REPUBLIC OF DJIBOUTI
DJIBOUTI ROADS AGENCY (ADR)

DATA COLLECTION SURVEY FOR STRENGTHENING LOGISTICS IN DJIBOUTI CITY

FINAL REPORT

FEBRUARY 2022

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

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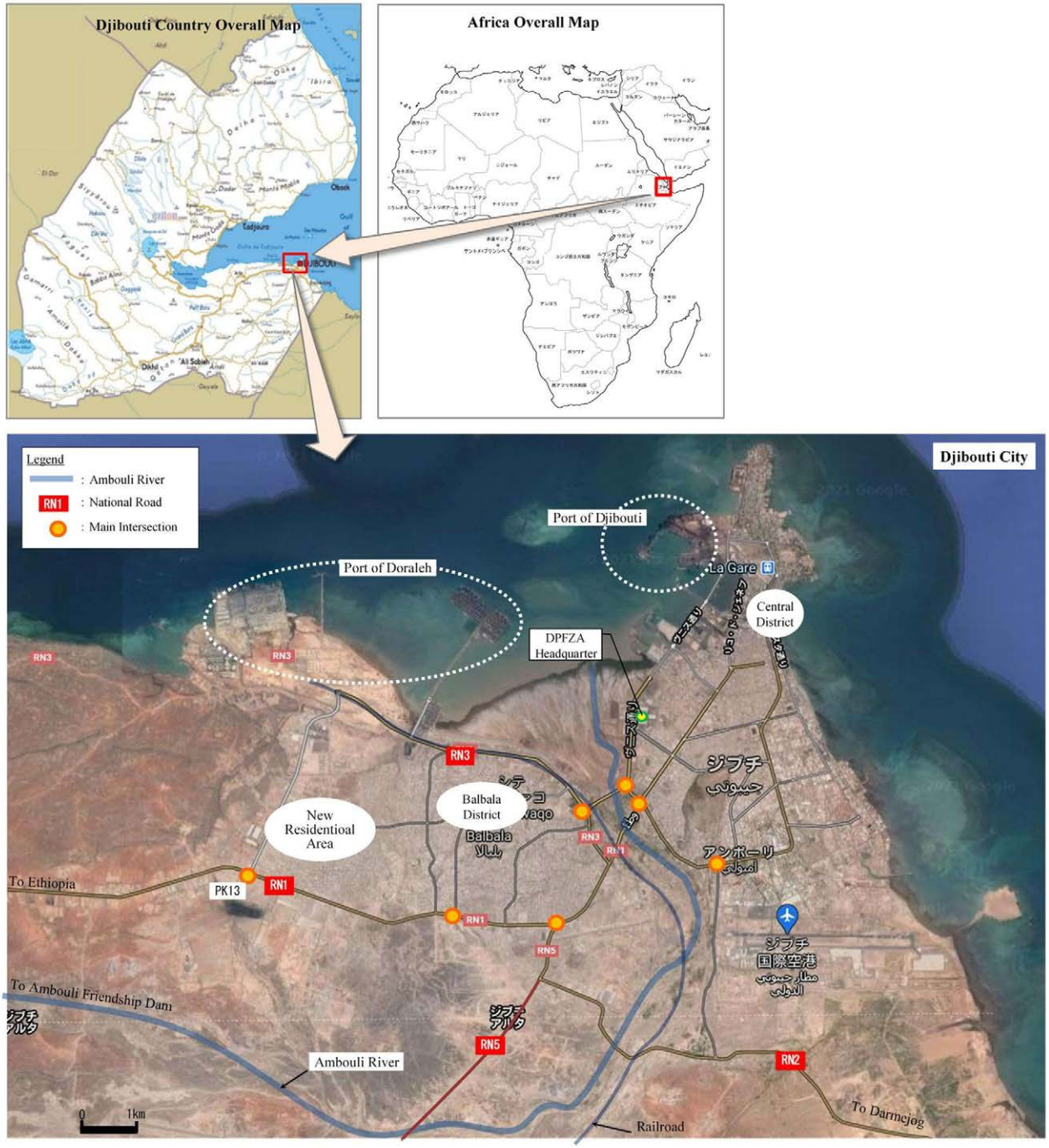
Exchange Rates: October, 2021

DJF	1.00	=	¥ 0.62833
USD	1.00	=	¥ 111.364

Survey Location Map



Basic Information on Target Country

- Country population: 974,000
  Djibouti City population: 569,000 [58.4%] (2019)
- GDP: USD 3.3 billion (2019)
- GDP per capita: 3,388 USD (2019)
- Economic growth rate: 7.7% (2019)

Source: https://data.worldbank.org/country/DJ

Field Survey Photo (1/4)

Port of Djibouti

Port of Doraleh

Darmerjog Industrial Park
(under construction)

Nagad Station

City Bus Usage

Ambouli River Flood Situation
（November, 2020）

Field Survey Photo (2/4)

Ambouli River Flood Situation
(Palmeraie Road)

Ambouli River Flood Situation
(Traffic Congestion)

Road Condition in Djibouti City
(Pavement Damage)

Road Condition in Djibouti City
(Unpaved, Stagnant Water)

Palmeraie Road Situation

Nagad Road Situation

Field Survey Photo (3/4)

FTZ Facility

Flower Park
（under construction, right bank of Ambouli River）

Italy Bridge
(Constructed in 1993)

Road Survey Status

Geological Survey Situation

Topographical Survey Situation

Field Survey Photo (4/4)

Kick-off Meeting with ADR
(16 May, 2021)

Meeting with Free Zone Authority
(24 May, 2021)

Interim Meeting with ADR
(15 June, 2021)

Meeting with Ministry of Equipment and Transport
(1 July, 2021)

Meeting with Meteorological Department
(30 August, 2021)

Reporting to the Director-General of ADR
(21 September, 2021)

DATA COLLECTION SURVEY FOR STRENGTHENING LOGISTICS IN DJIBOUTI CITY

Table of Contents

- Map of the survey Location
- Photos of the Site Survey
- Table of Contents
- List of Figures and Tables
- Abbreviation
- Summary of Survey Results

Chapter 1 Outline of the Survey 1-1

1.1 Background and Objectives of the Survey 1-1

1.1.1 Background of the Survey 1-1

1.1.2 Purpose of the Survey 1-2

1.1.3 Targeted Area 1-2

1.2 Description of the Survey 1-2

1.3 Composition of the Survey Team 1-2

Chapter 2 Outline of the Target Area 2-1

2.1 Natural Environment 2-1

2.1.1 Geographical Features 2-1

2.1.2 Climate 2-2

2.1.3 Geological Features 2-2

2.1.4 Survey of Natural Conditions 2-4

2.2 Socio-Economic Situation 2-10

2.2.1 Population 2-10

2.2.2 Industrial Structure 2-10

2.2.3 Import and Export Trend 2-11

2.3 Records of Natural Disasters 2-14

2.4 Understanding the Present Conditions of the Ambouli River 2-15

2.4.1 The Ambouli River Basin 2-15

2.4.2 Ambouli Friendship Dam 2-15

2.4.3 Countermeasures against Flood from the Ambouli River 2-19

Chapter 3 Present Status and Issues of the Transport and Road Sector 3-1

3.1 Present Status of the Road Network of Djibouti City 3-1
3.1.1 Present Status of the Road Network Development (Review of existing materials) 3-1
3.1.2 Present Status of Road Development (Road inventory survey) 3-4
3.1.3 Status of Traffic Regulations 3-15
3.2 Present Status of Road Traffic in Djibouti City 3-16
3.2.1 Implementation of the Traffic Volume Survey 3-16
3.2.2 Road Traffic Volume 3-17
3.3 Present Status of the Transport Sector of Djibouti City 3-19
3.3.1 Transport Administration 3-19
3.3.2 Present Status of the Transport Sector 3-21
3.3.3 Present Status of the Logistics Sector 3-27
3.3.4 Aid of Other Donors 3-27
Chapter 4 Flood Risk Analysis in the Target Areas 4-1
4.1 Risks due to Flooding in Ambouli River 4-1
4.1.1 Probable Flood Inundation Areas 4-1
4.1.2 Identifying the Flood Risks of the Ambouli River 4-2
4.2 Channel Conditions and Changes in the Ambouli River 4-3
4.2.1 River Channel Conditions after Completion of the Rehabilitation Project 4-3
4.2.2 Changes in the River Channel after the Completion of the Rehabilitation Project 4-4
4.2.3 Evaluation of the Discharge Capacity of the Existing River 4-5
4.2.4 Land Use of the Floodplain in the Ambouli River 4-6
4.3 River Improvement Plan in Ambouli River 4-8
4.3.1 Current Condition of Ambouli River and Policy for River Improvement 4-8
4.3.2 Hydrological Data Arrangements for River Improvement Plan 4-9
4.3.3 River Improvement Plan for Ambouli River 4-14
CHAPTER 5 Identification of Problems and Investigation of Counter- Measures Related to Strengthening Logistics of Djibouti City 5-1
5.1 Forecast of Future Traffic Demand 5-1
5.1.1 Methodology for Traffic Demand Forecast 5-1
5.1.2 Prediction Results 5-3
5.2 Issues in the Transportation and Logistics Network of Djibouti 5-4
5.3 Measures to Strengthen the Logistics Network in Djibouti 5-5

5.3.1 Strengthening the Logistics Network 5-5
5.3.2 Improving Urban Roads 5-5
5.3.3 Facilitating Urban Traffic 5-5
5.3.4 Planning for Flood Control 5-5
Chapter 6 Direction of Assistance by Japan 6-1
6.1 Direction of Assistance and Selection of Specific Measures 6-1
6.1.1 Direction of Assistance 6-1
6.1.2 Selection of Specific Measures 6-1
6.1.3 Selection of Priority Road Improvement Projects 6-3
6.2 Consideration of priority project plans 6-4
6.2.1 Examination of Palmeraie Road Measures 6-4
6.2.2 Examination of Related Improvement Plan 6-35
6.2.3 Examination of Cost Reduction 6-40
6.2.4 Project Evaluation 6-41
6.2.5 Summary of Measures for Other Projects 6-45
6.3 Strategies for Project Implementation 6-53
6.3.1 Consideration of the Project Scheme 6-53
6.3.2 Schedule for Project Implementation 6-55
6.3.3 Project implementation Issues 6-56
Chapter 7 Conclusion and Future Tasks 7-1
7.1 Conclusions 7-1
7.2 Future Tasks 7-2

Appendix

List of Figures and Tables

[List of Figures]

Figure 1.1.1 Land Use Overview of Djibouti City 1-1
Figure 1.3.1 Survey Implementation Structure 1-3
Figure 2.1.1 The Republic of Djibouti, Topographic Features of the Area around Djibouti City 2-1
Figure 2.1.2 Distribution Trend of Monthly Rainfall and Monthly Average Temperature 2-2
Figure 2.1.3 Flood damage in 2004 (National Road Route 1) 2-2
Figure 2.1.4 Flood damage in 2019 (Palmeraie Road) 2-2
Figure 2.1.5 Geographical Features of Djibouti City and its Surrounding Area 2-3
Figure 2.1.6 Progress of Topographic Survey (UAV-based) 2-5
Figure 2.1.7 Target Areas for the Topographic Survey 2-5
Figure 2.1.8 Results of the Topographic Survey 2-6
Figure 2.1.9 Progress of Geological Survey 2-7
Figure 2.1.10 Geological Survey 2-7
Figure 2.1.11 Outline of SPT Test, N Value and Stratum 2-8
Figure 2.1.12 Photo of Extracted Cores Showing Soil Property 2-8
Figure 2.2.1 Changes in the Population of the Republic of Djibouti 2-10
Figure 2.2.2 Ratio of Employed Population by Industry 2-11
Figure 2.2.3 Changes in GDP (US Dollar, nominal) and Growth Rate 2-12
Figure 2.2.4 Changes in Population and GDP per Capita (US Dollar, nominal) 2-12
Figure 2.2.5 Changes in Trade Balance (million DJF) 2-12
Figure 2.2.6 Countries from which Djibouti Imports (Top 10 Countries) 2-13
Figure 2.2.7 Import Weight by Partner Country 2-13
Figure 2.3.1 Flood Damages in 2004(National Road Route 1) 2-14
Figure 2.3.2 Flood Damages in 2019 (Palmeraie Road) 2-14
Figure 2.4.1 Map of the Entire Amboli Catchment Area and Location of the Friendship Dam 2-15
Figure 2.4.2 Ambouli Friendship Dam 2-16
Figure 2.4.3 Outline of the Reservoir of the Ambouli Friendship Dam (Completed in 2019) 2-17
Figure 2.4.4 Top View of the Ambouli Friendship Dam 2-17
Figure 2.4.5 Lateral Profile along the Axis of the Crestline of the Ambouli Friendship Dam 2-18
Figure 2.4.6 Ambouli Friendship Dam (Enlarged profile along the crestline) 2-18
Figure 2.4.7 Typical Cross-section of Ambouli Friendship Dam 2-18
Figure 2.4.8 Top View of the Flood Spillway of the Ambouli Friendship Dam 2-19
Figure 2.4.9 Vertical Profile of Flood Spillway of the Ambouli Friendship Dam 2-19
Figure 2.4.10 Profile of the Right Side Embankment Repair Work of the Ambouli River (No.1) 2-21
Figure 2.4.11 Profile of the Right Side Embankment Repair Work of the Ambouli River (No.2) 2-21
Figure 3.1.1 Completeley National Roads where Pavement Work is Completed 3-2
Figure 3.1.2 Current Road Network in the City of Djibouti 3-3
Figure 3.1.3 Routes Targeted in the Road Inventory Survey 3-4

Figure 3.1.4 Overview of Pavement Condition in Djibouti City 3-6
Figure 3.1.5 Overview of Drainage Condition in Djibouti City 3-7
Figure 3.1.6 Overview of Structure Condition in Djibouti City 3-8
Figure 3.1.7 Arrangement of Road Conditions (Road Width) 3-10
Figure 3.1.8 Arrangement of Road Conditions (Sidewalk) 3-10
Figure 3.1.9 Arrangement of Road Conditions (Median) 3-11
Figure 3.1.10 Arrangement of Road Conditions (Intersection) 3-11
Figure 3.1.11 Arrangement of Road Conditions (Culverts) 3-12
Figure 3.1.12 Arrangement of Road Conditions (High-Voltage Cable Towers) 3-12
Figure 3.1.13 Arrangement of Road Conditions (Road Bridges and Railroad Bridges) 3-13
Figure 3.1.14 Arrangement of Road Conditions (Existence of Lighting System) 3-13
Figure 3.1.15 Arrangement of Road Conditions (Pavement Condition) 3-14
Figure 3.1.16 Control of Illegal Parking Conducted by the Traffic Police (in CBD) 3-15
Figure 3.1.17 Examples of Traffic Regulation Signs in the City 3-15
Figure 3.1.18 Traffic Regulation Signs for Large-Sized Vehicles on the Italy Bridge 3-16
Figure 3.2.1 Sites of Traffic Volume Survey 3-16
Figure 3.2.2 City Road Traffic Volume 3-18
Figure 3.2.3 Traffic Congestion during Flooding 3-18
Figure 3.3.1 Estimated Future Population of the Republic of Djibouti and Djibouti City 3-19
Figure 3.3.2 Estimated GDP Growth of the Republic of Djibouti 3-19
Figure 3.3.3 Future Land Use Plan of the City of Djibouti 3-20
Figure 3.3.4 Volume of Imports Handled at the Port of Djibouti 3-21
Figure 3.3.5 Volume of Exports Handled at the Port of Djibouti 3-22
Figure 3.3.6 New and Old Railway Routes between the Port of Djibouti and Addis Ababa 3-22
Figure 3.3.7 Transition of Rail/Truck Transportation Sharing Ratio by Scenario 3-24
Figure 3.3.8 Djibouti City Bus Routes 3-25
Figure 3.3.9 Traffic Lights Installed in Djibouti City 3-26
Figure 3.3.10 Changes in the Truck Traffic Volume on the National Road Route 1 3-27
Figure 4.1.1 Probable Inundation Areas by Ambouli River Flooding 4-1
Figure 4.1.2 Probable Inundation Areas by Ambouli River Flooding 4-2
Figure 4.2.1 Photographs of the Ambouli River after Project (2009, No.1/3) 4-3
Figure 4.2.2 Photographs of the Ambouli River after Project (2009, No.2/3) 4-4
Figure 4.2.3 Photographs of the Ambouli River after Project (2009, No.3/3) 4-4
Figure 4.2.4 Comparison of the Conditions after the Ambouli River Improvement in 2008 and the current one in 2020 (Upstream Section of Italian Bridge) 4-5
Figure 4.2.5 Comparison of the Conditions after the Ambouli River Improvement in 2008 and the Current one in 2020 (Upstream Section of Riverbed Crossing Road) 4-5
Figure 4.2.6 Current River Discharge Capacity of the Ambouli River 4-6
Figure 4.2.7 Comparison of Land Use in the Upstream Section of the Italian Bridge of the Ambouli River .. 4-6

Figure 4.2.8 Comparison of Land Use in the Upstream Section of Riverbed Crossing Road of the Ambouli River 4-7
Figure 4.2.9 Current Conditions from Riverbed Crossing Road to Italian Bridge 4-7
Figure 4.2.10 Current Conditions of Downstream Section from the Italian Bridge 4-8
Figure 4.3.1 Flood Protection Areas and Ambouli River 4-9
Figure 4.3.2 Trend in Annual Maximum Rainfall (1980-2011) 4-10
Figure 4.3.3 Distributions of Annual Maximum Rainfalls and Regression Curve 4-11
Figure 4.3.4 Peak Water Level for Flood Mark (4.7m) in 2019 Flood Event 4-13
Figure 4.3.5 Elevation (H)-Discharge (Q) Curve and Estimated Peak Discharge based on Water Level 4-13
Figure 4.3.6 Target Section of River Improvement Plan (Section Length: 4km) 4-14
Figure 4.3.7 Two (2) Alternatives Examined in River Improvement Plan 4-15
Figure 4.3.8 Design Discharge Distribution Plan for Two (2) Alternatives 4-15
Figure 4.3.9 Typical Cross Section for Alternative 1 A (Q=1,500 m^3/sec) 4-16
Figure 4.3.10 Typical Cross Section for Alternative 1B (Q=1,800 m^3/sec) 4-16
Figure 4.3.11 Typical Cross Section for Alternative 2 A (Q=1,160 + 360 m^3/sec) 4-17
Figure 4.3.12 Typical Cross Section for Alternative 2B (Q=1,160 + 640 m^3/sec) 4-17
Figure 4.3.13 Longitudinal Water Level Profiles for Alternative 1A (Q=1,500 m^3/sec) 4-18
Figure 4.3.14 Longitudinal Water Level Profiles for Alternative 1B (Q=1,800 m^3/sec) 4-18
Figure 4.3.15 Longitudinal Water Level Profiles for Alternative 2A (Q=1,160 +340 m^3/sec) 4-18
Figure 4.3.16 Longitudinal Water Level Profiles for Alternative 2B (Q=1,160 +640 m^3/sec) 4-19
Figure 5.1.1 Procedure of Traffic Demand Forecast 5-1
Figure 5.1.2 Changes in the Number of Registered Automobiles 5-2
Figure 5.1.3 Palmeraie Traffic Forecast 5-3
Figure 5.1.4 Italy Bridge Traffic Forecast 5-4
Figure 5.1.5 Nagad Traffic Forecast 5-4
Figure 6.1.1 Identifying the Direction of Support and Concrete Measures (draft) 6-2
Figure 6.2.1 Study Flow Palmeraie Road countermeasure 6-4
Figure 6.2.2 New Urban Planning Project at the Mouth of the Ambouli River 6-5
Figure 6.2.3 Facilities around Palmeraie Road 6-6
Figure 6.2.4 Current Conditions around Palmeraie Road 6-7
Figure 6.2.5 Detailed Status of FTZ Facilities 6-8
Figure 6.2.6 Detailed Status of Flower Park 6-8
Figure 6.2.7 High-voltage line layout 6-9
Figure 6.2.8 Typical Width of Planned Palmeraie Road 6-13
Figure 6.2.9 Type of Bridge on the Palmeraie Road (typical cross-section drawing, type comparison) 6-14
Figure 6.2.10 Outline of Plan (Alternative 1: Main Stream Improvement) 6-16
Figure 6.2.11 Outline of Plan (Alternative 2: Sub-stream Improvement) 6-17
Figure 6.2.12 Outline of Plan (Alternative 3: Main+Sub-stream Improvement) 6-18
Figure 6.2.13 Outline Drawing of the Countermeasures (Alternative 1: Main Stream Improvement) 6-19
Figure 6.2.14 Outline Drawing of the Countermeasures (Alternative 2: Sub-stream Improvement) 6-20

Figure 6.2.15 Outline Drawing of the Countermeasures (Alternative 3: Main+Sub-stream Improvement) .. 6-21
Figure 6.2.16 Image of the Palmeraie Road Countermeasure (Alternative 3) [1/2] 6-22
Figure 6.2.17 Image of the Palmeraie Road Countermeasure (Alternative 3) [2/2] 6-23
Figure 6.2.18 Palmares Road Phased Improvement Plan (draft) 6-25
Figure 6.2.19 Proposed Phased Improvement of the Palmeraie Road and Structural ReRsponse
(Alternative 1, Alternative 3) 6-26
Figure 6.2.20 Outline of Plan (Add. Alternative 1） 6-29
Figure 6.2.21 Outline of Plan (Add. Alternative 2） 6-30
Figure 6.2.22 Outline of Plan (Add. Alternative 3） 6-31
Figure 6.2.23 Outline drawing of the Countermeasures (Additional Alternative 2) 6-34
Figure 6.2.24 Palmeraie Road Intersection and Roundabout 6-35
Figure 6.2.25 Volume of the Traffic Passing Through the intersection
on the East Side of Palmeraie Road 6-36
Figure 6.2.26 Improvement Alternatives for the Eastside Intersection of Palmeraie Road. 6-37
Figure 6.2.27 Proposed Palmeraie Road Westside Intersection Improvement 6-38
Figure 6.2.28 Improvement Plan Drawing for the Eastside Intersection of Palmeraie Road 6-39
Figure 6.2.29 Outline of Cost Reduction Alternatives 6-40
Figure 6.2.30 Logistics lines and Traffic Survey Points in Djibouti City 6-42
Figure 6.2.31 Situation Around Nagad Road 6-46
Figure 6.2.32 Typical width of Nagad Road 6-47
Figure 6.2.33 Outline of the Nagad Road Countermeasure Plan 6-48
Figure 6.2.34 Situation Around Italy Bridge 6-49
Figure 6.2.35 Italy Bridge Construction Documents, Construction Photos, and Specifications 6-50
Figure 6.2.36 Overview of Measures for the Italy Bridge (new bridge construction) 6-52
Figure 6.3.1 Buried or Underground Obstructions 6-54

[List of Tables]

Table 2.1.1 Survey of Natural Conditions 2-4
Table 2.1.2 Quantitative Details of the Topographic Survey 2-4
Table 2.1.3 Quantitative Details of the Geological Survey 2-6
Table 2.1.4 Groundwater Level of Each Borehole 2-9
Table 2.2.1 GDP of Industry 2-11
Table 2.3.1 Summary of Major Floods and Disasters in Djibouti 2-14
Table 2.4.1 Specifications of the Ambouli Friendship Dam 2-16
Table 2.4.2 Outline of the Ambouli River Countermeasure Works Implemented following the 2004 Flood (FERP) 2-20
Table 3.1.1 Road Extension under ADR Management (as of June 2021) 3-1
Table 3.1.2 Total Length of National Roads under the Ministry of Infrastructure and Facilities (as of June 2021) 3-1
Table 3.1.3 Djibouti City Road Length in Charge of the Ministry of Infrastructure and Equipment (as of June 2021) 3-2
Table 3.1.4 Contents of Road Inventory Survey 3-5
Table 3.2.1 Contents of Traffic Volume Survey 3-16
Table 3.2.2 Results of Traffic Volume Survey (Sectional Traffic Volume) 3-17
Table 3.2.3 Comparison of 2014 and 2021 Survey Results 3-17
Table 3.3.1 Organizations Related to the Transport Sector 3-21
Table 3.3.2 Rail Service Operation Plans 3-23
Table 3.3.3 Number of traffic through Ambouli River (morning peak 1 hour) 3-26
Table 3.3.4 Number of traffic through Ambouli River (morning peak 1 hour) 3-26
Table 3.3.5 Donor Trends in Urban Development and Transport Sector in Djibouti 3-28
Table 3.3.6 Recent Grant Aid Projects to Djibouti 3-28
Table 4.1.1 Probable Discharge and Estimated Inundation Volume of Ambouli River (BCEOM) 4-1
Table 4.3.1 Annual Maximum Daily Rainfall (1980-2020) 4-10
Table 4.3.2 Results of Probability Calculation of the Annual Maximum Daily Rainfall (1980-2020) 4-11
Table 4.3.3 Return Period and Probable Daily Rainfall 4-12
Table 4.3.4 Synodic Monthly Average Tidal Levels in the Flood Seasons 4-12
Table 4.3.5 Probability Evaluation for Major Floods and Rainfalls in Djibouti 4-13
Table 5.1.1 Forecast of Ethiopian GDP Growth Rate 5-3
Table 5.1.2 Results of the Future Traffic Forecast 5-3
Table 5.2.1 Issues in the Transportation and Logistics Network of Djibouti 5-5
Table 5.3.1 Study of Countermeasures to Strengthen the Logistics Network in Djibouti City 5-6
Table 6.1.1 Evaluation of Concrete Measures (draft) 6-2
Table 6.1.2 Alternatives for the Improvement Roads Crossing the Ambouli River 6-3
Table 6.2.1 Basic Conditions for Palmeraie Road Countermeasures 6-5
Table 6.2.2 Proposed Palmeraie Road Countermeasures (1/2) 6-10
Table 6.2.3 Proposed Palmeraie Road Countermeasures (2/2) 6-11

