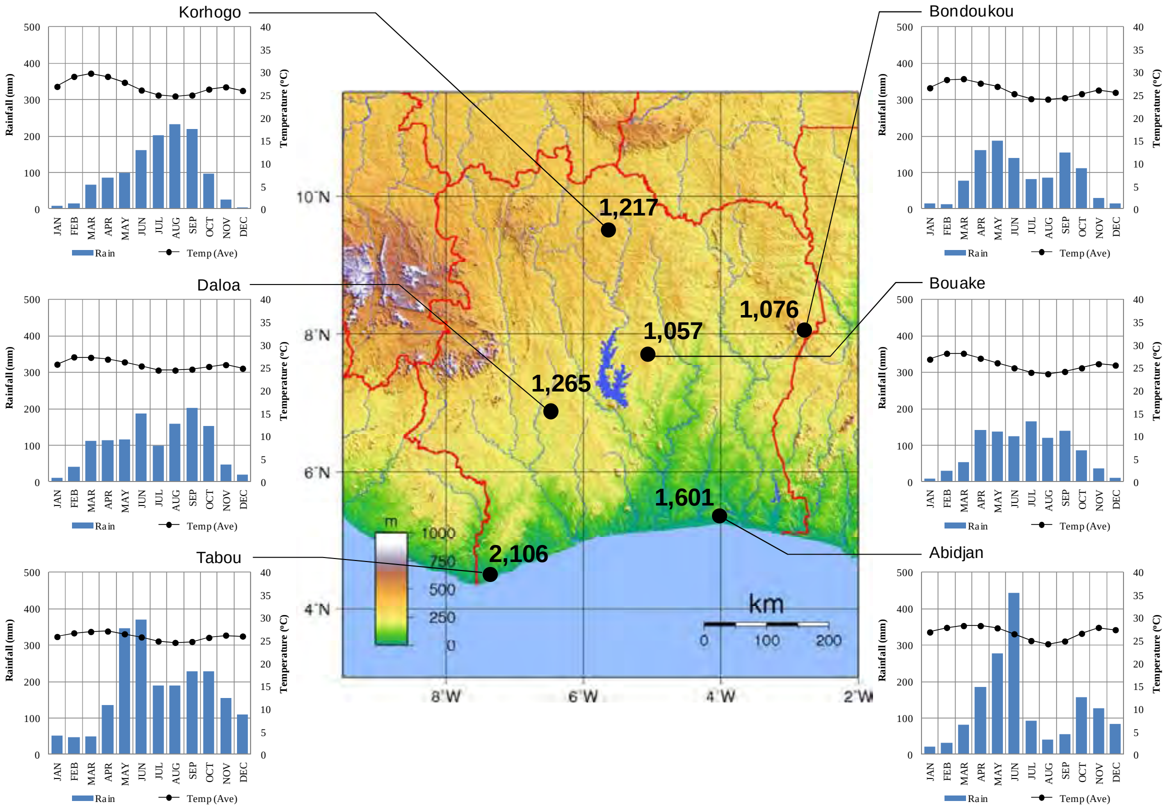
The available information is outlined regarding the institutional system for public-private partnership (PPP) and introduction of PPP to water supply.

4.2 Geography and Climate

4.2.1 Cote d’Ivoire

The Republic of Cote d’Ivoire is located in Western Africa and has an area of 322,000 km^2. The country faces toward the Gulf of Guinea to the south and is bordered by Ghana to the east, Liberia to the west, and Mali and Burkina Faso to the north. The lagoon extends from east to west along the southern coast. Most of the territory is gently sloping from north to south with an elevation of 500 m or lower. A part of the mountainous area is located on the western border with Guinea and its elevation ranges from 600 to 1,700 m[1]. Figure 4.1 provides information on the topography, rainfall, and temperature in Cote d’Ivoire.

[1] The Study on the Agneby River Integrated Development and Management Project, Preparatory Study Report (2002)



Source: Topographic Map - Wikimedia Commons, Rainfall and Temperature - Website of Japan Meteorological Agency[2]

Figure 4.1 Topography, Rainfall, and Temperature in Cote d'Ivoire

Based on the Koppen-Geiger climate classification, the southern coastal region is classified into Tropical Monsoon (Am) and the other inland region falls into Tropical Savannah (Aw)[3]. The seasonal climate in the countries along the Gulf of Guinea, including Cote d'Ivoire, changes due to the Intertropical Convergence Zone (ITCZ) moving north and south between the dry continental air mass in the Sahara Desert and the wet maritime air mass in the Gulf of Guinea. When ITCZ stays in the southern coastal region of Cote d'Ivoire, it brings a long rainy season from May to July. A single rainy season takes place in the central and northern region from August to September with the movement of ITCZ toward the north. ITCZ moves toward the south again from October to November and causes a second (short) rainy season in the southern coastal region[4].

Annual rainfall by region ranges from 1,400 to 2000 mm along the southern coastal region, from 1,200 to 2,000 mm in the west to the northeast region, and from 1,000 to 1,200 mm in the central to the northeast region. Mean monthly temperature varies from 24 to 28 ^{o}C in Abidjan and from 25 to 30 ^{o}C in Korhogo.

4.2.2 Angola

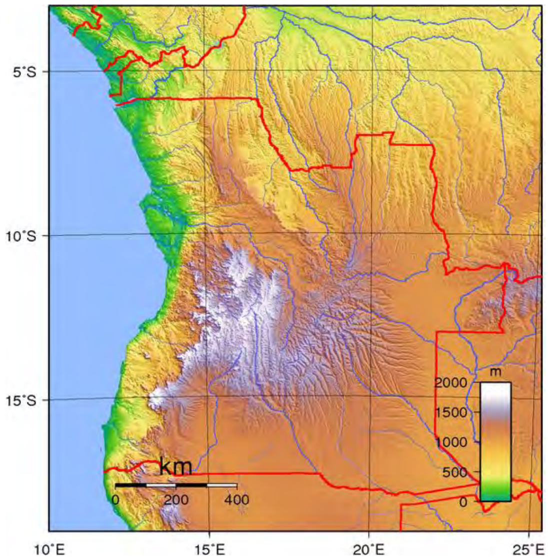
The Republic of Angola is located in Central Africa and has an area of 1,247,000 km^2. The territory is bordered by Namibia to the south, Zambia to the east, and Congo to the north. The west coast faces toward the Atlantic Ocean. The Cabinda Province is an isolated territory. The topography of Angola (Figure 4.2) is broadly classified into coastal lowlands (elevation below 200 m), the mountains

2 Prepared by the Survey Team based on the data extracted from the website of Japan Meteorological Agency

3 Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification

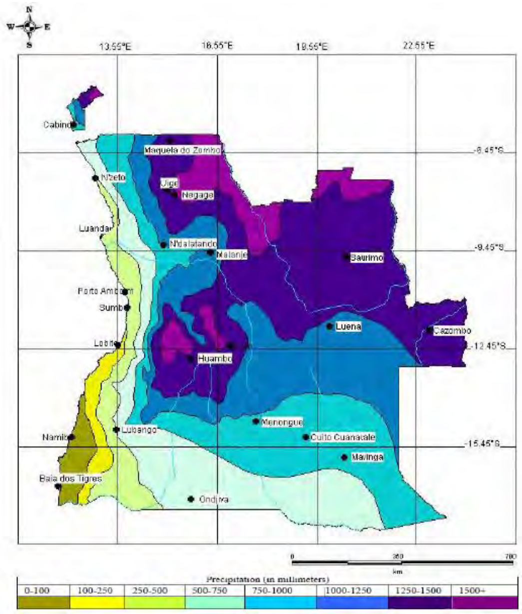
4 Data Collection Survey on the Project for Development of Wharf Site of Sassandra City, Final Report (2014)

(highest elevation of 2,620 m) running north to south along with the coastal lowlands, and the inland plateaus (elevation of 1,500 to 2,000 m) expanding towards the east[5]. The highlands with elevation above 1,000 m cover two-thirds of the territory but the coastal lowlands are flat[6].



Source: Wikimedia Commons

Figure 4.2 Topography of Angola



Source: The Preparatory Survey on Rural Electrification Works, Final Report (2011)

Figure 4.3 Rainfall in Angola

Based on the Koppen-Geiger climate classification, the coastal region is classified into Arid and comprises Arid Steppe Hot (BSh) in the north and Arid Desert Hot (BWh) in the central and south. The inland region is classified into Tropical Savannah (Aw) in the north, Temperate Dry Winter Warm Summer (CWb) or Temperate Dry Winter Hot Summer (CWa) in the mountains and inland plateaus, and Arid Steppe Hot (BSh) in the south around the border of Namibia[7].

Two factors have a strong effect in Angola's climate, namely, the south Atlantic high-pressure cell and the cold northward flowing Benguela current. The high-pressure cell limits the southward migration of the ITCZ while the Benguela current generates a strong temperature inversion along the coast that has a pronounced stabilizing effect on the lower atmosphere. This preempts the upward movement of cloud-forming moist air along the Namibian and southern portions of the Angolan coastline. The result is a gradient of increasing precipitation from south to north and from west to east. Generally, climate in Angola is characterized by cool and dry season from May to October and hot and wet season from November to April[8].

Annual rainfall by region varies from 400 mm at Luanda in the northern coast and 50 mm at Namibe in the southern coast. Annual rainfall exceeds 1,500 mm in the central mountains and northern border with Congo. Mean monthly temperature at Luanda ranges from 23 to 29 ^{o}C. Figure 4.3 shows the rainfall data in Angola.

---

5 The Basic Design Study Report on the Project for Emergency Rural Water Supply in Neighboring Provinces of Luanda (2006)

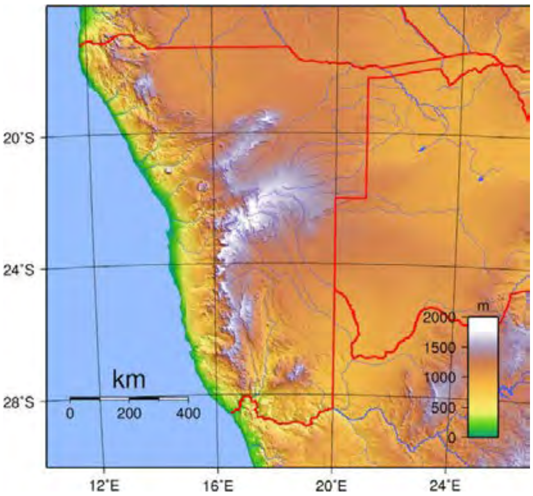
6 The Preparatory Survey on Rural Electrification Development Works, Final Report (2011)

7 Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification

8 The Preparatory Survey on Rural Electrification Works, Final Report (2011)

4.2.3 Namibia

The Republic of Namibia is located in Southern Africa and has an area of 824,000 km^2. The territory is bordered by Angola and Zambia to the north, Botswana to the east, and South Africa to the south. The west coast faces toward the Atlantic Ocean. The territory is mostly covered with desert and plateau. The Namib Desert, the oldest desert in the world, is located along the coast. The highest peak of 2,606 m is located on the Brandberg Mountain to the north of the Namib Desert[9]. Figure 4.4 shows the topography of Namibia.



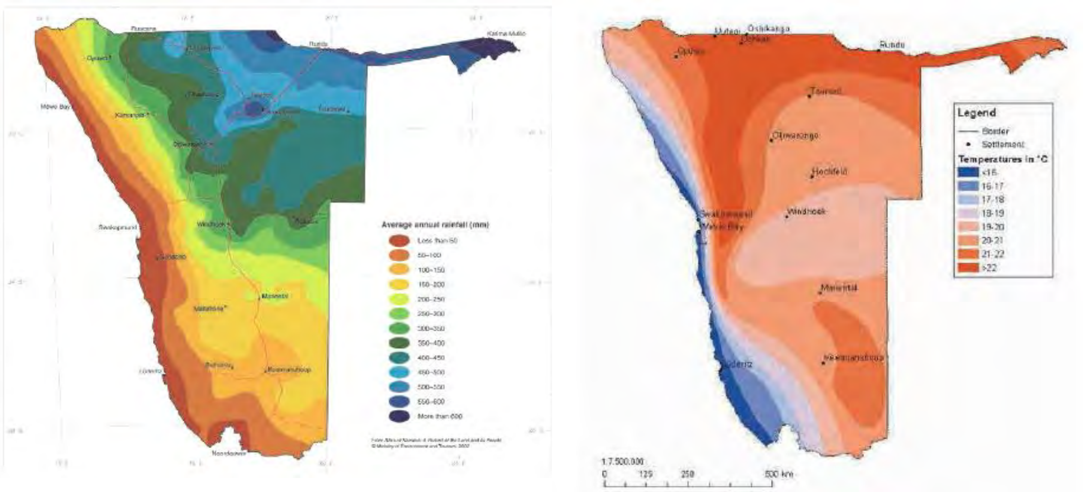
Source: Wikimedia Commons

Figure 4.4 Topography of Namibia

Based on the Koppen-Geiger climate classification, the coastal region and the central and south inland region are classified into Arid Desert Hot (BWh) and Arid Desert Cold (BWk)[10], respectively. The northern region falls into Arid Steppe Hot (BSh). The Benguela Ocean Current, a cold current from the Antarctic, runs along the southwestern coast of the African Continent. Because of this cold current, the coastal region in Namibia becomes cooler than the regions located in the same latitude and is highly arid[11]. Annual rainfall is less than 50 mm in the coastal region. Annual rainfall of more than 500 mm occurs to a limited extent in the northeastern region. Annual mean temperature is less than 16 °C in the southern coastal region, 20 °C in the central region, and more than 22 °C in the northern region. Figure 4.5 presents the rainfall and temperature in Namibia.

Annual Rainfall

Annual Mean Temperature



Source: The Detail Planning Survey Report on Master Plan for Development of an International Logistics Hub for SADC Countries (2013)

Figure 4.5 Rainfall and Temperature in Namibia

---

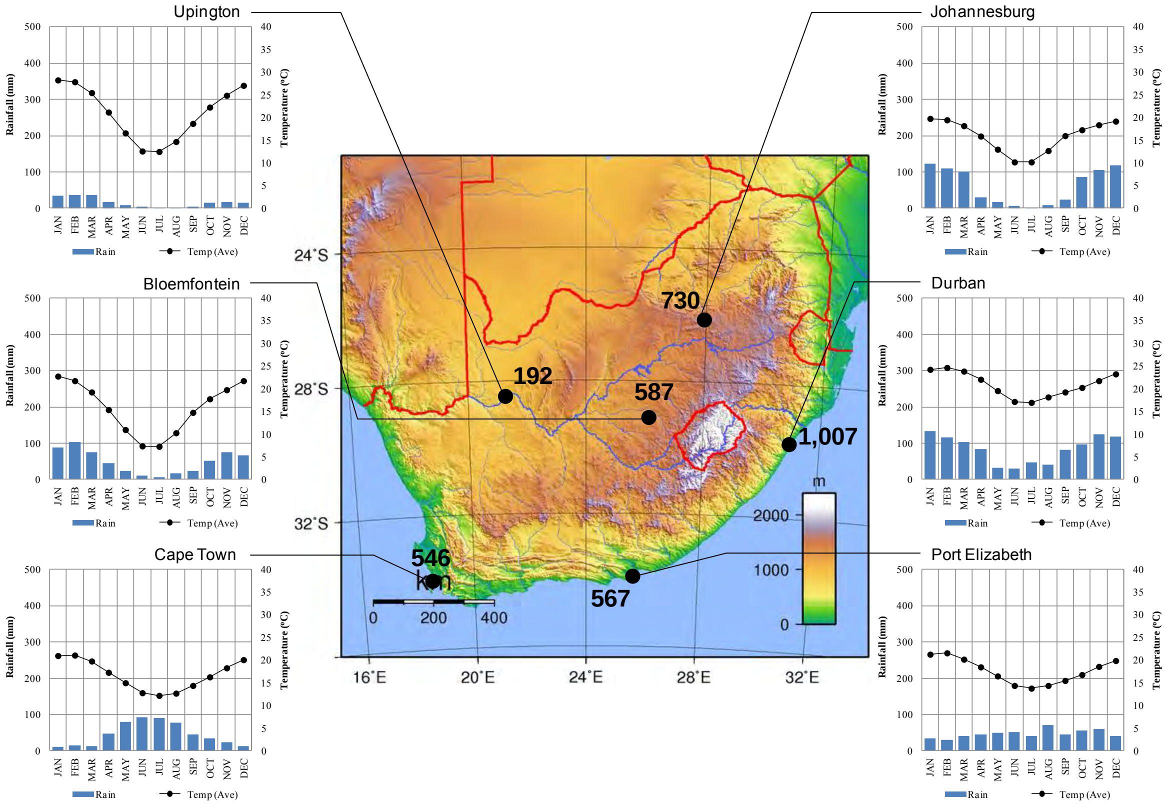
9 The Detailed Planning Survey Report on Master Plan for Development of an International Logistics Hub for SADC Countries (2013)

10 Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification

11 The Detailed Planning Survey Report on Master Plan for Development of an International Logistics Hub for SADC Countries (2013)

4.2.4 South Africa

The Republic of South Africa is located in the southern part of Africa and has an area of 122,000 km^2. It has a long coastline with its southwestern part facing the South Atlantic Ocean and its southern and eastern parts facing the Indian Ocean. The highest point in South Africa is Mt. Mafadi (altitude of 3,450 m) at the border with Lesotho. South Africa is made up of three types of topography, namely: 1) inland plateau, 2) coastal zone, which descends from the inland plateau toward the coastline, and 3) escarpment, which separates the inland plateau and the coastal zone. South Africa, as a whole, is on high ground. The inland plateau, which exceeds an altitude of 1,000 m, accounts for most of the national land[12]. Figure 4.6 illustrates the topography, rainfall, and temperature in South Africa.



Source: Topographic Map - Wikimedia Commons, Rainfall and Temperature - Website of Japan Meteorological Agency [13]

Figure 4.6 Topography, Rainfall, and Temperature in South Africa

Based on the Koppen-Geiger climate classification, the inland highlands, which spread over the east to the northeast of the country, are classified into Temperate Dry Winter (Cwa, Cwb). The east to south coast along the Indian Ocean coast falls into Temperate Without Dry Season (Cfa, Cfb) known as West Coast Marine Climate. On the other hand, the central-west highlands spreading toward the border with Namibia and Zimbabwe is a dry zone characterized by Arid Desert (BWh, BWk). The central highland falls into Arid Steppe (BSh, BSk). The Atlantic coast also belongs to Arid Desert (BWk). Meanwhile, Cape Town and its surroundings fall into Temperate Dry Summer (Csa, Csb) known as Mediterranean Climate[14].

---

[12] Data Collection Survey on Railway Sector, Final Report (2013)

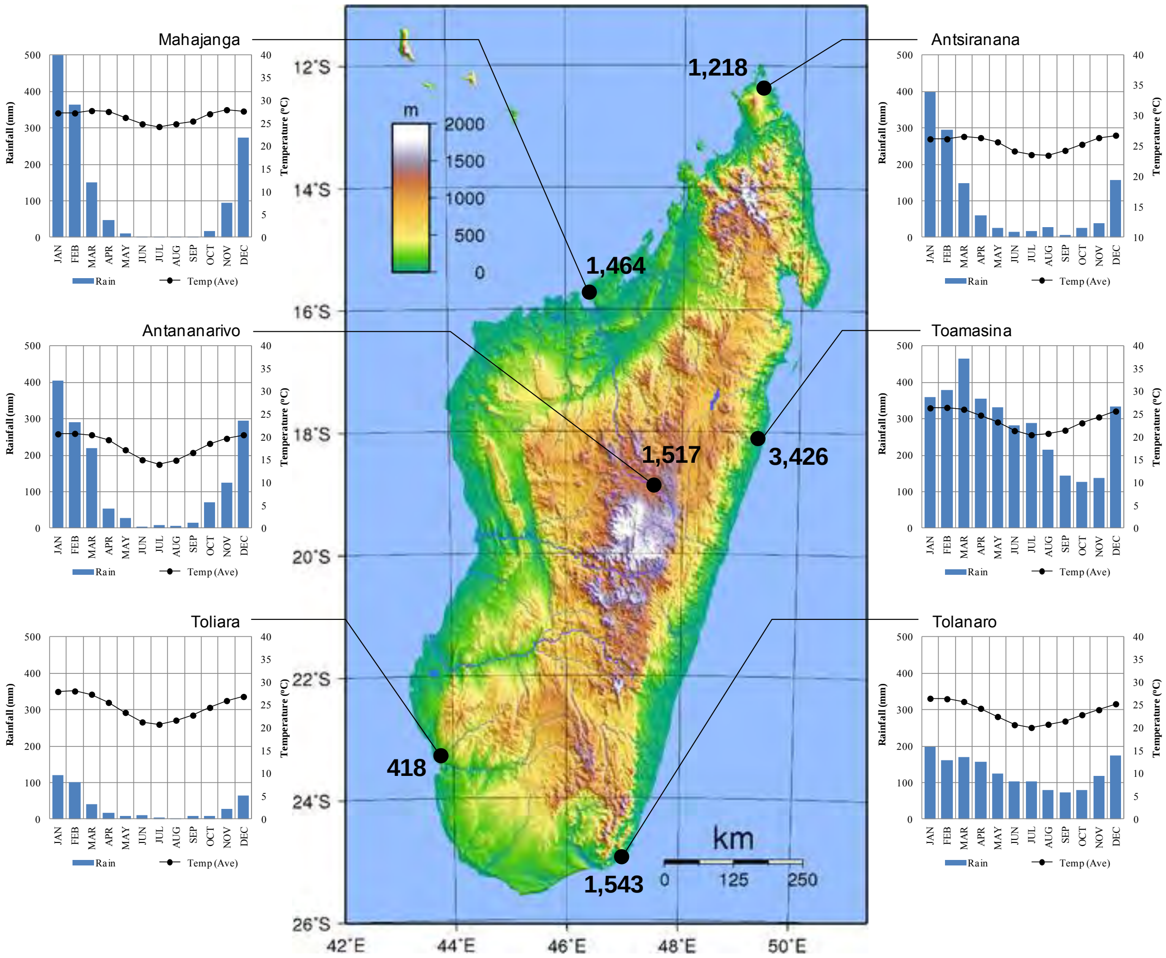
[13] Prepared by the Survey Team based on the data extracted from the website of Japan Meteorological Agency

[14] Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification

Annual average rainfall is 1,007 mm at Durban in the coastal area of the Indian Ocean and 730 mm at Johannesburg in the northeast highlands. Annual average rainfall is less in the coastal areas from south to west such as 546 mm at Cape Town. The northwest inland is a dry zone with an annual average annual rainfall of 192 mm at Upington. Mean monthly temperature varies from 15 to 25 °C at Durban, 12 to 23 °C at Johannesburg, and 13 to 24 °C at Cape Town.

4.2.5 Madagascar

The Republic of Madagascar is located in Eastern Africa and its land area is 587,000 km^2, which makes it the fourth largest island in the world. The territory is classified into five regions, namely: the Tsaratanana Mountains, the Central Highlands, the West Coast, the Southwest, and the Southeast. The Central Highlands expand over almost the entire distance from north to south of the island with altitudes varying from 800 to 1,800 m in the form of hills and mountains[15]. Figure 4.7 provides information on the topography, rainfall, and temperature of Madagascar.



Source: Topographic Map - Wikimedia Commons, Rainfall and Temperature - Website of Japan Meteorological Agency[16]

Figure 4.7 Topography, Rainfall and Temperature in Madagascar

Based on the Koppen-Geiger climate classification, the Central Highlands around the capital of Antananarivo fall into Temperate Dry Winter (Cwa, Cwb). The north to east coast of the Indian Ocean is characterized by Tropical Rainforest (Af). The northern inland to the west coast and the southeast

[15] The Report on Data Collection Survey for Agriculture Sector (2014)

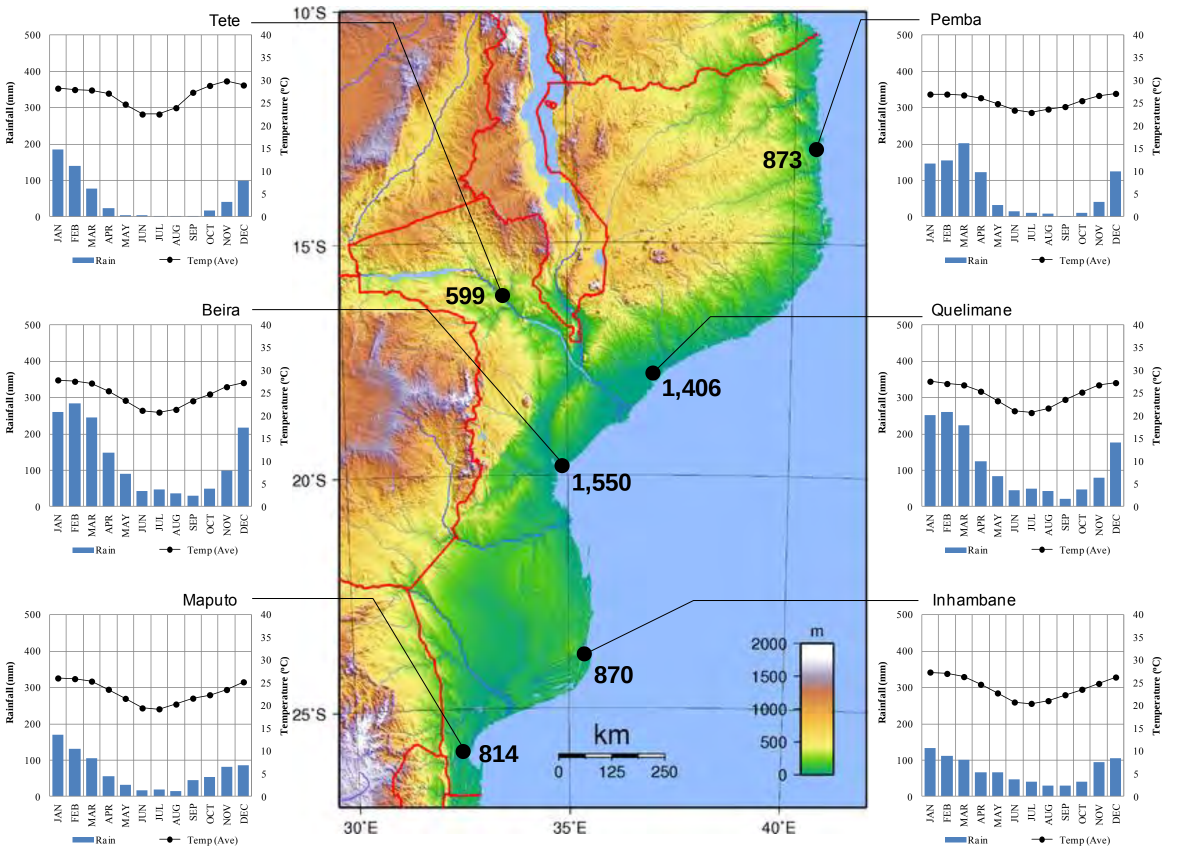
[16] Prepared by the Survey Team based on the data extracted from Website of Japan Meteorological Agency

coast fall into Tropical Monsoon or Tropical Savannah (Am, Aw). On the other hand, the southwest is a drying zone. Toliara falls into Arid Desert (BWh) and its surrounding region belongs to Arid Steppe (BSh)[17].

Annual average rainfall is 1,218 mm at Antsiranana in the northern end and 1,517 mm at Antananarivo in the Central Highlands. Annual average rainfall is 3,426 mm at Toamasina in the eastern coast of the Indian Ocean. On the other hand, the average annual rainfall at Toliara in the southwest coast is extremely small at 418 mm. Mean monthly temperature ranges from 23 to 27 ^{o}C in Antsiranana, 14 to 21 ^{o}C at Toamasina and 20 to 27 ^{o}C at Antananarivo.

4.2.6 Mozambique

The Republic of Mozambique is located in Eastern Africa and its land area is 799,000 km^2. It is bordered by South Africa and Swaziland to the south, Zimbabwe to the west, Zambia and Malawi to the northwest, and Tanzania to the north. Figure 4.8 provides information on the topography, rainfall, and temperature of Mozambique.



Source: Topographic Map - Wikimedia Commons, Rainfall and Temperature - website of Japan Meteorological Agency[18], The Detailed Planning Survey on the Project for the Capacity Enhancement of Meteorological Observation, Weather Forecasting and Warning (2014)[19]

Figure 4.8 Topography, Rainfall, and Temperature in Mozambique

[17] Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification

[18] Prepared by the Survey Team based on the data extracted from the website of Japan Meteorological Agency (Inhambane, Beira, Tete, Quelimane)

[19] Prepared by the Survey Team based on the data extracted from the report (Maputo, Pemba)

The territory is broadly divided into two by the Zambezi River, i.e., the hilly grasslands with an altitude of 200 m or less in the south and the plateaus with an altitude of 200 to 1,000 m to the north. In the northwest, the mountains run around the border of Malawi with an altitude of 1,500 m or higher. The coastal plains are relatively narrow in the north and become wider toward the south[20].

Based on the Koppen-Geiger climate classification, the north/central region and southern coastal region are classified into Tropical Savannah (Aw) and the south inland around the upstream catchment of the Limpopo near the border with Zimbabwe falls into Arid Desert (BWh). The middle Limpopo catchment and the central inland near Tete fall into Arid Steppe (BSh). The northern inland near the border of Malawi and the central inland to the south of the Zambezi River near the border of Zimbabwe belong to Temperate Dry Winter (Cwa, Cwb) [21].

Annual average rainfall is 873 mm at Pemba in the northern coast, 1,550 mm at Beira in the central coast, and 814 mm at Maputo in the southern coast. Annual average rainfall is about 2,600 mm in Zambezia Province to the north of the Zambezi River around the border with Malawi. On the other hand, the average annual rainfall is about 300 mm in the upstream catchment of the Limpopo River around the border of Zimbabwe and South Africa. Mean monthly temperature varies from 23 to 27 ^{o}C at Pemba, 21 to 28 ^{o}C at Beira, and 19 to 26 ^{o}C at Maputo.

4.2.7 Tanzania

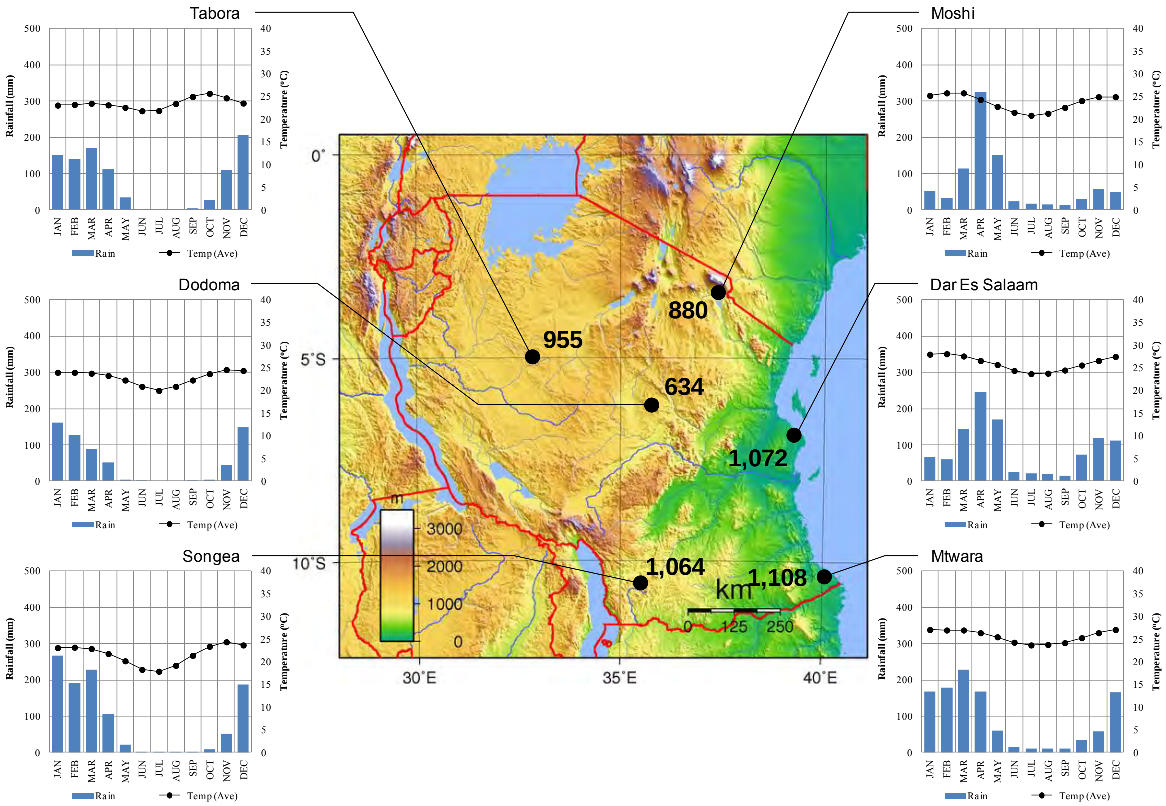
The United Republic of Tanzania is located in the eastern part of Africa and has a land area of 945,000 km^2. It is bordered by Kenya and Uganda to the north, Mozambique to the south, Rwanda, Burundi and Congo to the west, and Zambia and Malawi to the southwest.

Figure 4.9 provides information on the topography, rainfall, and temperature of Tanzania. The eastern coast faces the Indian Ocean and is characterized by the fertile alluvial fan. The mountain ranges in the north are represented by Mount Kilimanjaro with the highest peak elevation of 5,895 m and Mount Meru at 4,566 m. The central and southern highlands are savannah, which is so called Masai Steppe[22].

Based on the Koppen-Geiger climate classification, the east coast of the Indian Ocean and the southern inland are characterized as Tropical Savannah (Aw). The central plateaus from Kilimanjaro to the border with Zambia fall into Arid Desert (BWh) or Arid Steppe (BSh). The northern and western highlands are classified into Tropical Savannah (Aw)[23].

Annual average rainfall is 1,064 mm at Dar es Salaam in the east coast, 1,072 mm at Moshi in the northern inland near Kilimanjaro, and 880 mm at Songea in the southern inland. Dodoma is located in the dry zone of the central inland with an average annual rainfall of 634 mm. Mean monthly temperature ranges from 24 to 28 ^{o}C at Dar es Salaam, 21 to 26 ^{o}C at Moshi, and 18 to 24 ^{o}C in Songea.

[20] The Preparatory Survey Report on the Project for Reinforcement of Transmission Network in Nacala Corridor (2015)
[21] Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification
[22] The Detailed Planning Survey Report on the Study on Water Resources Development and Management in Wami/Ruvu Basin (2010)
[23] Prepared by the Survey Team based on the World Map of the Koppen-Geiger climate classification



Source: Topographic Map - Wikimedia Commons, Rainfall and Temperature - Website of Japan Meteorological Agency[24], The Study on the Groundwater Resources Development and Management in the Internal Drainage Basin, Final Report (2008)[25]

Figure 4.9 Topography, Rainfall, and Temperature in Tanzania

4.2.8 Mauritius

The Republic of Mauritius is an island country located southwest of the Indian Ocean and its land area is 2.045 km^2 (Figure 4.10). Mauritius Island is located 2,000 km from the east coast of the African continent or 855 km east of Madagascar. The territory also includes Rodrigues Island located around 560 km to the east of Mauritius Island, Agalega Islands located around 1,000 km to the north, and Brandon Island located around 430 km to the northeast[26].

Based on the Koppen-Geiger climate classification, the west of Mauritius Island is classified into Tropical Savannah (Aw). The east falls into Tropical Monsoon (Am). Annual average rainfall is 2,010 mm and the average temperature is 24.7 °C in the summer (November to April) and 20.4 °C in the winter (June to September)[27] (Figure 4.11). Average annual rainfall is 1,000 mm or less in the west coast, 1,000 to 2,000 mm in the northern/eastern region and southern coast, and 2,000 to 3,000 mm or more in the central and southern mountains[28] (Figure 4.12).

---

24 Prepared by the Survey Team based on the data extracted from the website of Japan Meteorological Agency (Dar es Salaam, Dodoma, Mtwara, Songea)

25 Prepared by the Survey Team based on the data extracted from the report (Moshi, Tabora)

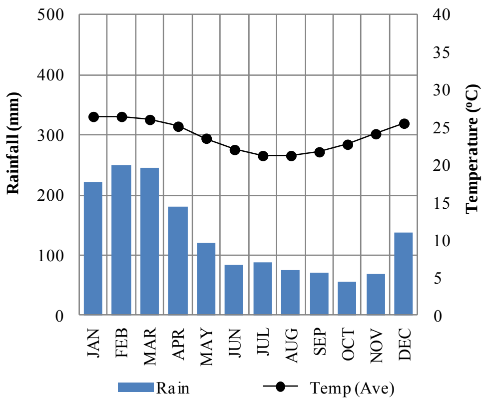
26 Republic of Mauritius, Location

27 Mauritius Meteorological Services

28 Water Sector of Mauritius - Opportunities, Challenges, and Constraints

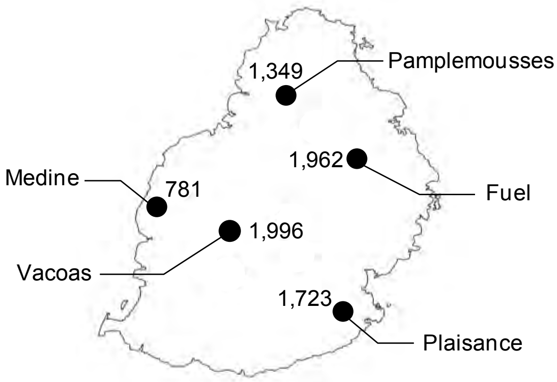
Source: Preparatory Survey Report on the Mauritius Meteorological Services Project (2012)

Figure 4.10 Location of Mauritius



Source: Website of Japan Meteorological Agency [29]

Figure 4.11 Rainfall and Temperature in Mauritius at Plaisance



Source: Mauritius Meteorological Services[30]

Figure 4.12 Average Annual Rainfall in Mauritius

4.3 Water Resources

4.3.1 Cote d'Ivoire

(1) Overview of Water Resources and Water Use

Table 4.1 below shows the indicators of water resources and water use in Cote d'Ivoire based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 1.84% (2005) [31].

[29] Prepared by the Survey Team based on the data extracted from the website of Japan Meteorological Agency

[30] Prepared by the Survey Team based on the data extracted from the Climate of Mauritius

[31] Freshwater withdrawal as % of total renewable water resources; e.g., Japan: 18.9% (2009), France: 15.5% (2010), UK: 7.2% (2011)

Table 4.1 Water Resources and Water Use in Cote d'Ivoire

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	1,348	
Total Renewable Surface Water (10^9 m^3/year)	81.3	
Total Renewable Groundwater (10^9 m^3/year)	37.84	
Overlap between Surface Water and Groundwater (10^9 m^3/year)[32]	35	
Total Renewable Water Resources (10^9 m^3/year)	84.14	
Dependency Ratio (%)	8.676	
Total Renewable Water Resources per Capita (m^3/year)	4,044	As of year 2014

Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	1.549	As of year 2005
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	38.43	As of year 2005
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	20.53	As of year 2005
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	41.05	As of year 2005
Total Water Withdrawal per Capita (m^3/year)	86.3	As of year 2005
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	1.841	As of year 2005

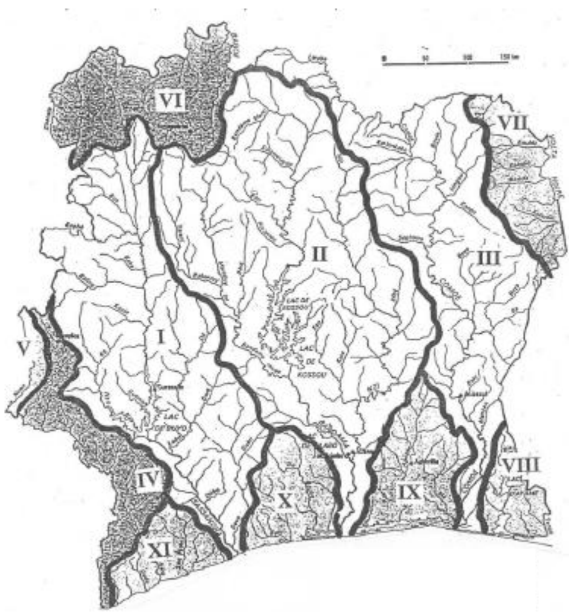
Source: AQUASTAT, FAO

(2) Surface Water[33]

The territory of Cote d'Ivoire is divided into 11 river basins (Figure 4.13). Out of the 11 river basins, four river basins, namely: Bandama (II), Agneby (IX), Boubo (X), and San Pedro (XI), are located entirely within the territory. The Sassandra (I) spreads over the northwest and partly belongs to Guinea. The Comoe (III) originates from Burkina Faso to the north and Ghana to the east. The Cavally (IV) covers a part of Guinea to the north and the right bank of its main stream belongs to Liberia. The majority of the Bia (VIII) upstream is located in Ghana. The Nuwon (V), Niger (VI), and Black Volta (VIII) cover only a part of the territory of Cote d'Ivoire.

The topography of the coastal region of Cote d'Ivoire is characterized by lagoons. The total surface area of the lagoons is about 1,400 km^2. The total length of the perimeter is about 1,500 km. Between Sassandra and Fresco located in the central to west, small lagoons are scattered. The large lagoons spread over the east for a distance of about 300 km. These lagoons are linked by channel and form a continuous waterway with a length of about 300 km.

[32] Part of the renewable freshwater resources that is common to both surface water and groundwater. It is equal to groundwater drainage into the rivers (typically, base flow of the rivers) minus seepage from rivers into aquifers.
[33] Master Plan Study on Integrated Water Resources Management, Final Report (2001)



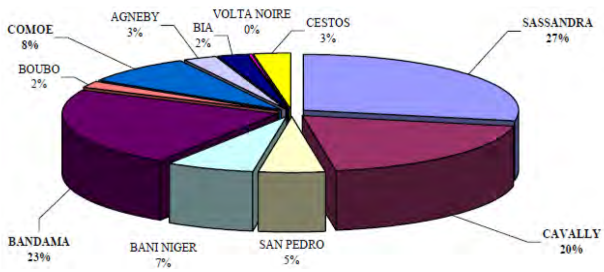
No.	Name of River Basin	Basin Area within Territory (km^2)	Whole Basin Area (km^2)
I	Sassandra	67,000	75,000
II	Bandama	99,700	99,700
III	Comoe	57,300	78,000
IV	Cavally	16,600	30,000
V	Nuon	2,300	12,700
VI	Niger	22,600	2,09,200
VII	Black Volta	12,500	149,000
VIII	Bia	6,800	26,200
IX	Agneby	16,000	16,000
X	Boubo	12,400	12,400
XI	San Pedro	12,400	12,400

Note: Shaded cells refer to international rivers.

Source: Master Plan Study on Integrated Water Resources Management, Final Report (2001)

Figure 4.13 River Basin Divisions in Cote d'Ivoire

More than 50% of the surface water resources exist in the western territory including the Sassandra (I), Cavally (IV), and San Pedro (XI). The surface water resources tend to decrease toward the east. In the central territory, 25% of the resources exist in the Bandama (II) and Boubo (X). The Comoe, Agneby (IX) and Bia (VIII) contribute to 13%. Figure 4.14 shows the percentage of surface water resources by river basin.



Source: Master Plan Study on Integrated Water Resources Management, Final Report (2001)

Figure 4.14 Surface Water Resources by River Basin in Cote d'Ivoire

(3) Groundwater[34]

There are two types of aquifer in the country. One is discontinuous aquifer formed in weathered and discontinuous fissure zone such as the fault in the Precambrian. It covers 97.6% of the country. Another is the general aquifer which is formed in the porous and pervious layer mainly of the continental terminal distributed in the coastal area.

(4) Water Resources and Water Demand in the Coastal Region

According to the Master Plan Study on Integrated Water Resources Management, Final Report (2001), the Agneby River basin (IX), where Abidjan[35] is located, and the adjacent Comoe River basin (III) are characterized by a large difference of flow by season. In the case of a drought probably occurring once in ten years (1/10 drought), it was predicted that water shortage would take place for a duration of ten months a year in the Agneby River basin (IX) and four months a year in the Comoe River basin (III).

34 Master Plan Study on Integrated Water Resources Management, Final Report (2001)
35 Autonomous District

In addition, it was also predicted that Abidjan would face water shortage due to future water demand exceeding largely the exploitable groundwater yield even though the groundwater potential is rich in Abidjan and its surroundings.

The population of Abidjan is 4.707 million in 2014. At the time of the Master Plan Study, the amount of water used in Abidjan was 220,000 m^3/day, which was served by groundwater only. The Master Plan Study predicted that the water demand of Abidjan in 2015 would be 570,000 m^3/day, which would exceed the exploitable groundwater yield of 380,000 m^3/day. Therefore, the Master Plan Study proposed the water resources development measures listed below for the water supply in Abidjan. However, the status of the proposed water resources development is still unknown due to the impact of the civil war since 2002.

- Integrated water resources development in the Agneby River (short term) 120,000 m^3/day
- Aghien Lagoon water resources development (short term) 120,000 m^3/day
- Groundwater development (short term) 380,000 m^3/day
- Integrated water resources development in the Comoe River (long term) 950,000 m^3/day

4.3.2 Angola

(1) Overview of Water Resources and Water Use

Table 4.3 below shows the indicators of water resources and water use in Angola based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 0.48% (2005).

Table 4.2 Water Resources and Water Use in Angola

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	1,010	
Total Renewable Surface Water (10^9 m^3/year)	145.4	
Total Renewable Groundwater (10^9 m^3/year)	58	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	55	
Total Renewable Water Resources (10^9 m^3/year)	148.4	
Dependency Ratio (%)	0.2695	
Total Renewable Water Resources per Capita (m^3/year)	6,704	As of year 2014

Water Use

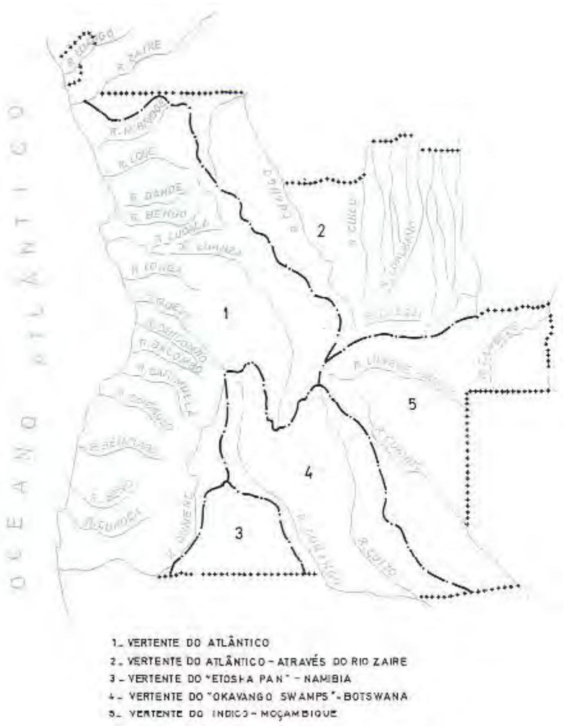
Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	0.7058	As of year 2005
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	20.78	As of year 2005
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	33.95	As of year 2005
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	45.27	As of year 2005
Total Water Withdrawal per Capita (m^3/year)	39.85	As of year 2005
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	0.4755	As of year 2005

Source: AQUASTAT, FAO

(2) Surface Water

The river systems in Angola are broadly divided into: 1) Western Angola, 2) Zaire (Congo), 3) Cuvelai, 4) Okavango, and 5) Zambezi (Figure 4.15). Within western Angola, there are 73 rivers including four flowing down through Cavinda Province. The major rivers are the Cuanza (catchment area: 150,446 km^2) pouring into the Atlantic Ocean near the capital of Luanda and the Cunene (113,835 km^2)

running along the border with Namibia and pouring into the Atlantic Ocean. Four rivers other than those within western Angola are international rivers originating from the central mountains and flowing down the internal highlands and then passing through the borders on the north, east, and south[36].



Source: The Preparatory Survey on Rural Electrification Development Works in the Republic of Angola, Final Report (2011)

No.	Name of River Basin	Basin Area within Territory (km²)	Whole Basin Area (km²)
1	Western Angola	500,395	
	Chiloango	4,638	12,571
	M'Bridge	18,937	18,937
	Loge	13,482	13,482
	Dande	10,802	10,802
	Bengo	12,371	12,371
	Cuanza	147,157	147,157
	Longa	22,489	22,489
	Queve	23,169	23,169
	Catumbela	16,640	16,640
	Coporolo	15,495	15,495
	Bero	10,601	10,601
	Curoca	19,436	19,436
	Cunene	94,003	106,500
	(Others)	91,175	
2	Zaire	289,206	3,800,000
3	Cuvelai	55,977	100,000
4	Okavango	156,122	570,000
5	Zambezi	246,737	1,800,000

Note: Shaded cells refer to international rivers.

Source: National strategy plan for rehabilitation of the hydrometric network in Angola (2004)

Figure 4.15 River Basin Divisions in Angola

The surface water resources in western Angola account for 39% of the total in the country (Figure 4.16). The remaining 61% exist in the central highlands and inland plateaus.

The Cuanza River originates from the central highlands and pours into the Atlantic Ocean near the capital of Luanda. The Cuanza contributes about 40% of the surface water resources within western Angola.

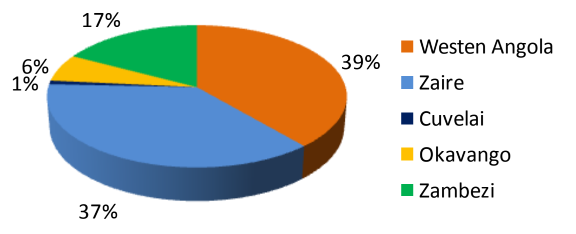


Figure 4.16 Surface Water Resources by River Basin in Angola

(3) Groundwater[38]

The geology in the mountains and inland plateaus is mostly characterized by metamorphic rocks such as gneisses and sedimentary rocks belonging to the Precambrian Congo Craton and African orogenic belt as well as plutonic rocks such as granite. On the other hand, the sedimentary basins are formed

36 A Rapid Water Resources and Water Use Assessment for Angola (2005)

37 Prepared by the Survey Team based on the data extracted from the captioned source

38 The Basic Design Study Report on the Project for Emergency Rural Water Supply in Neighboring Provinces of Luanda (2006)

toward the Atlantic Ocean in the coastal regions where sedimentary rocks of Mesozoic Cretaceous are distributed.

In Luanda Province, Bengo Province, and Cuanza Sul Province, the low consolidated sedimentary rocks are distributed in the lowlands along the coast. Hard rocks composed of Precambrian metamorphic and plutonic rocks are distributed in the inlands.

The former includes groundwater in the permeable formation spreading in a strep. The latter includes the aquifers in weathered zones and fissure zones by fault. The depth of the aquifer depends on the topographical conditions and is 20 to 30 m in some regions. It is presumed that the depth would be greater than 100 m in other regions. The available records indicate that groundwater yield is 100 liters/min in the sedimentary rocks and 50 liters/min in the hard rocks.

(4) Water Resources and Water Demand in the Coastal Region

The Final Report of the National Water Sector Management Project, Activity C, A Rapid Water Resources and Water Use Assessment for Angola (March 2005), describes the water resource and water demand assessment in 77 river basins in Angola. The results of the assessment are compiled in Table 4.3 below, focusing on the major coastal cities. Based on the results of the assessment, water shortage is not expected in the major river basins in the north and central coast. The southern coast around Namibe is probably faced with water shortage as the rivers are dried up during the dry season.

Table 4.3 Water Resources and Water Demand in Coastal Region in Angola

River Basin	Catchment Area (km^2)	Estimated Population (2015)	Water Demand (2015) Water Supply (m^3/s)	Agiriculture Livestock (m^3/s)	Total (m^3/s)	Ave. Annal Rainfall (mm)	Ave. Annal Flow (m^3/s)	Dry Season Flow (m^3/s)	Water Shortage	Remarks Coastal City	Census (2014)
Chiloango	12,571	288,000	0.243	0.0	0.243	1,170	114.9	91.8		Cabinda	598,210
Zaire	290,395	1,643,190	0.719	4.9	5.619	1,375	2,540.9	1,597.2		Soyo	218,193
Dande	11,446	1,203,740	0.543	7.8	8.343	832	59.0	27.5		Dande	217,929
Bengo	11,089	4,376,232	2.025	9.4	11.425	883	43.8	16.6		Cazenga	862,351
Cuanza	150,446	4,622,503	1.857	52.0	53.857	1,188	1,064.4	240.7		Cacuaco	882,398
										Viana	1,525,711
										Luanda	2,107,648
										Belas	1,065,106
Queve	22,815	291,044	0.101	18.3	18.401	1,131	213.4	59.3		Port Amboim	119,742
N'Gunza	2,309	242,471	0.130	1.9	2.030	763	13.6	6.0		Sumbe	267,693
Catumbela	16,533	961,294	0.778	2.5	3.278	1,182	149.1	29.8		Lobito	324,050
										Catumbela	167,625
Cavao	4,398	648,468	0.654	5.0	5.654	751	19.4	7.0		Benguela	513,441
Bero	10,476	264,722	0.212	6.0	6.212	364	4.9	0.0	Shortage	Namibe	282,056
Curoca	19,338	80,878	0.030	1.3	1.330	238	3.69	0.0	Shortage	Tombwa	54,873

Source: Water Resources Assessment and Water Demand - A Rapid Water Resources and Water Use Assessment for Angola (2005)
Census Population - Resultados Preliminares do Censo 2014, Instituto Nacional de Estatística

4.3.3 Namibia

(1) Overview of Water Resources and Water Use

Table 4.4 shows the indicators of water resources and water use in Namibia based on AQUASTAT (FAO). The ratio of external water resources by the Cunene, Cuvelai, Okavango, and Zambezi rivers is as high as 85%. Freshwater withdrawal as percentage of the total renewable water resources is 0.71% (2005).

Table 4.4 Water Resources and Water Use in Namibia

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	285	
Total Renewable Surface Water (10^9 m^3/year)	37.85	
Total Renewable Groundwater (10^9 m^3/year)	2.1	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	0.05	
Total Renewable Water Resources (10^9 m^3/year)	39.91	
Dependency Ratio (%)	84.57	
Total Renewable Water Resources per Capita (m^3/year)	16,997	As of year 2014

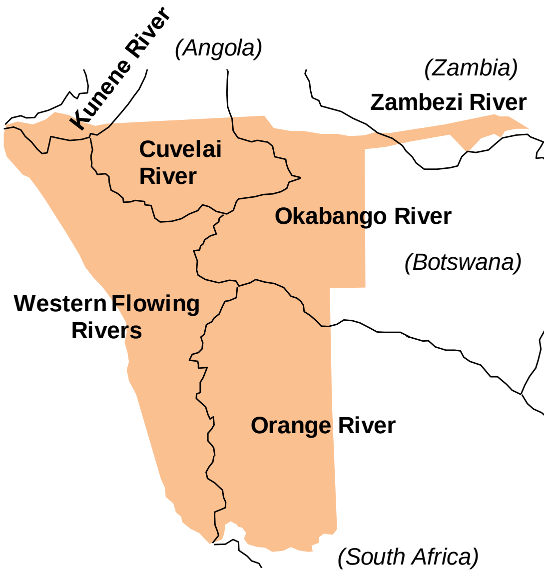
Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	0.288	As of year 2002
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	69.79	As of year 2002
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	4.861	As of year 2002
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	25.35	As of year 2002
Total Water Withdrawal per Capita (m^3/year)	147.1	As of year 2002
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	0.7063	As of year 2002

Source: AQUASTAT, FAO

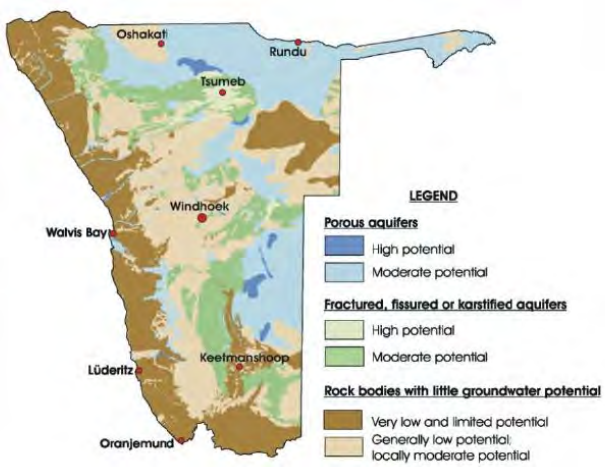
(2) Surface Water

The river systems in Namibia are classified into five, namely: 1) western flowing rivers that originate from the mountain ranges running north to south and then pour into the Atlantic Ocean, 2) Cunene, 3) Cuberai, 4) Okavango, and 5) Orange (Figure 4.17). The Cunene River drains a part of the northern territory. A small part of the northeast inland belongs to the catchment of the Zambezi.



Source: NamWater[39]

Figure 4.17 River Basin Division in Namibia



Source: Data Collection Survey on the Namibia - Japan High-level Forum on Economic Development in Republic of Namibia, Final Report

Figure 4.18 Groundwater Potential in Namibia

The Cunene River flows down the border with Angola and pours in the Atlantic Ocean. The majority of its catchment belongs to Angola. The Cuvelai River originates from the mountains in Angola and

39 Prepared by the Survey Team based on the data extracted from the documents of NamWater

flows through northern Namibia. It does not have an outlet to the sea and its end is the Etosha Wetlands (salt lake). The Okavango River originates from southeast Angola and flows through northeast Namibia. The end of the Okavango is the Okavango Delta which is the largest inland delta in the world. The southeastern part of the country belongs to the catchment of the Orange River that flows along the border with South Africa and eventually pours into the Atlantic Ocean.

Many of the western flowing rivers are not perennial and flow only for two to three months after the rainy season. Only two rivers, namely, Swakop and Kuisebu, are perennial. The south of the Atlantic coast corresponds to the Namib Desert where no river flows down to the Atlantic Ocean[40].

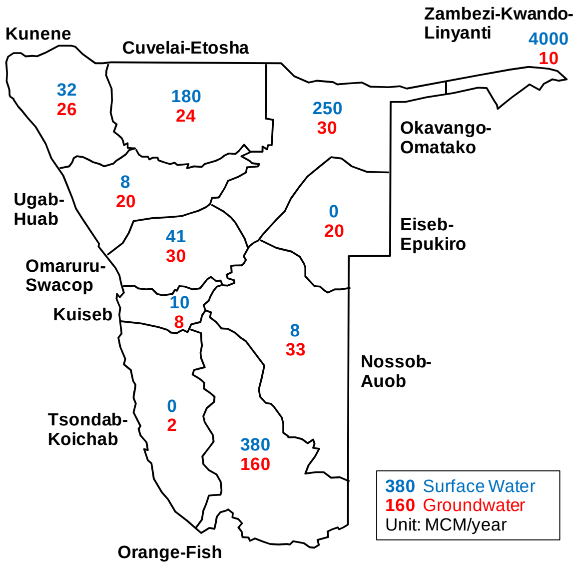
(3) Groundwater

Major aquifers of Namibia are classified into: 1) porous gravel rocks, 2) fault zone, 3) tear, cracks and penetration, 4) fissure-cavity of carbonate rocks, and 5) semi-consolidated and unconsolidated rocks (Figure 4.18). Groundwater level exists at a depth of 100 to 200 m in the aquifers except for a limited case in alluvium deposits[41]. The Atlantic coast has extremely low groundwater potential.

(4) Water Resources and Water Demand in the Coastal Region

Water resources potential in Namibia is estimated to be 5.3 billion m^3/year but 4.0 billion m^3/year corresponds to the Zambezi River, which passes through the northeast end of the country and does not contribute to the water resources development within Namibia. The availability of water resources is largely different by region (Figure 4.19). The water resources potential is low along the Atlantic coast.

The Atlantic coast is less populated. According to the 2011 census data, there are only three cities having population over 10,000, namely: Walvis Bay (62,096), Swakopmund (44,725), and Luderitz (12,537).



Source: Integrated Water Resource Management Plan for Namibia (2010)

Figure 4.19 Water Resource by Region in Namibia

40 Data Collection Survey on the Namibia - Japan High-level Forum on Economic Development in Republic of Namibia (2011)

41 -ditto-

Table 4.5 Water Resources and Water Demand in Namibia

Basin	Water Resource Potential (MCM/year)			Demand (MCM/year)		Surplus (MCM/year)	
	Surface	Ground	Total	2008	2030	2008	2030
Cuvelai-Etosha	180.0	24.0	204.0	63.7	85.6	140.3	118.4
Eiseb-Epukiro	0.0	20.0	20.0	8.6	11.2	11.4	8.8
Kuiseb	**9.8**	**8.0**	**16.8**	**8.4**	**12.6**	**8.4**	**4.2**
Kunene	**31.5**	**26.2**	**57.7**	**10.0**	**11.2**	**47.7**	**46.5**
Nossob-Auob	8.0	32.5	40.5	31.1	34.9	9.4	5.6
Okavango-Omatako	250.0	29.6	279.6	58.1	215.1	221.5	64.5
Omaruru-Swakop	**41.0**	**29.5**	**70.5**	**50.6**	**74.9**	**19.9**	**-4.4**
Orange-Fish	379.9	160.0	539.9	74.8	119.6	465.1	420.3
Tsondab-Koichab	**0.0**	**1.8**	**1.8**	**3.9**	**5.1**	**-2.0**	**-3.3**
Ugab-Huab	**7.5**	**19.8**	**27.3**	**14.7**	**22.0**	**12.6**	**5.3**
Zambezi-Kwando-Linyanti	4,000.0	10.0	4,010.0	10.3	179.6	3,999.7	3,830.4
Total	4,907.7	361.4	5,268.1	334.2	771.8	4,934.0	4,496.3

Note: Bold texts refer to the basins located in the Atlantic coast.

Source: Integrated Water Resource Management Plan for Namibia (2010)

4.3.4 South Africa

(1) Overview of Water Resources and Water Use

Table 4.6 shows the indicators of water resources and water use in South Africa based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 24.2% (2000).

Table 4.6 Water Resources and Water Use in South Africa

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	495	
Total Renewable Surface Water (10^9 m^3/year)	49.55	
Total Renewable Groundwater (10^9 m^3/year)	4.8	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	3	
Total Renewable Water Resources (10^9 m^3/year)	51.35	
Dependency Ratio (%)	12.84	
Total Renewable Water Resources per Capita (m^3/year)	966.3	As of year 2014

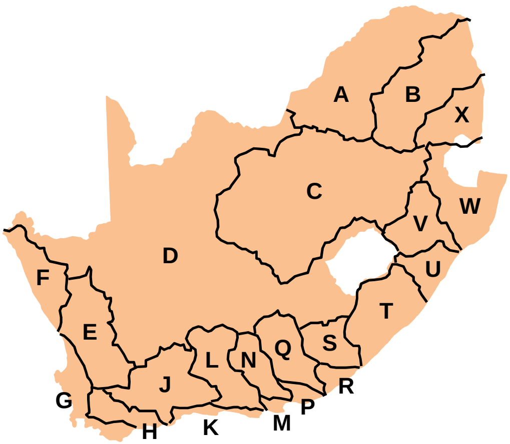
Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	12.5	As of year 2000
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	62.69	As of year 2000
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	6.048	As of year 2000
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	31.23	As of year 2000
Total Water Withdrawal per Capita (m^3/year)	270.6	As of year 2000
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	24.23	As of year 2000

Source: AQUASTAT, FAO

(2) Surface Water

The territory of South Africa is divided into 22 drainage regions (Figure 4.20). The Orange River has the largest catchment area which corresponds to 48% of the territory and is sub-divided into lower-middle (D) and upstream (C). Drainage Regions A, B, C, D, X, and W are the catchments of international rivers.



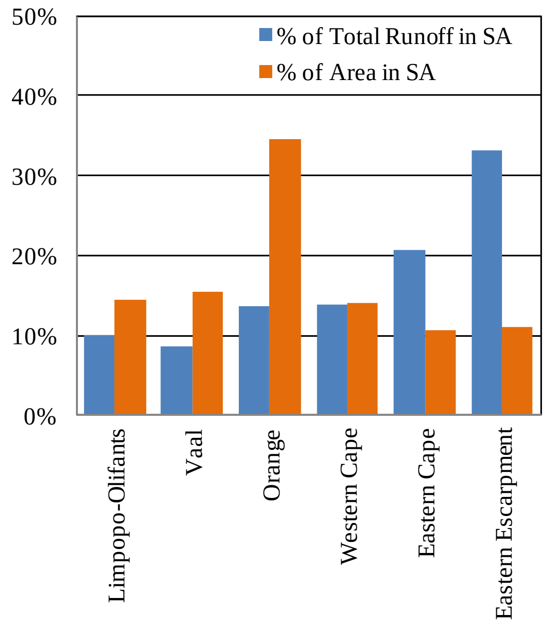
	Drainage Region	Area (km²)
A	Limpopo	109,883
B	Olifants (W)	73,674
C	Vaal	196,606
D	Orange	410,116
E	Olifants (W)	49,103
F	Buffels	28,588
G	Great Berg	25,322
H	Breede	15,535
J	Gourits	45,156
K	Kromme	7,222
L	Gamtoos	34,751

	Drainage Region	Area (km²)
M	Swartkops	2,628
N	Sundays	21,238
P	Bushmans	5,361
Q	Great Fish	30,249
R	Keiskamma	7,939
S	Great Kei	20,498
T	Mzimvubu	46,679
U	uMngeni	18,343
V	Thukela	29,081
W	Phongolo	60,165
X	Crocodile	31,218

Source: Department of Water Affairs (DWA)[42]

Figure 4.20 River Basin Divisions in South Africa

The surface water resources are distributed unevenly over the country. The catchment of the Orange River accounts for 35% of the country but its surface water resources correspond to 14% of the total in the country. In contrast, the Eastern Escarpment located along the Indian Ocean occupies 11% of the country but contributes 33% of the surface water resources. The Eastern Cape covers 11% of the country and has 21% of the surface water resources. These two drainage regions located along the east to south coast, corresponding to 22% of the territory, have 54% of the total water resources available in the country. Figure 4.21 shows the water resources by region in South Africa.



Limpopo-Olifants	A, B
Vaal	C
Orange	D, F
Western Cape	E, G, H, J, K, L
Eastern Cape	M, N, P, Q, R, S, T
Eastern Escarpment	U, V, W, X

Source: Department of Water Affairs (DWA)[43]

Figure 4.21 Water Resource by Region in South Africa

Annual average runoff is estimated to be 49 billion m^3/year. The water resources management plan is based on the exploitable amount of water with a reliability of 98% (98/100 years), which is 10 billion m^3/year, or about 20% of the annual average runoff. Many regions are faced with water shortage or uneven distribution of water. The frequency of water shortage is more than 2/100 years. The current

42 Prepared by the Survey Team based on the data extracted from the documents of DWA

43 -ditto-

water withdrawals are estimated to be 9.5 billion m^3/year, of which 3.0 billion m^3/year is usable by inter-basin transfer[44].

(3) Groundwater

Groundwater is an important and the sole water resources in a number of local areas of the country but its yield is generally low. According to the latest estimates, the sustainable yield of groundwater is 7.5 billion m^3/year. On the other hand, the current groundwater usage is estimated to be 2.0 billion m^3/year. Even if the current groundwater usage is based on a lower estimate, an additional groundwater development of 3.5 billion m^3/year is considered to be allowable[45].

(4) Water Resources and Water Demand in the Coastal Region

The National Water Resources Management Strategy of June 2013, Second Edition, describes the so called Reconciliation Strategy plan, which is developed in the major regions of the country. Of these, the plans in the coastal regions are listed as follows:

- Western Cape - Greater Cape Town, West Coast Towns and Irrigation
- Outeniqua Area (George, Mossel Bay)
- Algoa - Nelson Mandela Bay Metropolitan Area (Port Elizabeth), Surrounding Towns and Gamtoos Irrigation Board
- Amatole - Buffalo City (East London) and Surrounding Towns
- KwaZulu-Natal Coastal Metropolitan Area (Durban)
- Richards Bay Area

The plans are already developed in four regions except in Outeniqua Area and Richards Bay Area as outlined in Table 4.7 below.

[44] National Water Resource Strategy, June 2013, Second Edition
[45] -ditto-

Table 4.7 Reconciliation Strategy along Coastal Region in South Africa

Unit: million m³/year

	Western Cape - Greater Cape Town, West Coast Towns and Irrigation	Algoa - Nelson Mandela Bay Metropolitan Area (Port Elizabeth), Surrounding Towns and Gamtoos Irrigation Board
Currently available water resource yield	580	170
2012 total water requirements	513	170
2012 balance	67	0
WCWDM targets, volume (date)	90 (2017)	15 (2015)
Date at which high growth requirement will exceed current resource	(2019)	(2012)
2035 High water requirement scenario	950	240
Drivers for growth in requirement	High population growth due to high in-migration and increased service levels	High population growth, High economic growth – Coega IDZ
Additional water required before 2035	370	70
Measures available to supply additional water	Surface water 80	Complete Nooitgedagt LLS 25
	Reuse of water 130	Reuse of water 35
	Groundwater 50	Groundwater 30
	Desalination 110	Desalination of Lower Sundays River return flows 10

	Amatole - Buffalo City (East London) and Surrounding Towns	KwaZulu-Natal Coastal Metropolitan Area (Durban)
Currently available water resource yield	108	375
2012 total water requirements	85	440
2012 balance	23	-65
WCWDM targets, volume (date)	10 (2015)	40 (2018)
Date at which high growth requirement will exceed current resource	(2025)	Already exceeded (2005)
2035 High water requirement scenario	120	600
Drivers for growth in requirement	Population growth	Urban growth and improved standards of living (upgraded service levels)
Additional water required before 2035	12	226
Measures available to supply additional water	Surface water 10	Spring Grove Dam 60
	Reuse of water 30	Hazelmere Raising 9
	Desalination	Lower Thukela BWS, Ph1 and Ph2 40
		Mvoti Rover Development 28
		Reuse of water 40
		Mkomazi River Development or Desalination of sea water 150

Source: National Water Resources Management Strategy, June 2013, Second Edition

4.3.5 Madagascar

(1) Overview of Water Resources and Water Use

Table 4.8 shows the indicators of water resources and water use in Madagascar based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 4.9% (2000).

Table 4.8 Water Resources and Water Use in Madagascar

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	1,513	
Total Renewable Surface Water (10^9 m^3/year)	332	
Total Renewable Groundwater (10^9 m^3/year)	55	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	50	
Total Renewable Water Resources (10^9 m^3/year)	337	
Dependency Ratio (%)	0	
Total Renewable Water Resources per Capita (m^3/year)	14,297	As of year 2014

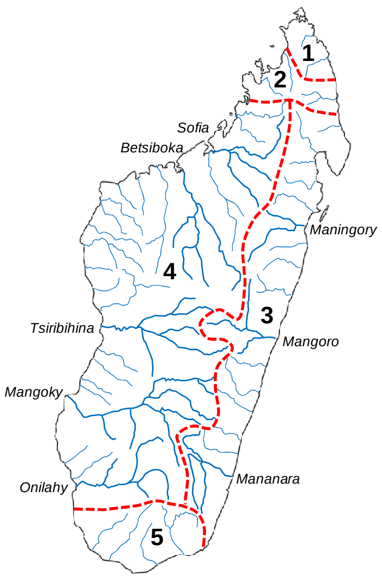
Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	16.5	As of year 2000
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	97.76	As of year 2000
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	0.7927	As of year 2000
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	1.447	As of year 2000
Total Water Withdrawal per Capita (m^3/year)	985.9	As of year 2000
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	4.896	As of year 2000

Source: AQUASTAT, FAO

(2) Surface Water

The territory of Madagascar is broadly divided into five regions by the hydrological characteristics (Figure 4.22). The major rivers with a large catchment area are located mostly in the western slopes.



Hydrological Divisions

No.	Hydrographic System	Area (km^2)	%
1	N-E Slopes and Ambre	11,200	1.8
2	Tsaratanana Slopes	20,000	3.3
3	Eastern Slopes	150,000	25.2
4	Western Slopes	365,000	61.3
5	Southern Slopes	48,750	8.2

Major Rivers : Western Slopes

Sofia	27,315	km^2
Betsiboka	49,000	km^2
Tsiribihina	49,800	km^2
Mangoky	55,750	km^2
Onilahy	32,000	km^2

Major Rivers : Eastern Slopes

Maningory	12,645	km^2
Mangoro	17,175	km^2
Mananara	16,760	km^2

Source: Rivers - FAO[46], Hydrological Divisions - Rivers and Streams on Madagascar by M. Aldegheri (1972)

Figure 4.22 River Basin Divisions in Madagascar

Annual average low flow based on mean monthly flow records is 10 to 30 L/s/km^2 in the north and east coast, 2 to 3 L/s/km^2 in the south coast, and 6 L/s/km^2 in the northwest coast (Betsiboka) (Table 4.9). Rivers and Streams on Madagascar by M. Aldegheri (1972) describes that many of the rivers in the vicinity of Onilahy in the southwest are dried up during the dry season.

[46] Prepared by the Survey Team based on the Data on Major Inland Waters in Africa

Table 4.9 Summary of Flow Regime in Madagascar

Region	River	Location	Drainage Area (km^2)	Annual Mean Flow (m^3/s)	Annual Mean Flow ($L/s/km^2$)	Monthly Low Flow (m^3/s)	Monthly Low Flow ($L/s/km^2$)
Tsaratanana Slopes	Sambirano	Ambanja	2,800	125	45	23	8
	Ramena	Ambodimanga	1,080	55	51	11	10
Eastern Slopes	Vohitra	Logez	1,950	76	39	42	22
	Iventro	Ringaringa	2,175	106	49	68	31
	Mananara	Maroangaty	14,300	209	15	44	3
Southern Slopes	Mananantanana	Tsitondronia	6,510	93	14	12	2
	Ihosy	Ihosy	1,500	16	11	4	3
Western Slopes	Mangoy	Banian	50,000	458	9	75	2
	Betsiboka	Ambodiroca	11,800	283	24	74	6

Source: Rivers and Streams on Madagascar by M. Aldegheri (1972)

(3) Groundwater

Any literature describing the nationwide or region-wide groundwater potential in Madagascar could not be identified.

(4) Water Resource and Water Demands in the Coastal Region

Any literature describing the water resources and water demand in the coastal region in Madagascar could not be identified.

4.3.6 Mozambique

(1) Overview of Water Resources and Water Use

Table 4.10 shows the indicators of water resources and water use in Mozambique based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 0.41%.

Table 4.10 Water Resources and Water Use in Mozambique

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	1,032	
Total Renewable Surface Water (10^9 m^3/year)	214.1	
Total Renewable Groundwater (10^9 m^3/year)	17	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	14	
Total Renewable Water Resources (10^9 m^3/year)	217.1	
Dependency Ratio (%)	53.8	
Total Renewable Water Resources per Capita (m^3/year)	8,201	As of year 2014

Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	0.8842	As of year 2001
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	78.04	As of year 2001
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	2.748	As of year 2001
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	19.22	As of year 2001
Total Water Withdrawal per Capita (m^3/year)	45.77	As of year 2001
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	0.4073	As of year 2001

Source: AQUASTAT, FAO

(2) Surface Water

There are 104 rivers in Mozambique, 13 of which are classified as main rivers and nine of which are international rivers (Figure 4.23). Others are small and medium rivers flowing down in the coastal areas along the Indian Ocean. These river basins are grouped into jurisdictions by five Regional Water Administrations (*Administração Regional de Águas*: ARA) under the Ministry of Public Works and Housing (*Ministério de Obras Públicas e Habitação*: MOPH)[47].

Major Rivers (except middle and small rivers pouring into the Indian Ocean)

ARA	Name of Major River Basin	Basin Area within Territory (km²)	Whole Basin Area (km²)
North	13- Ruvuma	101,600	155,400
	12- Messlo	24,000	24,000
Central North	11- Lurio	60,800	60,800
	10- Ligonha	16,299	16,299
	9- Licungo	27,726	27,726
Zambezi	8- Zambezi	140,000	1,200,000
Central	7- Pungwe	28,000	29,500
	6- Buzi	25,600	28,800
	5- Save	4,550	88,395
South	4- Linpopo	79,620	412,000
	3- Incomati	14,925	46,246
	2- Umbeluzi	2,356	5,600
	1- Maputo	1,570	29,800

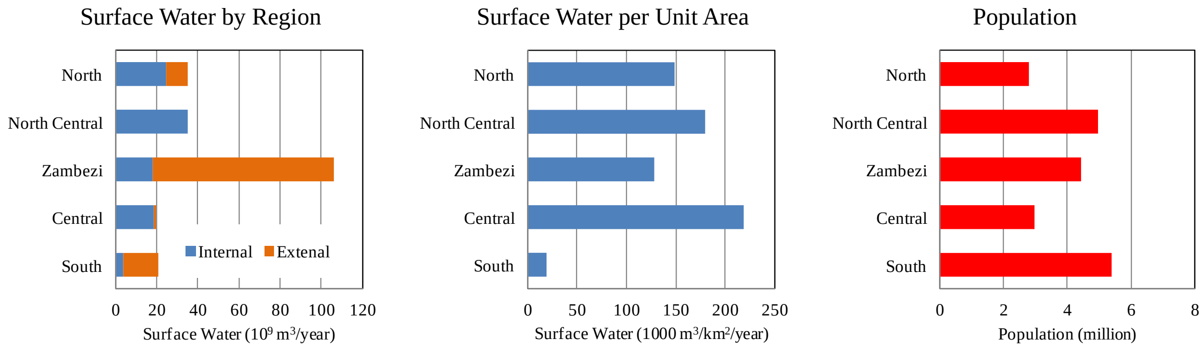
Note: Shaded cells are international rivers.

Source: The Report on Data Collection Survey on Disaster Management (2013)

Figure 4.23 River Basin Divisions in Mozambique

Fifty-four percent of the surface water in Mozambique corresponds to cross-border flows including a large contribution by the Zambezi River. The capital Maputo is located in the jurisdiction of ARA South, which has the largest population among the ARA jurisdictions. ARA South is highly dependent on the cross-border flow and the catchment of the Limpopo River within Mozambique is mostly a dry zone. Therefore, surface water by internal flow is quite small compared to the others. Figure 4.24 shows the surface water resources by region in Mozambique.

[47] The Report on Data Collection Survey on Disaster Management (2013)



Source: Mozambique, Country Water Resources Profile, NEPAD Water Centers of Excellence [48]

Figure 4.24 Water Resources by Region in Mozambique

(3) Groundwater

Regional distribution of groundwater in Mozambique is described in Table 4.11. Five cities, namely: Pemba, Tete, Xai-Xai, Quelimane, and Chokwe, use groundwater for urban water supply[49].

Table 4.11 Regional Distribution of Groundwater in Mozambique

Region	Geology	Groundwater Potential
North of Zambezi River, upstream of Beira River	Basement rocks consisting of Precambrian metamorphic rocks and granite	● Fresh bedrocks are regarded as impermeable. The weathered surface layer and fault include groundwater. ● Groundwater yield is low or about 1 to 5 m^3/hour as classified into Class-C in the hydrogeological map of Mozambique. On the other hand, the groundwater quality is mostly classified as moderate good.
South of Zambezi River	Cretaceous - Tertiary sedimentary rocks	● Cretaceous - Tertiary sedimentary rocks are composed of volcanic rock, sandstone, mudstone, conglomerate, and limestone. Groundwater productivity and quality are largely different depending on the variety of formations. ● Groundwater yield is generally high in sandstone and limestone compounds in these sedimentary rocks at about 3 to 50 m^3/hour as classified into Class-B in the hydrogeological map of Mozambique. ● Groundwater quality varies by region. The salinity of more than 1,500 mg/L is observed widely in the coastal regions.
	Alluvium deposits	● Alluvium deposits consist of unconsolidated clay, silt, and sand and form the good aquifers. ● Groundwater yield is high at 3 to 50 m^3/hour as classified into Class-A in the hydrogeological map of Mozambique. ● The salinity tends to be higher in the coastal areas due to the influence of the seawater.