Table 6.2.4 Comparison of the Palmeraie Road Measures for Preliminary Selection 6-12
Table 6.2.5 Summary and Evaluation of the Alternatives for Palmeraie Road Countermeasures 6-15
Table 6.2.6 Palmeraie Road Improvement Issues and Additional Alternativess..... 6-27
Table 6.2.7 Summary and Evaluation of the Additional Alternatives
for Palmeraie Road Countermeasures..... 6-27
Table 6.2.8 Estimated Project Cost（Palmeraie Road） 6-33
Table 6.2.9 Results of the Calculation of the Saturation at Intersection (current situation)..... 6-36
Table 6.2.10 Proposed Improvement Measures for the Eastside Intersection of Palmeraie Road 6-38
Table 6.2.11 Storage Length at Each Approach..... 6-38
Table 6.2.12 List of Cost Reduction Alternatives 6-40
Table 6.2.13 Cost Breakdown of Cost Reduction Alternatives..... 6-41
Table 6.2.14 Results of Traffic Volume Survey on Logistics Main Road (cross-sectional traffic volume) .. 6-42
Table 6.2.15 List of Economic Analysis Results 6-45
Table 6.2.16 Estimated Project Cost（Nagad Road） 6-47
Table 6.2.17 Comparison of Basic Countermeasure Plans for Italy Bridge..... 6-51
Table 6.3.1 Items of Undertakings by Djibouti Side on each Project Phase 6-54
Table 6.3.2 Draft Schedule for Project Implementation..... 6-55

Abbreviation

Abbreviation	English / *French*
ADETIP	*Agence Djiboutienne de travaux d'intérêt public*
ADDS	*Agence Djiboutienne de Développement Social*
ADR	*Agence Djiboutienne des Routes*
AFD	*Agence Française de Développement*
BCD	*Banque Centrale de Djibouti*
BRT	Bus Rapid Transit
CBD	Central Business District
DHA	Department of Humanitarian Affairs
DISED	*Direction de la Statistique et des Etudes Démografiques*
DJF	*Djibouti Franc*
DPCR	Djibouti Ports Corridor Road
DPFZA	Djibouti Ports and Free Zones Authority
EDD	*Électricité De Djibouti Agence Palmeraie*
EU	European Union
FERP	Flood Emergency Rehabilitation Project
FRUD	*Front pour la Restauration de l'Unite et de la Democratie*
FTZ	Djibouti International Free Trade Zone
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
HWL	Hight Water Level
JICA	Japan International Cooperation Agency
LRT	Light Rail Transit
MAWFLFR	*Ministre de l'Agriculture, de la Pêche, de l'Elevage et des Ressources Halieutiques*
NMA	National Meteorological Agency
ODA	Official Development Assistance
ONEAD	*Office National de l'Eau et de l'Assainissement de Djibouti*
PAID	*Port Autonome International de Djibouti*
PC	Prestressed Concrete
PID	Project Information Document
SCAPE	Strategy of Accelerated Growth and Promotion of Employment
SDAU	*Schéma Directeur d'Aménagement Urbain de Djibouti ville*
SLSC	Standard Least-Squares Criterion
SPT	Standard Penetration Test
TICAD	Tokyo International Conference on African Development
WB	World Bank

Summary of Survey Result（Final Report）

1. Outline of the Target Area

Topography and Geology

The Republic of Djibouti is a country located along the Red Sea coast and at the north end of the African Great Rift Valley, bordering Eritrea in the north, Ethiopia in the west, Somaliland in the south and the Gulf of Aden in the east. The country is facing the Gulf of Aden, while, more precisely, its land area is located at the mouth of the Gulf of Tadjoura that cuts into Djibouti's land area from the east to the west.

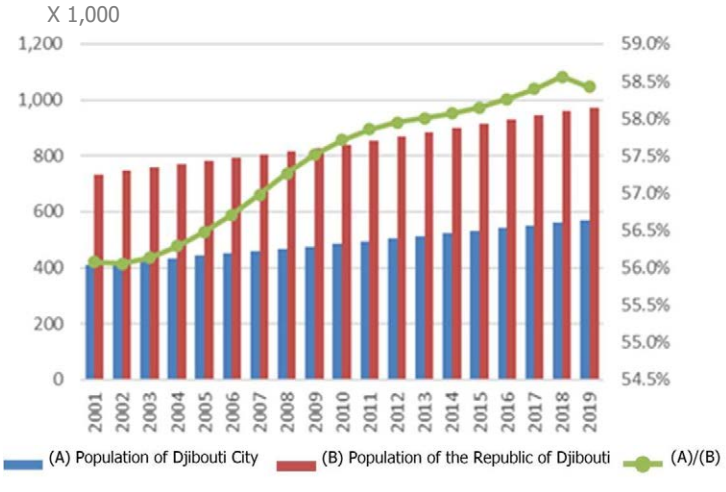
The Ambouli River flowing through Djibouti City has its source in the mountainous area in the western part of the country with elevation of over 500m above the sea level. The river runs toward the east at the west side of the city, collecting water from a number of branch streams and changes its course more to the north at a point about 6km east of Chabelley Airport to flow into the Gulf of Aden. The river has large alluvial floodplain terrains and forms a large delta near its river mouth.

Djibouti City has two different terrains on its east and west sides divided by the Ambouli River. On the east side, there is a flat land of 5 to 15m above the sea level, while the west side has a stretch of lava plateau of several tens to several hundreds of meters above the sea level (mountainous area). The plateau on the east side of the river shows a ridge-line pattern that indicates the flow direction of lava(Figure-1).

Figure-1 Natural Environment in Djibouti

Population and GDP

The population of the Republic of Djibouti is about 974,000 as of 2019, of which, 569,000 (58.4%) live in Djibouti City (World Development Indicators) [1]. Although the concentration of population in Djibouti City had been progressing for some time, it dropped for the first time in 2019 compared to the previous year, and Djibouti City seems to become stable in terms of population concentration. Figure-3 shows GDP (in nominal US dollar) and its growth rate. The country's economy has been developing well except for an economic fall experienced due to the breakout of the civil war in 1990s. The growth rate has slowed down since 2013, although a minor recovery could be seen in 2019.



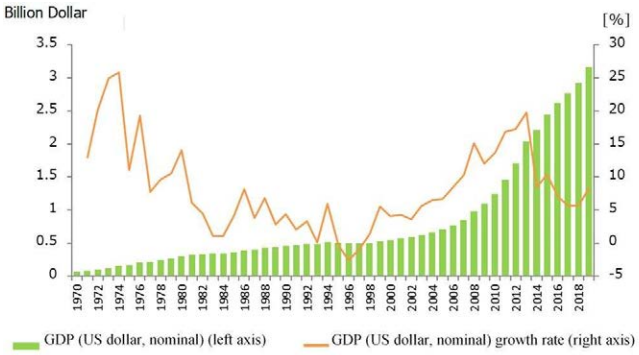
Source: World Development Indicators (World Bank)

Figure-2 Changes in the Population of the Republic of Djibouti

[1] No extensive population census has been conducted in the Republic of Djibouti since 2009 and population data of recent years are all estimate. The Department of Statistics and Demographic Studies of Djibouti publishes estimated population but somewhat difference can be seen between the two (World Development Indicators: 929,111, DISED: 992,635).

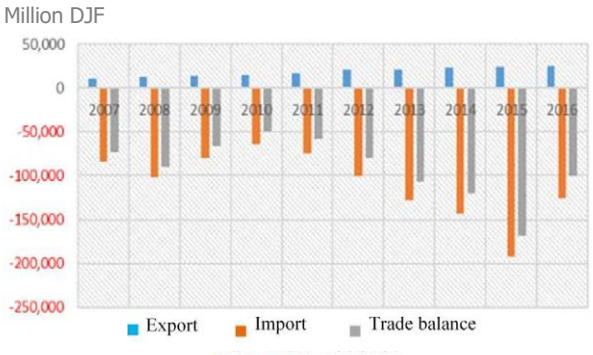
Import and Export

Figure-4 shows countries from which Djibouti imports, in value terms. Three countries, China, UAE and Ethiopia, account together for nearly a half of the total imports. Excluding Ethiopia, all imports are made via sea through the Port of Djibouti, showing the important role of the port. Figure-5 shows import from the same countries in terms of weight, and Ethiopia accounts for more than one third of the total. Imports from Ethiopia are made by land, showing the importance of the Djibouti-Ethiopia corridors.



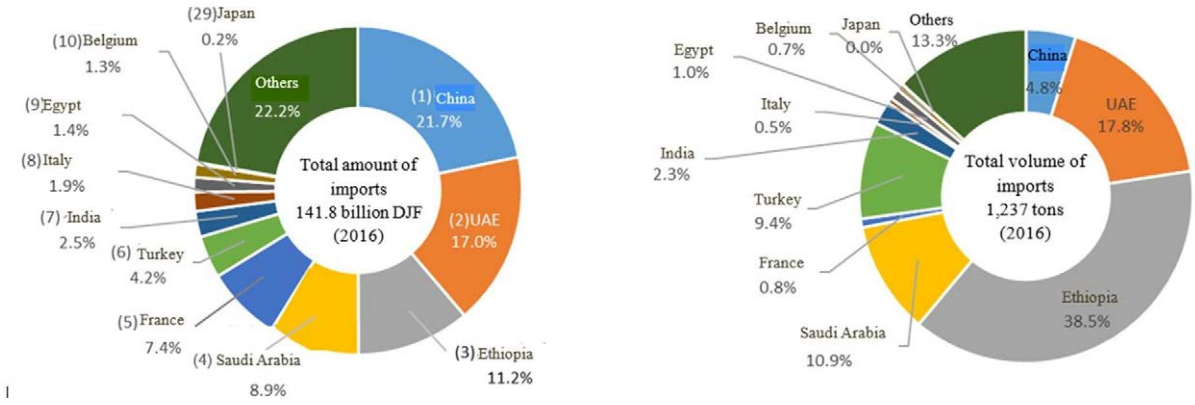
Source：UN National Accounts DB

Figure-3 Changes in GDP and Growth Rate



Source: BCD

Figure-4 Changes in Trade Balance



Source: Department of Statistics and Demographic Studies (DISED)

Figure-5 Countries from which Djibouti Imports (Top 10 Contries) in Monetary and Volume Terms

2. Records of Natural Disasters in Djibouti City

Natural disasters occurred in the Ambouli River basin in the past, and they were mainly damages caused by the Ambouli River flooding during heavy rains. Waterway flooding (inland water) occurred due to underdeveloped rainwater discharge channels and blockage of channels by dumped waste.

Table-1 Summary of Major Floods and Disasters in Djibouti

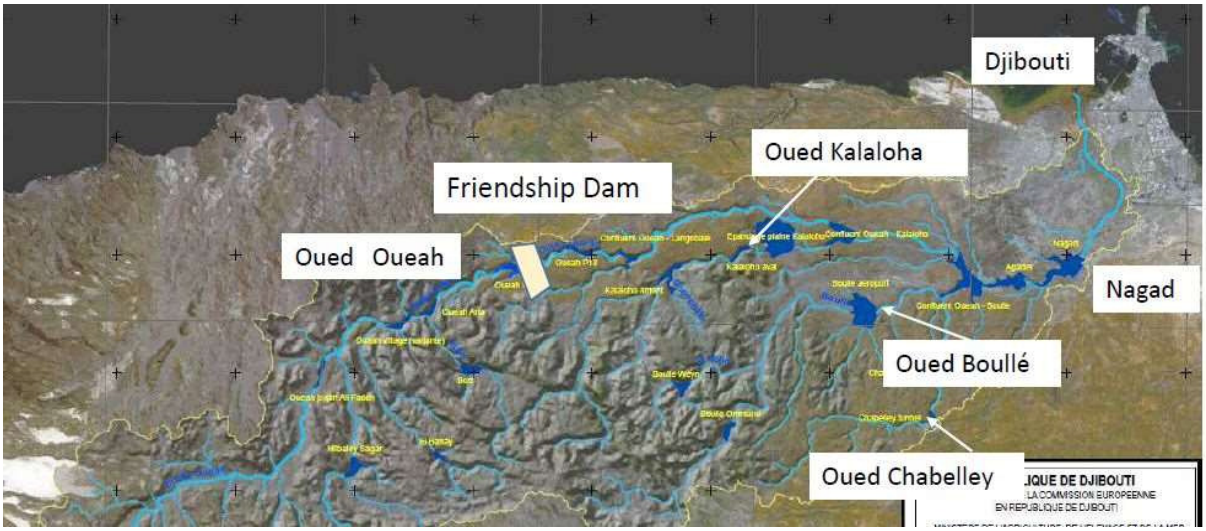
	Occurrence date and time (period)	Daily rainfall (mm)	Fatalities (people)	Affected population (people)
1	1989.4.6-10	507 (3days)	(unknown)	150,000
2	1994.11.22	360 (2days)	105 (unknown40)	100,000
3	2004.4.11-14	92.9	300	100,000
4	2013.3.25	26	8	No data
5	2018.5.19-21	110 (1day)	2	5,000-10,000
6	2019.11.21-25	155	11	200,000
7	2020.4.20-21	80	8	110,000

Source: 1. United Nations Department of Humanitarian Affairs (DHA) report (1989.4, 1994.12)

Flood damages in 2019 (Palmeraie Road)

3. Current Status of the Ambouli River and Flood Countermeasures.

The Ambouli River has a total length of about 60km with a catchment area of 600km^2. As shown in the map below, it has a number of branch streams and the main stream is Wadi Oueah, which accounts for 31.3% of the entire catchment area. The Wadi Oueah joins the Oued Boille at Nagad, a point 23km from the downstream.



Source: Etude d' identification des ouvrages de rétention des ruissellements et de recharge des nappes sur l'ensemble du bassin versant (2007)

Figure-6 Map of the entire Ambouli Catchment Area and Location of the Friendship Dam

In Wadi Oueah, there is the Ambouli Friendship Dam, which was built with the aid of Turkey. The dam has a height of 71m and capacity of 14 million cube meters. The dam was built for flood prevention and irrigation purposes, and it covers 45% of the entire basin. When the 2019 flood occurred, the friendship dam was already completed and retained about 10 million cubic meters of water for flood prevention, indicating that the dam has a flood controlling effect. Although the dam was constructed for agriculture and flood control purposes, there are no established operating rules to achieve these two objectives (between the Ministry of Agriculture and the Ministry of Interior), according to information obtained from the Ministry of Agriculture.

Table 2 Specifications of the Ambouli Friendship Dam

Item	Specifications	Remarks
1) Reservoir area	270km^2	Total area of 600km^2
2) Structure type	Central core type rock-fill dam	Core material: clay
3) Dam crest height	338.00 (m, asl)	Above sea level
4) Height of fill-point base above sea level	300.00 (m, asl)	
5) Height of dam base above sea level	267.00 (m, asl)	
6) Dan height (foundation plain)	71.0 (38.0)m	4)-6)=71.0m, 4)-5)=38.0 m
7) Crest width	10. m	
8) Highest water level	336.78m asl	
9) Lowest water level	316.00m asl	
10) Total reservoir capacity	14,370,000m^3	
11) Effective reservoir capacity	12,060,000m^3	
12) High water discharge at dam site	157.0m^3/sec	100-year recurrence interval
13) Design flow for flood spillway	3,000m^3/sec	

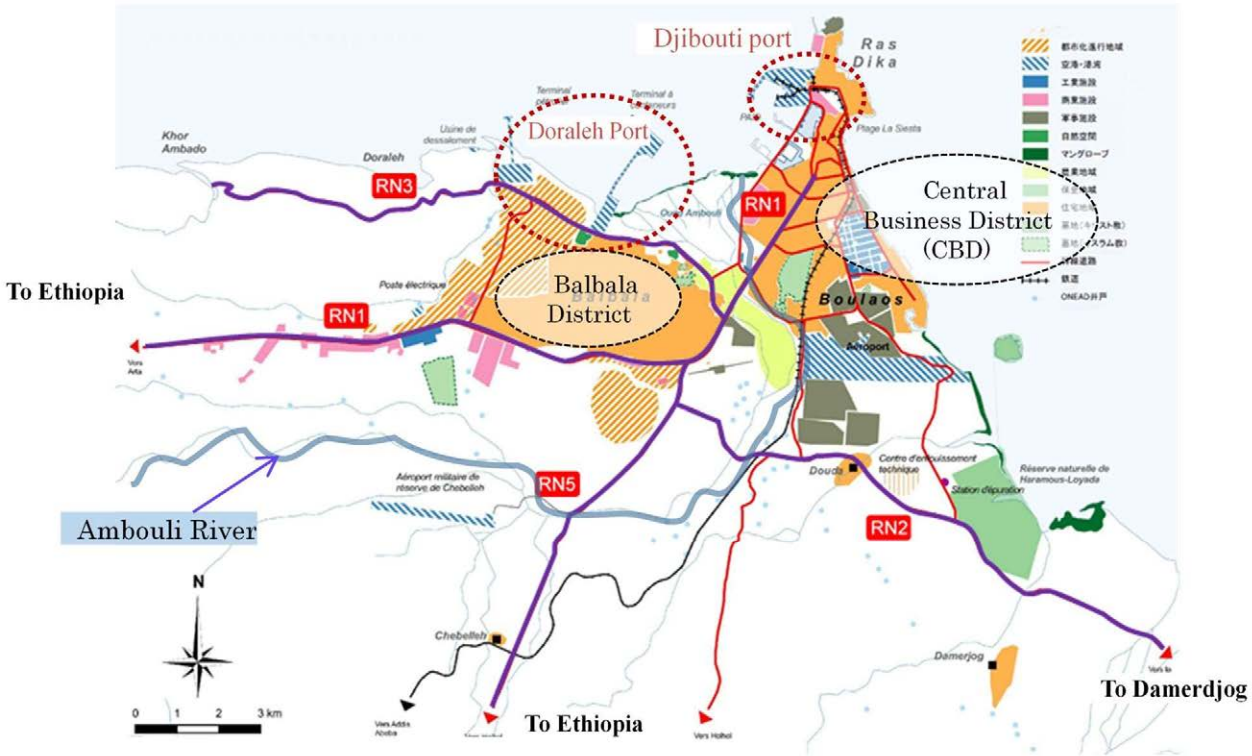
Source: Ambouli Friendship Final Report (Volume 1), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

In addition, following the April 2004 floods, the World Bank implemented flood control measures for the Ambouli River. The ADETIP (Agency for the Implementation of Public Works) was the lead agency, and the total cost of the project was MUS$6.46, of which US$3.23M was grant aid. In this project, whicj was called Flood Emergency Rehabilitation Project (FERP), about 2km of embankment was constructed on the right bank upstream of Italy Bridge (completed in 2009).

4. Present Status of the Road Network of Djibouti City

Road Network

The city's roads consist of four national roads and other arterial roads (Figure-4). The most critical route is RN1 (National Road Route 1), and most of the freights for Ethiopia now utilize this route. In December 2020, a renovation project supported by Japan was completed and a part of the route started operation. RN2 is a road connecting Damerjog Industrial Park with the city center and continues to Somalia. RN3 is a road connecting the city center with the Doraleh New Port. RN5 is also a road connecting Djibouti and Ethiopia as an alternative route to RN1. Currently the use of this route is limited because the pavement work of the Ethiopian side is currently in progress. However, when the paving of Ethiopian side is completed, this route will function as an alternative route to RN1.



Source: Prepared by the survey team based on SDAU

Figure-7 Current Road Network in the City of Djibouti

In addition, a road inventory survey was conducted to obtain information on the width, pavement condition, drainage condition, road structures, lighting, sidewalks, medians, etc. for the major routes in the city (23 routes in total including 4 national routes). These data were organized in a GIS.

Figure-8 shows the pavement condition of the city roads. The pavement condition has deteriorated in the east-west direction in the city center and in the Balbala area. The pavement of the Palmeraie Road that crosses the Ambouli River and the Venice Road that is connected to the Palmeraie Road are also severely damaged, resulting in reduced performance.

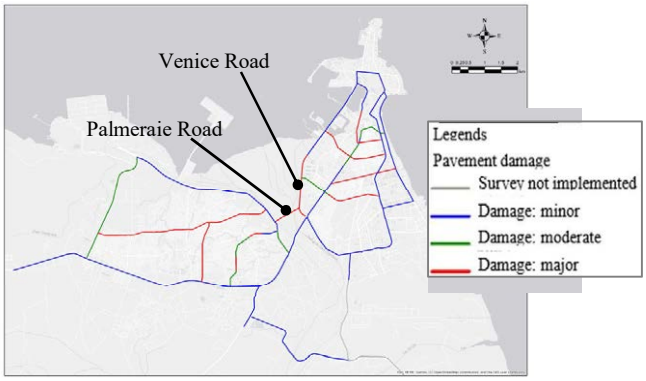


Figure-8 Pavement Condition in Djibouti City

Road Traffic

Although ADR conducted a traffic volume survey covering all districts of the city, it has already been six years since then and the traffic volume has changed. Therefore, a new traffic volume survey is implemented on major locations shown in Figure-9, besides using existing materials.

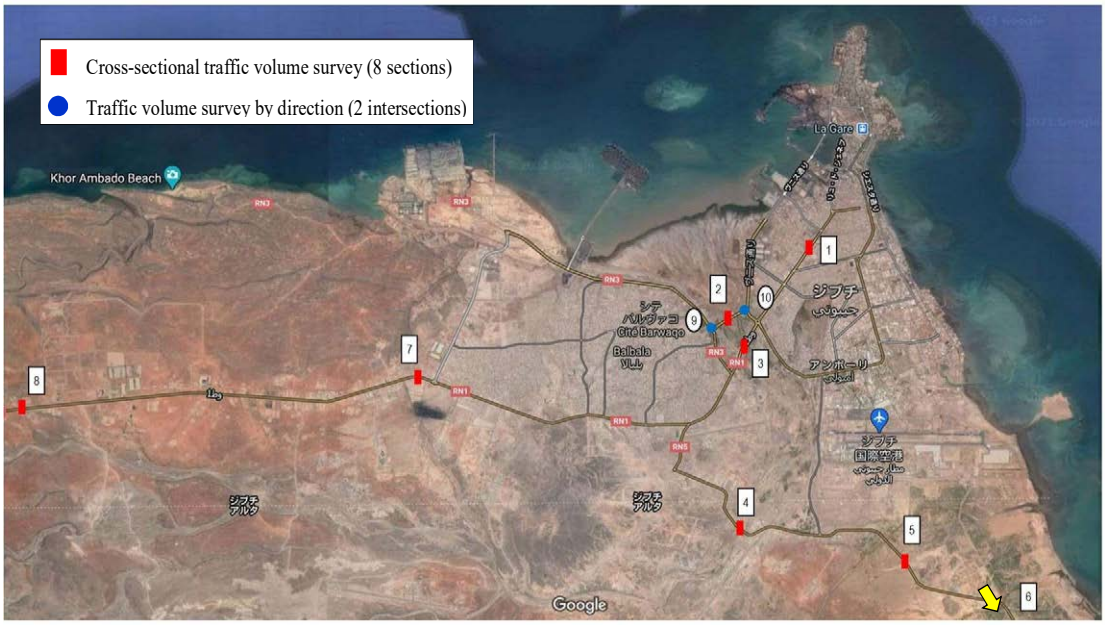


Figure-9 Sites of Traffic Volume Survey

The results of the traffic volume survey are shown in Table-3. On the Palmeraie Road (No. 2), the daily traffic volume exceeds 30,000 vehicles, the largest volume found in this survey, followed by the Italy Bridge (No. 3) with 22,000 vehicles per day. The traffic volume of these two roads that cross the Ambouli River is very large, which indicates these two roads play the most important role in terms of the city traffic movement.

In terms of vehicle type, higher motorbikes and public transport vehicles are observed in the city center area (No. 1 to No. 3 of the Table below), while the number of trailers is the largest at No. 7 and No. 8 on the National Road Route 1, a major traffic route for logistics between Djibouti and Ethiopia. The number of trucks and trailers using the Palmeraie Road is relatively large, as it is an important road connecting the old Port of Djibouti.