Source: The Preparatory Survey Report on Urgent Water Supply Program (2009)

(4) Water Resources and Water Demand in the Coastal Region

Mozambique, Country Water Resources Profile (2013) describes the water resources and water demand in ARA South, ARA Central, and ARA Zambezi (Table 4.12). Water shortages are forecasted in the Umbeluzi River basin and Limpopo River basin in ARA South and in the Buzi River basin in ARA Central. No data is shown regarding ARA Centro-Norte and ARA Norte, which were established in 2008 and 2006 respectively while the other three ARAs had been established in the year 2000 or earlier. It is presumed that the latter established ARA-Centro Norte and ARA Norte could not be ready for preparing the analysis of water resource and water demand.

[48] Prepared by the Survey Team based on the date extracted from the reference
[49] Mozambique Country Water Resources Assistance Strategy (2007)

The Mozambique Country Water Resources Assistance Strategy (2007) of the World Bank describes the priority project of the water resources development and management of the Incomati River basin, which is adjacent to the Umbeluzi River basin, in ARA South in order to mitigate the water shortage in the capital of Maputo. In addition, the construction of medium and small dam reservoirs is prioritized in the northern region for the purpose of water supply to Nampula, Nacala, and Quelimane.

Table 4.12 Water Resources and Water Demand by Region in Mozambique

ARA South

River Basin	Mean Annual Runoff	Water Yields 2003	Water Demand 2015 (MCM)							Water Balance
			Irrigaton	Livestock	Water Supply	Large Industries	Forestry	Environmental Flow	Total Demand	
Maputo	3,800.0	1,331.0	60.0	0.1	6.0			930.0	996.1	334.9
Umbeluzi	296.0	144.5	60.0	0.1	162.2			44.4	266.7	-122.2
Incomati	2,677.0	908.3	251.0	1.2	4.6	17.3		401.6	675.7	232.6
Limpopo	5,773.0	1,003.6	210.0	4.5	59.7			866.0	1,140.2	-136.6
Total	12,546.0	3,387.4	581.0	5.9	232.5	17.3	0.0	2,242.0	3,078.7	308.7

ARA Central, ARA Zambezi

River Basin	Mean Annual Runoff	Water Yields 2003	Water Demand 2015 (MCM)							Water Balance
			Irrigaton	Livestock	Water Supply	Large Industries	Forestry	Environmental Flow	Total Demand	
Buzi	6,420.0	1,031.6	91.5	12.0	20.4			993.9	1,117.8	-86.2
Pungue	3,375.0	1,000.3	159.3	12.0	30.2	3.0		680.1	884.6	115.7
Save	n.a									
Zambezi	106,000.0	28,912.3	126.0	41.0	89.2	5.0	47.0	15,900.0	16,208.2	12,704.1
Total	115,795.0	30,944.2	376.8	65.0	139.8	8.0	47.0	17,574.0	18,210.6	12,733.6

Source: Mozambique, Country Water Resources Profile (2013)

4.3.7 Tanzania

(1) Overview of Water Resources and Water Use

Table 4.13 below shows the indicators of water resources and water use in Tanzania based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 5.4% (2002).

Table 4.13 Water Resources and Water Use in Tanzania

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	1,071	
Total Renewable Surface Water (10^9 m^3/year)	92.27	
Total Renewable Groundwater (10^9 m^3/year)	30	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	26	
Total Renewable Water Resources (10^9 m^3/year)	96.27	
Dependency Ratio (%)	12.75	
Total Renewable Water Resources per Capita (m^3/year)	1,897	As of year 2014

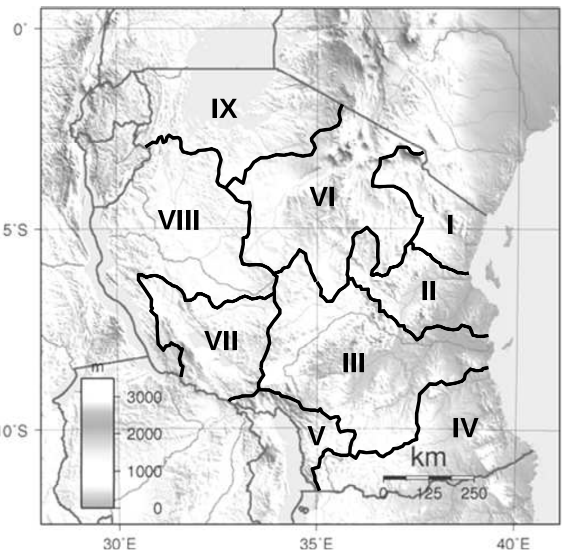
Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	5.184	As of year 2002
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	89.35	As of year 2002
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	0.4823	As of year 2002
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	10.17	As of year 2002
Total Water Withdrawal per Capita (m^3/year)	144.8	As of year 2002
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	5.385	As of year 2002

Source: AQUASTAT, FAO

(2) Surface Water

The territory of Tanzania is broadly divided into nine river basins (Figure 4.25). Of these, the river basins with river flowing down to the Indian Ocean are Pangani (I), Wami/Ruve (II), Rufiji (III), and Ruvuma (IV). Internal Drainage (VI) and Lake Rukwa (VII) have no outlet to the sea. The Nyasa Lake (IV), Tanganyaka (VIII), and Lake Victoria (IX) pour into the inland lakes and belong to the large river basins such as the Zambezi, Congo, and Nile.



No.	Name of River Basin	Area (km^2)
I	Pangani	56,300
II	Wami/Ruvu	72,930
III	Rufiji	177,420
IV	Ruvma/Southern Coast	103,720
V	Lake Nyasa	75,230
VI	Internal Drainage	153,800
VII	Lake Rukwa	81,180
VIII	Lake Tanganyka	137,900
IX	Lake Victoria	79,570

Source: The Study on the Groundwater Resources Development and Management in the Internal Drainage Basin, Final Report (2008)

Figure 4.25 River Basin Divisions in Tanzania

(3) Groundwater

The aquifers in Tanzania are classified into: 1) Cenozoic Sediments, 2) Volcano-Plutonic, and 3) Plutonic-Metamorphic (Table 4.14).

The Cenozoic Sediments are unconsolidated or semi-consolidated. Groundwater exists in gaps of gravel in unconsolidated or semi-consolidated layer. The aquifers are distributed widely in the coastal plain of Dar es Salaam. Groundwater yield is relatively high in the quaternary aquifers. More than 50% of the wells are located in the quaternary aquifers and the average yield exceeds 100 liters/min. The Neogene aquifers are distributed widely with many wells. Groundwater yield is 24.5 liters/min.

The Volcano-Plutonic is mostly consolidated. Groundwater exists in gaps in the semi-consolidated layer due to weathering. Groundwater yield of the aquifer is different by location but is lower than the aquifer of quaternary sediments.

The Plutonic-Metamorphic is composed of hard rocks and includes groundwater in the weathered surface layer and fissure zone with cracks. Groundwater yield is generally low in this aquifer.

Table 4.14 Classification of Aquifers in Tanzania

Category	Aquifer Type	Geology	Area (%)
1	Cenozoic Sediments	Gravel, clay, limestone, etc.	20
2	Volcano-Plutonic	Black clay, yellow volcanic ash, white pumice, basalt, etc.	15
3	Plutonic-Metamorphic	Marble, schist, granite, gneiss, slate, etc.	65

Source: Assessment of Groundwater Availability and Its Current and Potential Use and Impacts (2010)

(4) Water Resources and Water Demand in the Coastal Region

There are three major coastal cities in Tanzania, namely: Tanga, Dar es Salaam, and Mtwara. Water resources, water supply, and water demand in each of these cities are summarized in Table 4.15 below. Water supply capacity (installation) in Tanga has exceeded the water demand and the water production is a little less than the water demand. In Dar es Salaam and Mtwara, the water supply capacity (installation) is below the water demand. The ratio of water production to water demand is 48% in Dar es Salaam and 68% in the Mtwara.

Table 4.15 Water Resources, Water Supply and Water Demand in Coastal Cities in Tanzania (2013/2014)

Water Intake Volume — Unit: million m^3/year

Utility	Borehole	Spring	Dam	Lake	River	Total
Tanga			11.52			11.52
Dar es Salaam	1.83				96.37	98.20
Mtwara	3.45	0.17				3.62

Water Supply Capacity, Water Production and Water Demand — Unit: million m^3/year

Utility	Installed Water Production Capacity	Water Production	Water Demand
Tanga	15.3	10.0	10.6
Dar es Salaam	109.5	89.7	188.2
Mtwara	4.4	3.1	4.6

Source: Water Utilities Performance Review Report 2013/2014, EWURA (2014)

4.3.8 Mauritius

(1) Overview of Water Resources and Water Use

Table 4.16 below shows the indicators of water resources and water use in Mauritius based on AQUASTAT (FAO). Freshwater withdrawal as percentage of the total renewable water resources is 26.4% (2003).

Table 4.16 Water Resources and Water Use in Mauritius

Water Resources

Indicator	Data	Remarks
Long-term Average Precipitation in Depth (mm/year)	2,041	
Total Renewable Surface Water (10^9 m^3/year)	2.358	
Total Renewable Groundwater (10^9 m^3/year)	0.893	
Overlap between Surface Water and Groundwater (10^9 m^3/year)	0.5	
Total Renewable Water Resources (10^9 m^3/year)	2.751	
Dependency Ratio (%)	0	
Total Renewable Water Resources per Capita (m^3/year)	2,203	2014

Water Use

Indicator	Data	Remarks
Total Water Withdrawal (10^9 m^3/year)	0.725	2003
Agricultural Water Withdrawal as % of Total Water Withdrawal (%)	67.72	2003
Industrial Water Withdrawal as % of Total Water Withdrawal (%)	2.759	2003
Municipal Water Withdrawal as % of Total Water Withdrawal (%)	29.52	2003
Total Water Withdrawal per Capita (m^3/year)	594.3	2003
Freshwater Withdrawal as % of Total Renewable Water Resources (%)	26.35	2003

Source: AQUASTAT, FAO

(2) Surface Water

The rivers in Mauritius originate from the central highlands of the island and pour into the sea. Many of these are perennial. The catchments of these rivers have been classified into 25 major catchments and 22 small catchments. Surface water intake volume in 2013 was 487 MCM/year, which includes 135 MCM/year from river intakes and 351 MCM/year from dam reservoirs. In addition, 280 MCM/year was taken for hydroelectric power generation[50].

(3) Groundwater

Groundwater yield in 2013 was 121 MCM/year. Groundwater yield is estimated to be nearing its exploitable limit[51].

(4) Water Resources and Water Demand in the Coastal Region

According to Water Account, Mauritius 2013, the total water intake volume in 2013 was 888 MCM/year consisting of 220 MCM/year (24.8%) for water supply by the Central Water Authority (CWA), 375 MCM/year (31.5%) for agriculture and livestock, 13 MCM/year (1.5%) for industry, and 280 MCM/year (31.5%) for hydroelectric power (Table 4.17). 220 MCM/year for water supply comprises 51% of surface water and 49% of groundwater.

Table 4.17 Water Intake Volume in Mauritius (2013)

Sources of abstraction	MCM	%
Water Supply Industry (CWA)	220	24.8%
Agriculture and Livestock	375	42.2%
Manufacturing and Services	13	1.5%
Hydropower	280	31.5%
Total	888	100.0%

Source: Water Account, Mauritius 2013

In Mauritius, the possible exploitation of water resources is estimated to be 1,300 MCM/year. 70% of the volume has been used and 80% will be exploited by 2040[52].

4.4 Water Supply

4.4.1 Cote d'Ivoire

(1) Administrative Framework of Water Supply Development and Management[53]

The legal framework governing the water sector has remained unclear due to the armed conflict that took place since 2002. Although the Government of Cote d'Ivoire (GOCI) passed the Water Code in 1998, it still has not passed implementing regulations. In 2011, the GOCI created the Ministry of Water and Forests (*Ministère des Eaux et Forêts*: MINEF). The Directorate of Water Resources (*Direction des Ressources en Eau*: DRE) within MINEF is responsible for implementing the Water Code. The MINEF must also work with the ministries in charge of economic infrastructure, environment, agriculture, health and animal resources, and fisheries to ensure integrated management of Cote d'Ivoire's water resources.

In June 2012, the High Commission on Water (*Haut Commissariat à l'Hydraulique*: HCH) approved the National Action Plan for Integrated Management of Water Resources (*Plan d'Actions National de*

[50] Water Sector of Mauritius - Opportunities, Challenges, and Constraints
[51] -ditto-
[52] -ditto-
[53] USAID Country Profile, Property Rights and Resource Governance, Côte d'Ivoire (2013)

Gestion Intégrée de Ressources en Eau: PLANGIRE), which further reforms the institutional framework on water management. The goal of PLANGIRE is to achieve water security and environmental sustainability through 2040. The new framework under PLANGIRE provides for institutions at four levels, namely: national, basin, regional/departmental, and local. Each level will have four categories of stakeholders, i.e.: (1) public administration, (2) territorial or local communities, (3) basin organizations, and (4) other actors such as users, the private sector, and non-governmental organizations (NGOs).

The Ministry of Economic Infrastructure (*Ministère des Infrastructures Economique*: MIE) takes the responsibility for ownership of water facilities, water policy, tariffs, decisions about water network extensions and hardware, and overall fiscal management of the sector. Within the ministry, the National Drinking Water Authority (*Office National de l'Eau Potable*: ONEP) is the executing unit of water infrastructure projects. It is also in charge of data collection. The ONEP guarantees access to safe drinking water for the people of Cote d'Ivoire. It also manages public and private assets related to the potable water sector.

Water consumption is classified into five different categories, namely: social, domestic, normal, industrial, and administrative. Fees are charged at different rates based on each category. Fees go into the National Water Fund (*Fonds National de l'Eau*: FNE) and Water Development Fund (*Fonds de Développement de l'Eau*: FDE) for the operation, maintenance, and new development of water systems. The financial resources of ONEP are provided by the FNE and FDE.

In Cote d'Ivoire, urban water supply is operated through concession. In 1959, the first concession contract was awarded to a French private water distributor which operates through its Ivoirian subsidiary Cote d'Ivoire Water Distribution Company (*Société de Distribution d'Eau de Côte d'Ivoire*: SODECI). Afterwards, SODECI has expanded its services to the major cities all over the country.

(2) Present Water Supply Development and Management

According to the World Health Organization (WHO)/United Nations Children's Emergency Fund (UNICEF), the proportion of urban population served with piped water supply in Cote d'Ivoire was 65.8% in 2015.

Table 4.18 below describes the number of consumers, water production, billed water volume, and revenue collection ratio in Cote d'Ivoire in recent years based on the annual report of SODECI[54].

Table 4.18 Number of Consumers, Water Production, Billed Water Volume, and Revenue Collection Ratio of SODECI

		2013	2014	2015
Abidjan				
Number of Consumers		375,617	388,467	406,677
Water Production	(1000 m^3)	141,379	139,375	157,684
Billed Water Volume	(1000 m^3)	100,869	97,986	112,747
Revenue Collection Ratio		71.3%	70.3%	71.5%
Other Regions				
Number of Consumers		364,790	398,859	413,491
Water Production	(1000 m^3)	66,491	69,440	74,400
Billed Water Volume	(1000 m^3)	57,009	60,946	65,066
Revenue Collection Ratio		85.7%	87.8%	87.5%

[54] Rapport de Gestion, 2014

		2013	2014	2015
Total, SODECI				
Number of Consumers		740,407	787,326	820,168
Water Production	(1000 m^3)	207,870	208,815	232,084
Billed Water Volume	(1000 m^3)	157,878	158,932	177,813
Revenue Collection Ratio		76.0%	76.1%	76.6%

Note: Actual results in 2013 and 2014, Planned in 2015
Source: SODECI

4.4.2 Angola

(1) Administrative Framework of Water Supply Development and Management [55]

The National Directorate of Water (*Direcção Nacional de Águas*: DNA) under the Ministry of Energy and Water (*Ministério da Energia e Águas*: MINEA) is responsible for water resources management and water administration. In the General Water Law in 2002 and the Water Sector Development Strategy in 2003, DNA is responsible for policy planning, implementation of the plan, guidance, advice, and supervision for provincial and district governments. The Luanda Water Supply Company (*Empresa Pública de Águas de Luanda*: EPAL) provides the water supply services for the capital Luanda. In other regions, provincial water supply and sanitation utilities are responsible for the water supply services. In addition, there are a number of small-scale water supply providers that are doing the water supply by tanker in the suburbs of Luanda and major cities[56].

(2) Present Water Supply Development and Management

According to WHO/UNICEF, the proportion of urban population served with piped water supply in Angola was 31.6% in 2015.

According to the website of EPAL[57], there are five water purification plants in Luanda and the total capacity is 493,000 m^3/day (Table 4.19). There are ten water distribution reservoirs and their total storage capacity is 142,400 m^3.

Table 4.19 Water Treatment Plants in Luanda

WTP	Capacity (m^3/day)
Candelabro	60,000
Kifangondo	140,000
Luanda Sudeste	216,000
Luanda Sul	60,000
Kikuxi	17,000
Total	493,000

Source: EPAL

4.4.3 Namibia

(1) Administrative Framework of Water Supply Development and Management[58]

The Ministry of Agriculture, Water and Forestry (MAWF) is responsible for overseeing water resources management in Namibia. Under MAWF, there are two departments, namely, Department of Agriculture and Rural Development and Department of Water Affairs and Forestry. The Department of Water Affairs and Forestry has three directorates, namely: Directorate Water Resource Management, Directorate of Water Supply and Sanitation Coordination, and Directorate Forestry.

Namibia Water Corporation (NamWater) under MAWF undertakes the development of water infrastructure and bulk water supply to the municipalities. Each municipality conducts the water

55 USAID, Angola Water and Sanitation Profile (2010)
56 An AMCOW Country Status Overview, Water Supply and Sanitation in Angola
57 EPAL website, http://www.epal.gv.ao/
58 Water Management in Namibia (2008)

supply services. The Directorate of Water Supply and Sanitation Coordination of MAWF also receives bulk water supply from NamWater and carries out water supply services for the rural areas.

(2) Present Water Supply Development and Management

According to WHO/UNICEF, the proportion of urban population served with piped water supply in Namibia was 69.3% in 2015.

The total volume of bulk water supply from NamWater to the municipalities was 76 million m^3/year in 2013. NamWater's water supply system is broadly divided into the following three regional systems[59]:

- Omaruru River Delta and the Kuiseb River: Using groundwater sources along the rivers, water supply is carried out for Walvis Bay, Swakopmund and other neighboring areas along the Atlantic coast.
- Central Areas Water Supply: The regional system covers the areas from Windhoek in the central to Grootfontein in the northeast. Water sources are surface water (dam reservoirs) and groundwater.
- Cuvelai Water Supply Network: The regional system covers the area near the border with Angola. Water conveyance is performed from the dam reservoir in Angola to Namibia through the open channel.

4.4.4 South Africa

(1) Administrative Framework of Water Supply Development and Management

The administrative framework for water sector in South Africa is established in accordance with the National Water Act (1999) and Water Service Act (1998).

The organizations in charge and their roles are described below.

Department of Water Affairs (DWA)[60]: DWA ensures that all components of value chain function in water sector efficiently and effectively. In the process of the institutional realignment, DWA is to focus on policy development, strategic planning, regulatory oversight and support. DWA will no longer be directly involved in development, financing, operation and maintenance of water resources infrastructure.

Water Boards: The existing 12 water boards (Figure 4.26) will be consolidated into nine viable regional water utilities (RWUs)[61]. The RWU's mandate is to include development and management of regional water resources, regional bulk water services and regional wastewater infrastructure. The RWU's will be responsible for financing, development, management, operation and maintenance of regional bulk water infrastructure.

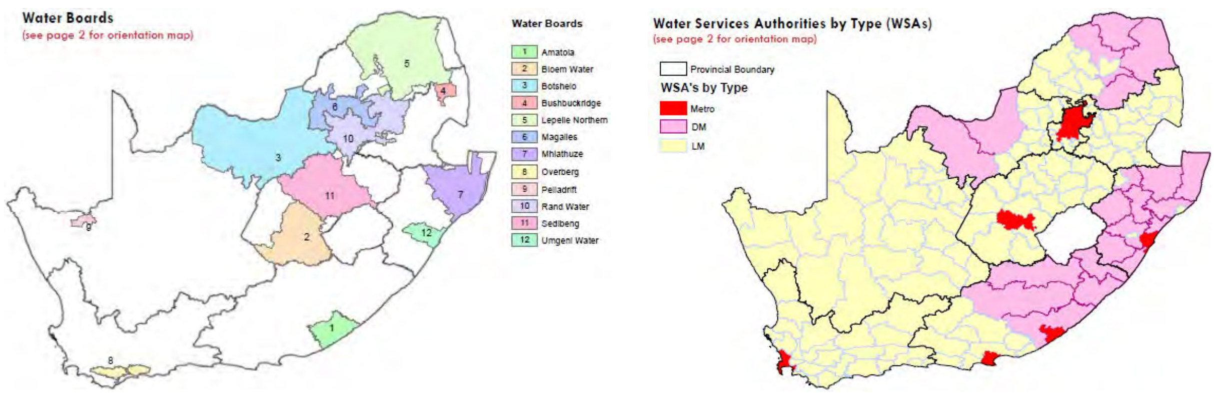
Water Services Authorities (WSAs): Municipalities as WSAs (Figure 4.26) have the constitutional responsibility for planning, ensuring access to and regulating provision of water services (water supply and sanitation). WSAs may provide water services themselves or contract external Water Services Providers (WSP). WSAs are responsible for securing from DWA licenses to abstract water from and to

---

59 Water Supply to 2 Million, The NamWater Perspective (2013)
60 Department of Water and Sanitation (DWS) since 2014
61 Proposed by DWS in 2014

discharge wastewater into a water resource. Although South Africa has 278 municipalities (made up of 8 metros, 44 district municipalities, and 226 local municipalities), not all have WSAs as there are only 152 WSAs in the country.

Water Services Providers (WSPs): A water services provider (WSP) is defined as: (i) any person who has a contract with a WSA or another WSP to sell water to or accept wastewater for the purposes of treatment from that Authority or Provider, who is usually a bulk water services provider; (ii) Any person who has a contract with a WSA to take responsibility for providing retail water services to one or more consumers within a specific geographic area; or (iii) A WSA that provides either or both of the above services itself. In the case where water services provision has been delegated to a WSP by means of a service delivery agreement, the WSP is responsible for applying for and obtaining a water use license.



Water Boards WSAs

Source: Strategic Overview of the Water Sector in South Africa 2013

Figure 4.26 Water Boards and WSAs in South Africa

(2) Present Water Supply Development and Management

According to WHO/UNICEF, the proportion of urban population served with piped water supply in South Africa was 91.7% in 2015.

DWA conducted a performance evaluation of the water service provision by WSAs using 16 performance indicators in 2012 (Table 4.20). Of the 152 WSAs, the level of water service provision was evaluated as follows: only 3% is satisfactory, 18% is at risk, 33% is at high risk, and 46% at crisis.

Table 4.20 Performance Indicators for WSAs

1. Water Services Development Planning	5. Water Resource Management	9. Infrastructure Asset Management	13. Information Management
2. Management Skill Level	6. Water Conservation and Demand Management	10. Operation and Maintenance of Assets	14. Organizational Performance
3. Staff Skill Levels	7. Drinking Water Quality	11. Financial Management	15. Water Service Quality
4. Technical Staff Capacity	8. Wastewater/ Environmental Safety	12. Revenue Collection	16. Customer Care

Source: Strategic Overview of the Water Sector in South Africa 2013

4.4.5 Madagascar

(1) Administrative Framework of Water Supply Development and Management

In 2008, the government established the Ministry of Water Resources (*Ministere de l'Eau*) which has the responsibility for coordinating the water and sewerage sector[62]. In urban areas, *Jiro Sy Rano Malagasy* (JIRAMA), a water supply and power entity, is responsible for water supply services. JIRAMA expands the water and power supply to 232 communes in 65 cities all over the country. JIRAMA has an operation center in 66 locations comprising five for water supply only and 61 for both water and power supplies[63].

(2) Present Water Supply Development and Management

According to WHO/UNICEF, the proportion of urban population served with piped water supply was 15.6% in 2015.

According to the annual report of the Ministry of Water Resources[64], the average proportion of urban population served with water in 2012 was 61% (Figure 4.21). It is presumed that this figure would include urban population served with both pipe water supply and improved water supply as defined by WHO/UNICEF.

Table 4.21 Urban Population Served with Water in Madagascar

Province	Region	Population	Population Served	%
Antananarivo	Analamanga	1,329,374	1,277,350	96
	Bongolava	53,225	39,080	73
	Itasy	84,367	25,580	30
	Vakinankaratra	407,668	166,560	41
Antsiranana	Diana	171,295	169,940	99
	Sava	119,465	58,940	50
Fianarantsoa	Amoron'i Mania	114,045	36,370	32
	Atsimo-Atsinanana	111,367	41,160	37
	Haute Matsiatra	269,911	145,950	54
	Ihorombe	52,172	17,030	33
	Vatovavy-Fitovinany	208,344	33,020	16
Mahajanga	Betsiboka	64,044	25,920	40
	Boeny	258,982	191,400	74
	Melaky	64,187	17,350	27
	Sofia	101,745	61,110	60
Toamasina	Alaotra-Mangoro	188,975	66,050	35
	Analanjirofo	194,249	44,010	23
	Atsinanana	368,954	183,010	50
Toliara	Androy	137,351	17,510	13
	Anosy	99,949	59,710	60
	Atsimo-Andrefana	274,342	170,060	62
	Menabe	111,613	78,640	70
	Total	4,785,624	2,925,750	61

Source: Ministere de l’Eau

4.4.6 Mozambique

(1) Administrative Framework of Water Supply Development and Management[65]

The institutional setting of the water sector in Mozambique is defined by the 1991 Water Law and the 1995 National Water Policy. The Water Law determines that the main bodies responsible for water resources management are the Ministry of Public Works and Housing (*Ministério de Obras Públicas e Habitação*: MOPH) and the National Directorate of Water (*Direcção Nacional de Águas*: DNA). The National Water Council (*Conselho Nacional de Águas*: CNA) and Regional Water Administrations (*Administração Regional de Águas*: ARAs) were also established by the law. The CNA is responsible for advising the government on issues related to water management and policy. The ARAs are to implement integrated water resources management at river basin level across the country.

62 IWRM Survey and Status Report: Madagascar (2009)
63 JIRAMA website, http://www.jirama.mg/
64 ANNUAIRE DU SECTEUR EAU POTABLE ET ASSAINISSEMENT 2013
65 Mozambique, Country Water Resources Profile

The institutional framework in place for water management includes central as well as regional/provincial and local levels. At the central level, the DNA is composed of the Department of Administration and Finance, Department of Urban Water, Department of Sanitation, Department of Water Resources Management, and Department of Rural Water and International Rivers Office. At the regional level, the management of water resources is performed by the five regional water agencies (ARA Sul, ARA Centro, ARA Zambezi, ARA Centro-Norte, and ARA Norte). At the provincial level, water management is performed by the Provincial Directorates of Public Works.

The DNA is in charge of overall planning and management of the country's water resources and the provision of water supply and sanitation services in both rural and urban areas. The Investment Fund and Water Supply Asset Holder (*Fundo de Investimento e Património de Abastecimento de Água*: FIPAG) is a public entity that entrusts water supply operation and management to water utilities. The Water Regulatory Council (*Conselho de Regulação do Abastecimento de Água*: CRA) is an independent regulatory agency that sets the tariff regime to ensure a viable and sustainable water sector[66]. The Water and Sanitation Infrastructure Administration (*Administração de Infraestruturas de Abastecimento de Água e Saneamento*: AIAS) under the MOH is responsible for water supply and sanitation systems in the population centers other than the jurisdictions by FIPAG.

(2) Present Water Supply Development and Management

According to WHO/UNICEF, the proportion of urban population served with piped water supply in Mozambique was 25.5% in 2015.

The 2012 annual report of the CRA[67] describes the operational indicators of water supply in the major coastal cities in Mozambique as shown in Table 4.22 below.

Table 4.22 Operational Indicators of Water Supply in the Major Coastal Cities in Mozambique (2012)

Indicator		Maputo /Matola	Beira /Dondo	Quelimane	Nacala	Pemba
Service Coverage	%	61	91	74	54	90
Hours of Water Distribution	Hour	16	24	21	19	16
Non-revenue Water	%	51	28	33	29	24
Revenue Collection Ratio	%	85	91	96	65	52
Operating Ratio		1.18	1.20	0.86	0.89	0.87

Source: CRA

4.4.7 Tanzania

(1) Administrative Framework of Water Supply Development and Management

For water resources and water supply development by the government, the National Water Policy in 2002 designated the administrative reform of water resources development and management system by the Ministry of Water from the administrative units (province) to nine river basins. In addition, the Ministry of Water took charge of the plans for capacity development on water resources management, rural water supply, urban water supply, and institutional strengthening on the basis of the Water Sector Development Programme established in 2007. Afterwards in 2009, the Ministry of Water and Irrigation was established through the administrative reform. The ministry takes charge of the

---

66 USAID Country Profile, Property Rights and Resource Governance, Mozambique (2011)

67 RELATÓRIO AO GOVERNO 2012

development of water sector policies, promotion, coordination, and supervision for implementing water supply projects, coordination and supervision, and technical advice to municipalities[68].

The Energy and Water Utilities Regulatory Authority (EWURA) is responsible for licensing and supervision of water supply services, establishment of standards for water supply development, pricing preparation of water pricing guidelines, approval for amendment of water tariff, and monitoring of water quality and service levels[69]. The regional water supply and sanitation authorities (Regional WSSAs) provide the water supply services in the major cities and their surrounding areas. The number of Regional WSSAs was 23 in the 2013/2014 fiscal year[70].

In the capital Dar es Salaam, the privatization of water supply service provider failed in the past. Afterwards, two public agencies co-exist, namely, Dar es Salaam Water Supply and Sewerage Authority (DAWASA), which is responsible for the asset management of water supply facilities, and Dar es Salaam Water Supply and Sewerage Corporation (DAWASCO), which is responsible for the operation of water supply services[71].

(2) Water Supply Development and Management

According to WHO/UNICEF, the proportion of urban population served with piped water supply in Mozambique was 27.7% in 2015.

The Water Utilities Performance Review Report 2013/2014 of EWURA describes the operational indicators of water supply in the major coastal cities in Tanzania as shown in Table 4.23 below.

Table 4.23 Operational Indicators of Water Supply in the Major Coastal Cities in Tanzania (2012)

Indicator		DAWASCO	Tanga WSSA	Mtwara WSSA
Population Directly Served with Water	%	50.1	96.6	44.0
Average Service Hours	Hour	8.0	23.5	10.5
Non-revenue Water	%	57.4	22.6	38.1
Revenue Collection Efficiency	%	95.5	94.1	92.1
Operating Ratio		1.29	0.98	1.20

Source: EWURA

4.4.8 Mauritius

(1) Administrative Framework of Water Supply Development and Management

The Ministry of Energy and Public Utilities is responsible for policy-making and establishment of the legal framework to manage the development of the energy sector and water supply and sewerage sector. Under the Ministry of Energy, the Central Water Authority (CWA) is the sole water supply entity in Mauritius and is taking charge of the water supply for households, government administrations, private firms, and other water consumers.

(2) Water Supply Development and Management

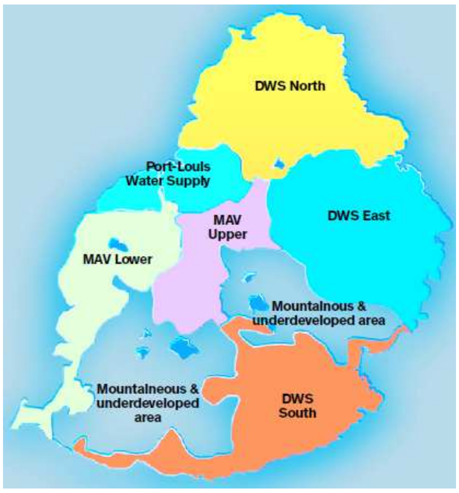
According to WHO/UNICEF, the proportion of urban population served with piped water supply in Mauritius was 99.9% in 2015.

---

68 The Detailed Planning Survey Report on the Study on Water Resources Development and Management in Wami/Ruvu Basin (2010)
69 Tanzania Water Supply and Sanitation Act (2009)
70 Water Utilities Performance Review Report 2013/2014
71 Water Supply and Sanitation in Tanzania

According to the Annual Report 2013 of CWA, Mauritius Island is divided into six water supply districts (Figure 4.27). The water production volume was 216.6 MCM/year (equivalent to 590,000 m^3/day) in 2013 consisting of 109.1 MCM/year of surface water and 107.5 MCM/year of groundwater.

Forty-five percent of the population is being served for 24 hours a day but 16% is being served for 16-20 hours, 12% for 12-15 hours, 25% for 8-12 hours, and 2% for less than eight hours. NRW rate was estimated to be 45% to 50%.



Source: Annual Report 2013, CWA

Figure 4.27 Water Supply Districts in Mauritius

4.5 Introduction of PPP

4.5.1 Cote d'Ivoire

In Cote d'Ivoire, urban water supply is operated through concession since 1959. This is one of the experiences of public-private partnership (PPP).

The decrees relating to PPP are accessible in the website of the National Steering Committee for PPP (*Comité National de Pilotage des Partenariats Public-Privé*: CNP-PPP)[72]. The website also shows a message by the president which mentions the following points:

- For Cote d'Ivoire to become part of the emerging countries by 2020, the major projects described in the National Development Program (*Programme National de Développement*: PND) should be completed.
- For the implementation of the National Development Program, it has been decided to assign a key role to the private sector through the promotion of PPPs. The financial contribution expected from the private sector is approximately 60% of the cost of the program.

The National Steering Committee for Public-Private Partnerships (CNP-PPP) is the decision-making, validation, and guidance body for the institutional framework for PPPs. The website describes the information about a number of PPP projects in various sectors such as agriculture, education, health, infrastructure, transportation, energy, and others. The water supply project of 300,000 m^3/day for Abidjan through the development of the Bandama River is one of the PPP projects in the infrastructure sector. The project will cover the construction and operation and maintenance (O&M) of water intake, water purification plant, and water transmission and distribution through build-operate-transfer (BOT) and concession.

4.5.2 Angola

In Angola, the PPP Act was passed by the parliament on January 14, 2011. Several international law firms have published their commentary about the PPP Act. The Public-Private Partnerships in Angola

[72] CNP-PPP, http://www.ppp.gouv.ci/message.html

(Gabinete Legal Angola, 2011)[73] suggested that it would be promising to promote PPP projects in sectors such as road, water and sewerage, energy, ports, airports, and logistics even though the PPP Act does not refer to specific sectors.

4.5.3 Namibia

The Namibia Public-Private Partnership Policy by the Ministry of Trade and Industry was approved by the government in 2012. According to the PPP Country Paper (2013), there were some PPP approaches before 2012 that include the power sector (NamPower), urban development sector (City of Windhoek: waste management, district development and services, water supply), and the mining sector (Ministry of Mines and Energy). The African Development Bank (AfDB) will support the Institutional Strengthening for Public-Private Partnerships (ISPPP) Project.

4.5.4 South Africa

The information relating to PPP in South Africa is described in detail in the website of the PPP Unit of the Department of the Treasury[74].

With regard to the legislation of PPP, a PPP framework was approved by the Cabinet in December 1999. An article was added to the Public Finance Management Act (PFMA) for the first time in April of the following year. Article 76 of the said Act stipulates that the National Treasury should establish the necessary regulations and orders. The Article 16 (REG 16) of the National Treasury Regulations 22 enacted in 2000, regulates the financial management of PPP[75].

The Government of South Africa is divided into three spheres: national, provincial, and local. The laws and regulations for each sphere are different. The PFMA is only used at the national and provincial levels; it does not apply to the PPPs of the local government. Instead, the Municipal Finance Management Act (MFMA) and Municipal Systems Act (MSA) are applicable[76].

The National Treasury has published the detailed manual of specific procedures to follow when implementing a PPP project. The manual consists of the following modules and gives a project cycle as shown in Table 4.24.

- Module 1: South African Regulations for PPPs
- Module 2: Code of Good Practice for BEE[77] in PPPs
- Module 3: PPP Inception
- Module 4: PPP Feasibility Study
- Module 5: PPP Procurement
- Module 6: Managing the PPP Agreement
- Module 7: Auditing PPPs
- Module 8: Accounting Treatment for PPPs
- Module 9: An Introduction to Project Finance

[73] Clifford Chance LLP, PLMJ International Legal Network, etc.
[74] http://www.ppp.gov.za/Pages/defaultold.aspx
[75] Data Collection Survey on Railway Sector in the Republic of South Africa, Final Report (2013)
[76] -ditto-
[77] Broad-Based Black Economic Empowerment

The Survey and Analysis of Water Sector Business Opportunities in South Africa by Price Waterhouse Coopers (2014) describes the potential opportunities of PPP, issues on implementation of PPP project, and successful experiences of PPP in the water sector.

Table 4.24 PPP Project Cycle in South Africa

Period	Phase	PPP Project Cycle	PPP Manual Reference
Project Preparation Period	Phase I	**INCEPTION** ● Register project with the relevant treasury ● Appoint project officer ● Appoint transaction advisor	Module 1 Module 2 Module 3 Module 6
	Phase II	**FEASIBILITY STUDY** Prepare a feasibility study comprising: ● Needs analysis ● Options analysis ● Project due diligence ● Value assessment ● Economic valuation ● Procurement plan **Treasury Approval: I**	Module 1 Module 2 Module 4 Module 6 Module 7 Module 8 Module 9
	Phase III	**PROCUREMENT** ● Design a fair, equitable, transparent, competitive, cost-effective procurement process ● Prepare bid documents, including draft PPP agreement **Treasury Approval: IIA** ● Pre-qualify parties ● Issue request for proposals with draft PPP agreement ● Receive bids ● Compare bids with feasibility study and each other ● Select preferred bidder ● Prepare value-for-money report **Treasury Approval: IIB** ● Negotiate with preferred bidder ● Finalize PPP agreement management plan	Module 1 Module 2 Module 4 Module 5 Module 6 Module 7 Module 8 Module 9
Project Term	Phase IV	**PPP agreement signed** **DEVELOPMENT** ● Measure outputs, monitor and regulate performance, liaise effectively, settle disputes	Module 1 Module 2 Module 5 Module 6 Module 7 Module 8 Module 9
	Phase V	**DELIVERY** ● Report progress in the Annual Report	
	Phase VI	**EXIT** ● Scrutiny by the Auditor-General	

Source, PPP Manual

4.5.5 Madagascar

The Procurement Law (2004) and Decrees on Public-private Partnership (2006-2007) in Madagascar are shown in the website of the Public-Private Partnership in Information Resource Center (PPPIRC)[78].

78 http://ppp.worldbank.org/public-private-partnership/legislation-regulation/laws/ppp-and-concession-laws

After the Water Code was passed in 1999, the first case of PPP in the water supply sector took place in Sabotsy Namehana Commune located in the suburb of the capital city Antananarivo. JIRAMA and the commune entrusted the development of public water taps in 25 locations and O&M and cost recovery for seven years to a private firm, i.e., Sandandrano. Afterwards, the contract was extended for additional seven years and public water taps increased in 35 locations with a total water supply of 150,000 liters/day. In addition, with the support of the World Bank, Ambohijanaka Commune located in Antananarivo suburb entrusted the construction of piped water supply for a population of about 6,000 and O&M for 25 years to Sandandrano. In relation to these opportunities, other private operators have also taken part in communal water supplies[79].

4.5.6 Mozambique

In Mozambique, the Public-private Partnership (PPP) Promotion Law was promulgated in August 2011. The government is promoting the development of infrastructure through private participation for road, railway, bridges, power, and communication and offers investment opportunities under PPP (e.g., BOT). The PPP Act prescribes the participation of state-owned enterprises and their obligation in PPP projects[80].

In 1999, FIPAG leased *Águas de Moçambique* (AdM) to a consortium led by an international private operator with significant experience - SEUR International. Other members of the consortium were *Águas de Portugal* (AdP) and Mazi-Mozambique (a group of five Mozambican private investors). In this arrangement, large investments in water distribution and disposal were still the responsibility of FIPAG, while AdM took over the management and revenue collection. After the withdrawal of SEUR International, AdP was left with 73% of the company and the contract was renegotiated in 2003. The contract for AdM was a full commercial concession for 15 years, covering the water demands of a large fraction of Maputo.

Due to a series of problems caused by water loss that remained unimproved at a level of 50%, FIPAG bought out AdP and took complete control of the water company in December 2010. FIPAG considered that the original objectives of PPP had been met, which is providing capital and know-how, and by then, AdM was mostly staffed by Mozambicans. Nevertheless, AdM is far from full cost recovery, perhaps because it still faces 50% water losses and the sector depends on donor financing[81].

4.5.7 Tanzania

The overview of PPP schemes is described in the website of the Tanzania Investment Centre as follows[82]:

Policy, legal, and regulatory framework: The Public-Private Partnership (PPP) Policy was issued in 2009, the Public-Private Partnership Act (PPP Act) was passed in 2010, and the PPP Regulations was passed in 2011. The new Public Procurement Act (2011) makes specific provision for PPP procurement, for both solicited and unsolicited proposals.

---

[79] Public-Private Partnerships in Madagascar: a promising approach to increase sustainability of piped water supply systems in rural towns

[80] Mozambique Investment Guide (2015)

[81] Assessment of Public-Private Partnership in Mozambique (2012)

[82] http://www.tic.co.tz/menu/314

Institutional arrangement: A finance unit (FU) has been created within the Ministry of Finance (MoF) to assess, manage and monitor fiscal risk, to assess affordability of projects, and to appraise value for money from PPPs with a view to recommend PPP projects for approval by the Minister of Finance. A coordination unit (CU) has been created within the Tanzania Investment Centre (TIC), which reports to the Ministry of Industry, Trade, and Investment. The CU is focusing on promotion and coordination of all matters relating to PPPs. Line ministries and other contracting authorities are required under the PPP Act to identify, appraise, develop, and monitor these projects.

Enabling environment: Currently, the government is working to create a healthy pipeline of potential projects. It is developing PPP Operational Guidelines, an implementation strategy and action plan. For easy and timely implementation of PPP projects, the government is finalizing the set up of a PPP Facilitation Fund.

Areas of investment: The PPP framework in Tanzania covers all areas of investment, although the emphasis is on infrastructure development. Some of the key important sectors are road, rail, port, airport, power, and agriculture.

In 2003, City Water Services (CWS), a private operator, was engaged under a lease contract with the Dar es Salaam Water and Sewerage Authority (DAWASA) to provide water supply and sewerage services in Tanzania's largest city. But the performance of CWS was disappointing and it encountered serious financial difficulties. Within two years, the contract collapsed. Afterwards, in June 2005, a public corporation, the Dar es Salaam Water and Sewerage Corporation (DAWASCO), took over the operation of the services and encountered many of the same constraints that CWS had. Despite new financial injections and an increase in the Operator's Tariff in 2006/07, its financial performance was unsatisfactory and, during the first two years, operational results were poor. After five years, operational performance had improved but further progress is still needed.

The case raises compelling questions about the preparation of PPP, the selection process, the allocation of risks in the contract, expectations regarding financial viability and service improvements, the effectiveness of the PPP that has existed since the private operator departed, and how to structure institutional relationships to ensure accountability. It also provides an opportunity to evaluate how customers, especially the poor, were affected[83].

4.5.8 Mauritius

The overview of PPP schemes is described in the website of the Public-Private Partnership Unit under the Ministry of Finance[84].

The PPP Act of 2004, which was amended in 2008, establishes a PPP Committee under the chairmanship of the Policy Procurement Office (PPO). The PPP Committee is expected to deal with all matters relating to PPP project. The members of the committee are as follows:

- Director of the Procurement Policy Office. He is the chairperson of the committee;
- Senior Analyst, representing the Ministry of Finance and Economic Development;
- Deputy Chief Architect, representing the Ministry of Public Infrastructure, Land Transport, and Shipping; and

[83] A Case Study of Public-Private and Public-Public Partnerships in Water Supply and Sewerage Services in Dar es Salaam (2012)

[84] http://ppp.mof.govmu.org/English/Pages/default.aspx

- State Counsel, State Law Office (SLO) representing the Attorney-General's Office.

The PPP Committee will be assisted by the PPP Unit which comprises staff from the Ministry of Finance and Economic Development. The functions of the committee are as follows:

- To make an assessment of the submitted feasibility studies and give recommendations to relevant contracting authorities;
- To develop best practice guidelines in relation to all aspects of PPP;
- To formulate policy in relation to PPP projects; and
- To develop PPP awareness in the country.

Public-Private Partnerships in Mauritius (PPP Unit, 2011)[85] describes the major projects as shown in Table 4.25:

Table 4.25 Major PPP Projects in Mauritius

Project	Description
Highland Project	920 ha of urban development, total project cost of USD 3 billion, project period of 15 years
Toll Road Project	Port Louis outer ring road and north-central road (new and upgraded), total project cost of USD 530 million, construction period of 38 months, concession of 30 years
Curepipe Wind Farm Project	Wind power generation by BOO (25 to 40 MW), total project cost of USD 56 million, electricity sales contract for 20 years
Maheborg Waterfront Project	Tourism development around the international airport, total project cost of USD 48 million, concession period of 60 years

Source: Public-Private Partnerships in Mauritius (2011)

[85] Public-Private Partnerships in Mauritius (PPP Unit, 2011), The Commonwealth iLibrary, OECD

Chapter 5 Selection of Locations to be Surveyed

5.1 Methodology for Selection of Locations to be Surveyed

Based on the data collection and compilation described in the previous chapters, the locations to be surveyed for seeking the feasibility of seawater desalination project are selected through the methodology explained below.

1) Identification of Potential Locations

There are a number of coastal cities within the surveyed counties. Of these cities, the potential locations are identified on the basis of a population scale as it is presumed that the city to need seawater desalination plant would have a certain large population.

2) Screening of Potential Locations

The potential locations are screened from the viewpoints of economic growth, water resources development (surface water and groundwater), water supply development level, and policy and planning for water supply development. The screening criteria are set for each of the viewpoints. The screened locations are further assessed to conclude the locations to be surveyed.

3) Selection of Locations to be Surveyed

For selecting the locations to be surveyed, the following alternative scenarios are assumed for assessing the possibility of seawater desalination project. The locations to be surveyed are concluded through the assessment.

- Scenario 1: Limitation of exploitable water resources
- Scenario 2: Solution for vulnerability of water supply against drought
- Scenario 3: Need for early expansion of water supply capacity

5.2 Identification of Potential Locations

5.2.1 Process for Identification of Potential Locations

The potential locations are identified through the following process.

- The scale of seawater desalination plant is assumed for possible project preparation envisaging Japanese ODA loan.
- The daily maximum capacity of the whole water supply system is computed, assuming the proportion of water supply capacity by seawater desalination to that of the whole water supply system.
- The scale of population served by the water supply system is estimated through the reverse process of water demand projection. The estimated population is regarded as a standard for identifying the potential location.
- The potential locations are identified in consideration of the population and other requirements taken into account, e.g., availability of seawater desalination planning and strategic locality of the economic corridor.

5.2.2 Assumed Scale of Seawater Desalination Plant

In the surveyed countries, the seawater desalination plants introduced or planned for public water supply are listed Table 5.1 below. Installed capacity of existing seawater desalination plant ranges from 750 to 4,000 m^3/day. Population size of corresponding coastal city varies from 25,000 to 50,000. Planned installed capacity of seawater desalination plant is more than 10,000 m^3/day.

Table 5.1 Seawater Desalination Plants Introduced or Planned for Public Water Supply in Surveyed Countries

Country	Capacity (m^3/day)	Existing/ Planned	Region	Coastal City	Population
Namibia	10,977	Planned	Erongo Region	Swakopmund	44,725 (2011)
Namibia	60,000	Planned	Erongo Region	Swakopmund	44,725 (2011)
South Africa	750	Existing (2009)	Ndlambe Municipality Cacadu District, Eastern Cape	Port Alfred	25,858 (2011)
South Africa	2,000	Existing (2010)	Knysna Municipality Eden District, Western Cape	Knysna	50,029 (2011)
South Africa	2,000	Existing (2011)	Bitou Municipality Eden District, Western Cape	Plettenberg Bay	31,822 (2011)
South Africa	1,700	Existing (2011)	Cederberg Municipality West Coast District, Western Cape		
South Africa	13,000	Planned	Nelson Mandela Bay Municipality Eastern Cape	Port Elizabeth	876,436 (2011)
South Africa	25,500	Planned	West Coast District Municipality Western Cape	Saldanha	28,142 (2011)
South Africa	100,000	Planned	City of Cape Town Western Cape	Cape Town	3,430,992 (2011)
South Africa	300,000	Planned	Ethekwini Kwazulu-Natal	Durban	2,786,046 (2011)
Mauritius	4,000	Existing (2005)	Rodrigues Island	Rodrigues Island	41,669 (2014)

Source: Seawater Desalination Plant – DesalData (GWI), Population - City Population

In recent years, the Japan International Cooperation Agency (JICA) has been implementing or preparing projects for construction of seawater desalination plant in Africa. These plant scales are 40,000 m^3/day (20,000 m^3/day×2 units) in Santiago Island in Cape Verde, 100,000 m^3/day in Sfax in Tunisia, and 50,000 m^3/day in Mamells in Senegal. The population scales of the corresponding water supply service area are 355,300 (year 2020) in Santiago Island, 737,900 (year 2025) in the Sfax Metropolitan Area, and 5,446,200 (year 2025) in Dakar Province.

The scale of seawater desalination plant is assumed to be 10,000 m^3/day or more for possible project preparation by JICA, in light of those planned in the surveyed countries within the present survey as well as the examples being implemented or under consideration by JICA.

5.2.3 Proportion of Water Supply Capacity by Seawater Desalination Plant

In consideration of seawater desalination plant to be introduced to public water supply, the present survey sets an assumption regarding the proportion of water supply capacity by seawater desalination to that of the whole system in terms of daily maximum water supply. For seawater desalination plants being financed or under consideration by JICA, the proportion of water supply capacity by seawater desalination to that of the whole system is summarized in Table 5.2.

Table 5.2 Proportion of Water Supply Capacity by Seawater Desalination Plant

Country	Service Area	Capacity of Whole System (m^3/day)	Capacity of Seawater Desalination Plant	
			(m^3/day)	(%)
Cape Verde	Santiago Island	55,000 (2020)	Existing 5,000 Planned 10,000 Planned (JPY Loan) 40,000	100
Tunisia	Sfax Metro	221,800 (2025)	Planned (JPY Loan) 100,000	45
Senegal	Dakar Province	664,200 (2025)	Planned 50,000 Planned (JPY Loan) 50,000	15

Source: Preparatory Survey Reports

At the time of planning in 2006, the water supply capacity in Santiago Island was 11,300 m^3/day including seawater desalination of 5,000 m^3/day. Meanwhile, the Santiago Island Project was planned on the condition that seawater desalination plants would contribute to 100% of the water supply. The Sfax Metropolitan Area is highly dependent on water resources transferred from the neighboring areas at present. It is forecasted that the allocation of water resources to the Sfax Metropolitan Area needs to decrease as water demand in the neighboring areas will increase in the future. The Sfax Project is planned to introduce seawater desalination plant in order to cope with future decrease of water resources allocation. The proportion of water supply capacity by seawater desalination results in a high rate accordingly. As the water supply capacity is large in the Daker Province, the proportion of the planned capacity of seawater desalination is relatively low.

There are only few data on the proportion of water supply capacity by seawater desalination within the water supply system. It is also dependent on the scale of the water supply system as well as availability of water resources. As it is not easy to set a generalized figure, the present survey assumes a proportion of 30% as an intermediate value between Tunisia (45%) and Senegal (15%). Based on the assumed figure, the water supply capacity of the whole system is computed to be 33,333 m^3/day (=10,000×100/30) when a 10,000 m^3/day of seawater desalination plant is introduced.

5.2.4 Scale of Population

The scale of population for identifying potential locations is estimated from the water supply capacity of the whole system as assumed. For computing the scale of population, the planning values of water demand projection are analyzed in terms of per capita demand (lpcd), non-domestic demand (% of domestic demand), water loss (% of total demand), and peak factor (for peak demand within a day). Planning values used for the seawater desalination plants being financed or under consideration by JICA are summarized in Table 5.3 below.

Table 5.3 Planning Values of Water Demand Projection for Seawater Desalination Plant

Country	Service Area	Per Capita Demand (lpcd)	Non-domestic Demand (%)	Water Loss (%)	Peak Factor[1]
Cape Verde	Santiago Island	121	10	15	1.007
Tunisia	Sfax Metro	126	18	22	1.400
Senegal	Dakar Province	73	15	22	1.100

Source: Preparatory Survey Reports

[1] Within the daily maximum water demand, the peak factor of 1.4 is applied only for tourism water demand in Cape Verde. The daily maximum water demand is calculated by multiplying the peak factor with the daily average water demand in Tunisia and Senegal.

The planning values in the countries surveyed are analyzed as follows:

1) Per Capita Water Demand

Per capita water demand used for planning seawater desalination plants by JICA ranges from 73 to 126 lpcd. On the other hand, the range of per capita water consumption is wider among six of the surveyed countries as shown in Table 5.4. In addition, per capita water consumption is 165 lpcd in Mauritius[2].

Table 5.4 Per Capita Water Consumption in Surveyed Countries

Water Utility	Water Consumption (lpcd)
South Africa, Cape Town	182
Namibia, Walvis Bay Municipality	179
Cote d'Ivoire, SODECI	40
Mozambique, AdM Maputo	42
Madagascar, JIRAMA	36
Tanzania, DAWASCO	39

Source: The Future of Water in African Cities, World Bank (2012)

Per capita water consumption is remarkably high in South Africa, Namibia, and Mauritius. In the other countries, it is presumed that their per capita water consumption would vary in a wide range by region in the country as well as by area in major city.

For example, *Société de distribution d'eau de Côte d'Ivoire* (SODECI), the water supply entity of Cote d'Ivoire, operates the water supply for cities all over the country. It is presumed that per capita water consumption would be different between Abidjan and other cities. According to the recent document by MIE/ONEP, per capita water consumption in the cities ranges from 50 to 100 lpcd in Cote d'Ivoire[3]. For the other countries, no data on the range of per capita water consumption was obtained from the available literature.

In consideration of a large difference in per capita water consumption between three countries (South Africa, Namibia, and Mauritius) and others, the present survey assumes the following planning values of per capita water demand:

- South Africa and Namibia: 180 lpcd (same as per capita water consumption)
- Mauritius: 165 lpcd (same as per capita water consumption)
- Cote d'Ivoire, Angola, Mozambique, Madagascar, and Tanzania: 100 lpcd (considering the high side of the range in Cote d'Ivoire)

2) Non-domestic Demand

For the surveyed countries, no data on water distribution by consumer category was identified from the available literature. The present survey assumes that non-domestic demand would be equivalent to 20% of domestic demand.

3) Water Loss

Water loss from transmission and distribution network does not coincide exactly with non-revenue water (NRW). Meanwhile, the majority of NRW is considered to be caused by leakage from water pipes. In addition, NRW is generally used as one of the principal indicators for evaluating the operational performance of water utility. Therefore, the present survey refers to NRW for setting the planning value of water loss.

---

[2] Water Account, Mauritius 2013

[3] Mécanismes de Financement du Secteur de l'eau Potable en Côte d'Ivoire

NRW remains at a high rate in the surveyed countries as shown in Table 5.5. It is expected that NRW will gradually improve in the future for the surveyed countries but will stay at a higher rate compared with those countries with seawater desalination projects being financed or under consideration by JICA. The present survey assumes a rate of 25% as the planning value of water loss.

Table 5.5 Non-revenue Water in Surveyed Countries

Water Utility	NRW (%)
Cote d'Ivoire, SODECI (Abidjan)	30
South Africa, eThekwini (Durban)	36
South Africa, Nelson Mandela Bay (P. Elizabeth)	43
South Africa, Buffalo City (East London)	48
South Africa, Cape Town	21
Tanzania, DAWASCO	57
Tanzania, Tanga WSSA	22
Mauritius, CWA	50

Source: Published documents in each country

4) Peak Factor

The peak factor is based on the analysis of hourly variations of water supply volume in a day in order to identify the ratio of peak to daily average water supply. For the surveyed countries, no such data was identified from the available literature. The present survey assumes a peak factor of 1.4 in light of those for the seawater desalination projects being financed or under consideration by JICA. It is a generally reasonable planning value for a water supply system serving a population of 1 million or less.

Based on the above, the scale of population for identification of potential locations is presented in Table 5.6 and is computed based on the condition that the corresponding water supply system has an installed capacity of 33,333 m^3/day including seawater desalination plant.

Table 5.6 Scale of Population for Identification of Potential Locations

Planning Value			Five Counties	South Africa Namibia	Mauritius
Population Served		A	158,729	88,183	96,199
Per Capita Water Demand	lpcd	B	100	180	165
Domestic Demand	m^3/day	C = A×B	15,873	15,873	15,873
Ratio of Non-domestic Demand	%	D	20	20	20
Total Demand	m^3/day	E = C×(1+D)	19,047	19,047	19,047
Water Loss	%	F	25	25	25
Daily Average Water Demand	m^3/day	G = E×(1+F)	23,809	23,809	23,809
Peak Factor		H	1.4	1.4	1.4
Daily Maximum Water Demand	m^3/day	I = G×H	33,333	33,333	33,333

Source: Prepared by the Survey Team

5.2.5 Potential Locations

The potential locations along the coast are selected in due consideration of the population scale as discussed above. Population of coastal city in 2025 is projected approximately based on the Population Estimates and Projections by the World Bank[4]. Some coastal cities are included in the potential locations even if their population scale is less. These coastal cities should: (i) have a plan of seawater desalination plant as suggested by DesalData (GWI) and (ii) correspond to a key location, i.e., economic corridor and/or growth pole, as described in Chapter 3 of this report. Table 5.7 and Figure 5.1 presents the potential locations.

[4] Population Estimates and Projections, World Bank, http://datatopics.worldbank.org/hnp/popestimates

Table 5.7 Potential Locations

Country	Coastal City	Population				Remarks	
		Recent Estimate		Projection		Plan of Seawater Desalination	Economic Corridor / Growth Pole
Cote d'Ivoire	San Pedro	174,287	(2014)	250,132	(2025)		✓
	Abidjan	4,707,404	(2014)	6,755,939	(2025)		✓
Angola[5]	Cabinda	475,577	(2014)	774,920	(2025)		✓
	Soyo	161,245	(2014)	262,737	(2025)		✓
	Dande	161,050	(2014)	262,419	(2025)		
	Cazenga	840,792	(2014)	1,370,012	(2025)		✓
	Cacuaco	860,338	(2014)	1,401,861	(2025)		✓
	Viana	1,487,568	(2014)	2,423,889	(2025)		✓
	Luanda	2,054,957	(2014)	3,348,409	(2025)		✓
	Belas	1,038,478	(2014)	1,692,128	(2025)		✓
	Sumbe	102,259	(2014)	166,623	(2025)		
	Lobito	203,503	(2014)	331,595	(2025)		✓
	Catumbela	105,269	(2014)	171,528	(2025)		✓
	Benguela	322,441	(2014)	525,395	(2025)		✓
	Namibe	185,029	(2014)	301,491	(2025)		✓
Namibia	Swakopmund	44,725	(2011)	74,225	(2025)	✓	✓
	Walvis Bay	62,096	(2011)	103,054	(2025)	✓	✓
	Luderitz	12,537	(2011)	20,806	(2025)		✓
South Africa	Saldanha	28,142	(2011)	37,104	(2025)	✓	
	Cape Town	3,430,992	(2011)	4,523,615	(2025)	✓	
	Somerset West	188,035	(2011)	247,916	(2025)		
	George	157,397	(2011)	207,521	(2025)		
	Port Elizabeth	876,436	(2011)	1,155,543	(2025)	✓	
	East London	295,644	(2011)	389,794	(2025)	✓	
	Durban	2,786,046	(2011)	3,673,282	(2025)	✓	✓
Madagascar	Antsiranana	118,100	(2014)	190,834	(2025)		
	Toamasina	282,100	(2014)	455,837	(2025)		✓
	Tolagnaro	50,400	(2014)	81,440	(2025)		✓
	Toliara	161,000	(2014)	260,155	(2025)		
	Mahajanga	226,600	(2014)	366,156	(2025)		
	Andoany	40,600	(2014)	65,604	(2025)		✓
Mozambique	Pemba	208,600	(2016)	285,016	(2025)		
	Nacala-Port	243,800	(2016)	333,110	(2025)		✓
	Quelimane	245,900	(2016)	335,980	(2025)		
	Beira	462,200	(2016)	631,516	(2025)		✓
	Maputo	1,257,500	(2016)	1,718,155	(2025)		✓
	Matola	962,100	(2016)	1,314,543	(2025)		✓
Tanzania	Tanga	221,127	(2012)	419,805	(2025)		
	Zanzibar	501,459	(2012)	952,009	(2025)		
	Dar es Salaam	4,364,541	(2012)	8,285,990	(2025)		✓
	Mtwara	100,626	(2012)	191,036	(2025)		✓
Mauritius	Mauritius Island	1,219,265	(2014)	1,243,449	(2025)		

Source: Country's Population Statistics, City Population

5 Population in coastal city is estimated to be (total population in district) × (urban population ratio in province).

Source: Prepared by the Survey Team

Figure 5.1 Potential Locations

5.3 Screening of Potential Locations

5.3.1 Screening Criteria

(1) Economic Growth

In Sub-Saharan Africa, a large demand for infrastructure development including water sector is expected at key locations where population and economic growth are taking place under large-scale development initiatives. To assess the possibility of economic growth, the screening criteria are set on the basis of information about the economic corridors and growth poles as described in Chapter 3.

For the economic corridors, JICA carried out a series of studies and selected eight economic corridors for further consideration. In addition, JICA is currently conducting the West African Growth Ring Corridors Strategic Master Plan Project. Potential locations relevant to these corridors are given ‘high’ mark in terms of economic growth potential as shown in Table 5.8. Potential locations relevant to other economic corridors and growth centers are marked as ‘medium’ in terms of economic growth.

Table 5.8 Screening Criteria for Economic Growth

Symbol	Economic Growth	Condition
A	High	Economic corridors surveyed by JICA
B	Medium	Other economic corridors and growth poles identified
C	Low	Not applicable for any of the above

Source: Prepared by the Survey Team

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

For seawater desalination as an alternative water resources development to surface water and groundwater, the issues to be discussed are: 1) competitiveness of capital expenditure (Capex) and operating expense (Opex) and 2) need for early implementation to cope with the rapid increase of water demand even with its high cost. The screening criteria are set considering that the project cost and construction period are dependent on the level of difficulty of the water resources development.

Based on the information on water resources described in Chapter 4, potential locations are given ‘high’ difficulty in case of the following conditions: (i) long-distance water conveyance is essential due to the absence of water resource nearby; (ii) new water resource development should be restricted under extensive regional water utilization that is already taking place; and (iii) the absolute limit of exploitable water resource is foreseeable in the island.

When water resources are available in the vicinity of potential locations, the project cost and construction period are dependent on the scale of the water resources development. For the time being, it is not possible to identify the scale of water resources development on the basis of the gap between water demand and supply in each potential location. ‘Medium’ difficulty and ‘low’ difficulty in terms of water resources development are defined in Table 5.9 depending on the scale of population.

Table 5.9 Screening Criteria for Water Resources Development

Symbol	Difficulty	Condition
A	High	Long-distance water conveyance
		Restriction and/or limitation of water resource development
B	Medium	Water resources are available nearby, population more than 500,000
C	Low	Water resources are available nearby, population less than 500,000

Source: Prepared by the Survey Team

(3) Water Supply Development Level

Seawater desalination requires high water production cost compared with water supply using surface water and groundwater. In order to ensure the recovery of Capex and Opex for the seawater desalination plant, the water utility should attain a high performance on its services. Even in developing countries, potential locations should attain a certain high level of water supply services as one of the conditions to increase the possibility of seawater desalination to be introduced to the public water supply system. The screening criteria are set in Table 5.10 considering the proportion of urban population served with piped water in African countries, where the introduction of seawater desalination to the public water supply system is already done or under consideration.

Table 5.10 Screening Criteria for Water Supply Development Level

Symbol	Development Level	Condition
A	High	Population served with piped water, more than 80%
B	Medium	Population served with piped water, more than 50%
C	Low	Population served with piped water, less than 50%

Source: Prepared by the Survey Team

(4) Policy and Planning for Water Supply Development

The screening criteria are set in Table 5.11 considering the mention of seawater desalination in the policy and planning for water supply development. Potential locations with information on seawater desalination, either planned or under consideration, are given 'high' mark in terms of policy and planning. Even though the specific region is not mentioned, potential locations in the country where the national policy describes the need to consider seawater desalination are given 'medium' mark in terms of policy and planning.

Table 5.11 Screening Criteria for Policy and Planning for Water Supply Development

Symbol	Policy and Planning	Condition
A	High	Seawater desalination, either planned or under consideration, for urban water supply
B	Medium	National policy to consider seawater desalination
C	Low	Not applicable for any of the above (or unknown)

Source: Prepared by the Survey Team

5.3.2 Screening and Assessment

Economic Growth: In South Africa, the North-South Corridor from Durban towards the north will be further developed as the trunk logistics route in Southern Africa. On the other hand, transportation infrastructure, such as road, railways, and port, has already been well developed in South Africa. Therefore, the remaining potential locations are given 'medium' even though these do not correspond with the economic corridors.

Water Resources Development: The screening and assessment are performed on the basis of the discussions in Chapter 4 - Water Resource and Water Supply. Namibe in Angola, and Swakopmund, Walvis Bay, and Luderitz in Namibia are located in the arid regions along the Atlantic coast. The coastal regions of South Africa are utilizing the water resources extensively and they are faced with the difficulty of developing exploitable water resources. Tolagnaro and Toliara in Madagascar are located in the southern regions where the surface water is reduced critically during the dry season. In Dar es Salaam in Tanzania, the water supply infrastructure is not enough to meet the water demand at present and the development of large-scale surface water is essential in order to cope with the water demand for the huge population. Andoany in Madagascar, Zanzibar in Tanzania, and Mauritius are island.

Water Supply Development Level: The data at the city level were identified for Tanzania and Mozambique. The data at the national level by the World Health Organization/United Nations Children's Fund (WHO/UNICEF) were used for the other countries as the data at the city level were not identified from the available literature.

Policy and Planning for Water Supply Development: In South Africa, Namibia, and Mauritius, the national policy on water resources development describes that seawater desalination should be considered as an alternative water resource. From DesalData and available literature, it has been identified specifically that seawater desalination plants are planned in some cities in South Africa and Namibia. Available literature suggests that seawater desalination would be discussed in Mozambique although water resources policy at the national level could not be confirmed. Any information on seawater desalination was not identified for Cote d'Ivoire, Angola, and Madagascar.

The potential locations are screened as listed in Table 5.12 below. The screening is based on the criteria of A, B and C in each of four viewpoints in principle but also considers the assessments from the data collected and complied as described in the previous chapters.

Table 5.12 Screening of Potential Locations - Summary

Country	Potential Location	Population Projection (2025)	Economic Growth	Difficulty	Development Level	Policy and Planning	Result
Cote d'Ivoire	San Pedro	250,132	B	C	B	C	Not Screened
	Abidjan	6,755,939	A	B	B	C	Not Screened
Angola	Cabinda	774,920	B	B	C	C	Not Screened
	Soyo	262,737	B	C	C	C	Not Screened
	Dande	262,419	C	C	C	C	Not Screened
	Cazenga	1,370,012	B	B	C	C	Not Screened
	Cacuaco	1,401,861					
	Viana	2,423,889					
	Luanda	3,348,409					
	Belas	1,692,128					
	Sumbe	166,623	C	C	C	C	Not Screened
	Lobito	331,595	A	B	C	C	Screened
	Catumbela	171,528					
	Benguela	525,395					
	Namibe	301,491	B	A	C	C	Screened
Namibia	Swakopmund	74,225	A	A	B	A	Screened
	Walvis Bay	103,054					
	Luderitz	20,806	B	A	B	B	Not Screened
South Africa	Saldanha	37,104	B	A	A	A	Not Screened
	Cape Town	4,523,615	B	A	A	A	Screened
	Somerset West	247,916	B	A	A	B	Not Screened
	George	207,521	B	A	A	B	Screened
	Port Elizabeth	1,155,543	B	A	A	A	Not Screened
	East London	389,794	B	A	A	B	Not Screened
	Durban	3,673,282	A	A	A	A	Screened
Madagascar	Antsiranana	190,834	C	C	C	C	Not Screened
	Toamasina	455,837	B	C	C	C	Not Screened
	Tolagnaro	81,440	B	A	C	C	Not Screened
	Toliara	260,155	C	A	C	C	Not Screened
	Mahajanga	366,156	C	C	C	C	Not Screened
	Andoany	65,604	B	A	C	C	Not Screened
Mozambique	Pemba	285,016	A	A	A	C	Screened
	Nacala-Port	333,110	A	A	B	A	Screened
	Quelimane	335,980	B	C	B	C	Not Screened
	Beira	631,516	A	B	A	A	Not Screened
	Maputo	1,718,155	A	A	B	B	Screened
	Matola	1,314,543					
Tanzania	Tanga	419,805	B	A	A	B	Screened
	Zanzibar	952,009	B	A	C	B	Screened
	Dar Es Salaam	8,285,990	A	A	C	B	Screened
	Mtwara	191,036	B	A	C	B	Screened
Mauritius	Mauritius Island	1,243,449	C	A	A	B	Not Screened

Source: Survey Team

The results of the screening are explained hereunder.

(1) Cote d'Ivoire (Table 5.13)

San Pedro: The city has a commercial port and is one of the key locations in the Gulf of Guinea Spatial Development Initiative (SDI). It is located in the region with rich water resources in the country.

Abidjan: The metropolis has a major commercial port and is one of the key locations of the West Africa Growth Ring Corridors. The existing water supply system is mostly dependent on groundwater but the present water supply amount has reached nearly the exploitable groundwater yield. In order to meet the water demand of the city having a huge population, it is essential to implement the proposed surface water development by the Master Plan Study on Integrated Water Resources Management. Recently, a project has been proposed under public-private partnership (PPP) to augment the water supply of 300,000 m^3/day in Abidjan through surface water development of the Bandama River.

Table 5.13 Screening of Potential Locations - Cote d'Ivoire

Potential Location	Assessment	Result
San Pedro	The need for seawater desalination is less as the urban center is located in the local region and its population scale is not large. In addition, it is located in the region where the water resources are rich in the country.	Not Screened
Abidjan	There is a possibility for seawater desalination to be required in the course of economic growth and development in the future. But any information about the need for seawater desalination has not been identified for the time being. At present, a large-scale surface water development is expected to be implemented for the augmentation of water supply.	Not Screened

Source: Prepared by the Survey Team

(2) Angola (Table 5.14)

Cabinda: The city has a commercial port and is one of the key locations in Malange Corridor. The Chiloango River (catchment area: 12,570 km^2) flows in the vicinity of the urban center and is rich in water flow even during the dry season.

Soyo: LNG is produced and exported utilizing natural gas associated with the deep sea oil fields offshore. There are abundant water resources, both surface water and groundwater, in the delta of the Zaire (Congo) River.

Dande: The city is located about 30 km north of Luanda. The Dande River (catchment area: 11,446 km^2) flows in the vicinity of the urban center and is rich in water flow even during the dry season.

Cazenga, Cacuaco, Viana Luanda, Belas: The capital of Luanda and the neighboring cities form a metropolitan area with a total population of about 6.3 million (2014). The metropolitan area is located around the mouth of the Cuanza River (catchment area: 150,445 km^2). The dry season flow of the Cuanza River is abundant and is sufficient for the water demand of the metropolitan area.

Sumbe: The city is located about 300 km south of the capital Luanda. The N'Gunza River (catchment area: 2,309 km^2) flows in the vicinity of the urban center and is perennial. The dry season flow is sufficient for the water demand of the city. The water supply project has been carried out with the African Development Bank (AfDB) support since 2011.

Lobito, Catumbela, Benguela: Lobito is the key location of the Lobito Corridor. Development is expected to take place with the Lobito Port, which is linked with the Democratic Republic of the Congo (DRC) through the Benguela Railway, which was extended to Luan in the territory of DRC.

There are two major rivers, namely, the Catumbela River (catchment area: 16,533 km^2) and the Cavaco River (catchment area: 4,398 km^2), in the vicinity of the cities. The dry season flows of these rivers are sufficient for the water demand of the cities. The availability of water resources should be further scrutinized in consideration of future water demand increasing with the economic development and anticipated drought.

Namibe: This city is the key location of the Namibe Corridor. JICA is carrying out the Preparatory Survey on the Namibe Port Rehabilitation Project at present. The 505 km railway from the southern inland area of Cassinga to Namibe Port is being developed through the investment of a Chinese firm. The Bero River (catchment area: 10,476 km^2) in the vicinity of the urban center dries up during the dry season. Groundwater potential is also low in the region.

Table 5.14 Screening of Potential Locations - Angola

Potential Location	Assessment	Results
Cabinda	The water resources potential is fair in the region.	Not Screened
Soyo	- ditto -	Not Screened
Dande	- ditto -	Not Screened
Cazenga, Cacuaco, Viana Luanda, Belas	- ditto -	Not Screened
Sumbe	- ditto -	Not Screened
Lobito, Catumbela, Benguela	The water resources are sufficient to meet the water demand at present. The possible need for seawater desalination will be dependent on the economic growth and development in the future.	Screened
Namibe	Water resources are scarce. The possible need for seawater desalination will be dependent on the economic growth and development in the future.	Screened

Source: Survey Team

(3) Namibia (Table 5.15)

Swakopmund: It is located about 30 km north of Walvis Bay. The city has been developed along with uranium development since the 1970s, as foreign engineers and people engaged in the exploitation have increased[6]. There is groundwater source called Omaruru Delta, located about 100 km north, serving water to Swakopmund and its surrounding areas as well as the mines. The groundwater yield had been 9 million m^3/year in the past but it was found that the sustainable yield was exceeded. Groundwater exploitation was limited to 4.5 million m^3/year in 2013 accordingly. The shortage of water supply has been compensated by seawater desalination[7].

According to DesalData, in 2010, Areva (France) launched water supply to the Trekkopje uranium mine of UraMin through a seawater desalination plant with a capacity of 55,000 m^3/day in Wlotzkasbaken located about 30 km north of Swakopmund. Afterwards, since 2014, the Namibian government and NamWater have been negotiating with Areva on the purchase of the plant. At present, the seawater desalination plant serves the uranium mines as well as Swakopmund and Walvis Bay.

DesalData also describes the plan of the next seawater desalination plant with a capacity of 60,000 m^3/day. The project site is also in the vicinity of Wlotzkasbaken. The project owner is the Ministry of Agriculture and Water and NamWater. Construction cost is estimated to be USD 145 million. The project was planned under a build–own–operate–transfer (BOOT) scheme with a concession period of 20 years. Request for Proposal (RFP) was distributed in November 2011 and three parties submitted

6 Data Collection Survey on the Namibia - Japan High-level Forum on Economic Development (2011)
7 Presentation: Improving the Bulk Water Supply to the Towns of Walvis Bay, Namibia, Burger, P.A. (2013)

their bids in May 2012. Bid evaluation took a long time with delays until the bid was cancelled eventually (as of April 21, 2014).

Walvis Bay: The city is the key location of the Trans-Caprivi Corridor and Trans-Kalahari Corridor and geographically favorable as a gateway to the Southern African Development Community (SADC) countries. Water consumption in Walvis Bay is 12,500 m^3/day. Even though population and economic growths take place, water consumption remains almost stable for the past ten years due to the increase of water tariff and water restrictions. On the other hand, the water demand is estimated to be 15,600 m^3/day in recent years. Water source is groundwater along the Kuiseb River located in the south. The groundwater yield has been 7 million m^3/year for the last 30 years and serves Walvis Bay and Swakopmund. Under the limitation of the water source, Walvis Bay is served for 24 hours a day and attains 15% of NRW rate[8]. The operational performance of the water supply is fair in Walvis Bay.

Luderitz: Cargo wharf was constructed under the renovation of Luderiz Port in 2000. The railway towards the inland area is further linked with South Africa. The scale of population is as small as 12,537 (2011). Water supply relies on water conveyance from the groundwater source about 120 km away inland[9].

Table 5.15 Screening of Potential Locations - Namibia

Location	Assessment	Result
Swakopmund / Walvis Bay	The existing water resources that serve Swakopmund, Walvis Bay, and surrounding areas are used nearly up to the limit and seawater desalination is considered to be a promising measure to cope with further increase of water demand.	Screened
Luderitz	The need for seawater desalination is identified but the population scale is small.	Not Screened

Source: Survey Team

(4) South Africa (Table 5.16)

Saldanha: The port is located about 120 km north of Cape Town and is operated for the shipment of iron ore transferred from the inland mines through the railway. A plan of seawater desalination plant with a capacity of 25,500 m^3/day is published in DesalData. The project owner is the West Coast District Municipality. Construction cost is estimated to be USD 46 million. The project is planned through design-build-operate (DBO) including a three-year concession period for operation. The design of the consultant is almost completed and the announcement of request for proposal (RFP) was scheduled in December 2014. The project owner was waiting for budgetary arrangements by the government (as of April 21, 2014).

Cape Town: The National Water Resources Management Strategy, June 2013, Second Edition, describes the Reconciliation Strategy for Cape Town and its surrounding areas, including desalination of 110 million m^3/year as one of the proposed measures to cope with the water demand by 2035.

DesalData describes a plan of seawater desalination plant with a capacity of 100,000 m^3/day. Project owner is the City of Cape Town government. The feasibility study conducted by the consultant was almost completed in December 2013 and was expected to be completed by July 2014 with the subsequent input from the project owner. Meanwhile, the supposed procurement for the seawater desalination would not be initiated for the time being as the water supply by seawater desalination plant would not be required until the 2021-2024 period (as of February 19, 2014).

[8] Case Study on Utilities' Good Practices, Municipality of Walvis Bay, Namibia (2012)
[9] Village-scale and Solar Desalination, Technology Experience in Namibia (2008)

Somerset West: The city is located in the east of Cape Town. No information was obtained on any plans of seawater desalination.

George: The National Water Resources Management Strategy, June 2013, Second Edition, describes the Reconciliation Strategy targeting the Outeniqua area (George and Mossel Bay), which is planned to be developed. But the subsequent information about the Reconciliation Strategy is not clear and no specific information about seawater desalination is identified at present. Meanwhile, there is an existing seawater desalination plant with a capacity of 15,000 m^3/day in Mossel Bay located about 30 km west of George. The plant is owned/operated by Petro SA. This plant was constructed after the critical drought in 2010. There is a possibility for George, located within the same region as Mossel Bay, to use seawater desalination as a countermeasure against drought.

Port Elizabeth: The National Water Resources Management Strategy, June 2013, Second Edition, describes the Reconciliation Strategy targeting the Nelson Mandela Bay Metropolitan Area and its surrounding areas, including the desalination of 10 million m^3/year of brackish river water as one of the proposed measures to cope with the water demand by 2035. On the other hand, the Municipality of Kouga, located adjacent to the west of the Nelson Mandela Bay Metropolitan Area, was preparing for the implementation of the feasibility study on desalination plant. No information about water source was obtained (as of December 2014). The population in the Municipality of Kouga was 98,558 (2011). The scale of population implies that the desalination plant under consideration in the Municipality of Kouga would not have large capacity.

East London: The National Water Resources Management Strategy, June 2013, Second Edition, describes the Reconciliation Strategy targeting Buffalo City and its surrounding areas. There is no desalination included in the proposed measures to cope with the water demand by 2035.

Durban: It is the key location of the North-South Corridor, the trunk logistics route in Southern Africa. The National Water Resources Management Strategy, June 2013, Second Edition, describes the Reconciliation Strategy targeting the KwaZulu-Natal Coastal Metropolitan Area, including desalination of 150 million m^3/year as one of the proposed measures to cope with the water demand by 2035. Reconciliation Strategy is planned for the regional water resources development management. Specific location and scale of seawater desalination plant need to be identified.