Table-3 Results of Traffic Volume Survey (Sectional Traffic Volume) unit : Number

№	Survey Site	Survey Duration	Traffic Volume by Vehicle Type					
			Motorbike	Car	Public	Truck	Trailer	Total
1	Arhiba	14hr	1,224	5,466	6,875	499	3	14,067
2	Palmeraie	24hr	3,502	17,436	8,047	1,565	1,000	31,550
3	Bridge	24hr	2,184	11,595	7,300	1,237	30	22,346
4	Nagad	14hr	155	1,264	570	479	118	2,586

5	RN2-Douda	24hr	214	1,507	323	392	70	2,506
6	RN2-Lawyade	14hr	7	199	26	51	24	307
7	RN1-PK20	14hr	58	1,412	997	683	1,820	4,970
8	RN1-PK24	24hr	31	999	239	283	2,122	3,674

Note: Nos. 2 and 3 survey data: May 19; Nos. 1, 7 and 8: May 20; Nos. 4 & 5: May 27; and No. 6: May 30

Table-4 shows a comparison with the traffic of the survey conducted by ADR in 2014 for the three roads crossing the Ambouli River. The total daily traffic volume crossing Ambouli River in 2014 and 2021 was 39,946 and 51,079, respectively, showing an increase of 11,133 per day, or 28%. In terms of traffic volume, Italy Bridge was serving more traffic seven years back, but it is now overtaken by Palmeraie Road. In addition, the traffic volume of the Nagad Road is still small but the growth rate is significant showing that development along the road has been progressing.

Table-4 Comparison of 2014 and 2021 Survey Results

№	Name of crossing	Traffic (veh./day)		(B-A)	(B/A)
		(A) 2014	(B) 2021		
2	Palmeraie	16,274	28,048	11,774	1.72
3	Italy Bridge	22,192	20,162	-2,030	0.91
4	Nagad	1,480	2,869	1,389	1.94
	Total	39,946	51,079	11,133	1.28

Note: Traffic figures are compared excluding motorbike.
Source: 2014 survey data are provided by ADR.

5. Present Status of the Transport Sector of Djibouti City

Upper Plan

In 2014, the Ministry of Economy and Finance of Djibouti announced Vision Djiouti 2035, a national development plan with a target year of 2035, which aims to promote the growth and transformation of the country with the goal “making Djibouti a lighthouse of the Red Sea and a hub of African Industries and Transport”. In the plan, the future population of Djibouti is planned and the annual economic growth rate is set at 7-8% per year until 2035.

SCAPE 2015-2019 was developed as a strategy to define priority actions and goals to implement and achieve during five years from 2015, following the approval of Djibouti Vision 2035 by the Cabinet. The main goal of the development strategy for the transport sector is defined as “strengthening its function as a regional multimodal transport center in the Horn of Africa.” The strategy underlines the need to ensure the country’s status as a major and privileged port for Ethiopia by maintaining and strengthening the competitiveness of a logistics chain. At the same time, it points out the importance of developing the domestic transport system, i.e., roads, for a balanced development and growth, and for the diversification of the economy of the country.

In addition, this plan was decided by the Ministry of Housing, Urban Planning and Environment in accordance with "Vision Djibouti 2035", and it has set the goal of "balanced development and growth of both east and west districts" across the Ambouli River. Then, road improvement connecting east-west urban districts separated by the Ambouli River, widening of existing roads, ring roads, LRT, etc. have been proposed for smoothing road traffic in the city. Among them, four major routes are positioned as important to connect east and west districts and to realize and promote the development of bases of the mentioned area (see Figure-10).

Concerned Organizations

The following four organizations are relevant to the transportation and traffic sector.

- ✓ Ministry of Infrastructure and Transport /ADR:

  This organization is responsible for overall transport policy in Djibouti, and it was the agency in charge of the Djibouti side of the “Urban Mobility Improvement Study” conducted by the World Bank in May 2020.

- ✓ Free Zone Authority / DPFZA:

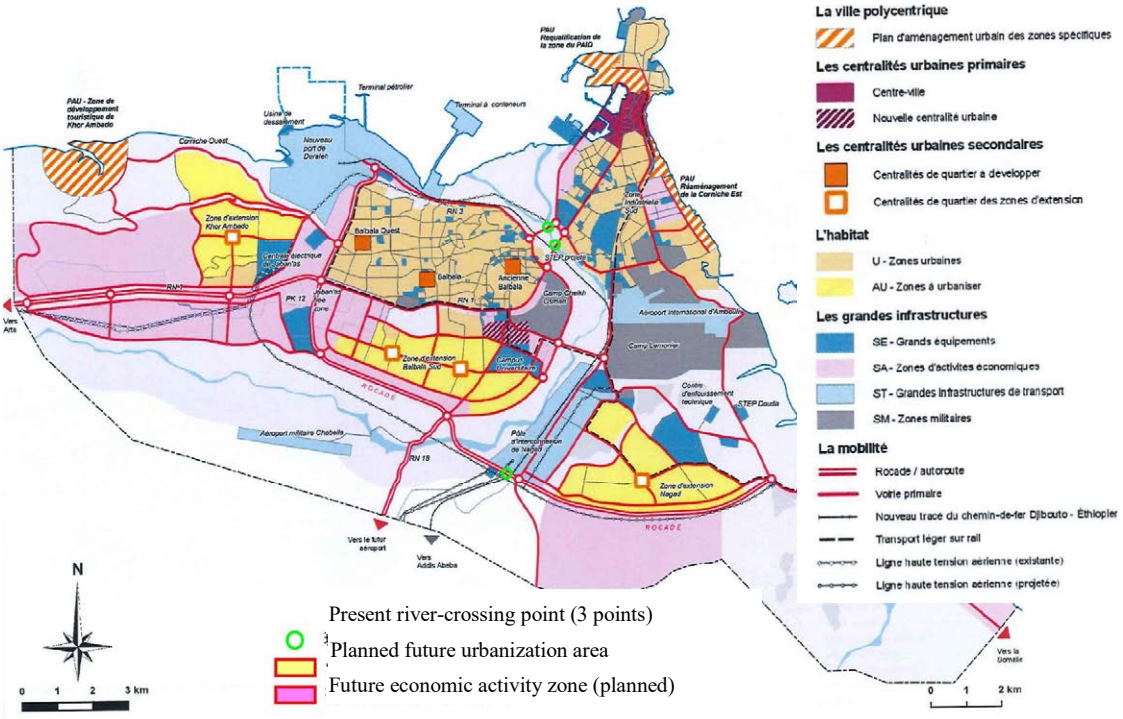
  This organization is responsible for the development and operation of ports and free zones. The Djibouti Ports Corridor Road (DPCR), a subordinate organization of this organization, is in charge of planning, maintenance and financing of the international corridor connecting Djibouti Port with neighboring countries.

- ✓ Ministry of Agriculture, Water, Fisheries, Animal Industry and Fisheries Resources /MAWFLFR:

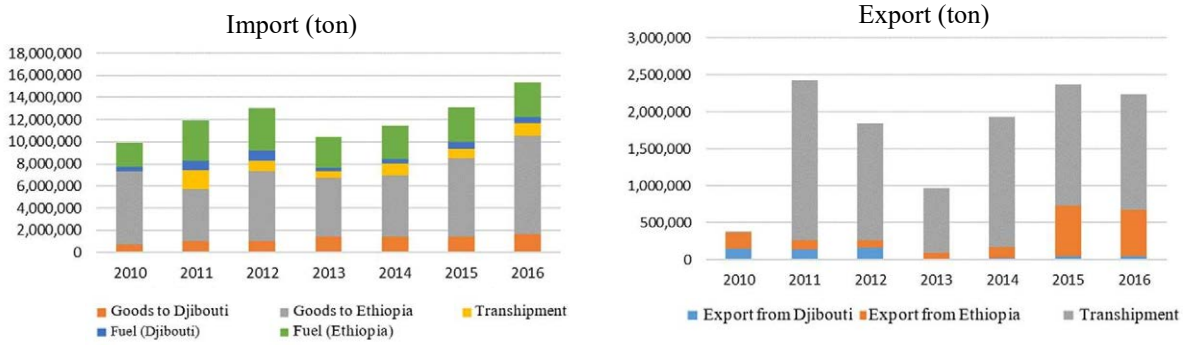
  This organization is responsible for flood control in Djibouti and is the administrator of major rivers in the country. It is also the implementing organization of the Ambouli Friendship Dam Project which was implemented with Turkish assistance in the upper Ambouli River basin and completed in May 2019

Marine Traffic

The Port of Djibouti handles large transshipment goods because of its ideal geographical location. In addition, the port also functions as a gateway for Ethiopia and about 80% of import is bound for Ethiopia. The export volume is 1/10 to 1/5 of that of the import, of which about 70% is transshipped goods (see Figure-11).



Source：SDAU **Figure-10 Future Land Use Plan of the City of Djibouti**



Souce：PAID (Djibouti Port)

Figure-11 Volume of Exports Handled at the Port of Djibouti

Railway Traffic

The railway in the Republic of Djibouti was first constructed by a French company in 1917 as the Ethio-Djibouti Railway (connecting the Port of Djibouti and Addis Ababa). A new railway adjacent to the old one was constructed as a new because of its difference in the gauge width and the propulsion system. Regarding the financing of the new railway, 70% of the investment of a total of 3.4 billion dollars was supplied by the Export-Import Bank of China and the construction was completed in 2017. The railway is being operated by two Chinese companies under a six-year operation agreement with public railway corporations of Djibouti and Ethiopia. The train has to go up from the Port of Djibouti located 0m above the sea level to Addis Ababa located 2,300m above the sea level, in a distance of about 700km. Therefore, it requires a system with a strong propulsion, and it was decided to introduce an electrified railway system. The section connecting Sebeta and Adama via Addis Ababa was constructed to have double tracks as a large demand was expected and the remaining route between Adama and the Port of Djibouti was constructed to have a single track (see Figure-12).

Source: https://en.wikipedia.org/wiki/File:Bahnstrecke_Addis_Abeba%E2%80%93Dschibuti.png

Figure-12 New and Old Railway Routes between the Port of Djibouti and Addis Ababa

Freight between Djibouti and Ethiopia is transported by both trucks and railway. The railway service started in 2018 and trains run to and from the Port of Djibouti and Addis Ababa, and currently the daily freight train frequency is limited to three round trips. Railway freight has a share of about 13% of the entire freight (freight volume carried by one train is equivalent to that of 53 trucks). The final goal is to increase the daily frequency of the freight trains to 19 round trips.

Urban Transport Sector

The modal split in Djibouti City is as follows: 20% travel by public transport, 50% on foot, 3% by own car and remaining by taxi and company bus (World Bank survey). The city has no established bus routes or bus stops, and the bus driver chooses the route to serve depending on the demand, which means customers can get on and off the bus wherever they want. Although the bus routes are not established, buses mostly serve routes connecting the east and the west sides of the Ambouli River and there are about 44 route.

Table-5 shows the number of public transport vehicles using the two bus routes crossing the Ambouli River based on the current survey. The total traffic of the two routes exceeds 1,400 vehicles during the morning peak hour (i.e., one hour in the morning peak time). By multiplying the number of vehicles by average number of passengers by vehicles type, the largest number of the peak-hour peak-direction traffic volume of Palmeraie and Italy Bridge routes is found to be 6,164 people, and 5,300 people, respectively (Table-6). Normally, the number of passengers that a bus can handle is said to be around 4,000 per hour (i.e., peak hour, per direction). Since the current passenger volume significantly exceeds the normal bus

capacity, it can be said that it is the time to introduce new urban transport systems (articulated bus, BRT, LRT, etc.).

Table-5 Number of traffic through Ambouli River (morning peak 1 hour)

		Bajaj	Taxi	Minibus	Midibus	Total
Palmeraie Road	To City Center	0	169	93	157	419
	To Suburb	2	102	157	100	361
	Subtotal	2	271	250	257	780
Italy Bridge	To City Center	1	111	50	149	311
	To Suburb	2	79	143	112	336
	Subtotal	3	190	193	261	647
Total	To City Center	1	280	143	306	730
	To Suburb	4	181	300	212	697
	Subtotal	5	461	443	518	1,427

Table-6 Number of traffic through Ambouli River (morning peak 1 hour)

		Bajaj	Taxi	Minibus	Midibus	Total
Palmeraie Road	To City Center	0	338	1,116	4,710	6,164
	To Suburb	8	102	942	1,500	2,552
	Subtotal	8	440	2,058	6,210	8,716
Italy Bridge	To City Center	8	222	600	4,470	5,300
	To Suburb	8	79	858	1,680	2,625
	Subtotal	16	301	1,458	6,150	7,925
Total	To City Center	8	560	1,716	9,180	11,464
	To Suburb	16	181	1,800	3,180	5,177
	Subtotal	24	741	3,516	12,360	16,641

Status of Movement of Goods

The volume of truck traffic on National Road Route 1, the main route for transporting goods between Ethiopia and Djibouti, is increasing every year, indicating the significance of logistics between the two countries (see Figure-13). At present, Ethiopia uses the Port of Djibouti to import or export almost all goods. In July 2018, however, the leaders of the governments of Ethiopia and Eritrea signed an agreement to normalize the two countries' relations, and as the result, Ethiopia is expected to use the ports of Eritrea, for mainly freights to or from the northern part, which is geographically closer. Therefore, Djibouti needs to take necessary measures to ensure its competitiveness over Eritrea.

Source : ADR

Figure-13 Changes in the Truck Traffic Volume on National Road Route 1

6. Flood Risk Analysis in the Target Areas

Calculation of Flow Capacity

Based on the results of the river topographic survey, the discharge capacity of the current river channel was calculated. The calculated section was from the survey starting point to about 4km upstream. The discharge capacity was evaluated separately for the right bank "height" and the left bank "height". The

discharge capacity of the right bank is approximately 500 - 1,000 m3/sec, while that of the left bank is 100-300m3/sec. At the time of the right bank embankment construction in 2008, the discharge capacity was estimated to be 1,200 m3/sec, and the current discharge capacity has decreased significantly. Although the decrease in discharge capacity is a cause of flooding, no overflow of water has been recorded for these sections since the embankment was constructed in 2008.

Probability Daily Rainfall Analysis

The probable rainfall was calculated based on the data of annual maximum daily rainfall for 40 years from 1980 to 2020 as shown in the Table-7.

Table-7 Return Period and Probable Daily Rainfall

Return period (1/year)	Probable daily rainfall (mm)
200	357.8
100	292.0
50	233.8
30	195.5
20	167.6
10	124.8
5	87.4
2	44.5

Evaluating the Flood Occurrence Scale

Based on the results of the probability rainfall analysis, the probability evaluation based on the daily rainfall of major floods is shown in Table-8. From this table, the 1989 flood (180 mm) is evaluated as the most significant 27-year flood. In recent years, the 2019 flood is 170 mm and is assessed as a 25-year event.

Table-8 Probability Evaluation for Major Floods and Rainfalls in Djibouti

SN	Period of Events	Total Amount of rainfall (mm)	Daily Rainfall (mm)	Return Period (1/year)
1	1989.4.6-10	507	180	27
2	1994.11.22	360	38	<2
3	2004.4.11-14	93	90	7
4	2013.3.25	-	33	<2
5	2018.5.19-21	181	111	8
6	2019.11.21-25	444	170	25
7	2020.4.20-21	80	80	<5

Ambouli River Improvement Plan

The planned flow rate of the Ambouli River at the crossing of the Palmaraie Road was set at 1,500 m3/s, the same as upstream of the Italy Bridge. According to the evaluation of the daily rainfall of the existing flood group based on probable daily rainfall, this probability of flood occurrence is about 25 years. Increasing the probability flow rate to 30 or 50 years would improve safety, but the cost of improvement would be significantly higher, requiring extensive improvement of the Ambouli River, including the replacement of the Italy Bridge. This is not a reasonable improvement plan at this time, and it is decided that a realistic and urgent response is needed at this time with a possibility of future expansion.

Two alternative river improvement plans were considered: one to handle the planned flow rate only in the main stream, and another to handle the planned flow in the main stream plus sub-stream. The standard cross sections of the river plans are shown in Figure-14, Figure-15, and Figure-16.

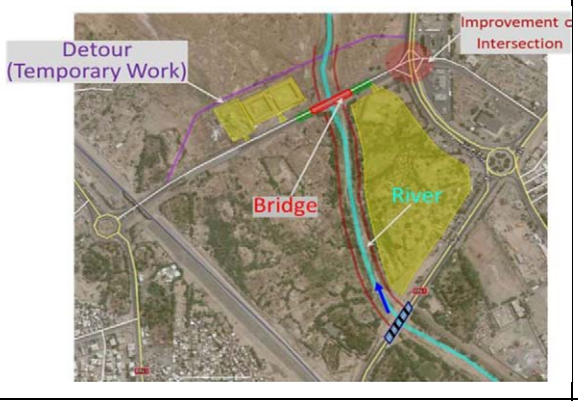
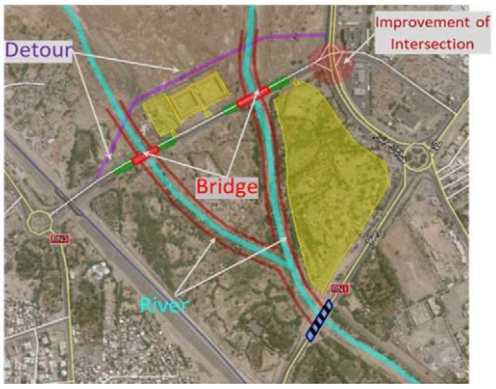
Main Stream Improvement Plan	Main+Sub-Stream Improvement Plan
	

Figure-14 Two (2) Alternatives Examined in River Improvement Plan

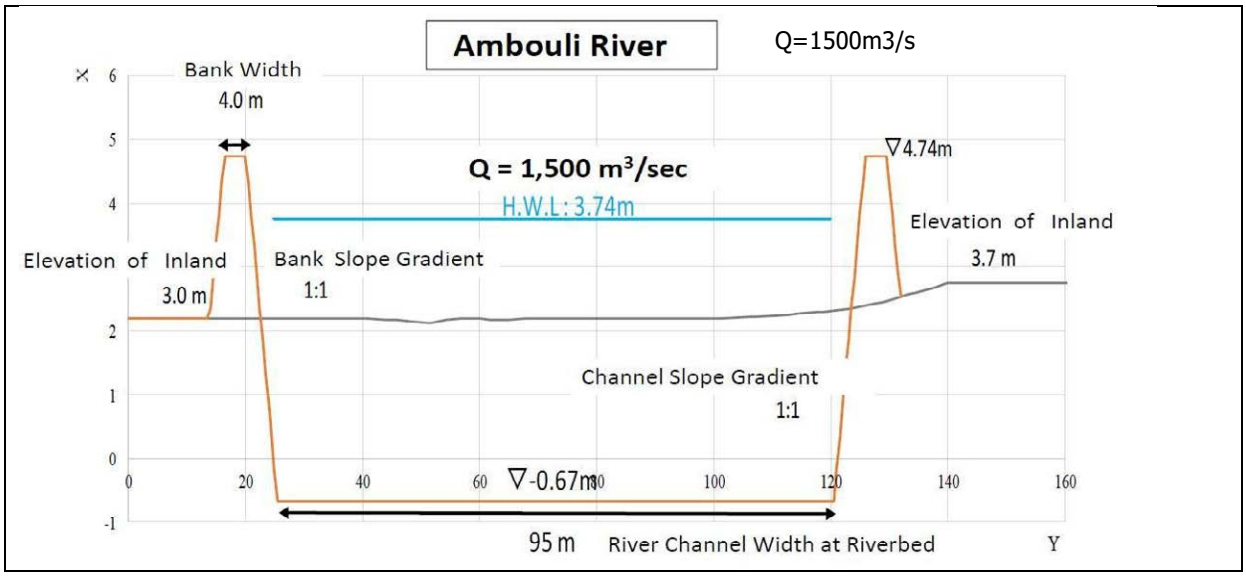
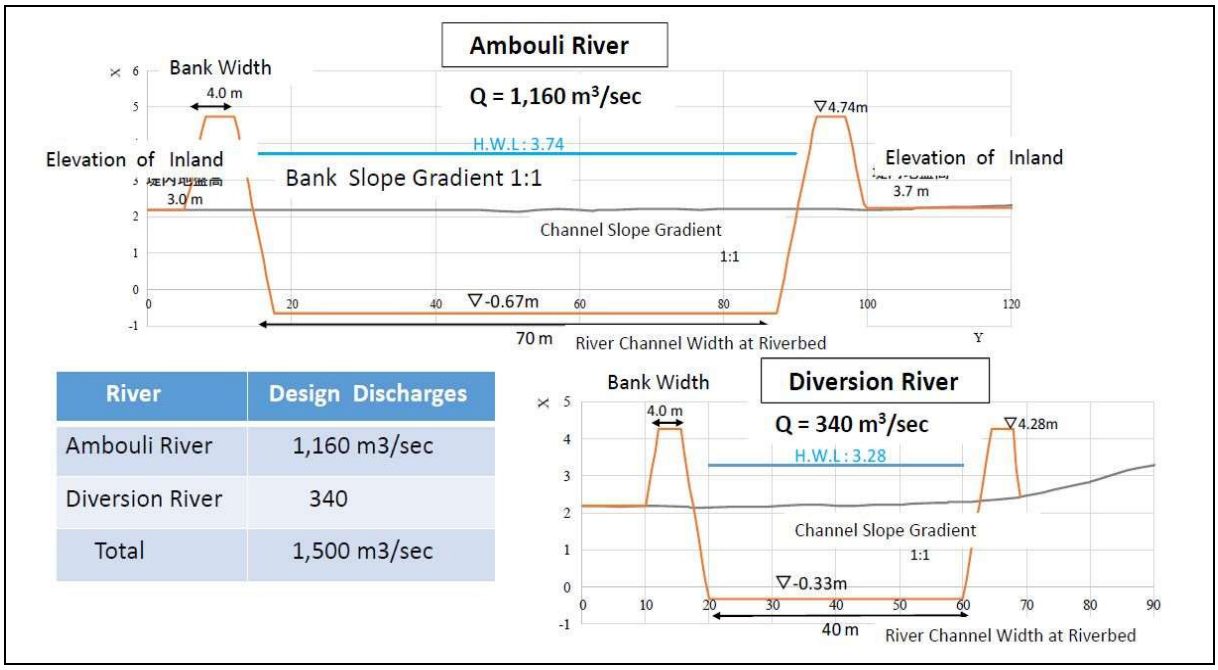


Figure-15 Typical Cross Section (Main Stream Improvement Plan, Q=1,500 m3/sec)



River	Design Discharges
Ambouli River	1,160 m3/sec
Diversion River	340
Total	1,500 m3/sec

Figure-16 Typical Cross Section (Main+Sub-Stream Improvement Plan, Q=1500m3/s [Q1=1160m3/s, Q2=340m3/s]）

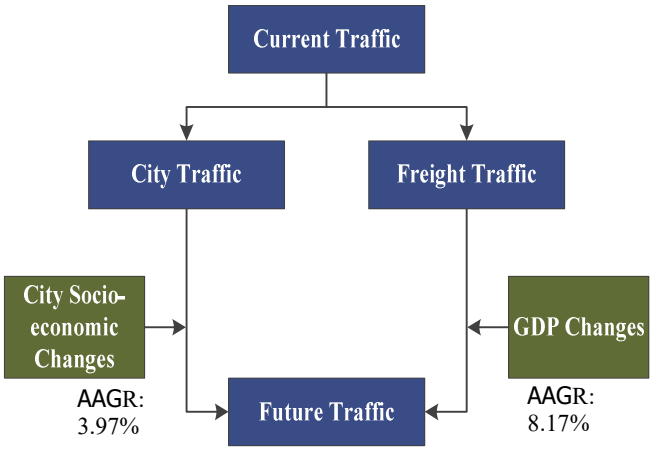
7. Identification of Problems and Investigation of Countermeasures Related to Strengthening Logistics

Forecast of Future Traffic Demand

Changes in traffic volume are closely related to the country's socio-economic changes. Djibouti City has two distinct traffic: urban traffic and trans-border freight traffic. The urban traffic or domestic traffic in general is closely related to the socio-economic change of the city or the country, while that of the freight is mainly driven by the demand of the neighboring countries, particularly Ethiopia, a landlocked country which heavily depends on Djibouti. Therefore, the two kinds of traffic are forecasted separately as shown in Figure-17.

Identification of Problems in the Transportation and Logistics Network

From the existing data and the traffic volume survey and road inventory survey in this study, seven problems related to road transportation in the target area were identified. These were summarized and the following four issues were identified: (1) strengthening of the logistics network, (2) development within the city, (3) facilitation of traffic in the city, and (4) planning for flood control (Table-9).



- General traffic growth rate of 3.97% per annum, which is the ADR estimate, was adopted.
- International cargo growth was assumed to be 8.17% per annum, referring to Ethiopia's GDP growth rate (IMF estimate)

	Traffic volume (vehicles/day)		
	Current (Year 2021)	Future (Year 2030)	Future (Year 2035)
Palmeraie Road	31,550	45,100	54,800
Italy Bridge	22,346	31,700	38,500
Nagad Road	3,052	4,300	5,300

Figure-17 Procedure of Traffic Demand Forecast

Table-9 Identification of Problems in the Transportation and Logistics Network of Djibouti City

Issues	Overview and Main Cause	Challenges
① Defectiveness on road network	❑ Division of the city by the Ambouli river (lack of crossing road) ❑ Division of the city by Djibouti – Ethiopian railway (lack of crossing road) ❑ Disconnected and bad alignment road network in the district	Stregthening the logistics network
② Unpaved and deteriorated pavement	❑ Deterioration of pavement due to lack of maintenance ability and inadequate system ❑ Many unpaved roads due to lack of budget	Improving urban roads
③ Deterioration of road structures	❑ Deterioration of road structures due to lack of maintenance ability and inadequate system	
④ Road flooding (outside water)	❑ Ford structure of roads that cross the Ambouli River (Parmeraie Road, Nagat Road) ❑ Sedimentation in rivers due to lack of maintenance	Facilitationg urban traffic
⑤ Road flooding (inland waters)	❑ Underdeveloped city drainage facilities and lack of maintenance	
⑥ Occurrence of road congestion	❑ Occurrence of traffic congestion due to insufficient capacity at intersections ❑ Deterioration of congestion due to street parking	Planning flood control
⑦ Lack of public transport	❑ Lack of public transport services and safety ❑ Concentration aof services on specific routes	

Measures to Strengthen the Logistics Network in Djibouti

For the four categories to which issues are summarized in the previous section, the following three types of measures are proposed: "Structural measures" such as road maintenance and introduction of a new transportation system, "Non-structural measures" which are centered on traffic regulation and enhancement of traffic management, and "Flood-control measures" for the problems of river flooding and urban drainage problems, which hinder logistics and urban traffic (see Table-10).

- ✓ **Strengthening the Logistics Network**: The improvement of the three trunk roads that cross the Ambouli River is desired along with the improvement of the Ambouli River. In addition, it will also be necessary to review the logistics system with Ethiopia, which is dominated by road transportation, by effective use of the Djibouti-Ethiopia railway. It is also desirable to review the logistics system in line with the future development plans in Damerjog and Nagad areas.

- ✓ **Improving Urban Roads**: It is necessary to alleviate traffic congestion in the city, and to improve drainage facilities in the city. Measures to alleviate congestion in the city include eliminating unpaved sections, improving intersections, and improving access roads to newly developed areas.
- ✓ **Facilitating Urban Traffic**: Public transportation is essential for the Djibouti City for the daily lives and economic activities of the citizens, but it is not properly managed currently. It is necessary to build a public management system and consider the introduction of new public transportation system. In addition, the enhancement of traffic management to alleviate traffic congestion in the city is also important.
- ✓ **Planning for Flood Control**: The overflowing of the Ambouli River and flooding of urban areas during the rainy season, which recurs every year, is directly caused by the lack of maintenance of river areas and inadequate drainage systems. However, there is a lack of a flood control plan to comprehensively plan, implement, and maintain these measures.

Table-10 Study of Countermeasures to Strengthen the Logistics Network in Djibouti City

	Structural measures	Non-structural measures
Strengthening the logistics network	・ Improvement of the roads crossing the Ambouli River (Palmeraie Road, Italy Bridge, and Nagad Road) ・ Road development in line with the planned development of the Damerjog and Nagad areas	・ Separation of trunk logistics and city routes (restriction of the movement of the large trucks in the city) ・ Installation of axle load gauge ・ Effective utilization of Djibouti-Ethiopian railway
Improving urban roads	・ Maintenance of trunk urban roads (especially in the east-west direction) ・ Intersection improvement (structural improvement, installation of advanced traffic lights) ・ Rehabilitation of the missing road (Vietnam Road) connecting Italy Bridge and Palmeraie Road ・ Balbala area road improvement (collector-distributor road improvement, pavement improvement) ・ Road development in the newly developed area	・ Planning of road maintenance ・ Strengthening of ADR implementation capacity ・ Securing funds for road maintenance
Facilitating urban traffic	・ Introduction of new public transportation system (BRT, etc.) ・ Introduction of measures prioritizing public transportation (bus only, priority lane, bus priority signal, etc.))	・ Street parking regulations ・ Advanced city traffic management (introduction of advanced traffic lights, traffic control system, etc.)
Planning for flood control	・ River improvement of Ambouli River ・ Improvement of drainage facilities in the city ・ Installation of mobile pump vehicles	・ Flood Warning System

8. Direction of Assistance and Selection of Specific Measures

Direction of Assistance

Assisting Djibouti, which is an important international partner for Japan, in solving various economic and social development problems through strengthening the country's national infrastructure contributes to the stabilization of the East African region and the revitalization of the regional economy. Therefore, such aid would be highly valued and have quite significant impact. Since various aids from different organizations and countries including the World Bank, China, the Saudi Foundation, etc. are being provided in the area, as described in Section 3.3.4, identifying the role of the Japanese aid from other donors is needed. In other words, the support that shows Japan's concrete presence among other active donors, including China and the United States, is required.

In order to ensure the continuity of the Japanese government's support to the region and to distinguish it from other donors, the following four points were set as the specific directions of the support:

(1) Strengthening the connectivity between the east and west urban areas that are divided by the Ambouli River.

(2) Development of a reliable international logistics network.
(3) Development of roads that contribute to urban and industrial development in the city.
(4) Development of a safe and comfortable road network in the city.

Selection of Specific Measures

Specific measures were identified in response to the defined directions of support, and these measures were compared and evaluated in terms of urgency, appropriateness, and feasibility. We then compared and evaluated them in terms of urgency, relevance, and feasibility, and selected the one that was evaluated the most, "Improvement of the road crossing the Ambouli River," as the concrete countermeasure.

Flooding of the Ambouli River, which divides Djibouti City into east and west, has been recurring every year and has had a significant impact on the lives of citizens and economic activities. There is no doubt that the development of roads that are resistant to flood damage is highly evaluated in terms of urgency and relevance. In addition, improvement of urban drainage systems and pavement condition to strengthen the functions of the capital city are also considered to be extremely important measures, but the scope of the project may be too wide and the project cost may be huge. Therefore, the evaluation was low in terms of their appropriateness as grant aid projects. The necessity and effectiveness of other measures are also recognized, but there are significant challenges in implementing them. As a result, it is thought that this should be further examined in the future.

Selection of Priority Road Improvement Projects

As shown in Table-12, there are three possible alternatives for the "Improvement of roads crossing the Ambouli River" that was selected as specific measures.

The Palmeraie Road improvement (widening and bridge construction) was selected as the priority improvement project here. The reasons for this are as follows.

Italy Bridge was reinforced in 2017 and heavy vehicles are restricted from using it. However, the bridge itself was never flooded, and it is still serving as a trunk road. Since it also serves as an alternative to the Palmeraie Road when it is flooded, the need to reconstruct it prior to the improvement of the Palmeraie Road is low. However, in the future, six lanes will be necessary to handle the future traffic volume, and as it is also aging, the bridge will need to be replaced.

The traffic on Nagad Road is currently a low, but this may change and it could become an important route once the Damerjog area is developed. However, the SDAU is planning an outer ring road in the future, and this may diminish the role of the Nagad Road. Therefore, the direction of its development should be examined in consideration to the progress of future developments.

Palmeraie Road is the busiest and most important road crossing the Ambouli River. However, it is flooded and becomes impassible when heavy rainfall, resulting in a serious hindrance to logistics and daily life activities of the citizens. In particular, the loss of access to heavy trucks would be critical for Djibouti, so immediate action is needed.

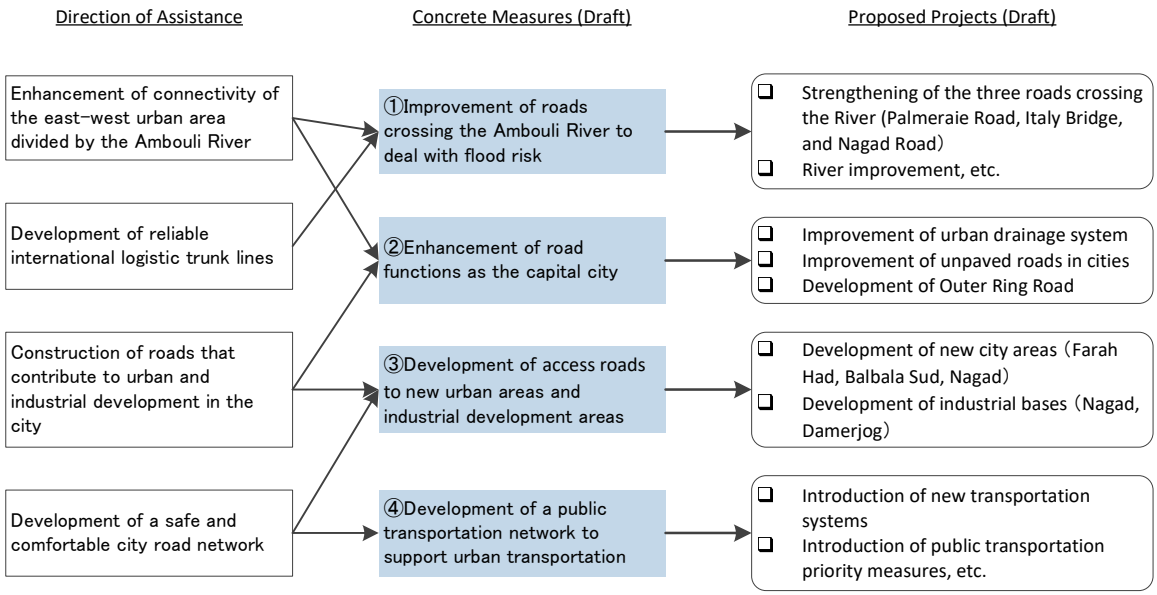


Figure-18 Identifying the Direction of Support and Concrete Measures (draft)

Table-11 Evaluation of Concrete Measures (draft)

	Evaluation Items			Comprehe-nsive evaluation
	Urgency	Validity	Feasibility	
1. Improvement of roads crossing the Ambouli River to deal with flood risk	◎	◎	△	◎
2. Development of new urban areas, and development of access roads to industrial development areas, etc.	△	△	○	△
3. Enhancement of road functions as the capital city	◎	△	○	○
4. Development of a public transportation network to support urban transportation	○	△	△	△

Note) ◎ : Excellent, ○ : Good , △ : Average

*The meaning of each evaluation is as follows;
- Urgency: Is it addressing issues that need to be addressed immediately?
- Validity: Is it appropriate as a Japanese grant aid project? Can it show Japan's presence?
- Feasibility: Are there any obstacles such as maturity of the plan, difficulty of the project, etc., to the implementation of the project?

Table-12 Alternatives for the Improvement Roads Crossing the Ambouli River

	Traffic volume (PCU/day)		Current	Improvement policy
	Current (2021)	Future (2035)		
Palmeraie Road (4-lane road)	31,550	54,800	• Highest traffic volume in the city • There is a lot of general traffic as well as logistics related to Djibouti port. • Major bus routes	• Widening to 6 lanes • Reducing congestion at nearby intersections • Responding to increasing bus traffic • Improvement of the structure to prevent flooding even during floods
Italy Bridge (4-lane road)	22,346	38,500	• Second busiest road in terms of traffic volume, next to Palmeraie Road • Damage was discovered and repaired in 2017. Since then, large vehicles are restricted from using it.	• Widening to 6 lanes • Responding to increasing bus traffic • Reinforcement or replacement
Nagad Road (2-lane road)	2,586	5,300	• Traffic volume is low, but the ratio of large vehicles is high.	• Measures against flooding

9. Consideration of Priority Project Plans

Examination of Palmeraie Road Measures

There are many facilities along the Palmeraie Road, including those under construction, and the river conditions must meet the requirements necessary to plan the river crossing structures。 After examining several alternatives, an outline design will be made for the best alternative, and the project cost will be calculated. The conditions that must be taken into consideration for the examination of alternatives are shown in Table-13.

Table-13 Basic Conditions for Palmeraie Road Countermeasures

Item	Assumptions
1. Target year for planning	2035 (roughly 15 years from now)
2. Design traffic volume	2021: 31,550 vehicles/day (4 lanes), 2025: 37,000 vehicles/day (6 lanes) 2030: 45,100 vehicles/day (6 lanes), 2035: 54,800 vehicles/day (6 lanes)
3. Exclusive bus lane	Not considered at this time

4. Improvement of the Ambouli River	• In order to make the road passable in all weather conditions by installing a river crossing structure, river channel improvement will also be carried out. • River cross-section enough for the design flood discharge should be secured (to be set separately). • The embankment will be constructed from the downstream side of Italy Bridge to about 100m downstream of the Palmeraie Road. In the downstream of the embankment, the river channel will be excavated.
5. Type of river crossing structure	• Since this is an important route and the Italy Bridge is located nearby upstream of the river, the structure will be basically the same as that of the Italy Bridge. Culvert type (multi-story structure) was judged unsuitable because the cross-sectional blocking ratio is not satisfactory and it has maintainability issues.
6. Main obstructed properties	• FTZ facility (owned by Chinese company, temporary and can be relocated) • Flower Park (under construction by a Chinese company) • High-voltage power line (63kV). • Railroad between Djibouti and Ethiopia.
7. Future plans	• Touch Road is a new urban planning project. An MOU was signed with the Djibouti government in 2014, but the progress of the project has not yet been determined. Land ownership has not been delegated, but care must be taken when planning permanent structures up to the river mouth.

Examination and Evaluation of Proposed Countermeasures

Based on the previous conditions, four possible alternatives were proposed, and three of them were selected from the overall perspective of the river alignment, impact on roadside facilities, and impact on the surrounding environment. In addition, three additional alternatives were selected to tackle the issues identified in the study process. As a result, it was determined that "Additional Alternative-2" was superior to the local conditions.

Outline Design

The conditions for the outline design are as follows.

-Road Classification: Class 4, Class 1

-Design speed: 50km/h

-Others : The width of the roadway is 3.25m, which is the standard width of the road.

A median strip was placed to ensure safety of traffic.

The width of the shoulder is reduced so that traffic can be maintained even when a broken-down vehicle is stopped.

A sidewalk is secured for pedestrian use (same for the upstream Italy bridge).

Note: The actual final road width should be determined by considering the project cost through outline calculations.

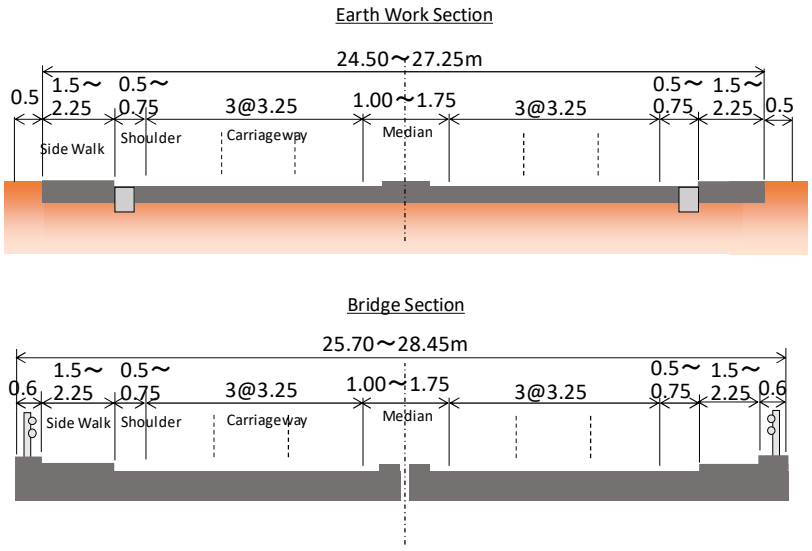


Figure-19 Typical Width of Planned Palmeraie Road

The type of the bridge superstructure to be planned for the river crossing is "PC hollow slab bridge" for the following reasons in consideration of the surrounding environment and constraints of the bridge location.

- Steel bridge types were not used because of maintenance issues such as painting for rust prevention.
- Special bridges such as cable-stayed bridges and suspension bridges are not suitable for the scale of the bridge and require a large number of members. The number of members is large, and maintenance and management are inferior, so they should not be used.
- A concrete bridge was chosen as the basic structure to prevent salt damage, and a high strength prestressed concrete bridge was chosen as the basic structure.
- In order to minimize the changes in the longitudinal profile of the road, the girder height should be kept low and the type of bridge should be easy to maintain in the future.

Table-14 Comparison of the Palmeraie Road Measures for Preliminary Selection

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Overview diagram				
FTZ facility	Partial relocation	No relocation	No relocation	Full relocation
River improvement alignment	○ Almost same as current condition	△ The Italy Bridge substructure is located in the downstream direction of the main stream	○ Almost same as current condition	○ Curvature of the river alignment can be reduced
Cross section of river improvement	△ Subject to restrictions by both FTZ and park	○ Only coordination with FTZ side	○ Set cross-section under constraint on the main stream side, and secure the shortage on the sub-stream side.	◎ No particular constraints
Connection to nearby facilities	△ Crossings are close to intersections and facilities, so connections need to be considered.	○ The distance from intersections and facilities is relatively secured.	△ Crossings are close to intersections and facilities, so connections need to be considered.	◎ Distance from intersections and facilities can be secured.
Impact on the surrounding environment	◎ Relatively small amount of excavation for river improvement.	△ Large amount of excavation for river improvement.	○ Large amount of excavation for river improvement is less than Alt.2.	▲ The largest amount of excavation in river improvement.
Impact on surrounding houses and farmland	◎ There are no houses or farmland in the area to be improved.	◎ There are no houses or farmland in the area to be improved.	◎ There are no houses or farmland in the area to be improved.	◎ There are no houses or farmland in the area to be improved.
Coordination with surrounding facilities(Administrators)	△ Need to coordinate the relocation of some FTZ facilities	△ Need to coordinate on the treatment of river sites along the park	○ No need to coordinate with FTZ facilities and parks	▲ Requires most intensive coordination for overall relocation of FTZ facilities, treatment of river sites along the main stream, etc.
Evaluation	Selected	Selected	Selected	

◎: Good , ○: Fair , △ : Poor, ▲: Very Poor

Table-15 Summary and Evaluation of the Alternatives for Palmeraie Road Countermeasures

<table>
<tr><td rowspan="8">Alternative 1</td><td colspan="5">Main Stream Improvement</td></tr>
<tr><td>Assumptions</td><td colspan="4">Partial relocation of FTZ facilities (the Flower Park is currently under construction, and demolition is expected to be difficult.)</td></tr>
<tr><td rowspan="5">Outline of Plan</td><td>Item</td><td>Plan</td><td>Item</td><td>Plan</td></tr>
<tr><td>Bridge Length</td><td>115m</td><td>Earth work Width</td><td>24.5m</td></tr>
<tr><td>Bridge Width</td><td>25.7m</td><td>Intersection</td><td>2 location</td></tr>
<tr><td>Width of Lane</td><td>3.25m</td><td>Else</td><td></td></tr>
<tr><td>Side Walk</td><td>1.5m×2</td><td></td><td></td></tr>
<tr><td>Estimated Cost</td><td colspan="4">4,600 million yen</td></tr>
<tr><td>Evaluation</td><td colspan="4">- The river alignment will not change significantly.
- In order to connect the road to the entrance/exit of the FTZ facility, the longitudinal length of the road needs to be about 6%. From the viewpoint of driving safety, it is desirable to keep it at about 2.5%. In this case, a separate side road arrangement will be required to connect to the FTZ facility. By raising the entire road, the road surface height is set higher than the HWL.
- The partial relocation of the FTZ facility will take time to coordinate with the administrator, which may affect the progress of the project.</td></tr>
<tr><td rowspan="8">Alternative 2</td><td colspan="5">Sub-stream Improvement</td></tr>
<tr><td>Assumptions</td><td colspan="4">Agreements with relevant organizations on the treatment of the main stream site along the park</td></tr>
<tr><td rowspan="5">Outline of Plan</td><td>Item</td><td>Plan</td><td>Item</td><td>Plan</td></tr>
<tr><td>Bridge Length</td><td>108m</td><td>Earth work Width</td><td>24.5m</td></tr>
<tr><td>Bridge Width</td><td>25.7m</td><td>Intersection</td><td>2 location</td></tr>
<tr><td>Width of Lane</td><td>3.25m</td><td>Else</td><td></td></tr>
<tr><td>Side Walk</td><td>1.5m×2</td><td></td><td></td></tr>
<tr><td>Estimated Cost</td><td colspan="4">4,300 million yen</td></tr>
<tr><td>Evaluation</td><td colspan="4">- As there are no restrictions on the sub-stream side other than the FTZ facility, it can be crossed at right angles to the Palmeraie road. However, the excavation of the river bed will be the largest among the alternatives.
- The location of the improved river is far from the Flower Park and the intersection on the east side, so the connection to these facilities is relatively easy.
- The Park is planned and developed along the current alignment of the main stream, and it is expected that it will take time to coordinate changes in the river channel and disposal of the site.</td></tr>
<tr><td rowspan="8">Alternative 3</td><td colspan="5">Main and Sub-stream Improvement</td></tr>
<tr><td>Assumptions</td><td colspan="4">Detailed study of river diversion plan</td></tr>
<tr><td rowspan="5">Outline of Plan</td><td>Item</td><td>Plan</td><td>Item</td><td>Plan</td></tr>
<tr><td>Bridge Length</td><td>87+51m</td><td>Earth work Width</td><td>24.5m</td></tr>
<tr><td>Bridge Width</td><td>25.7m</td><td>Intersection</td><td>2 location</td></tr>
<tr><td>Width of Lane</td><td>3.25m</td><td>Else</td><td></td></tr>
<tr><td>Side Walk</td><td>1.5m×2</td><td></td><td></td></tr>
<tr><td>Estimated Cost</td><td colspan="4">5,200 million yen</td></tr>
<tr><td>Evaluation</td><td colspan="4">- The total project cost will be the highest among the three proposals because the total bridge length will be the longest.
- The overall project cost will be the highest among the three proposals because the total bridge length will be the longest, and the issue of the longitudinal alignment of the road to connect the entrance and exit of the FTZ facility is the same as in Alternative 1. The length of river improvement will be longer, and the burden of maintenance and management after improvement will be higher than other proposals.</td></tr>
</table>

Note: Estimated cost includes detour construction, relocation of buried pipes such as power and communication pipes, consultant cost, and contingency cost.

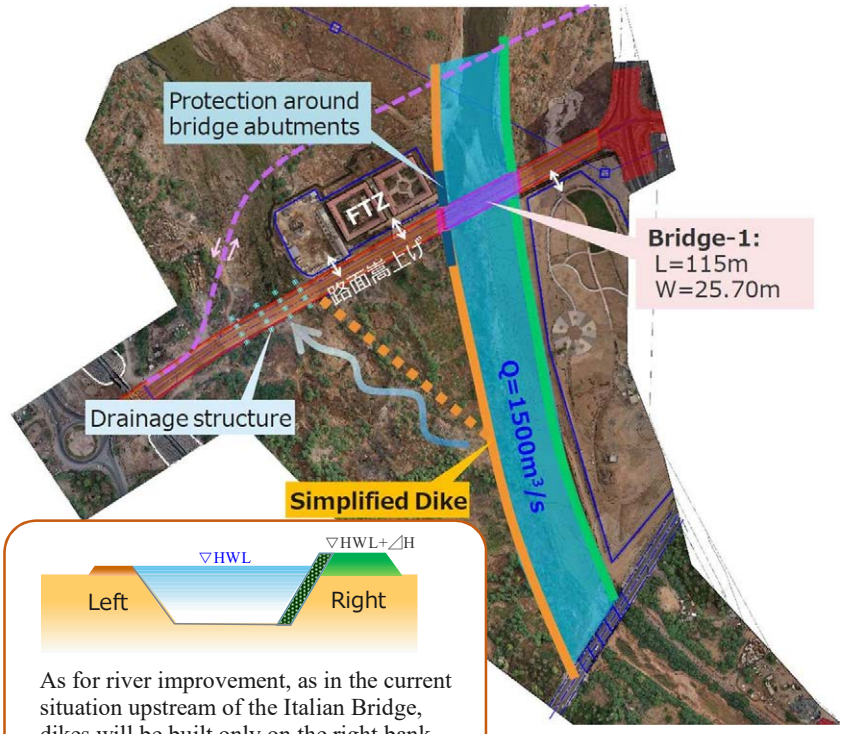
Table-16 Summary and Evaluation of the Additional Alternatives for Palmeraie Road Countermeasures

Add. Alternative 1	Special Retaining Wall Arrangement				
	Assumptions	Partial relocation of FTZ facilities (The Flower Park is currently under construction, and demolition is expected to be difficult.)			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	115m	Earth Work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Lane Width	3.25m	Else	Special retaining wall
		Side Walk	1.5m×2		
	Estimated Cost	4,500 million yen			
	Evaluation	- A special retaining wall (assuming concrete sheet pile) will be placed on the left bank downstream from the Palmeraie Road, where the river cross section is close to the FTZ, to avoid relocating part of the FTZ facilities. - Construction cost will increase due to additional structures. - The longitudinal road plan to connect the FTZ facility and the park to the entrance/exit is the same as the Alternative 1 shown in (7).			
Add. Alternative 2	Simple Improvement of Left Bank Dike.				
	Assumptions	The dike on the left side of the river should be improved at the same simple level as upstream of the Italy bridge.			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	108m	Earth Work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Lane Width	3.25m	Else	Left side dike improved simply
		Side Walk	1.5m×2		
	Estimated Cost	4,300 million yen			
	Evaluation	- The improvement of the left bank of the river will be limited to a simple dike equivalent to the one upstream of the Italy Bridge to avoid countermeasures against the FTZ facility. - Improvement of the left bank of the river will be carried out at the time of future planned flow in consideration of climate change. In this case, upstream improvements including the Italy Bridge are also necessary. - It is possible to reduce investment in FTZs whose future existence is unclear.			
Add. Alternative 3	Road Improvement with Detour Road Alignment				
	Assumptions	Detailed study of river diversion plan			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	108m	Earth Work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Lane Width	3.25m	Else	Simple dike(left bank)
		Side Walk	1.5m×2		
	Estimated Cost	4,500 million yen			
	Evaluation	- It is the most economical among the alternatives due to the reduction of detour construction cost and the reduction of the scale of left bank river improvement. - The construction cost for relocation and restoration of buried pipes can be reduced, and the construction period can be shortened accordingly. - In the longitudinal road plan, coordination with FTZ facilities and park entrances and exits is unnecessary. - The construction of the bridge is constrained by the presence of high voltage lines above the planned bridge site.			