DesalData describes a plan of seawater desalination plant with a capacity of 2,500 m^3/day. The project owner is Umgeni Water. The capacity of the plant is considered to increase up to 10,000 m^3/day in the future. Firms interested in design and construction supervision services were requested to submit proposals before December 3, 2015 (as of November 17, 2015).

Table 5.16 Screening of Potential Locations - South Africa

Location	Assessment	Result
Saldanha	For the planned seawater desalination plant, preparation of bidding and financial arrangement is already in progress.	Screened
Cape Town	Reconciliation Strategy is planned for the regional water resources development management, including desalination of 110 million m^3/year by 2035. Specific location and scale of seawater desalination plant need to be identified.	Screened
Somerset West	The city is involved in the Reconciliation Strategy for Cape Town.	Not Screened
George	The information about Reconciliation Strategy is not clear and no specific information about seawater desalination is identified at present. There is a possibility for George, located within the same region as Mossel Bay, Knysna and Bitou, to use seawater desalination as a countermeasure against drought.	Screened

Location	Assessment	Result
Port Elizabeth	Reconciliation Strategy includes the desalination of brackish river water by 2035. The scale of desalination plant would not be large.	Not Screened
East London	There is no desalination included in the Reconciliation Strategy by 2035.	Not Screened
Durban	Reconciliation Strategy is planned for the regional water resources development management, including desalination of 150 million m^3/year by 2035. Specific location and scale of seawater desalination plant need to be identified.	Screened

Source: Prepared by the Survey Team

(5) Madagascar (Table 5.17)

Toamasina Port is the largest in Madagascar and handles about 90% of international cargo in the country. The port is an international access of the capital Antananarivo and also takes charge of the shipment of the mineral resources produced from the mines such as the Ambatovy nickel mine, which is the largest around the world. Antsiranana, Mahajanga, and Toliara are also handling international cargo. Information about water resources and water supply at the city level was not identified. It is presumed that water scarcity would take place around Tolagnaro and Toliara located in the arid regions of the south and Andoany in the island region. But there is no clear information about the economic growth and development that can result in an increase of water demand in the future.

Table 5.17 Screening of Potential Locations - Madagascar

Location	Assessment	Result
Antsiranana	The city is located at the northern end of Madagascar and is known as one of the major ports in the country. But there are very few international cargo volumes handled as compared with Toamasina. Development of infrastructure such as road, railways, and power is left behind.	Not Screened
Toamasina	The city is the most promising in terms of economic development with the largest port in Madagascar. The regional water resources are abundant along the coast of the Indian Ocean, where an annual rainfall of 3,000 mm or more occurs.	Not Screened
Tolagnaro	The city is located in the southeast region and is known as one of the growth poles in Madagascar. But no clear information about the growth pole is identified. The population scale is not big.	Not Screened
Toliara	The city is located in the southwestern region and is known as one of the major ports in the country. But there are very few international cargo volumes handled as compared with Toamasina. Development of infrastructure such as road, railways, and power is left behind.	Not Screened
Mahajanga	The city is located in the northwestern region and is known as one of the major ports in the country. But there are very few international cargo volumes handled as compared with Toamasina. Development of infrastructure such as road, railways, and power is left behind.	Not Screened
Andoany	The city is located in the Nosy Be Island known as one of the growth poles in Madagascar. But no clear information about the growth pole is identified. The population scale is not big.	Not Screened

Source: Prepared by the Survey Team

(6) Mozambique (Table 5.18)

Pemba: The city is a key location in the northern region and has an international port. It is expected that Pemba will be one of the economic growth centers in Mozambique in the process of natural resources development in the future. Pemba is located in the river basin named Orla Marítima 1 comprising small rivers flowing down to the Indian Ocean[10]. The total area of the Orla Marítima 1 is 4,121 km^2 but the catchment area of each river is much smaller. The Muaguide River, a major river

[10] ARA Norte, http://www.ara-norte.co.mz/index.php

with a catchment area of 1,423 km^2, is not a stable water source as its flow rate is less during the dry season. Groundwater is used for water supply accordingly. In 2012, the service coverage was 90% and the ratio of NRW was 24%. The average service duration was 16 hours a day and revenue collection rate was 52%. These two figures remain at a low level among the major cities in Mozambique.

Nacala: The city is the key location of the Nacala Corridor and has an international port. Japanese official development assistance (ODA) has been actively deployed, e.g., Nacala Port Development Project to be financed by Japanese ODA loan. In addition, support from donor countries and investment activities by private sector have also been active. In 2012, the service coverage was 54% and the ratio of NRW was 29%. The average service duration was 19 hours a day and revenue collection rate was 65%. The operational performance of the water supply service is not satisfactory.

It has been reported that the Investment Fund and Water Supply Asset Holder (*Fundo de Investmento e Patrimonio do Abastecimento de Agua*: FIPAG) will start a feasibility study on seawater desalination in order to solve the water shortage of Nacala City. Similarly, FIPAG is also considering to provide funds to start a feasibility study on dam construction in the suburbs for augmentation of the water supply in Nacala. These alternatives are envisaged to solve the water shortage around Nacala City[11].

Quelimane: It is the main city of the central region. There is a river port located about 20 km upstream from the sea. In the vicinity of the city, the construction of Macuse Port is under consideration. Groundwater is used for the water supply. Rainfall is abundant in Zambezia Province. Quelimane is located in the Zambezi River delta; groundwater potential is relatively high. In 2012, the service coverage was 74% and the ratio of NRW was 33%. The average service duration was 21 hours a day and revenue collection rate was 96%.

Beira: The city is the key location of the Beira Corridor with the role of logistics hub from Zimbabwe and Zambia. In 2012, the service coverage was 91% and the ratio of NRW was 28%. The average service duration was 24 hours a day and revenue collection rate was 91%. These performance indicators are better than those in other cities of the country. According to the Beira Urban Water Master Plan 2035, the current water supply capacity in Beira is 49,200 m^3/day by Mutua Water Treatment Plant (WTP). The water source is the Pungwe River, the major river in ARA Centro, with a catchment area of 29,500 km^2. To cope with the water demand in 2035, the required water supply capacity will be 147,600 m^3/day equivalent to three times of the current water supply capacity. The flow rate of the Pungwe River is considered to be sufficient for expanding the water supply capacity by 2035. Meanwhile, the Beira Urban Water Master Plan 2035 describes an option of reverse osmosis (RO) desalination in parallel with the proposal to extend the water supply capacity of Mutua WTP[12].

Maputo/Matola: The Greater Maputo Metropolitan Area (GMMA) is the key location of the Maputo Corridor where further economic growth will continue in the future. The development of the water supply system does not keep pace with the population growth. In 2012, the service coverage was 61% and the ratio of NRW was 51%. The average service duration was 16 hours a day and revenue collection rate was 85%.

In GMMA, it was predicted that new water resource development would be required to cope with the water demand in 2015. A series of studies have been carried out for the alternatives such as 1) water

[11] Mozambique Infrastructure Related Information, JETRO Johannesburg, August 2015
[12] Beira Urban Water Master Plan 2035 by Adam Morón

conveyance from the Umbeluzi River, Incomati River, and Maputo River, 2) groundwater development in Maputo and its surrounding areas, 3) seawater desalination, 4) water reuse, and 5) long-distance water conveyance from the Limpopo River. FIPAG is working on the expansion of the water treatment plant to take water from the Pequenos Libombos Dam on the Umbeluzi River. In addition, the Corumana Dam on the Sabie River will contribute to further augmentation of the water supply capacity. The Word Bank provides financial support for the completion of the Corumana Dam under the National Water Resources Management Project[13].

Table 5.18 Screening of Potential Locations - Mozambique

Location	Assessment	Result
Pemba	The city is a key location in the northern region and has an international port. It is expected that Pemba will be one of the economic growth centers in Mozambique in the process of natural resources development in the future. To cope with the future increase of water demand, the development of sustainable water resources is considered to be a major issue.	Screened
Nacala	The city is the key location of the Nacala Corridor and has an international port. Support from donor countries and investment activities by the private sector have also been active. These alternatives including dam reservoir and seawater desalination are envisaged to solve the water shortage around Nacala City.	Screened
Quelimane	Water resources are abundant as the rainfall is much in Zambezia Province and Quelimane, which is located in the Zambezi River delta.	Not Screened
Beira	Beira Urban Water Master Plan 2035 describes an option of RO-desalination in parallel with the proposal to extend the water supply capacity of Mutua WTP. The flow rate of the Pungwe River is considered to be sufficient for expanding the water supply capacity by 2035.	Not Screened
Maputo/Matola	Resulting from a series of studies carried out for the alternatives including seawater desalination, the expansion of the water treatment plant with the surface water source is implemented. The succeeding augmentation of the water supply capacity will also be based on the surface water source. Both of these are distant water conveyance schemes.	Screened

Prepared by the Survey Team

(7) Tanzania

Tanga: There is a concept of economic corridor that is based on the development of the New Tanga Port, export processing zone (EPZ) and railway toward Uganda and DRC. With the surface water resources, the existing water supply satisfies the water demand at present. Development of water supply stays at a better level among the water supply and sanitation authorities (WSSAs) in Tanzania with a NRW rate of 22.6%, average hours of service of 23.5 hours a day, and a ratio of population served by individual connection of 96.6% in 2013/2014[14].

Zanzibar: There is an initiative of Free Economic Zone in the economic policy. The law was enacted in 2004. The island is dependent mostly on groundwater resources. Volume of water supply in 2010 was planned to be 40,100 m^3/day but the actual volume of water supply in March 2011 was 35,800 m^3/day. The NRW ratio was estimated to be 50 % or more. Development of water supply does not stay at a high level[15]. JICA is carrying out the Enhancement of Water Supply Management of Zanzibar Water Supply Authority Phase 2 for the period of 2011-2016 and will initiate the Preparatory Survey on Zanzibar Urban Water Distribution Facilities Improvement Project in February 2016. The Deutsche

[13] National Water Resources Management Project, Project Appraisal Document, World Bank, August 2011
[14] Population Directly Serviced with Water (%)
[15] Detailed Planning Survey on Enhancement of Water Supply Management of Zanzibar Water Authority Phase 2 (2011)

Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is collaborating with the private firm for introducing the small-scale seawater desalination plant to rural areas[16].

Dar es Salaam: Further economic growth is expected in the metropolis of Dar es Salaam Corridor in the future. Water supply is mostly based on surface water resources. The existing water supply capacity is significantly insufficient against the water demand at present. Quantitative issue on water resources can be improved by carrying out the development of the Wami/Ruve River[17]. Improvement and development of water distribution network is a critical issue in Dar es Salaam. The NRW ratio was 57.4%, average service duration was 8.0 hours a day, and the ratio of population served by individual connection was 50.1% in 2013/2014. It was reported that the Dar es Salaam Water and Sewerage Corporation (DAWASCO) mentioned a proposal of seawater desalination by an Israeli firm in 2014.

Mtwara: There is a concept of economic corridor that is based on Mtwara Port and surrounding developments. Water supply relies on groundwater but is insufficient for the water demand at present. Development of water supply is left behind; the NRW ratio is 38.1%, average service duration is 10.5 hours a day, and the ratio of population served by individual connection is 44.0%.

Table 5.19 Screening of Potential Locations - Tanzania

Location	Comments	Result
Tanga	Status of infrastructure development in relation to economic corridor is unclear. Water supply is dependent mostly on Mabayani Dam on the Sigi River. The catchment area of Mabayani Dam is 700 km^2. Further, distant water conveyance will be required when the water demand largely increases with the development relevant to the economic corridor.	Screened
Zanzibar	Status of infrastructure development in relation to free economic zone is unclear. Water distribution network is expected to be improved through a project to be financed by Japanese ODA loan in the future. There is a possible water scarcity in the island when the development of free economic zone is activated.	Screened
Dar es Salaam	Quantitative issue on water resources can be improved by the development of surface water resources. As existing water supply capacity is significantly left behind against water demand, it is hard to catch up with the population growth and economic development.	Screened
Mtwara	Status of infrastructure development in relation to the economic corridor is unclear. Water supply is dependent mostly on groundwater. There is no large river nearby. Further, distant water conveyance will be required when water demand largely increases with the development relevant to the economic corridor.	Screened

Source: Prepared by the Survey Team

(8) Mauritius (Table 5.20)

Mauritius Island: Port Louis is a major maritime logistics hub connecting Asia, Australia, Africa, and Europe. In Mauritius Island, the need for seawater desalination is discussed among a series of measures against water scarcity as the absolute limit of the exploitable water resources has been foreseeable. In the six regions, i.e.: Port Louis, North, East, South, Mare aux Vacoas-Upper, and Mare aux Vacoas-Lower, the total water supply amounted to 594,000 m^3/day[18].

Water supply development stays at a high level. Piped water supply covers 100% of the population in urban areas. On the other hand, the NRW ratio is as high as 50% comprising 35% of water leakage and

[16] Potable Water for Zanzibar's Poor
[17] Information collected by Nippon Koei Co., Ltd. through interview with concerned personnel in Tanzania
[18] Research Perspectives and Recommendation on Water Resources in Mauritius (2012)

15% of commercial loss. The total length of the water distribution network of the Central Water Authority (CWA) is about 4,000 km. Of these, 1,570 km are old and need to be replaced[19]. The ratio of water utilization accounts for 70% of the exploitable water resources up to date and is forecasted to be 80% in 2040[20].

Table 5.20 Screening of Potential Locations - Mauritius

Location	Comments	Result
Mauritius Island	There is a potential need for seawater desalination as the absolute limit of the exploitable water resources has been foreseeable in the island. Meanwhile, population growth has already been stabilized and large increase in water demand is not expected in the future. The NRW ratio should be improved.	Not Screened

Source: Prepared by the Survey Team

5.4 Selection of Locations to be Surveyed

5.4.1 Assumed Scenarios for Potential Need for Seawater Desalination

Through the preparatory assessment for identifying the potential need for seawater desalination in Sub-Saharan Africa, it is assumed that the need of seawater desalination for the public water supply would take place with the following alternative scenarios:

Scenario 1: Regional water resources are absolutely limited and do not cope with the demand. Seawater desalination is a promising solution for increasing the water supply capacity. This scenario is considered as applicable for arid countries (e.g., Middle East, Northern Africa) and small islands.

Scenario 2: Even though the water supply infrastructure itself is designed and constructed with nominal capacity to meet the water demand, it is faced with vulnerability against drought. The vulnerability of water supply infrastructure is likely to occur due to the limitation of flow measurement records for water resources assessment at the time of planning and design. In addition, the vulnerability is also further anticipated due to climate change. To cope with the vulnerability, the introduction of seawater desalination is a possible solution in order to ensure the actual water supply capacity. This scenario is considered as applicable for semi-arid and monsoon countries prone to seasonal variation of water resources availability and drought taking place repeatedly.

Scenario 3: Large-scale development of water supply infrastructure comprising dam reservoir, water intake, water purification, and water transmission and distribution requires a certain number of years for planning, design, and construction, as well as funding arrangements for project implementation. Even though such large-scale development is planned as a permanent solution, seawater desalination is also taken into consideration as an early solution to cope with the rapid increment of water supply capacity. This scenario is highly dependent on administrative decision-making where a large increment of water demand is projected definitively under activated economic growth in the future.

[19] Water Sector of Mauritius - Opportunities, Challenges and Constraints
[20] -ditto-

Table 5.21 Potential Need for Seawater Desalination Expected in Screened Locations

Country	Location	Potential Need for Seawater Desalination		
		Scenario 1	Scenario 2	Scenario 3
Angola	Lobito/Catumbela/Benguela		✓	✓
	Namibe	✓		
Namibia	Swakopmund/Walvis Bay	✓		
South Africa	Saldanha	✓		
	Cape Town		✓	✓
	George	✓		
	Durban		✓	✓
Mozambique	Pemba			✓
	Nacala			✓
	Maputo/Matola		✓	✓
Tanzania	Tanga			✓
	Zanzibar	✓		
	Dar Es Salaam		✓	✓
	Mtwara			✓

Source: Prepared by the Survey Team

5.4.2 Potential Need for Seawater Desalination by Location

(1) Angola

Lobito/Catumbela/Benguela: The modernization and expansion of Lobito Port has been implemented together with railway development towards the landlocked countries. There is also the expectation of oil and natural gas production in the southern offshore of Angola. There is a possibility to accelerate the economic development causing rapid increase of water demand in the future. For the time being, available information on the existing water supply in terms of infrastructure development and operation is not sufficient to study the potential need for seawater desalination.

Namibe: The rehabilitation of Namibe Port has been considered to be carried out by Japanese ODA. The railway to the inland countries is also being rehabilitated. Along with these projects, there is a possibility to accelerate economic development which will result in a rapid increase of water demand in the future. Because of regional water scarcity, the possible introduction of seawater desalination is expected to cope with the rapid increase of water demand. For the time being, available information on the existing water supply in terms of infrastructure development and operation is not sufficient to study the potential need for seawater desalination.

(2) Namibia

Swakopmund/Walvis Bay: As the regional water resources development has almost reached its limit, the seawater desalination is already introduced. The government is negotiating to purchase the existing seawater desalination plant (55,000 m^3/day) owned by a private firm. In the meantime, the bidding for the succeeding plant (60,000 m^3/day) was canceled. It is presumed that the present situations resulted from the operating trend of uranium mining companies which receive water supply from the seawater desalination plant. On the other hand, water supply by desalination plants will likely be required to meet the increasing water demand due to further development of Walvis Bay. In addition, there is a possibility of full-scale water supply by seawater desalination when the government and NamWater operate the seawater desalination plant.

(3) South Africa

Saldanha: There is a project to introduce seawater desalination to the public water supply system. It can be the subject of field investigation in terms of collecting information on the background of the seawater desalination project.

Cape Town: As part of the measures to cope with the projected water demand in 2035, seawater desalination of 110 million m^3/year (corresponding to 300,000 m^3/day) is specifically proposed. A seawater desalination project is expected to be promoted within a series of measures to ensure future water resources to meet the water demand and alleviate drought.

George: There are experiences of introducing seawater desalination to the public water supply system. The need for further seawater desalination is expected. In addition, it can be the subject of field investigation in terms of collecting information on the existing seawater desalination.

Durban: As part of the measures to cope with the projected water demand in 2035, seawater desalination of 150 million m^3/year (corresponding to 410,000 m^3/day) is specifically proposed. A seawater desalination project is expected to be promoted within a series of measures to ensure future water resources to satisfy and meet the water demand and alleviate drought.

(4) Mozambique

Pemba/Nacala: With the activation of investments by the private sector and donor countries for the Nacala Corridor, economic development is expected to be accelerated in the region. The water supply development in the region will need to cope with the large increase in water demand as well as drought. There is a possibility for seawater desalination as a future water source, coupled with improvement and development of water distribution system.

Maputo/Matola: The basic policy in developing water supply at present is based on surface water sources. Similar to other metropolis, the improvement of water distribution network is a major challenge. As water distribution covers a wide area, it is presumed that seawater desalination would possibly be needed in a certain emerging development district. Due to the NRW rate of 50.1%, it is anticipated that the introduction of large-scale seawater desalination to the public water supply system would face financial difficulties.

(5) Tanzania

Tanga: As it is presumed that further water resources development would require long-distance water conveyance, seawater desalination is likely to be considered as an alternative. A possible increase in water demand needs to be clarified based on reality as there are plans to develop the new port, EPZ, and railway towards Uganda and DRC.

Zanzibar: There is a possibility to use seawater desalination in the island. But there is no such clear trend regarding Free Economic Zone, which may cause a rapid increase in water demand. A crucial issue is to develop the water distribution system which shall be investigated through a preparatory study for a project expected to be financed by Japanese ODA loan.

Dar es Salaam: The biggest challenge is to improve water distribution. As water distribution covers a wide area, it is presumed that seawater desalination would possibly be needed in a certain emerging development district. Due to the NRW rate of 57.4%, it is anticipated that the introduction of large-scale seawater desalination to the public water supply system would face financial difficulties.

Mtwara: From the expected natural gas production in the southern offshore of Tanzania, there is a possible accelerated development in Mtwara Port and its surroundings in the future. Meanwhile, the population scale is not large at present, and the need for a large-scale expansion of water supply is unlikely to take place.

5.4.3 Priority of Potential Locations to be Surveyed

Potential locations to be surveyed are selected as shown in Table 5.23 through assessment of priority with due consideration of the following points:

- Priority A: Need for seawater desalination is identified clearly. Principal viewpoints of the survey for project promotion opportunity can be itemized specifically.
- Priority B: Need for seawater desalination is identified potentially. Additional data collection is necessary for reviewing project promotion opportunity.
- Priority C: Need for seawater desalination is identified potentially but possibility of project promotion opportunity is considered to be less.

Table 5.22 Priority of Potential Locations to be Surveyed

Country, Location	Viewpoints for Project Promotion Opportunity	Priority
Angola		
Lobito/Catumbela/Benguela	● Development and economic growth in Lobito Port and surrounding areas ● Water demand and supply balance ● Development, management, and future plan of water supply	C
Namibe	● Development and economic growth in Namibe Port and surrounding areas ● Water demand and supply balance ● Development, management, and future plan of water supply	B
Namibia		
Swakopmund/Walvis Bay	● Principles for operation of seawater desalination plant by the government/ NamWater (further water supply by the government-owned seawater desalination plant) ● Scale of seawater desalination plant and timing of its introduction in view of water demand/supply balance and alleviation of drought vulnerability	A
South Africa		
Saldanha	● Background to seawater desalination project and current progress of project implementation	A
Cape Town	● Scale of seawater desalination plant and timing of its introduction in view of water demand/supply balance and alleviation of drought vulnerability ● Institutional arrangement for project preparation	A
George	● Progress in preparing Reconciliation Strategy ● Institutional arrangement for project preparation	C
Durban	● Scale of seawater desalination plant and timing of its introduction in view of water demand/supply balance and alleviation of drought vulnerability ● Institutional arrangement for project preparation	A

Country, Location	Viewpoints for Project Promotion Opportunity	Priority
Mozambique		
Nacala	● Regional water supply development plan within the development of Nacala Corridor ● Scale of seawater desalination plant and timing of its introduction in view of water demand/supply balance and alleviation of drought vulnerability	B
Maputo/Matola	● Possible zone to be served by seawater desalination plant within the large-scale water supply system ● Affordability of seawater desalination in view of water distribution management	C
Tanzania		
Tanga	● Development and economic growth of Tanga Port and surrounding areas ● Development, management, and future plan of water supply	C
Zanzibar	● Development and economic growth in the Free Economic Zone ● Development, management, and future plan of water supply[21]	C
Dar Es Salaam	● Possible zone to be served by seawater desalination plant within the large-scale water supply system ● Affordability of seawater desalination in view of water distribution management	C
Mtwara	● Development and economic growth in Mtwara Port and surrounding areas ● Development, management, and future plan of water supply	C

Source: Prepared by the Survey Team

As a conclusion of the above, the locations to be surveyed are selected as follows.

1) Swakopmund/Walvis Bay (Namibia) and Nacala (Mozambique)

The second stage survey envisages validating the possibility of a seawater desalination project to be financed by Japanese ODA loan through the site surveys, (i) to clarify the need for seawater desalination and the development environment for a possible introduction of seawater desalination, and (ii) to study conceptual facility plan, operation and maintenance system, cost estimate, and framework of project implementation. Swakopmund/Walvis Bay in Namibia and Nacala in Mozambique are found to be the conceivable locations in carrying out the site surveys.

There is the existing seawater desalination plant in Swakopmund/Walvis Bay and also the plan of an additional plant as well. The focal points on the possible project preparation are clearly recognized: (i) the realization of the existing seawater desalination plant to be owned and operated by the government/NamWater, and (ii) the time for construction of the additional plant with due consideration of water demand and supply balance in the future. For the time being, the project preparation in Swakopmund/Walvis Bay is considered as the most promising among the surveyed countries.

The site survey in Nacala is a case study for seeking the promotion of seawater desalination project in Sub-Saharan Africa. Through the site survey in view of economic growth, uneven water resources availability by region, and status of water supply development, the issues on future seawater desalination project are to be clarified. In other words, the site survey is a useful opportunity to acquire the practical knowledge of the conditions to promote the seawater desalination project in the location rather than the arid region.

[21] To be surveyed under the Preparatory Survey on Zanzibar Urban Water Distribution Facilities Improvement Project

2) Saldanha, Cape Town, Durban (South Africa) and Namibe (Angola)

There are still discussions seeking any possible manner of Japanese ODA loan to be acceptable by the Government of South Africa. Meanwhile, future seawater desalination projects are found to be promising in Saldanha, Cape Town and Durban. As the need for seawater desalination is already justified in these locations, the site visits are meaningful for understanding the conditions to introduce the seawater desalination to the public water supply.

Namibe is located in the arid region in the southern coast of Angola. The possible introduction of seawater desalination is expected to cope with the rapid increase of water demand when the economic development is accelerated. For the time being, available information on the water sector is not sufficient. Further basic information on the water sector needs to be collected through site visit in order to study the potential need for seawater desalination.

Second Stage Survey

Chapter 6 Site Surveys

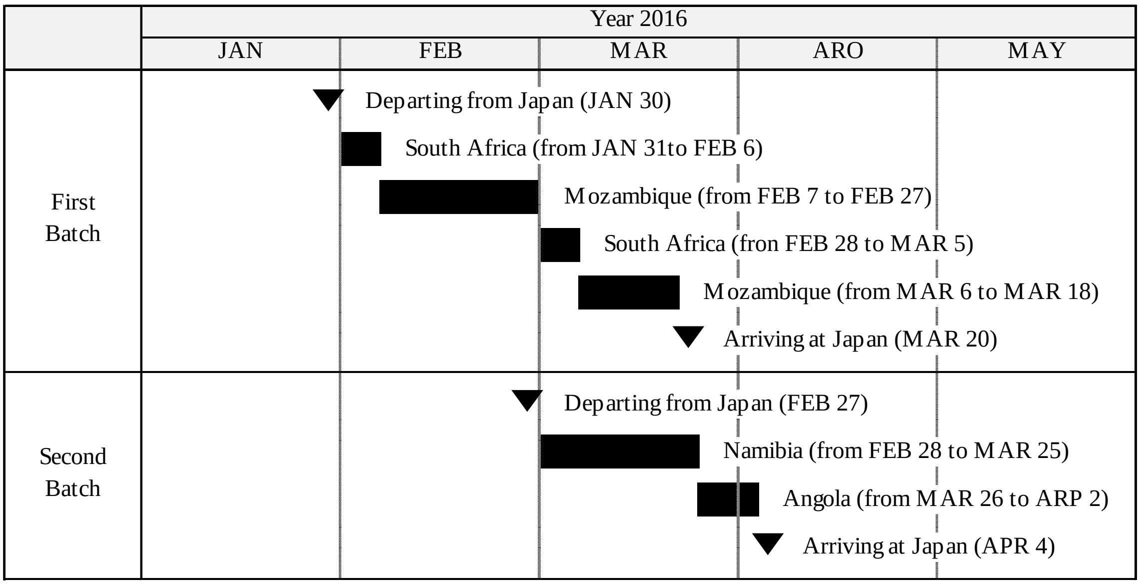
6.1 Overall Schedule

Resulting from the first stage survey, the surveyed locations are selected as shown in Table 6.1 and the overall schedule of the site surveys is illustrated in Figure 6.1.

Table 6.1 Surveyed Sites

Purpose	Country	Location
Validating the possibility of seawater desalination project	Namibia	Walvis Bay
	Mozambique	Nacala
Updating the information relevant to water supply including seawater desalination	South Africa	Saldanha, Cape Town, Durban
	Angola	Namibe

Source: Prepared by the Survey Team



Source: Prepared by the Survey Team

Figure 6.1 Overall Schedule of Site Surveys

6.2 Outlines of Site Survey

6.2.1 South Africa

According to the information collected through the first stage survey (work in Japan), the need for introducing seawater desalination plant to public water supply in the mid- to long-term is identified in the major coastal cities such as Cape Town and Durban. In addition, the feasibility study on the seawater desalination project was already done and is currently in the project preparation stage in Saldanha Bay located in the suburb of Cape Town. The site survey aims at collecting further information about the updates in these locations.

The site survey in South Africa was carried out from 30 January to 6 February 2016 and from 28 February to 5 March 2016 as shown in Table 6.2. The results are described in Chapter 7.

Table 6.2 Site Survey in South Africa

Date		Itinerary	Place to Stay
January 30	(Sat)	Narita - Dubai	
January 31	(Sun)	Dubai - Johannesburg	Pretoria
February 1	(Mon)	JICA Office, EOJ	Pretoria
February 2	(Tue)	Johannesburg - Cape Town	Cape Town
February 3	(Wed)	Cape Town - Saldanha / Saldanha Bay Municipality	Saldanha
February 4	(Thu)	West Coast District Municipality / Saldanha - Cape Town	Cape Town
February 5	(Fri)	City of Cape Town	Cape Town
February 6	(Sat)	Faure Water Treatment Plant (WTP)	Cape Town

Date		Itinerary	Place to Stay
February 28	(Sun)	Nampula - Johannesburg	Pretoria
February 29	(Mon)	Development Bank of Southern Africa, JICA Office	Pretoria
March 1	(Tue)	Johannesburg - Durban	Durban
March 2	(Wed)	eThekwini Metropolitan Municipality, Tongaat WTP	Durban
March 3	(Thu)	Umgeni Water	Durban
March 4	(Fri)	Hazelmere Water Works	Durban
March 5	(Sat)	Durban - Johannesburg	Johannesburg

Source: Prepared by the Survey Team

6.2.2 Mozambique

Nacala is the major hub of the economic corridor development, where Japanese official development assistance (ODA) including the port development project has been activated. In addition, assistances by donor countries and investments by private firms have also become active. According to the information collected through the first stage survey (work in Japan), the water supply in Nacala needs further improvement and two options are under consideration, namely, the dam construction in the suburbs and seawater desalination, in order to solve the water shortage in Nacala. The site survey aims at collecting further information about the updates relating to the water supply development under consideration in order to seek the future possibility of seawater desalination project.

The site survey in Mozambique was carried out from 7 February to 28 February 2016 and 6 March to 20 March 2016 as shown in Table 6.3. The results are described in Chapter 8 and Chapter 11.

Table 6.3 Site Survey in Mozambique

Date		Itinerary	Place to Stay
February 7	(Sun)	Cape Town - Johannesburg - Maputo	Maputo
February 8	(Mon)	FIPAG, GAZEDA, DNA, JICA Office	Maputo
February 9	(Tue)	Maputo - Nampula / ARA Centro-Norte / Nampula - Nacala	Nacala
February 10	(Wed)	GAZEDA Nacala, Nacala Porto Municipality, EDM Nacala	Nacala
February 11	(Thu)	FIPAG Nacala	Nacala
February 12	(Fri)	Site inspection (Nacala Inner Bay entrance, Nacala Port north)	Nacala
February 13	(Sat)	Site inspection (Nacala Port south, Nacala Outer Bay, Ocean)	Nacala
February 14	(Sun)	Review of collected data	Nacala
February 15	(Mon)	Nacala-a-Velha District	Nacala
February 16	(Tue)	Nacala Porto Municipality	Nacala
February 17	(Wed)	Review of collected data, schedule arrangement	Nacala
February 18	(Thu)	Review of collected data, schedule arrangement	Nacala
February 19	(Fri)	Maritime Administration	Nacala
February 20	(Sat)	Site inspection (Nacala Inner Bay)	Nacala
February 21	(Sun)	Review of collected data	Nacala
February 22	(Mon)	Nacala Porto Municipality	Nacala

Date		Itinerary	Place to Stay
February 23	(Tue)	FIPAG Nacala, Site inspection (Nacala-a-Velha)	Nacala
February 24	(Wed)	Review of collected data, internal meeting	Nacala
February 25	(Thu)	Review of collected data, internal meeting	Nacala
February 26	(Fri)	Site inspection (Nacala Inner Bay)	Nacala
February 27	(Sat)	Review of collected data	Nacala
February 28	(Sun)	Nacala - Nampula	Nampula

Date		Itinerary	Place to Stay
March 6	(Sun)	Johannesburg - Nampula	Nampula
March 7	(Mon)	FIPAG Regional North, ARA Centro-Norte	Nampula
March 8	(Tue)	Nampula - Nacala	Nacala
March 9	(Wed)	Nacala Porto Municipality	Nacala
March 10	(Thu)	Site inspection (Nacala Inner Bay)	Nacala
March11	(Fri)	FIPAG Nacala	Nacala
March 12	(Sat)	Review of collected data	Nacala
March 13	(Sun)	Nacala - Nampula	Nampula
March 14	(Mon)	Review of collected data	Nampula
March 15	(Tue)	Review of collected data	Nampula
March 16	(Wed)	Nampula - Maputo	Maputo
March 17	(Thu)	Preparation of site survey report	Maputo
March 18	(Fri)	FIPAG, DNA, JICA Office	Maputo
March 19	(Sat)	Maputo - Johannesburg	
March 20	(Sun)	Johannesburg - Dubai - Narita	

Source: Prepared by the Survey Team

6.2.3 Namibia

The site survey in Namibia focuses on the central coast area of Erongo Province where the provincial capital of Swakopmund, the principal seaport of Walvis Bay, and neighboring towns are sharing the water resources.

According to the information collected through the first stage survey (work in Japan), there is an existing seawater desalination plant and a next plant is also under consideration. Therefore, the site survey considers clarifying the need and scale of the future seawater desalination project, proposing the scope of the project, and identifying the issues to be further discussed for the project preparation.

The site survey was carried out from 27 February to 25 March 2016 as shown in Table 6.4. The results are described in Chapter 9 and Chapter 12.

Table 6.4 Site Survey in Namibia

Date		Itinerary	Place to Stay
February 27	(Sat)	Narita - Hong Kong - Johannesburg	
February 28	(Sun)	Johannesburg - Windhoek	Windhoek
February 29	(Mon)	EOJ, JICA Office, Directorate of Water Resources Management, Ministry of Agriculture, Water and Forestry	Windhoek
March 1	(Tue)	Headquarters of Namibia Water Corporation (NamWater)	Windhoek
March 2	(Wed)	Windhoek - Swakopmund	Swakopmund
March 3	(Thu)	Areva, Namib Office of NamWater, Walvis Bay Corridor Association, Walvis Bay Municipality	Swakopmund
March 4	(Fri)	Swakopmund Municipality	Swakopmund
March 5	(Sat)	Review of collected data	Swakopmund
March 6	(Sun)	Review of collected data	Swakopmund
March 7	(Mon)	Walvis Bay Municipality	Swakopmund
March 8	(Tue)	Namibia Port Administration	Swakopmund

Date		Itinerary	Place to Stay
March 9	(Wed)	Review of collected data, schedule arrangement	Swakopmund
March 10	(Thu)	Namib Office of NamWater	Swakopmund
March 11	(Fri)	Hangana Seafood	Swakopmund
March 12	(Sat)	Review of collected data	Swakopmund
March 13	(Sun)	Review of collected data	Swakopmund
March 14	(Mon)	Wlotzkasbaken Seawater Desalination Plant (Areva)	Swakopmund
March 15	(Tue)	Review of collected data, schedule arrangement	Swakopmund
March 16	(Wed)	Walvis Bay Municipality	Swakopmund
March 17	(Thu)	Review of collected data, schedule arrangement	Swakopmund
March 18	(Fri)	Namibia Mining Association	Swakopmund
March 19	(Sat)	Review of collected data	Swakopmund
March 20	(Sun)	Review of collected data	Swakopmund
March 21	(Mon)	Swakopmund - Windhoek	Windhoek
March 22	(Tue)	Namibia Power Corporation (NamPower), NamWater	Windhoek
March 23	(Wed)	Ministry of Finance	Windhoek
March 24	(Thu)	NamPower	Windhoek
March 25	(Fri)	Review of collected data	Windhoek

Source: Prepared by the Survey Team

6.2.4 Angola

The site survey in Angola focuses on Namibe located in the arid region along the coast of the Atlantic Ocean in the south of the country.

According to the information collected through the first stage survey (work in Japan), it is recognized that the water resources are scarce in Namibe but the available data relating to the water sector are not sufficiently identified. Therefore, the site survey aims at collecting the basic data of the water sector at the national and provincial levels and assessing the water demand and supply balance based on the available data of water demand and exploitable water resources including possible seawater desalination.

The site survey was carried out from 26 March to 4 April 2016 as shown in Table 6.5. The results are described in Chapter 10.

Table 6.5 Site Survey in Angola

Date		Itinerary/Destination	Place to Stay
March 26	(Sat)	Windhoek - Luanda	Luanda
March 27	(Sun)	Internal meeting	Luanda
March 28	(Mon)	JICA Field Office, EOJ / Luanda - Namibe	Namibe
March 29	(Tue)	Provincial Energy and Water Directorate of Namibe	Namibe
March 30	(Wed)	Provincial Urban Development and the Environment Directorate of Namibe / Namibe - Luanda	Luanda
March 31	(Thu)	DNA	Luanda
April 1	(Fri)	JICA Field Office	Luanda
April 2	(Sat)	Windhoek - Johannesburg	Johannesburg
April 3	(Sun)	Johannesburg - Hong Kong	
April 4	(Mon)	Hong Kong - Tokyo	

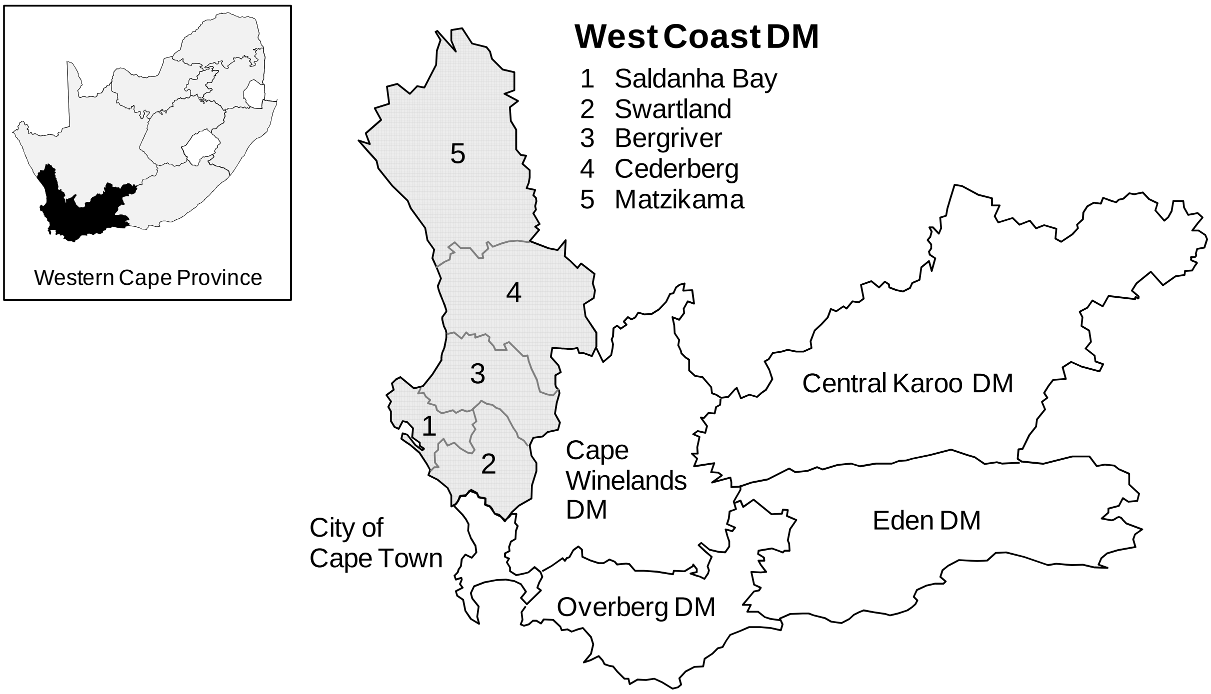
Source: Prepared by the Survey Team

Chapter 7 South Africa

7.1 Saldanha Bay

7.1.1 Survey Area

The Western Cape Province of South Africa consists of the city of Cape Town and five district municipalities; and the West Coast District Municipality (DM) is one of them. The West Coast District Municipality has a total area of 31,100 km² and consists of the following five local municipalities as shown in Figure 7.1.



Source: Prepared by the Survey Team

Figure 7.1 Location of West Coast District Municipality

The total population of the West Coast District Municipality was 391,766 according to 2011 census. The recent estimate indicates that the total population is 416,025 in 2015 and will increase up to 444,503 in 2020[1]. The population of each local municipality is shown in Table 7.1. The population growth rates of Swartland and Saldanha Bay, which are next to Cape Town, are high.

Table 7.1 Population in West Coast District Municipality

	Local Municipality	2001	2011	Annual Growth Rate (2001-2011)
1	Saldanha Bay	70,261	99,193	3.5%
2	Swartland	72,115	113,762	4.7%
3	Bergriver	46,538	61,897	2.9%
4	Cederberg	39,559	49,768	2.3%
5	Matzikama	54,199	67,147	2.2%
	West Coast DM	282,672	391,767	3.3%

Source: West Coast District Municipality, Integrated Development Plan, 2012/2016, Review 3 Final (2015)

[1] Socio-economic Profile, West Coast District Municipality, 2015, Working Paper

In the Saldanha Bay Local Municipality, Vredenburg has the largest population with 38,382, followed by Saldanha with 28,135 in 2011 as shown in Table 7.2.

Table 7.2 Population in Saldanha Bay Local Municipality

Town/Area	Population (2011)
St. Helena Bay	11,527
Saldanha Bay NU	2,962
Paternoster	1,971
Vredenburg	38,382
Swartriet	82
Jacobs Bay	416
Langebaanweg	952
Saldanha	28,135
Hopefield	6,449
Langebaan	8,294
Total	99,170

Source: Saldanha Bay Municipality

Saldanha has the port for shipment of iron ore and coal. The hinterland of the port is planned to be developed with oil and gas industry. In addition, there is a development plan for the industrial development zone (IDZ). Figure 7.2 and Figure 7.3 show the view and location of the port and IDZ. The plan for developing the IDZ is led by the central government, and the President formally announced its implementation on 31 October 2013[2].

The Saldanha Bay IDZ will be developed for the period of 25 years, comprising port facilities for oil and gas carriers (e.g., ship repair dock and cargo handling facilities), iron plant, titanium-silicon complex, wind blade manufacturing, renewable energy industry, customs areas, and light industrial areas as shown in Table 7.3. The whole development area is 650 ha and the total project cost for developing the IDZ and its surrounding infrastructures (e.g., transport, water, electricity, housing, and education) is estimated at ZAR 84 billion. Currently, the infrastructure in some areas in the development zone has been initiated as shown in Figure 7.4.

Table 7.3 Outlines of Saldanha Bay IDZ Plan

Project	Description
Marine Repair	Port infrastructure development of a new quay and dry-docking facilities for the repair of oil and gas vessels.
Offshore Supply Base	Port infrastructure development of a supply quay and laydown area for supply of goods to offshore oil and gas sector
Hot Briquetted Iron Manufacturing	50,000 tons per annum via a finesmelt-type plant
Titanium and Zircon Complex	15,000 tons per annum of titanium metal, 2,000 tons per annum of zirconium metals, 3,000 tons per annum of solar grade silicon, and 5,000 tons per annum high grade silicon.
Wind Blade Manufacturing	100 sets of wind turbine blades per annum
Renewable Energy Industry	2,000 solar water heater units per month
IDZ Customs Controlled Areas (CCAs)	To anticipate the importation and exportation of goods to and from the IDZ
IDZ Light Industrial Areas	To house complementary downstream business enterprises as per the industries and services areas definition

Source: Saldanha Bay IDZ: Feasibility Study (2011)

2 Saldanha Bay Industrial Development, http://sbid.co.za/

Source: Photo taken by the Survey Team

Figure 7.2 Saldanha Port and IDZ (Distant View)

Source: Google Earth

Figure 7.3 Saldanha Port and IDZ (Satellite Image)

Source: Photo taken by the Survey Team

Figure 7.4 Infrastructure Development in Saldanha IDZ

7.1.2 Water Resources and Water Supply

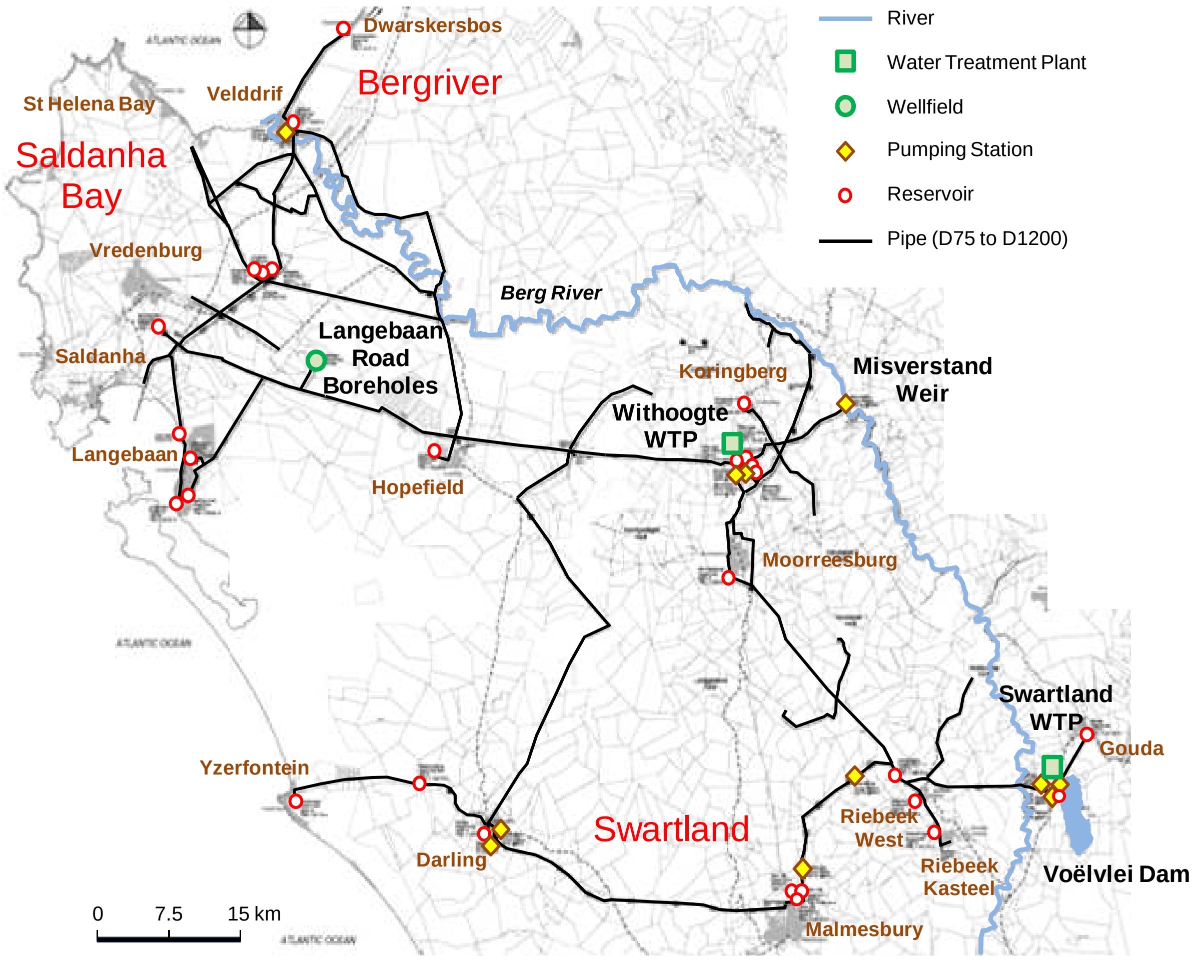
The local municipalities of Saldanha Bay, Swartland, and Berg River, where the population is concentrated, are served by two water supply systems as shown in Table 7.4 and Figure 7.5. The West Coast District Municipality manages these bulk water supply systems, including water intake, conveyance, purification and transmission facilities and water distribution reservoirs. Each local municipality receives purified water from the water distribution reservoir and provides water supply services for citizens through its own water distribution network.

Table 7.4 Bulk Water Supply Areas of West Coast District Municipality

Bulk System	Local Municipality	Towns
Withoogte	Berg River	Velddrif and Dwarskersbos
	Saldanha Bay	Hopefield, Langebaan, Vredenburg, Saldanha, and St. Helena Bay
	Swartland	Koringberg and Moorreesburg
Swartland	Swartland	Malmesbury (Abbotsdale, Kalbaskraal, Chatsworth, and Riverlands), Darling, PPC, Riebeek West, Riebeek Kasteel, and Yzerfontein
	Drakenstein	Gouda

Note: Drakenstein Municipality belongs to Cape Winelands District Municipality.

Source: Western Cape Water Supply System (WC WSS) Reconciliation Strategy, Status Report, October 2014



Source: West Coast District Municipality, Water Master Plan, June 2013

Figure 7.5 Bulk Water Supply System of West Coast District Municipality

The Berg River is the major water resource in the West Coast District Municipality. The total water intake volume is 22.99 million m^3/year in accordance with the registered permission as shown in Table 7.5. However, the actual water intake volume has already exceeded the registered permission as shown in Table 7.6. In 2013, the West Coast District Municipality requested the Department of Water and Sanitation (DWS) to allow them to increase the water intake volume to 30.3 million m^3/year for the Withoogte and 11.1 million m^3/year for the Swartland until year 2033[3].

Table 7.5 Permitted Water Intake Volume for West Coast District Municipality (Registered, million m^3/year)

Name of Water Source	Resource Name	Permit Reg. Certificate	Current Allocation (million m^3/year)
Withoogte from Misverstand Weir	Berg River	No. 22062820	17.440
Swartland from Voëlvlei Dam	Berg River (Voëlvlei Dam)	No. 22062777	4.200
Langebaan Road Boreholes	Saldanha Underground	No. 22062688	1.500
Minus 10% of Langebaan Road (as recommended by the monitoring committee)			-0.150
Total Allocation for West Coast District Municipality			22.990

Source: WC WSS Reconciliation Strategy, Status Report, October 2014

[3] WC WSS Reconciliation Strategy, Status Report, October 2014

Table 7.6 Permitted Water Intake Volume for West Coast District Municipality (Actual, million m^3/year)

Source	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Withoogte from Misverstand Weir	17.488	16.932	16.706	17.525	18.692	20.363
Swartland from Voëlvlei Dam	6.661	6.762	6.636	6.592	6.595	6.497
Langebaan Road Boreholes	0.436	0.621	0.972	1.088	0.931	0.000
Total	24.585	24.315	24.314	25.205	26.218	26.860

Source: WC WSS Reconciliation Strategy, Status Report, October 2014

In the bulk water supply system managed by West Coast District Municipality, water treatment loss is 7.31% while bulk distribution loss is 4.96% (2013/2014) as shown in Table 7.7. The local municipalities receive the bulk water supply and their rates of non-revenue water (NRW) are 15.80% in Saldanha Bay, 12.39% in Swartland, and 9.05% in the Berg River, respectively, as shown in Table 7.8.

Table 7.7 Water Treatment Loss and Bulk Distribution Loss of West Coast District Municipality (%)

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/4
Treatment Loss	6.11	6.36	6.32	6.01	6.37	7.31
Bulk Distribution Loss	5.60	3.04	5.63	5.07	4.98	4.96

Source: WC WSS Reconciliation Strategy, Status Report, October 2014

Table 7.8 NRW by Local Municipality (%)

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/4
Saldanha Bay	16.5	13.89	11.57	12.61	9.40	15.80
Swartland	15.08	13.44	16.26	15.27	17.73	12.39
Berg River	(N/A)	16.30	15.60	6.90	8.30	9.05

Source: WC WSS Reconciliation Strategy, Status Report, October 2014

According to the year 2011 census data published on the website of Saldanha Bay Municipality, out of total population of 99,193, 96% of the total population (95,458) have been served by the public water supply.

7.1.3 Need and Feasibility of Seawater Desalination Project

The West Coast District Municipality started with a comprehensive study in 2007 to identify a sustainable long-term alternative water source for the region, in order to ensure sustainable economic development. Various alternative sources and combinations thereof were evaluated and eventually a 25,500 m^3/day seawater desalination plant in the Saldanha Bay area was identified as the most cost beneficial alternative. The proposed location and view of the site for the seawater desalination plant are shown in Figure 7.6.

In the Withoogte, the water demand will reach 30.3 million m^3/year in 2028 as shown in Table 7.9. The Withoogte will be able to receive 31.025 million m^3/year that is considered as the maximum limit. When the water demand exceeds the maximum limit, the seawater desalination will be required.

Table 7.9 Water Demand Projection for Bulk Water Supply System of West Coast District Municipality (m^3/year)

Year	Swartland	Withoogte
2013	6,390,000	18,807,000
2018	7,335,000	21,482,000
2023	8,422,000	25,514,000
2028	9,668,000	30,302,000
2033	11,100,000	35,989,000

Source: West Coast District Municipality, Water Master Plan, June 2013

According to the WC WSS Reconciliation Strategy, Status Report, October 2014, the water demand of Saldanha IDZ is estimated to be 28,000 m^3/day in an ordinary case and 13,500 m^3/ day in an optional case of water use rationalization by water recycling and water demand management.

Source: Image; Google Earth, Location; West Coast District Municipality

Source: Photo taken by the Survey Team

Figure 7.6 Planned Location for Saldanha Bay Seawater Desalination Plant

The interviews from the West Coast District Municipality and the Saldanha Bay Municipality about the Saldanha Bay Seawater Desalination Plant Project are summarized below.

- The plant is located a few kilometers from the seashore. The water transmission main about 25 km will be constructed towards the east and linked with the water distribution reservoir managed by the West Coast District Municipality.
- The planned site called Danger Bay for the Saldenha Bay Desalination Plant is located within the state-owned land. For construction of the plant, the West Coast District Municipality needs to get the approval for the use of the state-owned land by the government.
- Civil engineering design of the seawater desalination plant has been finished. The environmental impact assessment (EIA) is in progress. The design of the plant is still being continued with due consideration of the development progress of membrane treatment technology being updated. In addition, the project implementation manners such as design-build-operate (DBO) and funding schemes such as public-private partnership (PPP) are also still under consideration.
- Since an overall plan of the IDZ is not yet finalized, the water demand forecast will need to be scrutinized. For the time being the development of the seawater desalination plant is divided into three stages. It is planned that the capacity will be increased by 8,500 m^3/day for each stage.
- The total construction cost of the proposed seawater desalination plant has been estimated at ZAR 500 million approximately. It is envisaged that the initial investment would be shared by the government subsidies, capital contributions by the municipalities and IDZ, and contributions from water revenue. Assuming that the operation and maintenance (O&M) costs will be fully covered from the water revenue, future water charge is estimated to be twice the current charge.

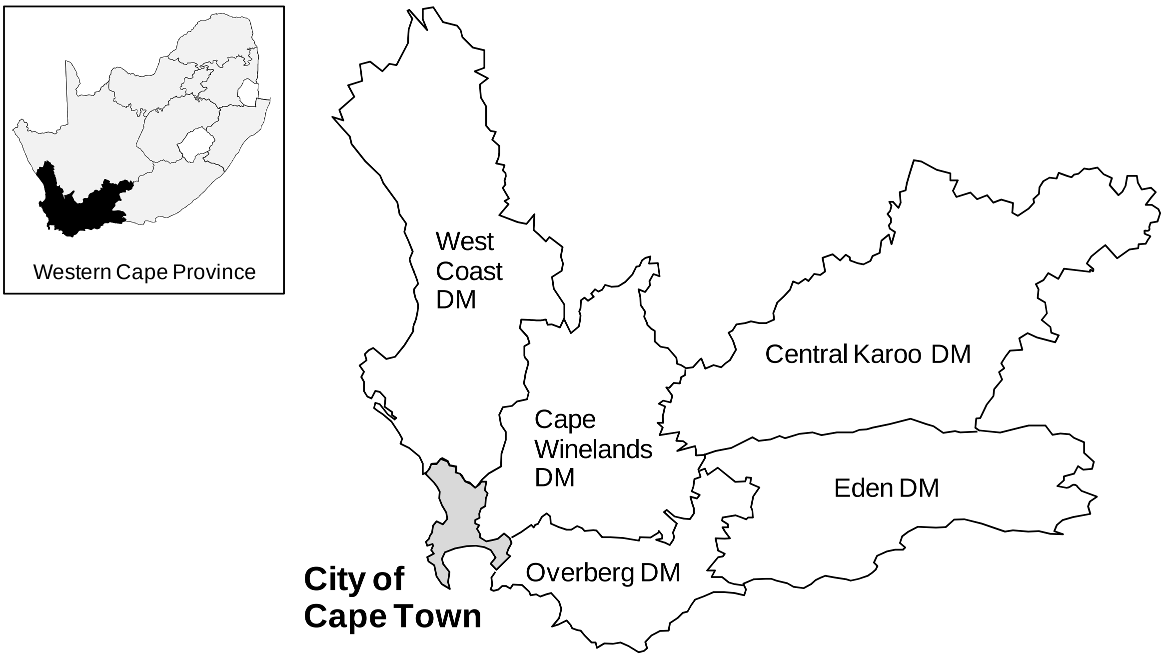
- Water treated by the seawater desalination plant will be blended with the existing bulk water supplied in principle. On the other hand, some firms and/or factories may need the water treated without remineralization. When the water charges for such firms and/or factories are set at a high price level, the increase of water charges for domestic consumers will be minimized. But a large increase of water charges will be inevitable and the project owner should be responsible for creating the consensus of domestic consumers when the project planning is fixed.

- Manners of project implementation and O&M are under consideration. Assuming the DBO, the ownership of the plant will be transferred to Saldanha Bay Local Municipality. As the municipality has the experience in operating a small-scale brackish water desalination plant, the municipality will be able to manage the plant operation. In addition, some private firms in South Africa have offered to operate the plant under a long-term contract.

7.2 Cape Town

7.2.1 Survey Area

The city of Cape Town (CCT) as shown in Figure 7.7 is the provincial capital of the Western Cape Province. Administratively, it is a metropolitan municipality, with an area of 2,455 km^2. According to the year 2011 census, the population of CCT is 3,740,026; the second largest city in South Africa to the city of Johannesburg (4,434,827). The population of CCT is 7.2 % of the total population in South Africa.

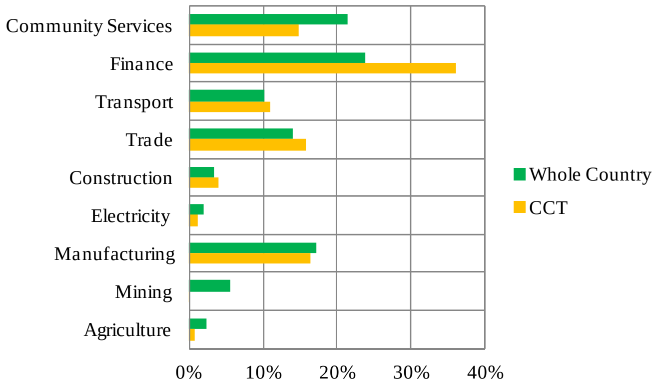


Source: Prepared by the Survey Team

Figure 7.7 Location of CCT

The percentage of CCT's gross domestic product (GDP) to the total GDP of South Africa was 11.3%; next to 16.7% of the city of Johannesburg in 2012. The GDP per capita of CCT was ZAR 58,844, higher than ZAR 37,404 for the whole South Africa with in 2012. A large part of CCT's gross value added (GVA) is composed of finance (36.1%), manufacturing (16.4%), and trade (15.8%). The ratio of mining and agriculture is very small[4]. The GVA by sector in CCT is shown in Figure 7.8 below.

Sector	Whole Country	CCT
Community Services	21.5%	14.9%
Finance	23.9%	36.1%
Transport	10.1%	11.0%
Trade	14.0%	15.8%
Construction	3.4%	4.0%
Electricity	2.0%	1.1%
Manufacturing	17.2%	16.4%
Mining	5.5%	0.1%
Agriculture	2.4%	0.7%

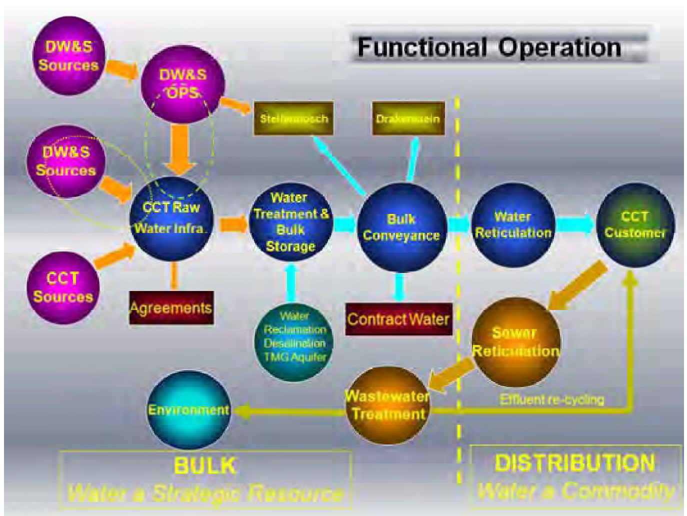


Source: State of Cape Town 2014

Figure 7.8 GVA of CCT by Sector (2012)

7.2.2 Water Resources and Water Supply

The CCT manages water supply and sewerage systems, e.g., water resources, water transmission, water purification, water distribution, water supply, and sewerage treatment and water environment, comprehensively as shown in Figure 7.9.



Source: Water and Sanitation Department, Business Overview, Peter Flower, Director: Water and Sanitation, February 2016

Figure 7.9 Comprehensive Management System of CCT for Water Supply and Sewerage Systems

Under the WC WSS Reconciliation Strategy, the water allocation to the CCT is 398.7 million m^3/year, in which surface water and groundwater account for 98% and 2%, respectively. The surface water sources are the 14 dam reservoirs. There are four large-scale dam reservoirs, which belong to the DWS and the others are owned by the CCT. The ratio of the surface water sources owned by the DWS is 73%, while the CCT owns 27%.

The salient features of the existing water supply system are the following:

- Dam reservoirs: 14 reservoirs, total storage capacity is 898,300,000 m^3
- Water purification plants: 12 plants, total water supply capacity is 1,655,000 m^3/day
- Distribution reservoirs (bulk water supply): 26 reservoirs, total distributing reservoir capacity is 2,740,000 m^3/day
- Water transmission mains (bulk water supply): total length 700 km
- Water distribution network: total length 10,700 km

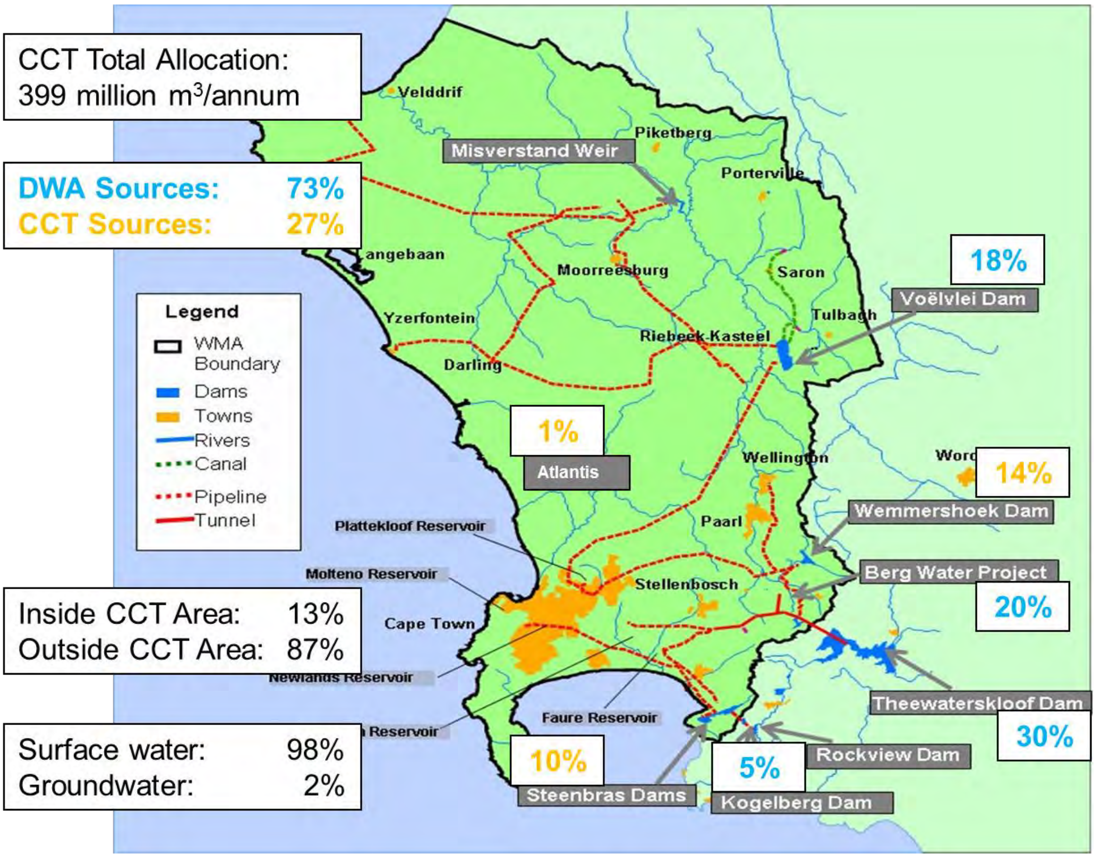
[4] State of Cape Town 2014

The water supply volume in 2014/15 was 340 million m^3/year. The average daily water supply volume was 930,000 m^3/day and the total population served was 3.8 million. The rate of non-revenue water was 22.3% (76 million m^3/year).[5]

Table 7.10 Water Allocation to CCT (m^3/year)

Water Supply Source	Owner	Current Allocation
Berg River Dam	DWS	81,000,000
Berg River (Voëlvlei Dam)	DWS	70,400,000
Theewaterskloof Dam, fixed volume	DWS	90,000,000
Theewaterskloof Dam, variable volume		28,000,000
Palmiet River (Rockview and Kogelberg dams)	DWS	22,500,000
Upper and Lower Steenbras Dam	CCT	40,000,000
Wemmershoek Dam	CCT	54,000,000
Total Allocation for CCT from WC WSS		**385,900,000**
Small dams	CCT	6,300,000
Albion Spring	CCT	1,500,000
Atlantis Aquifer	CCT	5,000,000
Total Allocation for CCT from Own Sources Outside the WC WSS		**12,800,000**
Total Allocation for CCT		**398,700,000**

Source: WC WSS Reconciliation Strategy, Status Report, October 2014



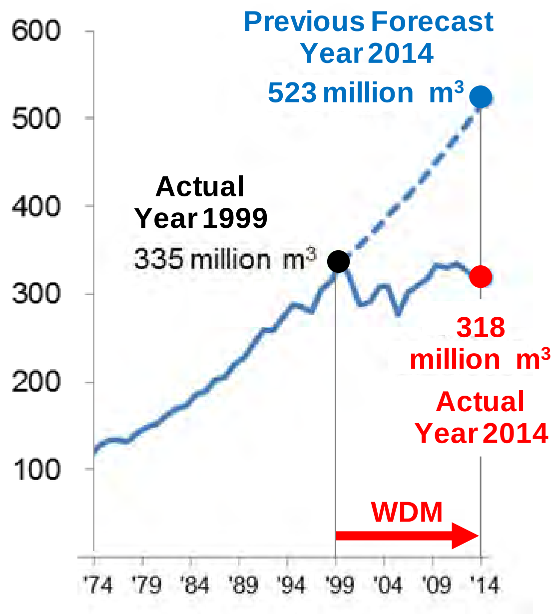
Source: Water and Sanitation Department, Business Overview, Peter Flower, Director: Water and Sanitation, February 2016

Figure 7.10 Water Resources for CCT

[5] City of Cape Town, Draft Annual Water Services Development Plan Performance and Water Services Audit Report, FY 2015

Since the year 2000, CCT has been implementing the initiative of the Water Demand Management (WDM). The WDM includes pressure management, treated effluent use, water pipe replacement, leak detection, water management devices, meter replacement, zone metering, building plumbing retrofit, plumbing repairs in indigent houses, springs investigation, and reducing response times to repair bursts and leaks. In addition to the above, education and awareness raising campaigns are carried out.

Until the year 1999, the water demand growth rate was 4%/year. It was predicted that water demand in 2014 would be 523 million m^3/year. With the WDM implementation since 2000, the actual water supply volume in 2014 stayed at 318 million m^3/year as shown in Figure 7.11. The concept of WDM is shared in South Africa and the CCT is the most dominant and has attained the greatest results. For the excellent achievement of the WDM, the CCT was awarded at the 21st Congress of the Parties for the United Nations Framework Convention on Climate Change (COP 21).



Source: Water and Sanitation Department, Business Overview, Peter Flower, Director: Water and Sanitation, February 2016

Figure 7.11 Achievement of WDM by CCT

7.2.3 Need and Feasibility of Seawater Desalination Project

With the implementation of WDM since 2000 in the CCT, water demand has not increased and water consumption per person has declined. Although the CCT has a large-scale commercial port, it does not have industries that consume a large amount of water (e.g., textile, and fish processing) as shown in Table 7.11. On the other hand, it is forecasted that water demand would increase due to the improvement of living environment in informal settlements. The CCT considers an increase rate of 2%/year for the water demand forecast as shown in Figure 7.12.

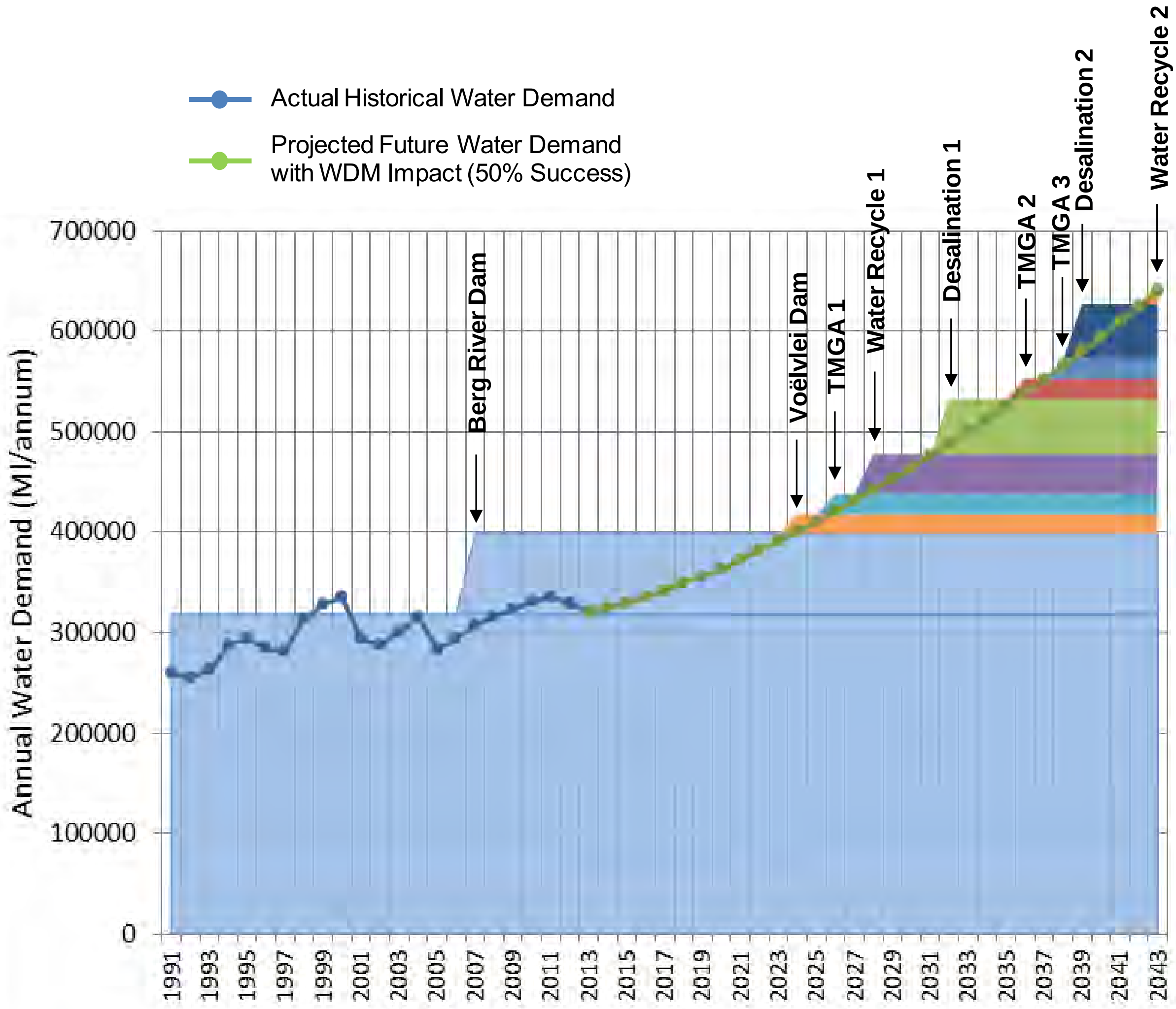
Table 7.11 Water Consumption in CCT (2013/14)

Usage	m^3	%
Domestic	165,713,389	73%
Commercial	24,482,281	11%
Municipal	12,245,285	5%
Industrial	8,717,188	4%
Government	5,176,392	2%
Other	10,805,954	5%
Total	227,140,489	100%

Source: WC WSS Reconciliation Strategy, Status Report, October 2014

The CCT's Bulk Water Augmentation Scheme (BWAS) presents the implementation schedule up to 2023. The main project is to build water conveyance, water purification, and water transmission, which can be done succeeding to the development of water sources through the Berg River Dam completed in 2007. This project will augment the water supply capacity and also cope with the risk of accident on the water conveyance tunnel from the Theewaterskloof Dam Reservoir, which is the present main water source, by means of a bypass line.

A series of developments expected after 2024 as shown in Figure 7.12 are: (i) water supply system from the Voëlvlei Dam Reservoir, (ii) recycled water, (iii) groundwater development in Table Mountain Group Aquifer (TMGA), and (iv) seawater desalination. The CCT considers that it will take ten to 15 years to plan and implement these projects and the priority is given (i), (ii), (iii) and (iv) in order.



Source: Water and Sanitation Department, Business Overview, Peter Flower, Director: Water and Sanitation, February 2016

Figure 7.12 Water Demand and Balance of CCT

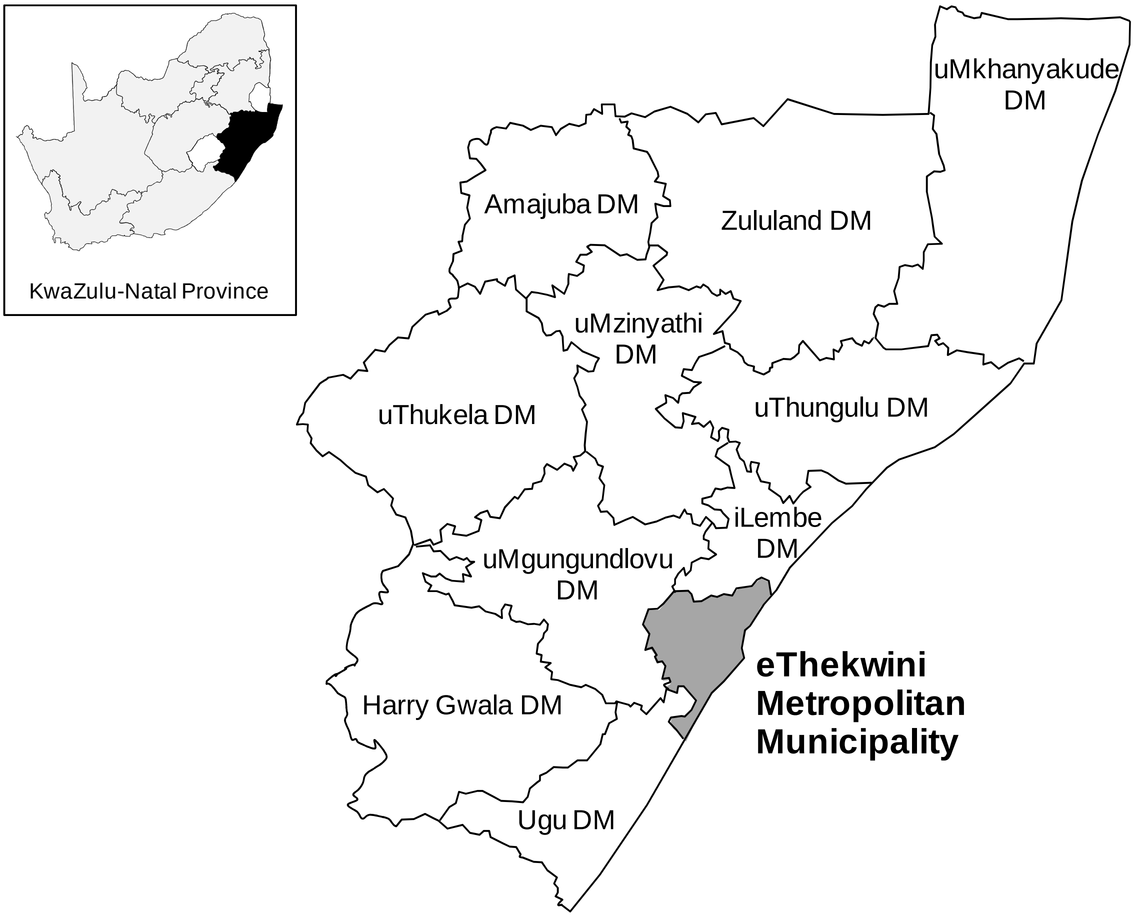
Seawater desalination has been studied in the CCT's northern coastal region. According to the WC WSS Reconciliation Strategy, Status Report in October 2014, a feasibility study of seawater desalination was carried out from July 2012 to December 2014. Two sites were selected as alternatives, one of which was located in the vicinity of the Eskom's Koeberg Power Station. The planned capacity of the seawater desalination plant is 150,000 m^3/day and may be expanded up to 450,000 m^3/day through succeeding two stages. It will take at least eight years for the design, environmental impact assessment (EIA), construction, and connection to the existing distribution network.

There are a lot of seaweeds and contains many organic components in the seawater around the CCT. The CCT has a plan to build a pilot plant for collecting data of pre-treatment and water quality over 18-24 months.

7.3 Durban

7.3.1 Survey Area

The eThekwini Metropolitan Municipality was formed in 2000, comprising the former Durban Metropolitan Municipality and the adjacent municipalities. The total area is 2,297 km^2. The location of the eThekwini Metropolitan Municipality is shown in Figure 7.13. According to the year 2011 Census, the population of 3,442,361 was the third largest in South Africa, next to the city of Johannesburg (4,434,827) and the city of Cape Town (3,740,026), and accounting for 6.6% of the total population of South Africa. The percentage of GDP of the eThekwini Metropolitan Municipality to the total GDP of South Africa was 10.9%, next to 16.7% of the city of Johannesburg and 11.3% of the CCT (2012).



Source: Prepared by the Survey Team

Figure 7.13 Location of eThekwini Metropolitan Municipality

7.3.2 Water Resources and Water Supply

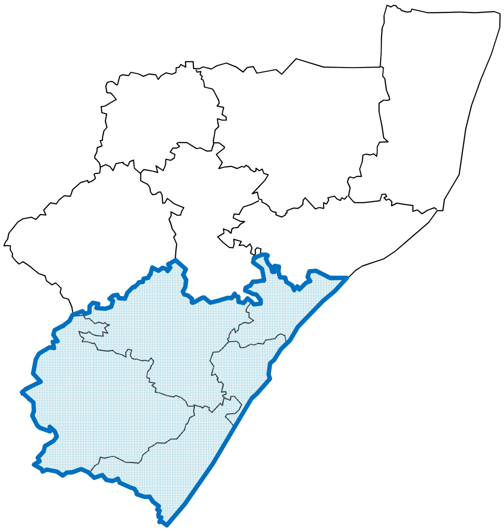
(1) Umgeni Water[6]

Umgeni Water is one of the water boards established in the 12 regions respectively in South Africa. It provides bulk water supply in the south of KwaZulu-Natal Province as shown in Figure 7.14 and Figure 7.15. The total of its service areas is 21,155 km^2 with the population about 6 million. The bulk water supply accommodates 447 million m^3/year (1,224,000 m^3/day) for the following municipalities.