Note: Estimated cost includes detour construction, relocation of buried pipes such as power and communication pipes, consultant cost, and contingency cost.

Add. Alternative-2: Simplified Improvement of Left Bank Dike

[JICA Project] Design Flow Rate Q=1500m3/s



As for river improvement, as in the current situation upstream of the Italian Bridge, dikes will be built only on the right bank (city side), while the left bank will be improved simply.

[Future Plan] Design Flow Rate Q=1800m3/s

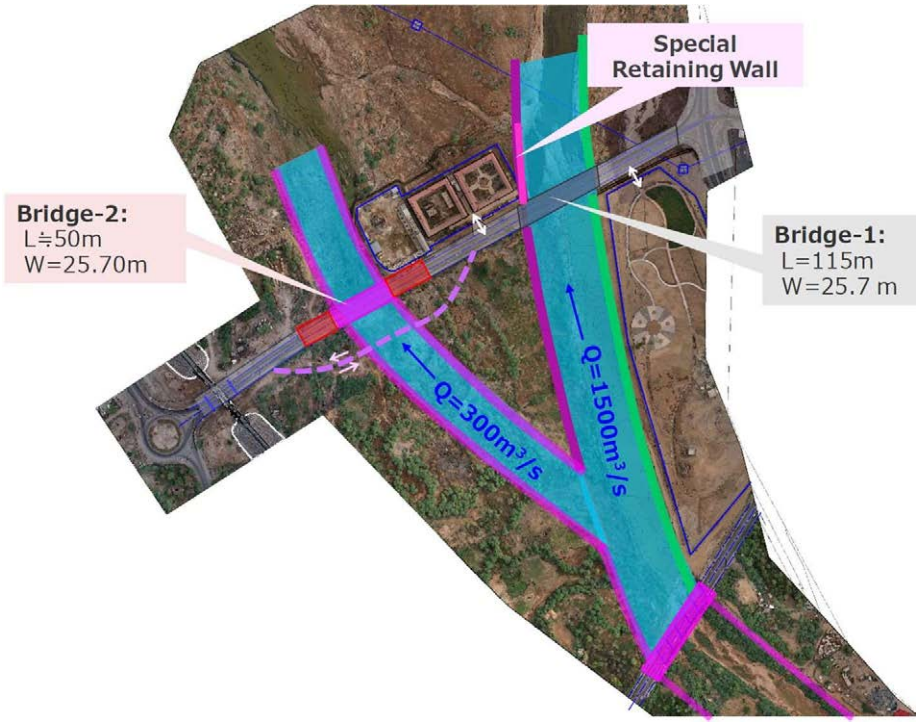


Figure-20 Outline of Plan（Add. Alternative-2）

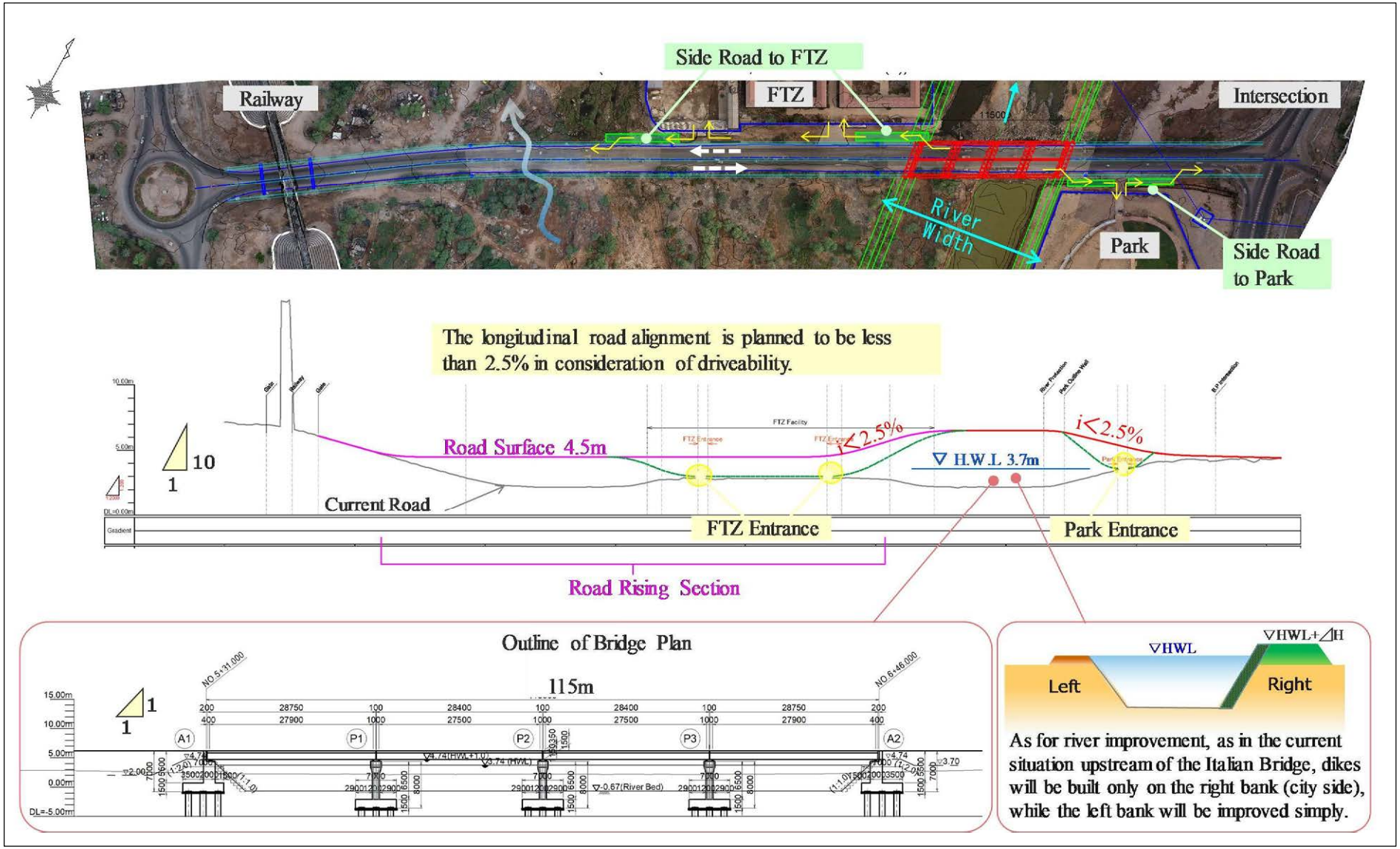


Figure-21 Outline Drawing of the Countermeasures (Additional Alternative 2)

Examination of Related Improvement Plan (Intersection Improvement)

The Palmeraie Road intersects with other roads at both ends. As shown in the figure below, the eastside intersection is signalized and the west side one is roundabout.

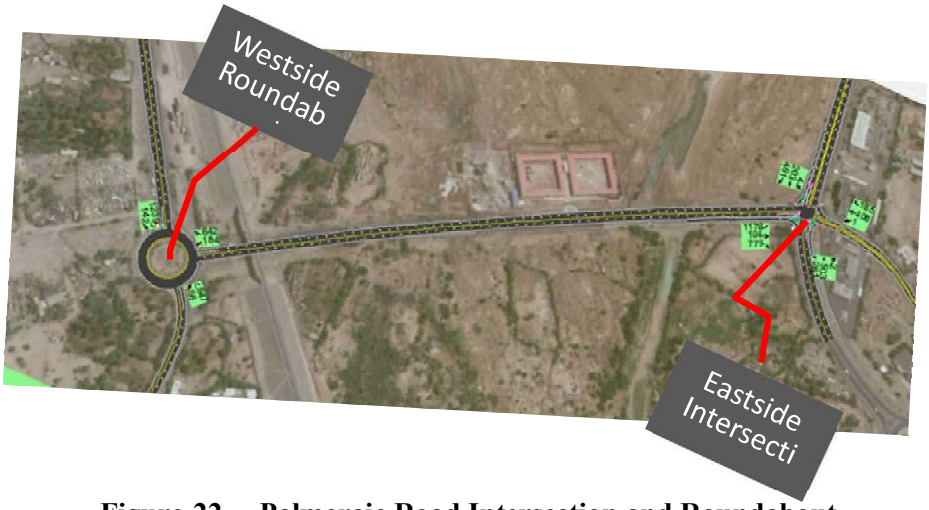


Figure-22 Palmeraie Road Intersection and Roundabout

(1) Eastside intersection

Current Status Analysis

As shown in Figure-23 the eastside intersection has heavy traffic from the direction of Balbala to the city center during the morning peak hours. This is especially noticeable for the traffic turning left onto Venice Road at the intersection. During the afternoon peak hours, the traffic in the opposite direction turning right from Venice Road and turning left from Fun City toward Palmeraie Road is high. Furthermore, the inbound EDD approach has only one lane, and although the traffic volume is low and is almost all through traffic towards Palmeraie Road, the efficiency of this intersection depends largely on the treatment of this traffic.

Table-17 shows the estimated intersection saturation and congestion by approach using traffic volumes and signal plan in the morning peak when the traffic is highest. The current intersection saturation is 1.011, which is above the standard (less than 0.9), and some countermeasures are needed even in the current situation. In addition, the congestion level of Palmeraie Road and EDD approaches is high.

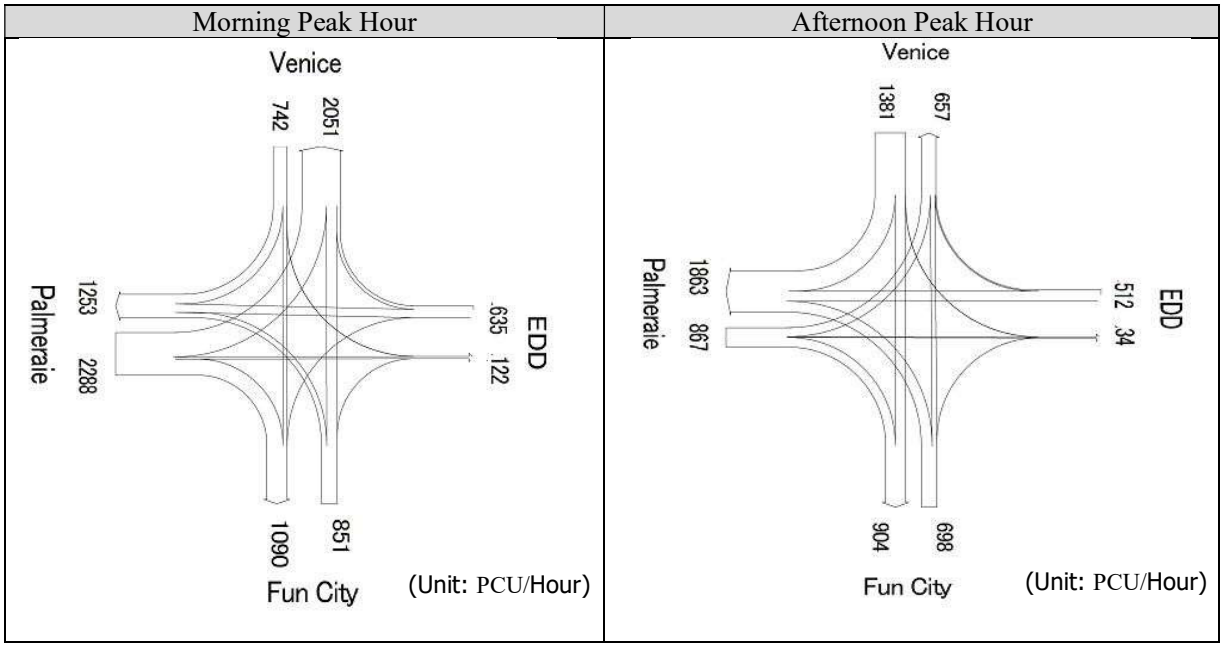


Figure-23 Volume of the Traffic Passing through the Intersection on the East Side of Palmeraie Road

Table 17 Results of the Calculation of the Saturation at Intersection (current situation)

	Entrance		Palmeraie	Venice	EDD	Fun City
Demand rate of the intersections	Cycle length (seconds)		140			
	Loss time (seconds)		16			
	Signal phase demand ratio	1ϕ	0.353			
		2ϕ		0.111		
		3ϕ			0,295	
		4ϕ				0.252
	Degree of saturation of intersection			1.011	≥	0.9
Congestion by	Saturation flow rate		3,640	4,000	1,940	3,800
	Green ratio		0.19	0.26	0.19	0.26
	Design capacity (PCU/h)		692	1,040	369	988
	Demand (PCU/h)		1282	207	572	764
	Degree of congestion		1.85	0.20	1.55	0.77

Current existing layout

Examination of Countermeasures

There are two ways to reduce congestion at intersections: structural measures, such as addition of new lanes and grade separation, and non-structural measures, such as the review of traffic regulations and signal timing. Figure-24 shows 3 at-grade and 1 grade-separated intersection alternatives.

In addition to widening the Palmeraie Road (left-turn lanes from 2 to 3, and total lanes from three), Proposal A-1 improves Fun City approach (right-turn lane to shared / right turn lane), Proposal A-2 improves EDD approach (shared through/left-turn lane to right-turn lane), and Proposal A-3 combines the above two improvements (widening Palmeraie approach and improving Fun City and EDD approaches). Proposal A-4 is a grade-separated alternative elevating two left-turn lanes from Palmeraie Road to Venice Road, and this requires widening Venice from its current three lanes to four lanes.

Table-18 shows the degree of saturation for each of the above alternative intersection plans for the years 2025, 2030, and 2035. The degree of saturation level of Proposal A-1 exceeds 0.9 except for the current condition and it will not able to handle the future traffic volume. Proposal A-2 can be handle the traffic until 2030, while Proposals A-3 and A-4 can handle until 2035.

The grade-separated intersection will ensure smooth flow of the left-turn traffic from Palmeraie Road to Venice, but the degree of saturation will be the same as that of Proposal A-3. In addition, the cost will be large, and there are still physical challenges, as the project may be affected by the high-voltage power lines that cross the Palmeraie Road. Therefore, Proposal A-3 is recommended in this study.

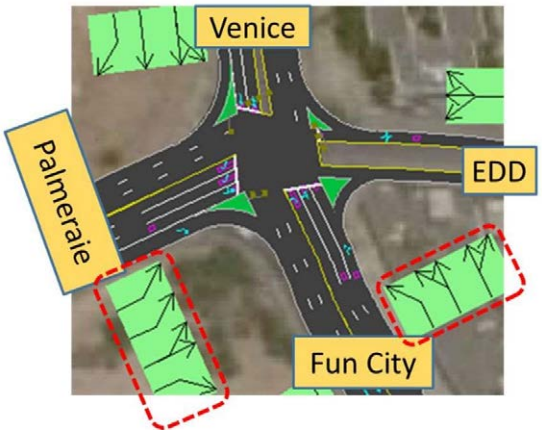
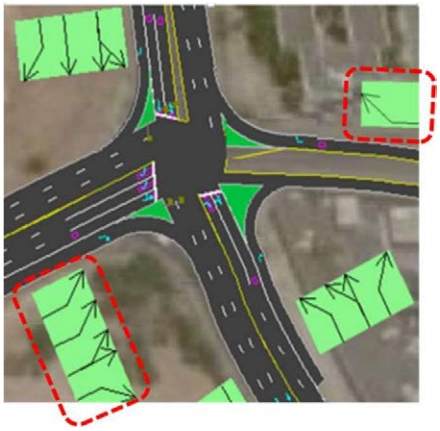
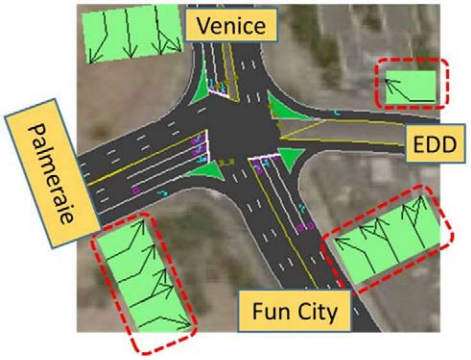
Proposal A-1	Proposal A-2
	
• Palmeraie: A left turn lane added (from one lane to two lanes) • Fun City: Right-turn lane⇒Through-right lane	• Palmeraie: A left turn lane added (from one lane to two lanes) • EDD : Left-through lane ⇒ Right-turn lane
Proposal A-3	**Proposal A-4**
	
• Palmeraie: A left turn lane added (from one lane to two lanes) • Fun City: Right-turn lane ⇒ Through-right lane • EDD: Left-through lane ⇒ Right turn lane	• Palmeraie: Left-turn lane elevated (two lanes) • Fun City: Right-turn lane ⇒ Through-right lane • Exit side of Venice Road: 1 lane added (from 3 to 4 lanes) • EDD approach: Left- through-right lane ⇒ Through-right lane

Figure-24 Improvement Alternatives for the Eastside Intersection of Palmeraie Road

Table-18 Proposed Improvement Measures for the Eastside Intersection of Palmeraie Road

Measures		Saturation rate (AM peak)			
		2021	2025	2021	2035
Basic	Do nothing	1.011	1.180	1.434	1.742
A-1	Palmeraie: L-LT-R>>L-L-LT-R	0.834	0.974	1.182	1.438
A-2	Palmeraie: L-LT-R>>L-L-LT-R + EDD: LTR>>R	0.598	0.700	0.849	1.032
A-3	Palmeraie: L-LT-R>>L-L-LT-R + EDD: LTR>>R + Fun City: L-TL-R>>L-TL-TR	0.494	0.578	0.702	0.853
A-4	Elevated Palmeraie left turn + Fun City: L-TL-R>>L-TL-TR + Restriction of EDD left turn	0.513	0.599	0.727	0.884

(1) West side roundabout

The west side roundabout is not a problem in its current state, but when left-turning traffic from the Draleh direction onto Palmeraie Road increases in the future, it will be difficult to enter from the south approach. For this purpose, a separate right-turn lane on Palmeraie Road from the south will be required (see Figure-25).

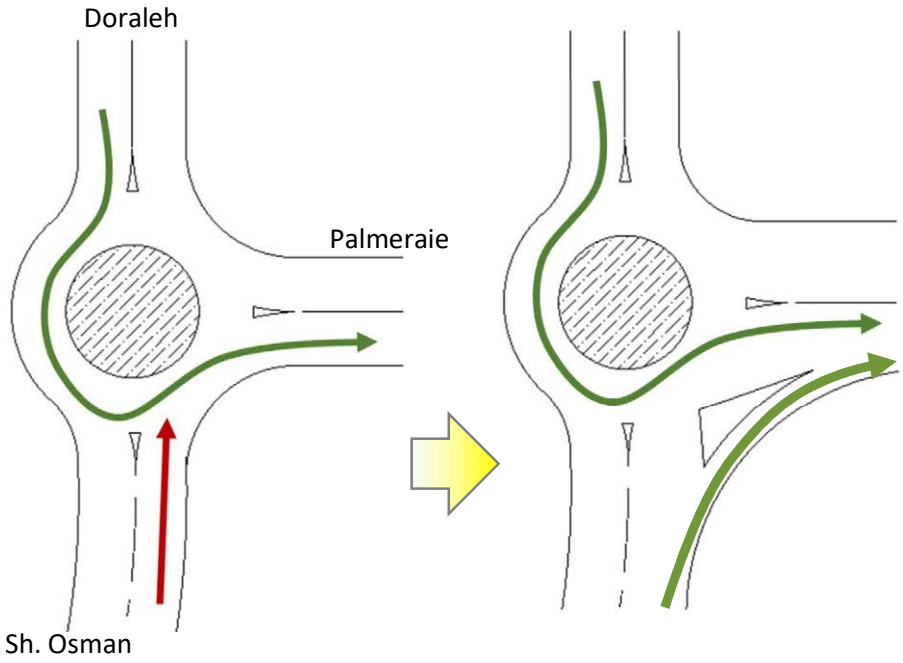


Figure-25 Draft Improvement Plan for West Side Intersection

Summary of Measures for Other Project

The Nagad Road improvement and Italy Bridge reinforcement alternatives, which were not ultimately selected as priority projects, are examined here.

(1) Countermeasure for Nagad Road

As with the Palmeraie Road, the Nagad Road is flooded and traffic is blocked when the water level rises, and a bridge is required to ensure traffic flow. The road has currently a steep gradient of more than 7%, and in order to secure traffic during the construction period, the road should be shifted downstream. Although no records of past floods were found, the river cross-section that corresponds to the planned flow rate at the Palmeraie Road should be secured. Other planning conditions should be as follows:

- The width of the roadway is 3.5m due to accommodate heavy traffic of large vehicles.
- Since the number of lanes will be limited by the width of the box culvert under the railway on the east side, the current two lanes should be used.
- The width of the road shoulder should be set so that two lanes can be secured even when a broken-down vehicle is stopped.
- Sidewalks should be installed since it is close to the railroad station and university.

(2) Countermeasure for Italy Bridge (National Route 1)

In order to ensure that the current Italy Bridge are in sound condition for vehicular traffic, two measures can be considered: (1) repair (reinforcement) of existing bridges and (2) construction of new bridges. After studying the contents of each of these measures, it is considered that (2) new bridge construction, which has fewer issues to be addressed, is superior when Japan implements the aid.

10. Examination of Cost Reduction

As a result of discussions with the Government of Japan based on the "Additional Alternative-2", which was judged to be superior among the alternatives, the following policy was presented regarding the content of support for the improvement of the Palmares Road.

- The measures should be aimed at strengthening against natural disasters.
- Further reduction of project costs should be pursued.

The largest part of the project cost is for bridge construction. However, bridge maintenance is the sole means of resilience against natural disasters, and it cannot be eliminated, so cost reduction measures in other portions of the project were considered. The outline of each proposal and the breakdown of the project cost are shown below.

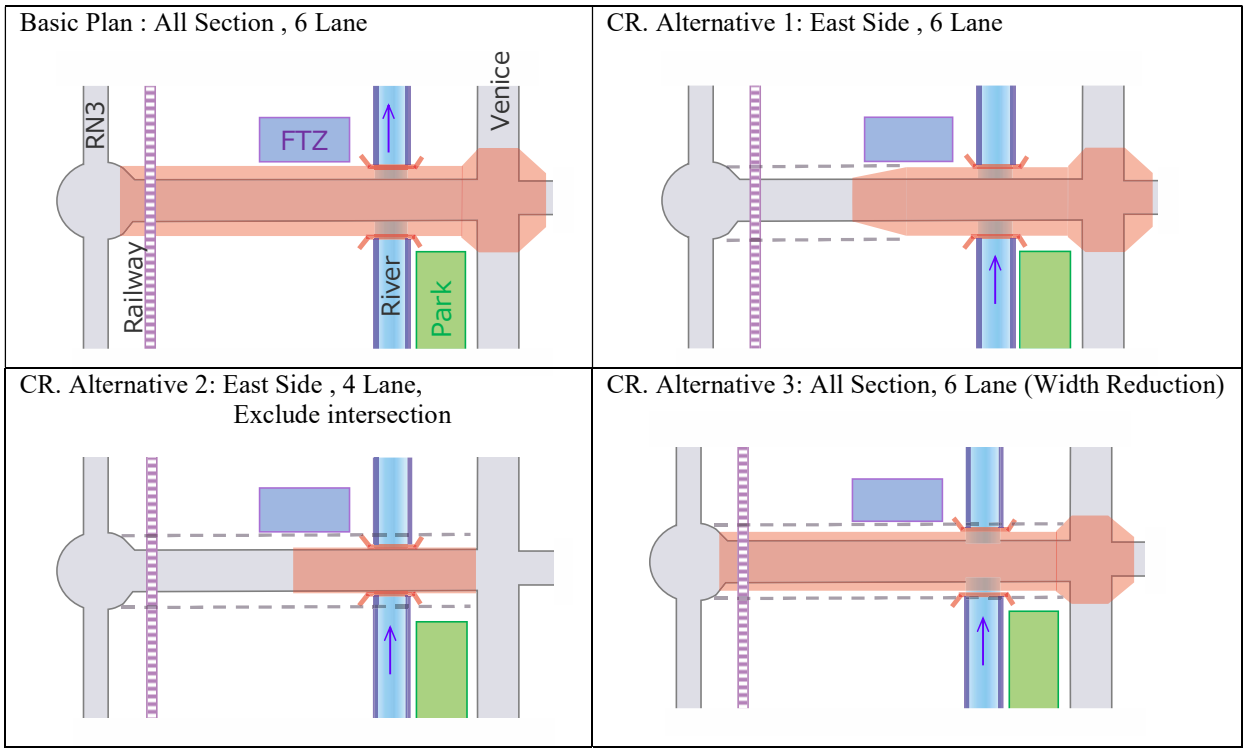


Figure-26 Outline of Cost Reduction Alternatives

Table-19 Cost Breakdown of Cost Reduction Alternatives

	Summary	Scope of Work	Estimated Cost (million yen)
Basic Plan	All six lanes between the east intersection and the west intersection will be improved.	Bridge Length: 115m Bridge Width: 25.70m Lane Width: 3.25m Side Walk: 1.5m×2 Earth Work Width: 24.50m Intersection: 2 Location	River Improvement: 100 Bridge: 2,540 Road, Intersection: 520 Relocation utilities: 400 Others: 210 Consultant Cost: 337 Contingency Cost: 185 Total **4,300**
CR. Alternative 1	Six lanes between the east intersection and bridge will be improved	Bridge Length: 115m Bridge Width: 25.70m Lane Width: 3.25m Side Walk: 1.5m×2 Earth Work Width: 24.50m Intersection: 1 Location (East Side)	River Improvement: 100 Bridge: 2,540 Road, Intersection: 210 Relocation utilities: 300 Others: 180 Consultant Cost: 292 Contingency Cost: 160 Total **3,800**
CR. Alternative 2	Four lanes for only bridge will be improved	Bridge Length: 115m Bridge Width: 19.20m Lane Width: 3.25m Side Walk: 1.5m×2 Earth Work Width: 18.00m Intersection: ---	River Improvement: 100 Bridge: 2,000 Road, Intersection: 80 Relocation utilities: 300 Others: 180 Consultant Cost: 236 Contingency Cost: 130 Total **3,100**

CR. Alternative 3	All six lanes with reduced road width between the east intersection and the west intersection will be improved.	Bridge Length: 115m Bridge Width: 22.20m Lane Width: 3.00m Side Walk: 1.5m×1 Earth Work Width: 21.00m Intersection: 2 Location	River Improvement: 100 Bridge: 2,370 Road, Intersection: 470 Relocation utilities: 400 Others: 210 Consultant Cost: 315 Contingency Cost: 174 Total **4,100**

11. Project Evaluation

(1) Necessity of the project

The appropriateness of implementing this project as Japan's grant aid will be evaluated from the following two points.

Securing Reliable Logistics Functions

Djibouti City functions as a gate for the import and export of Ethiopia[2], a landlocked country, and securing a smooth and safe logistics function between Djibouti and Ethiopia is a major challenge for Djibouti. The distribution route between Djibouti and Ethiopia is via the Palmeraie Road between Djibouti Port on the east bank of the Ambouli River and Doraleh Port on the west side, and from Doraleh Port to Ethiopia via National Route 1. According to the results of the traffic survey, the volume of cargo vehicles on the Palmeraie Road (point № 2) is the highest compared to other points on the route (№ 7 and 8).

Table-20 Results of Traffic Volume Survey on Logistics Roads (cross-sectional traffic volume)

№	Survey Site	Survey Duration	Traffic Volume by Vehicle Type						
			Motor-bike	Car	Public	Truck	Trailer	Total	Truck + Trailer
2	Palmeraie	24hr	3,502	17,436	8,047	1,565	1,000	31,550	2,565
7	RN1-PK20	14hr	58	1,412	997	683	1,820	4,970	2,503
8	RN1-PK24	24hr	31	999	239	283	2,122	3,674	2,405

Note: Survey date: Nos. 2 May 19, Nos. 7 and 8: May 20

Strengthening Connectivity Between the East and West Urban Areas

There have been seven major natural disasters in the Ambouli River basin since 1989. In particular, in recent years, floods have occurred three years in a row, which is assumed to be related to climate change. The duration of floods ranges from one to five days, during which crossing the Ambouli River is difficult. Since major urban functions are concentrated on the east side of the Ambouli River and many citizens usually cross the river to commute to work or school, economic and daily life activities are greatly affected. In addition, there are only three roads crossing the Ambouli River, including the Palmeraie Road, but only the Italy Bridge can be used during flooding. It is impossible for the Italy Bridge to handle all the traffic, which is nearly 60,000 vehicles per day, and this causes a citywide traffic disruption.

According a World Bank survey, 20% of Djibouti City trips are made by public transport, 50% on foot, 3% by private cars, and the rest by cabs and corporate buses. In other words, excluding walking, more than 90% of the total population uses some form of public transportation, including buses, indicating its importance in Djibouti. Most of the bus routes connect the east and west sides of the Ambouli River through the Palmaraie Road and the Italy Bridge (World Bank survey). Based on the results of the traffic survey conducted in this study, the number of people using public transportation on the Palmeraie Road and the Italy Bridge was estimated to be over 80,000 per day, indicating the importance of both roads as bus routes.

This means that strengthening of the Palmeraie Road, which has the function of connecting the east and west urban areas, is highly appropriate for maintaining a smooth daily life activities of the citizens.

[2] About 80% of the import cargo at the Port of Djibouti is destined for Ethiopia. In addition, exports from Ethiopia have been increasing in recent years, rising to about 30% of total volume (see Chapter 3).

(2) Calculation of Economic Benefits

The following benefits are expected by widening the Palmeraie Road to six lanes and making it passable even during floods:

i. Elimination of time loss due to the blocking of the Palmeraie Road during floods (Palmeraie Road and Italy Bridge)
ii. Benefits related to the reduction of travel and delay time due to the widening of the Palmeraie Road to six lanes and the improvement of intersections
iii. Elimination of economic losses in the logistics sector caused by the blocking of the Palmeraie Road during the floods

The project cost was calculated for each fiscal year with the construction period as a 3year (10%, 30% and 60%). The project cost is converted to economic cost by multiplying the project cost by 0.85. On the other hand, the benefits are calculated from the aforementioned benefits a) to c) per 20year from the start of its operation.

Table-21 shows the results of calculating B/C and EIRR when the discount rate is set at 8%. The B/C of the basic case and Alt-3: All 6-lanes with reduced width exceeded 1.0, indicating that they are economically feasible. However, the project costs for these two cases are still large, and there are still concerns about traffic safety for Alt-3. Thus the evaluation from a comprehensive perspective is necessary.

Table-21 List of Economic Analysis Results

	Project Cost (billion yen)	B/C	EIRR (%)	NPV (billion yen)
Basic case	4.3	1.138	9.29	0.526
Alt-1: Bridge and east intersection	3.8	0.825	6.07	-0.590
Alt-2: 4-lanes bridge only	3.1	0.703	4.30	-0.819
Alt-3: All 6-lanes with reduced width	4.1	1.193	9.78	0.704

12. Strategies for Project Implementation

Estimation of the Project Scheme

The following is a draft of the items of undertakings by both countries under Japan's grant aid scheme assumed for this project.

- ✓ Undertakings by Japan side: Main work parts including the construction of roads, bridges, or river improvement work that are eligible for grant aid
- ✓ Undertakings by Djibouti side: The implementing agencies of the Djibouti side will implement the works listed in the table below in cooperation with the relevant organizations.

Table-22 Undertakings by Djibouti Side in each Project Phase

No.	Burden items	Project phase		
		Before implementation (Before bidding)	During Implementation (During construction)	After implementation (After construction)
1	Project approval for the implementation of this plan (environment, road occupancy, etc.)	✓		
2	Briefing residents and holding stakeholder meetings in the vicinity of the planned facility construction site	✓	✓	
3	Securing land for construction under appropriate legal procedures	✓		
4	Relocation or removal of obstructions (power cables, communication cables, water and sewage pipes, etc.)	✓*		
5	Provision of land for installation of temporary facilities (site office, warehouse, batcher plant, access road, construction yard, temporary bridge, etc.)	✓		
6	Construction, maintenance and management of detours for general vehicles required for the construction.	✓*	✓*	
7	Provision of disposal facilities and locations for the disposal of construction waste	✓	✓	
8	Notifying residents, passing vehicles, and passing vessels about traffic restrictions	✓	✓	
9	Guidance of general vehicles to detour routes and traffic control in the vicinity during the construction period, etc.		✓*	
10	Legal measures and work permits necessary for Japanese and third-country personnel engaged in construction to enter and stay in Djibouti	✓	✓	
11	Process for exemption of corporate income tax, customs duties, internal taxes, and other taxes imposed in Djibouti on those using Japanese grant funds.	✓	✓	
12	Process for issuing Authorization for Payment (A/P) required for payment to Japanese consultants and contractors, and bearing the issuing and payment fees	✓	✓	
13	Appropriate operation, maintenance, and management of facilities (roads, bridges, and river facilities) constructed through the project			✓
14	Appropriate maintenance and management of river facilities (dredging work, etc.)	✓	✓	✓
15	All costs not included in grant assistance that are incurred in the implementation of this project.	✓	✓	✓

Schedule for Project Implementation

Table-23 is a draft schedule for project implementation, assuming Japan's grant aid project scheme.

Table-23 Draft Schedule for Project Implementation

■ In the case of preliminary work to be carried out by the Japanese side

Year	1 year				2 years				3 years				4 years				5 years			
Quarter of a Year	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.Outline design and cost estimation																				
2. cabinet approval				▼																
3. E/N, G/A				▼																
4. Detailed design																				
5. Preparation and approval of bidding documents																				
6. Pre-qualification, bidding																				
7. Evaluation of bids																				
8. Signing of vendor contracts								▼												
9. Preparation works																				
10. Preliminary work (Detour、Relocation of utilities)																				
11. Main Work																				
12. Project Completion																		▼		

■ In the case of preliminary work to be carried out by the Djibouti side

Year	1 year				2 years				3 years				4 years				5 years			
Quarter of a Year	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.Outline design and cost estimation																				
2. cabinet approval																				
3. E/N, G/A																				
4. Detailed design																				
5. Preparation and approval of bidding documents																				
6. Pre-qualification, bidding																				
7. Evaluation of bids																				
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9. Preparation works																				
10. Preliminary work （Detour、Relocation of utilities）																				
11. Main Work																				
12. Project Completion																				

Work of Djibouti Side

Project implementation Issues

- Grasping the latest trends of development projects around the target area (in the planning stage or under implementation), and reflecting them in the grant aid plan as appropriate
- Consultation and coordination with relevant organizations in Djibouti (body in charge of the Ambouli River management, electricity authority, ONEAD, Djibouti Telecom, police, etc.) during the planning stage of the grant aid assistance program
- Clarification of the roles of relevant organizations in Djibouti (body in charge of the Ambouli River management, Electric Power Authority, police, etc.) and establishment of an operation system for appropriate operation and maintenance of the cooperation targeted facilities (roads, bridges, intersections, rivers) subject to cooperation.

Chapter 1 Outline of the Survey

1.1 Background and Objectives of the Survey

1.1.1 Background of the Survey

The facilitation of logistics in Djibouti City, which is a port city, is the fundamental for driving not only the economic development of the country but also that of East African region. However, frequently recent flood and the increase in traffic volume associated with urbanization in the city, have made need for the formulation and implementation of plans for strengthening of the logistics network an urgent issue.

In recent years, in addition to the Djibouti Port (old port), which is close to the central business district (hereinafter referred to as CBD), deep container berths and petroleum loading/unloading bases have been developed in the Doraleh area (new port) of Djibouti City. Therefore, the city is expected to the further develop as a port and logistics base. The severe weather conditions of Djibouti has limited the land suitable for agriculture, making the port and and logistics industry the life line of the country. The inflow of population to the city is also increasing. The City of Djibouti is largely divided by the Ambouli River into two areas: an eastern area including the old city area, CBD, medical facilities and airport area, and a western area including the new port and residential area. Many of the rural immigrants live in a residential area called the Balbala district in the western area with an estimated population of 0.2-0.3 million, which is about 40% of the total population of the City of Djibouti.

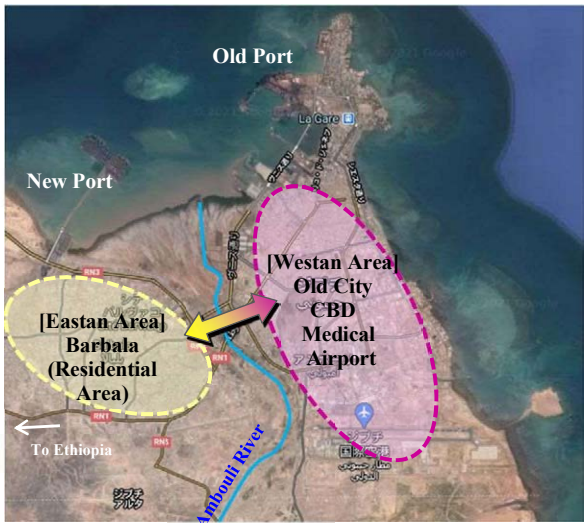


Figure 1.1.1 Land Use Overview of Djibouti City

The the roads connecting the east and west areas of the city across the Ambouli River are limited to three: Palmeraie Road, the Italy Bridge on National Road Route 1, and the Nagad Road. These roads, particularly Palmeraie Road and the Italy Bridge which directly connect Balbala district with CBD, are congested. They specifically become major bottlenecks in the urban network during morning and evening rush hours.

The above crossing roads have also two additional problems. First, the Palmeraie Road and the Nagad Road have a ford structure, and they are flooded by the Ambouli River when heavy rains falls and become impassable. In such case, the Italy Bridge remains the only road connecting the east and west sides. This situation causes further serious traffic congestion, forcing the government to take measures to restrict the traffic between the east and west, which affects significantly the daily civilian life and economic activities. Second, as more than 30 years has passed since the Italy Bridge was built, the bridge condition has deteriorated considerably that the passage of large vehicles is currently prohibited. Therefore, when the Palmeraie Road and Nagad Road are flooded, the flow of large vehicles is disrupted, and this would have an extremely serious impact on the country in which the port and logistics industries are playing a major role in the economy.

As mentioned above, Djibouti City requires urgent measures to strengthen its logistics network in consideration of flood risks, but due to the lack of basic information for the formation of specific projects, this survey was decided to be carried out.

1.1.2 Purpose of the Survey

This survey aims to identify problems by analyzing the present state of the transport and logistics sector in Djibouti City , to show comprehensive measures for the improvement the urban road network for strengthening the logistics network considering the flood risk, and to collect and analyze basic information such as the preconditions for the formation and implementation of the most suitable projects as ODA projects.

1.1.3 Targeted Area

Djibouti City and its surroundings are the target of the survey

1.2 Description of the Survey

(1) Review of the Outline of Target Areas (Chapter 2)

For understanding the outline of target areas, the natural environment and socio-economic conditions as well as natural disaster situations (records of disasters) are reviewed. In addition, existing materials are reviewed and interviews are conducted to understand the present status of the Ambouli River, and the actual status of countermeasures against flood that have already been implemented.

(2) Actual Status and Issues of the Transport and Road Sector (Chapter 3)

In order to understand the actual status of the city road network, a traffic volume survey and a road inventory survey on major trunk roads in the city are implemented. By utilizing the result of these surveys and existing materials, the issues of the city road network are identified.

(3) Analysis of Flood Risks in the Target Areas (Chapter 4)

After estimating the probable flood peak runoff based on the past meteorological data, areas where the Ambouli River overflowed in the past along with the status of river courses and their changes are analyzed, and a method to rehabilitate the Ambouli River was examined.

(4) Identification of Issues Related to the Strengthening of Logistics in Djibouti City and Examination of Countermeasures (Chapter 5)

After estimating future traffic volumes on the three roads crossing the Ambouli River and analyzing the current and potential future issues, countermeasures necessary for strengthening the logistics network, including developing city roads and streamlining urban traffic through structural and non-structural measures are examined.

(5) Direction of Support of Japan (Chapter 6)

From the planned countermeasures identified in (4) above, the supports that Japan could provide are examined by taking into account the requests made by the Djibouti side and policies of planned projects and cooperation with other donors, etc. Among those supports, the most suitable one for a Japanese ODA project (draft) is selected after making comparison and reviewing several alternatives including their estimated costs.

1.3 Composition of the Survey Team

Figure 1.3.1 shows the implementation structure of this survey. From Japan, six experts and one interpreter (Japanese to French) are dispatched. Local coordinators and interpreters (English-French) are hired to support the activities of JICA survey team. In addition, field investigators are used to conduct traffic surveys, road inventory surveys, and the geological survey and topographical survey are outsourced to a local contractor.

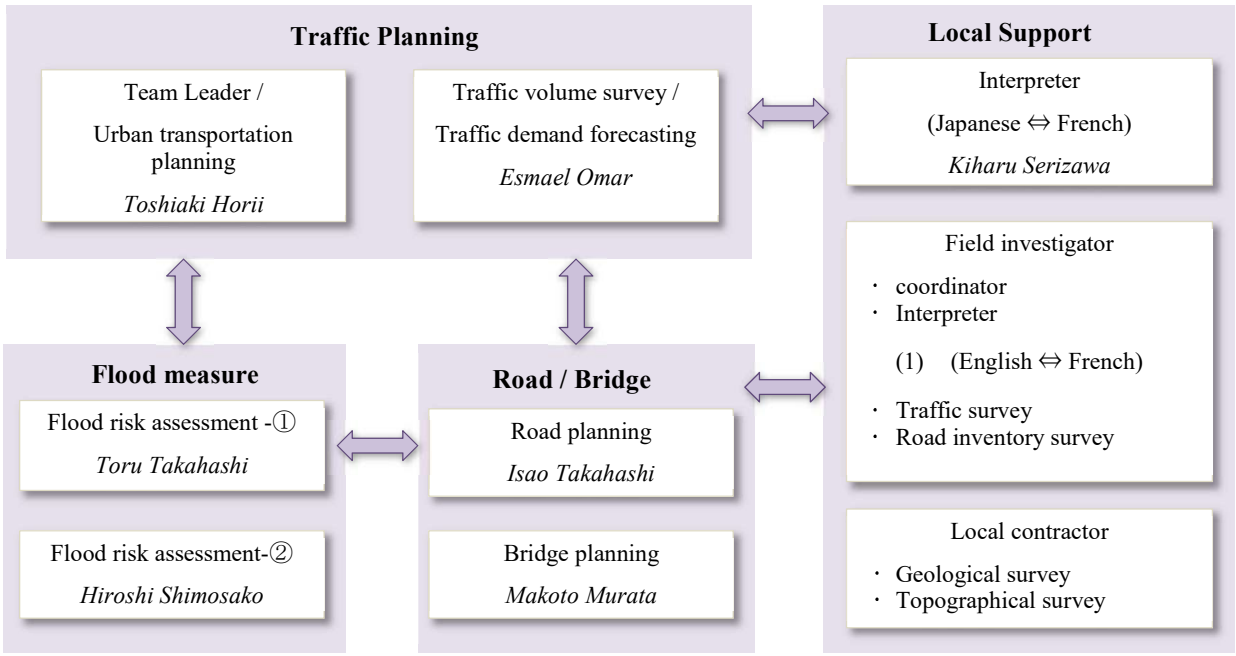


Figure 1.3.1 Survey Implementation Structure

Chapter 2 Outline of the Target Area

2.1 Natural Environment

2.1.1 Geographical Features

The Republic of Djibouti is a country located along the Red Sea coast and at the north end of the African Great Rift Valley, bordering Eritrea in the north, Ethiopia in the west, Somaliland in the south and the Gulf of Aden in the east. The country is facing the Gulf of Aden, while, more precisely, its land area is located at the mouth of the Gulf of Tadjoura that cuts into Djibouti's land area from the east to the west (Figure 1).

The Republic of Djibouti, at its central part, has a salt lake, Assal, which is 155m below the sea level and was formed by activities of the African Great Rift Valley. On the other hand, the country has Mt. Moussa Ali, which is over 2,000m above the sea level at its north end. The Republic of Djibouti, therefore, is unique as it has a terrain with a series of rises and falls. This specific topography was formed because the country is located in the southern part of the Afar Triangle, a contact area of the African Plate, Arabian Plate and Somali Plate, where a rift valley was formed by extensional tectonics and the accompanying eruption of basalt, and the like.

The Ambouli River flowing through Djibouti City has its source in the mountainous area in the western part of the country with an elevation of over 500m above the sea level. The river runs toward the east at the west side of the city, collecting water from a number of branch streams and changes its course more to the north at a point about 6km east of Chabelley Airport to flow into the Gulf of Aden. The river has large alluvial floodplain terrains and forms a large delta near its river mouth.

Djibouti City has two different terrains on its east and west sides divided by the Ambouli River. On the east side, there is a flat land of 5 to 15m above the sea level, while the west side has a stretch of lava plateau of several tens to several hundreds of meters above the sea level (mountainous area). The plateau on the east side of the river shows a ridge-line pattern that indicates the flow direction of the lava.

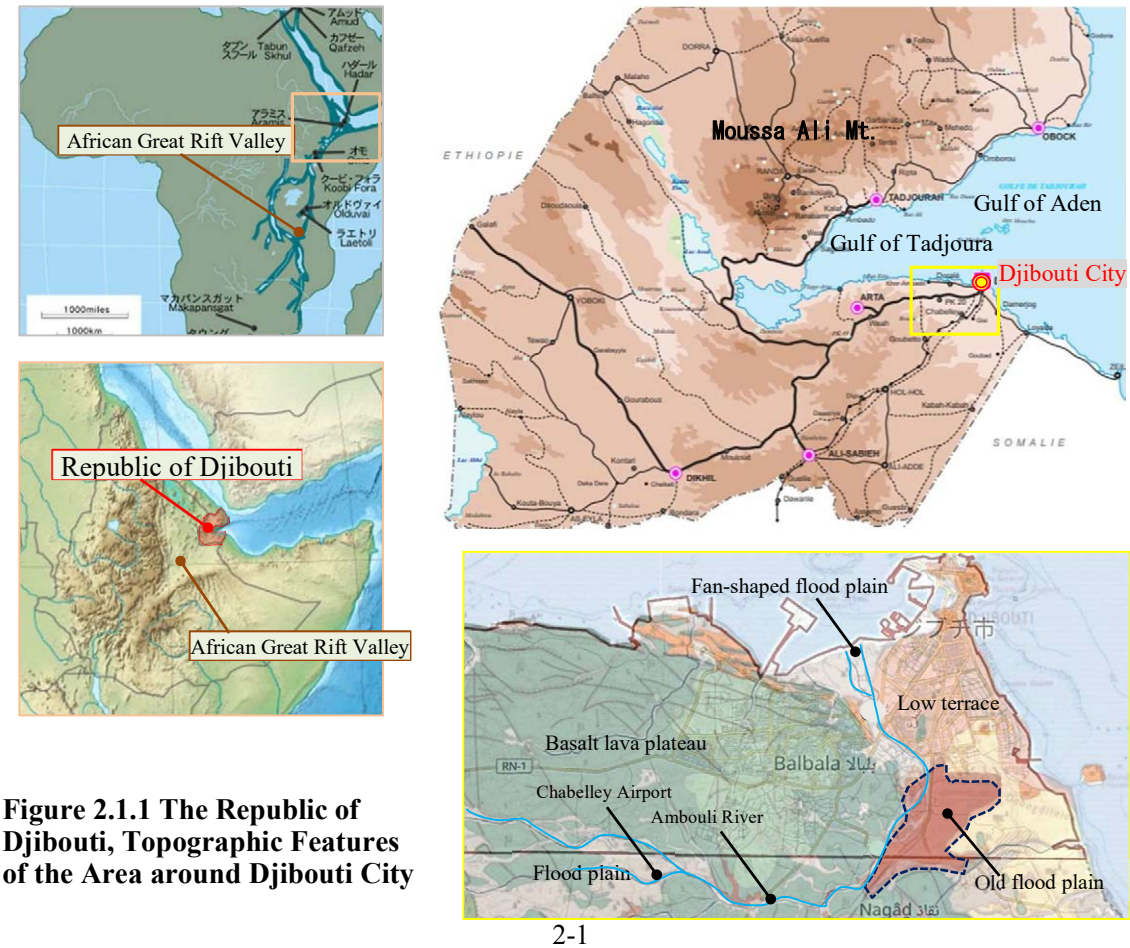
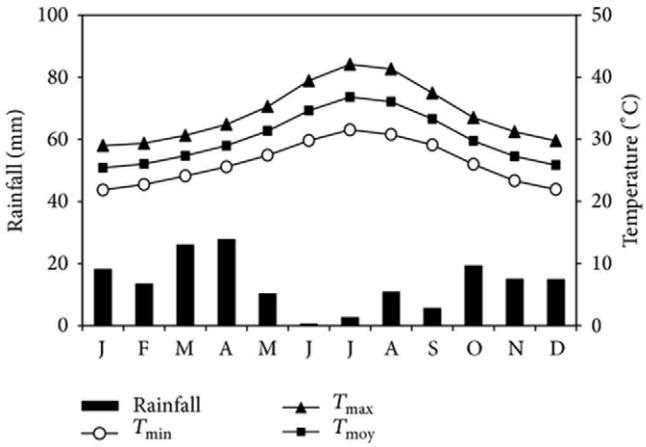


Figure 2.1.1 The Republic of Djibouti, Topographic Features of the Area around Djibouti City

2.1.2 Climate

The climate of the Republic of Djibouti is largely characterized by two seasons, the dry and rainy seasons. In the dry season (from May to September), the temperature is high, while the humidity is low. On the other hand, in the rainy season (from October to April), the temperature is low and the humidity is high. The temperature rises and falls between 25 and 35 degrees Celsius with the lowest being recorded between December and January. Days with temperature exceeding 30 degrees Celsius continue from May to September, sometimes reaching almost 50 degrees Celsius. A high humidity exceeding 70% is recorded from October to May, which falls to 45 to 55% from June to August.