---
6 Umgeni Water, Annual Report 2014/15

- eThekwini Metropolitan Municipality
- iLembe District Municipality
- Ugu District Municipality
- Harry Gwala District Municipality
- uMgungundlovu District Municipality
- Msunduzi Local Municipality

The dam reservoirs and associated water intake facilities are owned by the government. Umgeni Water has been entrusted for the O&M of these by the government. Umgeni Water owns the raw water conveyance mains, water purification plants, water transmission mains linked with the municipality's water distribution network and implements the O&M of these as described below.

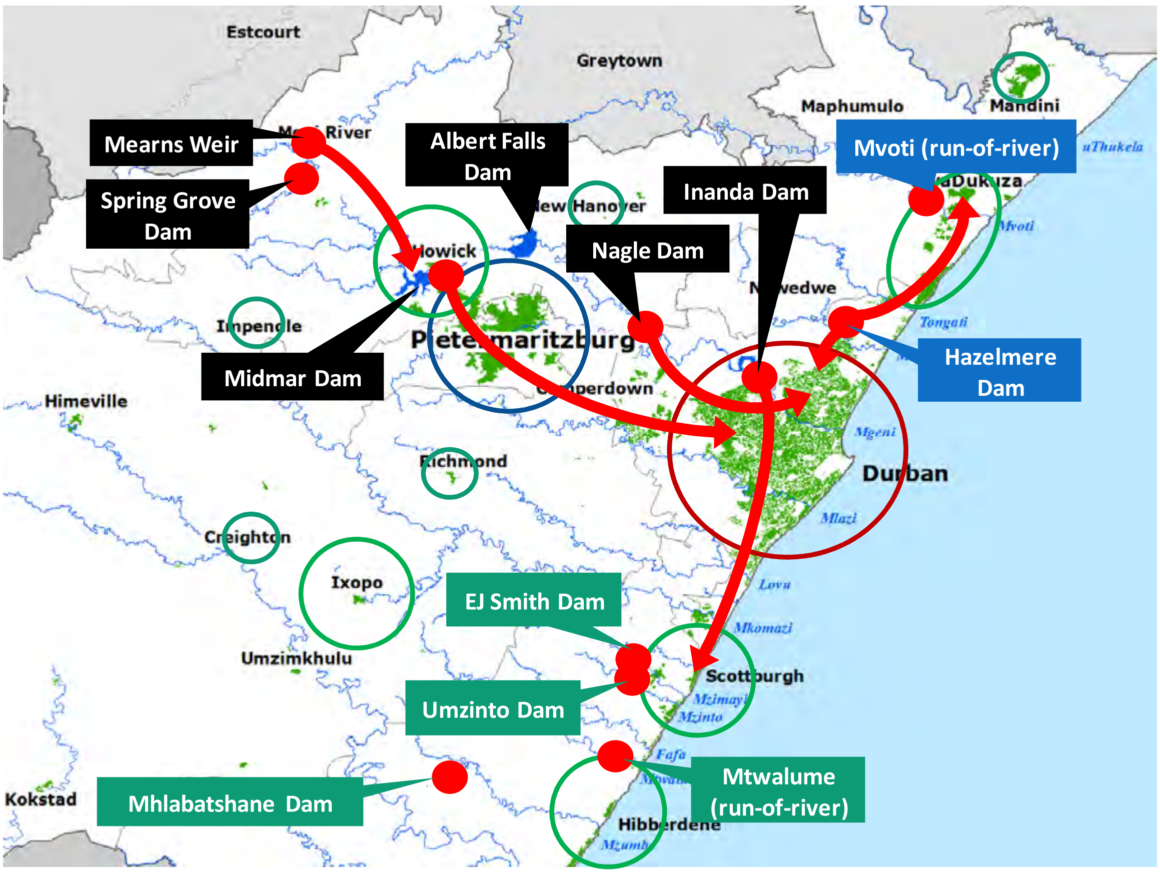


Source: Prepared by the Survey Team

Figure 7.14 Jurisdiction of Umgeni Water

- 746 km pipelines and 66 km tunnels
- 14 dam reservoirs
- 14 water purification plants
- 14 small water treatment plants and ten well facilities

In addition, Umgeni Water receives 28 million m^3/year (77,000 m^3/day) bulk wastewater by the four wastewater treatment plants.



Source: Umgeni Water

Figure 7.15 Bulk Water Supply by Umgeni Water

(2) eThekwini Metropolitan Municipality

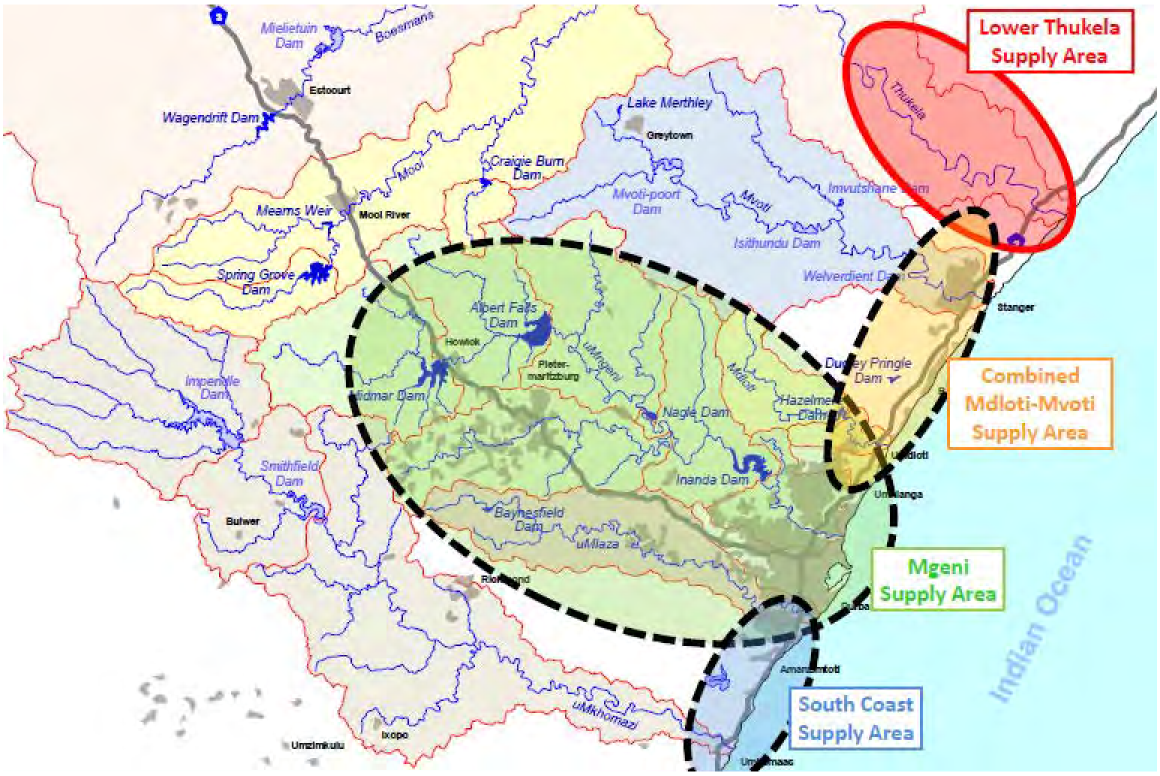
The eThekwini Metropolitan Municipality distributes 920,000 m^3/day that includes bulk water received from Umgeni Water and water produced by five small-scale water purification plants. It also carries out the wastewater treatment of a total of 460,000 m^3/day at the 27 wastewater treatment plants. According to the Water Utility Database, 2016, the population served in 2012 was 3,409,564 almost equivalent to the total population. 75% of the population (2,561,568) was served through household connections.

The eThekwini Metropolitan Municipality is trying to introduce water recycling by membrane treatment facility. An indirect method is being considered in such manners that; the wastewater treated at the wastewater treatment plant is once transmitted to the upstream and discharged to the river; the mixture of the water from the river is taken and treated at the water purification plant. It is envisaged that the water recycling would be implemented by public-private partnership (PPP) in the three regions of Tongaat, Umdloti, and Sappi Saiccor. Since the effluent from wastewater treatment plants to the rivers and sea is strictly regulated, it is crucial to introduce the water recycling that meets the water quality standards for industrial use. The eThekwini Metropolitan Municipality expects that private partners will introduce the water treatment technology to cope with the required standards.

The eThekwini Metropolitan Municipality is making preparation for construction of the pilot plant by Hitachi, Ltd., for seawater desalination and water reuse integrated system (capacity 6,250 m^3/day with a mix of 50% wastewater and 50% seawater). Through the discussions with the New Energy and Industrial technology Development Organization (NEDO), the project for construction of the pilot plant is scheduled to start in mid-May 2016. It is envisaged that a capacity of full-scaled plant will be 100,000 m^3/day starting operation in 2022 under a PPP scheme.

7.3.3 Need and Feasibility of Seawater Desalination Project

The bulk water supply area by Umgeni Water is divided into four as shown in Figure 7.16. Each of the areas has its own bulk water development plan based on the study of water demand forecasts and water resources development alternatives. Water resources development alternatives include surface water, water recycling, and seawater desalination. Regarding seawater desalination, a feasibility study of the seawater desalination plants has been carried out in two places, one in the north (Tongaat) and the other in the southern part (Lovu) of eThekwini Metropolitan Municipality. Both of the plans are planned with a capacity of 150,000 m^3/ day.



Source: Umgeni Water

Figure 7.16 Bulk Water Supply Areas of Umgeni Water

Bulk water supply alternatives by Umgeni Water are shown in Table 7.12 and Figure 7.17.

In the North Coast (Lower Thukela Supply Area and Combined Mdloti-Mvoti Supply Area), Raising of Hazelmere Dam and Lower Thukela Bulk Water Supply System (BWSS) (Phase 1 and 2) are prioritized. Compared with these surface water developments, the priority of Tongaat Seawater Desalination Plant is not high.

Table 7.12 Bulk Water Supply Alternatives by Umgeni Water

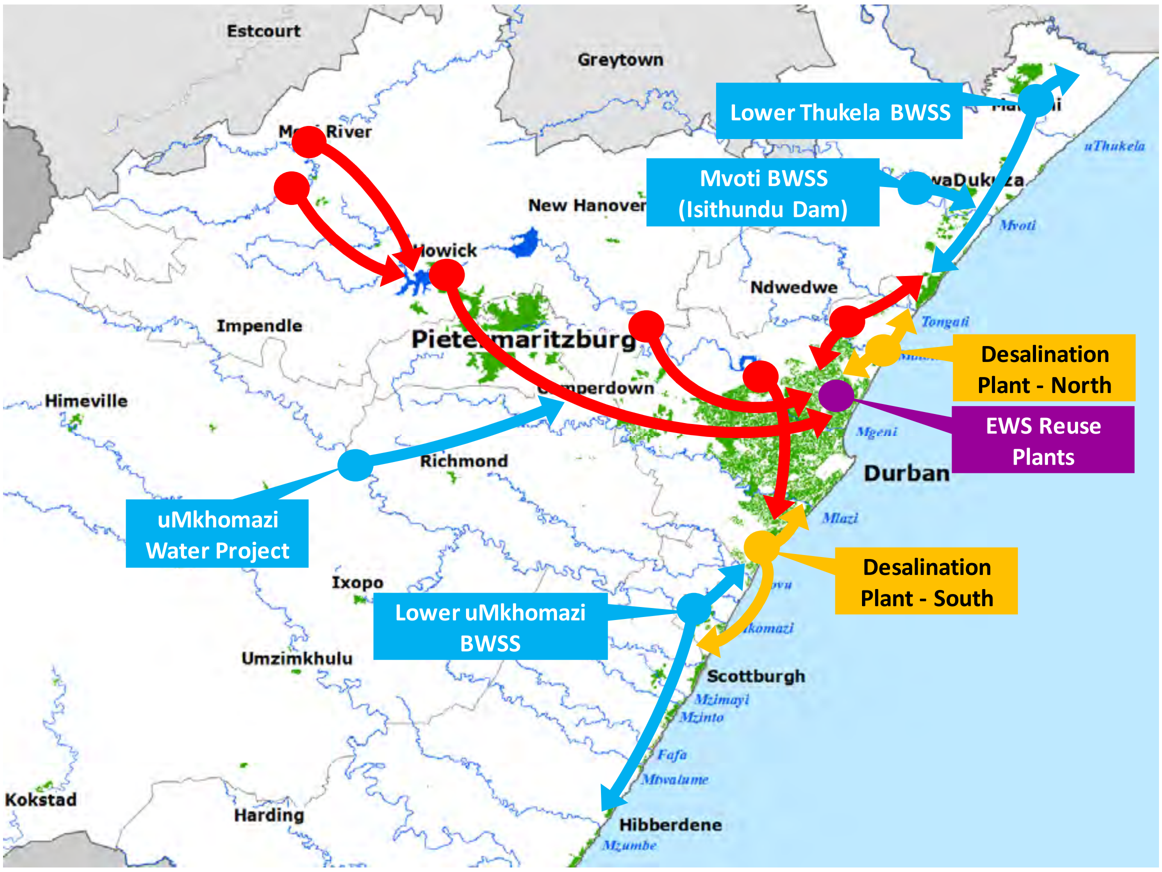
North Coast Alternatives	Capacity (m^3/day)	Capital Cost (Million ZAR)
Raising of Hazelmere Dam	20	550
Lower Thukela BWSS Phase 1	55	1,400
Lower Thukela BWSS Phase 2	55	250
East Coast Desalination Plant – North	150	3,500

Mengi Alternatives	Capacity (m^3/day)	Capital Cost (Million ZAR)
uMkhomazi Water Project Phase 1	602	17,000
East Coast Desalination Plant – North	150	3,500
Reuse Plants (Northern & KwaMashu)	110	2,500

South Coast Alternatives	Capacity (m^3/day)	Capital Cost (Million ZAR)
Lower uMkhomazi BWSS Phase 1	55	2,000
Lower uMkhomazi BWSS Phase 2	55	600
East Coast Desalination Plant – South	150	3,500

Source: Umgeni Water

The Mengi is the largest bulk water supply area and the uMkhomazi Water Project (Smithfield Dam) is considered as promising. In the South Coast, the alternatives of the Lower uMkhomazi BWSS (Phase 1 and 2) and Lovu Seawater Desalination Plant are still under consideration.



Source: Umgeni Water

Figure 7.17 Bulk Water Supply Alternatives by Umgeni Water

The total project cost for the Southern (Lovu) Plant is estimated at ZAR 4.2 billion and the O&M cost is estimated to be ZAR 436 million/year including 10% contingency. Electricity charge accounts for 74% of the O&M cost (excluding contingency). The water production cost to recover the initial investment and O&M cost is estimated at ZAR 13.78/m^3. Umgeni Water considers that design, construction, commissioning, and O&M for the seawater desalination plant will be done by DBO alliance with private sector's participation including investment. In DBO alliance, the O&M by private sector's participation will be performed for seven years after the completion of the plant. Afterward Umgeni Water will be responsible for the O&M.

There is a large amount of algae in the sea around the eThekwini Metropolitan Municipality. Therefore, Umgeni Water is considering the construction of a pilot plant for researching various pre-treatment methods in order to seek the optimal pretreatment method for removal of algae. In addition, Umgeni Water is also considering the construction of small-scale plants as a countermeasure against drought. The capacity of the plant is considered to be 2,500 to 10,000 m^3/day. The locations are identified at Ballito (north) and Elysium (south). Among these two locations, the tender was carried out for the design works of the plant in Elysium. The deadline of the tender was at the end of 2015 and the tender evaluation is being continued.

Chapter 8 Mozambique

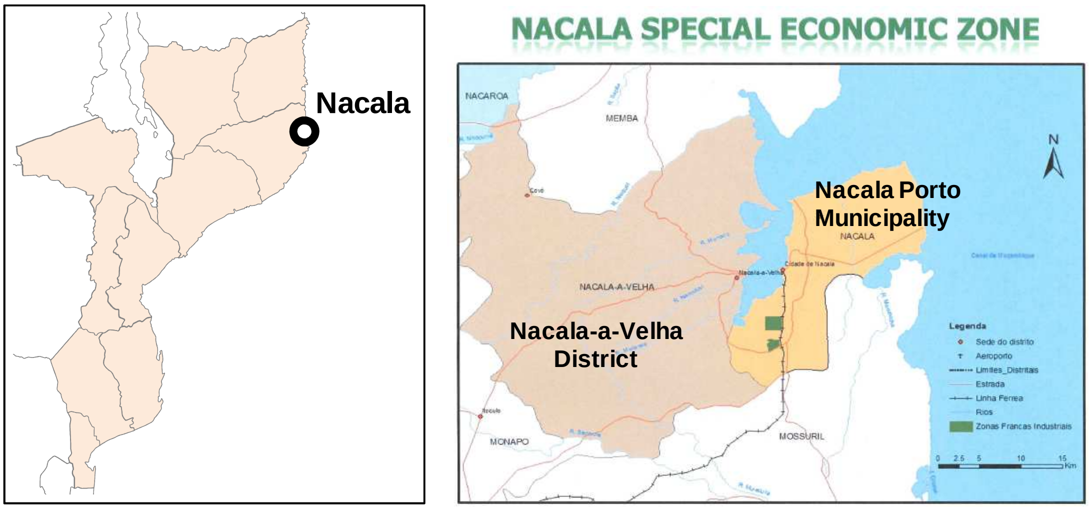
8.1 Survey Area

8.1.1 General

The Nacala Corridor, located in the northern region of Mozambique, has potential opportunities of the development and industrial promotion with the natural port called Nacala Port as the key location, and activates the natural resources development such as the inland coal mines in Tete Province and the agriculture development utilizing the vast fertile lands and abundant water resources in Nampula, and Niassa in Zambezia Provinces.

8.1.2 Nacala Special Economic Zone

The Nacala special economic zone (SEZ) is one of four SEZs in Mozambique. The Nacala SEZ comprising Nacala-Porto Municipality and Nacala-a-Velha District was established in accordance with the Decree No. 76/2007 of December 18. Figure 8.1 shows the position and range of Nacala SEZ covering a total area of 1,500 km^2. The Special Economic Zones Office (*Gabinete das Zonas Económicas de Desenvolvimento Acelerado*: GAZEDA), mandated to manage the SEZs, was established in accordance with the Decree No. 75/2007 on December 24[1]. There are 150 projects implemented up to date in the Nacala SEZ, with the total investments of USD 3 billion, including the major projects such as airport, tourism and services.



Source: GAZEDA

Figure 8.1 Location and Area of Nacala SEZ

8.1.3 PEDEC-Nacala

The Japan International Cooperation Agency (JICA) conducted the Project for Nacala Corridor Economic Development Strategies (*Projeto do Estratégias de Desenvolvimento Econômico do Corredor de Nacala*: PEDEC-Nacala) from 2012 to 2015. The Nacala Corridor in the northern region of Mozambique is being developed with the donors' assistances and private sector investments

[1] The Preliminary Study for Master Plan Formulation on Nacala Special Economic Zone, Final Report (2008)

activated. Meanwhile, the Government of Mozambique has not formulated any master plan for the development of the northern region yet and the current developments are sprawling without any grand design or fundamental principle. The PEDEC-Nacala aims at managing the resources and promoting private sector investments properly based on the strategic development planning through the assessments of current situations such as constraints and potentials in the northern region.

8.1.4 Trends of Development

(1) Port

The Nacala Port is the third largest international port in Mozambique and has sea transportation routes between Europe and Asia. The port handles transit cargos for Malawi and also plays the role of trans-shipment with the domestic ports such as Pemba and Quelimane. With a 14 m of water depth, the port is well-known as the best natural port in the southeast of Africa and attracts attentions in view of the trade around the Indian Ocean-Rim. In addition, the Nacala Corridor, extending from the Nacala Port to Malawi and Zambia, and its wayside areas have high potentials of underground resources and agriculture.

With the development of the Nacala Corridor, the cargo volume handled by the Nacala Port is forecasted to increase largely. In order to cope with the increase in the cargo volume, the port requires the renovation of aged facilities and the efficiency of cargo handling. For these requirements, JICA has been focusing on the assistance for the development of the Nacala Port as shown in Table 8.1.

Table 8.1 Assistance by JICA for Nacala Port Development

<table>
<tr><th>Cooperation</th><th>Period</th><th>Features</th></tr>
<tr><td>The Preparatory Survey on Nacala Port Development Project</td><td>Jun 2010 – May 2011</td><td></td></tr>
<tr><td>The Preparatory Survey on the Project of Urgent Rehabilitation of Nacala Port Development</td><td>Apr 2012 – Nov 2012</td><td></td></tr>
<tr><td>The Project for Urgent Rehabilitation of Nacala Port Development (Grant Aid, JPY 3.2 billion)</td><td>Dec 2012 – Nov 2015</td><td>Renovation of the north pier, development of container yard, cargo handling facility, and fire fighting facility</td></tr>
<tr><td>The Project for Improvement of Nacala Port (Technical Cooperation)</td><td>Apr 2012 – Feb 2015</td><td>Capacity development for operation and maintenance of port facilities and cargo handling technique</td></tr>
<tr><td>Nacala Port Development Project Phase I
(ODA loan, JPY 7.889 billion)</td><td>Mar 2013 – Jul 2017</td><td rowspan="2">Civil works include: 1) berth dredging, land reclamation and leveling, and work related to environmental considerations, 2) construction of access road, 3) widening entrance road into port, 4) work for gate of container terminal, 5) work for container yard pavement, and 6) renovation of north pier.
Procurement of equipment includes: 1) tire type transfer cranes, 2) gantry crane, and 3) yard chassis.</td></tr>
<tr><td>Nacala Port Development Project Phase II
(ODA loan, JPY 29.235 billion)</td><td>Mar 2013 – Jan 2018</td></tr>
</table>

Source: JICA

Through the projects financed by the official development assistance (ODA) loan, it is expected that the cargo handling capacity of Nacala Port will increase from 1,351,000 tons in 2012 to 5,071,000 tons in 2020 and the annual volume of container cargo handling will increase from 65,153 twenty-foot equivalent unit (TEU) in 2012 to 251,000 TEU in 2020.

(2) Railway

The Northern Railway (Nacala Railway) is composed of a main line from the Nacala Port via Nampula, Cuamba to Entre-Lagos at the Malawi border, and a branch line from Cuamba to Lichinga, and another branch line from Monapo to Mozambique Island.

The Vale Company has constructed a railway transport route for coal transportation from Moatize of Tete Province, passign through Malawi, to Nacala-a-Velha. This project comprises the construction of dedicated coal terminal in Nacala-a-Velha and rehabilitation and extension of the existing railway for transporting 18 million tons of coal per year. The total length of the railway is 912 km. The transportation of coal was planned originally to start at December 2014 but delayed due to the damage by flood. At the time of the site visits in February 2016, it was found that the vessel for exporting coal came to the terminal in Nacala-a-Velha and the freight train loaded with coal was traveling.

(3) Road

The renovation of National Highway 12 from Nampula to the Nacala Porto Municipality was completed in 2008. At present, JICA has been considering to implement the Nacala Corridor Road Network Upgrading Project with ODA loan. The project is assumed to include the following works:

- Nacala access road (length of 13.5 km, two lanes each way),
- Nampula southern bypass road (length of 32.5 km, two lanes each way), and
- Cuamba bypass road (length of 11.1 km, one lane each way).

The Nacala access road aims at developing the access from National Highway 12 to the Nacala Port, considering the increase of traffic volume associated with the Nacala Port development.

(4) Airport

In the past, there was only a small military airport in Nacala. The project was carried out to expand this airport to develop the international air port by assistance of Brazil. The international airport was opened in December 2014. Currently there are regular flights between Nacala and Maputo. The international airport can facilitate Boeing 747-400 and its capacity corresponds to 500,000 annual passengers and 5,000 tons annual cargo handling. It is expected that the airport will have international flights to Europe and Asia and will function as the regional hub of Malawi, Tanzania, Zambia, and Zimbabwe in the future.

(5) Electric Power

About 88% of the total electric power generation in Mozambique comes from the Cahora Bassa hydropower station located on the Zambezi River (Output: 2,075 MW). The electric power transmission system of Mozambique is divided into two: the Southern system and the Northern-Middle system. The electric power supply of the Northern-Middle system relies on the distant transmission lines from the Cahora Bassa hydropower station.

The problems on the electric power system are the insufficient electricity supply capacity and low reliability of the transmission system. The Nacala Corridor wayside areas are involved in the Northern system but its 110 KV transmission system is fragile. The accidents on the transmission lines have occurred six times and power outage reached 80 hours 34 minutes in 2013[2]. To mitigate the power outage, the Mozambique Electricity Company (*Electricidade de Moçambique*: EDM) has introduced to a vessel equipped with power generation equipment to the Nacala Port in late February 2016. It has been reported that the purposes of introduction of the power generation vessel (output: 100 MW) are: to augment the electric power supply for the northern region, to enable the Cahora Bassa hydropower station to increase the sales of electricity to Zambia, and to minimize the risk of power outage due to accident on the transmission lines from the Cahora Bassa hydropower station to the northern region.

The electric power demand is forecasted to increase rapidly in the northern region including the Nacala Corridor wayside areas in the future. To meet the future electric power demand, the development of electric power supply system is planned including 400 kV transmission line, 220 kV transmission line, and transformer substations and expected to be assisted by donor countries.

JICA conducted the 'The Preparatory Survey on the Project for Reinforcement of Transmission Network in Nacala Corridor' from March 2014 to April 2015. Afterward the project for construction of Namiaro Substation (110/33 kV) by Japanese grant aid was initiated in June 2015. In addition, JICA is carrying out the 'The Preparatory Survey on Nacala Corridor Transmission and Distribution Network Reinforcement Project' since March 2015. This project will include augmentation of existing substation, construction of 220 kV and 110 kV transmission lines, distribution lines, and installation of 30 to 40 MW-class generator in the region including Nampula, Nacala, and Monapo, assumed to be assisted by the Japanese ODA loan.

8.2 Water Resources and Water Supply

8.2.1 Water Resources

In January 2015, the Ministry of Public Works and Housing was reorganized as the Ministry of Public Works, Housing and Water Resources (*Ministério das Obras Públicas, Habitação e Recursos Hidricos*). The National Water Directorate (*Direcção Nacional de Águas*: DNA) was responsible for the management of water resource, water supply and sewerage at the government level. At the meeting with DNA during the site survey in early February 2016, it was informed that the DNA has been recently reorganized into the two organizations below.

- National Directorate for Water Resources
- National Directorate for Water Supply and Sanitation

Nacala is located on coast of the Indian Ocean within the jurisdiction of the Regional Water Administration (*Administração Regional de Águas*: ARA) Centro-Norte as shown in Figure 8.2. There are three major river basins designated in the jurisdiction of ARA Centro-Norte: the Lurio River basin (60,800 km^2), the Ligonha River basin (16,299 km^2), and the Licungo River basin (27,726 km^2). The rivers in suburbs of Nacala are small in catchment area and located between the Mecuburi River basin (8,925 km^2) and the Monapo River basin (7,724 km^2). The mean monthly flows of the Lurio River and Monapo River are shown in Table 8.2. Meanwhile, these small rivers in suburbs of Nacala are seasonal and their flow rates become zero for six months a year as shown in Figure 8.3. Even though the Monapo River has a large catchment area, its flow rate becomes zero due to drought[3]. At present, the

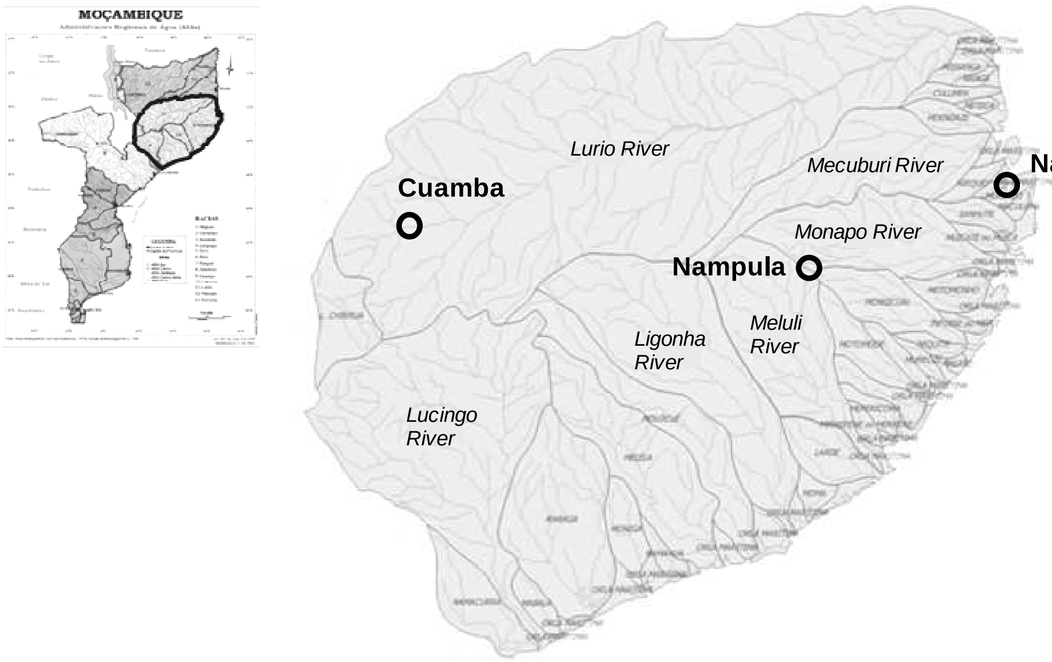
[2] The Preparatory Survey Report on the Project for Reinforcement of Transmission Network in Nacala Corridor (2015)
[3] MCA-Mozambique, Final Feasibility Study Report, City of Nacala, Volume I - Water (2010)

Nacala Dam with a catchment area of 136.8 km^2 is only a dam reservoir in the suburb of Nacala and is utilized as the water source for Nacala Porto Municipality.

Table 8.2 Mean Monthly Flow of Lurio River and Monapo River

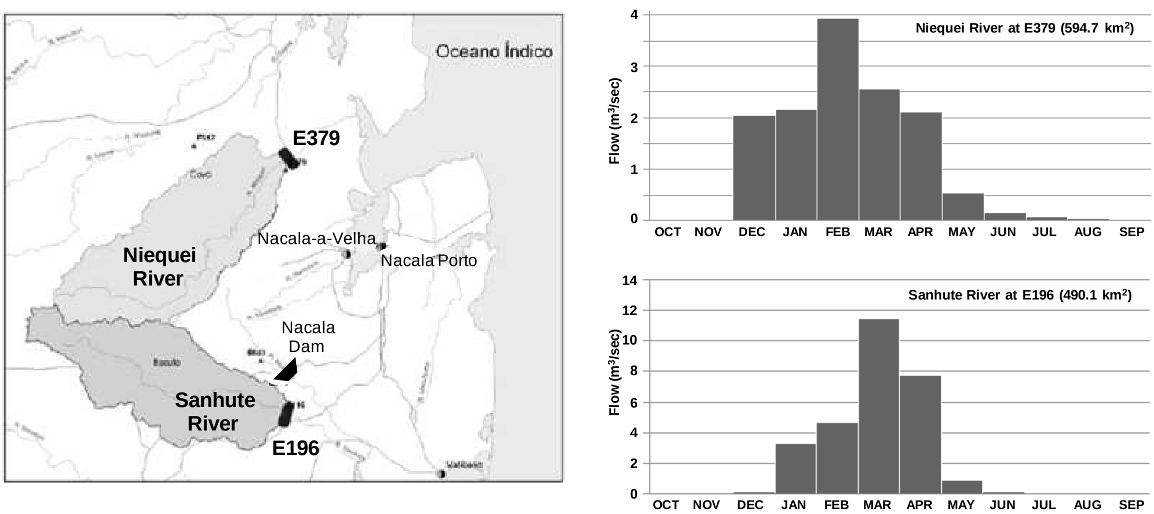
River	Station	CA (km^2)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lurio	E128		13.3	18.0	289.1	1282	2493	2242	1156	356.2	130.4	78.4	45.6	23.5
Monapo	E140	6,000	1.9	9.6	55.7	156.7	165.3	172.9	100.0	53.6	15.7	11.3	7.0	3.5

Source: ARA Centro Norte



Source: ARA Centro-Norte

Figure 8.2 Jurisdiction of ARA Centro-Norte



Source: MCA-Mozambique, Final Feasibility Study Report, City of Nacala, Volume I - Water (2010)

Figure 8.3 Mean Monthly Flow of Rivers in Nacala Suburbs

8.2.2 Water Supply

(1) FIPAG

The Investment Fund and Water Supply Asset Holder (*Fundo de Investimento e Património de Abastecimento de Água*: FIPAG) owns 15 water supply systems in 21 cities of Mozambique. Water supply facilities constructed by the government are handed over to FIPAG. All decisions about planning, design, implementation, and budget for water supply development are made by FIPAG headquarters. FIPAG has four regional branches across the country; these are North, Central, South, and Maputo. The water utilities under the jurisdiction of the FIPAG Regional North are "6 plus 1". The "6" are Nampula, Pemba, Nacala, Angoche, Lichinga, and Cuamba, where water supply facilities are owned by FIPAG. The "1" is Mozambique Island where the water supply facilities are owned by the Management Infrastructure for Water Supply and Sanitation (*Administração de Infraestruturas de Abastecimento de Água e Saneamento*: AIAS). The FIPAG Regional North gathers and adjusts the needs and concept of water supply development in the"6 plus 1", and then sends the reports to the FIPAG headquarters. In Nacala Porto Municipality, FIPAG Nacala, as a water utility, operates the water supply facilities, provide services to the residents, and carries out the maintenance of the water supply facilities.

(2) Nacala Porto Municipality

1) Existing Water Supply System and Ongoing Project

The population of Nacala Porto Municipality was 241,066 (2015). In Nacala Porto Municipality, the service coverage by FIPAG is about 50%. The remaining population depend on wells and water tankers organized by the municipality but any detail about the water supply capacity by the municipality was not available. The existing water supply facilities of Nacala Porto Municipality are also shown in Table 8.3 and Figure 8.3.

The existing water supply facilities consist of: water treatment plant, water transmission and distribution facilities using Nacala Dam as water source, and water transmission and distribution facilities using two well fields, M'Paco and Mutuzi, with six wells in total as shown in Figure 8.4. Under the Water Services and Institutional Support Project (WASIS) assisted by the World Bank, the existing wells and associated facilities have been rehabilitated and the present water supply capacity by FIPAG stays at 18,000 m^3/day as shown in Table 8.3. The World Bank is also assisting the development of the water supply facilities successively under the Integrated Growth Poles Project (IGPP). Through the IGPP, the water supply capacity will increase up to 30,200 m^3/day as shown in Table 8.4.

Table 8.3 Existing Water Supply Facilities for Nacala Porto Municipality

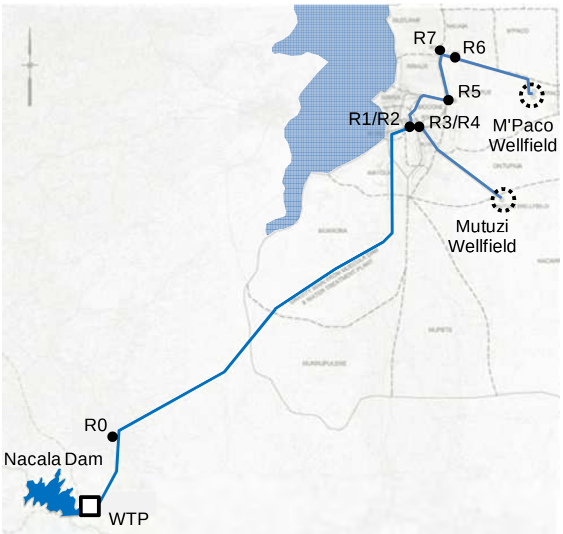
Component	Description
Water treatment plant	7,200 m^3/day
Water transmission main	30 km
M'Paco well-field	6,500 m^3/day
Mutuzi well-field	4,320 m^3/day
Reservoir (seven)	Total 5,000 m^3
Water distribution mains	143 km

Source: FIPAG

Table 8.4 Water Supply Improvement Project for Nacala Porto Municipality

Water Source	Present	2019 (IGPP)	2023 (WASIS II)
Boreholes	10,820	23,000	23,000
Nacala Dam	7,200	7,200	12,000
Total	18,020	30,200	35,000

Source: FIPAG



Source: MCA-Mozambique, Final Feasibility Study Report, City of Nacala, Volume I - Water (2010)

Figure 8.4 Existing Water Supply Facilities for Nacala Porto Municipality

Under the IGPP, ten wells are being constructed together with the water transmission and distribution facilities for expanding the water distribution network with a total length of 110 km. These are scheduled to be completed in 2019. In consideration of the experience that the existing wells became unusable because of salinity intrusion in the adjacent Nacala-a-Velha District, it was decided that the study on measures protecting the wells from salinity intrusion should be conducted under the IGPP. On the World Bank website, request for express of interest (EOI) of the consultancy services contract for the Study for Saline Intrusion and Groundwater Management Plan for Nacala was published. Deadline for EOI submission was on November 30, 2015.

2) Water Supply Development Plan by MCA

The captioned plan is described in the Final Feasibility Study Report, City of Nacala, Volume I - Water (2010) done by the Millennium Challenge Account (MCA) - Mozambique (hereinafter referred as the MCA report) as follows:

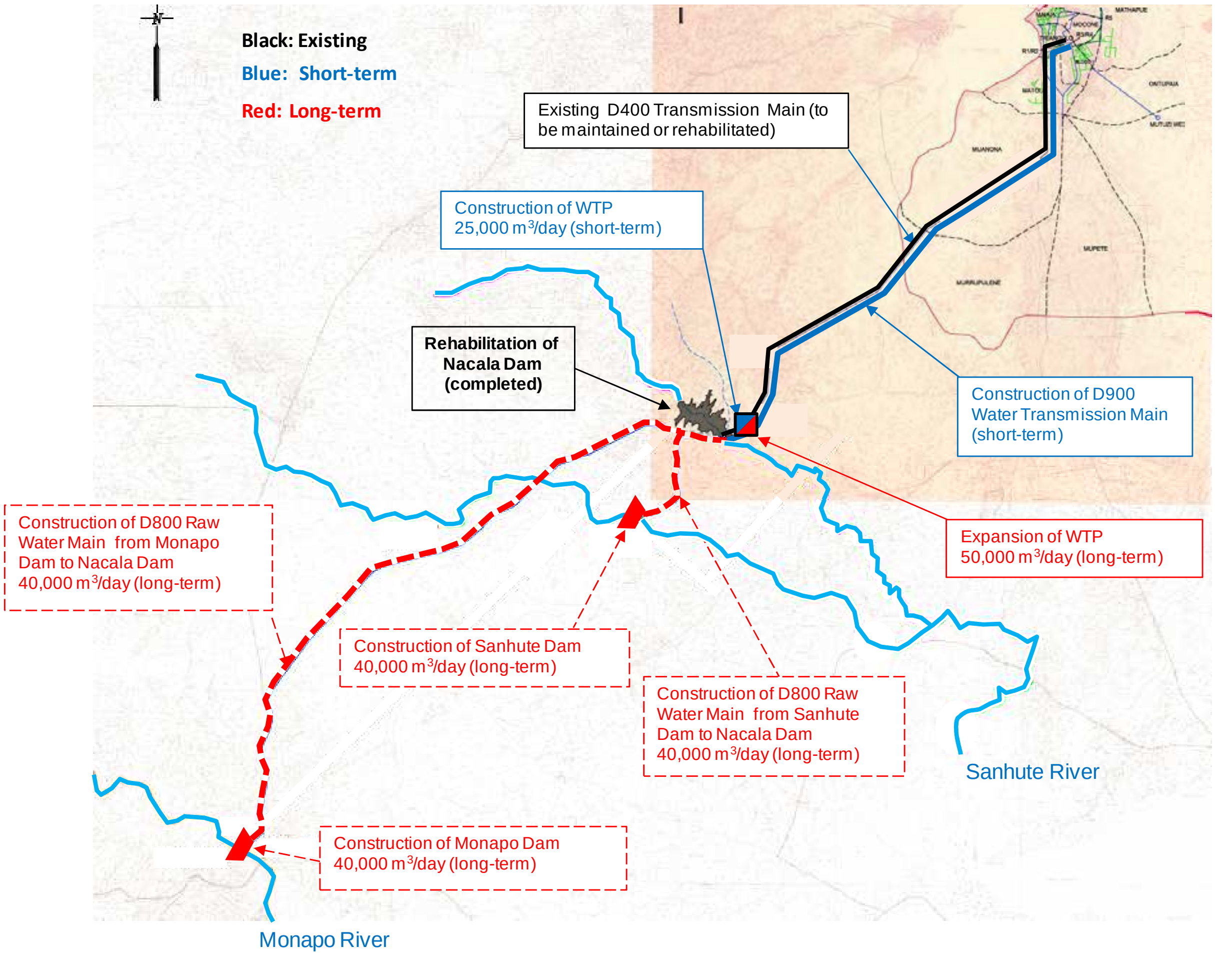
- The water demand will be 43,557 m^3/day in 2019 and 61,133 m^3/day in 2029 as shown in Table 8.5.

Table 8.5 Water Demand Forecast for Nacala Porto Municipality (by MCA, 2010)

Year		2009		2019		2029	
Total population	(person)	220,757		309,160		434,314	
Population served	(person)	174,398	79%	273,607	89%	402,175	93%
Domestic water demand	(m^3/day)	9,603		18,744		28,982	
Non-domestic water demand	(m^3/day)	1,921	20%	5,623	30%	10,144	35%
Total water demand	(m^3/day)	11,524		24,367		39,126	
Unaccounted-for water (UFW)	(m^3/day)	7,721	40%	10,478	30%	9,781	20%
Average daily demand	(m^3/day)	19,244		34,846		48,907	
Peak factor		1.25		1.25		1.25	
Maximum daily demand	(m^3/day)	24,055		43,557		61,133	

Source: MCA-Mozambique, Final Feasibility Study Report, City of Nacala, Volume I - Water (2010)

- In addition to the existing wells with the capacity of 10,000 m^3/day, the water supply capacity by the surface water development will be extended up to 50,000 m^3/day in the long-term plan to meet the water demand in 2029. Two alternatives of Monapo Dam and Sanhute Dam are shown in the long-term plan as shown in Figure 8.5 and Table 8.6.
- In the short-term plan, the water treatment plant will be constructed with the capacity of 25,000 m^3/day that corresponds to half of the capacity in the long-term plan. The renewal of water transmission main will also be carried out for supplying the maximum of 25,000 m^3/day to Nacala Porto Municipality. But it should be noted that the water supply of 25,000 m^3/day is planned as provisional and is not sustainable throughout a year[4].



Source: MCA-Mozambique, Final Feasibility Study Report, City of Nacala, Volume I - Water (2010)

Figure 8.5 Water Supply Development Plan of Nacala Porto Municipality (Short-term and Long-term)

The rehabilitation of the Nacala Dam (reservoir capacity increased by raising spillway crest) was already completed with the assistance by the MCA. It was scheduled that the water treatment plant and water transmission main to Nacala Porto Municipality would be constructed in conjunction with the rehabilitation of the Nacala Dam. However, the government terminated the contract for construction of the water treatment plant and water transmission main in September 2013 at the end of the assistance by the MCA. Afterward the government negotiated with the World Bank to

[4] The MCA report describes 'Reduced Reliability'.

include these works into the Water Services and Institutional Support Project II (WASIS II) to be implemented but did not succeed. These is no schedule to implement these works at this moment.

According to the MCA report, the water transmission from the Nacala Dam will increase from 7,200 m^3/day to 10,000 m^3/day[5]. Meanwhile, the short-term plan includes the development of: the water treatment plant with the capacity of 25,000 m^3/day corresponding to half of the capacity in the long-term plan, and about 30 km of the water transmission main for 50,000 m^3/day in the long-term plan, for increasing the water transmission by 2,800 m^3/day only. These are planned on the premise that the long-term plan should be completed essentially succeeding to the short-term plan. Therefore, the sole implementation of the short-term plan is regarded as less feasible.

Table 8.6 Water Supply Development Plan for Nacala Porto Municipality (by MCA, 2010)

Component	Short-term (finished by 2019)	Long-term (finished by 2029)	
		Alternative: Monapo River	Alternative: Sanhute River
Surface water source	Nacala Dam: 10,000 m^3/day	Nacala Dam: 10,000 m^3/day Monapo Dam: 40,000 m^3/day	Nacala Dam: 10,000 m^3/day Sanhute Dam: 40,000 m^3/day
Water intake and water conveyance main	One pumping station at Nacala Dam Raising main, ND 900, 250 m	One pumping station at Monapo Dam Two booster pumping stations ND 800, 35.5 km Two pumping stations at Nacala Dam Raising main, ND 900, 250 m	One pumping station at Sanhute Dam ND 800, 8.0 km Two pumping stations at Nacala Dam Raising main, ND 900, 250 m
Water treatment plant (WTP)	Slow sand filter 25,000 m^3/day	Slow sand filter 50,000 m^3/day	Slow sand filter 50,000 m^3/day
Water transmission main	ND 900 27.35 km from WTP to R1/R2	ND 900 27.35 km from WTP to R1/R2	ND 900 27.35 km from WTP to R1/R2
Water distribution mains and reservoirs	Primary water distribution network, 84.8 km 3,000 m^3 grade, One reservoir at R0 1,500 m^3 grade, One reservoir at R1/R2	Primary water distribution network, 195.9 km 3,000 m^3 grade, One reservoir at R0 1,500 m^3 grade, Two reservoirs at R1/R2 5,000 m^3 grade, One reservoir at R3/R4 1,500 m^3 grade, Two reservoirs at R6	Primary water distribution network, 195.9 km 3,000 m^3 grade, One reservoir at R0 1,500 m^3 grade, Two reservoirs at R1/R2 5,000 m^3 grade, One reservoir at R3/R4 1,500 m^3 grade, Two reservoirs at R6

Source: MCA-Mozambique, Final Feasibility Study Report, City of Nacala, Volume I - Water (2010)

(3) Nacala-a-Velha District

The total population of the Nacala-a-Velha District was 118,911 (2015) in which the population in the town was 19,553. The population provided with water supply services is 5,600 in the town. Besides, there are 188 wells in the district. In the entire district, the population provided with water supply services by these wells is 38,176 corresponding to 37% of the total population. In the town, water is supplied by the water transmission main from the Nacala Dam. The water transmission main was constructed by the Vale Company requested by FIPAG. Nacala-a-Velha District is proposing a plan

[5] The MCA report describes that the sustainable water taken from the Nacala Dam is estimated in a range of 10,000 to 12,000 m^3/day and applies 10,000 m^3/day (with 98% reliability) for planning. On the other hand, FIPAG uses 12,000 m^3/day as shown in Table 8.4.

consisting of water transmission and distribution mains (length 15 km), water distribution reservoir (capacity 100 m^3), and pump lifting water to the elevated tank and discussing it with FIPAG. FIPAG is planning to integrate the water supply systems of Nacala Porto Municipality and Nacala-a-Velha District until June 2016 in order to unify the management[6]. Any detail about the water demand in Nacala-a-Velha District was not available.

8.3 Need and Feasibility of Seawater Desalination Project

8.3.1 Water Demand Forecast

The PEDEC-Nacala defines the Nacala Bay Area as a future development area that consists of: Nacala Porto Municipality and neighboring Matibane Administrative Post in Mossuril District to the south, and Nacala-a-Velha District and neighboring Memba-sede Administrative Post in Memba District to the north. It is forecasted that the population of the Nacala Bay Area in 2035 will be 927,100 and the industrial area will be 1,000 ha. In an option for limited supply areas covering 80% of the urban population, the water demand forecast in 2035 is: 158,827 m^3/day for domestic and institutional use, 185,000 m^3/day for industrial use, and total of 343,827 m^3/day as shown in Table 8.7.

Table 8.7 Projection of Population, Industrial Area and Water Demand by PEDEC-Nacala

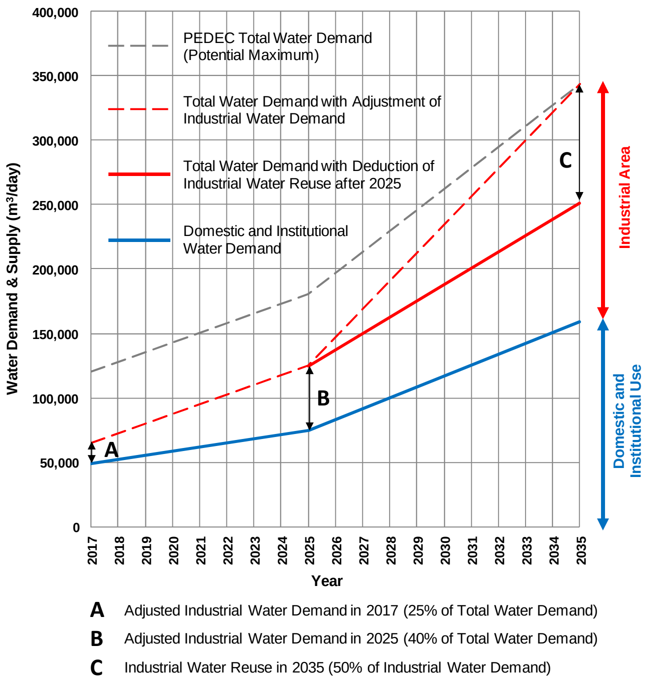
	2017	2025	2035
Population (persons)	387,600	579,000	927,100
Industrial area (ha)	300		1,000

Prediction water of demand (m^3/day)

	2017	2025	2035
Domestic and institutional use	48,685	74,983	158,827
Industrial area	71,500	105,500	185,000
Total	120,185	180,483	343,827

Source: PEDEC-Nacala

It is presumed that the water demand forecast by PEDEC-Nacala would be based on the industrial area corresponding to the potential maximum development. On the other hand, the volume of the industrial water supply Nacala is 22% of the total water supply volume by FIPAG in 2015. With due consideration of the actual industrial water supply in 2015, the industrial water demand forecast should be adjusted. The percentage of the industrial water demand to the total water demand is adjusted to 25% in 2017 and 40% in 2025.



Source: Prepared by the Survey Team

Figure 8.6 Water Demand Projection for Nacala Bay Area

6 One of the conditions for the loan as described in the Project Appraisal Document of the IGPP assisted by the World Bank

In addition, it is assumed that; the industrial development would be fully activated in 2025 when the basic infrastructure including port, road and electricity to be developed would be operational; and the industrial water reuse would be initiated in 2025 and a rate of the industrial water reuse would be 50% by 2035 as shown in Figure 8.6.

8.3.2 Water Resources Development

Considerations on the water resources development to cope with water demand of Nacala Bay Area in the future are described hereunder.

1) Nacala Dam (expansion) and Sanhute River

By the integration of the following plans prepared by the MCA, it is conceivable to increase the water supply capacity using the Nacala Dam from 7,200 m^3/day to 52,000 m^3/day[7]. In other words, all the works composed of the long-term plan prepared by the MCA are implemented as one project.

- Rehabilitation of Nacala Dam for increasing storage capacity by raising spillway crest (completed)
- Construction of Sanhute Dam and water conveyance main from Sanhute Dam to Nacala Dam
- Completion of intake facility at Nacala Dam and construction of water treatment plant, water transmission and distribution facilities from Nacala Dam to Nacala Bay Area.

During the first stage survey (work in Japan), the information was found regarding a plan of dam construction on the river in Nacala suburbs. It is recognized that the information corresponds to the Sanhute Dam shown in the list of priority projects proposed by Nampula Province. A PPP project is envisaged implementing the construction of the Sanhute Dam[8]. It is presumed that the PPP project would be planned with the same as above-mentioned. According to the ARA Centro-Norte, DNA signed a concession agreement of the PPP project with Jeffares & Green (South Africa) in 2014 but there is no further information about the subsequent progress.

For the Sanhute Dam, the focal point is the availability of the water source for supplying 40,000 m^3/day as planned. As described in Subsection 8.2.1 before, the Sanhute River is seasonal and has no flow for the period of six months or more in a year. It is essential for the Sanhute Dam to ensure a reservoir capacity for storing the river run-off during the rainy season in order to sustain a water supply of 40,000 m^3/day (0.46 m^3/s) throughout a year.

The MCA report did not study details of the Sanhute Dam. According to the literature describing the existing Nacala Dam located in the vicinity of the planned Sanhute Dam, the catchment area of the Nacala Dam is 136.8 km^2 and the sustainable water intake volume is around 12,000 m^3/day with the rehabilitation of the Nacala Dam[9]. Aside from the MCA report, it is suggested the detail

---

7 The MCA report planned a capacity of 50,000 m^3/day in the long-term plan. The capacity of 52,000 m^3/day shown here is based on 12,000 m^3/day by the rehabilitation of the Nacala Dam and 40,000 m^3/day by the Sanhute Dam.

8 There is a relevant description in Urban Water Supply System and Investment Plan in the Northern Region, JETRO Johannesburg Office, March 2016

9 Nacala Dam Feasibility Study, Environmental and Social Impact, Assessment, Design and Supervision, Volume 5 Environmental Impact Assessment Report, July 2010

analysis for the sustainable water intake volume was elaborated at the time of the feasibility study on the rehabilitation of the Nacala Dam. The Sanhute Dam requires the similar detail analysis essentially.

At the location of the Sanhute Dam, corresponding to a hydrological station E196, the catchment area is 490.1 km^2 that is 3.6 times of the catchment area of the Nacala Dam. Therefore, it is presumed that the annual flow rate at the Sanhute Dam would also be 3.6 times approximately but sustainable water intake volume could not be known due to the need for a reservoir. When the topographic conditions near the currently planned location allow the Sanhute Dam to ensure the enough storage capacity, the water supply of 40,000 m^3/day may be viable.

2) Niequei River

The catchment area at a hydrological station E379 of the Niequei River is 594.7 km^2. The MCA report excluded the Niequei River from the alternative water resources as there is salt water intrusion and the flat topography is not suitable for dam reservoir. During the site survey, it was informed by the ARA Centro-Norte that Niequei Dam would be reconsidered together with the study on the PPP project for construction of the Sanhute Dam[10].

3) Monapo River

In the long-term plan of the MCA report, two alternative water sources, Monapo Dam and Sanhute Dam, are shown in the development plan for the water supply in Nacala. On the other hand, the Monapo River needs to be considered as a water source succeeding to the Sanhute Dam in order to meet the future water demand in the Nacala Bay Area. The MCA report planned 40,000 m^3/day to be taken from the Monapo Dam. Meanwhile the Monapo Dam may be developed as further large-scale water source as its catchment area is comparatively large.

The Monapo River basin covers an area of 7,724 km^2. Although the mean monthly flow rates from December to May at a hydrological station E140 (catchment area: 6,000 km^2) ranges from 50 to 170 m^3/s, the flow rate is extremely lowering in the dry season (see Table 8.2). Further, the MCA report suggested that the flow rate would be nearly zero during two months in the dry season[11]. For utilizing the Monapo River as a water source, a dam reservoir having a storage capacity enough to sustain water supply throughout a year.

The MCA report did not study details of the Monapo Dam but pointed out the major difficulty in constructing the dam with a crest length about 1.6 km due to the flat topography.

On the other hand, it is presumed that the water of the Monapo River would be utilized for different purposes. The following major water uses are so far indentified:

- Water Supply in Nampula Municipality: The existing Monapo Dam[12] is located about 10 km north of Nampula Municipality. The intake and water purification facilities were constructed with the assistance by the MCA and the water supply capacity has become 20,000 m^3/day. In addition, a project is under consideration for increasing the water supply capacity up to

[10] There is a relevant description in Development Situations of Drainage and Sewerage Sector and Water Resources, JETRO Johannesburg Office, December 2015

[11] A satellite image of Google Earth as of December 2005 suggests that the Monapo River was dried up.

[12] This dam is not the proposed alternative by the MCA report but is located far upstream of the Monapo River.

60,000 m^3/day by constructing the Saua Saua Dam located at about 8 km downstream from the existing Monapo Dam. This project is listed on the PPP Investment Plan 2015-2020 of Nampula Province[13].

- Irrigation: Private banana firm in the vicinity of Namialo owns the dam for water intake[14].
- Mining: The Vale Company has a plan to mine phosphorus ore in Monapo and produce phosphoric acid for fertilizer in Nacala. Monapo is located about 70 km away from Nacala to the southwest. The use of the existing railway from Monapo to Nacala is considered to transport the phosphorus ore. The phosphorus ore mine is located near the Monapo River and construction of a dam reservoir is also planned on the river. It is envisaged that water taken from the dam reservoir will be transported to the phosphoric acid production factory in Nacala by rail or through pipeline[15].

Because of the existing and planned water uses from the Monapo River, the use of the Monapo River as water source of the water supply should be studied in detail under a comprehensive water resources management plan based water resources assessment, present and future water uses, and water demand and supply balance focusing on the entire Monapo River basin.

4) Mecuburi River

ARA Centro-Norte assumes the Mecuburi River (catchment area: 8,925 km^2) as one of the water sources for the Nacala Bay Area in the future. The FIPAG's presentation document in November 2014, 'Dams in Strengthening of Urban Water Supply Development' (*Barragens no Reforço dos Abastecimentos Urbanos*), describes the Mecuburi Dam together with the Sanhute Dam. It was informed by the ARA Centro-Norte that a distance of water conveyance from the Mecuburi Dam to Nacala Bay Area would be about 80 km. But any information about the location of the dam reservoir, water intake point, and water conveyance route was not made available.

The satellite view of the Mecuburi River on Google Earth shows that the downstream is a braided channel. Therefore it is hard to select the location of water intake. Even if a suitable site for water intake can be identified in the middle of the basin, it is extremely difficult to select the water conveyance route due to a large difference of altitude between river and watershed. Moreover, it is essential to have a comprehensive water resources management plan, similar to the Monapo River as mentioned above.

5) Lurio River

The Lurio River is the largest in the jurisdiction of ARA Centro-Norte, with a catchment area of 60,800 km^2. The water conveyance from the Lurio River is shown as a long-term project in the list of the priority projects prepared by Nampla Province. From a water intake site about 170 km northwest from Nacala Bay Area, water will be conveyed once to the Mecuburi River through 56 km tunnel. A water intake site on the Mecuburi River will be located about 110 km downstream and water will be further conveyed to the Nacala Bay Area through 60 km open channel. The planned water supply volume is 518,000 m^3/day.

[13] Urban Water Supply System and Investment Plan in Northern Mozambique, JETRO Johannesburg Office, March 2016
[14] Detailed Planning Survey Report on the Project for Nacala Corridor Economic Development Strategies (2012)
[15] This project is suspended at present.

Meanwhile, there will be a lot of technical and financial difficulties anticipated in carrying out such a large-scale project to be operational in 2035.

Within the Mozambique National Water Resources Development Project assisted by the World Bank, the DNA announced the procurement of consultants for the Strategic Basin Plan for the Utilization and Development of the Lurio River Basin. EOI submission deadline was dated on February 26, 2013. The water conveyance from the Lurio River should be justified in the Strategic Basin Plan before preparation of project study.

6) Groundwater

In consideration of the experience that the existing wells became unusable because of salinity intrusion in the adjacent Nacala-a-Velha District, it was decided that the study on measures protecting the wells from salinity intrusion should be conducted under the IGPP assisted by the World Bank. In Nacala Bay Area, it should be cautious about further increase of the groundwater yield from 23,000 m^3/day after the completion of the IGPP. Therefore the groundwater is not expected to cope with the large increase of water demand in the future.

7) Seawater Desalination

During the first stage survey (work in Japan), the information was found regarding a plan of seawater desalination in Nacala. The seawater desalination project for the water supply in Nacala Porto Municipality is shown as a long-term project in the list of priority projects proposed by Nampula Province. According to DNA and FIPAG, any specific study on seawater desalination has not been conducted yet for the time being.

8.3.3 Water Demand and Supply Balance

Through the considerations for the water resources development to cope with the water demand in the Nacala Bay Area in the future, the plan of the Nacala Dam (expansion) and Sanhute Dam proposed in the MCA report is the most realistic for the time being. The Monapo Dam planned by the MCA report should be further scrutinized in terms of site and water volume to be taken under a comprehensive water resources management plan based on water resources assessment, present and future water uses, and water demand and supply balance focusing on the entire Monapo River basin.

There is a possibility to develop the Niequei River. But its technical viability is unknown at present. In addition, the scale of the catchment area is small and the available water resources will not meet the large water demand in the future. Therefore, the Niequei River is not included in the consideration of the subsequent water demand and supply balance.

The water conveyance from the Lurio River through the Mecuburi River is a large-scale project. The conditions for its implementation are: formulation of the Strategic Basin Plan for the Utilization and Development of the Lurio River Basin, justification of its viability under the Strategic Basin Plan, preparation of its implementation program to be decided clearly as a government policy, and formation of consensus among the various stakeholders in the northern region. Therefore, the lead time before commencement of the project should be taken into consideration for a series of the discussions relevant to the process as mentioned. In addition, a number of years will be required to construct the water intake facility, 56 km tunnel and 60 km open channel. Considering these matters, it is unlikely that the project can be operational by 2035.

Based on the above considerations, the following can be assumed to increase the water supply capacity for the Nacala Bay area until 2035. Table 8.8 shows the assumptions of increasing the water supply capacity for Nacala Bay Area.

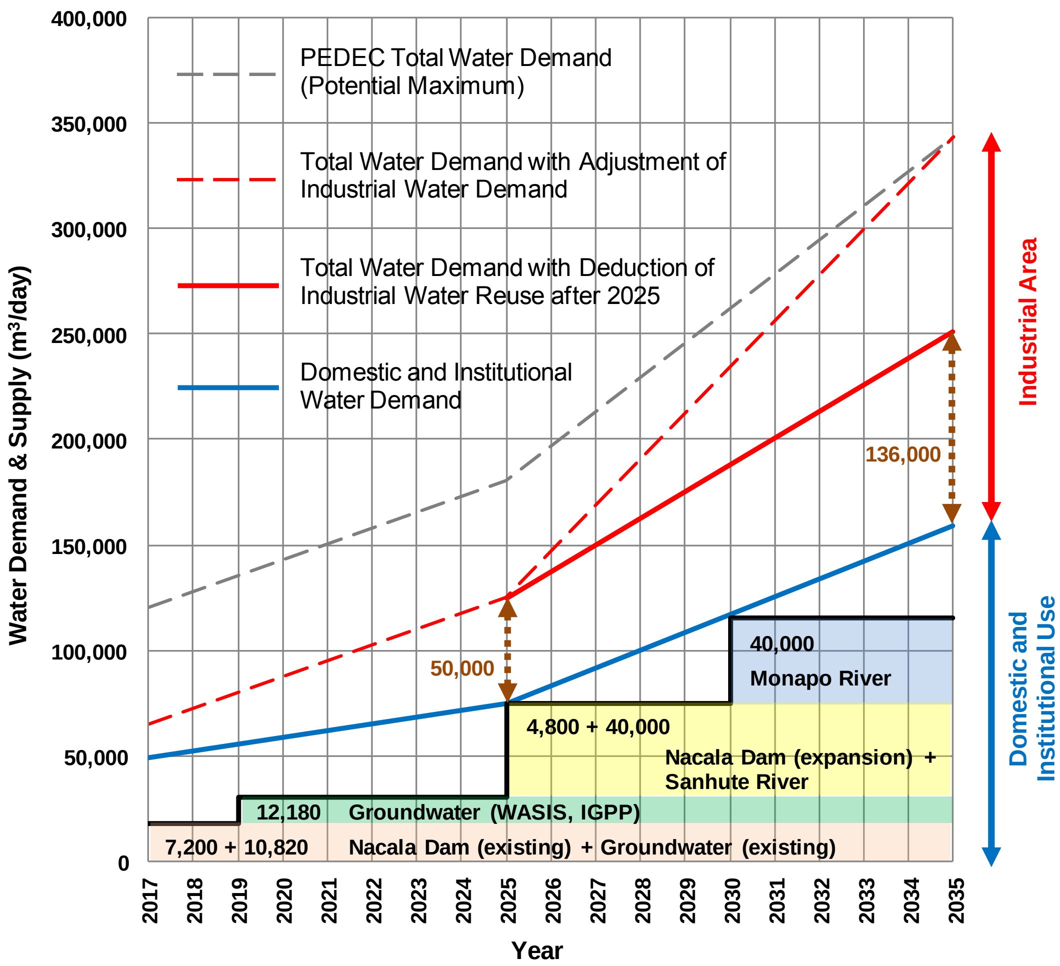
- The development of the Nacala Dam (expansion) and Sanhute Dam is already presented as the long-term plan in the MCA report and the development components are clear. In addition, there is a possibility of implementation as a PPP project. Therefore, it is assumed that the the Nacala Dam (expansion) and Sanhute Dam will be completed and operational by 2025.
- The development of the Monapo Dam is also presented as the long-term plan in the MCA report and the development components are clear, but its viability should be confirmed within the water resources management plan of the entire river basin. Although there is a possibility of review and change through the confirmation of the viability in the future, the plan by the MCA report is considered as applicable for the time being. Considering the time taken for possible review and change through the confirmation of the viability, it is assumed that the Monapo Dam will be completed and operational by 2030.

Table 8.8 Assumed Increase of Water Supply Capacity for Nacala Bay Area

Year	Water Source	Volume (m^3/day)	Accumulated (m^3/day)
2017	Nacala Dam (existing) + Groundwater (existing)	7,200 + 10,820 = 18,020	18,020
2019	Groundwater (WASIS/IGPP)	12,180	30,200
2025	Nacala Dam (expansion) + Sanhute River	4,800 + 40,000 = 44,800	75,000
2030	Monapo River	40,000	115,000

Source: Prepared by Survey Team

In comparison with the water demand forecast and the assumption for increasing the water supply capacity, the shortage will be 50,000 m^3/day in 2025 and 136,000 m^3/day in 2035. Figure 8.7 shows the water demand and supply balance in the Nacala Bay Area.



Source: Prepared by the Survey Team

Figure 8.7 Water Demand and Supply Balance for Nacala Bay Area

8.3.4 Water Distribution Management

There are many issues on the existing water distribution network, water distribution management, and services of FIPAG Nacala. The water supply performance indicators computed from the data provided by FIPAG Nacala are shown in Table 8.9. Based on the total population and population served estimated by FIPAG Nacala, the service coverage ratio is less than 40%. Although the total water distribution volume in 2014 increased because of the WASIS and IGPP assisted by the World Bank, the ratio of non-revenue water (NRW) also increased at the same time. It is suggested that the development of a water distribution network could not keep up with the development of the water supply facilities[16].

The water distribution volume classified by consumer category indicate that the sum of domestic and standpipe accounts for more than 60% of the total the water distribution volume as shown in Table 8.10. The industrial increased largely in 2015 and implies that the WASIS and IGPP could contribute to the increase of the industrial water supply.

[16] The population served and service coverage ratio in 2015 are not shown because of the discrepancies on the data given by FIPAG Nacala.

Table 8.9 Water Supply Performance Indicators of FIPAG Nacala

			2013	2014	2015
(1)	Total population	person	241,912	248,928	256,147
(2)	Population served	person	94,116	93,281	
(3) = (2)/(1)	Service coverage	%	39%	37%	
(4)	Total water distribution	m^3	2,353,430	3,832,940	3,548,952
(5)	Revenue water	m^3	1,433,987	1,617,145	1,886,105
(6) = (4)-(5)	Non-revenue water	m^3	919,443	2,215,795	1,662,847
(7) = (6)/(4)	NRW ratio	%	39%	58%	47%
(8)	Total domestic water distribution	m^3	1,169,582	1,529,290	1,546,622
(9) = (8)/(2)	Per capita consumption	liter/day	34	45	

Source: Prepared by the Survey Team based on the data provided by FIPAG Nacala

Table 8.10 Water Distribution Volume Classified by Consumer Category of FIPAG Nacala

	2013		2014		2015	
	m^3	%	m^3	%	m^3	%
Total Water Distribution	**1,734,211**	**100%**	**2,196,384**	**100%**	**2,367,234**	**100%**
Commercial/Service	181,764	10%	197,777	9%	176,116	7%
Domestic	1,112,161	64%	1,469,098	67%	1,482,107	63%
Standpipe	57,421	3%	60,192	3%	64,515	3%
Industrial	247,645	14%	299,986	14%	511,628	22%
Municipal	1,625	0%	1,724	0%	15,477	1%
Public	81,594	5%	101,765	5%	90,476	4%
Bulk supply	52,001	3%	65,842	3%	26,915	1%

Source: FIPAG Nacala

8.3.5 Need and Feasibility of Seawater Desalination Project

(1) Time to Introduce Seawater Desalination and Its Scale

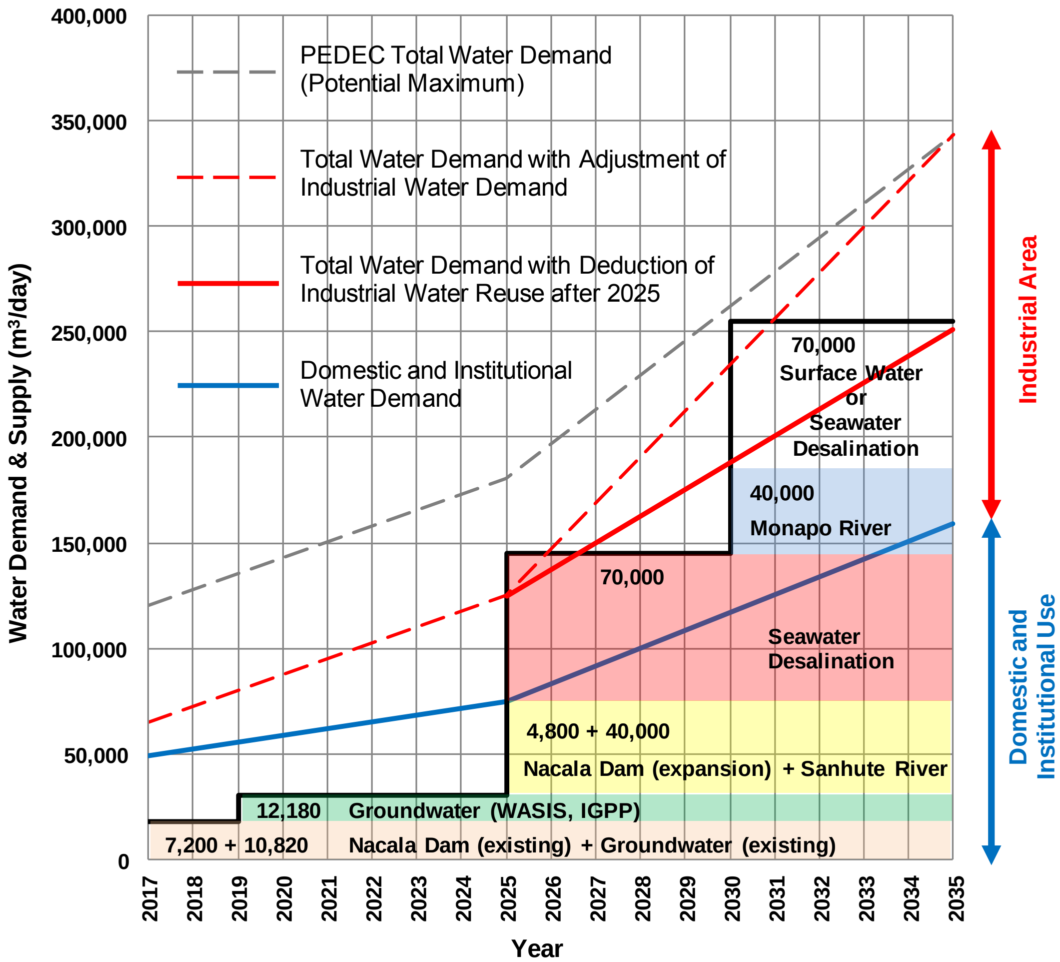
To meet the large increase of water demand in the Nacala Bay Area, the water resources development with an inter-basin water conveyance will be required in the mid- and long-term. But it is not easy to implement such a water conveyance. Therefore, it is anticipated that the difficulty in developing further water resources due to geographical conditions would be a critical bottleneck in the development of the Nacala Bay Area. For the time being, the development of other basic infrastructure (ports, roads, and power supply) is already in progress, solutions for the bottleneck of water should be identified in order to promote the development in the Nacala Bay Area.

From the considerations in this chapter, it is presumed that the need for seawater desalination would take place within the timescale of promoting the development in the Nacala Bay Area. When the development and port, road, and electric power being in progress is completed and operational, the development in the Nacala Bay Area will be fully activated. Therefore, it is assumed that the seawater desalination would also be introduced at the same time, e.g., in the year 2025 at the earliest. In order to meet the water demand up to 2035, an example scenario for introducing the seawater desalination is described as follows and further shown in Figure 8.10.

- The water supply development with the Sanhute Dam will be completed and operational by 2025.
- Any long-distance water conveyance project from the outside of Nacala Bay area will not be completed and operational by 2025. Therefore, a seawater desalination plant with capacity of

70,000 m³/day will be installed by 2025 in order to promote the full-scale development of Nacala Bay area.

- The Monapo Dam with the capacity of 40,000 m³/day will be completed and operational in 2030. Taking into account the scale of the river basin, it is expected that the Monapo Dam will be developed as a further large-scale water source, e.g., 110,000 m³/day to meet the water demand up to 2035. On the other hand, the Monapo Dam (40,000 m³/day) in combination with the seawater desalination (70,000 m³/day) will also be an alternative. An optimum plan will be proposed through a comparative study for two alternatives.



Source: Prepared by the Survey Team

Figure 8.8 Scenario of Introducing Seawater Desalination to Nacala Bay Area

(2) Further Discussions

The water demand forecast by the PEDEC-Nacala is based on the conceptual goal for developing the Nacala Bay Area up to 2035. This chapter presents the considerations with the timescale of the water demand and supply balance for contributing to further discussions rather than any specific project proposal. With the progress of the development in the Nacala Bay Area in the future, the water demand forecast, and water demand and supply balance should be reviewed and updated successively in the process of the specific development planning for the water resources and water supply infrastructure.

As a summary of this chapter, the following points are recommended for further discussions:

- Improvement of water supply development and management of FIPAG Nacala is a crucial issue. The present conditions do not meet 'achievement of water supply development at a certain high standard' as one of the conditions to increase the feasibility of seawater desalination project. The water distribution network is scheduled to be expanded with construction of 110 km water distribution mains under the IGPP assisted by the World Bank. In addition, it is essential for FIAPG Nacala to carry out effective initiatives to improve the water distribution management and services for increasing the service coverage ratio and water supply per capita and reducing NRW.

- In FIPAG Nacala, the water supplied from groundwater sources in 2019 will be 23,000 m^3/day by the IGPP. Together with 7,200 m^3/day from the existing water treatment plant, the total water supply capacity will be 30,200 m^3/day. However, any schedule is not prepared for the succeeding water supply development proposed by the MCA report. It is recognized that the feasibility of the sole short-term plan would not be expected. On the other hand, the long-term plan increasing the water supply capacity to 52,000 m^3/day by the Nacala Dam (expansion) and the Sanhute River (or the Monapo River) will contribute to the basic infrastructure development in the Nacala Bay Area.

- For a large increase of the water supply in Nacala Bay Area in medium and long term, there are conceivable water conveyance alternatives from the Lurio River, Mecuburi River, and Monapo River. These alternative should be studied in detail under a comprehensive water resources management plan based water resources assessment, present and future water uses, and water demand and supply balance focusing on the entire river basin. The need for seawater desalination should also be studied through the comparative assessment with the water conveyance alternatives.

- The water conveyance alternatives and seawater desalination are shown on the PPP project list of DNA and/or Nampula Province. But the project preparation should not be based on the sole individual proposal by private sector. The large water conveyance across the watershed will cause base-wide impacts on the natural and social environments. Therefore, the consensus among various stakeholders in the northern region must be created in the process of the project preparation. The seawater desalination can be an alternative to the large water conveyance because of the geographical restrictions in the water resources development for the Nacala Bay Area. Meanwhile, the accountability relating to the seawater desalination must be fulfilled as the increase of financial burden to beneficiaries, especially private firms investing the Nacala SEZ, accompanied by increase of water charges is inevitable. Therefore, the project preparation and implementation should be done by decisions of the government for both water conveyance and seawater desalination.

- The survey and planning for the seawater desalination project should be initiated, taking into account the possible introduction at the earliest in 2025. As a first attempt, Chapter 11 of this report describes the preliminary study on seawater desalination through the considerations in this chapter and results of the site survey. The preliminary study prepares the salient features and approximate cost for seawater desalination and organizes the major issues on project preparation in the future.

Chapter 9 Namibia

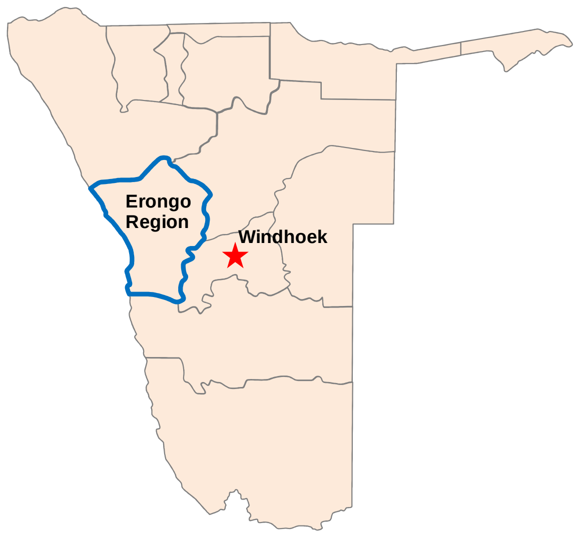
9.1 Survey Area

9.1.1 General

The survey area is a coastal area (hereinafter referred to as “the Central Coast area”) located 350 km away to the west from the capital of Windhoek in Namibia.

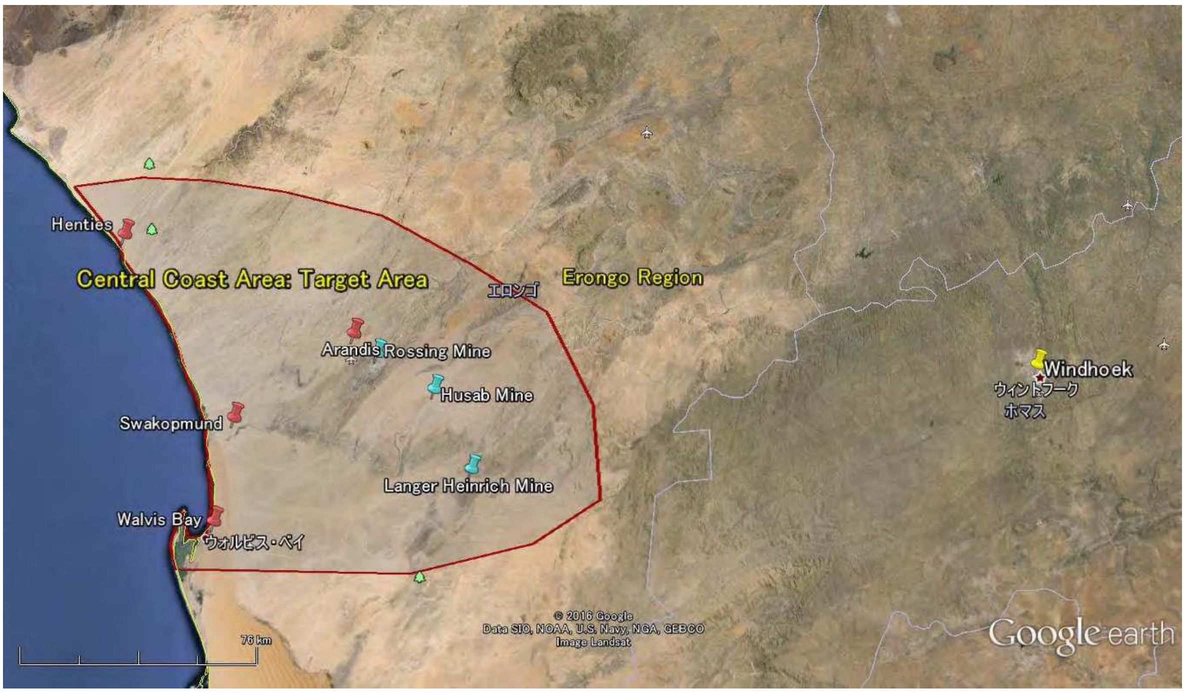
The Central Coast area is located within Erongo Region (see Figure 9.1) that involves Walvis Bay with the second largest population in Namibia and the provincial capital of Swakopmund. It is also known as an economic zone characterized with the growth of industries such as logistics, seafood processing, mining, and tourism.