Source: Recent Extreme Precipitation and Temperature Changes in Djibouti City (1996-2011, Journal of Climatology, 2013)

Figure 2.1.2 Distribution Trend of Monthly Rainfall and Monthly Average Temperature

According to Djibouti City's weather observation data, the monthly rainfall increases between October and May (Figure 2.1.2). In recent years, however, including 2004 and the years between 2018 and 2020, a daily rainfall of around 100mm and flood damages were recorded in Djibouti City area.

Figure 2.1.3 Flood Damage in 2004 (National Road Route 1)

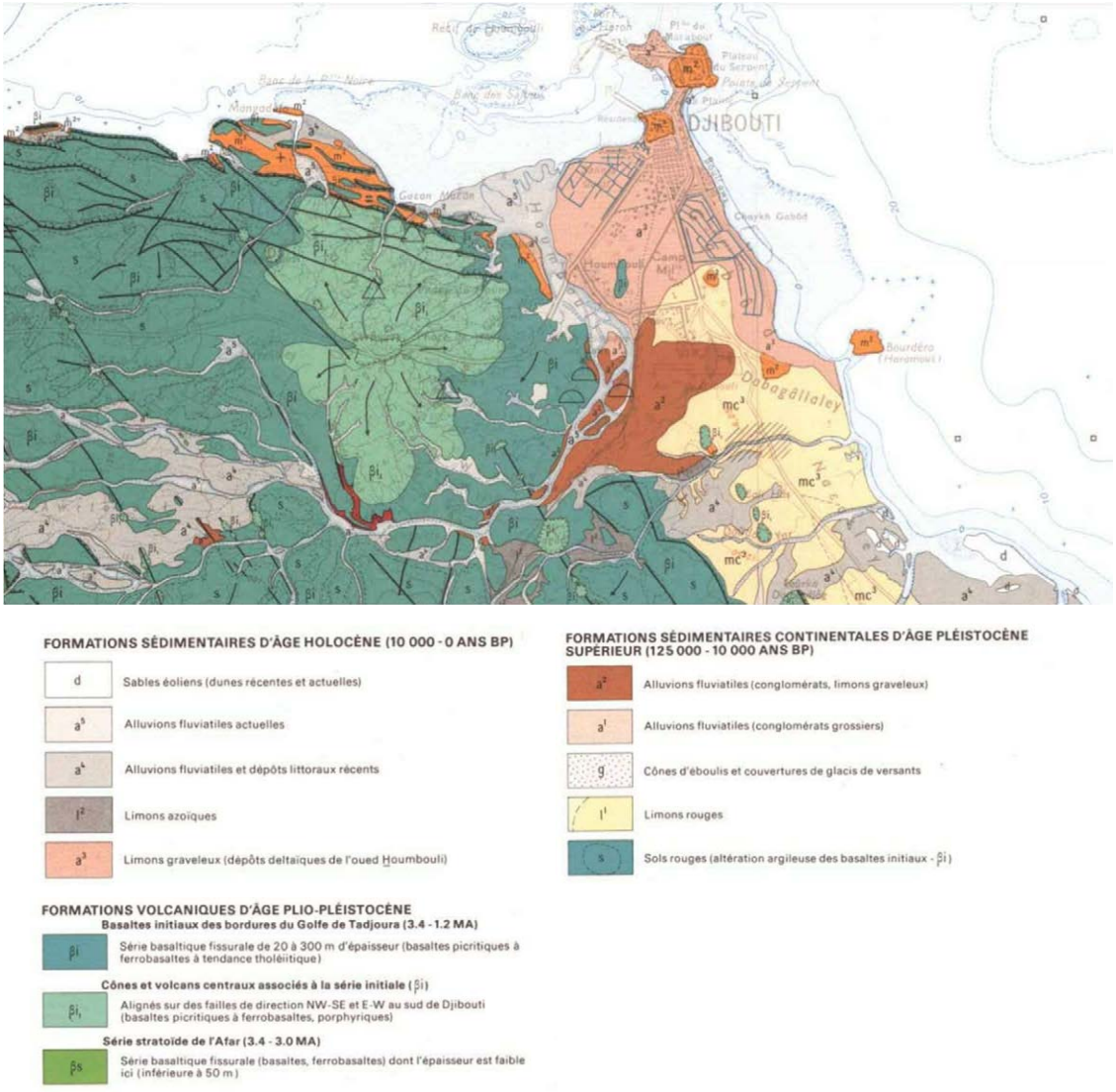
Figure 2.1.4 Flood Damage in 2019 (Palmeraie Road)

2.1.3 Geological Features

The extensional activity of the ground that formed the African Great Rift Valley also created a huge scale of eruption of basalt. The eruption of basalt lava is estimated to have occurred later than the Tertiary of the Cenozoic (mostly 1.2 to 3.4 million years ago) based on the results of age measurement. The direction of the African Great Rift Valley is NW-ES and the flow-down direction of the lava in Djibouti City area is estimated to be ESE-E, which is confirmed by examining the striped pattern.

Many rivers including the Ambouli River have their origin in the lava plateau (mountainous area), and produce and transport a large amount of earth and sand, causing flood along the way. Along the Ambouli River, there is a tongue-shaped gravel layer (al layer) of diluvial soil near a point 6km east of Chabelley Airport, where the river changes its flow direction to the north (Figure 3). The gravel layer is considered to be an old flood plain deposit based on the distribution profile, and the deposit is considered to cause the river's flow path to change to the north. The Ambouli River has a huge fan delta deposition at the river mouth.

The flat land of 5 to 15m above the sea level located to the east of the Ambouli River in Djibouti City is composed of alluvial soil (silt, sand and gravel) and wetlands (mangrove forests), and coral reefs can be seen along the coast.



Source: Geological map of the Republic of Djibouti. (IN) Geological map of the Republic of Djibouti at 1:100,000 : Djibouti / prepared by M. Fournier, F. Gasse, J.-C. Lépine, O. Richard, and J.-C. Ruegg

Figure 2.1.5 Geographical Features of Djibouti City and its Surrounding Area

2.1.4 Survey of Natural Conditions

To grasp the natural conditions, the following surveys on topography and geology were implemented.

Table 2.1.1 Survey of Natural Conditions

Survey Item	Objectives and Description of the Survey	Remarks
Topographic Survey	・Objectives: To understand the topological status of the area where road improvement is expected to be implemented in Djibouti City (to reflect in the outline plan) ・Points of survey: Of the roads crossing the Ambouli River, Palmeraie Road and Nagad Road will be the target. The river courses of these targeted road areas will also be surveyed as a hydraulic analysis is expected to be made. ・Survey method: Basically, surveying will be done using UAVs, while a conventional GPS-based survey will be done for spots close to airports where UAV-based surveying is banned as well as water-bearing river areas.	・This survey will target the topography, and not the features on the surface. ・Benchmarks established based on the information given by the Government of Djibouti will be used.
Geological Survey	・Objectives: To understand the basic ground conditions of the area where road improvement is expected to be implemented in Djibouti City (to reflect in the outline plan) ・Points of survey: Similar to the topographical survey, areas of Palmeraie Road and Nagad Road will be the target. ・Survey method: In addition to an SPT test, etc. to be done in-situ, materials will be tested at a laboratory.	・This survey will be implemented by the central laboratory, a government organization (the only organization to implement geological surveys for public works and to approve the test results under a president decree).

The details of these surveys are described below and detailed survey results can be seen in the Appendix.

(1) Topographic Survey

The topographic survey is outlined as follows.

1) Quantitative details of this survey

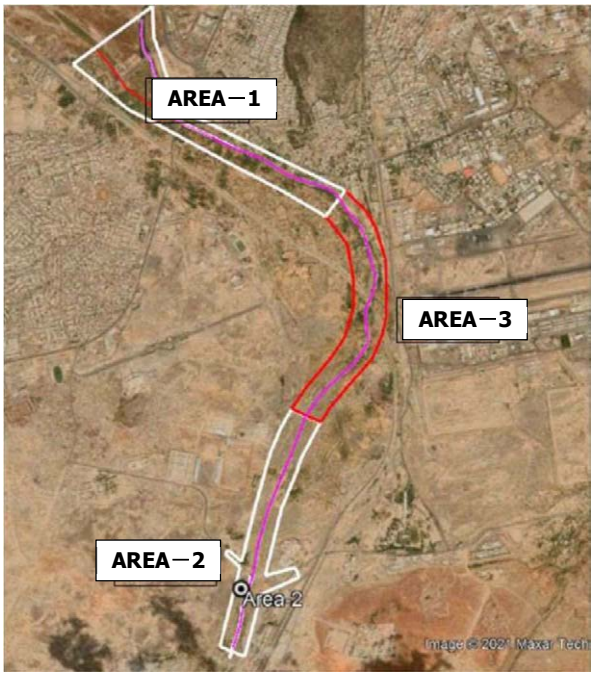
Table 2.1.2 Quantitative Details of the Topographic Survey

	Quantity	Remarks
Benchmark survey	1 set	
UAV-based survey	1 set	Palmeraie Road and Nagad Road areas
GPS-based survey GPS	1 set	River course and water-bearing areas
Preparation of reports	1 set	

2) Progress of survey

Figure 2.1.6 Progress of Topographic Survey (UAV-based)

3) Survey areas



AREA-1：Palmeraie Road area (UAV-based)

AREA-2：Nagad Road area (GPS-based)

AREA-3：Area between Palmeraie Road and Nagad Road (UAV-based)

Figure 2.1.7 Target Areas for the Topographic Survey

4) Outline of the survey results (details are shown in the Attachment)

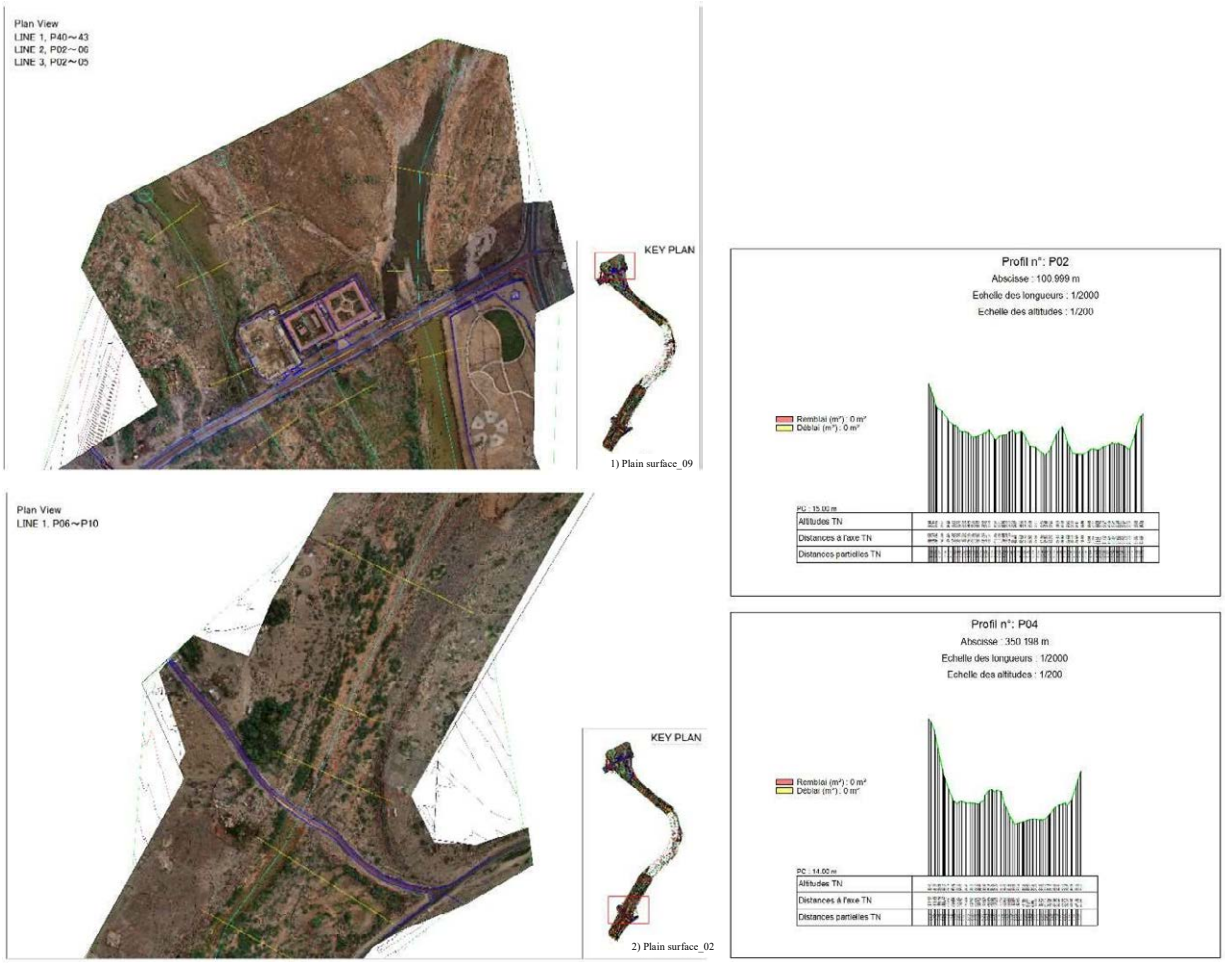


Figure 2.1.8 Results of the Topographic Survey (excerpts)
(Left: Top plain view, Right: River cross section)

(2) Geological Survey

1) Quantitative details of this survey

Table 2.1.3 Quantitative Details of the Geological Survey

Item	Quantity	Remarks
SPT test	1 set	2 spots along Palmeraie Road and 1 spot along Nagad Road
Water level measurement	1 set	
Particle size determination	1 set	Laboratory test
Saturation test	1 set	〃
Liquid and plastic limit test	1 set	〃

2) Progress of survey

Figure 2.1.9 Progress of Geological Survey (Left: Palmeraie Road, Right: Nagad Road)

1) Points of survey

No.	Latitude	Longitude
SCO1	11.529431°	43.127720°
SCO2	11.568336°	43.124180°
SCO3	11.569358°	43.126999°

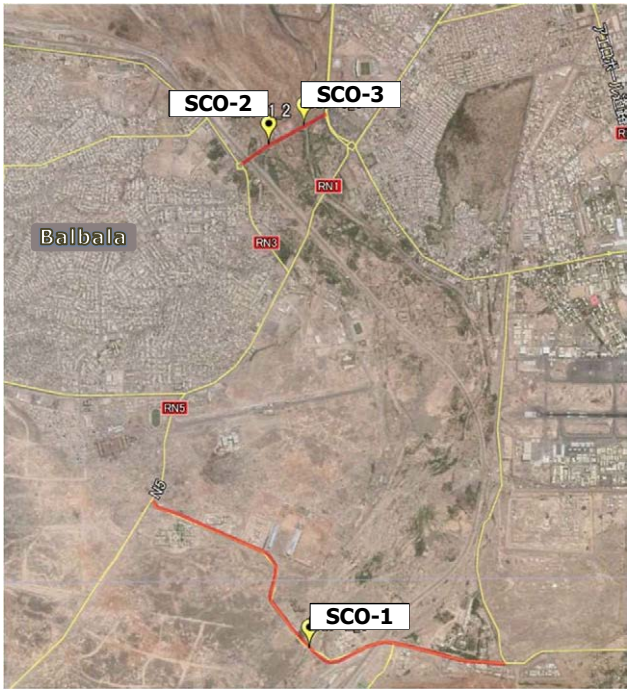


Figure 2.1.10 Geological Survey

2) Outline of survey results (details are shown in the Attachment)

✓ Geological features and N value

- Distribution is in the order of gravel of alluvium deposit, sand and silt layer, which is covered by surface soil.
- SC01 has a3 layer of 1m deep from the ground surface followed by βi layer (basalts composed of lave and pyroclastic rock).

- SC02 has a soft ground surface in layer of 1.4m thick, and has gravel mixed with silt with an N value of 17 to 30, up to 3.25m deep underneath. In addition, it has a βi layer below that (basalts composed of lave and pyroclastic rock).
- SC03 has a soft ground surface of 2m thick, and has gravel mixed with silt with an N value of 2 to 10, up to 9m deep underneath. Below that it has a βi layer (basalts composed of lave and pyroclastic rock) with an N value over 50.

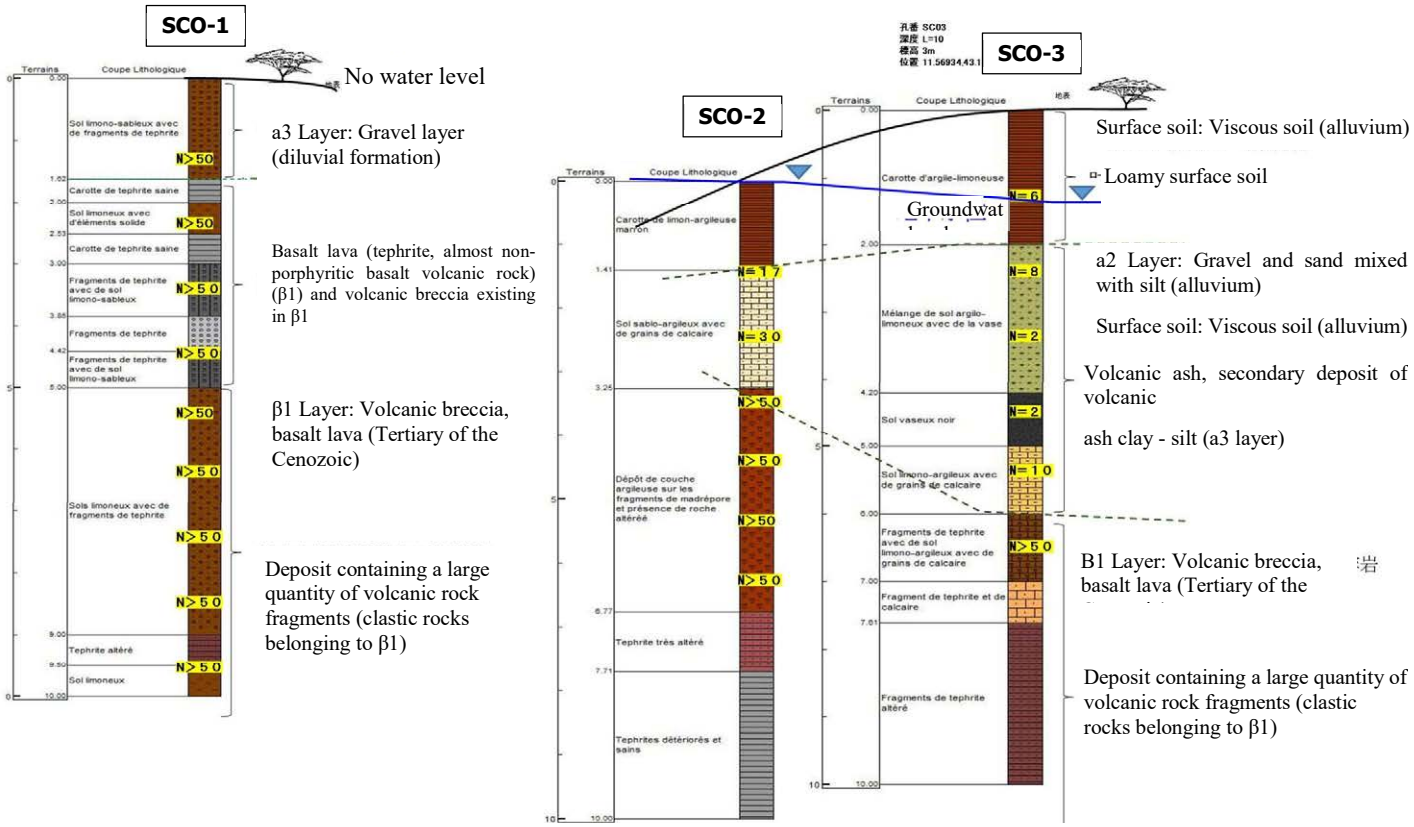


Figure 2.1.11 Outline of SPT Test, N Value and Stratum

Figure 2.1.12 Photos of Extracted Cores Showing Soil Property

✓ Results of the tests:

Regarding the tests, SPT tests were implemented in-situ and soil particle determination, consistency (liquid and plastic) tests and soil saturation tests at laboratory. In addition, specific gravity and porosity (water absorption) measurement was implemented on the bedrock (basalt lava).

The results are outlined below.

- The surface soil is composed of silt mixed with sand and gravel and its liquid limit is high.
- a2 layer (gravel layer), βi layer Vb (volcanic clastic rock) and βi layer lava (lava) with N value of over 50. The N value is high because these layers have large quantity of hard gravel.
- a3 layer (silt layer mixed with gravel) is a softer ground with N value of 2 to 30 (12.5 on average).
- N value of each layer is as follows:

  N value of surface soil: of 6

  N value of a2 layer (gravel layer): over 50

  N value of a3 layer (silt layer mixed with gravel): 2 to 30 (12.5 on average)

  N value of βi layer Vb (volcanic breccia (lava): over 50

✓ Borehole water level:

The borehole water level observed immediately after boring is shown in Table 8. Since the water permeability of the ground is high, it is considered that the ground water level is affected by the hydrological environment of the surface soil and fluctuates depending on the weather.

- SCO1: As the bedrock is composed of the porous volcanic clastic rocks or highly cracked basalt lava, water leakage is observed.
- SCO2: As it is located near the river, the groundwater level is almost the same as that of the river water.
- SCO3: As it is located near the river, the groundwater level is almost the same as that of the river water.

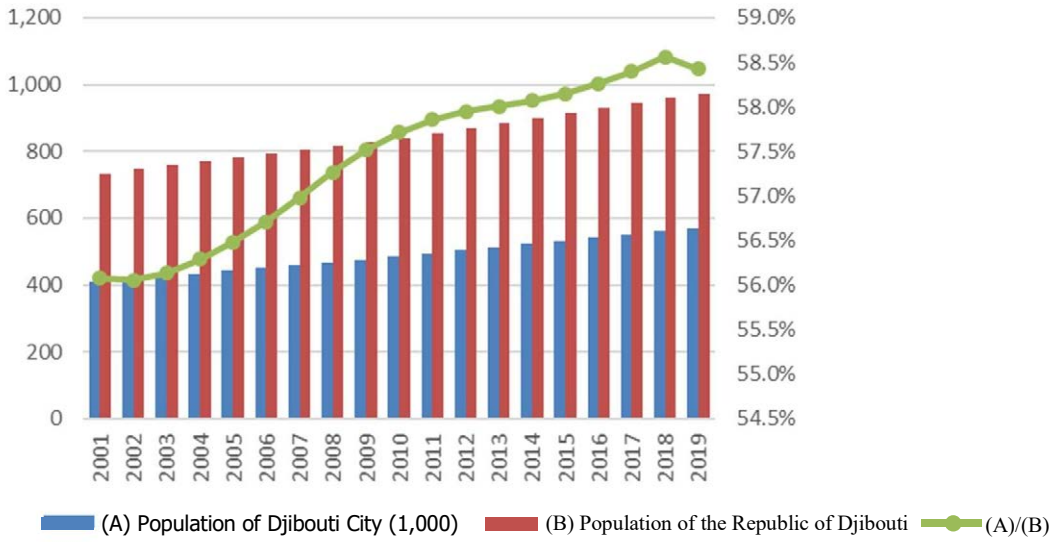
Table 2.1.4 Groundwater Level of Each Borehole

No.	Boring depth	Elevation of bore opening	Groundwater level (Elevation of water level)	Remarks
SCO1	10m	24m	NA (Deeper than 14m above sea level)	The constituent rock species (cracked basalt and highly porous, volcanic clastic rock) which are highly permeable are the reason behind water leakage.
SCO2	10m	2m	0m (2m)	Water level is the same as that of the adjacent river.
SCO3	10m	3m	1.3m (1.7m)	Water level is the same as that of the adjacent river.