The Central Coast area is defined as a jurisdiction of the Namib Office under the Namibia Water Corporation Ltd. (NamWater) (see Figure 9.2).



Source: Prepared by the Survey Team

Figure 9.1 Location of Erongo Region



Source: Prepared by the Survey Team

Figure 9.2 Survey Area (Central Coast Area)

9.1.2 Socioeconomic Conditions

(1) Population

The population of Namibia is concentrated in the northern and central regions including Khomas Region, where the capital of Windhoek is located. Erongo Region is inhabited by 7.14% of the total population in Namibia or the seventh largest population among the regions (see Table 9.1). The regional capital of Swakopmund and the neighboring port of Walvis Bay in the south were formed as navigational base towards Southern African colonies. Seventy percent of the total population in Erongo Region is concentrated in the two municipalities (see Table 9.2).

Table 9.1 Population by Region in Namibia

Region	Population		Growth Rate	Share
	2001	2011		
Khomas	250,262	342,141	3.67%	16.19%
Ohangwena	228,384	245,446	0.75%	11.62%
Omusati	228,842	243,166	0.63%	11.51%
Kavango	202,694	223,352	1.02%	10.57%
Oshikoto	161,007	181,973	1.30%	8.61%
Oshana	161,916	176,674	0.91%	8.36%
Erongo	107,663	150,809	4.01%	7.14%
Otjozondjupa	135,384	143,903	0.63%	6.81%
Caprivi	79,826	90,596	1.35%	4.29%
Kunene	68,735	86,856	2.64%	4.11%
Hardap	68,249	79,507	1.65%	3.76%
Karas	69,329	77,421	1.17%	3.66%
Omaheke	68,039	71,223	0.47%	3.37%
Total	1,830,330	2,113,067	0.15%	100.00%

Source: The Namibia Labor Force Survey 2013, etc.

The population of Erongo Region has increased at an average rate of 4.01% between 2001 and 2011 and reached 150,400 in 2011. The growth rate outweighed other regions. The reasons of population growth are attributed to the inflow of labor force due to the development of the port in Walvis Bay, development of mining industry, and increase of inhabitants in Swakopmund known as a resort area.

Table 9.2 Population in Erongo Region

Municipality	Population	Area (km^2)	Density (pop/km^2)
Arandis	10,200	13,490	0.8
Daures	11,300	17,752	0.6
Karibib	13,300	14,521	0.9
Omaruru	8,500	8,425	1.0
Swakopmund	44,700	196	228.0
Walvis Bay Rural	26,900	9,134	2.9
Walvis Bay Urban	35,500	19	1886.2
Total	150,400	63,539	2.4

Source: Website of Erongo Region

In addition, the intensive container yard development activities in Walvis Bay between 2011 and 2012 resulted in an increase in population of 10,000.

(2) Industry

Erongo Region has ample natural resources and natural beauties, intended to be used as a leverage for industry development. Walvis Bay, in particular, focuses on international logistics hub development supported by the Japan International Cooperation Agency (JICA) and container terminal development lead by the Chinese firm, in order to reinforce its function as a gateway for logistics of the landlocked countries including Botswana, Zambia, and Zimbabwe through the Trans-Caprivi Corridor and Trans-Kalahari Corridor.

1) Logistic Hub Development

Both Swakopmund and Walvis Bay are linked to the capital of Windhoek for a distance of about 350 km through the Trans-Kalahari Highway and railway. Both bulk and container cargoes unloaded at the port of Walvis Bay are transferred with trucks and freight trains. Walvis Bay is regarded as an international logistic hub and is connected to Botswana, Zambia, DPR Congo, Zimbabwe, and the northern region of South Africa.

Walvis Bay Municipality plans to build an integrated logistics center in the hinterlands of the port and outskirts. Walvis Bay Municipality is promoting the pivotal project within the Integrated Urban Spatial Development Framework (IUSF). According to Walvis Bay Municipality, Erongo Region can offer natural resources and labor forces but is not stable in infrastructure such as water and electricity. Thus, industry promotion tends to focus on less-energy intensive, light industries such as warehouse and logistics hub development.

2) Fishery

Offshore of Namibian coast up to Angola border is a juncture of two sea current systems and create a rich fishing ground. Walvis Bay's wharf is lined with processing factories for this haul. Namibian fishing industry started its export businesses since the early 1990s. According to FAO's statistics of the Fishery and Aquaculture Country Profile, labor force working in the fishing industry is 15,000 and commercial catching boats are 20,000. Export-oriented processing factories are located largely in Walvis Bay and less in Ludelitz because of its logistic advantages.

Major companies such as Pescanova and Hangana are operating their businesses. Most of the fishing industries are shared by Europeans from Spain and Portugal. Hangana, the second largest processing company in Walvis Bay, owns eight boats for catching and purchases fish from local fishermen. The Walvis Bay's factory is processing hake, cod, sole, etc., to be frozen, filleted, and canned products for export to Europe and South Africa. Ninety percent of the products are exported. There is a fish catching quota allocated to Namibia. Due to the quota, it is unlikely that the fishing industry in Walvis Bay will boost suddenly.

3) Mining

The Central Coast area is rich in natural mining resources and uranium mines that have been developed since the late 1970s. There are four uranium mines in operation, i.e., Rossing, Langer-Heinrich, Husab, and Trekkopje and some are exploring like Valencia (see Table 9.3).

Table 9.3 Major Uranium Mines

Mine	Developer	Description
Rossing	Rio Tento	The oldest uranium mine in the region developed by Rio-Tinto since 1976. Produce 4,000 tons of U3O8 annually.
Langer-Heinrich	Paladin	Australian Paladin Energy Ltd. is operating with highly prospective production expansion. Annual production estimated to exceed 2,000 tons.
Husab	Swakop Uranium	Initially developed by American and Canadian investors but transferred its ownerships to China General Nuclear Power (CGN) in 2012. The full-operation expected in late 2016 and production targeting 6,800 tons of annual production.
Trekkopje	Areva	Developed by Areva. Pilot phase operation started in 2011 to prove technical feasibility of production by yielding 435 tons. Areva decided to put the mine into "care and maintenance" status due to soften global uranium markets since technical trial.

Source: Website of Each Company

Each uranium mine holds more than 10,000 labor forces. These laborers reside in the mine, like Rossing, or commute using company's transportation from Swakopmund and/or Walvis Bay.

According to the local industry group, the Uranium Institute, uranium prices are expected to recover around 2017 to 2020 due to tighter market while the current market is characterized by the depressed resource prices since 2008 and the Fukushima incident in 2011. Particularly, the

Husab Mine is operating regardless of the market situation because the operator is a Chinese quasi-state entity and its exploration aims to operate the Chinese-owned nuclear power stations rather than sales to the market. Both Rossing and Langer-Heinrich have already experienced years of production, thus, these mines break-even thresholds are lower than the new mines and can operate more stably.

9.1.3 Spatial Development

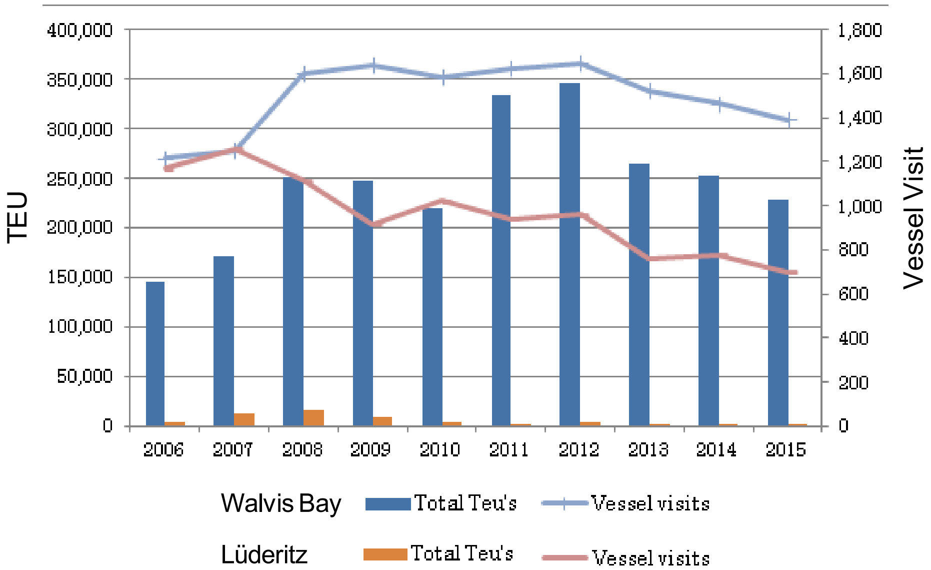
(1) Port Development

The port of Walvis Bay is developed at the inlet, formed by northward coastal current and sandbar with sediments of the Kuiseb River. German settlers developed the port area together with Swakopmund for the depot of voyage to the colonies in Southern Africa. The area is geographically isolated by the Namib Desert but is connected with the inland regions by highways further approaching to Botswana, Zambia, and Zimbabwe (see Figure 9.3).

NamPort operates both the ports of Walvis Bay and Ludelitz. Majority of the cargoes are handled by in the port of Walvis Bay (see Figure 9.4).

Source: Walvis Bay Corridor Group

Figure 9.3 Port of Walvis Bay and Regional Links in Sub-Saharan Africa



Source: Prepared by the Survey Team based on the data provided by NamPort

Figure 9.4 TEU and Vessel Visit

According to the NamPort's observation, the port of Ludelitz is close to the southern border and its cargo handling is limited as cargoes destined to South Africa tend to be brought directly to the ports in South Africa. The port of Walvis Bay is the closest one to Windhoek and has the advantages of highway connections to the inland countries.

NamPort owns and operates the port of Walvis Bay with an area of 110 ha, wharf length of 505 m for wharf Nos. 1 to 3 and 910 m for Nos. 4 to 8, respectively. The wharf has a 14.5 m draft to accept a grade of 9,000 TEU container liners on daily basis.

JICA conducted the preparatory survey for the container terminal development project in 2009. Afterward, the China Harbor Engineering Co., Ltd. is carrying out the construction of a container terminal. NamPort also envisions a 1,350 ha of northern port development for bulk cargo terminals and facilities catering logistic services to the inland countries. The northern port development is involved in the Integrated Urban Spatial Development Framework (IUSDF) and development of bulk cargo terminal, which will promote heavy industry development. However, the northern port development does not have a clear milestone or timeline for its realization.

(2) Harambee Prosperity Plan

The Harambee Prosperity Plan has been announced in April 2016 by President Hage Geinkob. The plan consists of 15 Harambee goals and outcomes. One of these is transport infrastructure including railroad construction between Walvis Bay and Tumeb, upgrade of major road links from Walvis Bay, and expansion of the port of Walvis Bay to be used for development of the international logistics hub by 2030. The plan supports the development of the port of Walvis Bay and associated infrastructure as a part of the national policy.

(3) Urban Development

1) Walvis Bay

IUSDF is a planning framework developed as basis of spatial development harmonizing industry and population growth while maintaining the living standards by prioritizing spatial development planning. The preparation of IUSDF was supported by the European Union (EU) and commenced in 2011. The reports were completed in 2013. The reports consist of two parts: one reporting analytical part and the other containing a series of data set used for analysis. The entire report was accepted at the end of 2014 by the municipality. The framework for commercial and industry development is outlined as follows:

- To create and nurture a healthy business environment;
- To facilitate and control the supply of business and industrial land in accordance with market needs;
- To improve the quality and reliability of utility services to the business sector;
- To create opportunities for industrial investment, especially for energy efficient and clean processing and manufacturing activities;
- To integrate informal business areas into the administration and control; and
- To create opportunities for small businesses.

IUSDF is trying to achieve both industry and infrastructure development harmonized with residential area through large-scale port development by differentiating Walvis Bay with four grids. Industry promotion focusing on the integrated logistics center development and manufacturing and heavy industry center in area called Dune 7 are coherent with the northern port development plan which cater and reinforce logistical functions.

2) Swakopmund

Spatial development planning of Swakopmund focuses on residential area development and improvement of the living standards. The most recent spatial development planning released is the Five-year Plan 2011-2015 which is developed as an implementation result of the Strategic Plan 2011-2015. Contents and aims of the document differ from IUSDF, which actively engage industry promotion. The plan tends to focus more onto housing development for low-income families and not much pages are devoted to growth of inhabitants or industry promotion.

(4) Industrial Development Organization

1) Namibia EPZ Corporation

Namibia Export Processing Zone (EPZ) Corporation was established aiming to promote export-oriented industry in Namibia and facilitate incentive programs for the export industry. The corporation does not implement area-based physical industry development. The corporation is expected to be dissolved while industry promotion through the corporation will be terminated before the end of 2016.

2) Walvis Bay Corridor Group

The Walvis Bay Corridor Group (WBCG) is an organization led by the Walvis Bay Municipality with membership given to export-oriented companies and/or local chamber of commerce as shown in Table 9.4. The group is trying to develop export products in the region and promote corridor development to maximize export opportunities of land-locked countries. WBCG has its own offices and representatives in neighboring countries, such as Zambia, Botswana, and South Africa in order to get opportunities to handle export products from these countries. WBCG provides services including Strategic Direct Investment Programme to potential investors, integration and simplification of custom declaration documents with neighboring countries, and wellness services to long-haul truck drivers. The activities are supported by funding from member companies, organizations, and income from market research assistance services provided by WBCG.

Table 9.4 Members of the Walvis Bay Corridor Group

Category	Organization
Business Association	Namibia Logistics Association
	Walvis Bay Port Users' Association
	Container Liners Operation Forum
	Namibia Transporters Association
	TransNamib Holdings Ltd.
Local Authority	Walvis Bay Municipality
	Namibian Ports Authority
	Roads Authority
Central Government	Ministry of Home Affairs and Immigration, Department of Immigration
	Ministry of Works and Transport, Department of Transport
	Ministry of Finance, Dept of Customs and Excise
	Ministry of Trade and Industry, Namibia Investment Centre

Source: Website of Walvis Bay Corridor Group

9.2 Water Resources and Water Supply

9.2.1 Institutional Framework

(1) Legal Basis

The Water Resources Management Act, 2013 designates the management, protection, development, use and conservation of water resources, regulatory and monitoring of water services, and incidental matters. The framework of water resources management consists of an integrated water resources management plan to be created under the responsibility of the Minister of Agriculture, Water and Forestry. The Water Advisory Council will be established as an advisory body on water resources management of the Minister, and a Water Regulator will be established to oversee the water service providers in the country.

The Integrated Water Resource Management Plan (August 2010) was created on the basis of the Water Resources Management Act, succeeding to the National Water Policy White Paper (2000) and Water Supply and Sanitation Policy (2008). The plan describes the analysis of the current problems related to water resources management in the whole country and the policies for measures such as water resources development to meet the water demand, data management for water resources conservation, institutional and human resource development, and community participation.

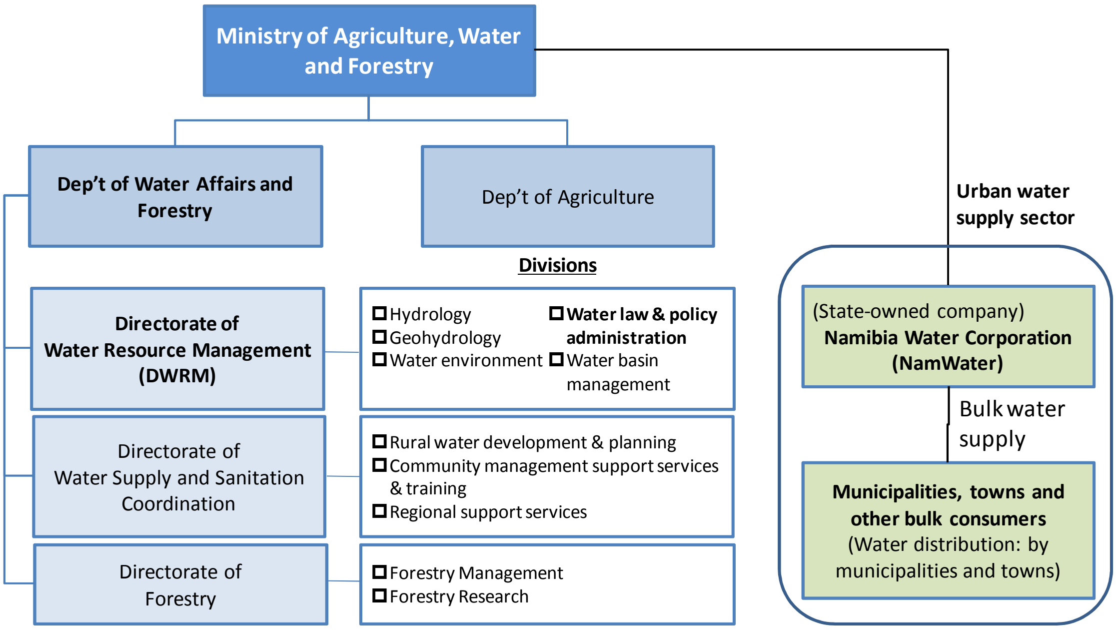
There is no restriction for the use of groundwater for domestic purposes in Namibia but the wells should be registered as stipulated in the Water Act No. 54 of 1956. The use of groundwater for industrial purposes is also allowed with the permission by the Ministry of Agriculture, Water and Forestry (MAWF).

(2) Organizations

Under the MAWF to oversee the water supply sector, there are two departments, namely, Department of Agriculture and Rural Development and Department of Water Affairs and Forestry. The Department of Water Affairs and Forestry consists of the Directorate of Water Resource Management (DWRM), Directorate of Water Supply and Sanitation Coordination, and Directorate of Forestry (see Figure 9.5). The DWRM manages the water uses of agriculture, domestic, and industrial purposes. The Directorate of Water Supply and Sanitation Coordination is responsible for water supply in rural areas.

The Namibia Water Corporation (NamWater), 100% shares held by the government, and municipalities operate the water supply in the urban areas. NamWater manages water resources and performs the bulk water supply to the municipalities. Each of the municipalities manages the development and operation and maintenance (O&M) for its water distribution facilities and serves water to citizens, commerce, and industry. NamWater also conducts the bulk supply directly to large industrial customers including the harbor and the mines. NamWater is responsible for ensuring the water resources. The DWRM has the authority for water intake permits and restrictions surface water and groundwater. Permission by DWRM should also be required for taking seawater in order to develop the seawater desalination plant.

At present, the MAWF’s supervisory function for NamWater is not clear as there is no specific division responsible for supervision and evaluation of NamWater to organize business achievements and activities. The MAWF is promoting the establishment of the Water Regulator in accordance with the Water Resources Management Act, 2013. The Water Regulator will act as the administrator to perform the supervision, evaluation, and necessary guidance for NamWater and all the water service providers in the country. It will also play the function to approve water tariffs.

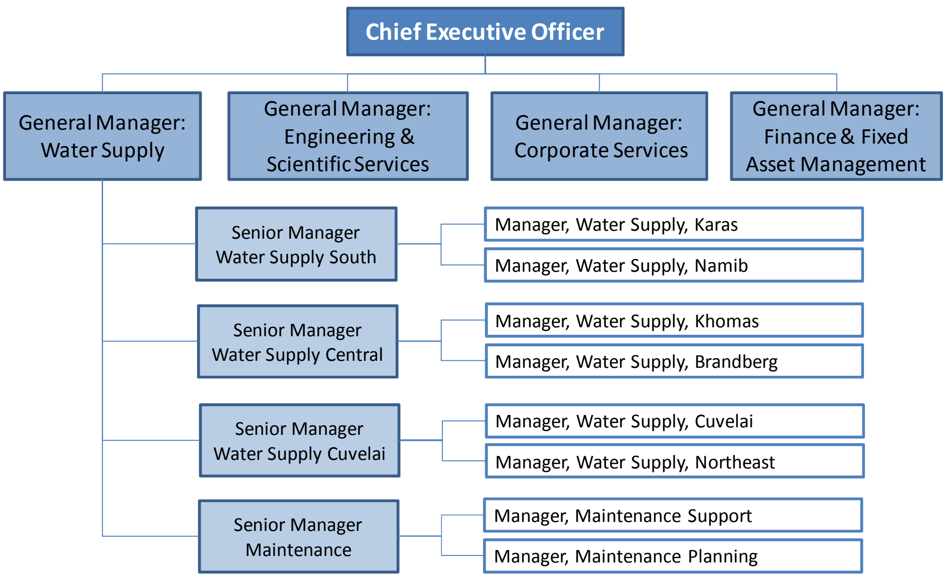


Source: Prepared by the Survey Team

Figure 9.5 Institutional Framework for Management of Water Resource and Water Supply in Namibia

(3) NamWater

NamWater was established in line with the Namibia Water Corporation Act, 1997 and it was given the role to perform bulk water supply to the urban areas. NamWater consists of four divisions under the Chief Executive Officer (CEO) with about 600 staff members (see Figure 9.6). The Water Supply Department has three regional divisions such as South, Central, and Cuvelai and each of the regional divisions has two local branches. In addition, within the Water Supply Department, Maintenance Division supports the maintenance works for the regional divisions and local branches.



Source: NamWater

Figure 9.6 Organizational Structure of NamWater

Each of the regional divisions and local branches is devoted to daily works for water supply. The Engineering and Scientific Services of the headquarters is responsible for the planning and design.

9.2.2 Existing Bulk Water Supply System

(1) Overview

The Namib Office of NamWater uses the wells to take the subsoil water of the Omaruru River and the Kuiseb River. The water quality of the subsoil water is satisfactory for drinking through chlorine disinfection only. In addition, NamWater purchases water from Areva, a French firm working on nuclear industry, operating the seawater desalination plant. NamWater transfers and sells the purchased water to three uranium mines (see Figure 9.7).

NamWater sets the water price for each of bulk water users on the basis of the actual costs for the water purification and transmission. The high-priced water from the seawater desalination plant is sold to the uranium mines only. The ordinary users such as Walvis Bay Municipality and Swakopmund Municipality receive the subsoil water in principle (see Figure 9.5).

Table 9.5 Bulk Water Users in the Central Coast Area

Bulk User	Water Use (2015)		Water Source	Remarks
	(m^3/year)	(m^3/day)		
Municipality and Industry				
Walvis Bay*1	6,198,034	16,981	Kuiseb River	
Namport*1	203,182	557	Kuiseb River	
Small Consumers (Kuiseb)*2	279,555	766	Kuiseb River	
Swakopmund*3	4,601,684	12,607	Omaruru River	
Henties*2	577,084	1,581	Omaruru River	
Arandis*2	480,000	1,315	Omaruru River	
Small Consumers (Omaruru)*4	201,706	553	OmaruruRiver	
Mines				
Rossing*2	2,715,634	7,440	Wlotskasbaken Seawater Desalination	
Langer-Heinrich*2	1,438,964	3,942	Wlotskasbaken Seawater Desalination	
Husab*2	1,661,000	4,551	Wlotskasbaken Seawater Desalination	Individual groundwater use permitted before commencement of mining operation in early 2016
Total	18,284,102	50,094		

Note: For the water consumption in 2015, the data given by NamWater are different from those given by the bulk water users. The data from the bulk water users, who paid the charges, are regarded as more reliable.

*1: Data of water purchased by Walvis Bay Municipality

*2: Data of water sold as shown in the presentation by NamWater

*3: Data of water purchased by Swakopmund Municipality

*4: Estimated by the Survey Team, as a difference between data of water purchased by Swakopmund Municipality and data water sold to Swakopmund Municipality as shown in the presentation by NamWater.

Source: From *1 thru *4 above

In 2015, the MAWF limited the water intake from the Omaruru River due to less rainfall in the recent years. As an emergency measure, NamWater supplied the water from the seawater desalination plant to Swakopmund Municipality during the period from November 2015 to February 2016. During those four months, Areva agreed to sell a volume of 300,000 m^3/month to NamWater with a charge similar to the subsoil water and then NamWater could continue the bulk water supply for Swakopmund Municipality as usual in terms of the bulk water pricing. However, the domestic water supply volume from the seawater desalination plant exceeded 300,000 m^3/month from December 2015 to February 2016. The excess volume purchased with high price resulted in the financial loss for the bulk water supply operation by NamWater.

Source: NamWater

Figure 9.7 Water Sources and Bulk Water Supply System in Central Coast Area

(2) Water Sources

The MAWF determines the permission for the usable volume to be taken from the water sources. As the MAWF estimates the usable volume on the basis of the groundwater recharge in line with the annual rainfall amount, the usable volume under permission is subject to change year by year.

According to the Namib Office of NamWater, the usable volume is determined annually in November and then permissions are updated for the next year.

An agreement is made between NamWater and Areva for the volume used from the seawater desalination plant in order to set a purchase/sales price of water practically. The volume of 5 million m^3/year (corresponding to 25% of the plant capacity) at present may be revised, depending on the forecast of water demand and supply. Both NamWater and Areva consider a possible increase of the volume to be agreed upon by each other, corresponding to 50% or 60% the plant capacity by the end of 2016.

The water quality along the Omaruru River is occasionally classified into Rank-C meaning there are some risks anticipated for human health, in the drinking water quality standard in Namibia. This does not directly cause problems on human health as the hardness exceeds slightly 650 mg/L corresponding to the upper limit of Rank-B. At the time of the visit to the Wlotskasbaken Seawater Desalination Plant, water quality records could not be confirmed. It is supposed that the water quality would not be below Rank-B under the present plant operation as it is being managed properly as observed when the Survey Team made a site reconnaissance to the plant. Therefore, it is presumed that the water quality through the seawater desalination would be satisfactory as drinking water (see Table 9.6).

Table 9.6 Water Sources Used by Namib Office of NamWater

Water Source	Usable Volume (2015)*1		Location	Water Quality*2	Remarks
	(m^3/year)	(m^3/day)			
Omaruru River	4.6 million	12,600	60 km north of Swakopmund	B (or C, due to hardness)	
Kuiseb River	7.0 million	19,180	20 to 70 km south/southeast of Walvis Bay	B	
Wlotskasbaken Seawater Desalination	5.0 million	13,700	30 km north of Swakopmund	-*3	Capacity 20 million m^3/year (54,800 m^3/day)

Note:
*1: Usable volume of subsoil water is permitted by MAWF. Usable volume of seawater desalination is contracted between NamWater and Areva through the purchase/sales agreement.
*2: Drinking water quality standard in Namibia, designated by MAWF; A: Water with an excellent quality, B: Water with acceptable quality, C: Water with low health quality, D: Water with a high health risk or water unsuitable for human consumption. Drinking water should be classified into A or B, but C is also allowable on the condition that attention should be given to this problem although the situation is not critical yet.
*3 No data on water produced by the plant was made available.
Source: NamWater

(3) Water Transmission Facilities

NamWater's jurisdiction covers water transmission mains and reservoirs in Walvis Bay Municipality, NamPort, and Swakopmund Municipality. The bulk meter is installed at the outlet of the reservoir. The subsequent water distribution is managed by each bulk water user.

There are two water transmission systems in the north from the Kuiseb River and in the south from the Omaruru River. Two systems are linked by a pipeline (diameter 700 mm). Except the pipelines to the mines, most of the existing pipelines were built in 1975. Deteriorated ones are being replaced. For the time being, the replacement of the reinforced concrete pipe linking the north and south is scheduled to be done due to its considerable deterioration.

The rate of water loss is estimated at 9% in the water transmission systems. The Namib Office of NamWater plans to implement the replacement of aged pipes and improvement of water pressure management to reduce the water loss to 5%.

9.2.3 Bulk Water Users

(1) Swakopmund Municipality and Walvis Bay Municipality

Swakopmund Municipality and Walvis Bay Municipality purchase the bulk water from NamWater and perform the water supply services to citizens as well as commercial and industrial facilities through the water distribution system under their jurisdiction in terms of development and O&M. The salient features of the water distribution systems are outlined as shown in Table 9.7 based on the information given by the municipalities.

Table 9.7 Outline of Water Supply Services in Swakopmund Municipality and Walvis Bay Municipality

Iterm	Swakopmund	Walvis Bay	Remarks
Population	44,720 (2011)	79,500 (2011)	Including non-residential population estimated (for Walvis Bay)
No. of Household	14,400 (2011)	25,247 (2011)	
Population Served	100%	100%	
No. of Connection	Approx. 18,000 (As of March 2016)	14,807 Domestic: 13,727 Commmercial and Industrial: 1,074 (As of December 2015)	
Water Consumption	3.99 million m^3 *1 (2015)	5.49 million m^3 (2014/2015)	NRW not included
Per Capita Consumption	244 lpcd *2	167 lpcd (90 lpcd for domestic only)	Estimated from water consumption in 2015 and population in 2011 (for Swakopmund)
Daily Duration of Service	24 hours/day	97%/day (3% supply failure due to power outage and pipe break)	
NRW (%)	17%	14.1% (2015)	
Metered Ratio	(Data not made available)	99%	
Water Quality	No problem	No problem	
Total Length of Water Distribution Main	(Data not made available)	430 km	
No. of Staff for Water Supply Service	24	37	
Water Tariff	NAD 7.95/m^3 (2014/2015)	NAD 11.00/m^3 (2014/2015)	Tariff for lowest range of water consumption
Revenue Collection Rate	(Data not made available)	77.50% (2014/2015)	
Revenue	(Data not made available)	NAD 112,501,649 (2014/2015)	

*1: Estimated by the Survey Team, based on the data of bulk water supply from NamWater to Swakopmund Municipality and a rate of NRW in Swakopmund Municipality.

*2: Computed as the total water consumption, including both domestic and non-domestic, divided by the population. It is larger than per capita domestic consumption.

Source: NamWater, Swakopmund Municipality and Walvis Bay Municipality

As seen in the table above, both Swakopmund Municipality and Walvis Bay Municipality attain a high standard of water supply services such as 100% of service coverage, 24 hours of service operation a day, and NRW rate less than 20% resulting from leakage management and billing/collecting operation.

Socioeconomic characteristics of Swakopmundand and Walvis Bay suggest a difference in per capita water consumption. Swakopmund indicates a per capita water consumption of 244 lpcd, which is almost equivalent to the figure in Japanese households, because of the high living standard of European origin residents and many of tourism accommodations attracting foreigners. But it should be noted that an actual per capita domestic consumption might be about 30% less than this figure computed as the total water consumption (including both domestic and non-domestic) divided by the population.

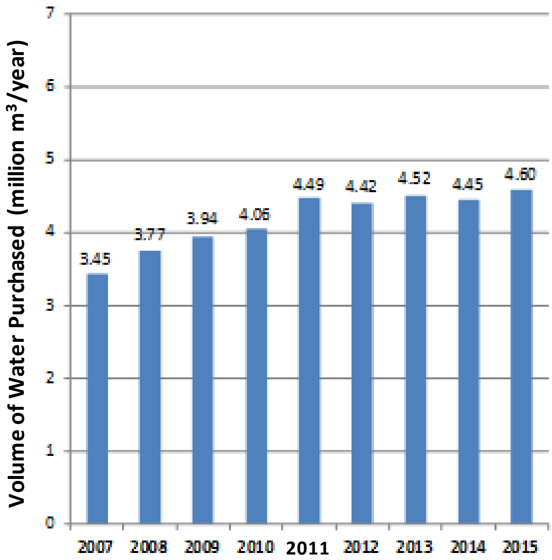
Walvis Bay's per capita water consumption is 167 lpcd, where many laborers live for working in the ports, factories, and construction sites. The total water consumption in Walvis Bay comprises 55% domestic and 45% commercial and industrial. Therefore, the per capita domestic consumption is 90 lpcd. This figure is higher than the per capita domestic consumption in other African cities but is not remarkable. In Walvis Bay, there are many non-registered households of laborers migrating from rural areas. Such households may receive water from neighboring registered households. With due consideration of water consumption by non-registered households, the substantial per capita domestic consumption is supposed to be rather less than 90 lpcd.

There is a great difference in population between Swakopmund and Walvis Bay. Swakopmund has less population but its number of service connections is larger. While the family size in Walvis Bay is larger, Swakopmund involves small-sized households, European origin elder couples, and non-residential facilities such as hotels and resort villas.

1) Swakopmund Municipality

The Engineering Services Department of Swakopmund Municipality manages the water supply. The information obtained from the General Manager of the Department is outlined below.

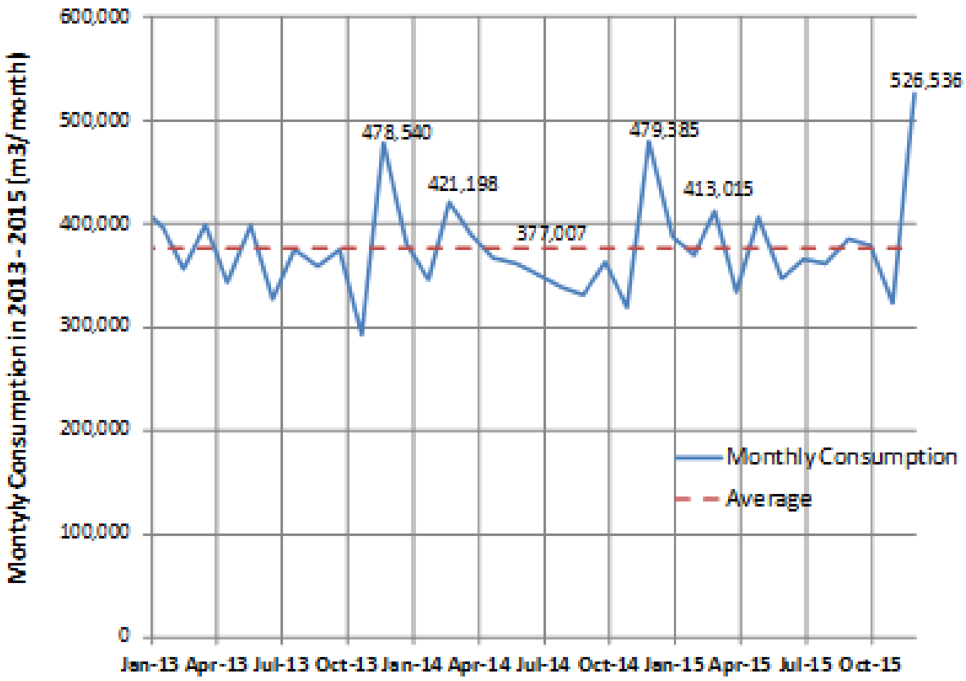
- The number of service connections in Swakopmund is about 18,000 at present.
- Water consumption in Swakopmund is nearly stabilized for the last five years. In 2011 and later, the annual volume purchased from NamWater was from 4.42 to 4.60 million m^3/year. Resulting from the water tariff increase, the consumers are aware of water-saving measures.



Source: Swakopmund Municipality

Figure 9.8 Annual Water Volume Purchased from NamWater (Swakopmund)

- A large water demand takes place in December, the peak season of tourism. The peak of monthly water consumption is from 1.3 to 1.4 times of the average. Except for the season of tourism, another monthly peak demand occurs in March and is 1.1 times of the average (see Figure 9.9).
- The rate of water reuse is 80% in Swakopmund. At present, 6,500 m^3/day of sewerage is treated. Of this volume, 5,500 m^3/day is reused and 1,000 m^3/day is discharged into the sea. Advanced sewerage treatment is not introduced. The sewerage is treated by the standard activated sludge and chlorination. The treated water is supplied through dedicated pipelines.
- The rate of non-revenue water (NRW) is 17 %. Water loss by leakage is estimated to be about 15%. Swakopmund Municipality works on the replacement of aged water distribution pipes and water meters by self-financing and performs water pressure management through a remote monitor system. The water pressure control is being done manually.



Source: Swakopmund Municipality

Figure 9.9 Monthly Water Consumption (Swakopmund)

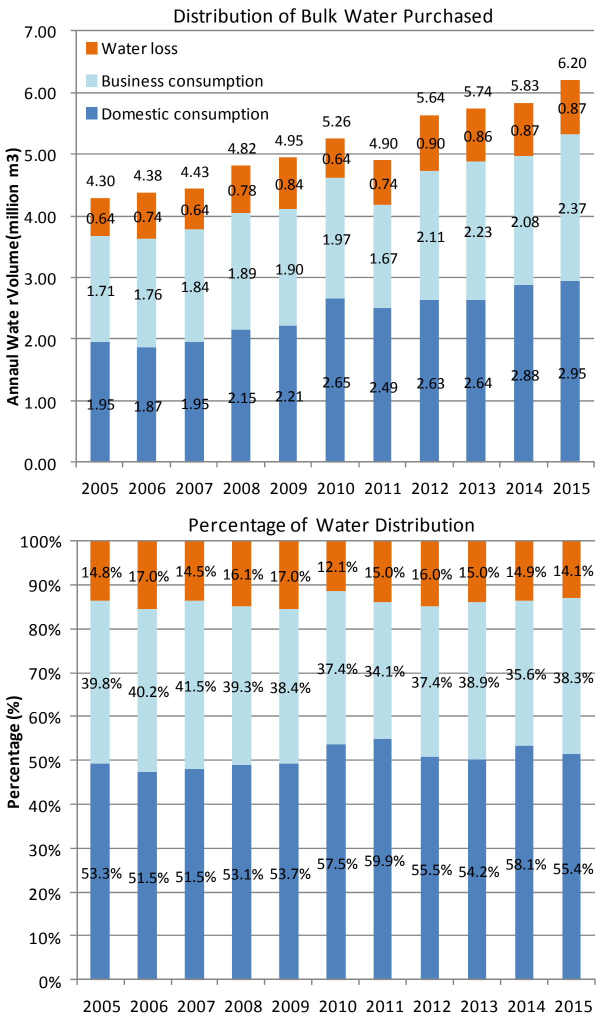
As described above, Swakopmund Municipality attains a high level of water supply services in terms of service coverage and duration and is also working on water conservation through water leakage reduction and water reuse resulting in an effective performance. In addition, suspension of water supply is not frequent. As water demand is stabilized in recent years, there is no problem in the existing water supply facilities in terms of capacity and performance.

It was pointed out that an increase in water tariff affects saving on water consumption. There is no room for further water saving other than reduction of water loss from 15% to 10%. When further population growth and tourism development take place, there will be a possible increase of the water consumption again.

2) Walvis Bay Municipality

The Water and Environmental Management Department of Walvis Bay Municipality manages the water supply. The information obtained from the General Manager of the Department is outlined below.

- The number of service connections is 14,807 in Walvis Bay, of which 93% are household connections.
- The gross water consumption in 2015 was 6.20 million m^3/year as purchased from NamWater. The gross water consumption has been increasing with an average rate of 3.73% during the past ten years. The net water consumption was 5.32 million m^3/year by subtracting the water loss from the volume purchased (see Figure 9.10). The increase of water consumption will continue with a rate of 4% to 5% per year in the future.
- The water consumption, exclusive of the volume of water loss being stabilized at about 15%, comprises the domestic water consumption of 55% and commercial and industrial water consumption of 45% since 2005. The fish processing industry is the largest water consumer within the commercial and industrial water consumers. The water consumption of the fish processing industry was 1.02 million m^3/year in 2015, resulting from the annual growth rate of 6.0%, 2.3%, and 4.3% for the last three years.
- As NamWater's intake at the Kuiseb River was damaged due to the flood, the water use was restricted in 2011. The water volume purchased from NamWater resulted to 9.85% lower than that in 2010.
- In Walvis Bay, there are many migrants from the rural areas. Majority of the migrants lived in shanties and get water through their neighboring households.



Source: Walvis Bay Municipality

Figure 9.10 Annual Water Volume Purchased from NamWater by Consumer Category (Walvis Bay)

- Walvis Bay Municipality considers the standardized figures of water consumption per household, inclusive of water loss at about 15%, as shown in Table 9.8. Compared with the domestic per capita water consumption, these figures might be somewhat excessive. When the figure for low-income households is regarded as the water consumption by registered households, it may not be far from the reality.

Table 9.8 Suggested Water Consumption per Household in Walvis Bay

Income Level	Monthly Consumption per Household (m^3)	Per Capita Consumption, Assuming Four Persons per Household (liter)	Remarks
High	20 to 25	167 to 208	Based on the records in 2015, domestic water consumption per capita is computed to be approximately 90 lpcd and 105 lpcd with 15% water loss.
Middle	20	167	
Low	15	125	

Source: Walvis Bay Municipality

- Walvis Bay Municipality has a reservoir with a storage capacity of 10,000 m^3 at the bulk water supply point from the NamWater in Mile 7 and a new one with a storage capacity of 20,000 m^3 to be completed in 2017 in order to cope with the increase in water demand. Another reservoir of 4,500 m^3 storage capacity is located in Mile 7 and it is owned by NamPort.
- The total length of water distribution mains is 430 km. Of these, about 40% use asbestos cement pipes. These are being replaced with new pipes.
- In Namibia, the municipalities having the population of more than 50,000 are obligated to perform a water quality test of the water distributed with an interval of once in 14 days. Walvis Bay Municipality is conducting the water quality tests more frequently. There is no water quality problem except in case of accident.
- In 2014, Harold Pupkewitz Graduate School of Business, Namibia University of Science and Technology (NUST) performed a National Customer Service Survey. According to the results of the survey, the percentage of respondents who answered “satisfied” with respect to water supply services is 62% in the whole country. In Walvis Bay, 74% answered “satisfied”. This rate was the highest among the municipalities surveyed, followed by 66% in the capital of Windhoek.
- The technical problem on the water distribution system in Walvis Bay is the existing reservoir capacity which is foreseen to be insufficient for water consumption in the near future. It is expected that this problem will be solved by the completion of the reservoir under construction.

As described above, Walvis Bay Municipality attains a high level of water supply services in terms of service coverage and duration. Its high service levels are confirmed objectively as shown in the result of the National Customer Service Survey, which ranked Walvis Bay the highest in 2014.

Although the asbestos cement pipes still remain widely used in some extent, the leakage reduction effects are satisfactory with a NRW rate of 14%. Further reduction of NRW is expected to continue upon replacement of aged pipes. But it is hard to accomplish a NRW rate less than 10% in general.

In the light of the recent trends, it is recognized naturally that the water demand will increase steadily in the future. To cope with the water demand, Walvis Bay Municipality is conducting the construction of an additional reservoir. Besides, water distribution system will need to be augmented as a mid-term measure.

(2) NamPort

NamPort receives the bulk water supply from NamWater. Through the interviews with NamPort and review of the bulk water supply data given by NamWater, the findings of the water consumption of NamPort are summarized below.

- NamPort has the bulk water supply point of NamWater in Mile 7. The existing reservoir with a storage capacity of 4,500 m^3 is located in Mile 7 and owned by NamPort.
- The water consumption of NamPort was 203,182 m^3/year (557 m^3/day) in 2015. The volume has been variable year by year. There is no clear trend in changing the annual volume of the water consumption.
- The port facilities do not use a large volume of water. Notable opportunity is to supply a large volume of water for the passenger ship arriving at the port.
- The expansion works of the port is ongoing and further large-scale expansion is also planned in the future. But it is unclear whether the expansion of the port will increase the volume of bulk water use or not as the techniques to save the volume of bulk water use such as ice production from seawater have been introduced.

As described above, NamPort is expanding the scale of the port but its water consumption is less compared with Swakopmund Municipality and Walvis Bay Municipality at present. NamPort is also introducing the water-saving technology. Large water demand of NamPort is not expected in the future.

(3) Fish Processing Industry

Fish processing industry marks the largest water consumption among the industries in Walvis Bay. Its water consumption accounts for approximately 20% of the total water consumption and tends to increase in recent years. Through the interview with Hangana Seafood, as second largest next to Pescanova Namibia in terms of production, situations of the current water usage and future prospects are found as follows.

- The factory in Walvis Bay operates as fish processing whose end products are frozen and filleting. These products are exported mainly to Europe.
- The factory uses a bulk water of 700 m^3/day. In addition, there is a seawater desalination plant with a capacity of 400 m^3/day in the compound of the factory. Among the fish processing firms in Walvis Bay, Hangana Seafood is the only firm to have a seawater desalination plant.
- The reason for the introduction of seawater desalination plant is to avoid the water use restriction experienced in 2011. At that time, Hangana Seafood was forced to transport the water required for the factory operation by vehicle (water tanker) from Swakopmund. The introduction of the seawater desalination plant was decided in consideration of possible water use restrictions anticipated in the future.
- The operational efficiency of the seawater desalination plant is low as it needs to be washed every 48 hours due to clogging and afterward requires to be dry for four hours. The substantial production capacity stays at around 350 m^3/day. Seawater is taken at the quay and

the salt-concentrated water after desalination is also discharged from the quay. After the construction of the southern container terminal of the port, the sea water quality is anticipated to be degraded due to possible change of tidal current in the bay.

- The bulk water charges paid to Walvis Bay Municipality amounted to NAD 40.0/m^3. The water production cost of the seawater desalination plant ranges from NAD 25.0 to 28.0/m^3 which is lower than the bulk water charge. In recent years, the lowest amount per month was NAD 24.7/m^3.
- Hangana Seafood also uses the ultraviolet disinfection seawater that costs NAD 4.0/m^3, in addition to the desalinated water. The factory manages to use the bulk water, desalinated water, and disinfected seawater, depending on the application and purpose.
- Majority of the water used in the compound of the factory are for ice production (80 m^3/day) and refrigeration for freezing. Even though desalinated water is expensive, it needs to be used for cleaning and sterilization.
- As Hangana Seafood is given the fish catch allocation by the government, the factory will not increase its production in the future.

As described above, Hangana Seafood manages to use the bulk water, desalinated water, and disinfected seawater to optimize the costs. The seawater desalination plant was introduced after experiencing the water use restriction in 2011. Afterwards, the desalinated water cost is lower than the bulk water due to the increase of charges in recent years. But other firms may not invest in seawater desalination because of the following reasons: complicated O&M works for seawater desalination will be a burden for them; and the limitation in their production is attributed to the allocation of fish catch provided by the government.

In the past three years, water consumption of the fish processing industry has been increasing with a rate of 6.0%, 2.3%, and 4.3% annually. However, water consumption of the fish processing industry will hit the ceiling in the near future as it is not expected to increase the quota of fish catch.

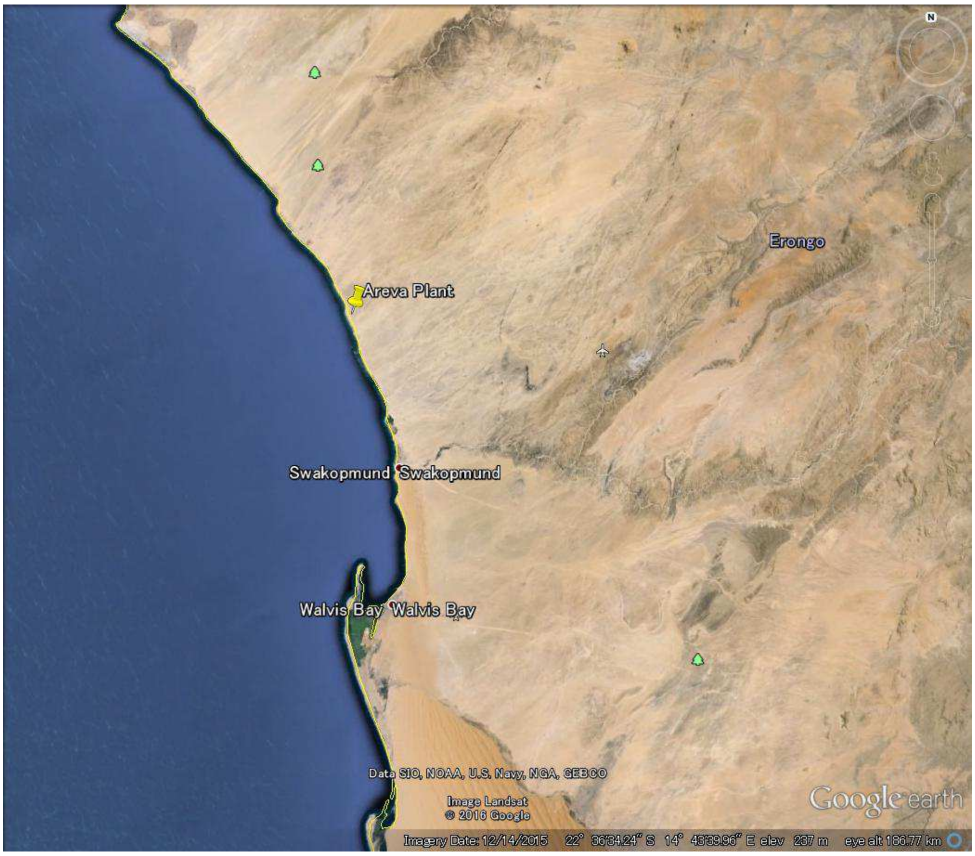
9.2.4 Existing Seawater Desalination Plant

(1) Background

The existing seawater desalination plant was built by Areva to supply freshwater to their Trekkopje Uranium Mine (see Figure 9.11). Uranium mine uses a lot of water when it produces the ‘yellow cake’. As water resources are scarce in the Central Coast area, it is quite natural that low-priced groundwater is used for public purposes and expensive freshwater produced at the seawater desalination plant is used for mining purposes.

The construction was started in 2009 and its operation in August 2013. When the construction started, there was an agreement that Areva would produce 20 million m^3/year (55,000 m^3/day) and NamWater would produce 25 million m^3/year (68,000 m^3/day). However, the agreement was cancelled and only the Areva’s portion of 20 million m^3/year was completed. The plant has a vacant space for expansion of an additional 6 million m^3/year (16,000 m^3/day) in the existing building. Therefore, the plant can increase its capacity up to 26 million m^3/year (71,000m^3/day) without any additional building. Infrastructures such as water intake/outfall and electricity were prepared to meet the agreed capacity, namely, 20 million m^3/year (55,000m^3/day) and 25 million m^3/year (68,000 m^3/day).

It was planned originally that desalinated water is to be supplied to the Trekkopje Mine which started its operation in 2012. However, the mining was suspended when it produced 440 tons of 'yellow cake' due to the poor uranium market. At present, the plant is operating with 25% capacity and supplies the water to the Rosing and Langer-Heinrich mines as well as the Husab Mine under commissioning (to be fully operational within 2016).



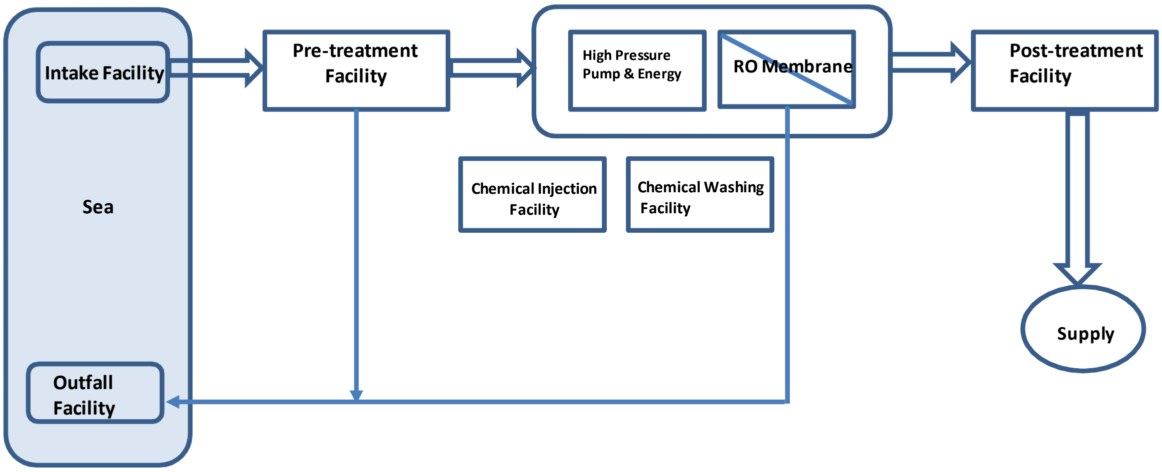
Source: Google Earth

Figure 9.11 Location of Existing Seawater Desalination Plant

(2) Salient Features

The South African Aveng Water (Pty) Ltd. was appointed as an EPC contractor. The contract between Areva and Aveng Water also includes ten years O&M for the plant and the period of O&M can be extended. The following are the salient features of the plant.

The capacity of the plant is 20 million m^3/year (55,000 m^3/day). The treatment process is shown in Figure 9.12 and the layout image of the plant is shown in Figure 9.13.



Source: Survey Team

Figure 9.12 Seawater Treatment Process

- **Intake:** A seawater inlet is 1,000 m away from the pumping station. Chlorine disinfection is used at the inlet. The pumping station is located 100 m from the seashore. A screen with 40 mm opening is set at the pumping station in order to remove trash. The intake can accommodate up to 45 million m^3/year.

  The reasons for selecting the position of the intake are as follows:

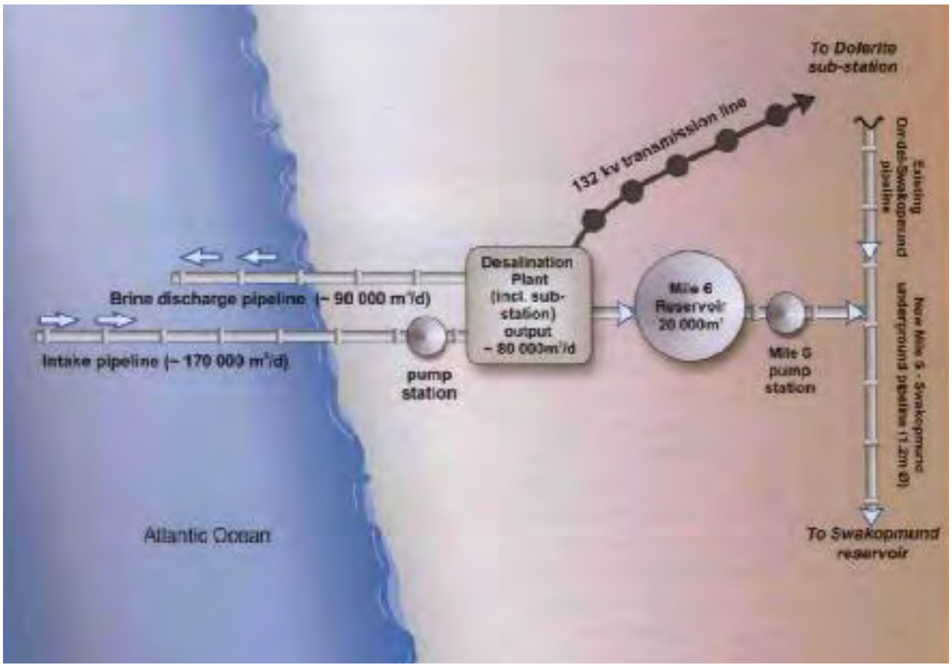
  (i) The road access is available to the seashore near the intake;

  (ii) The distance from the pumping station is the shortest, therefore, it makes the pipeline construction easier; and

  (iii) Seawater quality is good. Location close to the estuary of the river is not appropriate due to sediment. The selected location is far enough from the estuary of the Swakop River, therefore, the intake is not affected by sediment of the estuary.

- **Pre-treatment:** coagulation with iron chloride →turbidity components removal by a rotary screen →minute particles removal by an ultra-filtration (UF) membrane
- **UF membrane:** Norit product, pore size 0.1 µm, 8 inch-hollow fiber membrane
- **RO membrane treatment:** Reverse osmosis (RO) membrane is Lanxess product, 8 inch-spiral membrane (a Toray product originally designed was replaced with the current one due to its high price).
- **Element:** 8 elements/vessel × 64 vessels × 9 skids
- **Energy Recovery System:** product of Energy Recovery Inc.
- **Post-treatment:** pH adjustment with calcium carbonate and chloride disinfection
- **Outfall:** Discharge line is laid in parallel with the intake line and salt-concentrated water is discharged at 500 m off the shore.

- **Construction Cost:** USD 200 million (including power transmission facility and water transmission facility)



Source: Namibia Water Resource Management Plan

Figure 9.13 Layout Image of Existing Seawater Desalination Plant in Wlotzkasbaken

(3) Operation

At present, the plant is operating at 25% of the installed capacity of 20 million m^3/year. The energy recovery rate is 75% for UF membrane and 47% for RO membrane. The total recovery rate is 35%. Energy consumption is 4 kWh/m^3.

In the storm season during winter (June and July), hydrogen sulfide may be released for two to three days or one week when sludge on the seabed is stirred up by the upwelling current. In this event, chloride injection is increased than usual to oxidize hydrogen sulfide then polysulfide ion is removed by a screen.

Aveng Water Engineers have been taking care of the plant operation. Operators and maintenance staffs are all Namibians, who were trained under Aveng Water’s on-the-job training (OJT), and are rotated in 28 staffs ×3 shifts.

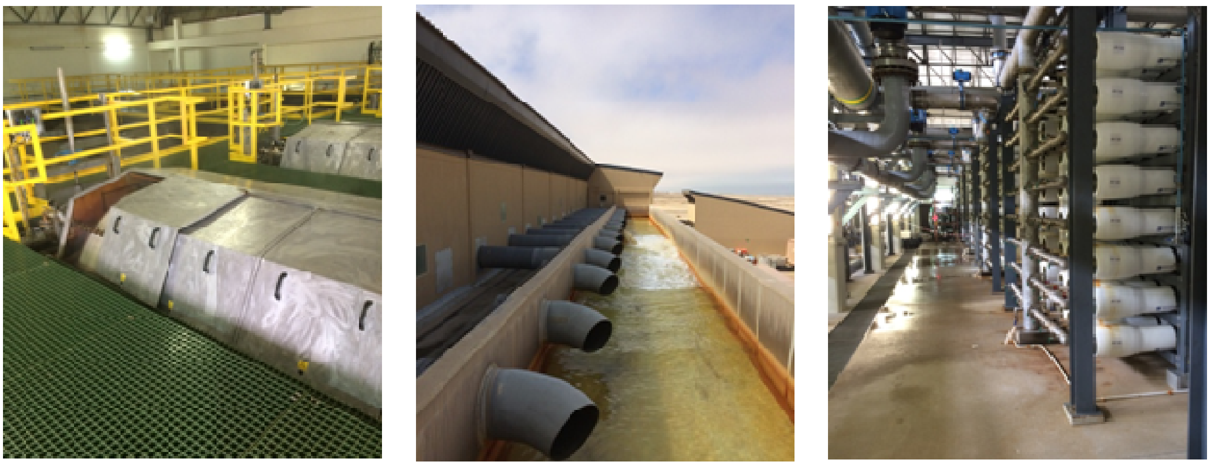
(3) Power Receiving System

The electric power supply to the Central Coast area, where the desalination plant is located, is planned to make a ring transmission network to connect the Central Coast area with Windhoek. The electric power is supplied from the Trekkopje Substation through 33 kV line by NamPower and no blackout or spike has been experienced throughout the year. The power receiving facility has a 40 MW transformer, which can accommodate up to 45 million m^3/year of the originally planned production.

(4) Operating Conditions

As any operation data including seawater quality, processed water quality and so on were not made available, it is hard to assess the operational soundness of the plant precisely. From the observation at the plant, it was stably operated as a whole (see Figure 9.14). The electric conductivity of the produced water showed 782 μS/cm; then TDS would be about 470 mg/L that is almost equivalent to the product of standard RO membrane. The produced water was good enough for drinking accordingly.

Rotary screen | Discharging backwash water from UF membrane | RO membrane



Source: Survey Team

Figure 9.14 Observation of Existing Seawater Desalination Plant in Wlotzkasbaken (March 14, 2016)

9.2.5 Financial Performance of NamWater

Financial performance of NamWater is aligned with the International Financial Reporting Standard (IFRS). The IFRS followed a financial statement which enables to apprehend cost amount at accrual basis. The Annual Report of NamWater suggests an application of IFRS rule from financial year of 2013/2014 and that the reported numbers before IFRS rule application are modified accordingly. The comparison of reported numbers before and after 2012 results to inconsistency due to the above reasons.

The Financial Statement of NamWater has been audited by Ernst & Young with an auditor's report stating that the reported financial statements present fairly. Water service entities in developing nations audited by international accounting firms are exceptional and reported numbers are reliable.

1) Comprehensive Profit Loss Statement (see Table 9.9)

Table 9.9 Comprehensive Profit Loss Statement of NamWater

	2014	2013	2012	2011
Revenue	832	654	544	448
Cost of Sales	▲ 89	0	0	0
Gross Profit	743	654	544	448
Other Income	43	33	26	21
Operating Expenses	▲ 735	▲ 669	▲ 551	▲ 460
Operating Profit/Loss	50	18	18	9
Investment Revenue	35	34	28	29
Financial Costs	▲ 7	▲ 8	▲ 9	▲ 11
Profit Before Taxation	78	43	38	27
Taxation	▲ 27	▲ 21	8	▲ 35
Profit for the Year	51	23	45	▲ 7
Actuarial Gain/Losses on Defined Benefit Plans	2	▲ 34	0	0
Revaluation Reserve	1,007	1,773	0	0
Tax Related to Components of Other Comprehensive Income	▲ 314	▲ 592	0	0
Comprehensive Income/Loss	745	1,169	45	▲ 7

Source: NamWater

Sales: The sales amount of 2014 increased by NAD 178 million from 2013, while the amount of water sales stayed at NAD 134 million m^3 and NAD 135 million m^3, respectively. Sales of desalinated water to mine operations started from 2014 and applied tariff, which is almost equal to production cost, resulted in an increase of revenue. Around cost of sales NAD 89 million m^3 suggests the purchase price of desalinated water.

Operating Expenses: Operating expenses are shown in Table 9.10. Depreciation value is increasing in recent years. Other operating expenses include expenses of retirement and losses of non-recoverable sales and covers major expense items.

Table 9.10 Operating Expenses of NamWater

Item	Expenditure (NAD in millions)	Percentage
Personnel Expenses	210	29%
Depreciation and Amortization	190	26%
Electricity Charges	190	26%
Repairs and Others	145	19%
Total	735	100%

Source: NamWater Annual Reports, 2011 to 2014

Corporate Tax: Reported corporate tax payment amounting to NAD 27 million is presumably negotiated in partial or full amount with the government.

Revaluation Reserve: Unrealized income is reported by revaluation of fixed assets.

Net Income: Net income after tax is reported at NAD 745 million which includes unrealized income. Therefore, actual net income shall be estimated at NAD 51 million. NamWater is concluded as a stably operated entity.

2) Balance Sheet (see Table 9.11)

Intangible Assets: The increase of fixed assets is caused by an application of IFRS rule and no major assets position.

Cash and Cash Equivalents: NamWater has an ample cash reserve. NamWater's financial situation suggests an ability to divide its profit; however, the entity reserves these profits for future needs.

Capital: Equity ratio is 66% and demonstrates very high financial stability of the entity.

Loans: Long-term and short-term loan reached to NAD 74 million and NamWater is capable of borrowing money with current balance.

Differed Tax: Statement shows the differed tax amount reached to NAD 853 million in 2014, which implies a cost associated with sales of owned assets but not immediate expenses to impact the balance sheet.

Table 9.11 Balance Sheet of NamWater (Unit: Million NAD)

	2014	2013	2012	2011
Assets				
Non-current Assets				
Property, plant and equipment	3,934	3,046	1,172	954
Intangible assets	3	4	6	8
Deferred tax	0	0	0	11
Subtotal	3,937	3,050	1,178	973
Current Assets				
Inventories	5	3	5	3
Other financial assets	666	622	524	420
Trade and other receivables	80	44	39	41
Prepayments	0	0	0	0
Cash and cash equivalents	206	72	131	75
Subtotal	956	741	699	538
Total Assets	**4,894**	**3,792**	**1,878**	**1,511**
Equity and Liabilities				
Equity				
Share capital	1,055	1,055	1,018	959
Non distributable reserves	1,763	1,191	74	10
Retained income	390	217	205	159
Subtotal	3,208	2,463	1,297	1,128
Liabilities				
Non-current Liabilities				
Long-term loans	63	74	84	95
Post retirement medical obligation	147	129	54	42
Deferred income	381	303	320	175
Deferred tax	853	585	12	0
Severance pay obligation	30	28	11	6
Subtotal	1,474	1,119	482	318
Current Liabilities				
Long-term loans	11	11	11	11
Current tax payable	73	40	2	7
Trade and other payables	122	152	86	47
Deferred income	6	7	0	0
Provisions	0	0	0	0
Subtotal	212	209	99	64
Total Liabilities	1,686	1,328	581	383
Total Equity and Liabilities	**4,894**	**3,792**	**1,878**	**1,511**

Source: NamWater

3) Credit Rating

Fitch Rating classified NamWater as BBB- in February 2015 by taking all above things into consideration. Fitch also pointed out the fact that NamWater is a sole bulk water supply entity in Namibia in foreseeable future and its tariff system is designed to favor stable management of NamWater, noting the absence of negative information in its recent annual reports.

9.2.6 Financial Performance of Municipalities

Table 9.12 shows the financial performances of the municipalities.

Table 9.12 Financial Performance of Swakopmund Municipality and Walvis Bay Municipality (Unit: NAD)

				2014	2015
Walvis Bay Municipality (Population 62,744)					
	Expenditure				
		Capital		307,065,971	336,942,941
		Operational		317,523,441	353,985,690
	Revenue			314,658,946	351,320,261
	Deficit			▲ 2,864,495	▲ 2,665,429

Swakopmund Municipality (Population 44,725)					
	Expenditure				
		Capital			208,000,000
			Direct Funding		63,000,000
			Excluding Loans		40,000,000
			Government Project		105,000,000
		Operational			244,000,000
	Revenue				240,000,000
	Deficit				▲ 4,000,000

Source: Prepared by the Survey Team based on the data provided by the municipalities

Both the municipalities are operating with significant deficits. Water supply business itself is well-managed; however, the entire financial performances of the municipalities remain negative. For instance, Walvis Bay's water supply services generate revenues almost equivalent to one-third of the total municipalities' revenue; however, the consolidated municipalities' financial performance is negative. This suggests a situation where inefficiency and inappropriate service management is compensated with operating profit of water supply services.

Municipalities oblige NamWater to perform sustainable water supply; and the lack of excuse for service is attributed to NamWater. The responsibilities of water supply and catering, which ultimately include the decision of alternating water supply sources to desalination facility, shall primarily be borne by the municipalities; however, users misunderstand the responsibilities of NamWater.

As a result, NamWater is deprived of the opportunities to set bulk water sale prices at an appropriate level and lost its possible internal reserve for upgrading and maintenance of its facilities due to municipalities' financial management highly relying on the revenue from water supply services.

9.2.7 Water Tariff

(1) NamWater

NamWater's bulk water sale prices are determined along with the production costs and actual catering costs for each user (see Table 9.13). For instance, Arandis Town located in Erongo's central highland accepts higher tariff due to pumping costs. Water tariff from the desalination plant to the uranium mines is "cost-based" and no definite number is disclosed. This "cost-based" tariff depends on the production costs at the Areva's Desalination Plant; and it costs around NAD 30/m^3.

NamPort informed the Survey Team that they have to accept the water from desalination plant and need to accept bulk water tariff increases because of a weaken supply from the subsoil water sources.

Table 9.13 Bulk Water Tariff and Volume Sold by NamWater (2015)

Area	Price (NAD/m^3)	Volume Sold (m^3)
Domestic and Public		
Walvis Bay Municipality	8.25	6,056,760
NamPort	8.25	271,715
Kuisebmund	8.05	279,555
Swakopmund Municipality	8.75	4,803,390
Henties Bay Municipality	8.45	577,084
Arandis Town Council	10.10	480,000
Industry		
Rossing Mine	Cost-based (approx. NAD 30.00)	2,715,634
Langer-Heinrich Mine		1,438,964
Husab Mine		1,661,000

Source: NamWater

(2) Municipalities

Swakopmund Municipality and Walvis Bay Municipality supply the water purchased from NamWater to the consumers. Table 9.14 shows the water tariff of the two municipalities.

Table 9.14 Water Tariff of Swakopmund Municipality and Walvis Bay Municipality

Walvis Bay Municipality	NAD/m^3
Purchase from NamWater	8.25
Domestic (kl/month)	
0 to 15	11.10
16 to 30	18.50
31 to 85	30.80
Over 85	46.20
Business (kl/month)	
0 to 500	31.90
500 to 1,500	35.10
1,500 to 3,000	36.95
Over 3,000	40.05

Swakopmund Municipality		NAD/m^3
Purchase from NamWater		8.75
Domestic		
Basic Tariff		
	For water supplied, for the first 8 m^3	7.95
	Plus meter rent: 20 mm/diameter	6.50
For Senior Citizens		
	For the first 8 m^3	2.75
	Plus meter rent: 20 mm/diameter	3.00
Staged tariff		
	9 to 30	12.30
	31 to 60	17.30
	Over 60	25.90
Small Holdings		
	Basic Tariff: up to 8 m^3	9.20
	Plus meter rent: 20 mm/diameter	6.50
Staged tariff		
	9 to 30	11.10
	31 to 60	12.30
	Over 60	25.90

Source: Swakopmund Municipality and Walvis Bay Municipality

Walvis Bay Municipality purchases water at a cost of NAD 8.25/m^3 from NamWater and supplies domestic and industry at a rate of NAD 11.10/m^3 and NAD 31.90/m^3, respectively. The following Table 9.15 shows the balances of payment of Walvis Bay's water supply services. Sales profit reaches at 28.9% which is relatively higher value.

Table 9.15 Revenue and Expenditure of Water Supply Service by Walvis Bay Municipality

Item	2011	2012	2013	2014
Water Sales	71,801,089	81,368,062	94,736,777	112,501,649
Water Purchases	31,705,373	39,887,961	38,466,419	44,331,453
Other Expenses	16,609,534	16,186,182	28,262,703	35,548,769
Balance	23,486,182	25,293,919	28,007,655	32,621,427

Source: Walvis Bay Municipality

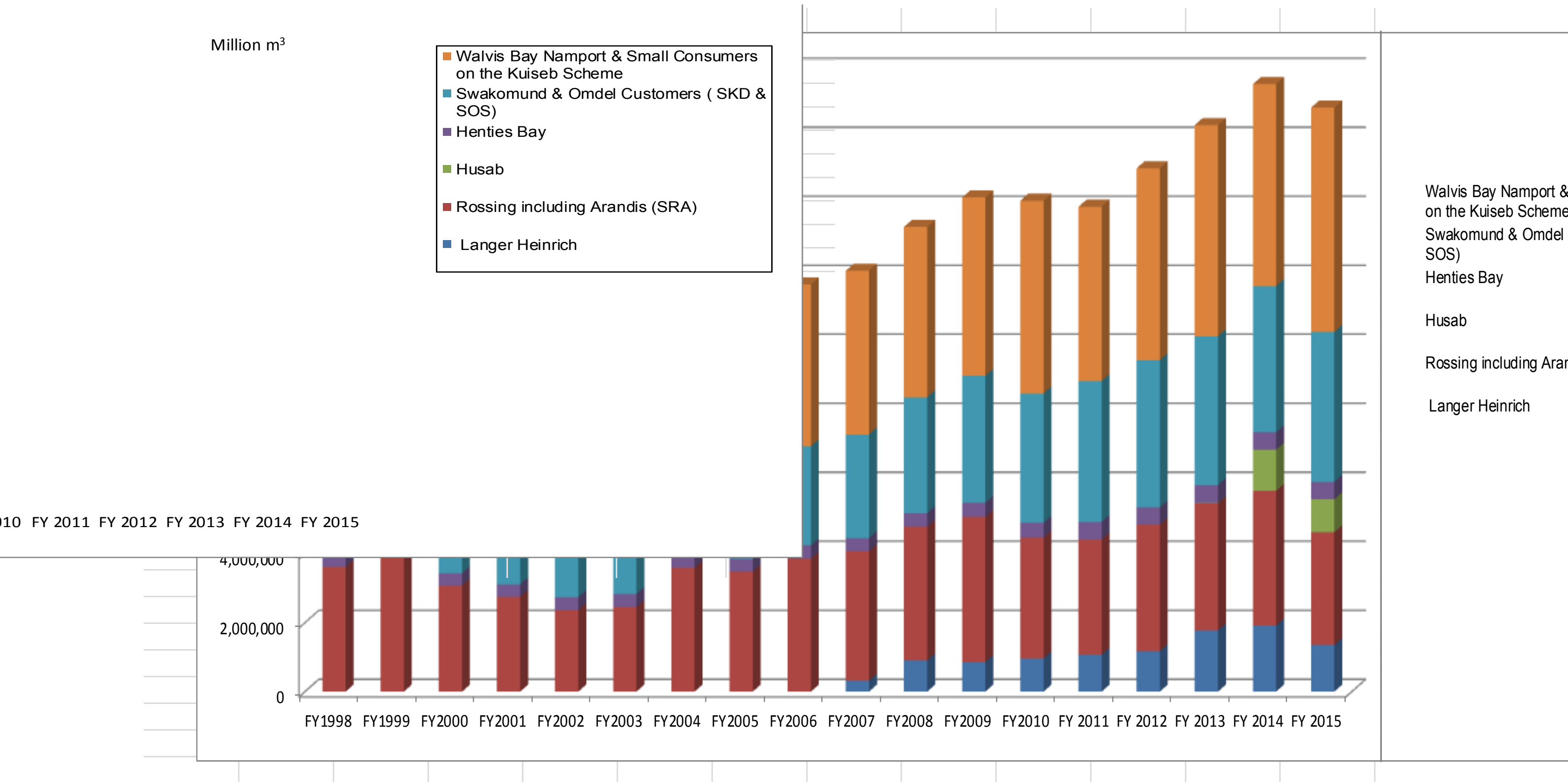
Swakopmund Municipality purchases water at NAD 8.75/m^3; however, domestic water is supplied at a rate of NAD 7.95/m^3 up to 8 m^3, with a loss of NAD 0.80/m^3. Aged households, which account to 5% of entire households, are supplied at a rate of NAD 2.75/m^3 again with yield losses amounting to NAD 6.00/m^3.

9.3 Need and Feasibility of Seawater Desalination Project

9.3.1 Past Trend of Water Consumption

(1) General (Based on the Data of NamWater)

The bulk water supply records received from the Namib Office of NamWater are shown in Figure 9.15. The annual water volume is recorded by each fiscal year from July to next June in Namibia rather than calendar year. Even though the records are corrected into a calendar year basis, there are discrepancies on the records between NamWater and water consumers. Therefore, the records of NamWater are referred to recognizing a long-term water consumption trend only. In this Chapter, the water consumption is discussed on the basis of other records such as those given by bulk water users.



Source: NamWater

Figure 9.15 Annual Volume of Bulk Water Sold by NamWater

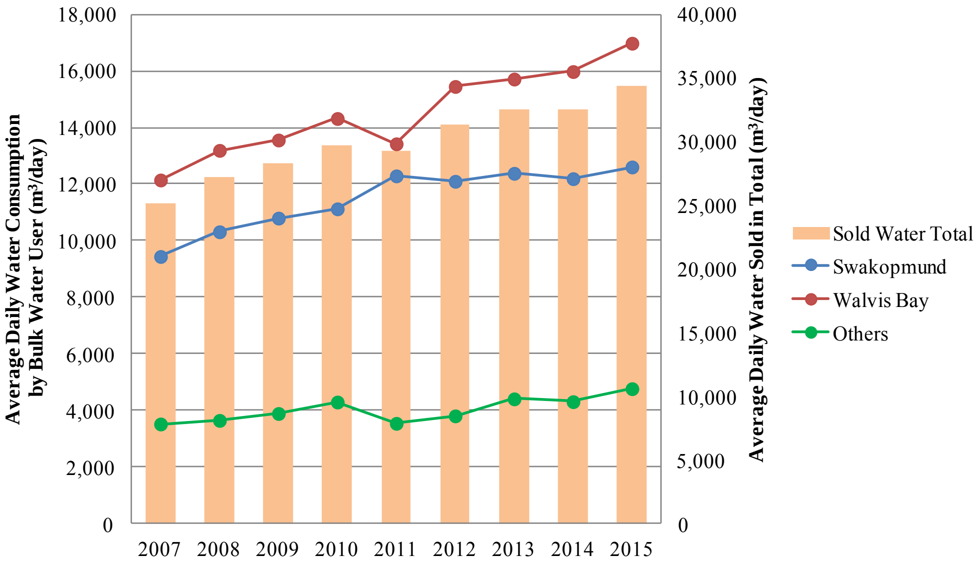
(2) Bulk Water Supply for Municipalities

The average daily water consumption is compiled on the basis of the data collected from NamWater, Swakopmund Municipality, and Walvis Bay Municipality as shown in Table 9.16 and Figure 9.16. The average daily water consumption is increasing as a whole, except in the year 2011 when the water intake from the Kuiseb River was restricted.

Table 9.16 Average Daily Water Consumption by Bulk Water User

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2007-2015
Swakopmund Municipality*1	9,444	10,317	10,800	11,128	12,292	12,101	12,383	12,194	12,607	-
	-	9.2%	4.7%	3.0%	10.5%	-1.5%	2.3%	-1.5%	3.4%	3.7%
Walvis Bay Municipality*2	12,147	13,194	13,560	14,320	13,426	15,452	15,714	15,979	16,981	-
	-	8.6%	2.8%	5.6%	-6.2%	15.1%	1.7%	1.7%	6.3%	4.3%
NamPort*2	368	424	580	408	395	434	848	425	557	-
	-	15.2%	36.9%	-29.7%	-3.1%	9.9%	95.3%	-49.9%	31.1%	5.3%
Henties Bay Municipality*3	1,075	1,091	1,167	1,258	1,301	1,403	1,428	(1,504)	1,581	-
	-	1.5%	6.9%	7.8%	3.4%	7.8%	1.8%	(5.4%)	5.1%	(4.9%)
Arandis Town Council*3	992	941	935	874	958	975	1,030	(1,172)	1,315	-
	-	-5.1%	-0.7%	-6.6%	9.6%	1.8%	5.6%	(13.8%)	12.2%	(3.6%)
Smaller consumers fed from Kuiseb*3	870	829	627	669	708	(722)	(737)	(751)	766	-
	-	-4.7%	-24.3%	6.6%	5.8%	(2.1%)	(2.0%)	(2.0%)	1.9%	(-1.6%)
Smaller consumers fed from Omaruru*3	219	366	586	1,091	185	(277)	(369)	(461)	553	-
	-	66.9%	60.1%	86.2%	-83.0%	(49.6%)	(33.1%)	(24.9%)	19.9%	(12.2%)
Sold Water Total	**25,115**	**27,162**	**28,256**	**29,748**	**29,264**	**(32,933)**	**(34,133)**	**(34,111)**	**(36,078)**	-
	-	**8.2%**	**4.0%**	**5.3%**	**-1.6%**	(7.2%)	(3.6%)	(-0.1%)	(5.8%)	**(4.0%)**

Note: Upper: Daily average water demand (m^3/day)
Lower: Increase rate from last year (%)
*1: Based on the data from Swakopmund Municipality
*2: Based on the data from Walvis Bay Municipality
*3: Based on the data from NamWater, some data are not available and figures in parentheses are estimated by the Survey Team as reference.
Source: *1, *2, and *3



Source: Prepared by the Survey Team

Figure 9.16 Bulk Water Supply by NamWater

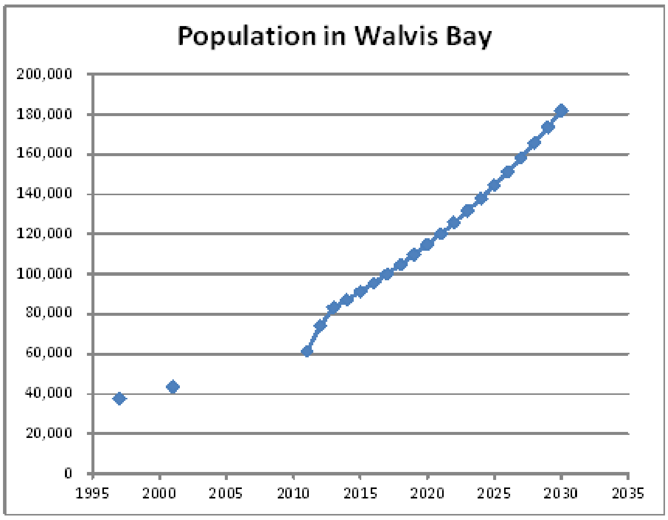
Swakopmund Municipality recorded a sharp increase in water demand up to 2011 but afterwards it has leveled off. It is recognized that less increase in water consumption could be attributed to the water reuse and rise of water tariff. On the other hand, Walvis Bay Municipality recorded a rapid increase in water consumption in 2012. Such rapid increase is considered to be a reaction from the water restriction experienced in 2011 as well as an increase in population. According to the Walvis Bay Municipality and NamWater, the increase in population is caused by the influx of workers due to the expansion works of the port (see Figure 9.17).

The bulk water supply for Swakopmund Municipality and Walvis Bay Municipality accounted for 85% of the total based from the Namib Office of NamWater. Of the others, Henties Bay Municipality and Arandis Town Council correspondingly are supplied with 4% of the total bulk water supply. The water consumption of the two municipalities has been increasing annually with an average rate of 4.9% in Henties Bay Municipality and 3.6% in Arandis Town Council from 2007 to 2015. A remarkable population growth has been taking place in Arandis Town Council for the past three years and suggests that a number of workers have been increasing in conjunction with the opening of the Husab Mine.

It is hard to recognize the recent trend of water consumption in other small settlements as the records are not made available from 2012 to 2014 and those until 2011 are irregularly variable. The water consumption has not been increasing in the settlements around the Kuiseb River. Meanwhile, the water consumption has been increasing remarkably in the settlements around the Omaruru River probably due to the influx of workers to the mines as occurred in Arandis Town Council.

Water consumption of NamPort is also variable. NamWater pointed out that NamPort purchased the bulk water not only from NamWater but also from Walvis Bay Municipality. The irregular fluctuations can be explained from the NamWater's point of view. Meanwhile, it is recognized generally that the water consumption of NamPort is increasing gradually.

Year	Population	Growth Rate	Remarks
1997	37,565		
		4.0%	
2001	43,611		Census
		3.5%	
2011	61,300		Census
2012	74,173	21.0%	
2013	83,236	12.2%	Forecast
2014	87,149	4.7%	Forecast
2015	91,245	4.7%	Forecast
2016	95,533	4.7%	Forecast
2017	100,023	4.7%	Forecast
2018	104,724	4.7%	Forecast
2019	109,646	4.7%	Forecast
2020	114,800	4.7%	Forecast
2021	120,195	4.7%	Forecast
2022	125,844	4.7%	Forecast
2023	131,759	4.7%	Forecast
2024	137,952	4.7%	Forecast
2025	144,435	4.7%	Forecast
2026	151,224	4.7%	Forecast
2027	158,331	4.7%	Forecast
2028	165,773	4.7%	Forecast
2029	173,564	4.7%	Forecast
2030	181,722	4.7%	Forecast



Source: Integrated Urban Spatial Development Framework for Walvis Bay (Approved in June 2014)

Figure 9.17 Population Growth and Projection in Walvis Bay

(2) Bulk Water Supply for Mines

At present, there are two mines, i.e., Rossing and Langer-Heinrich in the jurisdiction of the Namib Office of NamWater. In addition, the Husab Mine will commence its operation soon. Each of the mines is using desalinated water from NamWater. The Husab Mine is allowed to use the groundwater before its commencement of operation. The Husab Mine has its own wells and is not served with bulk water sales by NamWater. The Langer-Heinrich Mine has been increasing the water consumption gradually except in 2015. The Husab Mine is using a limited volume of water for pre-operation purposes but will increase its water use rapidly in 2016 after its commencement of operation.

9.3.2 Perspective of Water Demand

(1) Annual Increase of Water Demand Rates

From the water consumption of bulk water users in recent years, the Survey Team predicts an increase in water demand in the jurisdiction of the Namib Office of NamWater as shown in Table 9.17.

Table 9.17 Annual Increase of Water Demand Rate in the Central Coast Area

	Increase Rate	Description
Swakopmund Municipality	2%	Population growth is not taking place since 2011 but is expected to take place again in line with the Husab Mine being operational and improvement of the global uranium market conditions.
Walvis Bay Municipality	4%	Walvis Bay Municipality is expecting an increase in population of 4.7%/year. As majority of the population growth will be workers migrating from rural areas, the increase rate of water demand is not expected to be equivalent to the population growth rate. Meanwhile, it is considered that the water demand will increase with the development of logistics and expansion of the port.
NamPort	5%	Even though this is not an industry that uses a large amount of water, the water demand will increase with a similar trend so far since the expansion of the port is planned to be implemented successively through several stages in the future.
Henties Bay Municipality	3%	The water consumption shows an increase of about 5% a year. As the municipality still has a room for expansion, the recent trend of the water consumption will continue but is assumed to slow down slightly in the future.
Arandis Town Council	5%	The Arandis Town Council is located near the Husab Mine. Impacts on the water demand will take place with the Husab Mine to be operational and improvement of the global uranium market conditions. After the completion of the Husab Mine, population growth will be led by the activation of the mining industry instead of influx of construction workers.
Smaller consumers fed from the Kuiseb	2%	Assuming 2% increase of the water demand from the recent trend.
Smaller consumers fed from the Omaruru River	4%	The water consumption has been increasing with a rate of 10% or more. It will slow down in the future but will continue to increase at a high rate.

Source: Survey Team

(2) Daily Peak Factor

The ratio of daily maximum demand to daily average demand is defined as a daily peak factor. Based on the fluctuation of the monthly water consumption in Swakopmund Municipality (see Figure 9.9), the daily peak factor is set at 1.1 in the Central Coast area except for the tourist demand. The difference of the monthly water consumption between December and March in 2015 was about 113,000 m^3/month in Swakopmund Municipality. The corresponding volume of 4,000 m^3/day taking place in the peak tourism season is added on top of the daily maximum demand.

(3) Water Loss from Transmission System

According to NamWater, the water loss rate from the transmission system is currently at 9% but is expected to be reduced to 5%. It is assumed that the water loss rate of 5% would be attained by 2020.

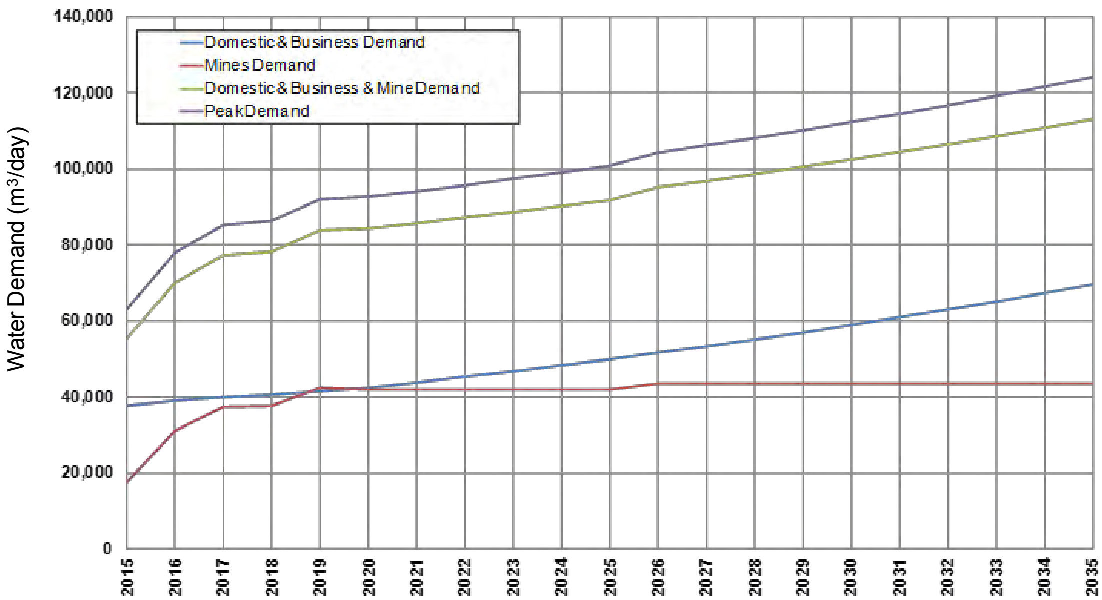
(4) Water Demand Forecast

The water demand forecast in the Central Coast area, based on (1), (2), and (3) above, is summarized in Table 9.18 and Figure 9.18.

Table 9.18 Water Demand Forecast in the Central Coast Area

	Bulk Water User	Item	2015	2020	2025	2030	2035
Domestic, Commercial and Industrial Demand	Swakopmund Municipality	Demand (m^3/day)	12,607	13,920	15,368	16,968	18,734
		Increase Rate (%)	3.4%	2.0%	2.0%	2.0%	2.0%
	Walvis Bay Municipality	Demand (m^3/day)	16,981	20,660	25,136	30,582	37,207
		Increase Rate (%)	6.3%	4.0%	4.0%	4.0%	4.0%
	NamPort	Demand (m^3/day)	557	710	907	1,157	1,477
		Increase Rate (%)	31.1%	5.0%	5.0%	5.0%	5.0%
	Henties Bay Municipality	Demand (m^3/day)	1,581	1,833	2,125	2,463	2,856
		Increase Rate (%)	5.1%	3.0%	3.0%	3.0%	3.0%
	ArandisTown Council	Demand (m^3/day)	1,315	1,678	2,142	2,734	3,489
		Increase Rate (%)	12.2%	5.0%	5.0%	5.0%	5.0%
	Smaller consumers fed from Kuiseb	Demand (m^3/day)	766	846	934	1,031	1,138
		Increase Rate (%)	1.9%	2.0%	2.0%	2.0%	2.0%
	Smaller consumers fed from Omaruru	Demand (m^3/day)	553	672	818	995	1,211
		Increase Rate (%)	19.9%	4.0%	4.0%	4.0%	4.0%
	Subtotal	Demand (m^3/day)	34,360	40,319	47,429	55,930	66,112
		Increase Rate (%)	5.8%	3.3%	3.3%	3.4%	3.4%
	Water Loss	Loss (%)	9%	5%	5%	5%	5%
		Loss(m^3/day)	3,398	2,122	2,496	2,944	3,480
	Domestic, Commercial and Industrial Demand	Demand (m^3/day)	**37,758**	**42,441**	**49,926**	**58,874**	**69,591**
		Increase Rate (%)	5.8%	2.2%	3.3%	3.4%	3.4%
Mine Demand	Rössing Mine	Demand (m^3/day)	7,440	9,863	9,863	9,863	9,863
	Langer Heinrich Mine	Demand (m^3/day)	3,942	3,960	3,949	5,479	5,479
	Husab Mine	Demand (m^3/day)	4,551	25,986	25,986	25,986	25,986
	Subtotal	Demand (m^3/day)	**15,933**	**39,809**	**39,798**	**41,329**	**41,329**
	Water Loss	Loss (%)	9%	**5%**	5%	5%	5%
		Loss(m^3/day)	1,576	2,095	2,095	2,175	2,175
	Mine Demand	Demand (m^3/day)	**17,509**	**41,904**	**41,893**	**43,504**	**43,504**
Total		**Demand (m^3/day)**	**55,267**	**84,345**	**91,818**	**102,378**	**113,095**

Source: Survey Team



Source: Survey Team

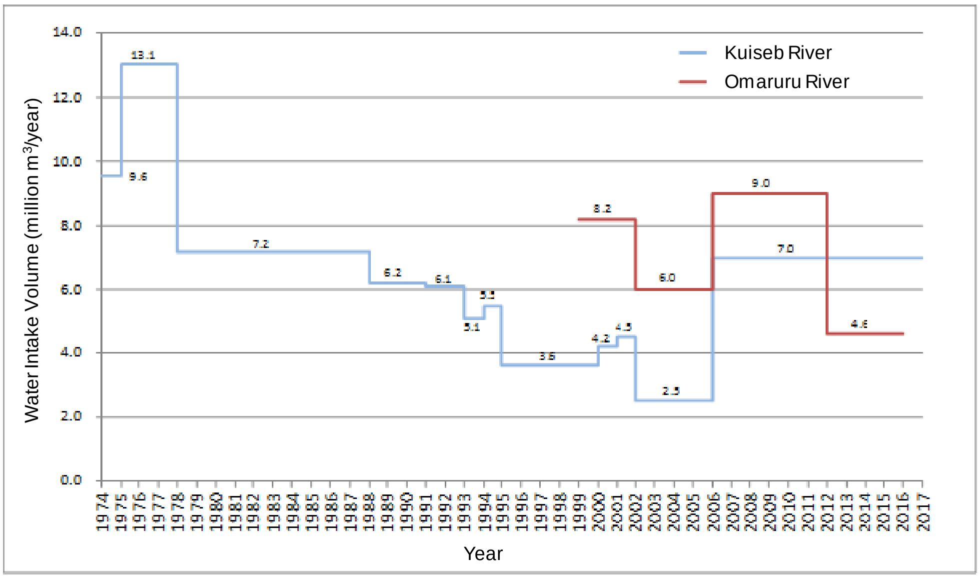
Figure 9.18 Water Demand Forecast in the Central Coast Area

9.3.3 Assessment of Existing Water Source and Alternative

(1) Existing Water Sources

1) Subsoil Water from the Kuiseb River and Omaruru River

NamWater has been taking the subsoil water from the Kuiseb River and the Omaruru River in accordance with the permissions given by MAWF. Under the current permissions, NamWater can take the subsoil water of 7.0 million m^3/year from the Kuiseb River (expiration date: March 3, 2017) and 4.6 million m^3/year from the Omaruru River (expiration date: October 14, 2016) as shown in Figure 9.19.

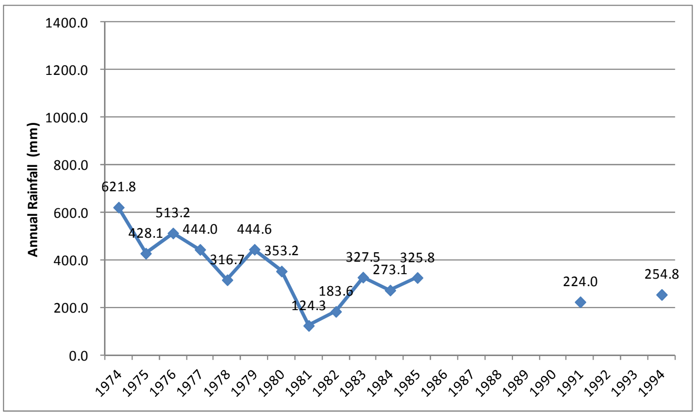


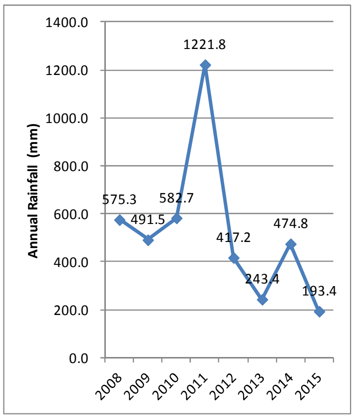
Note: Data is not available when NamWater could take 7.0 million m^3/year of the subsoil water from the Kuiseb River. The Survey Team presumes that 7.0 million m^3/year might take place in 2006 as the rainfall was much and the increase also occurred in the Omaruru River in the same year.

Source: NamWater

Figure 9.19 Usable Water Volume Permitted by MAWF for NamWater

The annual rainfall records in Windhoek, located on the upstream of the Swakop basin and Kuiseb basin, are shown below. As there are many missing records, the annual rainfalls are shown for the years when the records are available throughout the year. The average of the annual rainfalls shown below is 451.7 mm. Exclusive of the abnormally large rainfall in 2011, the average is 411.2 mm.





Source: Namibia Weather Network (http://www.namibiaweather.info/)

Figure 9.20 Annual Rainfall Records in Windhoek

The usable water volume from the subsoil water sources has been fluctuating both from the Kuiseb and Omaruru rivers. The current volume from the Kuiseb stays at a large level compared with the past 18 years from 1988 to 2006, as a large volume of groundwater recharge occurred by the heavy rains in 2006[1] and 2011.

On the other hand, the usable water volume from the Omaruru River stays at the lowest level since 1999. The volume was once increased in 2006 when the annual rainfall was great but was lowered in 2012 to the current volume. In 2011, the annual rainfall was large in Windhoek located in the upper basin of the Swakop River near the watershed with the upper basin of the Kuiseb River. The water intake of the Kuiseb River was damaged due to flood caused by the heavy rainfall in 2011. The upper basin of the Omaruru River is located about 200 km northwest from Windhoek. As there is no rainfall observatory located in the Omaruru River basin, the annual rainfall in 2011 is unknown. Meanwhile, it is presumed that such heavy rainfall in the Omaruru River might not take place in 2011 as there was no particular damage to the water intake of the Omaruru River.

After the heavy rainfall in 2011, the annual rainfall in Windhoek stays at an average or lower. According to the Namib Office of NamWater, there is a possible concern that the usable water volume from the Kuiseb River will be lowered to the level before 2006.

As the usable water volume from the Kuiseb and Omaruru rivers is highly dependent on the rainfall, it is hard to forecast the usable water volume after the expiration of the current permission. From the available past records of the usable water volume and annual rainfall, the usable water volume is assessed by hydrological condition, i.e., abundant, normal, and drought as tabulated in Table 9.19.

Table 9.19 Assessment of Usable Water Volume from the Kuiseb River and Omaruru River

Hydrological Condition	Kuiseb River	Omaruru River	Total
Abundant	7.0 m^3/year (19,178 m^3/day)	8.0 m^3/year (21,917 m^3/day)	15.0 m^3/year (41,095 m^3/day)
Normal	4.5 m^3/year (12,328 m^3/day)	6.0 m^3/year (16,438 m^3/day)	10.5 m^3/year (28,767 m^3/day)
Drought	2.5 m^3/year (6,849 m^3/day)	3.0 m^3/year (8,219 m^3/day)	5.5 m^3/year (15,068 m^3/day)

Source: Survey Team

2) Existing Seawater Desalination Plant in Wlotzkasbaken

Areva owns the seawater desalination plant in Wlotzkasbaken. The plant has a production capacity of 20 million m^3/year (55,000 m^3/day) and currently is producing 5 million m^3/year. The plant was built for the Areva's Uranium Mine. But the Areva's Mine is not in operation yet. NamWater purchases the water from Areva and transfers the water for the other mines. Within this year 2016, an agreement is scheduled between NamWater and Areva to increase the water production up to 50% or 60% of the plant capacity. When the water demand increases in the future, the plant will be able to increase the water production up to the maximum capacity.

(2) New Water Source

NamWater is seeking a new source of water available in the area of the Namib Office. Southern Palaeo Channel is so far identified as a possible water source. It is an aquifer in the south of the Omaruru

[1] Even though the rainfall records in Windhoek are missing in November and December 2006, the sum of the rainfall from January to October is 688 mm.

River. NamWater is conducting a survey for evaluating the potential of this water source. The results are not finalized yet. According to the NamWater Headquarters, the potential is estimated to be 1 million m^3/year (2,740 m^3/day). In addition, this water source seems to be saline and will require desalination.

9.3.4 Required Capacity of Seawater Desalination Plant

(1) Methodology

In this subsection, the future water supply and demand is assessed firstly for the case of "Without the Project" on the condition that the sole additional local aquifer will be developed in the future. Secondary, the future water supply and demand is assessed for a case of "With the Project" to meet the future water demand by the introduction of the additional seawater desalination plant. Through the assessment of "With the Project", a capacity required for the additional seawater desalination plant is estimated.

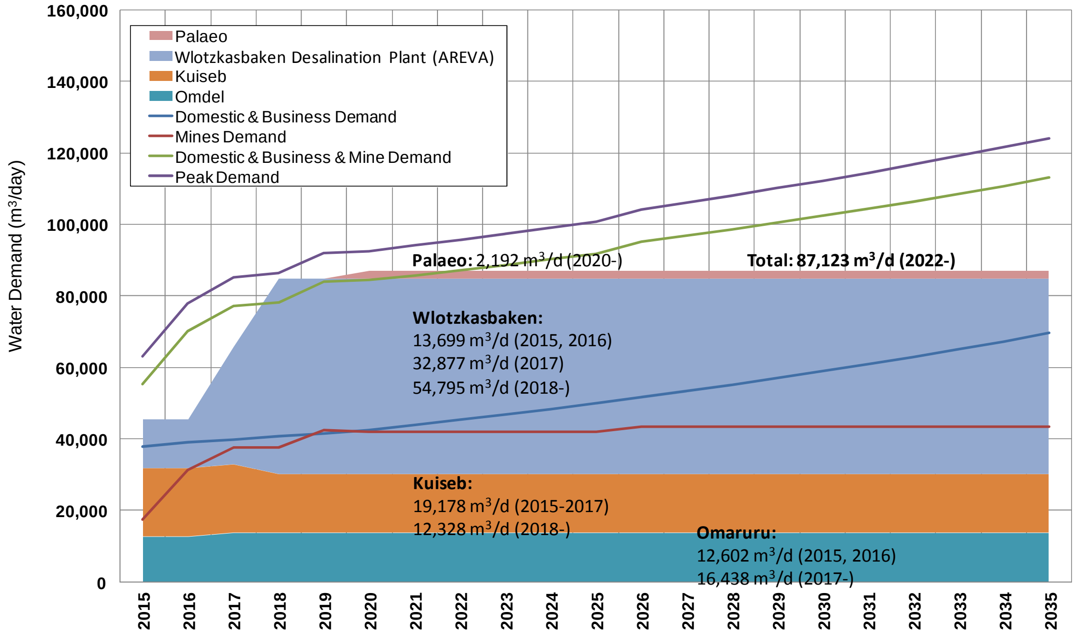
The conditions to be considered for the assessment are listed below.

- Both cases of "Without the Project" and "With the Project", the water intake from the subsoil water sources of the Kuiseb River and Omaruru River will stay at the volume designated under the normal hydrological conditions after the expiration of the current water permit in 2018 and 2017, respectively.
- Under the case of "With the Project", the required capacity of the additional seawater desalination plant is estimated to satisfy the average daily demand. It is assumed that the water demand fluctuation in a day would be controlled by pumping operation in the subsoil water sources.
- The required capacity of the additional seawater desalination plant is also estimated for the options to cope with drought and to meet the daily maximum demand.
- An exploitable volume from the Southern Paleo Channel to be developed is assumed to be 80% of the planned volume of 1 million m^3/year.
- Other than the existing and additional seawater desalination plant, further increment of 6 million m^3/year by using the vacant space available within the existing building is not taken into account. This vacant space is considered to be used for the working area at the time to replace the equipment of the plant.
- The additional seawater desalination plant will be operational in 2022 or later, considering the time taken for the project, i.e., two years for feasibility study and funding, 0.5 year for recruiting consultants, and 3.5 years for bidding, design, and construction.

(2) Case of Without the Project

The daily average water demand will not be satisfied in 2022 even though the conventional water sources will be augmented with the additional local aquifer to be developed and the existing seawater desalination plant is operated with full capacity (see Figure 9.21). As there is no promising alternative, the additional seawater desalination plant will be duly required. Without the additional seawater desalination plant, the daily maximum water demand will not be satisfied in 2017. The additional seawater desalination plant needs to be implemented as early as possible accordingly.

As illustrated, the existing water sources do not satisfy the water demand at present but the water demand should be equivalent to the bulk water supply in 2015 theoretically. Meanwhile, the actual bulk water supply has exceeded the total of usable intake volume from the subsoil water sources and the agreed production of 5 million m^3/year by the existing seawater desalination plant. One of the reasons for the gap in 2015 is an excessive water production at the existing seawater desalination plant over the agreed production as experienced. Another would be an excessive water intake at the subsoil water sources in order to cope with the peaks of water demand.

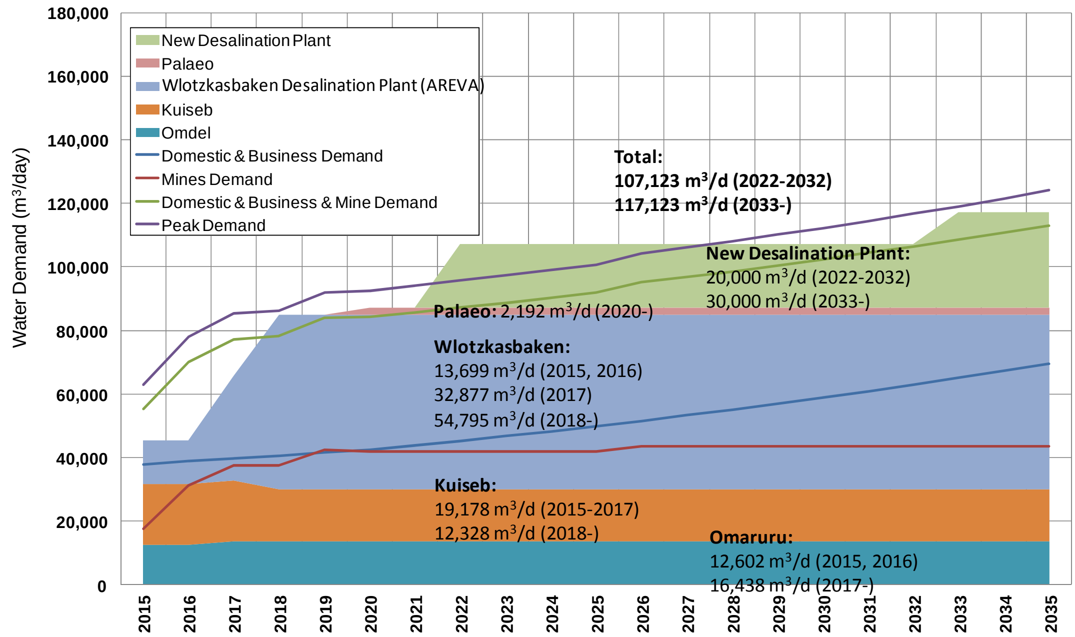


Source: Survey Team

Figure 9.21 Water Demand and Supply Balance in the Central Coast Area (Without the Project)

(3) Case of With the Project

The required capacity of the additional seawater desalination plant will be 20,000 m^3/day and need to be expanded up to 30,000 m^3/day by 2033 as shown in Figure 9.22.

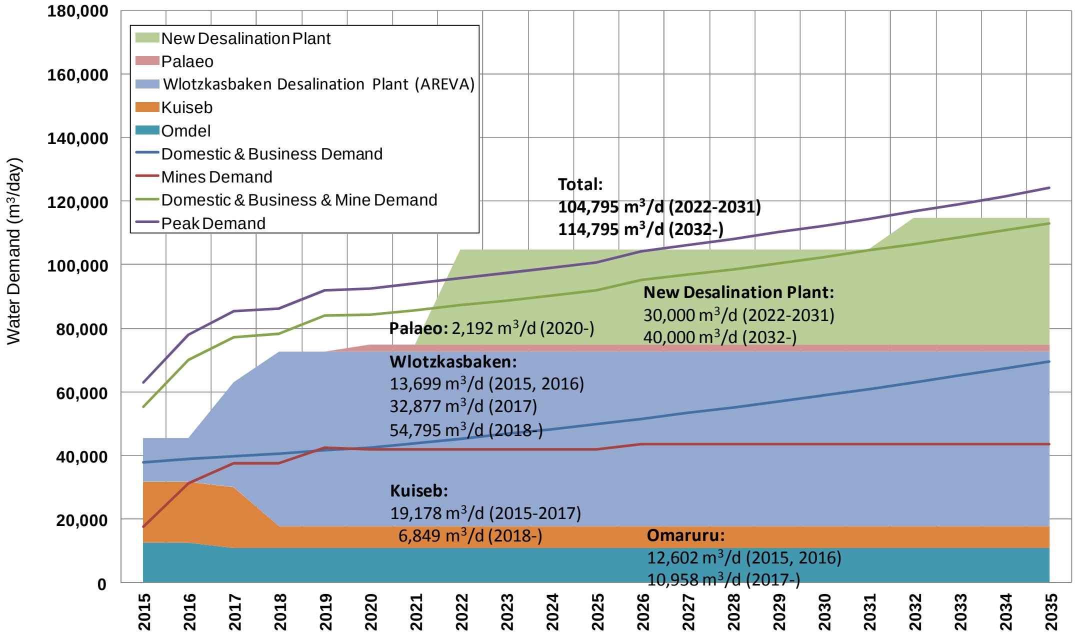


Source: Survey Team

Figure 9.22 Water Demand and Supply Balance in the Central Coast Area (With the Project)

(4) Case of With the Project (Option for Drought)

This option assumes that the water intake volume from the existing subsoil water sources would be reduced due to the drought. The required capacity of the additional seawater desalination plant will be 30,000 m^3/day and need to be expanded up to 40,000 m^3/day by 2032 as shown in Figure 9.23. The water demand will not be satisfied until 2021 due to the time to be taken for the augmentation of water sources. The Central Coast area will face water shortage before the augmentation of water sources for several years.



Source: Survey Team

Figure 9.23 Water Demand and Supply Balance in the Central Coast Area (With the Project, Drought)

(5) Case of With the Project (Option for Maximum Daily Demand)

For minimizing the capacity of the additional seawater desalination plant, an option is to have the reserve capacity of pumps installed at the existing subsoil water sources for responding the daily maximum water demand. But this option may increase the water intake volume excessive of the exploitable volume sustained by actual groundwater recharge. Even the excessive water intake is performed within a short-term, it increases the possible risks such as salt water intrusion and land subsidence.

In order to avoid such environmental risks, the water intake volume from the existing subsoil water sources should be kept constant throughout the year. The water demand fluctuation should be covered by changing the utilization rate of the seawater desalination plant. As the difference between daily average demand and day maximum demand is about 10,000 m^3/day, the required capacity of the additional seawater desalination plant will need to cover another 10,000 m^3/day with the capacity based on the daily average demand.

(6) Summary

It is recognized that the additional seawater desalination plant needs to be operational by 2022 as summarized in Table 9.20.

Table 9.20 Proposed Capacity of Additional Seawater Desalination Plant

Case	Description	Phase	Capacity	Year of Commissioning
1. Base	**Water intake from subsoil water sources under normal hydrological conditions**	**1**	**20,000 m^3/day**	**2022**
		2	**10,000 m^3/ day**	**2033**
2. Drought	Water intake from subsoil water sources under drought	1	30,000 m^3/day	2022
		2	10,000 m^3/day	2032
3. Subsoil Water Conservation	Water intake kept constant from subsoil water sources	1	30,000 m^3/day	2022
		2	10,000 m^3/day	2033

Source: Survey Team

9.3.5 Need and Feasibility of Seawater Desalination Project

As a conclusion in this chapter, the need and feasibility of seawater desalination project is considered to be promising in the Central Coast area represented by Swakopmund Municipality and Walvis Bay Municipality. Further assessments of the seawater desalination project are discussed in Chapter 12 later from the viewpoints of technical, organizational, financial, environmental, and social aspects.

In the Central Coast area, the usable water volume from the existing subsoil water sources highly depends on the variation of annual rainfall. Other reliable water sources are local aquifers yielding a limited volume and seawater desalination. A possible increment of usable water volume by additional local aquifers does not sufficiently contribute to meeting the future water demand. To satisfy the average daily demand in the future, an additional seawater desalination plant needs to be operational by 2022. It is also recognized that augmentation of water supply with seawater desalination to cope with the water shortage in the Central Coast area is consistent with the policy emphasized in the Integrated Water Resource Management Plan as well as the Harambee Prosperity Plan.

NamWater has been carrying out water supply projects over the country for a long time and its organization is capable to implement a large-scale project in the Central Coast area. In addition, the existing seawater desalination plant is operated in the Central Coast area. NamWater will be able to operate the additional seawater desalination plant with support from the human resources of Namibian experienced local staff at this plant. There is a possibility to apply an O&M contract with EPC contractor to construct the additional seawater desalination plant and handle O&M as well.

As described in Chapter 12 later, the water tariff is already similar to the water production cost by seawater desalination at present and will not require a large increment after introduction of the additional seawater desalination plant. Full cost recovery will be expected with an acceptable increase in the water tariff. Regarding environmental and social considerations, land acquisition and resettlement will not take place. When the prescribed procedures in accordance with the relevant laws and regulations are made properly, any problem affecting the implementation of the seawater desalination project is not expected.

Chapter 10 Angola

10.1 Survey Area

10.1.1 General

The survey area is Namibe Municipality, with a distance of about 750 km to the south of the capital Luanda. Namibe Municipality is the provincial capital of Namibe Province, located on the coast of the Atlantic Ocean, a distance of 230 km from the southern border with Namibia (see Figure 10.1). The Cunene River is an international river flowing along the southern border. Namibe Province takes its name from the Namib Desert extending along the coast of the Atlantic Ocean from Namibia. Namibe Municipality was known as *Moçâmedes* in the past.

Namibe Municipality has been developed with a natural port on the coastline that penetrates inland. The municipality is one of the major hubs, similar to Luanda and Lobito, for sea transport in the Atlantic Ocean.

The Namibe Port handles exports of natural resources produced in Huila Province adjacent to the east and the fish landings from the Atlantic Ocean. The port is a nodal point of passenger and cargo as well as natural resources produced in the inland region. The Namibe Corridor is a trunk route for inland transportation starting from the port. Considering the geographical position of the port, the Japanese government made a grant aid, namely, the Project for Emergency Rehabilitation of Port Facilities from 2005 to 2010. In addition, the Japan International Cooperation Agency (JICA) carried out the Preparatory Survey for the Rehabilitation of the Namibe Port from 2010 to 2011. Then, this preparatory survey is being updated starting from January 2016.

Source: Google Earth

Figure 10.1 Location of Namibe

10.1.2 Population

Around 26% of the population in Angola is concentrated in Luanda Province with the capital Luanda, followed by Huila Province located in the east of Namibe Province and Benguela Province with the major cities of Benguela and Lobito. The population in Namibe is 471,613 that stays at 16th among the 18 provinces of the country as shown in Table 10.1.

Based on the provincial statistics, the population of Namibe Province has been increasing from 313,667 in 2006 at an annual rate of about 5%. The Provincial Directorate of Physical Planning, Urbanism and Environment predicts that the population will increase at a rate of 5% per year. Namibe Municipality has a population of 282,056, which accounts for about 60% of the total population of the province as shown in Table 10.2.

Table 10.1 Population by Province in Angola

Province	Population	Percentage
Luanda	6,542,944	26.83%
Huila	2,354,398	9.66%
Benguela	2,036,662	8.35%
Huambo	1,896,147	7.78%
Cuanza Sul	1,793,787	7.36%
Uige	1,426,354	5.85%
Bie	1,338,923	5.49%
Malanje	968,135	3.97%
Cunene	965,288	3.96%
Lunda Norte	799,950	3.28%
Moxico	727,594	2.98%
Cabinda	688,285	2.82%
Zaire	567,225	2.33%
Lunda Sul	516,077	2.12%
Cuando Cubango	510,369	2.09%
Namibe	**471,613**	**1.93%**
Cuanza Norte	427,971	1.76%
Bengo	351,579	1.44%
Total	24,383,301	

Source: Resultados Preliminares do Censo 2014, Instituto Nacional de Estatística (INE)

Table 10.2 Population by Municipality in Namibe Province

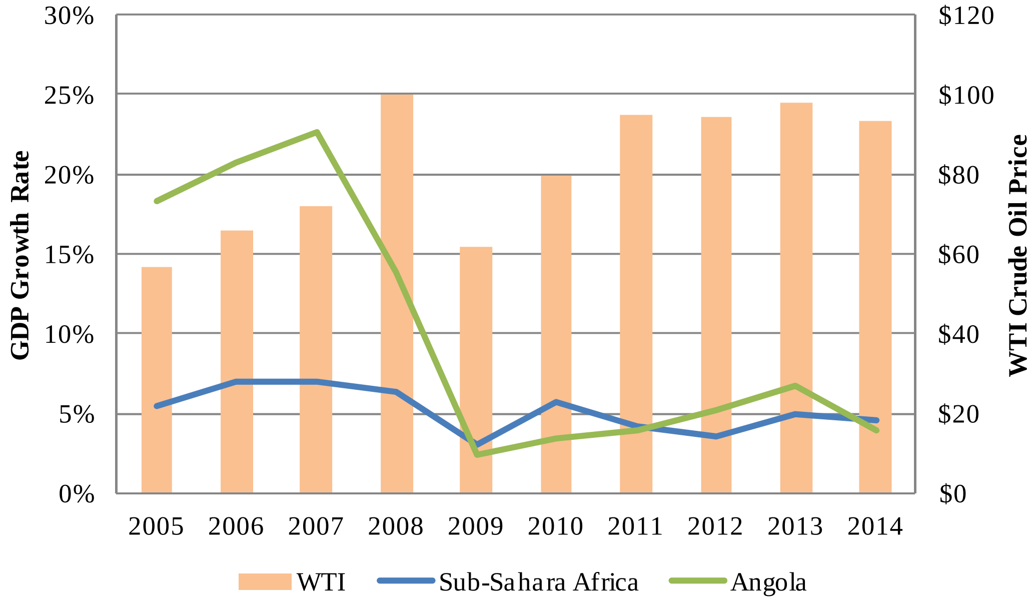
Municipality	Population	Percentage
Namibe	**282,056**	**59.8%**
Tombwa	54,873	11.6%
Virei	29,975	6.4%
Bibala	55,399	11.7%
Camucuio	49,310	10.5%
Total	471,613	100.0%

Source: Resultados Preliminares do Censo 2014, Instituto Nacional de Estatística (INE)

10.1.3 Economy

(1) Economic Growth

Angola’s economic growth is synchronized with crude oil prices and the annual growth rate was more than 20% in 2006 and 2007. The Angolan economy became stagnated in 2009 due to the decline in crude oil prices and the growth rate also slowed down to 2%. A correlation between Angola’s economy and crude oil price is illustrated in Figure 10.2. The figure also shows the comparison with the other Sub-Saharan countries’ trends.



Source: World Bank

Figure 10.2 Economic Growth of Angola and Sub-Saharan Africa vs. Crude Oil Prices

Angola's economy is characterized by high dependency on the petroleum industry and meager manufacturing industry. This results in high unemployment and hyperinflation similar to the Dutch disease. The following Table 10.3 shows the structure of Angola's gross domestic product (GDP) by industry. Forty percent comes from the petroleum industry and this number is far higher than 12.9% in Nigeria which is the largest oil producing country in Africa. The revenue of oil sales is likely to be concentrated in the capital Luanda. The government is trying to disperse the benefits for the development of the local regions.

Fundamentally, the Angolan government's administrative capabilities, including statistical abilities, are believed to have a large room for improvement. Statistics other than presented by the international organizations are not robust. Some critics point out that the lack of capacity to apprehend the current status is attributed to inappropriate budget execution and/or insufficient fiscal management.

Table 10.3 GDP by Sector (Percentage of GDP) in Angola

Sector	2009	2013
Agriculture, forestry, fishing and hunting	6.4%	5.4%
Mining and quarrying	39.7%	39.4%
(Oil)	(39.1%)	(38.5%)
Manufacturing	3.7%	4.1%
Electricity, gas, and water	1.1%	0.7%
Construction	8.2%	10.4%
Wholesale and retail trade; Repair of vehicles Household goods; Restaurants and hotels	9.9%	7.1%
Transport, storage, and communication	4.8%	4.4%
Finance, real estate, and business services	5.4%	3.6%
Public administration and defense	13.5%	17.5%
Other services	7.3%	7.4%

Source: African Economic Outlook, Angola 2015, the African Development Bank

(2) Oil Sector

According to the statistics of the U.S. Energy Information Administration, Angola has 9 billion barrels of confirmed oil reserve, the world's 17th largest which is almost equivalent to that of Mexico. Angola's oil production peaked at 2,000,000 barrels per day in 2008; however, it stagnated at 1,742,000 barrels per day in 2014 combined with a weakened oil market.

On the other hand, Angola recognizes the risks leaning towards the oil sector and promotes foreign direct investments to non-oil sectors by providing broader incentive package towards service industries. The Angolan government launched the Sovereign Wealth Fund (SWF) in 2012 and the fund is operated aiming to diversify oil revenues to other sectors.

(3) Foreign Capital - Results and Issues

Another feature of the Angolan economy is the large presence of foreign capital such as from China. China is the largest importer of Angolan oil. The oil export revenues, however, are appropriated for infrastructure development projects which are given to foreign companies and less opportunities are given to the local companies to enjoy the fruits from the oil production. This is particularly the case of Chinese construction companies.

In Namibe, for instance, 400 ha of middle-income apartment housing projects are ongoing. The project is being carried out by a Chinese construction company within a high wall executed by stationed Chinese experts and workers. As a result, no local employment is being generated. Similar practices are observed nationwide and criticisms are heard about practices of the same kind in some housing projects such as the famous Kilamba New City (*Nova Cidage de Kilamba*), which is a large housing development 30 km (18 miles) from Luanda.

10.1.4 Industry in Namibe

(1) General

The economy of Namibe Province consists of locally-consumed agriculture and fishery. The outskirts of Namibe Municipality are fringed by small orchards growing olive and vegetables. Inland valleys are inhabited by farmers who are harvesting vegetables and grazing cattle, which are all small-scale commercial farming.

Namibe Municipality is surrounded by the desert and not appropriate for commercial farming. Lubango, the provincial capital of Huila, is a regional center of agro-products. Rails and roads are catering to agricultural harvests into Namibe Province. The distance between Namibe and Lubango is 185 km and there is a road connecting these two municipalities.

The Namibe Port is regarded as an exit for the ocean transport of natural resources exploitation in inland Angola. The port is supposed to have export facilities. The Preparatory Survey for Southern Africa Integrated Regional Transport Program done by JICA reported the function of Namibe Corridor and the rehabilitation of the rail transport from the Cassinga Iron Mine in Huila; however, there was no detailed assessment made.

(2) Port and Relevant Development

Namibe Province intends to develop the northern wharf in addition to the existing southern wharf of the port where the Japanese grant aid project took place. The northern wharf is located between the urban center and the estuary of the Belo River and designed to handle both bulk cargo and container. Land acquisition has already been started and rails are passing and connecting the two wharf areas. Construction has not started yet on the shore and the sunken ship has been discarded at the sandy beach since 2011. Also, no clear indication of port construction is observed.

The regional developments are led by the Provincial Directorate of Industry, Geology and Mining. As a part of industrial development, a fishing institute is constructed near the port and students are solicited. The institute provides training not only for catching skills but also entrepreneurship as a fisherman for how to manage a fishing business. Around 400-500 entrants are expected and graduates are expected to work in the fishing industries in Namibe and/or Tombwa.

10.2 Water Resources and Water Supply

10.2.1 Institutional Framework

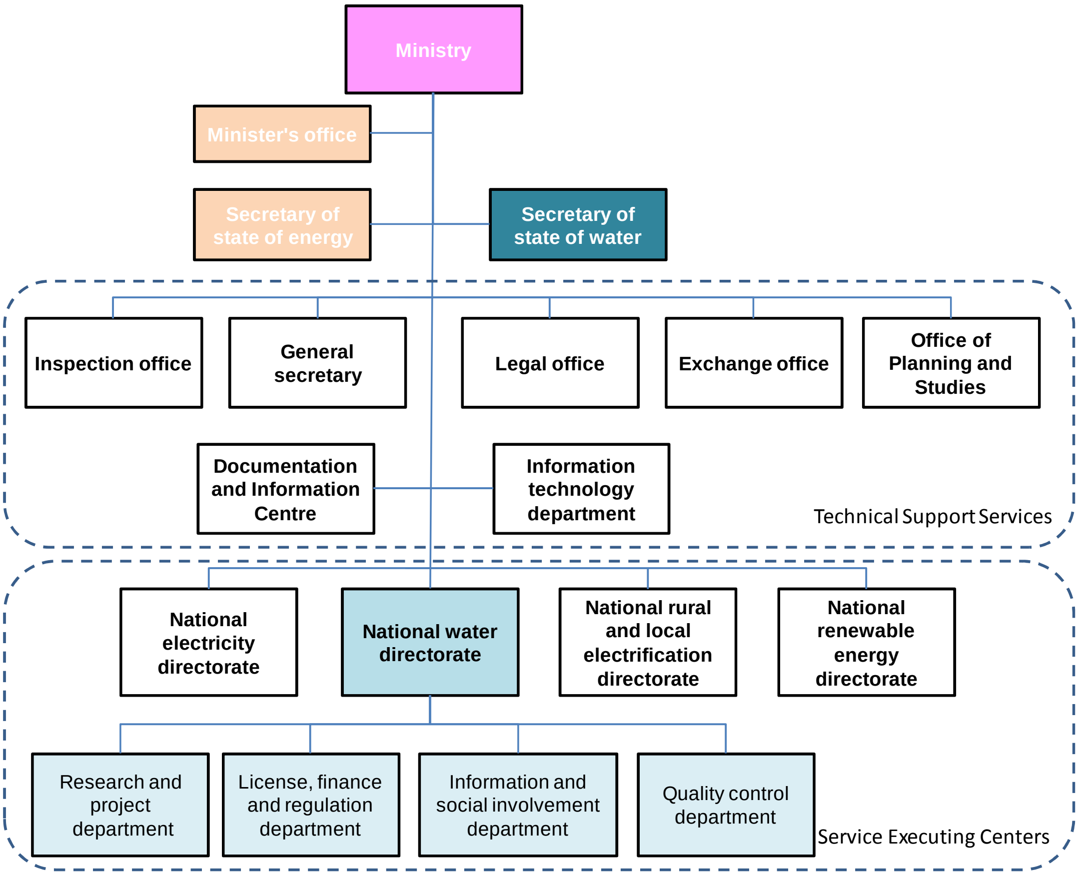
(1) Organizations

In Angola, the National Directorate of Water (*Direçcão Nacional de Águas:* DNA) under the Ministry of Energy and Water (*Ministério da Energia e Águas:* MINEA) has the jurisdiction for water supply over the country as shown in Figure 10.2. The National Water Resources Institute (*Instituto Nacional de Recursos Hídricos:* INRH) under MINEA is responsible for water resources management at the national level. The Provincial Directorate of Water and Energy (*Direçcão Provinciais de Energia e Águas:* DPEA) works as a water utility.

The roles of DNA are listed below.

- Planning, implementation, and monitoring of the policy of water supply and sewerage at the national level
- Information collection and management of water resources, water supply, and sewerage systems
- Coordination of water uses for each river basin
- Promotion of pollution control planning for sustainable water use
- Promotion of citizen’s enlightenment and participation for sustainable water use
- Handling application and registration for licensing to perform water supply and sewerage service and water use
- Scientific and technical research on water resources management and development and water and sewerage service
- Survey and research on water and sewerage charge
- Preparation of inventory at the national level for water distribution network and drainage and sewerage network, and promotion of ledger for each entity
- Planning and coordination among water utilities for implementing large-scale water supply and sewerage project, and monitoring and evaluation of project implementation
- Preparation and implementation of regulations and standards on water use, water quality for water supply and sewerage service, treatment method, planning and design, construction, and operation and maintenance
- Monitoring the management and operation of water and sewerage service, and providing necessary guidance

- Monitoring and evaluation of water utility's planning and implementation to formulate water supply and sewerage master plan



Source： MINEA and DNA

Figure 10.3 Organizational Structure of MINEA

(2) Provincial Water and Sewerage Utility

DNA is promoting the establishment of water utilities with the assistance of the World Bank and the African Development Bank. For example, in Luanda Province, where the capital of Luanda is located, the Luanda Water Supply Company (*Empresa Pública de Águas de Luanda:* EPAL) has been established. In nine out of 18 provinces, the Provincial Water Supply and Sanitation Utilities (PWSUs) have been established. However, in Namibe Province, PWSU has not been established yet.

According to DNA, the corporatization aims to achieve financial autonomy and effective utilization of human resources of the water utility. After the corporatization, DNA will provide financial support to the water utility for two years. Afterwards, the water utility should manage itself from the revenue that it will collect in providing water and sewerage service to the consumers. Therefore, the water utility must introduce a tariff structure that can recover its operating expenses during the first two years.

(3) Donors

The World Bank and the African Development Bank carry out financial and technical cooperation for the water sector in Angola. Table 10.4 describes the recent major cooperation projects. The establishment of PWSU in Namibe Province is promoted with the financial and technical cooperation of the African Development Bank under the Institutional and Sustainability Support to Urban Water Supply and Sanitation Service Delivery Project.

Table 10.4 Projects Supported by Donor

No.	Project Name	Description	Project Cost (USD million) Funding Source	Implementation Period
1	Project for supporting improvement and operation of water supply and sewerage in Sumbe City (*Projecto de Abastecimento de Água, Saneamento e Apoio Institucional ao Sumbe*)	The project consists of the following six components for water and sanitation improvement in Sumbe, the provincial capital of Cuanza Sur: 1. Water supply facility development 2. Health facility development 3. Enlightenment of citizens relating to health and environment 4. Support for establishment of PWSU 5. Preparation of national water supply and rural sanitation program 6. Monitoring of project implementation status	Project cost：36.6 Angolan government (50%) AfDB*1 of AfDF*2 (50%)	Scheduled from February 2010 to September 2016 Loan agreement signed on 7 January 2008
2	Institutional and Sustainability Support to Urban Water Supply and Sanitation Service Delivery Project (*Projecto de Apoio Institucional e de Sustentabilidade ao Abastecimento de Água Urbano e ao Serviço de Saneamento*)	Seven provinces (Cabinda, Bengo, Cuanza Sul, Lunda Norte, Lunda Sul, Namibe, and Cunene) are targeted. The purposes of the project are: a) governance improvement of the water supply sector, b) human resources development and organizational efficiency improvement of the central government and provinces in water supply and sanitation sector, and c) improvement of access for sustainable water supply and sanitation services. It consists of the following four components: 1. Establishment of water supply and sewerage system in the province 2. Improvement of sanitation and water supply facility 3. Capacity development and organizational improvement 4. Monitoring of project implementation status	Project cost : 154.71 Angolan government (20%) AfDB*1 (80%)	Scheduled for six years from August 2015 Loan agreement signed on 24 June 2016
3	Water Sector Institutional Development Project (*Projecto de Desenvolvimento Institucional do Sector de Águas: PDISA*)	Improvement of reliability, access, and efficiency of water supply and capacity development of water administration are carried out. Nine provincial capitals (Menongue, M'banza Congo, Lubango, Luena, Malange, Cuito, N'Dalatambo, Huambo, Uige) are targeted. The following are the main components: 1. Water supply organization improvement: establishment of fund management and procurement unit, PWSU, and supervisory organization 2. Water supply management: establishment of water source management organization 3. Improvement of water supply facilities: construction of a 240 km distribution pipe network, installation of 72,000 house connections, and development of ledger 4. Improvement of organization and system: training to managers of the central and provincial government and support for organizational changes for PWSU	Project cost：Initial cost 113, and additional cost 120 Angolan government (50% of initial cost) World Bank (50% of initial cost and 100% of additional cost)	Scheduled for nine years up to the end of June 2019 The loan agreement for the initial cost was signed on 25 February 2010 Loan agreement for the additional cost was signed on 31 October 2012

*1: AfDB: African Development Bank

*2: AfDF: African Development Fund

Source: DNA (written reply to the questionnaire from the Survey Team)

10.2.2 Legal Basis

(1) Water Sector Administration

Table 10.5 lists the laws and regulations regarding the water sector in Angola.

Table 10.5 Laws and Regulations Regarding the Water Sector in Angola

No.	Document Number	Outline
1	Law No. 06/02, 21 June 2002	Water act for water supply and sewerage system and water resources
2	Presidential Decree 261/11, 6 October 2011	Water quality standard
3	Presidential Decree 141/12, 21 June 2012	Water environment and water resources conservation
4	Executive Decree 246/12, 11 December 2012	Positioning and functions of DNA
5	Presidential Decree 83/14, 22 April 2014	Regulations on sanitation
6	Presidential Decree 253/10, 16 November 2010	Establishment of INRH
7	Presidential Decree 205/14, 15 August 2014	Positioning and functions of INRH
8	Executive Decree 359/14, 12 November 2014	Internal rules of DNA
9	Presidential Decree No. 82/14, 21 April 2014	Regulations related to water use

Source: DNA

(2) Environmental and Social Considerations

In Angola, the framework of environmental impact assessment (EIA) is defined in Decree 51/04 of 23 July 2004. According to Decree 51/04, the necessity of environmental impact assessment is determined by the seriousness of environmental and social impact that can be caused by the activities and business. In the seawater desalination project, the Provincial Directorate of Physical Planning, Urbanism and Environment will supervise directly the procedures in Decree 51/04. The directorate will conduct the instruction and guidance for the procedures relating to EIA for the business operator and will also perform the introduction of registered consultant who has the license to implement the EIA.

According to the directorate, for environmental and social considerations necessary in the construction of seawater desalination plant, they need to evaluate the impact on the animals and plants in the construction site and surroundings, impact on the marine environment caused by chemicals and salt-concentrated water from the plant, and environmental impact caused by large amounts of energy consumption in the plant.

10.2.3 Organization for Water Supply in Namibe

In Namibe Province, PWSU has not been established yet. The Provincial Energy and Water Directorate operates the water supply. The directorate consists of three departments, namely: power department, water department, and general affairs department. There are 45 staff and 65 external staff for construction and maintenance works. For the establishment of PWSU, the provincial government is leading the work on the reorganization.

An interview with the director-general was held to collect the information about the current status and future plans of the water supply in Namibe. The response by the director-general included some vague and incorrect points about the water supply as his expertise is on energy. The water consumption data was not presented but the energy consumption data was presented smoothly. It seems that the water supply sector is behind the energy sector in terms of human resources and management system.

10.2.4 Water Resources and Water Supply in Namibe Municipality

(1) Existing Water Source and Water Supply System

The subsoil water of the Belo River is drawn from two well fields as shown in Table 10.6 and Figure 10.9. One is located in Benfica approximately 2 km upstream from the river mouth and supplies water to the center of Namibe Municipality to the south of the Belo River. Three wells (215 m^3/hour×3) are being operated. On the other hand, another well (180 m^3/hour) is serving the northern areas. The water quality of pumped groundwater is acceptable as drinking water, but there are complaints that the consumers' water equipment gets rusty due to iron in the water. Water purification facilities for iron removal are being constructed.

Table 10.6 Existing Water Sources of Nambie Municipality

No.	Name	Existing Pumping Capacity	Water Supply Destination	Remarks
1	Benfica wells	215 m^3/hour×3 (15,480 m^3/day)	South of Namibe Municipality	Construction of a new well has begun.
2	Unknown	180 m^3/hour×1 (4,320 m^3/day)	South of Namibe Municipality	—

Source：Interview with Provincial Energy and Water Directorate of Namibe

Source: Google Earth

Figure 10.4 Location of Benfica Well Field

Table 10.7 shows the outlines of water supply service in Namibe Municipality. Pumped water from Benfica wells is sent to the urban center through two water transmission mains. The water is distributed to the consumers from three major service reservoirs (storage capacity of 2,000 m^3, 1,000 m^3, and 1,000 m^3, respectively). Existing water distribution mains are installed in the urban center for a total length of about 40 km. In the remaining areas, the residents need to obtain water in privately-owned shallow wells or buy water from private provider operating the water tanker. Most of the existing pipes are made of reinforced concrete with less durability and some have been in use for 70 years after installation. According to the Provincial Energy and Water Directorate, the leakage rate is about 50%. The major water consumers are Sonagol that owns gas stations, Namibe Port, and a tomato processing factory.

Table 10.7 Outline of Water Supply Service in Namibe Municipality

Items	Indicator	Remarks
No. of consumers	16,000	21,000 according to DNA.
Service coverage rate	40%	Population served is estimated to be about 113,000.
Water supply volume	19,800 m^3/day	
Water usage/person*	87.6 L/person/day	Based on the water supply volume, population served, and leakage rate of 50% suggested by the directorate.
Water distribution mains	40 km	Most of the pipes are reinforced concrete. There are aged pipes that have been in use for 70 years after installation.
Service reservoir	3 locations, total of 4,000 m^3	Urban center in the south only.
Status of water meter installation	Installed, but renewal is needed.	
Water charge	For household： AOA 1.7/m^3 For industrial use： AOA 2.0/m^3	DNA pointed out that AOA 1.7 and AOA 2.0 may be incorrect, because these are too low.

*：The target values of water usage per person of DNA are shown below.

- For connecting to household：90-120 L/person/day
- For connecting to yard (shared by several households)：50-70 L/person/day
- Public standpipe (shared by 150 persons)：30 L/person/day

Source：Interview with the Provincial Energy and Water Directorate

(2) Water Tariff

As mentioned above, according to the Provincial Energy and Water Directorate, the water tariff of Namibe Municipality is Angolan Kwanza (AOA) 1.7/m^3 for household use and AOA 2.0/m^3 for industrial use. Namibe Municipality tried to revise the water tariff in 2008; however, the central government did not approve the revision. The water tariff has been maintained for a long period but the timing of the last revision is unknown.

DNA is conducting a study about the water tariff that can recover the operating expenses for PWSU. According to the interview with DNA, the possible water charge is AOA 150-200/m^3. The water tariff has already been increased to AOA 70/m^3 in Luanda Province and AOA 280/m^3 in Benguela Province.

If the water tariff from the interview with the directorate is correct, the revenue is far less than the operating expenses to sustain the financially autonomous water supply in Namibe Province. It is unlikely that the central government will not approve the water tariff revision as the central government is now promoting the financial autonomy of PWSU. However, it will be a long way for PWSU to have the water tariff at a profitable level. Even if there is a need for seawater desalination from the viewpoint of water demand and supply balance, it is necessary to have medium- to long-term efforts to fix the water tariff system covering the desalination cost.

(3) Development of Water Source and Water Supply

In Namibe Municipality, the project is being carried out to increase the water supply capacity in terms of the water source and water distribution in order to improve the water supply service. The project includes: (i) construction of additional wells in Benfica, (ii) construction of water purification facilities for removal of iron, (iii) construction of water distribution network to expand the service coverage areas, and (iv) renewal of the existing water distribution pipes in the urban center. The Provincial Energy and Water Directorate expects that the project will be completed in 2016 or early 2017. The time of the completion is ensured probably as DNA also expects the completion within 2016. The project introduces ductile cast iron pipes and/or high-density polyethylene pipes for water distribution and also conducts the renewal of household connections. The project will attain the service coverage ratio of 80% by achieving a reliable water distribution network.

Table 10.8 describes the salient features of the project being implemented. There are some discrepancies on the information between two sources, i.e., the interview with the Provincial Energy and Water Directorate and the written reply from DNA through questionnaires. This chapter presents the information from DNA.

Table 10.8 Overview of Water Supply Facilities Construction Projects Currently Underway in Namibe Municipality

Item	Features	Remarks
New Well*	210 m^3/hour×4 = 840 m^3/hour (20,160 m^3/day)	Not mentioned in the information from DNA
Water purification plant	1,200 m^3/hour (28,800 m^3/day) Iron removal treatment	According to the Provincial Energy and Water Directorate, the capacity is 20,000 m^3/day.
Service reservoir	25,000 m^3	-
Expansion of distribution network	About 150 km	According to the Provincial Energy and Water Directorate, the total 176 km consists of 96 km renewal and 76 km new installation.
Household connections	15,000	Including renewal
Yard connections	3,790	Including renewal
Public taps	40	-
Service coverage rate	80%	According to the Provincial Energy and Water Directorate, the current rate is 40%.

Note: * Information from the interview with the Provincial Energy and Water Directorate

Source: DNA (written reply to the questionnaires), except for the information about the new wells

DNA estimates the need for water supply infrastructure by 2035 as shown in Table 10.9. However, the basis of the estimation is not clear. DNA is preparing a master plan of water supply and sewerage network nationwide. It was reported that the master plan was nearly completed but has not been disclosed yet. It is presumed that DNA's estimation would be derived from the master plan. From the population served and water purification plant capacity presented by DNA, per capita water consumption in 2035 is calculated at about 150 L/person/day assuming a leakage rate of 20%.

Table 10.9 Needed Water Supply Infrastructure in Namibe Municipality by 2035

Item	Needed Infrastructure by 2035	Development Done by Ongoing Project	Needed Development by 2035
Water purification plant	4,088 m^3/hr (98,112 m^3/day)	1,200 m^3/hr (28,800 m^3/day)	2,888 m^3/hr (69,132 m^3/day)
Expansion of distribution pipe network	250 km	150 km	100 km
Household connections	36,710	15,000	21,710
(population served)*	513,941	155,530	382,411

Note: * Target service coverage rate is assumed to be 100%. Population growth is expected to be 2.9% from 2014 to 2035.

Source: DNA (written reply to the questionnaires)

(4) Future Water Source

Both DNA and the Provincial Energy and Water Directorate do not have specific survey data regarding the sustainable exploitation of the subsoil water of the Belo River for use of Namibe Municipality. In the written response to the questionnaires, DNA said that Benfica wells will be able to exploit the subsoil water of the Belo River to satisfy the water demand by 2035.

(5) Experience of Small-scale Seawater Desalination

The provincial government of Namibe purchased a seawater desalination plant (8 m^3/hour: 192 m^3/day for a 24-hour operation) from Basico, a Spanish firm, and installed it at the tombolo (sand bar) called Tiger Island in northern part of the province. According to the Namibe Provincial Energy and Water Directorate, although the plant was operated from 2003 to 2005, problems in water supply to the residents occurred due to frequent failures in its operation. As a result, the residents returned to the mainland and the plant was abandoned.

Compared with construction of conventional water supply facilities, the seawater desalination plant can ease the problems in water supply and start supplying water through the early installation by the manufacturer. However, the case of Tiger Island is a typical experience of failure in the introduction of advanced equipment without taking care of the operation and maintenance (O&M) in terms of technical and financial aspects.

10.3 Need and Feasibility of Seawater Desalination Project

As a conclusion in this chapter, the discussion about the necessity and feasibility of seawater desalination project in Namibe Municipality is considered to be premature. Based on the available water sources and water demand forecast by 2035, the seawater desalination project is regarded with less priority than the currently planned works for the development of water supply infrastructure. In addition, there are also high priority issues in the organizational and financial aspects that are being initiated. Accordingly, the implementation of a seawater desalination project is not foreseeable in the future.

Table 10.10 below details the assessment of the necessity and feasibility of seawater desalination project in Namibe Municipality from the viewpoints of technology, organization, and finance.

Table 10.10 Need and Feasibility of Seawater Desalination Project in Namibe Municipality

Viewpoint	Assessment
Technology	<u>Water demand forecast</u>: According to the water demand forecast of DNA, water supply capacity of 98,112 m^3/day will be required in 2035. This is based on of the population growth rate of 2.9% per year and a unit water consumption of 150 L/person/day. Although the population growth rate in recent years is about 5% per year, it will slow down probably before 2035. It is presumed that the average growth rate would be about 3% to 4% until 2035. From the current socioeconomic conditions in Angola, there is uncertainty whether a large increase of water demand in the industrial sector will take place or not in the future. There is a plan to expand the Port of Namibe but it is not likely that large development activities will take place within 5 or 10 years as far as recognized through the site reconnaissance. Per capita water consumption of 150 L/person/day is fairly high in African countries. But it is regarded as acceptable in consideration of the planning standard in Angola of 90-120 L/person/day and assumed to be inclusive of 25% of industrial water consumption. Assuming per capita water consumption of 150 L/person/day, service coverage rate of 100%, population growth ranging from 2.9% to 4.0%, and leakage rate of 20%, the water demand in 2035 is estimated to be in the range of 96,000 m^3/day to 121,000 m^3/day and the intermediate value is 108,500 m^3/day.

Viewpoint	Assessment
	Water Source: The currently planned volume of water intake from the wells is 39,960 m^3/day (=19,800+21,600). Further development will be required in the range of 56,000 to 81,000 m^3/day (an intermediate value of 68,500 m^3/day) by 2035. Even though the potential subsoil water along the Belo River is not precisely clarified, DNA considers that it will be able to cover 98,000 m^3/day. There is no water source other than the Belo River. The Provincial Energy and Water Directorate suggests water conveyance from the Cunene River, but DNA considers that it is unrealistic as there is no surplus water in the Cunene River and such water conveyance is hardly possible due to the difficulty in the construction conditions. Conclusion: Namibe Municipality has no water source other than the Belo River. If the water demand exceeds its exploitable volume, there is a possibility to rely on seawater desalination. However, the Belo River will be able to cover the water demand until 2035. There is no reason to justify the viability of seawater desalination at present.
Organization	Namibe Province is promoting the establishment of PWSU and has initiated organizational reform through the project supported by AfDB since August 2015. Namibe Province needs to focus on the strengthening and reform of the organization as well as human resources development. For the time being, it is hard for Namibe Province to introduce new technology such as seawater desalination.
Finance	The water tariff in Namibe Province is far from the level to cover the operating expenses of the water supply system using surface water and groundwater. The central government requests PWSU to introduce the water tariff that can recover the operating expenses within two years. The main issue is to attain the recovery of the operating expenses of the water supply system using the Belo River before the introduction of seawater desalination.
Environment and Society	In Namibe Municipality, there are many vacant lands at present. Therefore, it is possible to acquire the land required for construction of a seawater desalination plant without resettlement and compensation. Seawater desalination plant may cause impacts on the marine environment and fisheries due to discharge of salt-concentrated water. Such impacts can be minimized by selecting a conducive construction site and properly designed discharge facility. As the framework of EIA is well established in Angola, there will be no problem anticipated regarding the procedures required for seawater desalination project.
General Evaluation	The need for seawater desalination is less prioritized at present. In Namibe Province, the existing water supply system should be improved and expanded. There are also the prioritized issues of organizational financial aspects, establishment of PWSU, organizational strengthening, and cost recovery.

Source：Survey Team

Chapter 11 Preliminary Study on Seawater Desalination: Mozambique

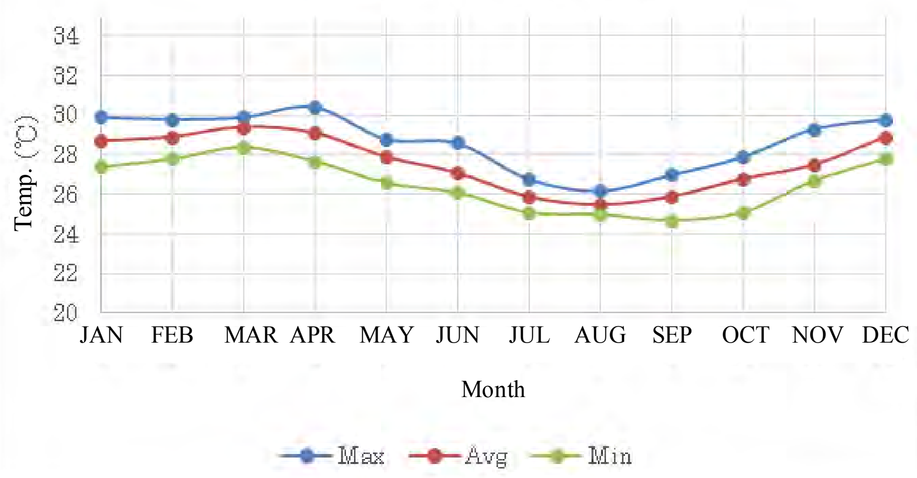
11.1 Facility Planning

11.1.1 Basic Conditions

The seawater desalination plant is planned to meet the future water demand. The planned scale is 70,000 m^3/day by 2025 and 140,000 m^3/day by 2035.

Marine conditions are set as follows:

- Water quality: Salt concentration refers to the data at a seawater depth around 10 m shown in World Ocean Atlas Climatology (National Oceanic and Atmospheric Administration: NOAA). The salt concentration of the Indian Ocean around Mozambique is 35 g/kg (about 35,000 mg/L).
- Water temperature: Seawater temperature data in the Nacala Bay, published by World Sea Temperature 2016, is taken as a reference. The rage of seawater temperature is found to be 24.7°C to 30.4°C (see Figure 11.1).
- Tide: According to the marine chart provided by the Maritime Administration, the highest and lowest tide is +4.32 m and +0.26 m varying from the Chart Datum Level (CDL) at the Nacala Port.



Source：World Sea Temperature 2016

Figure 11.1 Water Temperature at Nacala Port

11.1.2 Site

The field observations were carried out at the potential locations of a seawater desalination plant as shown in Figure 11.2. The potential locations were assessed mainly from the viewpoints of water depth around seashore, land use, and distance to the water demand center. There would be other potential locations: the coast of the Indian Ocean to the southeast of Nacala Porto Municipality and the coast of the Nacala Bay to the north of Nacala-a-Vehla. But the field observations were not carried out for these locations which are distant from Nacala Porto Municipality and road access is not good in the rainy season.

No.	Location
1	Near the entrance of inner Nacala Bay
2	
3	
4	North of Nacala Airport, outer Nacala Bay
5	Indian Ocean, northeast of Nacala
6	Northeast of Nacala, outer Nacala Bay
7	North of Nacala Port
8	
9	
10	South of Nacala Port
11	Near town of Nacala-a-Velha
12	
13	

Source: Map-GAZEDA, Location-Survey Team

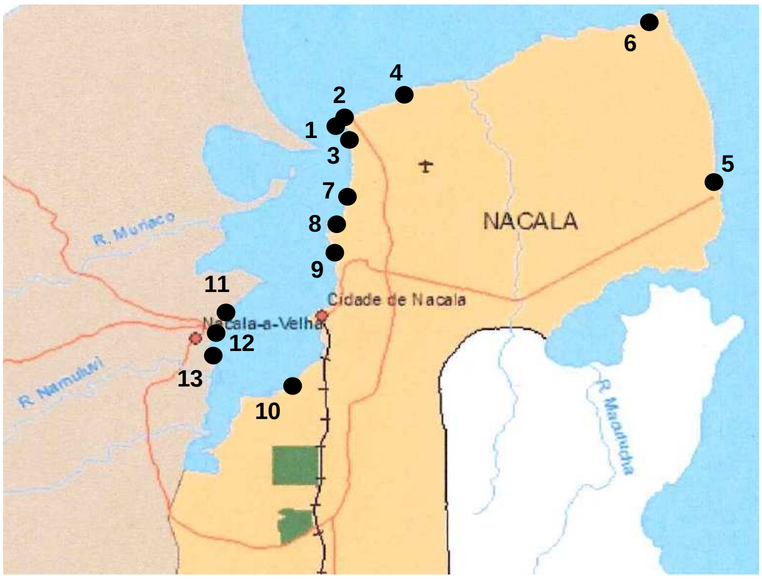


Figure 11.2 Locations of Field Observation

The observations of the seaside and landside are summarized in Table 11.1 and described below:

- Entrance of Inner Nacala Bay (No. 1, 2, 3, and 4): The areas along the coast have been occupied by tourist facilities. It is hard to acquire the land required for construction.
- Indian Ocean, Northeast of Nacala Porto Municipality (No. 5): The off-shore water depth is shallow. Inlet of seawater intake needs be located distant from the coast.
- Outer Nacala Bay, Northeast of Nacala (No. 6): The coast is rocky and the off-shore water depth is fair for construction of seawater intake. The landside is vacant. Due to the distance from the center of Nacala Porto Municipality, a water transmission main will be required for a length around 20 km.
- North of Nacala Port (No. 7, 8, and 9): The off-shore water depth is fair for construction of seawater intake. The majority of coastal land is sloping and vacant. There is a training facility (*Ajuda de Desenvolvimento de Povo para Povo*: ADPP) located nearby. There are tourist facilities scattered near the locations No. 7 and No. 8.
- South of Nacala Port (No. 10): The location is closest to the planned industrial zone. The coast is vacant but and the off-shore water depth is shallow.
- Near Town of Nacala-a-Velha (No. 11, 12, and 13): The off-shore water depth is shallow. There are private houses and tourist facilities along the coast. It is not easy to acquire the land required for construction.

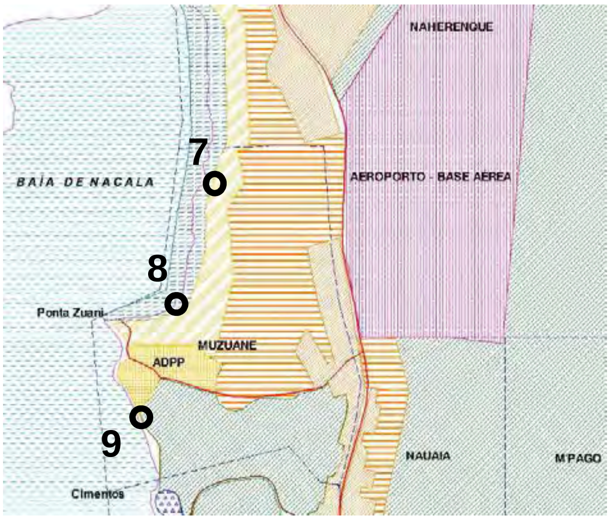
Table 11.1 Summary of Field Observations

No.	Coastal Side	Inland Side
1, 2, 3	Sandy beach, shallow sea	Tourism areas
4	Sandy beach, shallow sea	Tourism areas
5	Sandy beach, shallow sea	Vacant
6	Rocky, relatively deep sea	Vacant
7, 8, 9	Slope, relatively deep sea	There is a training facility nearby. There are scattered tourism facilities.
10	Sandy beach, shallow sea	Vacant
11, 12, 13	Sandy beach, shallow sea	There are some houses and tourism facilities.

Source: Survey Team

Resulting from the above, the locations of No. 7, 8, and 9 were further assessed for selecting the site. The Survey Team received the future land use plan of Nacala Porto Municipality and interviewed the officials about the planned area for the training facility and future tourism zone.

As the locations No. 7 and No. 8 are within the tourism zone, the location No. 9 to the south of the training facility (ADPP) was selected for planning the seawater desalination plant. The surrounding area is sloping and designated as protected area against landslide in the land use plan. As the site is relatively flat and distant enough from the valley, the difficulty in construction can be minimized.

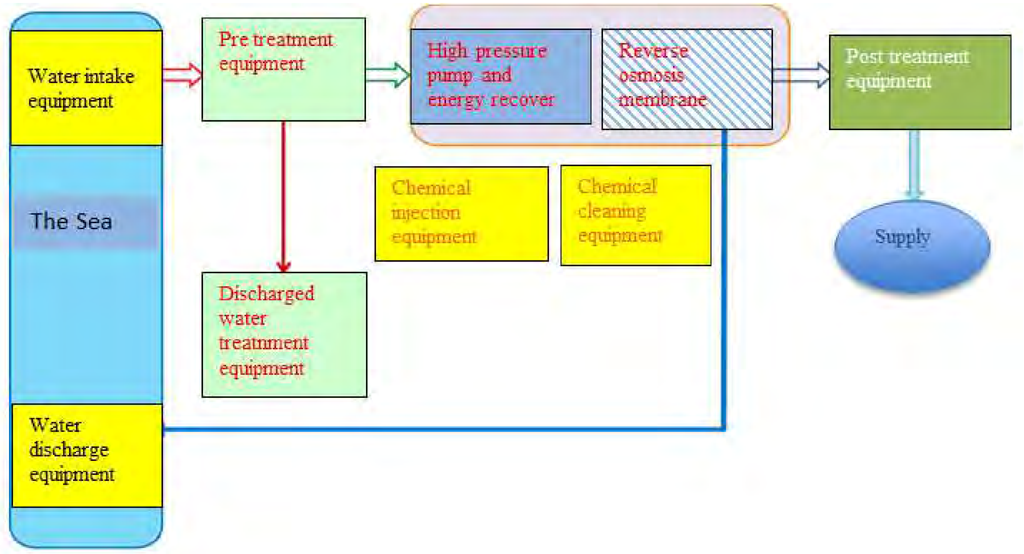


Source: Map-Nacala Porto Municipality, Location-Survey Team

Figure 11.3 Alternative Sites for Seawater Desalination Plant

11.1.3 Seawater Desalination Process

Seawater desalination plant consists of the main facilities: (i) seawater intake facility to take seawater, (ii) seawater pre-treatment facility to remove turbidity components in the seawater, (iii) reverse osmosis (RO) membrane facility to desalinate the pre-treated seawater under high pressure, (iv) post-treatment facility to adjust the quality of desalinated water for use, and (v) outfall facility to discharge salt-concentrated water released from the RO membrane facility. As the RO membrane facility requires a large amount of energy for creating the high pressure, the energy recovery device is incorporated with the RO membrane facility for saving energy. In addition, the auxiliary facilities such as chemical injection facility for the pre-treatment, chemical cleaning facility for the membranes, and discharge treatment facility for water drained from the pre-treatment facility are incorporated with the plant. The outline of the process of seawater desalination is shown in Figure 11.4 below.



Source: Survey Team

Figure 11.4 Seawater Desalination Process

Conceivable seawater desalination process is briefly explained below.

- **Seawater Intake Facility:** Pumping station is installed on the coast and an inlet is positioned where the seawater depth becomes about 10 m by extending water pipe from the intake chamber at the pumping station to off-shore. An automated screen to remove trash is set at the intake chamber.

- **Pre-treatment Facility:** It prevents the RO membrane from clogging by treatment of suspended solids, scale components, organic materials, organisms, etc. contained in the seawater and also protects the membrane from deterioration. The pre-treatment is performed in such manners as sterilization of biological organism, aggregating filtration for removal of turbid components, and pH adjustment for minimizing scale formation, and thus obtains an acceptable quality of water for the membrane module in terms of Silt Density Index (SDI). Depending on the raw water quality, the pre-treatment facility usually adopts (i) dissolved air flotation (DAF) and filtration, (ii) coagulation, flocculation and dual media filtration, or (iii) ultra-filtration (UF) membrane treatment.

- **RO Membrane Facility:** It separates freshwater from seawater. As the seawater have an osmotic pressure about 25 atmospheres, the higher pressure is required for separating freshwater from seawater through the RO membrane. Therefore, the RO membrane facility includes high-pressure pump to pressurize the seawater.

- **Energy Recovery Device:** In the RO membrane facility, the high-pressurized seawater is supplied to the RO membrane. After separating freshwater from seawater, the residual salt-concentrated water is discharged out as brine. As the residual salt-concentrated water is still highly pressurized, its energy can be recycled to save the energy required for the plant. The energy recovery device is built-in with the RO membrane facility.

- **Post-treatment Facility**: The freshwater passed through the RO membrane does not meet the drinking water standards and needs pH adjustment by calcium carbonate and sterilization by chlorine.

- **Discharge Treatment Facility:** Other than the residual salt-concentrated water, the wastewater contaminated with turbid component occurs from the pre-treatment facility through filtration and cleaning of membrane. Before discharged to the sea, the wastewater should be treated adequately.

- **Outfall Facility:** The residual salt-concentrated water is discharged to the sea, together with the treated wastewater. The outfall is installed with water pipe in the vicinity of the seawater intake. The position of the outfall should be selected carefully through detail assessment of the discharge diffusing in the sea for minimizing impacts on the sea environment.

11.1.4 Electric Power

According to the master plan prepared by Mozambique Electricity Company (*Electricidade de Moçambique*: EDM), the electricity demand of the Nacala service area (*Area de Servico ao Cliente*: ASC) is expected to be 369 MW in 2026.

In the northern region where the development associated with the Nacala Corridor is taking place, the electric power demand is expected to increase rapidly in the future. To meet the future electric power demand, there are the projects under consideration: to build a 400 kV transmission line, to improve the 220 kV transmission line, and to install the substations in the power grid system in the northern region. Different donors including Japan consider assisting these projects. In addition, a 200 MW coal-fired power plant is planned in the northern coast in Nacala-a-Velha District[1], assuming that a 110 kV transmission line would be constructed from the power plant to the Nacala Porto substation located in the vicinity of the port of Nacala in the future.

The International Desalination Association gives a reference for energy consumption by seawater desalination plant; RO membrane facility consumes 3 kWh/m^3 for desalinating seawater with a salt concentration of 35,000 mg/L; and the whole plant including pre-treatment and other facilities requires 4 kWh/m^3. Besides, the data of existing plants in the region where the salt concentration of seawater is relatively high indicate 3.4 to 3.9 kWh/m^3 at Ashkelon in Israel and 3.6 kWh/m^3 at Perth in Australia. From these references, an energy consumption of 4 kWh/m^3 is regarded as applicable.

When the energy consumption of 4 kWh/m^3 is given the seawater desalination plant with a capacity of 70,000 m^3/day, it corresponds to 12 MW approximately. As the overall plan for urban development and industrial development in Nacala SEZ is unclear for the time being, it is hard to identify the total energy consumption by these developments. When the projects proposed by the EDM's master plan are implemented, it is believed that the electricity supply required for the seawater desalination plant can be ensured.

[1] Feasibility Study on High-efficiency Coal-fired Power Plant in Mozambique, Study Report, March 2015

11.2 Cost Estimate

11.2.1 Construction Cost

The Cost Estimator provided by DesalData (GWI) computes the breakdown of the EPC construction cost on the basis of inputs specifically designated for the project site as shown in Table 11.2. Seawater temperatures refer to the data of the Nacala Bay. Salt concentration refers to the data of the Indian Ocean. The construction conditions for pre-treatment facility, seawater intake facility and outfall facility are designated as 'Difficult'.

Table 11.2 Conditions for Construction Cost Estimate

Item	Condition	
Seawater	35,000 mg/L	
Seawater Min. Temp.	24°C	
Seawater Max. Temp.	30°C	
Pre-treatment	Difficult	
Second Pass	0%	
Remineralization	Yes	
Intake / Outfall	Difficult	
Country	Mozambique	
Capacity (m^3/day)	70,000	140,000

Source：Survey Team

The estimated EPC construction costs are shown in Table 11.3.

Table 11.3 Construction Cost

Factors	Construction Cost (USD)	
	70,000 m^3/day	140,000 m^3/day
Pretreatment	10,016,623	17,974,333
Civil costs	13,944,710	25,023,091
Pumps	8,497,607	15,077,600
Equipment and materials	22,942,485	41,169,152
Design costs	7,905,276	14,185,625
Legal and professional	1,718,538	3,083,832
Installation services	6,284,940	11,278,013
Membranes	5,155,615	9,251,495
Pressure vessels	1,473,033	2,643,284
Piping, High-grade alloy	12,766,284	22,908,463
Intake / Outfall	10,311,229	18,502,990
Energy recovery devices	831,600	1,663,200
Capex Total	101,847,940	182,761,078
Capex / Capacity (USD/m^3/day)	1,455	1,305

Source：Survey Team

11.2.2 Operation and Maintenance Cost

The Cost Estimator provided by DesalData (GWI) computes the operation and maintenance (O&M) cost for seawater desalination plant on the basis of inputs such as utilization ratio of plant, energy consumption, electricity price[2] and labor factor specifically designated for the project as shown in Table 11.4.

Table 11.4 Conditions for O&M Cost Estimate

Items	Condition
Utilization Rate (%)	95
Energy Consumption (kwh/m^3)	4.0
Electricity Price (USD/kWh)	0.084
Labor Factor	Determined by Country

Source：Survey Team

The estimated O&M costs are shown in Table 11.5.

[2] Electricity price used for financial analysis in Feasibility Study on High-efficiency Coal-fired Power Plant in Mozambique, Study Report, March 2015

Table 11.5 O&M Cost

Factors	O&M Cost (USD/year)	
	70,000 m³/day	140,000 m³/day
Parts	728,175	1,456,350
Chemicals	1,699,075	3,398,150
Labor	2,608,556	3,391,540
Membranes	728,175	1,456,350
Electrical energy	8,155,560	16,311,120
Total	13,919,541	26,013,510

Source：Survey Team

11.2.3 Water Production Cost

The water production cost is computed as the sum of annual costs, consisting of amortization, variable costs, labor, and overheads, divided by annual water production. Amortization is computed on the basis of the repayment conditions: interest rate 6% and repayment period 20 years. Valuable costs consist of parts, chemicals, membranes, and electrical energy shown in Table 11.5 before. The estimated water production costs are shown in Table 11.6.

Table 11.6 Water Production Cost

Factors	Water Production Cost (USD/m^3)		Remarks
	70,000 m^3/day	140,000 m^3/day	
Total capital cost and amortization	0.37	0.33	
Total variable costs	0.47	0.47	
(Energy costs)	*(0.34)*	*(0.34)*	Inclusive of total variable costs
Labor	0.11	0.07	
Overhead	0.06	0.04	
Water Price	1.01	0.91	

Source：Survey Team

11.3 Environmental and Social Considerations

11.3.1 Legal Framework

The National Environmental Policy was established in 1995, aiming at ‘establishing appropriate environment laws and policies, and promoting sustainable development and rational usage of natural resource for national reconstruction and development.’

The Environment Law (Law No. 20/97 of 01 October) is the foundation for the whole set of legal instruments regarding the preservation of the environment. The objective of the Environment Law is to define the legal basis for judicious utilization and management of the environment and its components, with a view to achieving sustainable development in the country. The ambit of the Environment Law comprises all activities public or private, which directly or indirectly may influence the environment.

The environmental impact assessment (EIA) process is a legal requirement governed by the Environmental Law applicable for any activity which could have direct or indirect impacts on the environment and is regulated by the Environmental Impact Assessment Regulations (Decree No. 45/2004 of 29 September and amended by Decree No. 42/2008 of 4 November). In terms of Articles 3 and 5 of the EIA Regulations, the definitions are given for the classification of the projects requiring the EIA with the corresponding environmental impacts and the process for screening the projects are given on the basis of the definitions. The EIA Regulations define the categories of project such as A, B, and C based on the degree of anticipated environmental impacts. Table 11.7 shows the requirements for the EIA study by category.

Table 11.7 Requirements for the EIA Study by Category

	Impact	Requirement
Category A	Significant and irreversible impacts are anticipated due to the project.	Environmental Impact Assessment (EIA) is required. At least one public consultation must be held.
Category B	Negative impacts anticipated but the degree of the impacts less compared with Category A.	Simplified Environmental Report (SER) is required. At least one public consultation must be held when resettlement occurs
Category C	Environmental impacts are negligible small.	There is no requirement for any of EIA and SER. Environmental management needs to be done including environmental monitoring.

Source: The Preparatory Survey Report on the Project for Reinforcement of Transmission Network in Nacala Corridor (2015)

The Ministry of Land, Environmental and Rural Development (*Ministério da Terra, Ambiente e Desenvolvimento Rural*: MITADER) oversees the licensing and registration relating to the EIA. The EIA process is handled by the National Directorate of Environment (*Direcção Nacional do Ambiente*) at the government level and the Provincial Directorate for Co-ordination of Environmental Affairs (*Direcção Provincial para a Coordenação da Acção Ambiental*: DPCA) at the provincial level. The National Directorate of Environment is responsible for the projects classified into Category A. The DPCA takes charge of the process for projects other than Category A from primary screening thru issuance of the environmental license. In Mozambique, only individuals and companies registered in accordance with EIA Regulations can undertake an EIA study.

11.3.2 Regulations

Regarding the regulations on construction activities in coastal and marine areas, the following information was obtained through interviews to local officials:

- Within the Nacala SEZ, there is no preferential condition for the EIA procedure. Any project should follow the government procedure.
- In the future land use plan of the Nacala Porto Municipality, some extent of coastal areas to the north and south of the Nacala Port are designated to be in the port facility area. The site of the seawater desalination plant is located outside these areas. No problem is expected in relation to the land use plan.
- There is no applicable law or regulation to development activities in the seashore for securing navigational routes in the Nacala Bay. Where required, the Maritime Administration will prepare recommendations on this subject through discussions with Nacala Porto Municipality. Depending on the scale of development, the governor of Nampula Province or the mayor of Nacala Porto Municipality will make a final decision.
- Regarding the inland area, 100 m from the high tide perimeter is considered as the boundary. The seaside area will be controlled by the Maritime Administration while the landside area is under the jurisdiction of the municipality. Each will review development activities and

prepare recommendations. Depending on the scale of development, the governor of Nampula Province or the mayor of Nacala Porto Municipality will make a final decision.

- Building on the seaside area defined above is not allowed in principle. In the landside area, the height of building is limited up to 45 m.
- The coastal area of the Nacala Bay is sloping and sandy. For construction of building, it is crucial to ensure stable foundation structure that meets the ground conditions.

11.3.3 Procedures

Article 15 of the Environment Law states that the licensing and registration of activities which may cause a significant impact on the environment must be carried out according to the EIA regulations and that the issuance of an Environmental License must be based upon an approved EIA of the proposed activity. The Environmental License is a pre-requisite to the issuance of any other license or permit which may be legally required.

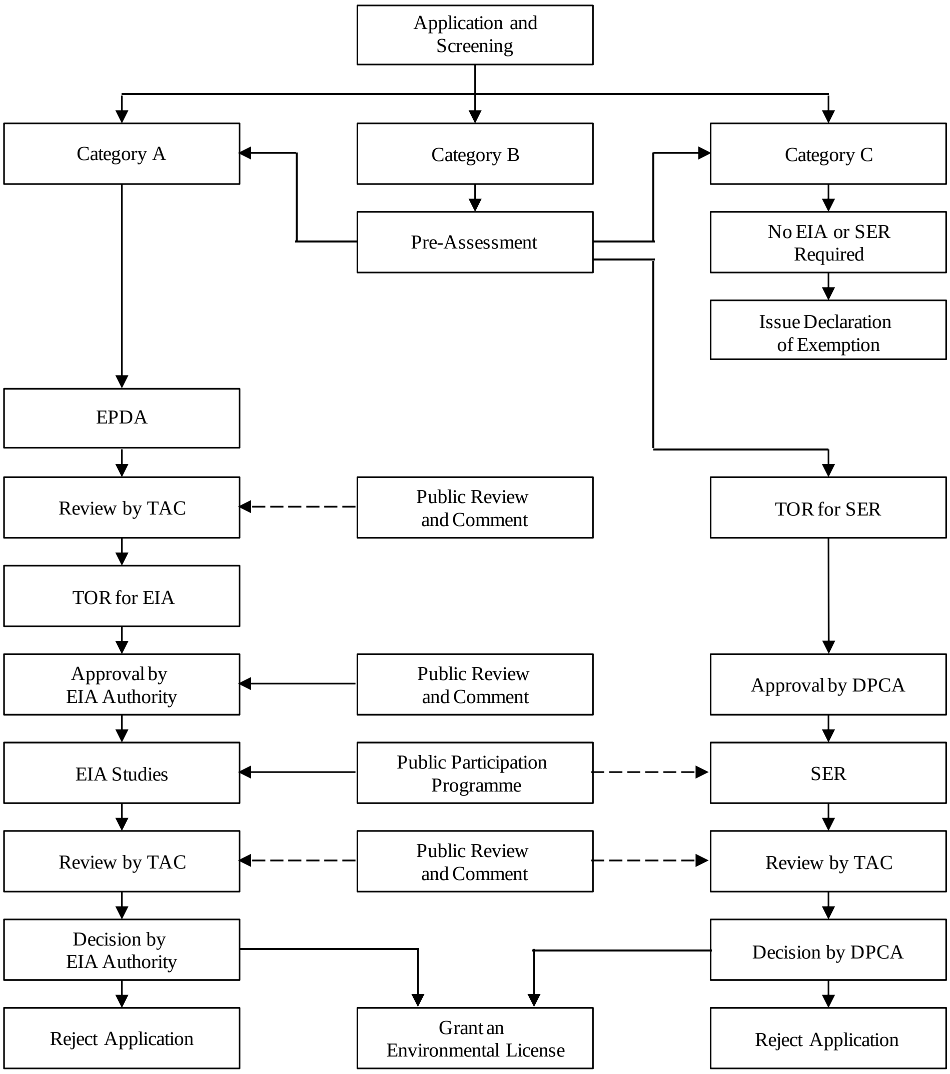
The EIA process consists of: (i) application and screening, (ii) pre-assessment, (iii) environmental pre-viability report and scope definition (EPDA), (iv) terms of reference (TOR), (v) environmental impact study, (vi) simplified environmental report (SER), (vii) public participation process, and (viii) review of the environmental impact report by Technical Assessment Commission (TAC) as shown in Table 11.9. The EIA process is also illustrated in Figure 11.5.

The seawater desalination plant does not correspond exactly to any of projects listed as Category A in the EIA procedures. Any resettlement is not anticipated so far at the identified site described in Subsection 11.1.2. Meanwhile, the seawater desalination plant may fall into Category A through the screening due to potential impacts by the salt-concentrated discharge to the sea.

Table 11.8 EIA Process by Category

	Component of EIA Process	Category A Projects (EIA required)	Category B Projects (EIA or SER required)	Category C Projects (no EIA or SER required)
1	Application and Screening	YES	YES	YES
2	Pre-Assessment	NO	YES	NO
3	Environmental Pre-Viability Report and Scope Definition (EPDA)	YES	NO	NO
4	Terms of Reference	YES	YES	NO
5	Environmental Impact Assessment (EIA)	YES	NO	NO
6	Simplified Environmental Report (SER)	NO	YES	NO
7	Public Participation Programme	YES	MAY BE	NO
8	Review by Technical Assessment Commission (TAC)	YES	YES	NO

Source: Handbook on Environmental Assessment Legislation in the SADC Region



Source: Handbook on Environmental Assessment Legislation in the SADC Region

Figure 11.5 EIA Process

11.3.4 Environment and Social Impacts Anticipated

(1) Impact by Seawater Desalination

As the seawater desalination will take seawater and discharge salt-concentrated water to the sea, there will be possible changes in habitat of marine species and fisheries environment. When the coastal area near the plant is regarded as potential tourism resource, mitigation measures for water intake and discharge in terms of type and position will be required through the detail assessment. There is no fishing facility in the Nacala Port and any fishery port does not exist in the Nacala Bay. Social consideration should be made to coastal residents who are doing fishery activities for their livelihood.

The inner Nacala Bay has a narrow entrance but there is no problem for ship navigation. It is said to be a semi-closed water area. From the tide data in Nacala Port as shown in Table 11.9, it is presumed that the sea current would be occurring between inner bay and outer bay. Although the salt-concentrated water discharged to the sea is far smaller than the sea current in volume, it is essential to assess impacts on the marine environment due to the discharge of salt-concentrated water diffusing with the sea current carefully.

Table 11.9 Tide at Nacala Port

High water level (HWL)	＋4.40 m
Mean sea level (MSL)	＋2.25 m
Low water level (LWL)	＋0.30 m
Chart datum level (CDL)	± 0.00 m

Source: Nacala Port Urgent Rehabilitation Project, Preparatory Survey Report, November 2012

Regarding electric power supply to the seawater desalination plant, the electric power distribution line will be required from the substation of Nacala near the port through the urbanized area of Nacala Porto Municipality. Impacts on the surrounding environment will be anticipated.

(2) Impact during Construction

Environmental impacts anticipated during construction and mitigation measures are shown in Table 11.10.

Table 11.10 Environmental Impact during Construction and Mitigation Measures

Category	Item	Impact	Mitigation Measure
Pollution Control	Air pollution	Dust occurs due to construction vehicles traveling to the construction site, particularly in the dry season.	● Vehicles will keep a speed limit. ● Access road to the construction site will be wetted by sprinkling water during the dry season.
	Water pollution	Temporary water pollution occurs due to effluent discharged from construction site or large-scale excavation/dredging required for construction of seawater intake and outfall facilities.	● Measures against soil erosion will be taken at the construction site. ● Drainage system, silt trap and onsite sedimentation tank will be installed. ● Environment-friendly construction methods will be applied; excavation and dredging work will be surrounded by water-tight enclosure for preventing diffusion of water contamination; and excavated sands will be returned as soon as possible.
	Waste	Tentative increase of construction waste is anticipated.	● Temporary storage site for construction waste will be designated and controlled properly. ● Construction waste will be transferred eventually to the designated disposal site.
	Noise and vibration	Heavy construction machinery for foundation work cause temporary noise and vibration.	● Time of construction work will be regulated. No construction work will be allowed during night. ● Preventive measures for noise and vibration from the machinery will be ensured periodically as recommended by manufacturer.

Category	Item	Impact	Mitigation Measure
	Bottom sediment	Large-scale excavation/dredging for construction of seawater intake and drainage facilities causes impacts on the bottom sediment of the sea.	● Environment-friendly construction methods will be applied; excavation and dredging work will be surrounded by water-tight enclosure for preventing diffusion of water contamination; and excavated sands will be returned as soon as possible.
Natural Environment	Ecosystem	Large-scale excavation/dredging for construction of seawater intake and drainage facilities causes impacts on the ecosystem of the sea.	● Environment-friendly construction methods will be applied; excavation and dredging work will be surrounded by water-tight enclosure for preventing diffusion of water contamination; and excavated sands will be returned as soon as possible.
Social Environment	Landscape	The waste generated by construction work is anticipated to deteriorate the existing landscape.	● Temporary storage site for construction waste will be designated and controlled properly. ● Construction waste will be transferred eventually to the designated disposal site.
	Existing social infrastructure and social services	Impacts on the training facility (ADPP) next to the construction site are anticipated, e.g., dust, noise and vibration, trouble relating to construction boundary.	● Buffer zone will be reserved along the construction boundary. ● Regular meetings between representatives of training facility and contractor will be held for avoiding possible troubles.
	Accidents	Possible accidents, such as fall accidents at excavation site and traffic accidents, are anticipated to occur during the works for the seawater desalination plant and transmission main.	● Traffic signs will be installed along access road to the construction site for safety driving of construction vehicles. ● All the staff of construction work will be educated and trained for safety management.

Source：Survey Team

11.4 Possibility of Project Preparation

11.4.1 Project Implementation and O&M

It is presumed that the seawater desalination project would be carried out using public funds including external loan. When the administrative framework regarding water supply does not change significantly, the Investment Fund and Water Supply Asset Holder (*Fundo de Investimento e Património de Abastecimento de Água*: FIPAG) will be the project implementation agency. FIPAG has experiences in implementing loan projects assisted by the World Bank and is currently implementing the Water Services Institutional Support Project (WASIS) and the Greater Maputo Water Supply Expansion Project.

It is necessary to look at the possible organizational reforms regarding operation and maintenance (O&M). On 29 March 2016, the World Bank approved the assistance to the Water Services Institutional Support Project II (WASIS II). In the Maputo metropolitan area, FIPAG has a lease agreement with *Águas da Região de Maputo* (previously *Águas de Moçambique*: AdM) to operate the water supply services. According to the published appraisal report of the WASIS II, it is planned that the same manner will be extended to other three regions (*Águas do Sul, Águas do Centro, Águas do Norte*). Water utility will cover not just an individual city but a number of cities in the region (hereinafter referred to as the regional water utility). Areas covered by *Águas do Norte* are the same as the areas currently covered by FIPAG Regional North; the target cities are Nampula, Nacala, Angoche, Pemba, Cuamba, and Lichinga.

FIPAG owns the water supply infrastructure (assets) and will lease these to the regional water utilities. The regional water utilities will operate the infrastructure and provide the water supply services. They will collect the water charges to cover operating expenses including the lease payments to FIPAG, financial expenses, depreciation, and amortization. In other words, they are required to operate as an individual entity rather than a subordinate organization of FIPAG. It should be noted that the 'privatization' is not described in the appraisal report of WASIS II and the regional water utility is still 100% owned by FIPAG for the time being. But private sector participation including financing is expected in the long term.

Therefore, the seawater desalination plant to be constructed by FIPAG will be leased to the regional water utility. Since the regional water utility has no experience in the O&M for water desalination plant, the following alternatives can be considered for the project implementation and O&M:

- Period of O&M contract is decided on the premise that the O&M for seawater desalination plant will be transferred to the regional water utility in the future. After construction of seawater desalination plant is completed, the EPC contractor will provide technical guidance regarding the O&M for the regional water utility during the period defined in the design-build-operate (DBO) contract. The regional water utility will need to establish its management structure for O&M within that period.

- The EPC contractor will perform the O&M in accordance with the DBO contract that defines a long-term period for the O&M and possible extension of the contract. The regional water utility will need to establish its management structure for monitoring and supervision of the O&M before construction of seawater desalination plant is completed and the O&M starts.

- The regional water utility will separately entrust the O&M to another firm. The DBO contract will define that the EPC contractor carries out the O&M for a few years after completing construction of seawater desalination plant and then transfer the O&M to the firm. The regional water utility will need to establish its management structure for monitoring and supervision of the O&M before construction of seawater desalination plant is completed and the O&M starts.

When the seawater desalination plant project is implemented in the manner of PPP, FIPAG will make a contract with the private entity to invest its capital for the project. The private entity will sell bulk water produced by the plant to the regional water utility.

11.4.2 Financial Viability

The water production cost by the seawater desalination plant is estimated before in this chapter and is compared with to the present water charges. The water charges of FIPAG Nacala from October 2015 are shown in Table 11.11 below. In the interviews with FIPAG Nacala and FIPAG Regional North, their general opinions were to use surface water and groundwater for domestic purpose and the seawater desalination for industrial purpose. Therefore, the water production cost by the seawater desalination plant is compared to the industrial water charge. The highest water charge for industrial consumers is MZN 26.65/m^3 (about USD 0.50/m^3) while the water production cost by seawater desalination plants is USD 1.01/m^3.

Table 11.11 Water Tariff of FIPAG Nacala (October 2015)

Consumer Category	Tariff
Standpipe	MZN 10.00 /m^3
Domestic	
Flat rate	MZN 55.00 /month
Minimum consumption up to 5 m^3/month	MZN 50.00 /month
5 m^3 to 10 m^3/month	MZN 16.68 /m^3
Consumption above 10 m^3/month	MZN 22.50 /m^3
Municipal	MZN 10.00 /m^3
General	
Commercial/Public - Minimum consumption up to 25 m^3/month	MZN 666.25
Industrial - Minimum consumption up to 50 m^3/month	MZN 1,332.00
Consumption above minimum	MZN 26.65 /m^3

Source：FIPAG Nacala

It is hard to forecast the impacts on the water charges by introduction of the seawater desalination plant for the time being. With the earliest installation of the seawater desalination plant in 2025, the total capacity of the water supply system in the Nacala Bay Area will be 145,000 m^3/day that corresponds to 4.8 times of 30,200 m^3/day at the completion of the IGPP. Therefore, the expansion of the water distribution network should be planned for supplying 145,000 m^3/day to cover both Nacala Porto Municipality and Nacala-a-Velha District. Such a plan has not been prepared yet.

The financial assessment will require the capital and O&M costs for the Nacala Dam (expansion) and Sanhute River or Monapo River, seawater desalination plant, and corresponding expansion of water distribution network after the completion of the IGPP.

11.4.3 Possible Involvement of JICA and Cooperation with Donors

As described in Chapter 8, the main subject for JICA and/or other donors to be involved is to seek solutions for the bottleneck issue on the water supply in order to activate the development in the Nacala Bay Area. In other words, the basic principles of water resources and water supply development should be established clearly for satisfying a large increase of water demand in the Nacala Bay Area in the mid- and long-term.

Improvement of water supply development and management of FIPAG Nacala is a crucial issue. The water distribution network is scheduled to be expanded with the assistance by the World Bank. In addition, it is essential for FIAPG Nacala to carry out effective initiatives to improve the water distribution management and services for increasing the service coverage ratio and water supply per capita and reducing non-revenue water (NRW).

In addition, it is hard to conduct the water resources development for the augmentation of the water supply capacity for the Nacala Bay Area due to the geographical constraints. Even though the development of the Nacala Dam (expansion) and the Sanhute River (or Monapo River) is realized, the succeeding the dam reservoir and distant water conveyance project should be scrutinized carefully from the viewpoints of the feasibility. The seawater desalination project is considered as an alternative and its need and feasibility should be also be scrutinized through comparative study with the dam reservoir and distant water conveyance project.

The future issues mentioned above require region-wide discussions to be assisted by donors through exchange of information and coordination.

It is presumed that the need for seawater desalination would take place within the timescale of promoting the development in the Nacala Bay Area. For seeking the time to develop the seawater desalination plant, the development trend of the Nacala Bay Area should be assessed carefully in the process of the major infrastructure developments and associated activities.

11.4.4 Risks and Mitigation Measures

In the site survey, the planned site for the seawater desalination plant was identified in consideration of the advantages; the seawater depth near the seashore is good enough for construction of water intake and outfall; and the location is closed to the water demand center.

Meanwhile, the major potential risks on the plant located along the coast of the inner Nacala Bay are considered as below:

- As the inner bay is a semi-enclosed water area, its effects of diluting the salt-concentrated water discharged from the plant is less, compared with the outer bay or ocean.
- Urban development and industrial development increase effluents of domestic sewerage and industrial wastewater discharged to the inner bay anticipated to be prone to the serious pollution.
- On the side of Nacala Porto Municipality, the coastal area is sloping and prone to soil erosion except the Nacala Port and training facilities (ADPP) where the ground is rocky and stable. Civil works at the plant require proper foundation treatment and slope protection which cause a large increase in construction cost.

When the site is selected in the outer bay or ocean, the above-mentioned risks are reduced. However, the impacts on the ocean environment will need to be further discussed. In addition, the capital investment for construction of water transmission main will increase due to the long distance to the demand center. The O&M cost will also increase due to the need of operating booster pumping station. Further information about the possibility of seawater desalination plant needs to be collected successively for the final selection of the site through in-depth assessments.

11.5 Summary of Preliminary Study

Through the rapid field observations, the planned site was identified in consideration of the advantages; the seawater depth near the seashore is good enough for construction of water intake and outfall; and the location is closed to the water demand center. However, the alternative sites on the coasts of the inner Nacala Bay, outer Nacala Bay, and Indian Ocean have both advantages and disadvantages, respectively. The selection of site for construction of seawater desalination should be further scrutinized through comprehensive assessments.

For the seawater desalination plant with a capacity of 70,000 m^3/day, the costs are estimated to be USD 101.8 million for construction, USD 13.9 million/year for O&M, and USD 1.01/m^3 for water production. It is hard to forecast the impacts on the water charges by introduction of the seawater desalination plant for the time being. With the earliest installation of the seawater desalination plant, the total capacity of the water supply system in the Nacala Bay Area will be 145,000 m^3/day that corresponds to 4.8 times of 30,200 m^3/day at the completion of the IGPP. Therefore, the expansion of the water distribution network should be planned for supplying 145,000 m^3/day. The financial assessment will require the capital costs for the augmentation of water supply capacity inclusive of the seawater desalination plant and expansion of water distribution network as well as the corresponding operation and maintenances costs.

The WASIS II assisted by the World Bank is scheduled to establish the regional water utility to manage the urban water supply systems. FIPAG will construct the seawater desalination plant and lease it to the regional water utility. For carrying out the O&M of the seawater desalination plant, the regional water utility will need to establish its capacity through transfer of technical knowledge from the EPC contractor to conduct the design-build-operate (DBO) for the seawater desalination plant. As an alternative, the regional water utility will need to have its capacity to monitor and supervise the O&M to be entrusted to another party.

Due to the geographical constraints of the Nacala Bay Area, it is hard to conduct the water resources development for the augmentation of the water supply capacity. When the development of the Nacala Bay Area is activated, the seawater desalination will be required in the future. For seeking the time to develop the seawater desalination plant, the development trend of the Nacala Bay Area should be assessed carefully in the process of the major infrastructure developments and associated activities.

Chapter 12 Preliminary Study on Seawater Desalination: Namibia

12.1 Facility Planning

12.1.1 Basic Conditions

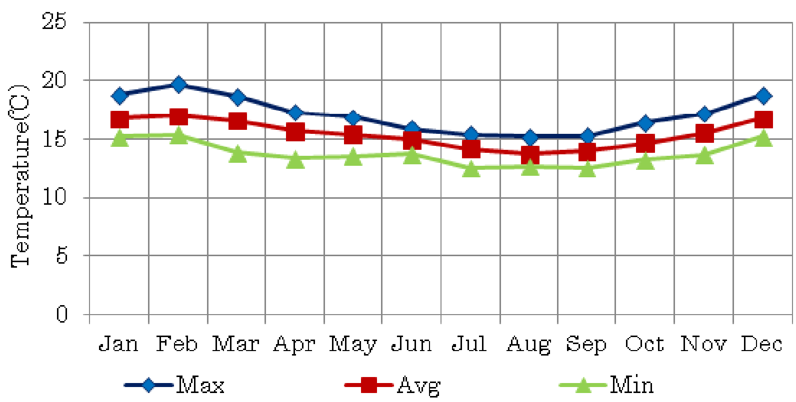
The basic conditions of the plan are the following:

Processing water volume: production of water, 20,000 m^3/day

Natural condition at the site:

- Climate: wind direction south to south-southwest, wind velocity at 10 m/s
- Marine conditions: current from 0.25 m/s to 0.35 m/s, spring tide from 0.25 m to 1.69 m, neap tide from 0.67 m to 1.29 m, wave height 1 m
- Seawater quality: Hydrogen sulfide may be released for two to three days or one week in June or July during stormy season in winter when the sludge on the seabed is stirred up by the upwelling current. The seawater contains a lot of plankton as the Benguela current flowing from the south is rich in nutrition.
- Seawater temperature: According to the information about the existing plant, the seawater temperature ranges from 17 ^oC f to 22 ^oC from December to March and goes down to 15 ^oC under the coldest climate. The seawater temperature is lower than that in Middle East where the temperature goes up to 30 ^oC.

  The United States (US) National Oceanic and Atmospheric Administration (NOAA) measures the seawater temperature around the world through satellites and publicizes the data. No data is available within the Erongo Region. The data are available in Luderitz 500 km south from Swakopmund and indicate the average ranging from 14 ^oC to 17 ^oC as shown in Figure 12.1. The information about the existing plant on the seawater temperature is considered to be reliable as the seawater temperature gradually rises toward the north.

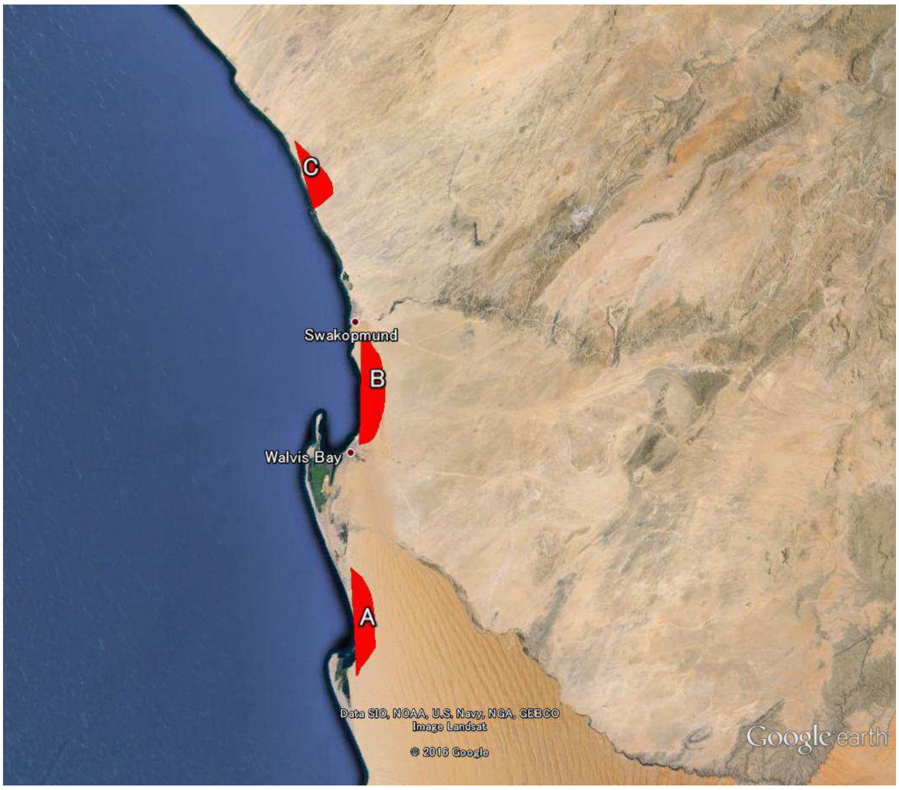


Source: US National Oceanic and Atmospheric Administration (NOAA)

Figure 12.1 Seawater Temperature at Luderits, Namibia

12.1.2 Site

The land requirement to build a seawater desalination plant with 20,000 m^3/day capacity is 10,000 m^2 to 20,000 m^2. There are three alternative locations identified through the consultations with the Namibia Water Corporation (NamWater) Namib Office, Swakopmund Municipality, and Walvis Bay Municipality. The sites that could be an alternative to the seawater desalination plant are: the Sandwich Harbor to the south of Walvis Bay (A), a location between Walvis Bay and Swakopmund (B), and the existing Areva Plant in Wlotzkasbaken (C) as shown in Figure 12.2.



Source: Google Earth

Figure 12.2 Alternative Sites of Seawater Desalination Plant

Out of those three alternatives, the Areva plant site in Wlotzkabasken seems to be the most suitable because of the following viewpoints:

- Sandwich Harbor to the south of Walvis Bay (A): This location is within the conservation area of the national park. It is hard to get construction permission.
- Location between Walvis Bay and Swakopmund (B): The vacant land of more than 10,000 m^2 is identified scarcely as there are existing residential areas along the coast. A vacant land is to be occupied by a planned convention center. The desert spreads over some distance away from the coast is reserved for recreation and is not suitable for construction of the plant due to the anticipated social impact. The seawater quality is not expected to be satisfactory due to possible effluents from the urbanized area of Walvis Bay.
- Areva Plant in Wlotzkasbaken (C): This site is surrounded with a vast vacant land. As the site is distant to the north from the estuary of the Swakop River, the seawater quality is not affected by the sedimentation brought by the river. As Areva owns the land for future expansion of the plant (230 m×80 m = 18,400 m^2), any additional land acquisition will not

be required. Furthermore, the water intake/outfall and power supply for the plant is constructed with the reserve capacity enough for another 20,000 m^3/day expansion. These will save construction cost for the additional plant. Besides, the vacant land exists a few kilometers south from the existing plant site. Even though such land is closer to the large service area of Swakopmund, the existing plant site is more promising due the consideration of the already available water intake/outfall and power supply for the additional plant.

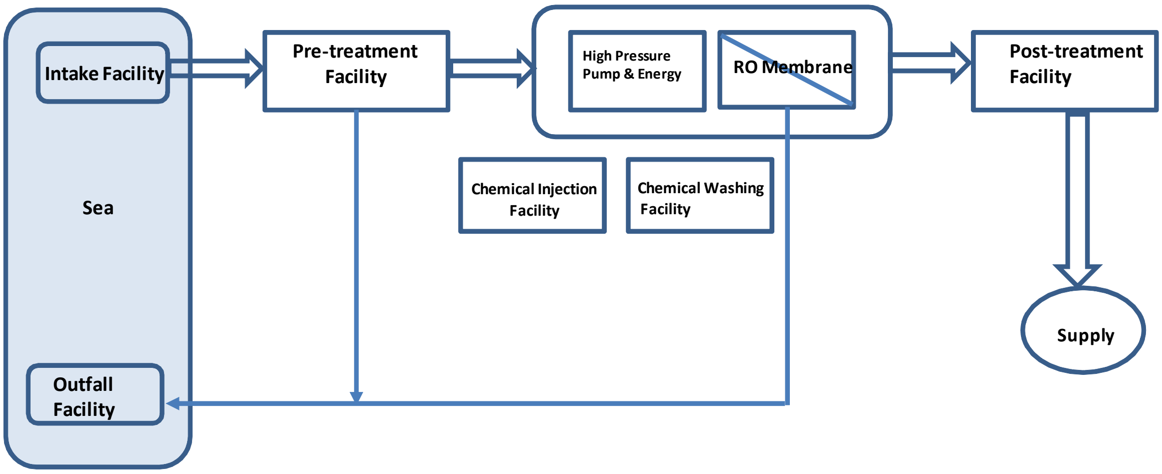
The general layout of the existing plant site is shown in Figure 12.3 below. The additional plant is planned to be constructed in the neighboring vacant land within the existing plant site.

Source: Google Earth

Figure 12.3 Location of Additional Seawater Desalination Plant

12.1.3 Seawater Desalination Process

Seawater desalination plant consists of the main facilities: (i) seawater intake facility to take seawater, (ii) seawater pre-treatment facility to remove turbidity components in the seawater, (iii) reverse osmosis (RO) membrane facility to desalinate the pre-treated water under high pressure, (iv) post-treatment facility to adjust the quality of desalinated water for use, and (v) outfall facility to discharge salt-concentrated water released from the RO membrane facility. As the RO membrane facility requires a large amount of energy for creating the high pressure, the energy recovery device is incorporated with the RO membrane facility for saving energy. In addition, the auxiliary facilities such as chemical injection facility for the pre-treatment, chemical cleaning facility for the membranes, and discharge treatment facility water drained from the pre-treatment facility are incorporated with the plant. The outline of the process of seawater desalination is shown in the Figure 12.4 below.



Source: Survey Team

Figure 12.4 Seawater Desalination Process

Conceivable seawater desalination process is briefly explained below.

- **Seawater Intake Facility:** The existing seawater intake has a reserve for future expansion of the plant's capacity. The existing pumping station has a reserve for additional installation as well. Additional pumps will be installed at the pumping station. No civil work will be required except for the connection with the existing facility.

- **Pre-treatment Facility:** It prevents the RO membrane from clogging by treatment of suspended solids, scale components, organic materials, organisms, etc. contained in the seawater and also protects the membrane from deterioration. The pre-treatment is performed in such manners as sterilization of biological organism, aggregating filtration for removal of turbid components, and pH adjustment for minimizing scale formation, and thus obtains an acceptable quality of water for the membrane module in terms of Silt Density Index (SDI). Because of the released hydrogen sulfide, the existing plant employs coagulation with iron chloride, turbidity components removal by a rotary screen, and minute particles removal by an ultra-filtration (UF) membrane. The same will be applied for the additional plant.

- **RO Membrane Facility:** It separates freshwater from seawater. As the seawater have an osmotic pressure about 25 atmospheres, higher pressure is required for separating fresh water from seawater through the RO membrane. Therefore, the RO membrane facility includes high-pressure pump to pressurize the seawater.

- **Energy Recovery Facility:** In the RO membrane facility, high-pressurized seawater is supplied to the RO membrane. After separating freshwater from seawater, the residual salt-concentrated water is discharged out as brine. As the residual salt-concentrated water is still highly pressurized, its energy can be recycled to save the energy required for the plant. The energy recovery device is built-in with the RO membrane facility.

- **Post-treatment Facility:** The freshwater passed through the RO membrane does not meet the drinking water standards and needs pH adjustment by calcium carbonate and sterilization by chlorine.
- **Discharge Treatment Facility:** Other than the residual salt-concentrated water, the wastewater contaminated with turbid component occurs from the pre-treatment facility through filtration and cleaning of membrane. Before discharged to the sea, the wastewater should be treated adequately.
- **Outfall Facility:** The residual salt-concentrated water is discharged the sea, together with the treated waste water. The outfall is installed with water pipe in the vicinity of the seawater intake. The existing outfall facility has a reserve for future expansion of the plant's capacity. No civil work will be required except for the connection with the existing facility.

12.1.4 Electric Power

According to Namibia Power Corporation (NamPower), the additional seawater desalination plant will be able to receive the required electricity (3.75 MW for 20,000 m^3/day) without any problem. Meanwhile, Namibia relies on the import accounting for 60% of its required electricity. NamPower seeks solutions for high dependency on the imported electricity in view of its security. Taking into consideration the said situation, the construction of a solar power plant, which supplies the necessary electricity for the additional seawater desalination plant is a promising alternative as more than 300 days a year are sunny at the site.

In addition, the Harambee Prosperity Plan, which has been announced by the President in April 2016, designates that a seawater desalination plant with capacity of 25 million m^3/year will be constructed using renewable energy at the coastal area within three years. It is obvious that renewable energy is expected to be used for seawater desalination which consumes much electricity.

1) Current Situations of Electric Power Supply in Namibia

The current power plants are the following:

- The Ruacana Hydroelectric Power Plant on the Cunene River is the main source. It was built in 1975 with 330 MW consisting of 80 MW×3 and additional 90 MW was installed in 2012. The Van Eck Coal Thermal Power Plant in the suburbs of the capital of Windhoek started its operation in 1972 with two 30 MW; and additional two 30 MW were installed in 1973 and 1979, respectively. The Anixas Diesel Power Plant of 7.45 MW×3 in Walvis Bay started its operation in 2011. Also, the Paratus Diesel Power Plant of 6 MW×4 was built in 1976 as standby.
- The hydroelectric power plants and diesel plants are operated to cope up with the peak demand. In addition, the country depends on imports from the Southern African Power Pool.
- The seasonal peak demand takes place from June to August in the winter. In order to level off the daily peak demand, the electricity charge is set high in the morning and evening.

2) Electricity Supply Situation in the Central Coast Area

To stabilize the electric power supply in the future, the current target of NamPower is to improve the transmission from the northern region of Namibia, South Africa, and Zambia. The electric power supply to the central coast area, where the desalination plant is located, is planned making a ring transmission network to connect the central coast area with Windhoek. Through the development of the transmission and distribution system, the Trekkopje Substation has the capacity to serve industries nearby including the mines and will be able to supply the required electric power for the future expansion of the seawater desalination plant. The electric power receiving facility at the Areva Plant has a 40 MW transformer, which can accommodate the electric power required to produce desalinated water of 45 million m^3/year.

3) Solar Power Generation

If a solar power plant needs to be built for supplying electricity to the seawater desalination plant, it should be sited in the inland as shown in Figure 12.5 in order to avoid degradation of the facility due to the salt and non-operational condition as a result of the reduction of radiation by heavy fog along the coast.

Source：NamPower

Figure 12.5 Location of Solar Power Plant

Location of solar power plant should be identified from 50 to 100 km away to inland to receive more solar energy and close to the existing electric power grid. An identified land for the solar power generation facility is owned by Erongo Region and there is no inhabitant around. It is not difficult to acquire the land for the solar power plant.

NamPower purchases renewable energy at a constant price throughout the year, regardless of its peak or off-peak, in accordance to the Renewable Energy Feed in Tariff (REFIT) in Namibia. The electricity generated at the solar power plant will be once sold to NamPower and then the sweater desalination plant will need to purchase electricity from NamPower.

In the solar power plant, two cases were studied: (a) to use solar energy at daytime and commercial energy at night time for producing 20,000 m^3/day, and (b) to use only solar energy at daytime (12 hours) for producing 20,000 m^3/day by the plant with a capacity of 40,000 m^3/day. Required land area and construction costs for solar power plant are shown in Table 12.1.

Table 12.1 Cost for Solar Power Plant

Item	Unit Value	Seawater Desalination Plant	
		(a) 20,000 m^3/day	(b) 40,000 m^3/day
Electricity		3.75 MW	7.5 W
Required Area	10 to15 m^2/kW*	3.8 to 5.6 ha	15 to 23 ha
Cost	JPY 730,000/kW*	JPY 2.74 billion	JPY 5.48 billion

* Handbook for Large-scale Solar Power Generation System, NEDO (March 2011)

Source: Survey Team

12.2 Cost Estimate

12.2.1 Construction Cost

The Cost Estimator provided by DesalData (GWI) computes the breakdown of the EPC construction cost on the basis of inputs specifically designated for the project site as shown in Table 12.2.

Salt concentration refers to the data of the South Atlantic Ocean. Seawater temperatures refer to the data of the existing plant. The construction conditions are designated as 'Difficult' for pre-treatment facility and 'Minimum' for seawater intake facility and outfall facility, respectively.

Table 12.2 Conditions for Construction Cost Estimate

Item	Condition	
Seawater	35,000 mg/L	
Seawater Min Temp	15°C	
Seawater Max Temp	24°C	
Pretreatment	Difficult	
Second Pass	0%	
Remineralization	Yes	
Intake / Outfall	Minimum	
Permitting	Typical	
Country	Namibia	
Capacity (m^3/day)	20,000	40,000

Source: Survey Team

The estimated EPC construction cost is shown in Table 12.3. As the existing intake and outfall facilities can be used for the additional plant, their cost is excluded from the total construction cost.

Table 12.3 Construction Cost

Factors	Construction Cost (USD)	
	20,000 m^3/day	40,000 m^3/day
Pretreatment	3,084,991	5,635,200
Civil costs	4,687,977	8,563,294
Pumps	2,398,051	4,324,235
Equipment and materials	7,145,384	13,052,117
Design costs	1,947,779	3,557,910
Legal and professional	278,254	508,273
Installation services	2,419,601	4,419,764
Membranes	1,814,701	3,314,823
Pressure vessels	453,675	828,706
Piping, High-grade alloy	4,234,301	7,734,588
Intake / Outfall*1	1,947,779	3,557,910
Energy Recovery Devices	324,000	648,000
Capex Total	30,736,493	56,144,820
Capex / Capacity (USD/m^3/day)	1,537	1,404
Capex Total, excluding Intake / Outfall	28,788,714	52,586,910

Note: *1 The intake/outfall cost is not required.
*2 The electricity receiving facility is not itemized above but its cost is not required.
Source: Survey Team

The total construction costs without and with solar power generation facility are summarized in Table 12.4 below.

Table 12.4 Construction Cost (Without and With Solar Power Generation)

Items	Without Solar Power	With Solar Power	
	20,000 m^3/day Cost (million USD)	(a) 20,000 m^3/day Cost (million USD)	(b) 40,000 m^3/day Cost (million USD)
Seawater Desalination Plant	28.8	28.8	52.9
Solar Power Generation Facility	0.0	24.7	49.3
Total	28.8	53.5	102.2

Source: Survey Team

12.2.2 Operation and Maintenance Cost

The Cost Estimator provided by DesalData (GWI) computes the operation and maintenance (O&M) cost for seawater desalination plant on the basis of inputs such as utilization ratio of plant, energy consumption, energy price and labor factor specifically designated for the project as shown in Table 12.5.

Table 12.5 Conditions for O&M Cost Estimate

Items	20,000 m^3/day	40,000 m^3/day
Utilization Rate (%)	95	95×0.5
Energy Consumption (kwh/m^3)	4.5	4.5
Electricity Price (USD/kWh)	0.066	0.066
Labor Factor	Determined by Country	Determined by Country

Source：Survey Team

Energy consumption of 4.5 kWh/m^3, which is higher than that used for Mozambique, is applicable in Namibia. The seawater temperature in Namibia is lower than that in Mozambique. Volume of water produced through RO membrane is proportional to the seawater temperature. Under a fixed pressure, the water volume passing through a RO membrane decreases with the seawater temperature lowering.

For maintaining a designated water production, the RO membrane is operated generally with the high pressure under the low seawater temperature. The higher energy consumption is applied here accordingly.

It is assumed that the energy generated by solar power plant would be sold to NamPower and then supplied to the seawater desalination plant through the power grid system. The REFIT prescribes the prices of solar energy purchased by NamPower. These prices are higher than the electricity charges. On the other hand, an annual utilization rate of solar power plant ranges from 25% to 28%[1] while the electricity charges for operating the seawater desalination plant will take place throughout a year. For a 5 MW solar power plant, the REFIT gives a price of USD 0.226/kWh[2]. The energy price applied for the O&M cost estimate is USD 0.066/kWh accounting for 29% (=0.066/0.226) of the price given by the REFIT. These percentages suggest that an annual amount to be paid by NamPower to purchase the solar energy would be almost equivalent to the annual energy cost for operating the seawater desalination plant. In estimating the O&M cost with solar power, it is therefore assumed that the energy cost would be appropriated only for operating (a) 20,000 m^3/day plant during night time; and no energy cost would be appropriated for (b) 40,000 m^3/day plant to be operated during day time only.

For the solar power plant, an annual maintenance cost is assumed to be 1% of the capital cost[3].

The estimated O&M costs are shown in Table 12.6.

Table 12.6 O&M Cost

(Unit: USD/year)

Factors	Without Solar Power	With Solar Power	
	20,000 m^3/day	(a) 20,000 m^3/day	(b) 40,000 m^3/day
Parts	208,050	208,050	416,100
Chemicals	485,450	485,450	970,900
Labor	787,661	787,661	1,304,430
Membranes	208,050	208,050	416,100
Electrical energy	2,059,695	1,029,848	0
Maintenance for solar power plant	0	246,627	493,254
Total	3,748,906	2,965,686	3,600,784

Source: Survey Team

12.2.3 Water Production Cost

The water production cost is computed as the sum of annual costs, consisting of amortization, variable costs, labor, and overheads, divided by annual water production. Amortization is computed on the basis of the repayment conditions: interest rate 6% and repayment period 20 years. Valuable costs consist of parts, chemicals, membranes, and electrical energy shown in Table 12.6 before. The estimated water production costs are shown in Table 12.7.

1 Information given by NamPower about the Omburu solar power plant (4.5 MW)
2 REFIT shown in the website of NamPower
3 Handbook for Large-scale Solar Power Generation System, NEDO (March 2011)

Table 12.7 Water Production Cost

(USD/m^3)

Item	Without Solar Power Generation	With Solar Power Generation		Remarks
		20,000 m^3/day	40,000 m^3/day	
Total capital cost and amortization	0.36	0.67	1.28	Inclusive of amortization for solar power plant
Total variable costs	0.43	0.28	0.13	
(Energy costs)	(0.30)	(0.15)	(0.00)	Inclusive of Total variable costs
Labor	0.11	0.11	0.09	
Overheads	0.06	0.06	0.05	50% of Labor
Maintenance for solar power plant	0.00	0.04	0.07	
Water price	0.97	1.17	1.63	

Source: Survey Team

The water production cost is estimated at USD 0.97/m^3 without solar power plant. With the solar power plant, the water production cost is found to be higher as the annual amortization for the capital investment of the solar power plant is larger than the save of the annual energy cost. Although the plan of operating (b) 40,000 m^3/day plant at daytime only is effective to save the energy cost, there is a possibility of damaging the membrane or equipment when the load to seawater desalination plant fluctuates due to turning its power on and off every half day. This plan is not recommended in view of operational sustainability.

The solar power plant will need to be further discussed in the future feasibility study on the seawater desalination plant. In this subsection, it is assumed that the capital investments for both seawater desalination plant and solar power plant should be fully recovered by water revenue. If the capital investment for the solar power plant is shouldered by the government in relation to the aforementioned policy issues in Subsection 12.1.4, an increase of water charge will be restrained. Assuming that the annual amortization for the capital investment of the solar power plant is born by the government, the water production cost could be minimized to USD 0.86/m^3.

12.3 Social and Environmental Considerations

12.3.1 Legislation Framework

Social and environment assessment processes in Namibia are regulated by the following two acts:

- Environmental Management Act, 2007
- Environmental Impact Assessment Regulations: Environmental Management Act, 2007

The Ministry of Environment and Tourism (MET) is responsible for controlling the social and environment assessment process. The projects subject to social and environmental assessment process are listed in the Guideline of the Environmental Impact Assessment Regulations titled as “Annexure: List of activities that may not be undertaken without Environmental Clearance Certificate”. The projects falling within the enlisted activities in the Annexure of the Guideline are obliged to conduct the environmental impact assessment (EIA) and report to MET in order to obtain environmental clearance certificate (ECC).

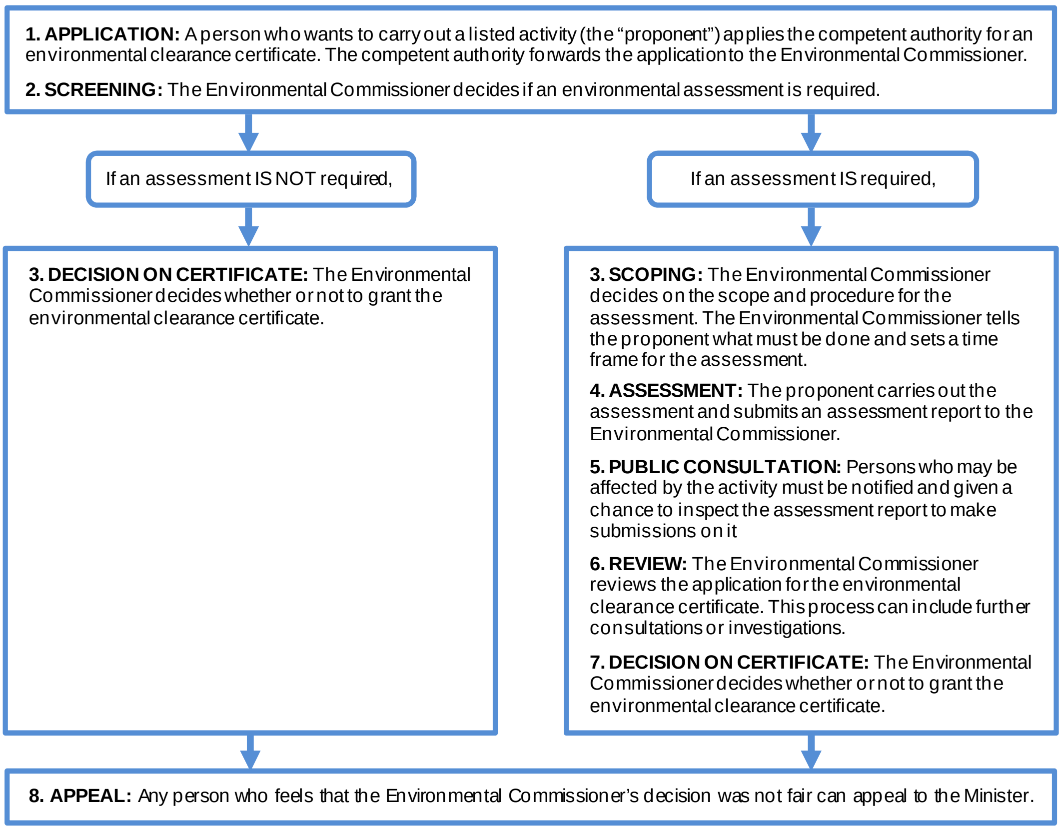
Seawater desalination project includes “8.12 The release of brine back into the ocean by desalination plants” as shown in Table 12.8. Therefore, the project is subject to the regulations. If the project intends to furnish with the solar power plant, the part of the project is also met with "1. The construction of facilities for (a) the generation of electricity", which is also a subject of EIA.

Table 12.8 Projects Required to Obtain Environmental Clearance Certificate

1. Energy Generation, Transmission and Storage Activities
2. Water Management, Treatment, Handling and Disposal Activities
3. Mining and Quarrying Activities
4. Forestry Activities
5. Land Use Development Activities
6. Tourism Development Activities
7. Agriculture and Aquaculture Activities
8. Water Resource Development
9. Hazardous Substance Treatment, Handling and Storage
10. Infrastructure
11. Other Activities

Source: Environmental Management Act 2007

The process of ECC is shown in Figure 12.6 below.



Source: Guide to the Environmental management Act No 7 of 2007

Figure 12.6 Process of Environmental Clearance Certificate

12.3.2 Regulations

The seawater desalination plant identified in Wlotzkasbaken such as the Areva Plant, does not conflict with the regulations of the national parks in Namibia. Meanwhile, the restrictions may be applied as shown in Table 12.9 below. Corresponding mitigations and/or resolutions are described as well.

Table 12.9 Environmental Restrictions Anticipated

Restriction	Mitigation/Resolution
State-owned land within 200 m from the seashore is subject to the development restrictions.	The additional plant will be constructed within the compound of the existing plant. No construction subject to the development restrictions will be conducted.
In Erongo Region, the desert areas not covered by the lands owned by Swakopmund Municipality and Walvis Bay Municipality are considered as part of the Naukluft National Park subject to the development restrictions.	The power transmission and distribution lines supplying electricity to the existing plant will be utilized for the additional plant as well. No construction subject to the development restrictions will be conducted.

Source: Interviews to MET and MFMR

In addition to above, the water intake and discharge activities of the seawater desalination plant may be subject to the approval from the Ministry of Fisheries and Marine Resources (MFMR). According to MFMR, the EIA for the Areva Plant concluded that the plant would give negligible impacts to the local fishing and/or oceanic biodiversity. The EIA results submitted by Areva at the time of construction are not disclosed yet.

If the project needs to expand out from the compound of the Areva Plant, the impacts on flora and fauna have to be examined particularly on the sensitivity of living change toward lichens in its surrounding area.

12.3.3 Procedures

The process to obtain ECC starts with the submission of application to the competent authority.

The identified possible location of the additional seawater desalination plant is occupied by Areva which owns its ECC. If the seawater desalination plant is expanded within its original intended capacity such as an annual treatment capacity of 45 million m^3/year, there is no need for obtaining new clearance. If the project is succeeding the status of the Areva Plant, the proposed desalination project can inherit the status by changing the name of original certificate awarded to Areva. Table 12.10 shows the items required to report for EIA to obtain the certificate.

Table 12.10 Contents of Environmental Impact Assessment Report

Item	Description
A	Description of the proposed project
B	Description of the environment
C	Description of the potential environmental impact
D	Description of the effects on Namibia's cultural heritage
E	Description of mitigation measures
F	Detailed explanation of how the predictions in the report were made
G	Identification of gaps in knowledge or uncertainties about environmental impacts
H	Description of steps taken to consult persons who may be affected by the activity
I	Outline for monitoring and managing the environmental impact of the activity, and for analysis of the activity after it is complete
J	Description of measures for restoring the environment after the activity is over, if appropriate
K	Summary in non-technical language

Source: Guide to the Environmental management Act No 7 of 2007

12.3.4 Environment and Social Impacts Anticipated

Table 12.11 summarizes the environment and social impacts of seawater desalination and solar power plants.

Table 12.11 Environment and Social Impacts Anticipated

Item	Seawater Desalination	Solar Power Generation
Environment	● Impact by seawater intake and salt-concentrated discharge ● Impact by construction works for power receiving facility ● Environmental restoration related to decrease of groundwater use	● Impact on flora and fauna, in particular, lichens ● Impact on ecosystem due to the installation and operation of solar panels
Social	-	● Impact on living condition of local inhabitants, e.g., cattle grazing and transportation ● Change in scenery ● Creation of job opportunity

Source: Survey Team

1) Seawater Desalination

Construction and operation of seawater desalination plant may have impacts to environment in the following aspects:

- Seawater Intake and Salt-concentrated Discharge: Seawater intake and salt-concentrated discharge may impact local oceanic biosphere and fishery.
- Electricity Receiving Facility: Currently, the operating electricity receiving facility enables to provide enough electricity for the additional plant. However, if additional works including reinforcement of distribution lines are required, environmental impacts need to be assessed.
- Groundwater: The additional desalination plant mitigates the heavy reliance on existing subsoil water from the two river systems and may promote recovery of water system environment along these rivers.

2) Solar Power Generation

Solar power plant is located inland which has better solar radiation conditions. Environmental considerations to be required are described hereunder.

- Impacts to Local Fauna: The solar power plant to be constructed and operated is inevitable to cause long-term impacts on lichens' habitation in the desert area. The MET points out that it is the difficult to deal with lichens in the Namibian Desert due to its sensitivity to the change of habitation and environment. Therefore it is difficult to design and implement mitigation measures and resolution.
- Living Condition of Local Inhabitants: Solar rich inland area is, in many cases, not a human-settled area but is distant from the existing power transmission lines. Therefore, another power transmission line to be required from solar power plant may overlap with living area of local inhabitants. People living in the remote rural area depend on cattle grazing and the solar power generation facility may contracts the cattle grazing area.

12.4 Possibility of Project Preparation

12.4.1 Project Implementation and O&M

(1) Project Implementation

NamWater will implement the project for the additional seawater desalination plant and the Ministry of Agriculture Water and Forestry (MAWF) will oversee the project implementation by NamWater. The following are the options in financing the project:

(a) Self-financing of NamWater: Given the scale of the present business by NamWater, it is not easy to loan the entire funds required for the project.

(b) Support through government funds: If a part of project cost is covered by government funds, NamPower needs to fund the remaining cost.

(c) External loan: The Ministry of Finance (MoF) coordinates with the donor to make the conclusion of the loan agreement. In this case, the MoF represents the government to sign a loan agreement and also carry out the repayment. The funds for the repayment covered by either the government subsidy or water revenue will be decided by the Namibian side.

(d) Private funds: Private investor builds the plant with their own funds and gets revenue in accordance with bulk water supply agreement with NamWater.

In any of the above, NamWater has the organizational capacity to carry out the project. There is an example of the private-funded project financed by Veolia for water recycling in Windhoek. Any of the funds by private or public is applicable for the project and will be determined by the policy of Namibia and/or willingness of donors.

(2) Operation and Maintenance (O&M)

There are options in performing the operation and maintenance (O&M) of the additional seawater desalination plant, which are the following:

- Direct management by NamWater: It can be applied to the project implementation options (a) to (c) as described above. Since NamWater has no experience in O&M of its own desalination plant, it needs to have a technology transfer by EPC contractor to build the plant for at least three years from the beginning of O&M period.
- Entrusted to private operator under supervision by NamWater: O&M is entrusted to EPC contractor to build the plant in accordance with design-build-operate (DBO) or another operator having O&M experiences. It can be applicable to the project implementation options (a) to (c) described above. According to the examples of DBO contract, the period of O&M by private operator ranges from 3 to 25 years. If NamWater wishes future direct management, O&M can be taken over after DBO or O&M for 3 to 10 years as NamWater has high technical capacity and can utilize the Namibian operators conducting O&M at the Wlotzkasbaken seawater desalination plant owned by Areva.
- Private business: It is applicable for the project implementation option (d) described above. Under the contract, e.g., design-build-operate-own (DBOO), design-build-operate-own-transfer (DBOOT), NamWater has the right to receive

predetermined reports from the private operator. However, the management of the plant is basically in the discretion of the private operator.

In any of the above, O&M of the additional seawater desalination plant will be managed without any difficulty. If NamWater takes charge of O&M directly, the technical transfer will need to be ensured.

12.4.2 Financial Viability

With the additional seawater desalination plant, impacts on water tariff and affordability are analyzed. Debt repayment capabilities of the Namibian government and NamWater are also assessed in case that the plant would be constructed with finance through Japanese ODA loan.

1) Impacts to Water Tariff and Affordability

The impact assessment is based in the year 2030 when the plant is operated with full-scale of 20,000 m^3/day.

The total water demand will reach at 102,378 m^3/day in 2030, as described in Subsection 9.3.2 before. Of total water demand, the demand for households and business will be 58,874 m^3/day and the remaining will be required for the mines which are supplied by existing desalination plant. The demand for households and business will be fulfilled by the lower-priced water primarily, namely, 33,972 m^3/day supplied by the subsoil water sources and 24,902 m^3/day supplied by the seawater desalination plant.

NamWater is selling water from the subsoil water sources to the Walvis Bay Municipality at the price of NAD 8.25/m^3 which may include water transmission and administration cost of NAD 5.00/m^3. Desalination plant's production cost is estimated at NAD 14.00/m^3 (USD 0.97/m^3) and the total water supply cost is estimated to be NAD 19.00/m^3. By weighing the costs according to the volumes from the subsoil water sources and desalination plant, an offered price is estimated at NAD 12.80/m^3. Compared with the current water sales price of NAD 8.25/m^3, the price will increase by NAD 4.55/m^3 as shown in Table 12.12.

The calculations described here are based on the assumption that the price of bulk water supply from the seawater desalination plant would be applicable for both municipalities and other bulk water users. In reality, other bulk water users will be charged with higher price than that for the municipalities. Therefore, the water price calculated here is regarded as the highest for the municipalities theoretically.

Table 12.12 Impact to Water Price with Additional Seawater Desalination Plant

		Subsoil Water	Seawater Desalination
Water Production Volume	m^3	33,972	24,902
Water Production Cost	NAD/m^3	3.00	14.00
Water Transmission and Administration Cost	NAD/m^3	5.00	5.00
Water Supply Cost	NAD/m^3	8.25	19.00
Water Supply Cost (Weighted Average)	NAD/m^3	12.80	

Source: Survey Team

Assuming that an average household size would be 3.5 persons/household with a per capita water consumption of 150 lpcd, the water consumption is estimated to be at 15.75 m^3/month. By applying the current water tariff, the average water expenses per household is estimated at NAD

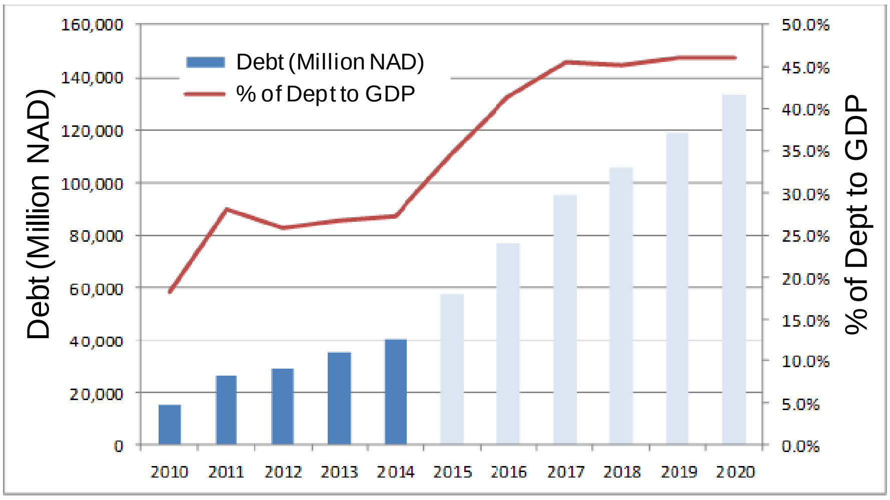
180.38/month. The weighted average water price of NAD 12.80/m^3 gives a 55% escalation from NAD 8.25/m^3. With the same escalation, the average water expenses per household will be NAD 279.79/month. Compared with the average annual household income of Erongo Region from the available statistics, NAD 84,989 per year equivalent to NAD 7,082.42 per month, the water expenses occupy 3.95% of the total household's income.

The proportion of 3.95% still falls within the Organization for Economic Cooperation and Development (OECD) ability to pay (ATP) standard and that additional desalination plant's operation and price escalation will be acceptable to the households of the Erongo Region.

2) Debt Repayment Ability

NamWater has received BBB- credit rating from Fitch Rating and its financial status has been assessed in Chapter 9. Its fixed asset is also reported at NAD 3,937 million. Investment and owing NAD 416 million (USD 28.8 million) of assets, the additional seawater desalination plant, for 15 years' depreciation period put an annual depreciation burden of NAD 27.7 million, which is observed as acceptable to NamWater's asset balance.

While Namibian government's debt repayment ability is examined with aspects of debt amount increases and proportion to gross domestic product (GDP). The Namibian Ministry of Finance expresses that the project associated with water supply, indispensable infrastructure project, does not necessarily bind with a principle of 35% ceiling against GDP. Even though these comments are viable, the increase of debt in primary balance and proportion of debt's increases in recent years should be paid full attention. The additional seawater desalination plant needs an investment of NAD 416 million that is equivalent to 1.02% of the total amount of debt in 2014/2015 as shown in Figure 12.7 and this impact should be an acceptable level in light of the immediate demand for water.



Source: Staff Report for the 2015 Article IV Consultation, IMF

Figure 12.7 Debt and Its Percentage to GDP

12.4.3 Possible Involvement of JICA and Cooperation with Donors

(1) JICA

The Japan International Cooperation Agency (JICA) may be involved in the project for the additional seawater desalination plant through the following financial schemes:

- Official Development Assistance (ODA) Loan: JICA provides a loan to all or part of the eligible items of the project cost. The loan is financed directly to the Namibian Ministry of Finance or in the manner of two-step loan through financial institutions such as the Development Bank of Southern Africa (DBSA).
- Private Sector Investment Finance (PSIF): When private business operator raises funds to implement the project, JICA will be able to finance for private business operator or invest for the special purpose company (SPC) established by private business operator for the project.

When JICA provides directly to ODA loan to Namibia, it is the major issue for Namibia to hedge fluctuation of foreign exchange rate for the water supply services to have revenues in the local currency. The two-step loan is considered as a method for such a risk hedge.

PSIF envisages substantial participation of Japanese firm in the project. However, NamWater is obliged to perform competitive bidding as it is a public company[4]. Even PSIF is attractive for Namibia, it is not easy to precede the finance on the premise that Japanese firm should be involved in the project for the additional seawater desalination plant as there are many strong competitors over the world in the field of seawater desalination.

Therefore, it is presumed that JICA would be involved in the project for the additional seawater desalination plant probably through ODA loan.

(2) Namibia's Interest of External Finance

The information through the interview to the Ministry of Finance (MoF) is summarized below.

- Currently, the government has been continuing negotiations regarding the acquisition of Areva's desalination plant. When construction of the additional seawater desalination plant requires an external loan, the government will bear the financial burden in addition to the acquisition expense. Besides, the MoF can consider the financial scheme including external loan only with the intention of MAWF responsible for water-related projects.
- The MoF recognizes that the revenue of water supply services is used to cover the deficit financing of municipalities in other regions as well. It should be carefully observed that the water charge is unified and made transparent by a Water Regulator to be established soon.
- The MoF has the experience of using the Japanese ODA loan in the northern road improvement project and will be able to consider further use of it. In view of high public nature of the project in the water supply sector, the ceiling set at 35% of GDP for external loan should be examined flexibly. On the other hand, the loan of USD or ZAR can be favorably considered for the government in order to reduce the currency risk.

[4] According to NamWater, the government advises NamWater to essentially perform competitive bidding.

In summary, the project for the additional seawater desalination plant can be implemented with finance by Japanese ODA loan when a consensus is created within the Government of Namibia.

(3) Cooperation with Donors

The construction cost of the additional seawater desalination plant is about JPY 3 billion. When all of the eligible items are financed, the amount of ODA loan is about JPY 4 billion. Co-financing with other donors is not expected for this scale of funding.

If the solar power generation facility is implemented coupled with the desalination plant, the total construction cost is about JPY 6 billion and an amount ODA loan becomes about JPY 8 billion. In this case, the project may seek possible co-funding sources, e.g., African Development Bank (AfDB) or German Development Bank (*Kreditanstalt für Wiederaufbau*: KfW), which have sufficient experience in energy sector in Namibia for the solar power generation facility.

12.4.4 Risks and Mitigation Measures

Risks and mitigation measures for construction of the additional seawater desalination are summarized in Table 12.13 below.

Table 12.13 Risks and Mitigation Measures for Construction of Additional Seawater Desalination Plant

Title	Risk	Mitigation Measure
Decline in the need for seawater desalination due to stagnant economy	The need for the additional seawater desalination may be declined if the increase of water demand slows down due to soft uranium market or natural disasters to hit tourism. If such situation occurs after the plant will be operational, its operation rate will be lowered remarkably.	As soft uranium market or natural disasters are unforeseeable, the capacity of the additional seawater desalination plant should be designed on a conservative consideration. The capacity of the plant should be based on an average daily demand but not on the maximum daily demand. In planning the capacity of the plant, the water demand and supply balance should be scrutinized on the premise that the usable volume from the existing subsoil water sources in the normal hydrological condition could be available. Possible water rationalization is considered as acceptable in the case of a drought.
Decline in the operational efficiency of seawater desalination plant due to shortage of energy	NamPower imports the energy accounting for 60% of the total domestic consumption. If NamPower's own energy development delays, the shortage of energy dependent on external conditions may cause unstable operation of the additional seawater desalination plant.	Dependency ratio to external energy sources should be reduced through introduction of the solar power plant.
Decline in the operational efficiency of seawater desalination plant due to insufficient O&M technique	When NamWater takes charge of O&M for the additional seawater desalination plant directly, the operational performance of the plant is highly dependent on NamWater's O&M staff who should acquire the necessary skills.	Technology transfer by EPC contractor to build the additional seawater desalination plant should be designated clearly in the EPC contract. For example, the period of technology transfer should be three years after the plant will be operational. Another option is to entrust O&M for the plant to an experienced private firm in accordance with DBO contract or O&M contract.

Source: Survey Team

12.5 Summary of Preliminary Study

The planned site of the additional seawater desalination plant at Wlotzkasbaken is the most promising from the technical and environmental viewpoints. The land required for both existing and additional seawater desalination plants was already acquired before the construction of the existing plant. The existing seawater intake/outfall and power receiving equipment have the capacity sufficient for the future expansion originally designed. In addition, the originally designed seawater desalination plant inclusive of the expansion is already authorized with the Environmental Clearance Certificate.

The additional seawater desalination plant will be able to receive the electricity from the existing power grid system. Through the preliminary study in this chapter, it is found that the water production cost for the plant with a capacity of 20,000 m^3/day can be saved by the utilization of solar power plant. At present, Namibia relies on the imported electricity accounting for 60% of the total electricity demand in the country. For minimizing the risk of outage due to external incident, the solar power plant for the electricity supply to the additional seawater desalination plant needs to be further scrutinized.

NamWater has the organizational capacity sufficient for implementing the project for the additional seawater desalination project. NamWater is also capable for any of the O&M options: (i) NamWater to handle the O&M directly through transfer of technology, or (ii) NamWater to monitor and supervise the O&M entrusted to another party.

For the additional seawater desalination plant with a capacity of 20,000 m^3/day, the costs are estimated to be USD 28.8 million for construction, USD 3.7 million/year for O&M, and USD 0.97/m^3 for water production (without solar power plant). With the additional seawater desalination plant, the water charge for the domestic use is estimated to increase from NAD 8.25/m^3 to NAD 12.80/m^3. The increase of the water charge results in the household water expenses accounting for 3.95% of the household income per month. This percentage still falls within OECD's ATP ("Affordable to Pay") Standard.

Namibian government's debt repayment ability is examined with aspects of debt amount increases and proportion to GDP. The additional seawater desalination plant needs an investment of USD 28.8 million (NAD 416 million) that is equivalent to 1.02% of total amount of debt in 2014/2015 and this impact should be an acceptable level. The project for the additional seawater desalination plant can be implemented with finance by Japanese ODA loan when a consensus is created within the government of Namibia.

Chapter 13 Possibility in Preparing Seawater Desalination Project in Sub-Saharan Africa

13.1 Verification of Assumed Scenario in Selecting of Surveyed Locations

In the first stage survey, the following three scenarios regarding the need of seawater desalination for public water supply were assumed for selecting the surveyed locations:

- Scenario 1- Limitation of exploitable water resources
- Scenario 2- Assurance of water supply capacity against drought
- Scenario 3- Need for early increase of water supply capacity

These scenarios are verified hereunder through the feedbacks from the findings through the site surveys.

1) Scenario 1 - Limitation of exploitable water resources

It was assumed that the need for seawater desalination would increase on the condition that the available water resources (surface water and groundwater) in the country-wide or region-wide would be insufficient compared with the future water demand, similar to the condition in the Middle East and North African countries.

As a result of the site surveys, it is recognized that the surveyed locations in South Africa and Namibia fall into Scenario 1.

The coastal areas of South Africa are not arid like the Middle East and North African countries. However, the dam reservoirs and inter-basin water conveyances are required for the development of water resources due to uneven distribution and seasonal variation of water resources availability. The major coastal cities such as Cape Town (population 3.74 million) and Durban (population 3.44 million) highly rely on the dam reservoirs and large-scale water conveyance facilities in order to cope with the large water demand.

On the other hand, both these cities forecast the limitation of water supply by the dam reservoirs and large-scale water conveyance facilities and consider introducing the seawater desalination to the public water supply. The discussions about the seawater desalination are based on the common approaches that consist of water resources assessment, water demand forecast, water demand and supply balance, and comparative assessment of water resources development alternatives. Therefore, the need of seawater desalination for public water supply is explained clearly. The scale of the seawater desalination project will be 150,000 to 450,000 m^3/day in Cape Town and 300,000 m^3/day in Durban.

Both Saldanha Bay (population 99 thousand) in South Africa and Swakopmund/Walvis Bay (population 107 thousand) in Namibia are arid and the usable water resources have reached the upper limit of the potential. Saldanha Bay has decided to implement the seawater desalination project (25,500 m^3/day) accordingly. There is the existing seawater desalination plant with a capacity of 55,000 m^3/day in Swakopmund and construction of the next plant is under consideration. In Saldanha Bay, the planned capacity of the seawater desalination project is almost the same as the water demand forecast of the industrial development zone (IDZ). Although the water demand will increase with the development of the port and tourism in Swakopmund/Walvis Bay, it should be noted that the major industrial consumers are uranium mines at present. Therefore, the time to implement the seawater desalination project will depend on the progress of the IDZ development in Saldanha Bay and on the progress of port and tourism development and the operating status of uranium mines in Swakopmund/Walvis Bay.

Namibe (population 282 thousand) in the south of Angola belongs to the arid region along the Atlantic coast. During the site survey, it was found that the subsoil water of the Belo River would satisfy the water demand until 2035 and the need for seawater desalination was not considered. At present, the status of Namibe does not fall into Scenario 1.

2) Scenario 2 - Assurance of water supply capacity against drought

In considering the possibility of seawater desalination in Sub-Saharan Africa, it was assumed that the need for seawater desalination would increase due to the seasonal variation of rainfall and possible drought affecting public water supply.

Any seawater desalination as a fundamental solution for the vulnerability of public water supply against drought was not identified in the site surveys.

Water supply planning and development in Cape Town and Durban have been done through common approaches as mentioned in Scenario 1 above. The seawater desalination is considered as one of a series of measures to mitigate the vulnerability of public water supply against drought.

Cape Town focuses on water saving measures through water demand management. Durban has a high sense of drought crisis and is increasing the reservoir capacity by heightening the existing dam (Hazelmere Dam). An emergency measure is taken for the recovery of reservoir storage by installing pump facility for water conveyance. In addition, the water recycling and small-scale seawater desalination plant (2,500 to 10,000 m^3/day) are also under consideration.

In South Africa, the local cities have introduced small-scale seawater desalination plants for public water supply due to the drought experienced in the past. However, it was informed by Umgeni Water that these plants are not in operation at present and only a plant is operated during the time of the peak water demand. Although the information has not been confirmed, it can be understood that operation and maintenance (O&M) cost of the seawater desalination plant is the financial burden for the local cities. It is presumed that the seawater desalination would not be fully operated under the normal climatic condition as the public water supply can use the conventional water sources (surface water and groundwater) primarily.

The climate in Nacala (population 241 thousand)[1], Mozambique, is characterized with the seasonal variation of rainfall. But it is recognized that Nacala does not meet the required condition for the introduction of seawater desalination in terms of the development level of water supply system. At present, Scenario 2 is not appreciable for Nacala.

In Swakopmund/Walvis Bay in Namibia, the availability of the existing subsoil water sources is highly dependent on the variation of the annual rainfall. The existing seawater desalination plant, supplying water for the uranium mines, served Swakopmund with water for the period from

[1] Population in Nacala Porto Municipality (2015)

November 2015 to February 2016 due to the water rationing. Therefore, the present status of the existing seawater desalination plant having a reserve capacity is considered as Scenario 2 but its utilization rate will be increased gradually along with the water demand. The forecast of water demand and supply balance in Swakopmund/Walvis Bay shows that the water shortage will take place in 2022 even though the existing seawater desalination plant is fully operated. As there is no alternative water source, the need for the additional seawater desalination plant in the mid- and long-term corresponds to Scenario 1.

3) Scenario 3 - Need for early increase of water supply capacity

It was assumed that the need for seawater desalination would increase when a specific development project in the coastal area is taking place and a rapid increase of water demand is forecasted clearly. This scenario considers that the water supply capacity needs to be increased as soon as possible without a long wait for the development of dam reservoir and/or distant water conveyance.

Resulting from the site survey, it is recognized that Scenario 3 can be applicable in Nacala but there are many challenges for its realization.

It is hard to develop water resources for increasing the water supply due to the geographical conditions around the Nacala Bay Area. However, the proposed augmentation of water supply by Nacala Dam (expansion) and the Sanhute River (or the Monapo River) has not been implemented yet. In addition, a large scale water conveyance across watershed will be required for further increase water supply in the Nacala Bay Area from the mid- and long-term view. But the status of large scale water conveyance project is unknown in terms of the feasibility from the viewpoints of technical and financial issues and social consensus.

The water demand forecast will need to be further scrutinized. The water demand forecast by the PEDEC-Nacala is based on the socio-economic framework in 2035 comprising the population of 927,100 (2.4 times of estimated population in 2017) and industrial area 1,000 ha (3.3 times of estimated industrial area in 2017), which assumes a comparatively larger growth potential than existing major cities. For realizing the growth, the development of basic infrastructure and relevant initiatives will be carried out. The water demand forecast will need to be reviewed and updated successively in the process of the development activities.

The geographical constraints and water demand forecast suggests Scenario 3 but its reality will depend on the progress of the development activated with basic infrastructure projects and relevant initiatives. Therefore, it is hard to forecast the reality of Scenario 3 at this moment. On the other hand, it is crucial to discuss the augmentation of the water supply for the Nacala Bay Area from the mid- and long-term view.

13.2 Conditions for Introduction of Seawater Desalination to Public Water Supply

Based on the verification of the scenarios in selecting the surveyed locations above, the conditions for introduction of seawater desalination to public water supply are clarified as follows:

1) Clear and Concrete Development Plan at Economic Growth Center

In the Sub-Saharan African countries, the coastal cities are well-known as the hub of the economic development corridor and are expected to be economic growth centers. In selecting the surveyed locations, the present survey focused on these coastal cities to have a rapid increase of water demand along with the economic growth in the future.

As a result, the survey locations were selected in South Africa and Namibia where the seawater desalination for public water supply is under consideration. In addition, both Nacala in Mozambique and Namibe in Angola were selected among the hubs of the economic corridors. The following points have been found through the site surveys in Nacala and Namibe.

- **Nacala:** PEDEC-Nacala has prepared a long-term development vision and strategy and the basic infrastructure development including port, road, and electric power projects are taking place or under consideration as described in Subsection 8.1.4 before. On the other hand, the Nacala SEZ is defined institutionally as an area to attract development investments with preferential supports given by GAZEDA. However, an overall picture of any specific urban development and industrial development is not clear within the Nacala SEZ. Therefore, the present water demand forecast is based on the conceptual development strategy of PEDEC-Nacala and includes a number of uncertainties.

- **Namibe:** It is expected that the Namibe corridor will facilitate exports of Angola's inland underground natural resources through the Namibe Port. The railway connecting the port with the inland regions has been rehabilitated. However, it has been found that there is no notable development causing a rapid increase in water demand in the hinterland of the port.

The coastal cities as hub of economic development corridor in the Sub-Saharan African countries have large development potential and are expected to be economic growth centers. However, as a lesson leant from the above, the information about development potentiality (see Subsection 5.3.2) should be scrutinized carefully. In order to discuss the need of improving water infrastructure including seawater desalination at the potential economic growth centers, the water demand forecast should be performed more precisely based on a clear and concrete development plan.

2) Quantitative Assessment of Need for Seawater Desalination

Except the region from the Guinea Gulf to the northern and central part of Angola, the water resources in the countries in the coastal areas of Sub-Saharan Africa, are unevenly distributed geographically and variable largely by season. Therefore, the seawater desalination can be introduced in the following situations:

- Regional water resources are absolutely limited and do not cope with the water demand. The seawater desalination is a promising solution for increasing the water supply capacity.

- When dam reservoir and long-distance water conveyance need to be developed for water supply, the seawater desalination can be an alternative from the viewpoints of cost competitiveness in terms of capital expenditure and operating expense, shortening construction period, and drought risk reduction.

In addition, the need for seawater desalination is justified through water resources assessment, water demand forecast, and water demand and supply balance analysis for the above. The project preparation for seawater desalination can be ensured with the quantitative assessment.

3) Water Supply System Acceptable for Introduction of Seawater Desalination

Both South Africa and Namibia have an organization responsible for development of regional water supply infrastructure including water source, intake, conveyance, treatment and transmission and O&M for these infrastructure, namely, Water Board[2] in South Africa, and NamWater in Namibia. Such an organization provides bulk water supply to municipalities that are responsible for development and O&M of water distribution infrastructure and water supply services for consumers in their respective jurisdictions. Under the administrative framework of water resources management and water supply operation, the value chain of water supply is well-functioning from water source thru water consumers.

The introduction of seawater desalination is likely to cause an impact on the whole water supply system due to the high initial investment and O&M costs. Therefore, it is desirable that the water supply system should attain a certain high standard in terms of infrastructure development, O&M, and services acceptable for introduction of seawater desalination. Under the well-organized water supply system, the responsible organization can explain the need of cost sharing among the stakeholders such as government, local administration, beneficiaries including private firms and citizens. The surveyed locations in South Africa and Namibia attain the high standard of water supply system. The large cites have the financial capability to introduce seawater desalination and the local cities need to have a particular factor to cope with financial burden as described below.

- Cape Town and Durban: The scale of the water supply system is large and can alleviate the impact on the water charges by the costs for the seawater desalination. As the seawater desalination capacity accounts for a small proportion of the entire water supply capacity, the capital and O&M costs for the seawater desalination plant can be recovered from the entire water supply system in order to minimize the impact on the water charges.
- Saldanha and Swakopmund/Walvis Bay: The scale of the water supply system is relatively small and the seawater desalination capacity accounts for a relatively large proportion of the entire water supply capacity. Meanwhile industry, commerce, and tourism charged with high water prices cover a large portion of water consumption. Therefore, it is possible to recover capital and O&M costs by water revenue in the long-term view.

13.3 Other Conditions

At the time of the commencement of the present survey, the capital city of Accra in Ghana has introduced a large-scale seawater desalination plant to public water supply for the first time in Sub-Saharan Africa. This project is an opportunity to increase the interest in the possibility of seawater desalination in Sub-Saharan Africa. The information about this project was collected and reviewed in the first stage survey.

A group of three firms: Abengoa Water (Spain), Sojitz Corporation (Japan), and Hydrocol, (Ghana), won the concession of the seawater desalination project and established a special purpose company

[2] Cape Town and West Coast District Municipality have the role of Water Board.

(SPC) called Befesa Desalination Developments Ghana Ltd. in January 2011. After the completion of the plant, the commercial operation of the plant with a capacity of 60,000 m^3/day was initiated in February 2015. The total project cost was USD 126 million. The project implementation and O&M is in the manner of build-own-operate-transfer (BOOT). The water produced by the plant is sold to the Ghana Water Company for the period of 25 years[3].

The background of the Ghana Water Company's decision to choose seawater desalination can be found in the Assessing Existing Water Demand and Supply Patterns and Re-use Options as Additional Sources of Water in the Greater Accra Metropolitan Area (GAMA), June 2013, as outlined below.

- Water quality in the Weija Dam has deteriorated and requires a large amount of chemicals for water treatment. Therefore, the water production cost becomes high.
- The water production cost of the water intake from the Kpong Dam is twice of the Weija Dam's water production cost. This is because of the long-distance water transmission with pumping from Kpong Dam to Accra.

From the information above, it is presumed that the seawater desalination would be considered as feasible due to the water quality deterioration risk of the Weija Dam and high water production cost of the Kpong Dam.

With the lessons learnt through the second stage survey, the present survey has reviewed this project in view of the conditions for introduction of seawater desalination water as described hereunder.

1) Economic Growth and Water Demand and Supply Balance

The average growth rate of gross domestic product (GDP) in Ghana was 8.5% in 2010-2014. The country achieved a particularly high economic growth of 14.0% in 2011 and 9.3% in 2012[4]. The population of the metropolitan area called the Greater Accra Metropolitan Area (GAMA) was about 4 million (2010)[5]. In 2012, the water demand of GAMA was 636,900 m^3/day while the water supply was 402,500 m^3/day[6]. In addition, the water demand in 2015 was expected to reach 158 million gallons/day (711,000 m^3/day)[7]. The water supply was not keeping up with the growth of water demand and population in GAMA with the high economic growth.

2) Water Resource and Water Supply

Ghana belongs to the tropical savanna climate, with an average annual rainfall of 1,187 mm. Its surface water is abundant, having the Volta Lake, which is the dam reservoir with the world's largest water surface area. The main water source of the GAMA is the Weija Dam (Densu River) located about 20 km west of the Accra center and the Kpong Dam (Volta River), located about 70 km northeast. In 2015, the water treatment capacity was 659,073 m^3/day consisting of the Weija water treatment olant (WTP) with 245,484 m^3/day and the Kpong WTP expanded up to 413,589 m^3/day. With a 60,000 m^3/day by the seawater desalination plant, the total capacity is about

[3] Sojitz Corporation Press Release 2015 April 24
[4] World Bank, http://data.worldbank.org/
[5] Ghana government website, http://www.ghana.gov.gh/index.php/about-ghana/regions/greater-accra
[6] Assessing Existing Water Demand and Supply Patterns and Reuse Options as Additional Sources of Water in the Greater Accra Metropolitan Area (GAMA), June 2013
[7] Gov't To Address Water Deficit, 9 July 2014, http://www.accra.io/blogs/p/88492/govt-to-address-water-deficit

720,000 m^3/day[8] that is approximately equal to the afore-mentioned 2015 water demand forecast. The Weija Dam (Densu River) does not have spare capacity to further increase from the current water intake volume[9]. The Kpong Dam (Volta River) can accommodate further increase of the water intake volume because of the presence of the Volta Lake upstream but requires a high water production cost due to the distant water transmission for 70 km to the center of Accra.

3) Water Supply Management and Service

The non-revenue water (NRW) of the Ghana Water Company was estimated to be about 50% in 2014[10]. The ongoing Greater Accra Metropolitan Area Water and Sanitation Project assisted by the World Bank will implement the expansion of the water distribution network to the low-income residential areas, procurement and installation of equipment such as water meters, water demand management, and NRW reduction. On the other hand, the water revenue of the Ghana Water Company increased from GHS 57 million in 2006 to GHS 146 million in 2010. In addition, the water charge collection rate before 2006 was around 75% and increased to around 90% from 2006 to 2010. It can be seen that the Ghana Water Company has been making efforts in improving the earnings[11]. With improvement of the financial conditions, it is supposed that the Ghana Water Company could manage a long-term payment for purchasing bulk water from the seawater desalination plant.

13.4 Viewpoints, Conditions and Issues for Preparation of Seawater Desalination Project

As a summary of this chapter, viewpoints, conditions and issues for preparation of seawater desalination project in Sub-Saharan Africa are presented in Table 13.1.

Viewpoints: The principal viewpoints for preparation of seawater desalination project are (i) increase of water demand with population and economic growth, (ii) exploitable water resources, and (iii) level of water supply infrastructure, management and services.

Conditions: The surveyed locations in South Africa and Namibia meet the conditions for preparation of seawater desalination project as listed in the table below.

Issues: The surveyed locations in Mozambique and Angola do not meet the conditions for preparation of seawater desalination project. In addition, it is presumed that the similar situations would exist in the major coastal cities in the remaining surveyed countries as suggested from the considerations described in Chapter 5 before. The principal issues to be discussed are listed in the table below when the need for seawater desalination takes place in these countries.

---

8 GAMA Technical Group Webinar, June 2015, http://www.slideshare.net/AndreHead/gtg-webinar-june

9 Runoff Estimates into the Weija Reservoir and Its Implications for Water Supply to Accra, Ghana, December 2008

10 GAMA Technical Group Webinar, June 2015, http://www.slideshare.net/AndreHead/gtg-webinar-june

11 Recently in December 2015, water charges for the residential consumers have increased by 67.2%.

Table 13.1 Viewpoints, Conditions and Issues for Preparation of Seawater Desalination Project

Viewpoints	Conditions	Issues
Increase of water demand with population and economic growth	● Water demand forecast should be performed more precisely based on a clear and concrete development plan. ● Water demand and supply balance in mid- and long-term is analyzed quantitatively.	● Water demand forecast based on potential growth of population and economy should be reviewed and updated successively along with the development perspectives. ● Increase of water demand mainly by industrial development in the future should be assessed carefully in terms of the reality.
Exploitable water resources	● Limitation of exploitable water resources on regional basis is assessed quantitatively. ● Feasibility of distant water conveyance from water source to major demand center is studied.	● Comprehensive water resources management plan should be prepared through water resources assessment, present and future water uses, and water demand and supply balance focusing on the entire river basin. ● The need for seawater desalination should be studied through the comparative assessment with the water conveyance alternatives.
Level of water supply infrastructure, management and services	● Water supply infrastructure is well-developed. ● Water distribution management and services are organized satisfactorily. ● Management of water utility is financially sound.	● Need for improvement of water supply infrastructure, management and services should be identified and confirmed. ● Assistance for Improvement of water supply infrastructure, management and services should be taken into consideration where required.

Source: Survey Team

Chapter 14 Preparation of ODA Project for Seawater Desalination

14.1 Project Implementation and O&M by Japanese ODA Loan

14.1.1 Data of Project Implementation and O&M for Seawater Desalination

Since the seawater desalination project requires technical knowledge for planning, design, and construction as well as operation and maintenance (O&M), the contractor is involved not only in EPC but also in O&M. For example, the EPC contractor conducts O&M after the construction of the plant in design-build-operate (DBO) and then transfers it to the owner. In other cases, the major water business firms carry out a long-term concession throughout a series of project stages.

The data derived from DesalData (GWI) are screened by the conditions specified: (i) contracted since 1996, (ii) capacity of 5,000 m^3/day or more, and (iii) customer type of municipalities as drinking water. Such seawater desalination plants are found to be 474 in number and the total installed capacity is 27.5 million m^3/day. Procurement types for these plants are summarized in Table 14.1.

There are 97 plants, corresponding to 20% of 474 plants, with the concession period of 10 years or more. The installed capacity of these plants amounts to 15.7 million m^3/day, which accounts for 57% of the total installed capacity of 474 plants. Of these plants, there are many of large-scaled plants, i.e., 57 plants (59%) with 100,000 m^3/day or more and 20 plants (21%) with 250,000 m^3/day or more. The remaining 377 plants are medium- or small-scaled as a whole, including 320 plants (85%) with the capacity less than 50,000 m^3/day and 133 plants (35%) with the capacity less than 10,000 m^3/day.

The long-term concessions (e.g., DBO, BOT, BOO) are predominant in the project implementation and O&M for large-scaled seawater desalination plant. These are in such manners that the private enterprise to get the concession, invests its capital in the project for seawater desalination plant, and performs the long-term O&M for gaining the profits.

Table 14.1 Procurement Type and Concession Period for Seawater Desalination Plant

Procurement	30 years or more	21-25 years	16-20 years	11-15 years	6-10 years	5 years or less	No Data	Total
EPC			2		2	1	335	340
DB		1			1		9	11
DBO		4	4	11	4	2	2	27
BOT	1	13	10	2	1		4	31
BOO	1	4	3				6	14
BOOT		3	2		1	1		7
DBOOT		1		1				2
IWP		1	2	1	1		3	8
IWPP	1	7	13	4				25
No Data							21	9
Total	3	34	36	19	10	4	380	474

Source: Prepared by the Survey Team based on DesalData (GWI) as of April 12, 2016

The seawater desalination plants operated under the concession for the period of 10 years or more are listed by region as shown in Table 14.2. There are 40 plants found in the Middle East. In the North Africa, 11 out of 12 plants are located in Algeria and the remaining one is installed in Morocco. The plants in Europe have the concession period of 20 years or less and the majority are located in Spain.

Table 14.2 Seawater Desalination Plant with Concession Period of 10 Years or More

Region	30 years or more	21-25 years	16-20 years	11-15 years	10 years	Total
Middle East	1	16	18	4	1	40
North Africa		11	1			12
Sub-Saharan Africa		1				1
Europe		1	2	12	3	18
North/Central/South America	1	1	9	2		13
Asia		1	4			5
Australia	1	3	2	1	1	8
Total	3	34	36	19	5	97

Source: Prepared by the Survey Team based on DesalData (GWI) as of April 12, 2016

Meanwhile, there are some plants by DBO with the concession period less than 10 years and capacity more than 100,000 m^3/day as shown in Table 14.3. It is presumed that these might be constructed by government finance as the concession period is not enough for profitable business.

Table14.3 Major Desalination Plant with Concession Period Less than 10 Years

Country	Project	Capacity (m^3/day)	Online Date (year)	Plant Supplier	Procurement	Concession Period (years)	Owner-Client
UAE	Al Fujairah 1 SWRO expansion	136,000	2015	Acciona S.A.	DBO	7	Abu Dhabi Water and Electricity Authority / Emirates Sembcorp Water and Power Company (ESWPC)
India	Chennai Nemmeli	100,000	2013	IDE Technologies Ltd.	DBO	7	Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) / Government of Tamil Nadu
Iraq	Basra river water plant	199,000	2016	Veolia	DBO	5	Ministry of Municipalities and Public Works
Kuwait	Az Zour South hybridisation	136,000	2014	Veolia	DBO	5	Ministry of Electricity and Water
Jordan	Wadi Ma'in	135,500	2006	GdF Suez	DBO	2	(No data)

Source: Prepared by the Survey Team based on DesalData (GWI) as of April 12, 2016

14.1.2 Project Implementation and O&M by ODA Loan

In Sub-Saharan Africa, the seawater desalination plant for the public water supply has been operated in Ghana firstly under the long-term concession by the private enterprise. Over the world, the seawater desalination projects for public water supply tend to be operated under the long-term concession. Meanwhile, it is not easy to forecast further possibility of project by long-term concession in Sub-Saharan Africa. Considering the results of the site surveys, it is presumed that the seawater desalination project might be implemented by the government in the manner of the DBO as mentioned in Table 14.3 before.

South Africa will be able to introduce the seawater desalination to the public water supply. The country has the well-organized administrative framework for management of water resources and water supply. For the time being, there is less opportunity to involve private sector in the value chain for the water supply services from water sources thru water consumers[1]. The seawater desalination project is under consideration in Durban with some involvements of private sector. But the basic concept of the project implementation and O&M remains in the manner of the DBO[2].

The private firm is operating the existing seawater desalination plant in Namibia. At present, the government is seeking to purchase the plant and is negotiating with the private firm. When the

1 PPP is under consideration for water recycling.
2 DBO alliance to demarcate the responsibility (including finance) between public and private is under consideration as mentioned in Chapter 7.

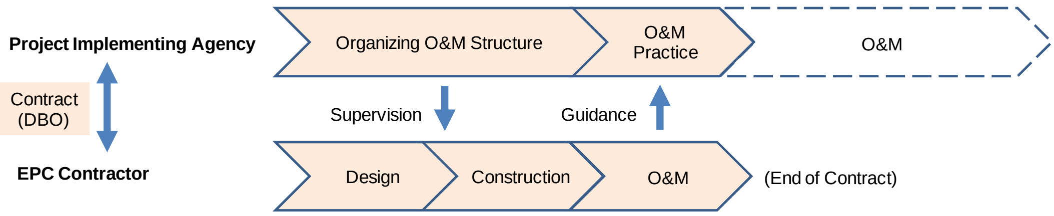
government considers managing all the water resources including the seawater desalination, the additional seawater desalination plant will be financed by the government and NamWater will take charge of the project implementation and O&M in the manner of the DBO.

In Mozambique, FIPAG as a government agency implements the infrastructure development in the urban water sector. In each of the cities under the jurisdictions by FIPAG, the operator belongs to FIPAG performs the water supply services by using the infrastructure developed by the government. For the time being, there are many technical and financial issues on the improvement of the water supply services. Therefore, it is not easy for private sector to make investments for the water supply services. When the need for seawater desalination takes place, the project will need to incorporate the main works with technical cooperation for improving the performance of the water supply services. The project for seawater desalination will require the assistance by ODA accordingly.

14.1.3 Manners of Project Implementation and O&M

When the seawater desalination project is considered as an ODA project, it should be noted that the project implementing agency and/or water utility has less experience of construction and O&M for seawater desalination plant. The following options are conceivable or the project implementation and O&M, depending on the administrative framework of the water sector in the borrower's country.

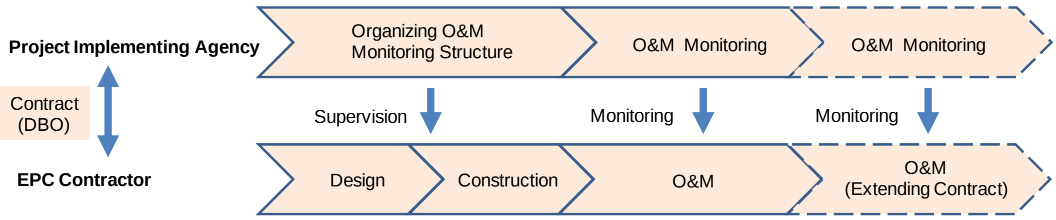
(a) Period of O&M contract is decided on the premise that the O&M for seawater desalination plant will be transferred to the project implementing agency in the future. After construction of seawater desalination plant is completed, the EPC contractor will provide technical guidance regarding the O&M for the project implementing agency during the period defined in the DBO contract. The project implementing agency will need to establish its management structure for the O&M within that period.



Source: Prepared by the Survey Team

Figure 14.1 Project Implementation and O&M for Seawater Desalination (Option-a)

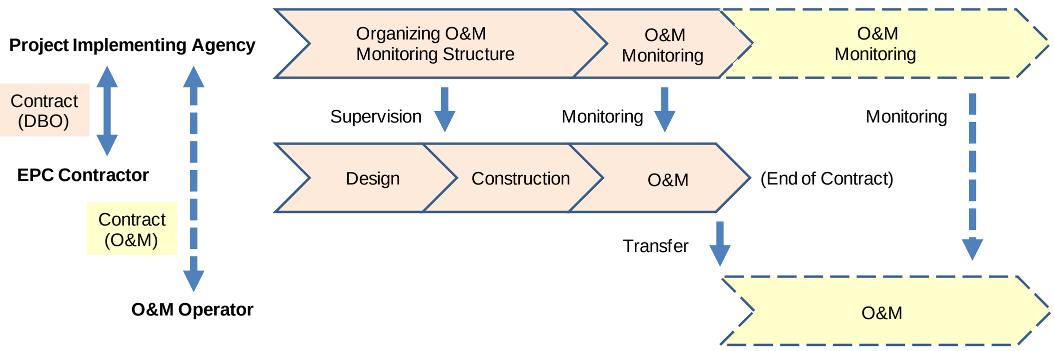
(b) The EPC contractor will perform the O&M in accordance with the DBO contract that defines a long-term period for the O&M and possible extension. The project implementing agency will need to establish its management structure for monitoring and supervision of the O&M before construction of seawater desalination plant is completed and the O&M starts.



Source: Prepared by the Survey Team

Figure 14.2 Project Implementation and O&M for Seawater Desalination (Option-b)

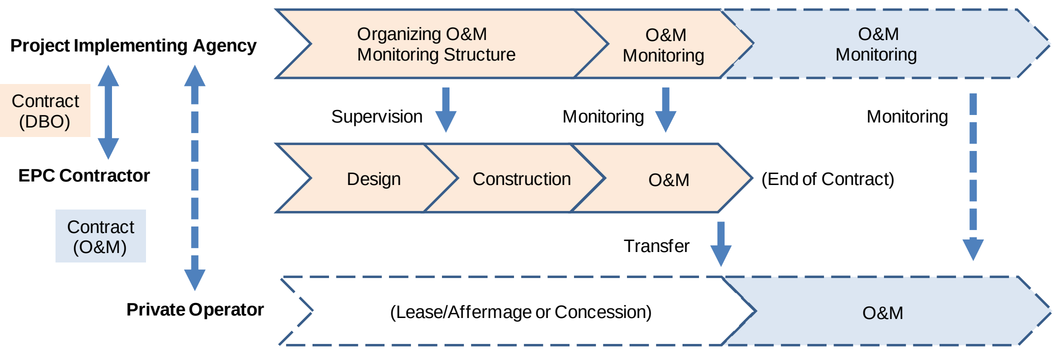
(c) The project implementing agency will separately sublet the O&M to another firm. The DBO contract will define that the EPC contractor carries out the O&M for a few years after completing construction of seawater desalination plant and then transfer the O&M to the firm. The project implementing agency will need to establish its management structure for monitoring and supervision of the O&M before construction of seawater desalination plant is completed and the O&M starts.



Source: Prepared by the Survey Team

Figure 14.3 Project Implementation and O&M for Seawater Desalination (Option-c)

(d) When water supply services are already operated in accordance with lease/affermage or concession contract, the project implementing agency will not be directly involved in the O&M for seawater desalination plant. The project implementing agency will conduct monitoring and supervision for the O&M by the EPC contractor and private operator. The project implementing agency will need to establish its management structure for monitoring and supervision of the O&M before construction of seawater desalination plant is completed and the O&M starts.



Source: Prepared by the Survey Team

Figure 14.4 Project Implementation and O&M for Seawater Desalination (Option-d)

14.1.4 Water Transmission and Distribution

In parallel with the seawater desalination plant, the water transmission and distribution facilities can be implemented by means of procurement from the neighboring or third countries. Besides, the assistance by ODA will be required in the process of the infrastructure development (e.g., planning, design, procurement and construction) and O&M. With the assistance, the water supply by the seawater desalination plant will contributes effectively to the improvement of services at water consumers.

Water Transmission Facility: the seawater desalination project will include at least the water transmission main to link the plant with existing water distribution network. Length of water transmission main and need of pumping station will be dependent on positions of the plant and connection point with water distribution network. When the plant is located far distant from the water distribution network, the large-scale works for water transmission may need to be procured by separated contract package or another project.

Water Distribution Facility: As the urban water supply systems in Sub-Saharan Africa are face with a high rate of non-revenue water (NRW) due to water loss and stolen from water distribution mains, the development of the supply side (water intake, treatment and transmission) can not contribute effectively to improvements at the demand side (water distribution). The seawater desalination project will need to result in the improvements at water consumers, namely, increase of population served, increase of per capita water consumption, and fulfillment of other water demands such as commerce, industry and tourism, together with implementation of rehabilitation and expansion of water distribution network. The works for expansion and rehabilitation of water distribution network may need to be procured by separated contract package or another project and will require collaboration by assistance for capacity development of water utility to improve its performance of water distribution management and services.

It is expected that the seawater desalination project assisted by Japanese ODA loan will be implemented in association with the development of the water transmission and distribution facilities as well as the assistance for capacity development of water utility. The project may be prepared in collaboration with another donor as exampled in Table 14.4.

Table 14.4 Examples for Project Preparation by Japanese ODA Loan in Collaboration with Another Donor

Infrastructure Development			Capacity Development
Seawater Desalination Plant	Water Transmission Facility	Water Distribution Facility	
JPY Loan	JPY Loan	JPY Loan	Japanese ODA
JPY Loan	JPY Loan	Another Donor	Another Donor
JPY Loan	Another Donor	Another Donor	Another Donor

Note: The works for water transmission main may need to be procured by separated contract package or another project.
Source: Survey Team

14.1.5 Collaboration with Technical Cooperation

(1) O&M for Seawater Desalination Plant

The technical cooperation for the option (a) afore-mentioned in Subsection 14.1.4 aims at the establishment of the organizational structure and capacity development for the project implementing agency to be responsible directly for handling the O&M of the seawater desalination plant. For the other options, the technical cooperation helps the project implementing agency to have its capability for supervision and monitoring of the O&M entrusted to the EPC contractor or another party. In any of the options, the technical cooperation starts from the commencement of the project and ends after a few years of the O&M period. With the seawater desalination project, the examples of the technical cooperation by Japanese ODA are shown in Table 14.5.

Table 14.5 Examples for Technical Cooperation for O&M of Seawater Desalination Plant

O&M Method	Type of Technical Cooperation	Subject
After construction of seawater desalination plant is completed, the EPC contractor provides technical guidance regarding the O&M for the project implementing agency during the period defined in the DBO contract. At the end of the DBO contract, the O&M for seawater desalination plant is transferred to the project implementing agency.	Dispatch of Expert	The project implementing agency will establish its management structure for the O&M before completion of the seawater desalination plant.
The project implementing agency sublets the O&M of the seawater desalination plant to in any of the following manners: ● DBO contract (long-term or extension) ● Separated contract with third party ● Separated contract with concessionaire	Dispatch of Expert	The project implementing agency will establish its management structure for monitoring and supervision of the O&M before completion of seawater desalination plant.
	Training in Japan or Third Country	Staff of the project implementing agency will learn the management of contract and technical subjects for the O&M through the training in a seawater desalination plant being operated in the manner of subcontract.

Source: Survey Team

(2) Capacity Development for Improving Performance of Water Distribution Management and Services

Water distribution network to be served by the seawater desalination plant may be faced with water loss and non-revenue water due to the problems on water distribution management and services. As a solution for the problems, the main works of the project will be prepared comprising construction of seawater desalination plant as well as improvement and expansion of water distribution network. Further, the technical cooperation for improving water distribution management and services of water utility will be helpful for ensuring the effects of the project. The examples of the technical cooperation by Japanese ODA are shown in Table 14.6.

Table 14.6 Examples of Capacity Development of Water Utility

Assistance	Description
Governance	Corporate management based on laws and accounting regulations, recruit and development of human resources, and record-based management (e.g., water volume, inputs of material and equipment, labor force, and cost)
Technical Issue	Improvement of problem on water supply facilities, measure for illegal connections, increase of revenue collection rate, promotion of awareness for water charge and measure for water loss
Financial Issue	Preparation of financial statements, rationalization of O&M costs, promotion of awareness for saving costs, preparation of corporate plan, and establishment and implementation of water tariff for full cost recovery
Upgrading Corporate Management	Water tariff based on concept of cross-subsidy, audit system for continuous development of autonomous corporate management, high reliability of water supply system, social welfare (consideration of low-income residents), and utilization of private finance

Source: Study Report on International Cooperation for Water Supply Sector (March 2015)

(3) Project Implementation and O&M Supported by ODA Loan and Technical Cooperation

In preparing the project in the manner of the main components supported by technical cooperation, the framework for project implementation and O&M will depend on the institutional framework for water supply by country. For two surveyed countries, the framework of project implementation and O&M is assumed as shown in Table 14.7.

Table 14.7 Framework for Project Implementation and O&M

<table>
<tr><td colspan="2">Institutions in target countries</td><td>Mozambique</td><td>Namibia</td></tr>
<tr><td colspan="2">Borrower</td><td>Government</td><td>Government</td></tr>
<tr><td colspan="2">Supervisory organization</td><td>MPH/DNA</td><td>MAWF/ DWRM</td></tr>
<tr><td rowspan="2">Project implementing agency</td><td>Seawater desalination plant</td><td rowspan="2">FIPAG at Central Level</td><td>NamWater</td></tr>
<tr><td>Improvement and expansion of water distribution network</td><td>Municipality</td></tr>
<tr><td rowspan="2">O&M organization to be supported by technical cooperation</td><td>Seawater desalination plant</td><td rowspan="2">FIPAG at Regional / Municipal Level</td><td>NamWater</td></tr>
<tr><td>Water distribution management and services</td><td>Municipality</td></tr>
</table>

Source: Survey Team

14.2 Project Implementation and O&M by PPP

As described before in this chapter, the seawater desalination projects for public water supply tend to be implemented under the long-term concession with private sector investment. With an initiative of Japanese ODA, a possible manner of the project implementation and O&M for PPP is considered hereunder.

When the project for construction of seawater desalination plant and succeeding O&M is designed in the manner of public-private partnership (PPP), the project will be implemented in such manners that the private entity will conduct construction of the seawater desalination plant and O&M by contract with the government and the off-taker (water utility) and perform bulk water supply to sell water to the off-taker from the plant.

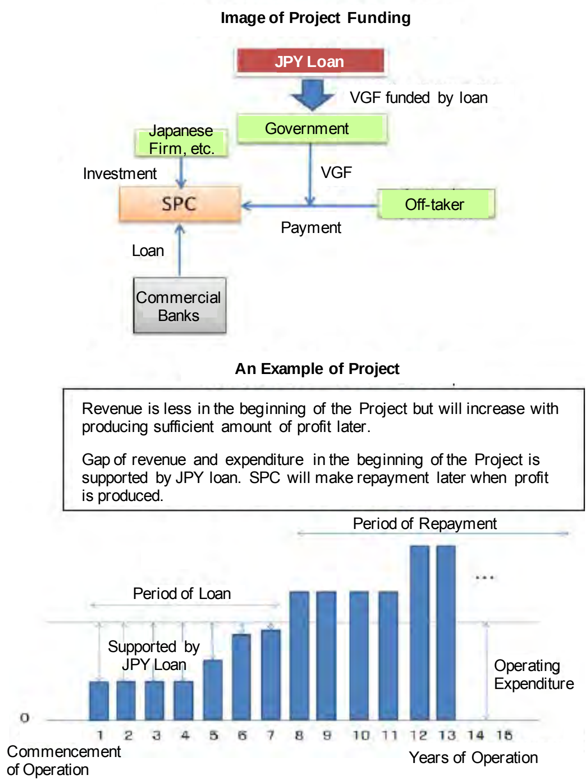
As the private entity needs to recover the initial investment and O&M costs and ensures the profits, the period of the contract will last for a long-term in general (e.g., more than 20 years). The special purpose company (SPC) financed by private investor will be responsible for the construction of seawater desalination plant and succeeding O&M.

The SPC will manage the seawater desalination plant and associated water transmission main up to the connection point with the existing water distribution network. The off-taker will operate the existing water distribution network from the connection point for supplying water eventually to water consumers.

Under the project implementation and O&M of PPP, the SPC will need to ensure its profits through water revenues received from the off-taker in accordance with the bulk water supply contract. However, many of urban water utilities in Sub-Saharan Africa have the financial problems such as low water tariff, insufficient revenue collection, and high rate of NRW, which are the major constraints on the private sector participation.

In recent years, as the comprehensive assistance by Japanese ODA loan for PPP infrastructure development has been established to use a loan for the purpose of risk management to support the government (borrower) and off-taker. Within the comprehensive assistance, Viability Gap Funding (VGF) shown in Figure 14.5 aims at providing a loan for the government of developing country in order to stabilize off-taker’s cash flow during the period of PPP project, which is not sufficiently affordable for financing by commercial capital. VGF is applicable for infrastructure projects including power, water, transportation, etc. sponsored by Japanese firm in principle[3].

VGF is a possible measure to build a financial plan for promoting PPP project to construct seawater desalination plant. Financial plan of the project for seawater desalination plant is based on a prospect that revenue from water supply will increase for medium- to long-term. Water production cost by seawater desalination is more expensive than cost for supplying water from the conventional water sources. In the initial stage of water supply by seawater desalination plant, the actual water tariff may not keep up with the financial plan if water demand does not increase as forecasted. In such a case, the off-taker needs to cover the shortage of revenue by subsidy from the government for the payment to the SPC. VGF is considered as effective for supporting financial arrangements by the government and off-taker.



Source: Reform of Economic Cooperation (as of June 2014), Ministry of Foreign Affairs, Ministry of Finance, and Ministry of Economy, Trade and Industry, Japan

Figure 14.5 Image of VGF

In application of VGF, the source of repayment for VGF should be produced by improving the off-taker's cash flow in surplus during the period of project. To achieve the improvement of the cash flow, the revenue from water charge should catch up with the project financial plan. For this purpose, the off-taker should improve water distribution volume, billed water volume, and revenue collection rate as well as its performance of service in order to set up water tariff to meet the water production costs. Therefore, VGF may need to collaborate with the technical cooperation by Japanese and/or other donors' ODA for off-taker to improve its operational and financial performance.

14.3 Opportunity for Japanese Firm

14.3.1 Issues on Japanese Firms to Participate in Seawater Desalination

It is not easy for Japanese firms to enter the seawater desalination project financed by Japanese ODA loan. When the project implementation including O&M is designed as EPC (DBO), the competitors are the international water business firms to handle any of business domains and also to have the technology and cost competitiveness based on their accumulated knowledge. In addition, a number of other firms also enter the water business and accelerate the competition in terms of bid prices.

[3] Reform of Economic Cooperation (as of June 2014), Ministry of Foreign Affairs, Ministry of Finance, and Ministry of Economy, Trade and Industry, Japan

The international water business by Japanese firms is divided into three domains: (i) business operations, maintenance, and management by general trading firms; (ii) equipment design, assembly, and construction by plant manufacturers; and (iii) members, parts, and equipment manufacturing by water treatment equipment manufacturers.

Japanese general trading firms have many achievements of the concession in the IWPP including seawater desalination plant in the Middle East. But their manner to entering the IWPP is mainly by capital participation. As the general trading firms also have experiences as EPC contractor in international infrastructure projects, they will be able to enter the seawater desalination project by Japanese ODA loan but require the partner firms for the technical fields. To win the competitive bidding against the foreign firms, the general trading firms are not necessarily to join with Japanese plant manufacturer and/or water treatment equipment manufacturer.

Japanese plant manufacturers have experiences of the IWPP in the Middle East as EPC contractor and have high technical capability. But they fall behind the international water business firms in terms of experiences in seawater desalination project. In addition, the plant manufacturers are faced with the price competition with emerging water business firms and their business environment stays in a tough situation. Moreover, the plant manufacturers have less experience in the domain of business operation, maintenance and management often adopted for seawater desalination projects under the concession. It is pointed out that they cannot pass the prequalification of bidding for the concession because of their less experience[4].

Japanese water treatment equipment manufacturers account for the large share of the products such as reverse osmosis membrane, filtration membrane, high-pressure pump with their advanced technologies and cost competitiveness in the global market. On the other hand, they are often affected by the price competition and forced to lower their prices by emerging concessionaire or EPC contractor. Moreover, emerging equipment manufacturers are catching up with the technology and price competitiveness, it is not easy for Japanese water treatment equipment manufacturers to keep a superior position[5].

Besides it is pointed out that Japanese firms have the high capability of ‘partial optimization’ in each of the domains but cannot take advantage against the international water business firms to propose ‘overall optimization’ based on the integration of the whole water supply system[6].

It should be noted that different approaches by business domain need to be taken for promoting opportunities for Japanese firms. For enhancing the advantageous qualifications of Japanese firms, the approaches should be studied with due consideration of the current situations of Japanese firms involved in seawater desalination projects as shown in Table 14.8.

---

[4] Issues and Approaches for International Water Business, April 2010

[5] -ditto-

[6] Present State and Issues on Water Business - Focusing on the Business Process Model - Waseda Business School (WBS) Research Center (2014)

Table14.8 Involvement of Japanese Firms in Seawater Desalination Projects

Japanese Firm	Business Domain	Opportunity	Status
General Trading Firms	Business Operations, Maintenance, and Management	Concession (Investment)	The general trading firms have experiences of the concession but require business partner for technical fields.
Plant Manufacturers	Equipment Design, Assembly, and Construction	EPC Contract	The plant manufacturers are involved in the consortium lead by concessionaire as business partner or EPC contractor.
Water Treatment Equipment Manufacturers	Manufacturing Members, Parts, and Equipment	Supply Contract	The water treatment equipment manufacturers supply their products for the concessionaire or EPC contractor and respond to replacement demands.

Source: Survey Team

14.3.2 Approaches for Promoting Opportunities for Japanese Firms

(1) Project by Japanese ODA Loan

The Export Strategy for Infrastructure Systems (updated as of May 23, 2016)[7] describes that Japanese firms are late in advancing their business to Africa behind European, Chinese, and South Koran firms and it is important to promote Japanese firms' attentions and support their business opportunities in Africa in order to attain successful cases as much as possible.

In promoting involvement of Japanese firms in the seawater desalination project to be financed by Japanese ODA loan, measures need to be taken for keeping the advantageous qualifications of Japanese firms against the foreign firms from the planning stage of the project. It is essential to create the borrower's understanding that the project implementation by Japanese ODA is more effective. Approaches are expected to emphasize that the Japanese products and services such as planning, design, construction, O&M and management to be integrated are the most beneficial for the borrower.

1) Strengthening Presence of Japanese ODA in Water Sector

It should be noted that the seawater desalination is not an issue on individual locality but is justified through the region-wide discussions on sustainable water resources and water demand. The viability of seawater desalination is clarified on the conditions that: (i) the water demand is not satisfied with the maximum use of sustainable surface water and groundwater, or (ii) the feasibility of dam reservoir with distant water conveyance is not expected. In order to strengthen the presence of Japanese ODA, the potential project for seawater desalination should be identified through the approaches to the administrative framework of the water sector in the target country for recognizing the region-wide issues on water resources and water demand. In addition, the potential project should be promoted based on the concept of 'overall optimization' focusing on the value chain of the water sector.

- The technical cooperation by Japanese ODA will be carried out in the locality or region where the need for seawater desalination project takes place in the mid- and long-term. The technical cooperation will include the regional water resources assessment for planning long-term water supply development and master plan for water supply and sanitation (including seawater desalination and water recycling). In addition, a Japanese expert will be

[7] The 24th meeting of the Management Council for Infrastructure Strategy held at the Prime Minister's Office on May 23, 2016

dispatched as resident advisor to the decision-makers through follow-up of the outcomes of the technical cooperation. The involvement of Japanese ODA in the water supply management will also be strengthened through the technical cooperation for capacity development.

- The preparatory study on the project for seawater desalination to be assisted by Japanese ODA loan will be carried out for preparing the project implementation plan, focusing on the overall optimization for the whole water supply system from the comprehensive view of technical, financial, social and environmental aspects. The preparatory study will also aim at approaching key organizations in the borrower's country for their better understandings on Japanese products and services to contribute to the better performance of the whole water supply system.

2) Validating Performance of Japanese Technology

Focusing on the need for seawater desalination project in mid- and long-term, the following approaches are envisaged seeking the utilization of Japanese technologies for seawater desalination.

- A pilot plant will be introduced and operated firstly by Japanese ODA for accumulating detail knowledge. The introduction of the pilot plant also aims at validating the performance of Japanese technology and ensuring the advantages for the introduction of full-scale seawater desalination in the future.
- When the urgent need for seawater desalination is identified, a small scale seawater desalination project will be prepared and implemented by Japanese grant aid[8]. In line with the grant aid, the full-scale project by Japanese ODA loan is promoted for the succeeding implementation.

3) Assuring Project Works' Quality by Japanese Technology

Japanese consultants will be involved in the engineering services for the seawater desalination project assisted by Japanese ODA loan. In the process of the engineering services, further details regarding the comprehensive advantages of Japanese products and services will be explained to the key organizations in the borrower's country. The recommendations by Japanese consultants will ease the key organizations to prepare the procurement conditions for assuring project works' quality as exampled below.

- Pre-qualification of applicants will be performed precisely for avoiding low quality of project due to low-pricing bidders.
- Life-cycle cost will be taken into consideration for bid evaluation.
- Requirements of non-price attributes including efficiency and compatibility of products, schedule management, quality management, safety management, environmental impact mitigation, after sales service, etc. will be emphasized as appropriate for assuring project works' quality.

[8] Construction cost for seawater desalination plant with a capacity of 2,500 m^3/day is estimated about ZAR 90 million (JPY 690 million) in Durban, South Africa.

(2) Project by PPP

There are already some cases of the seawater desalination projects financed or expected by Japanese ODA loan. But the seawater desalination projects that have been implemented in the manner of the concession with private sector investment are increasing and the international market in such manners is expanding in the future. Therefore, future projects for introduction of seawater desalination plant to public water supply will be implemented mainly in the manner of PPP. Possible measures for promoting seawater desalination project in the manner of PPP need to be taken together with the involvement of Japanese firms.

A manner of project implementation commonly applicable for PPP is that the private firm wins bid to have a concession, establish a special purpose company (SPC) to implement construction of seawater desalination and O&M by their own investment, and sell bulk water from the plant to off-taker. For getting the concession, it is inevitable for Japanese firm to overcome the competition with the international water business firms, not only the major firms having historical experiences and knowledge for the concession but also the emerging firms bidding competitive prices.

Regarding the concession, International Challenges and Measures for Development of Water Business (April 2010) describes that Japanese firms need to accumulate experiences in the domain of business operations, maintenance and management through (i) joint investment with foreign firm, (ii) M&A of foreign firm, (iii) participation in comprehensive privatization of water supply services in Japan. The general trading firms, plant manufacturers, and water treatment equipment manufacturers are making efforts in their business domains, respectively. However, except for the IWPP in the Middle East, there are few cases that Japanese firm participates in the concession of seawater desalination plant introduced to public water supply.

The general trading firms having the experiences of IWPP are bidding on the concession of seawater desalination plant but their partners in technical field are not necessarily Japanese firms. For winning the bid, the general trading firms are likely to join with the foreign firms having experiences and cost competitiveness. It is not easy to find out any effective way to extend the Japanese technologies (plant and water treatment) in the PPP of seawater desalination project under the current situation. For seeking the involvement of Japanese ODA, the following approaches can be envisaged in addition to those described in (1) Project by Japanese ODA Loan.

- The seawater desalination project will be prepared in the manner of the preparatory study for PPP infrastructure project assisted by Japanese ODA loan. In the process of finalizing the project implementation plan that may include supports such as VGF and/or improvement of water distribution, Japanese ODA will keep its presence in order to ensure the comprehensive advantages of Japanese products and services to be incorporated in the project.
- The grant aid scheme (or loan[9]) for assisting the concession will be utilized. The main works of the project comprise the seawater desalination plant by Japanese firm and water transmission and distribution mains by the grant aid. The Japanese firm performs the O&M of the seawater desalination plant as well. It should be noted that the feasibility of seawater desalination plant needs to be scrutinized carefully before application of the grant aid scheme.

[9] Proposed by Follow-up Measures of "Partnership for Quality Infrastructure" on November 2015

When the project for seawater desalination is realized in this manner, the Japanese water utilities having the knowledge of the long-term O&M for water supply system can be involved in the project in addition to general trading firms, plant suppliers, and water treatment equipment manufacturers. In mid- and long-term, this manner will also support Japanese firms to accumulate the experiences of the concession and strengthen their competitiveness in the global market.

On the other hand, Japanese plant manufacturers and equipment manufacturers may need to reconsider their business strategy when they participate in PPP project. They are focusing on development of advanced technologies for keeping their competitiveness against foreign firms. It is anticipated that they would be faced with the problem of 'high-quality with high cost' resulting from the sole development of advanced technologies as many competitive players enter into the global market. When many of qualified products are supplied in the global market, 'high-quality with high-price' will cause the loss of competitiveness as the clients consider mainly prices rather than advanced technologies in selecting products. In addition to the development of advanced technologies, the manufactures may need to offer products and services in conformity of the client's requirement. Focusing on the targeted region and/or countries, such a way of business can be developed through establishment of foreign branch and alliance with local firm and/or firm specialized for foreign business.

(3) Guidelines for Procurement

Guidelines for Procurement under Japanese ODA Loans describe the following as a note for Section 5.06 Evaluation and Comparison of Bids.

> Under Japanese ODA Loans, the use of the Merit Point System, according to which price and technical factors are given relative weights, and the bid that obtains the highest point total is selected, is not accepted in principle. Evaluation using Merit Point System tends to be subjective since no objective or impartial rule has been established for the allocation of weights to price and technical factors. These Guidelines require the Borrowers to set clear technical specifications and to compare bids which conform to the technical specifications on the basis of their evaluated cost. The Merit Point System does not conform to this requirement.

The Merit Point System, as introduced by the Ministry of Land, Transport, Infrastructure and Tourism (MLIT), Japan for quality assurance of public works[10], is not applicable for Japanese ODA loan project.

For implementing Japanese ODA loan projects, the implementing agency in the borrower's country, JICA, and Japanese consultants are carrying out the discussions about the procurement conditions for main works in order to ensure quality control and scheduled completion. However, Japanese firms having qualifications sufficient for the procurement conditions cannot win the bid due lower price offered by other country's competitor in many cases. Problems on quality of works take place in some cases when such competitors are awarded with lower bid price. As the conclusion of bid is highly dependent on the offered price, the issues on the present Guidelines for Procurement need to be

[10] Guidelines for Application of Merit Point System to Works Procured by MLIT (March 2013)

discussed from the viewpoints of the effective use of Japanese technology and quality assurance for infrastructure development by Japanese ODA.

Japan Society of Civil Engineers (JSCE) is concerned about the situations that Japanese technologies are not effectively utilized for many of projects financed by Japanese ODA loan due to intensified pricing competitions with firms of other countries and infrastructure development investments jointly planned by Japan and borrower's country under Japanese ODA are not implemented as scheduled in terms of cost, time and quality[11]. JSCE is seeking the possible solutions for the above-mentioned situations by the new manners of project implementation; (i) a construction firm is appointed for collaboration with project owner for risk management from early stage of the project in order to minimize the costs and shorten the time for implementation[12], and (ii) a group of construction firms is appointed with a comprehensive agreement for pre-scheduled project contracts on a regional basis in order to conduct successive infrastructure developments[13].

---

11 Report by Subcommittee for Utilization of ODA, Realizing Long-term Investment for High-quality Infrastructure, June 2015, JSCE Construction Management Committee

12 Wrap-up Construction Service: WCS

13 Wrap-up Regional Agreement: WRA

Annexes

List of Personnel Attended in the Meetings with the Survey Team

South Africa

West Coast District Municipality	
Nic Faasen	Senior Manager, Water
Ben van der Merwe	
Saldahna Bay Local Municipality	
Smith Gerrit	Director, Engineering and Planning Services
Gavin Williams	Engineering and Planning Services Water & Sanitation Department
Junius N Minnaar	Engineering and Planning Services, Manager: Bulk Distribution (Water & Sewerage)
City of Cape Town	
Peter Flower	Director, Water and Sanitation
Development Bank of Southern Africa	
Godfrey Mwiinga	Program / Fund Manager, SADC Water Fund Program
Manuel Chidziva	Water Infrastructure Planner, Infrastructure Delivery Division
Boitumelo Helen Moatshe	Project Manager
Tomomi Tokuori	TICAD Advisor
eThekwini Municipality	
Speedy Moodliar	Senior Manager, Strategic Planning
Dhevan Govender	Senior Manager, Commercial & Business
Umgeni Water	
Kevin Meier	Planning Services Manager
Boodhoo Pravesh	Area Manager - North

Mozambique

DINAAS (National Directorate for Water Supply and Sanitation)	
Julieta Felicidade Paulo	Ex-Head of Department of water and Sanitation
GAZEDA	
Gil de Conceição Bires	Deputy General Director
FIPAG	
Fernanda Quintano	Director of Projects and Investment
Yazald Tayobe	Head of Department of Projects and Investment
ARA Centro-Norte	
Inocêncio Armado Escova	Director General

GAZADA Nacala	
Josê Joaquim Gonçalves Ferreira	Regional Delegation
FIPAG Nacala	
Agostinho A. Dava	Director of Operational Area of Nacala
Nacala Porto Municipality	
Evaristo Simoco	Councilor for Area of Institutional Development
Adelino Cobre	Director of Urban Service
Nacala-a-Velha District	
Francisco Selemane Viagem	Director of Infrastructure
Celestino Linha	Director of District Service for Economic Activity
EdM Nacala	
António Marunganhe	Director
Maritime Administration	
Martinho F. Mafumo	Administrator
FIPAG Regional North	
Elídio Biquel Kohossa	Director, Regional North
Roberto Maria	Coordinator, Department of Water Supply Zone

Namibia

MAWF	
Maria Amakali	Director
Victor Slinger	Deputy Director, Rural Water Supply Infrastructure Planning
Henry Beukes	Geohydrologist
NamWater	
Vaino Shivute	Chief, Executive Officer
Cliff Olivier	Chief, Water Supply Central
John Sirunda	Head, Research & Development
Hinasha Mbudje	Corporate Legal Advisor
Willem Venter	Senior Manager, Fixed Asset Management
Areva	
Tommie Gouws	Manager, Finance, Mining Business Group
Antony Kostopoulos	Plant Manager, Aveng Water
NamWater, Namib Office	
Erwin Shiluama	Area Manager
Koenie Koegelenberg	

Walvis Bay Corridor Group	
Thigipo Victor	Board Member / General Manager, Community & Economic Development, Municipality of Walvis Bay
Walvis Bay Municipality	
Frans Gonteb	General Manager, Finance
Andrei Burger	Acting Manager, Water Supply and Wastewater
Johannes Heita	General Manager, City Planning Division
Swakopmund Municipality	
Eckart Demasius	Chief Executive Officer
Dewald Duvenhage	General Manager, Engineering Services
Marco Swarts	General Manager, Corporate Services & Human Resources
NamPort	
Elzevir Gelderbloem	Port Authority Department, Executive, Port Authority
Hangana Seafood Ltd.	
Michael Viljoen	Project Manager
Namibian Uranium Institute	
Gabriele Schneider	Executive Director
NamPower	
Johannes K. Mukusuka	Senior Engineer, System Security and Planning
Gert Fourie	Engineer, Transmission System Planning
Paulina Kandari Iyambo	Trading Unit, Acting Senior Manager
Ministry of Finance	
Angelina N. Sinvula	Director, Asset Cash and Debt Management
Marten Ashikoto	Deputy Director, Cash and Debt Management

Angola

MINEA	
Alexandrina Pires	Senior Consultant, Environment
Elsa Ramos Sisas	
Provincial Government of Namibe	
Antonio Correia	Vice Governor
Arlindo Tavares	Director, Provincial Energy & Water Directorate

Bibliography

1 Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings, United Nations
http://unstats.un.org/unsd/methods/m49/m49regin.htm#africa

2 Website of Ministry of Foreign Affairs, Japan
http://www.mofa.go.jp/mofaj/area/index.html

3 Global Water Intelligence (GWI), DesalData.com
https://www.desaldata.com/

4 Desalination Market 2016, Global Water Intelligence

5 Causes of Problem on Water Resources
http://www.mlit.go.jp/mizukokudo/mizsei/mizukokudo_mizsei_tk2_000021.html

6 World Bank Open Data
http://data.worldbank.org/

7 United Nations, World Population Prospects, Key Findings and Advance Tables, 2015 Revision

8 World Bank, Population Estimates and Projections
http://datatopics.worldbank.org/hnp/popestimates

9 Thomas Brinkhoff: City Population
http://www.citypopulation.de

10 Website of Japan Meteorological Agency
http://www.data.jma.go.jp/gmd/cpd/monitor/normal/index.html

11 World Map of the Koppen-Geiger Climate Classification, Department for Farm Animals and Veterinary Public Health, University of Veterinary Medicine Vienna

12 AQUASTAT, FAO
http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

13 Website of Public-Private Partnership in Information Resource Center
http://ppp.worldbank.org/public-private-partnership/legislation-regulation/laws/ppp-and-concession-laws

14 The Research on the Cross-Border Transport Infrastructure: Phase 3, Final Report, March 2009, Japan International Cooperation Agency, PADECO Co., Ltd., Mitsubishi UFJ Research and Consulting Co., Ltd.

15 GRIPS African Industry Strategy, 3rd Study Meeting, The African Development Corridors Initiatives: Cases in East and Southern Africa, April 2009, Mitsubishi UFJ Research and Consulting Co., Ltd.

16 Preparatory Survey for Southern Africa Integrated Regional Transport Program, Final Report, March 2010, PADECO Co., Ltd., Mitsubishi UFJ Research and Consulting Co., Ltd.

17 Data Collection Survey for Economic and Industrial Development along Economic Corridors in Southern Africa, Final Report, May 2013, Japan International Cooperation Agency, PADECO Co., Ltd., Nippon Koei Co., Ltd.

18 Southern Africa Growth Belt Initiative Phase 2, Corridor Development for Economic Growth, March 2013, Japan International Cooperation Agency

19 Oil and Natural Gas Developments in West African Countries, May 2015, Japan Petroleum Energy Center (JPEC)

20 Oil and Natural Gas Developments in Equatorial South African Countries, July 2015, Japan Petroleum Energy Center (JPEC)

21 Analysis, East African Oil-producing Countries: Research for State-owned Company from the Viewpoints of Public Administration, May 2015, Japan Oil, Gas and Metals National Corporation (JOGMEC)

22 Current Status of Deep Sea Exploration and Development in East Africa (Mozambique, Tanzania and Kenya), May 2013, Japan Oil, Gas and Metals National Corporation (JOGMEC)

23 Analysis, Prospects for Potential Oil and Natural Gas Exporting Countries in East and Southern Africa, March 2015, Japan Oil, Gas and Metals National Corporation (JOGMEC)

24 Preparatory Survey Report on the Water Supply System Development Project in the Republic of Cape Verde, January 2011, Japan International Cooperation Agency, Toyo Engineering Corporation, INGEROSEC Corporation, UNICO International Corporation

25 The Preparatory Survey on Sfax Seawater Desalination Plant Construction Project in the Republic of Tunisia, Final Report, August 2015, Japan International Cooperation Agency, NJS Consultants Co., Ltd., INGEROSEC Corporation, Japan Techno Co., Ltd.

26 Republic of Senegal, Preparatory Survey on Mamelles Seawater Desalination Plant Construction Project, October 2015, Japan International Cooperation Agency, Nippon Koei Co., Ltd., CTI International Co., Ltd.

27 The Future of Water in African Cities: Why Waste Water? - Michael Jacobsen, Michael Webster, Kalanithy Vairavamoorthy (eds.), World Bank, 2012

28 World Ocean Atlas Climatology, National Oceanic and Atmospheric Administration (NOAA)

29 Sojitz Corporation, News Release, 24 April 2015

30 Website of the Govenment of Ghana
http://www.ghana.gov.gh/index.php/about-ghana/regions/greater-accra

31 Assessing Existing Water Demand and Supply Patterns and Reuse Options as Additional Sources of Water in the Greater Accra Metropolitan Area (GAMA), June 2013, Abbey Fenella Marilyn, University of Ghana

32 GAMA Technical Group Webinar June 2015
http://www.slideshare.net/AndreHead/gtg-webinar-june

33 Gov't To Address Water Deficit, 9th July 2014
http://www.accra.io/blogs/p/88492/govt-to-address-water-deficit

34 Public Utilities Regulatory Commission, Ghana, Press Release, Approved Electricity and Water Tariffs Effectve 14th December 2015

35 Journal of Urban and Environmental Engineering, Journal of Urban and Environmental Engineering, v.2, n.2, p.33-40, Runoff Estimates into the Weija Reservoir and Its Implications for Water Supply to Accra, Ghana, December 2008, Jerry S. Kuma and Donald N. Ashley, Department of Geological Engineering, University of Mines and Technology, Tarkwa, Ghana

36 Ghana, Greater Accra Metropolitan Area Sanitation and Water Project, May, 10, 2013, World Bank

37 Reform of Economic Cooperation (as of June 2014), Ministry of Foreign Affairs, Ministry of Finance, and Ministry of Economy, Trade and Industry, Japan

38 Issues and Approaches for International Water Business, April 2010, Study Group for International Water Business, Ministry of Economy, Trade and Industry, Japan

39 Stury Report on Trend of Global Water Market, March 2015, Ministry of Economy, Trade and Industry, Japan, Fuji Keizai Co., Ltd.

40 Present State and Issues on Water Business - Focusing on the Business Process Model - Shin'ya Nagasawa, Akihiro Imamura, Waseda University, 2014

41 Study Report on International Cooperation for Water Supply Sector, March 2015, Japan International Corporation of Welfare Services (JICWELS)

42 Proposed by Follow-up Measures of "Partnership for Quality Infrastructure" on November 2015, Ministry of Foreign Affairs, Japan

43 Guidelines for Application of Merit Point System to Works Procured by Ministry of Land, Transport, Infrastructure and Tourism, Japan, March 2013

44 Report by Subcommittee for Utilization of ODA, Realizing Long-term Investment for High-quality Infrastructure, June 2015, Construction Management Committee, Japan Society of Civil Engineers

Cote d'Ivoire

1 Project commissioned by the Ministry of Agriculture, Forestry and Fisheries of Japan, Fiscal 2013 Survey Project Report on Support in Development of Overseas Markets for Japanese Food Products and Food Industry, March 2014, Mitsubishi Research Institute, Inc.

2 Cote d'Ivoire, Infrastructure Map, March 2013, Japan External Trade Organization (JETRO) Abidjan Office

3 The Report on Data Collection Survey for Resuming ODA in the Republic of Cote d'Ivoire, April 2010, Japan International Cooperation Agency

4 Republic of Cote d'Ivoire, the Project for the Development of the Urban Master Plan in Greater Abidjan (SDUGA), Final Report, Japan International Cooperation Agency, Oriental Consultants Global Co., Ltd., Japan Development Institute, International Development Center of Japan Inc., Asia Air Survey Co., Ltd.

5 Master Plan Study on Integrated Water Resources Management in the Republic of Cote d'Ivoire, Final Report, January 2001, Japan International Cooperation Agency, Sanyu Consultants Inc., Katahira & Engineering Inc.

6 The Study on Agneby River Integrated Development and Management Project in the Republic of Cote d'Ivoire, Preparatory Study Report, October 2002, Japan International Cooperation Agency

7 Data Collection Survey on the Project for Development of Whalf Site of Sassandra City in the Republic of Cote d'Ivoire, Final Report, March 2014, Japan International Cooperation Agency, INTEM Consulting, Inc.

8 Reviewing of Climate in West and Central Africa to Inform Farming Systems Research and Development in the Sub-humid and Semi-arid Agroecologies of the Region, West and Central African Council for Agricultural Research and Development (CORAF/WECARD), 2011

9 The OPEC Fund for International Development (OFID), Côte d'Ivoire, Water Supply Project for Eastern Region in Côte d'Ivoire (Aboisso), Report of OFID Management to the Government Board, September 2014

10 USAID Country Profile, Property Rights and Resource Governance, Côte d'Ivoire, May 2013

11 Rapport de Gestion 2014, Société de Distribution d'Eau de Côte d'Ivoire (SODECI)

12 Comité National de Pilotage des Partenariats Public-Privé (CNP-PPP)
http://www.ppp.gouv.ci/home.html

13 Mécanismes de Financement du Secteur de l'eau Potable en Côte d'Ivoire, Office National de l'Eau Potable (ONEP), Ministère des Infrastructures Economique (MIE)

Angola

1 Macro-economy in Emerging Country 'WATCH', Angola Updates, July 2014, Japan Bank for International Cooperation (JBIC)

2 The Survey on Investment Environment in Angola, March 2012, Japan External Trade Organization (JETRO), Johannesburg Office

3 The Preparatory Survey on Rural Electrification Development Works in the Republic of Angola, Final Report, December 2011, Japan International Cooperation Agency, NEWJEC Inc.

4 The Survey on Investment Environment in the Republic of Angola, October 2012, Japan Oil, Gas and Metals National Corporation (JOGMEC)

5 Trend of Mining Industry in the World, 2014, Angola, Japan Oil, Gas and Metals National Corporation (JOGMEC)

6 The Basic Design Study Report on the Project for Emergency Rural Water Supply in Neighboring Provinces of Luanda in the Republic of Angola, May 2005, Japan International Cooperation Agency

7 Angola, National Adaptation Program of Action under the United Nations Framework Convention of Climate Change (UNFCCC), 2011

8 USAID, Angola Water and Sanitation Profile, 2010

9 An AMCOW Country Status Overview, Water Supply and Sanitation in Angola, Turning Finance into Services for 2015 and Beyond

10 Final Report, National Water Sector Management Project, Activity C, A Rapid Water Resources and Water Use Assessment for Angola, SWECO Grøner AS, March 2005

11 National Strategy Plan for Rehabilitation of the Hydrometric Network in Angola, Norwegian Water Resources and Energy Directorate, 2004

12 Resultados Preliminares do Censo 2014, Instituto Nacional de Estatístic

13 Empresa Pública de Águas de Luanda (EPAL)
http://www.epal.gv.ao/

14 Public-Private Partnerships in Angola, Clifford Chance LLP, April 2011

15 Public-Private Partnerships in Angola, Gabinete Legal Angola, PLMJ International Legal Network, March 2011

16 African Economic Outlook, Angola 2015, African Development Bank, OECD, UNDP

Namibia

1 Present Conditions of Logistics in Namibia, September 2012, Japan International Cooperation Agency, IMG Inc.

2 African Economic Outlook, Namibia, AfDB, OEDC, UNDP, 2015

3 Master Plan for Development of an International Logistics Hub for SADC Countries in the Republic of Namibia, Final Report, May 2015, Japan International Cooperation Agency

4 Infrastructure Financing in Namibia, Bank of Namibia, September 2014

5 JOGMEC News Release, July 31, 2015, Termination of Off-shore Exploitation Project by CIECO Namibia

6 Trend of Mining Industry in the World, 2015, Namibia, Japan Oil, Gas and Metals National Corporation (JOGMEC)

7 The Detailed Planning Survey Report on Master Plan for Development of an International Logistics Hub for SADC Countries in the Republic of Namibia, December 2013, Japan International Cooperation Agency

8 Water Supply to 2 million, The Namwater Perspective, Luther Rurika, 01 February 2013

9 Water Management in Namibia, Presented at Zaragoza Water Turbine, Sept 2008, by Abraham Nehemia (MSc, MBA), Under Secretary: Department of Water Affairs and Forestry, Namibia

10 Integrated Water Resource Management Plan for Namibia, Ministry of Agriculture and Forestry, August 2010

11 Data Collection Survey on the Namibia-Japan High-level Forum on Economic Development in the Republic of Namibia, Final Report, October 2011, Japan International Cooperation Agency (JICA), International Development Center of Japan Inc. (IDCJ)

12 Ministry of Trade and Industry, Namibia Public-Private Partnership Policy

13 PPP Country Paper, Submitted to SADC DFRC 3P, NETWORK Public-Private-Partnership Working Group, Axis Consulting, 2013

14 Proceedings of the Resilient Cities 2013 Congress, Session: B4 Adapting Urban Water Management, 4th Global Forum on Urban Resilience Adaptation, Bonn, Germany, 31 May - 2 June 2013, Presentation: Improving the bulk water supply to the town of Walvis Bay, Namibia, Burger, P.A.

15 Village-scale and Solar Desalination, Technology Experience in Namibia, Detlof von Oertzen and Robert Schultz, CuveWaters Papers, No. 4, July 2008

16 Global Water Partnership Alliance (GWPA), Case Study on Utilities’ Good Practices, Municipality of Walvis Bay, Namibia, May 2012

17 Handbook for Large-scale Solar Power Generation System, New Energy and Industrial Technology Development Organization (NEDO), Japan, March 2011

18 Water Resources Management Act, 2013

19 Integrated Water Resources Management Plan for Namibia, August 2010

20 Environmental Management Act 2007, Ministry of Environment and Tourism

21 Guide to Environmental Management Act, No 7 of 2007, Ministry of Environment and Tourism, Republic of Namibia, 2008

22 Namibia, Staff Report for the 2015 Article IV Consultation, September 2015, International Monetary Fund

South Africa

1 Basic Data, The Republic of South Africa, Ministry of Foreign Affair of Japan
http://www.mofa.go.jp/mofaj/area/s_africa/data.html#section4

2 African Economic Outlook, South Africa, AfDB, OEDC, UNDP, 2015

3 Study on Private-Initiative Infrastructure Projects in Developing Countries in FY2011, Study on High Speed Railway Project between Johannesburg and Durban in the Republic of South Africa, Final Report, February 2012, Ministry of Economy, Trade and Industry, Japan, Japan Railway Technical Service, Mitsubishi Research Institute, INC.

4 Metal Resources Report, Impact on Chromium and Manganese Production due to Power Shortage and Labor Disputes in the Republic of South Africa, September 2013, Japan Oil, Gas and Metals National Corporation (JOGMEC)

5 Trend of Mining Industry in the World, 2015, South Africa, Japan Oil, Gas and Metals National Corporation (JOGMEC)

6 Data Collection Survey on Railway Sector in the Republic of South Africa, Final Report, March 2013, Japan International Cooperation Agency (JICA), Japan International Consultants for Transportation Co., Ltd., Mitsubishi Research Institute, Inc.

7 National Water Resources Management Strategy, June 2013, Second Edition, Department of Water Affairs

8 2015 National Water Week Event, Launch of the WR2012 Website, Water Resource Planning in South Africa: An Overview, Protea Hotel, Centurion, 19 March 2015, Presented by: Dr. Ronnie McKenzie, WRP (Pty) Ltd.

9 Strategic Overview of the Water Sector in South Africa 2013, Department of Water Affairs

10 Department of Treasury, PPP Unit
http://www.ppp.gov.za/Pages/defaultold.aspx

11 Market Research and Analysis of the South African Water Sector, Research Compendium, PricewaterhouseCoopers, Published on the website of the Ministry of Economy, Trade and Industry, Japan, August 2015

12 West Coast District Municipality, Integrated Development Plan, 2012/2016, Review 3 Final, March 2015

13 Socio-economic Profile, West Coast District Municipality, 2015, Working Paper

14 Saldanha Bay IDZ Feasibility Study, Revision 1, October 2011

15 Saldanha Bay Industrial Development
http://sbid.co.za/

16 WC WSS Reconciliation Strategy, Status Report, October 2014

17 West Coast District Municipality, Water Master Plan, June 2013

18 State of Cape Town 2014

19 City of Cape Town, Draft Annual Water Services Development Plan Performance and Water Services Audit Report, FY 2015

20 Water and Sanitation Department, Business Overview, Peter Flower, Director: Water & Sanitation, February 2016

21 Umgeni Water, Annual Report 2014/15

22 Mitigation measures to ensure the short and long term sustainability of supply in Umgeni Water's operational area, October 2015, Kevin Meier - Manager of Planning Services at Umgeni Water

23 East Coast Desalination Plants, Desalination Community of Practice, Kevin Meier

24 ETHEKWINI MUNICIPALTY Water and Sanitation, Private Public Partnership

25 Public Private Partnership Manual, PPP Unit, National Treasury

Madagascar

1 e-NEXI, May 2014, Nippon Export and Investment Insurance (NEXI)

2 Trend of Mining Industry in the World, 2014, Madagascar, Japan Oil, Gas and Metals National Corporation (JOGMEC)

3 The Feasibility Study on Toamasina Port Development in the Republic of Madagascar, Final Report, December 2009, Japan International Cooperation Agency, The Overseas Coastal Area Development Institute of Japan, Echo Corporation, Ides Inc.

4 Preliminary Study for Expansion of Manandona Hydroelectric Power Station in Madagascar, Study Report, March 2009, Engineering and Consulting Firms Association, Japan, NEWJEC Inc.

5 Request for Proposal, Toamasina Port Expansion Project Implementation Support in the Republic of Madagascar, September 2009, Japan International Cooperation Agency

6 The Report on Data Collection Survey for Agriculture Sector in the Republic of Madagascar, June 2014, Japan international Cooperation Agency

7 Data on Major Inland Waters in Africa, FAO
http://www.fao.org/docrep/005/d0780b/D0780B04.htm

8 Rivers and Streams on Madagascar by M. Aldegheri, 1972

9 Global Water Partnership South Africa, IWRM Survey and Status Report: Madagascar, Mrs Perlive RAHAGA RABENITANY, CABINET L'ACTION, April 2009

10 JIRAMA Website
http://www.jirama.mg/

11 ANNUAIRE DU SECTEUR EAU POTABLE ET ASSAINISSEMENT 2013, Ministere de l'Eau

12 6th Rural Water Supply Network Forum 2011 Uganda, Rural Water Supply in the 21st Century: Myths of the Past, Visions for the Future, Long Paper, Title: Public-Private Partnerships in Madagascar: a promising approach to increase sustainability of piped water supply systems in rural towns, Jonathan Annis (CARE Madagascar), Gerald Razafinjato (Enterprise Sandandrano)

Mozambique

1 Mozambique Investment Guide, January 2015, Centro de Promoção de Investimentos (CPI), Japan International Cooperation Agency

2 The Feasibility Study on Smart-AHAT Gas Power Plant in Mozambique, October 2014, Mitsubishi Hitachi Power Systems, Ltd.

3 Trend of Mining Industry in the World, 2014, Mozambique, Japan Oil, Gas and Metals National Corporation (JOGMEC)

4 The Detailed Planning Survey on the Project for the Capacity Enhancement of Meteorological Observation, Weather Forecasting and Warning, November 2014, Japan International Cooperation Agency

5 The Preparatory Survey Report on the Project for Reinforcement of Transmission Network in Nacala Corridor, March 2015, Japan International Cooperation Agency, Oriental Consultants Global Co., Ltd., Tokyo Electric Power Services Co., Ltd.

6 The Report on Data Collection Survey for Disaster Management in the Republic of Mozambique, August 2013, Japan International Cooperation Agency

7 Mozambique, Country Water Resources Profile, NEPAD Water Centers of Excellence

8 The Preparatory Survey Report on Urgent Water Supply Program in the Republic of Mozambique, Japan International Cooperation Agency, August 2008, Kokusai Kogyo Co., Ltd.

9 Mozambique Country Water Resources Assistance Strategy: Making Water Work for Sustainable Growth and Poverty Reduction, Preliminary Publication, AFTWR, Africa Region, The World Bank, August 2007

10 USAID Country Profile, Property Rights and Resource Governance, Mozambique, February 2011

11 RELATÓRIO AO GOVERNO 2012, Conselho de Regulação do Abastecimento de Água (CRA)

12 International Growth Center, Working paper, Assessment of Public-Private Partnership in Mozambique, Ronald Fischer, Vasco Nhabinde, September 2012

13 The Report on Data Collection Survey for Nacala Corridor Water and Sanitation Sector in the Republic of Mozambique, January 2012, Japan International Cooperation Agency

14 Administração Regional de Águas do Norte
http://www.ara-norte.co.mz/index.php

15 Mozambique Infrastructure Related Information, Japan External Trade Organization (JETRO) Johannesburg Office, August 2015

16 Beira Urban Water Master Plan 2035 by Adam Morón, in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering at the Delft University of Technology, to be defined publicly on Thursday, May 8, 2014 at 4:00 PM

17 National Water Resources Management Project, Project Appraisal Document, World Bank, August 2011

18 The Preliminary Study for Master Plan Formulation on Nacala Special Economic Zone (ZEEN), Final Report, November 2008, Japan International Cooperation Agency, Mitsubishi UFJ Research and Consulting Co., Ltd.

19 MCA-Mozambique, Feasibility Study, Environmental & Social Impact Assessment, Design and Supervision of Water Supply, Sanitation and Drainage Improvements in Nacala, Mocuba and Gurúè and Water Supply Improvements in Monapo and Montepuez, Final Feasibility Study Report, City of Nacala, Volume I - Water, R.J. Burnside International Limited in association with Austral-COWI and Consultec, December 2010

20 Detailed Planning Survey Report on the Project for Nacala Corridor Economic Development Strategies in the Republic of Mozambique, January 2011, Japan International Cooperation Agency

21 The Preparatory Survey Report on the Project of Urgent Rehabilitation of Nacala Port Development in the Republic of Mozambique, November 2012, Japan International Cooperation Agency, ECOH Corp., Oriental Consultants Co., Ltd.

22 The Project for Nacala Corridor Economic Development Strategies in the Republic of Mozambique, Final Study Report, April 2015, Japan International Cooperation Agency (JICA), Oriental Consultants Global Co., Ltd., RECS International Inc., International Development Center of Japan, Kokusai Kogyo Co., Ltd., Eight-Japan Engineering Consultants Inc.

23 Development Situations of Drainage and Sewerage Sector and Water Resources, Japan External Trade Organization (JETRO) Johannesburg Office, December 2015

24 Urban Water Supply System and Investment Plan in the Northern Region, Japan External Trade Organization (JETRO) Johannesburg Office, March 2016

25 MCA-Mozambique, DNA, Nacala Dam Feasibility Study, Environmental and Social Impact, Assessment, Design and Supervision, Volume 5 Environmental Impact Assessment Report, July 2010, submitted by Jeffares & Green, Inc. in association with CONSENG and LAMONT

26 Investment Projects Taking into Account Priority Sequence, Sistama de Informação de Nampula (SINA)
www.sina.gov.mz

27 Feasibility Study on High-efficiency Coal-fired Power Plant in Mozambique, Study Report, March 2015, Ministry of Economy, Trade and Industry, Japan, Tokyo Electric Power Services Co., Ltd.

28 The Preparatory Survey Report on the Project for Training Health Workers in Nacala in the Republic of Mozambique, November 2015, Japan International Cooperation Agency, Matsuda Consultants International Ltd., INTEM Consulting, Inc.

29 Walmsley, B and Tshipala, K (2009): Handbook on Environmental Assessment Legislation in the SADC Region. Published on the web by the Southern African Institute for Environmental Assessment with funding from the Development Bank of Southern Africa. Windhoek, Namibia.

30 Mozambique, Water Services and Institutional Support Project II, Project Appraisal Document, March 8, 2016, World Bank

Tanzania

1 Macro-economy in Emerging Country ‘WATCH’, Tanzania: Its Potential and Future, January 2015, Japan Bank for International Cooperation (JBIC)

2 Ex-Ante Evaluation, Tenth Poverty Reduction Support Credit, Japan International Cooperation Agency

3 Ex-Ante Evaluation (Technical Cooperation for Development Planning), Project for Formulation of Power System Master Plan In Dar es Salaam and Review of the Power System Master Plan (2012), November 2015, Japan International Cooperation Agency

4 Trend of Mining Industry in the World, 2015, Tanzania, Japan Oil, Gas and Metals National Corporation (JOGMEC)

5 The Study on the Groundwater Resources Development and Management in the Internal Drainage Basin in the United Republic of Tanzania, Final Report, February 2008, Japan International Cooperation Agency, OYO International Corp., Kokusai Kogyo Co., Ltd.

6 Water Utilities Performance Review Report 2013/2014, Energy and Water Utilities Regulatory Authority, December 2014

7 Final Report, Assessment of Groundwater Availability and Its Current and Potential Use and Impacts, Report Prepared for the International Water Management Institute (IWMI), by Dr. Japhet J. Kashaigili, Sokoine University of Agriculture, P.O. Box 3003, MOROGORO, TANZANIA, December 2010

8 The Detailed Planning Survey Report on the Study on Water Resources Development and Management in Wami/Ruvu Basin in the United Republic of Tanzania, December 2010, Japan International Cooperation Agency

9 Tanzania Water Supply and Sanitation Act (2009)

10 An AMCOW Country Status Overview, Water Supply and Sanitation in Tanzania, Turning Finance into Services for 2015, and Beyond

11 Website of Tanzania Investment Centre (TIC)
http://www.tic.co.tz/menu/314

12 Water Papers, No 69032, April 2012, A Case Study of Public-Private and Public-Public Partnerships in Water Supply and Sewerage Services in Dar es Salaam, Researched and written by Thelma Triche, Managed and supervised by Mukami Kariuki and Midori Makino, AFTUW, Africa Region, The World Bank

13 The Detailed Planning Survey Report on Enhancement of Water Supply Management of Zanzibar Water Authority Phase 2, April 2011, Japan International Cooperation Agency

14 Project Outlines (Japanese ODA Loan), Zanzibar Urban Water Distribution Facilities Improvement Project, Ministry of Foreign Affairs, Japan

15 Development Partnership with the Private Sector, Potable Water for Zanzibar’s Poor, Small-scale Seawater Desalination is a Feasible Option for Clean Water Supply, GIZ

Mauritius

1 Basic Data, The Republic of Mauritius, Ministry of Foreign Affair of Japan
http://www.mofa.go.jp/mofaj/area/mauritius/data.html#section4

2 Digest of Road Transport and Road Accident Statistics 2014, Statistics of Mauritius, Ministry of Finance and Economic Development

3 Digest of Road Energy and Water Statistics 2014, Statistics of Mauritius, Ministry of Finance and Economic Development

4 Preparatory Survey Report on the Mauritius Meteorological Services Project in the Republic of Mauritius, November 2012, Japan International Cooperation Agency, Japan Weather Association, International Meteorological Consultant Inc.

5 Republic of Mauritius, Location
http://www.govmu.org/English/ExploreMauritius/Geography-People/Pages/GeographyPeople/Location.aspx

6 Mauritius Meteorological Services
http://metservice.intnet.mu/climate-services/climate-of-mauritius.php#

7 Water Sector of Mauritius - Opportunities, Challenges and Constraints, L. Juggoo, Director, Water Resources Unit, Ministry of Energy and Public Utilities

8 Water Account, Mauritius 2013, Statistics Mauritius, Ministry of Finance and Economic Development

9 Central Water Authority, Annual Report 2013

10 Website of Public-Private Partnership Unit
http://ppp.mof.govmu.org/English/Pages/default.aspx

11 Public-Private Partnerships in Mauritius (PPP Unit, 2011), The Commonwealth iLibrary, OECD
http://www.oecd-ilibrary.org/commonwealth/economics/small-states/public-private-partnerships-in-mauritius_smalst-2011-5-en

12 National Water Research Group (NWRG), Final Consultative Meeting of the National Water Research Group, February 2nd, 2012, Research Perspectives and Recommendation on Water Resources in Mauritius, Mauritius Research Council