2.2 Socio-Economic Situation

2.2.1 Population

The population of the Republic of Djibouti is about 974,000 as of 2019, of which, 569,000 (58.4%) live in Djibouti City (World Development Indicators).[1] Although the concentration of population in Djibouti City had been progressing for some time, it dropped for the first time in 2019 compared to the previous year, and Djibouti City seems to become stable in terms of population concentration.



Source: World Development Indicators (World Bank)

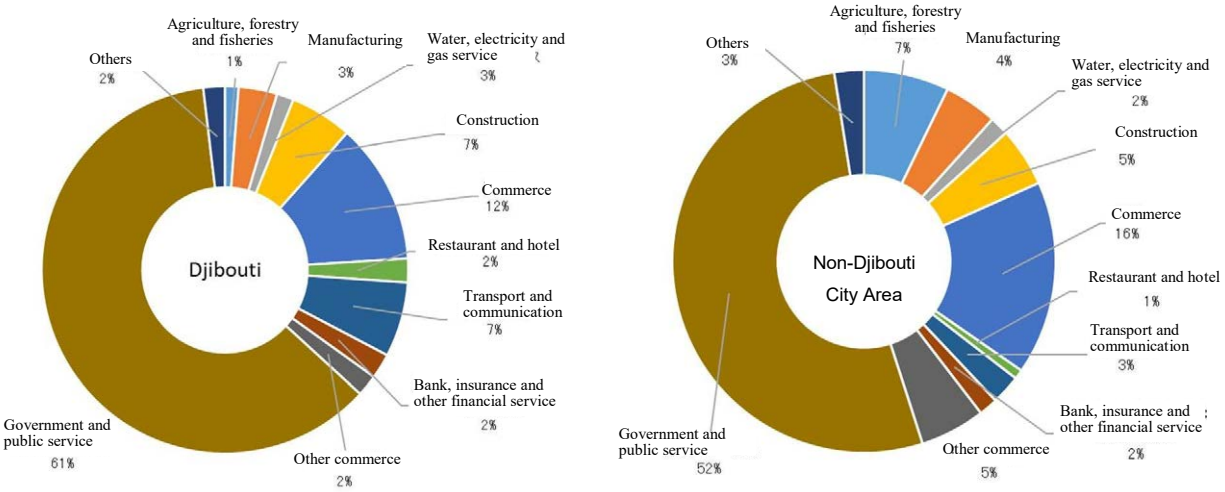
Figure 2.2.1 Changes in the Population of the Republic of Djibouti

2.2.2 Industrial Structure

Figure 2.2.2 shows a comparison of working population by industry, and the population working in the "government and service" sector account for over 50% of the total in both inside and outside of Djibouti City. It means that the country has a unique employment structure, as one-half of the populations' employment opportunities are provided by the government/government-affiliated organizations. Other sectors which provide higher employment opportunities are "commerce" (12%), "construction" (7%) and "transport/communication" (7%) in Djibouti City, and "commerce" (16%) and "agriculture, and forestry fisheries" (7%) in areas outside Djibouti City.

Table 2.2.1 shows the composition of nominal GDP by industry. In 2019, 84.4% of the country's GDP was produced by the tertiary industries, with the "wholesale/retail and automobile service, hotel and restaurant" being at the top accounting for 31.2% of the total GDP followed by "transport, warehousing and communication" (24.2%). The "wholesale/retail and automobile service and hotel and restaurant" has increased its share since 1999 by more than double and become a major industry, overtaking the "transport, warehousing and communication" industry which has not shown any change. Djibouti does not have a rich natural environment, and agriculture has not developed well due to low productivity of its soil.

[1] No extensive population census has been conducted in the Republic of Djibouti since 2009 and population data of recent years are all estimate. The Department of Statistics and Demographic Studies of Djibouti publishes estimated population but somewhat difference can be seen between the two (World Development Indicators: 929,111, DISED: 992,635).



Source: DISED/EDAM3-IS 2012

Figure 2.2.2 Ratio of Employed Population by Industry

Table 2.2.1 GDP of Industry

		1999	2009	2019
Primary industry	Agriculture, hunting and forestry and fisheries	**3.5**	**3.4**	**1.3**
Secondary industry	Mining and quarrying, electricity, gas and water service	7.9	6.0	7.5
	Manufacturing	2.6	2.4	2.9
	Construction	6.5	11.0	3.9
	Subtotal	**17.0**	**19.4**	**14.3**
Tertiary industry	Wholesale/retail and automobile service	15.4	22.2	31.2
	Transport, warehousing and communication	25.7	24.5	24.2
	Other service	38.4	30.5	29.0
	Subtotal	**79.5**	**77.2**	**84.4**
Total		**100.0**	**100.0**	**100.0**

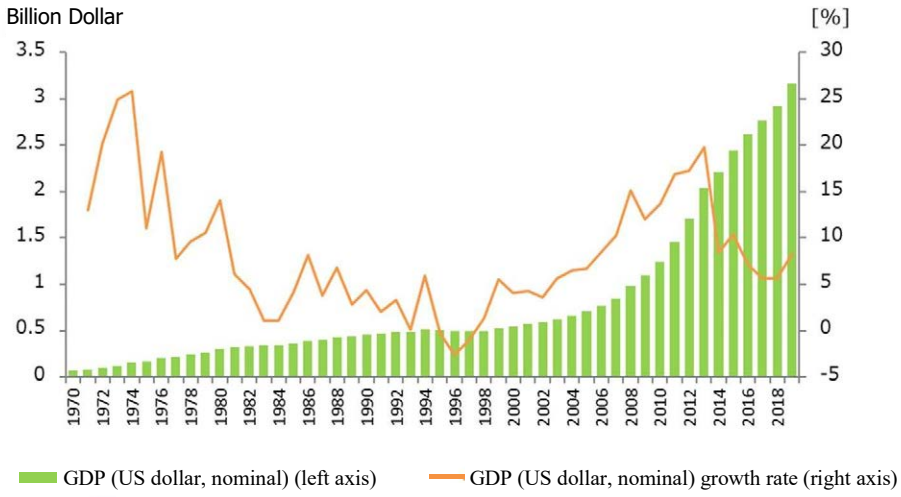
Note: 1. GDP is based on nominal US dollar. 2. It excludes “extraterritorial organizations and bodies” and “those could not be classified.”
Source: World Development Indicators (World Bank)

Figure 2.2.3 shows GDP (in nominal US dollar) and its growth rate. The country’s economy has been developing well except for an economic fall experienced due to the breakout of the civil war in 1990s. The growth rate has slowed down since 2013, althoght a minor recovery could be seen in 2019.

Figure 2.2.4 shows changes in population and GDP per capita (in nominal US dollar). GDP per capita has increased rapidly since 2000 because of the final peace agreement made between the government and armed FRUD in May 2001.

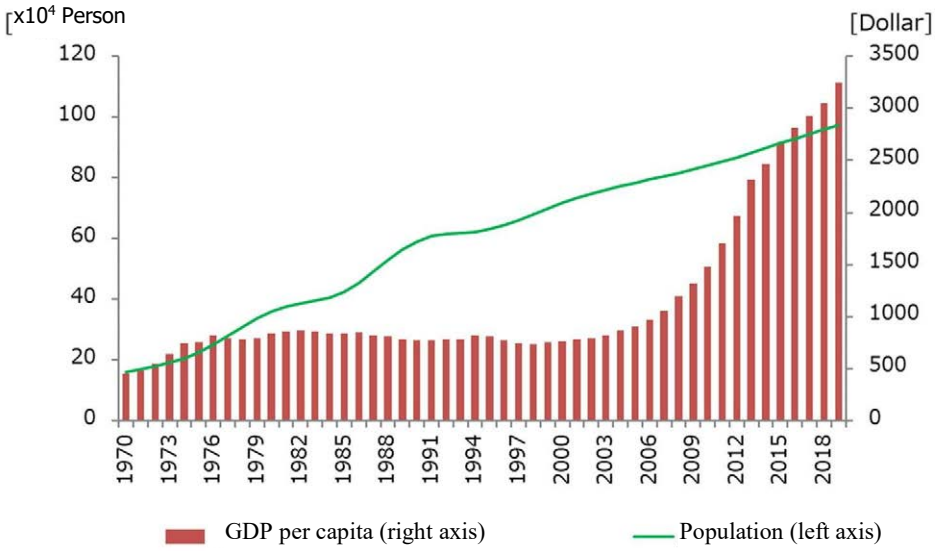
2.2.3 Import and Export Trend

Figure 2.2.5 shows changes in trade balance of the Republic of Djibouti. The volume of import exceeds that of export significantly, creating a large trade deficit.



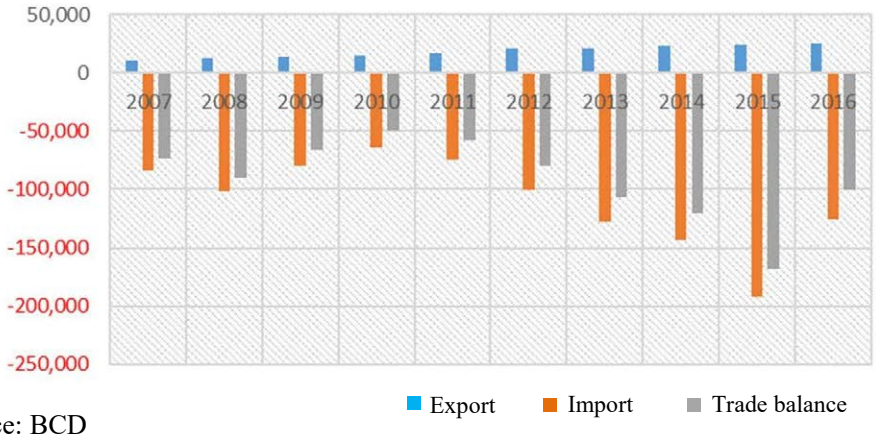
Source: UN National Accounts DB

Figure 2.2.3 Changes in GDP (US Dollar, Nominal) and Growth Rate



Source: UN National Accounts DB

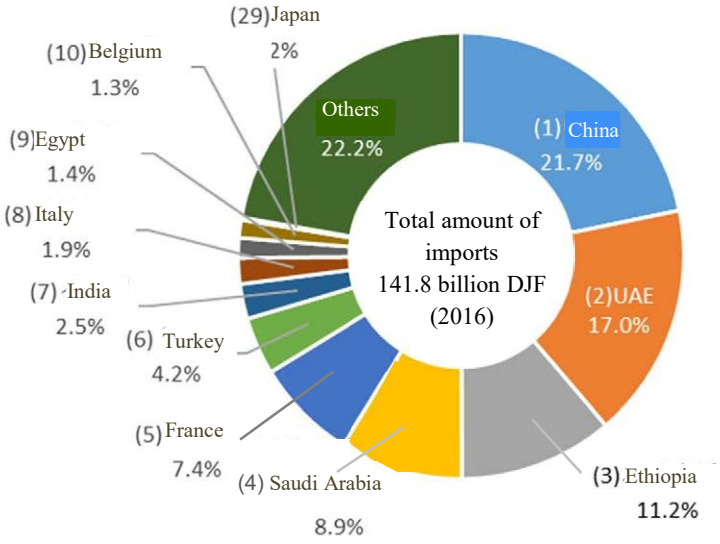
Figure 2.2.4 Changes in Population and GDP per Capita (US Dollar, nominal)



Source: BCD

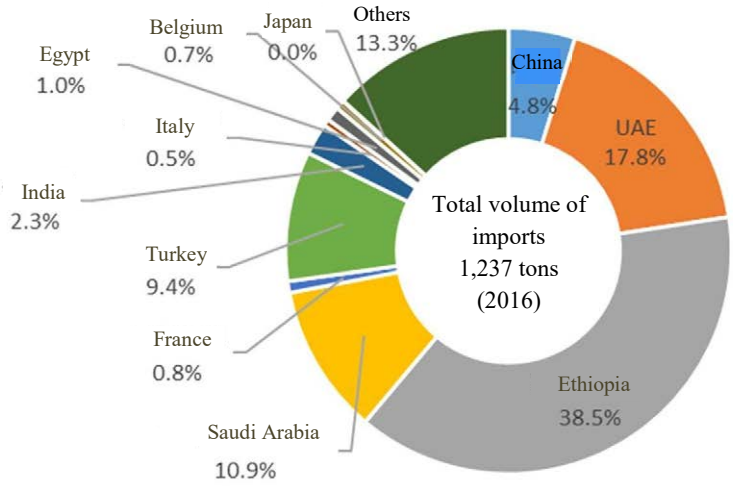
Figure 2.2.5 Changes in Trade Balance (million DJF)

Figure 2.2.6 shows countries from which Djibouti imports with volumes in value terms. Three countries, China, UAE and Ethiopia, account together for nearly a half of the total imports. Except for Ethiopia, all imports are made via sea through the Port of Djibouti, showing the important role of the port. Figure 2.2.7 shows imports from the same countries, on a weight base. Ethiopia accounts for more than one third of the total. Imports from Ethiopia is made by land, showing the importance of the Djibouti-Ethiopia corridors.



Source: Department of Statistics and Demographic Studies (DISED)

Figure 2.2.6 Countries from which Djibouti Imports (Top 10 Countries)



Source: Department of Statistics and Demographic Studies (DISED)

Figure 2.2.7 Import weight by partner country

2.3 Records of Natural Disasters

Natural disasters occurred in the Ambouli River basin in the past, and they were mainly damages caused by the Ambouli River flooding during heavy rains. Waterway flooding (inland water) occurred due to underdeveloped rainwater discharge channels and blockage of channels by dumped waste. Table 2.3.1 outlines natural disasters and their damages.

By early 2000s, the country experienced already five major flooding events, and particularly a huge one in April 2004 resulted in enormous damages including 300 deaths, 600 destroyed houses and 100,000 affected people. In recent years, flood damages occur almost every year, and the flood in 2019 caused the largest damages of recent years with the largest number of affected people totaling 200,000. Following the disaster in 2004, international organizations developed embankment on the right bank of the Ambouli River and, as a result, the degree of potential flood damages in Djibouti City has been reduced since the 2014 flooding, although it still remains high and increases with the population increases due to the increasing urbanization and changes in land uses.

Table 2.3.1 Summary of Major Floods and Disasters in Djibouti

	Occurrence date and time (period)	Daily rainfall (mm)	Fatalities (people)	Affected population (people)	Remarks (Source)
1	1989.4.6-10	507 (3days)	(unknown)	150,000	1.
2	1994.11.22	360 (2days)	105 (unknown40)	100,000	1.&2.
3	2004.4.11-14	92.9	300	100,000	WHO & 3.
4	2013.3.25	26	8	No data	
5	2018.5.19-21	110 (1day)	2	5,000-10,000	Tropical Cyclone Sagar, AFD
6	2019.11.21-25	155	11	200,000	IFRC & 4. AFD
7	2020.4.20-21	80	8	110,000	Flood list & 5. AFD

Source: 1. United Nations Department of Humanitarian Affairs (DHA) report (1989.4, 1994.12)
2. Application of the Coastal Hazard Wheel methodology for coastal multi-hazard assessment and management in the state of Djibouti (2014)
3. A Study of water use of surface runoff for irrigation in Djibouti (2014)
4. Final report Djibouti: Flash Floods (2019)
5. Diagnostic et Recommendations pour une gestion integree du resque inodation sur l'agglomeration de Djibouti (AFD, Sepia, 2021)

Of the three road crossing the Ambouli River, two excluding the National Road Route 1 have no bridge but a "ford structure". When considering the causes of flood damages in relation to the local topography and the urban plans, this structure can be the reason of flood damages as the structure itself becomes an obstacle to the flow of water and makes the water level of river higher when a flood occurs.

Djibouti City has a low flat terrain formed on a high plain of coral by means of landfilling. This topographic condition and low flow capacity of poorly maintained drainage channels allow floodwater to remain longer and cause diseases related to floodwater including contagious ones.

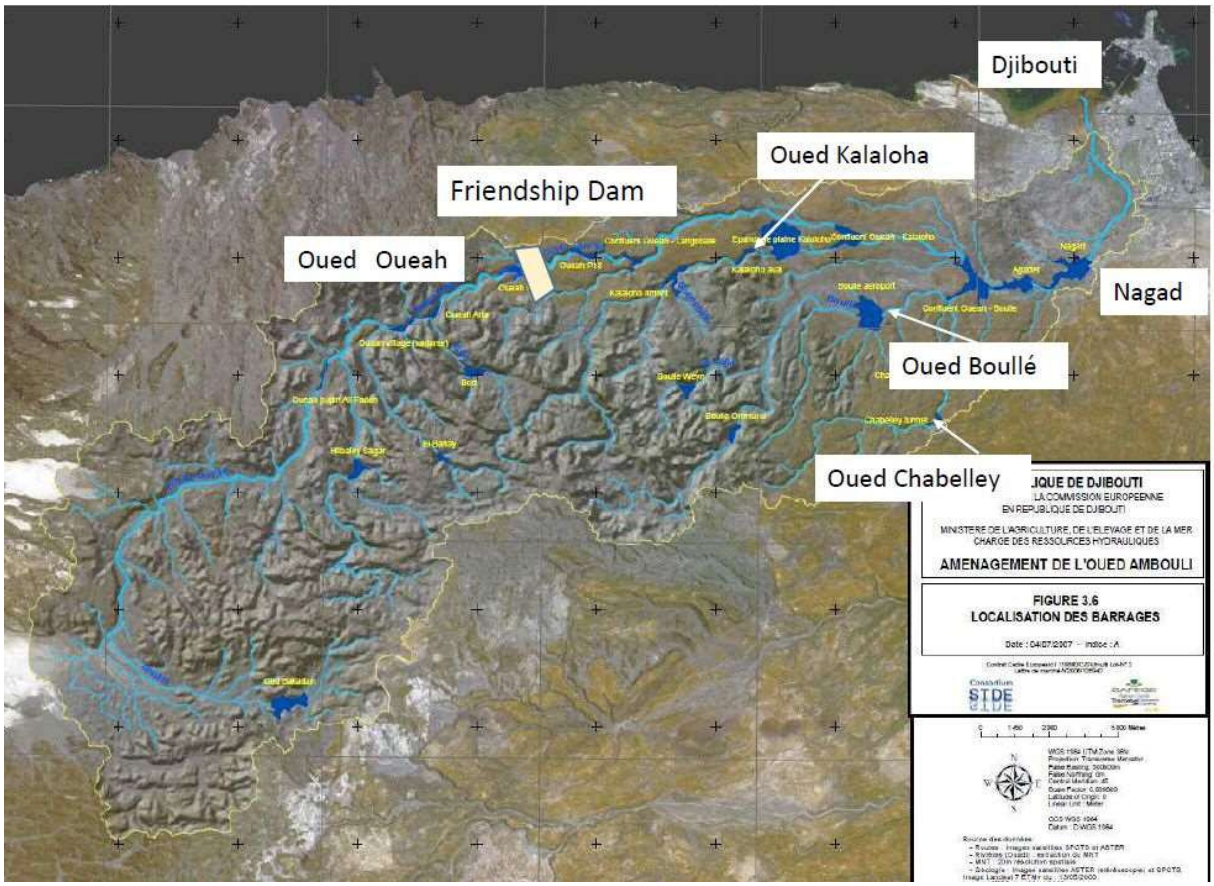
Figure 2.3.1 Flood Damages in 2004 (National Road Route 1)

Figure 2.3.2 Flood Damages in 2019 (Palmeraie Road)

2.4 Understanding the Present Conditions of the Ambouli River

2.4.1 The Ambouli River Basin

The Ambouli River (Oued Ambouli) has a total length of about 60km with a catchment area of 600km^2. As shown in the map below, it has a number of branch streams and the main stream is Wadi Oueah, which accounts for 31.3% of the entire catchment area. The Wadi Oueah joins the Oued Boille at Nagad, a point 23km from the downstream.



Source: Etude d'identification des ouvrages de rétention des ruissellements et de recharge des nappes sur l'ensemble du bassin versant (2007)

Figure2.4.1 Map of the entire Amboli Catchment Area and Location of the Friendship Dam

2.4.2 Ambouli Friendship Dam

The Ambouli Friendship Dam is constructed across the Wadi Oueah with the aid of Turkey. The dam was constructed under the "agreement concerning cooperation for water" signed in 2014 between Turkey and Djibouti and completed in 2019. The dam, which costed 20 million dollars, has a height of 71m and capacity of 14 million cube meters. The purpose of dam construction is stated as flood prevention and supply of agricultural water, and it covers 45% of the entire basin.

When the 2019 flood occurred, the friendship dam was already completed and retainde about 10 million cubic meters of water for flood prevention, indicating that the dam has a flood controlling effect. According to information obtained from the Ministry of Agriculture, the dam was constructed for agriculture and flood control purposes, but there are no established operating rules to achieve these two objectives (between the Ministry of Agriculture and the Ministry of Interior).

Source: Dam built by Turkey helps Djibouti control floods (Daily Sabah, December 13, 2019)

Figure 2.4.2 Ambouli Friendship Dam (Completed in 2019, DSi (Develet Su isleri): State Hydraulic Works)

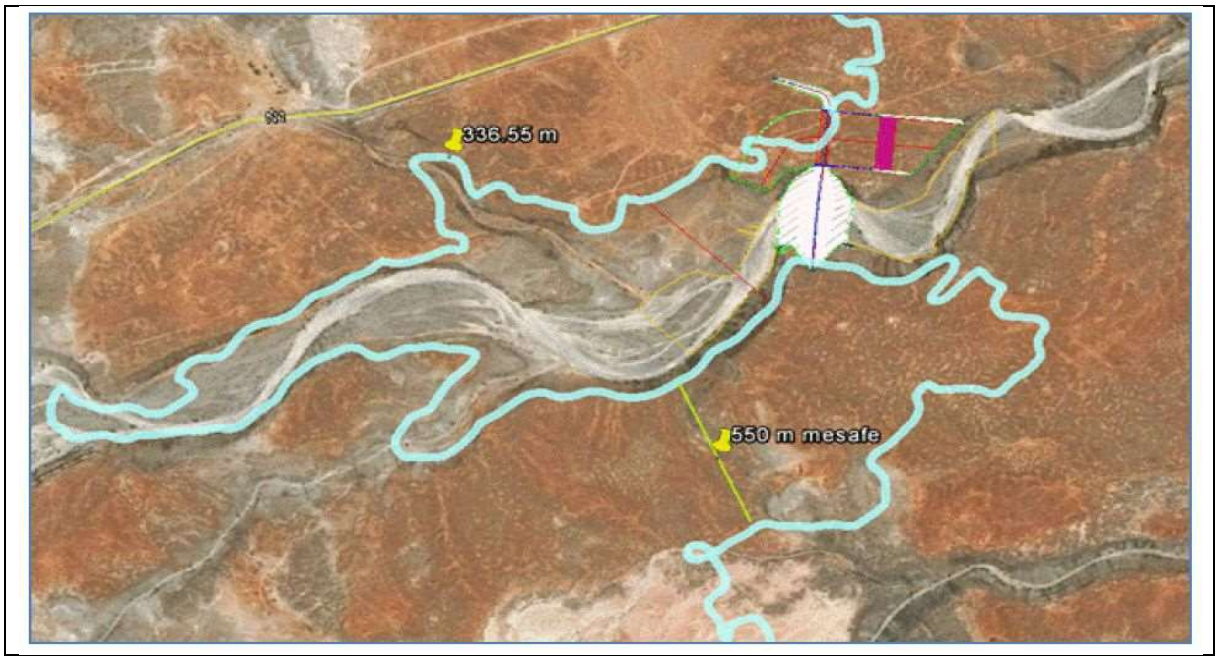
The Ambouli Friendship Dam specifications are shown below.

Table 2.4.1 Specifications of the Ambouli Friendship Dam

Item	Specifications	Remarks
1) Location	Wadi Obeah (Branch stream of Ambouli River)	
2) Reservoir area	270km^2	Total area of 600km^2
3) Structure type	Central core type rock-fill dam	Core material: clay
4) Dam crest height	338.00 (m, asl)	Above sea level
5) Height of fill-point base above sea level	300.00 (m, asl)	
6) Height of dam base above sea level	267.00 (m, asl)	
7) Dan height (foundation plain)	71.0 (38.0)m	4)-6)=71.0m, 4)-5)=38.0 m
8) Crest width	10. m	
9) Upstream slope	1:2.5	
10) Downstream slope	1:2.0	
11) Highest water level	336.78m asl	
12) Lowest water level	316.00m asl	
13) Total reservoir capacity	14,370,000m^3	
14) Effective reservoir capacity	12,060,000m^3	
15) High water discharge at dam site	157.0m^3/sec	100-year recurrence interval (French consultant)
16) Design flow for flood spillway	3,000m^3/sec	

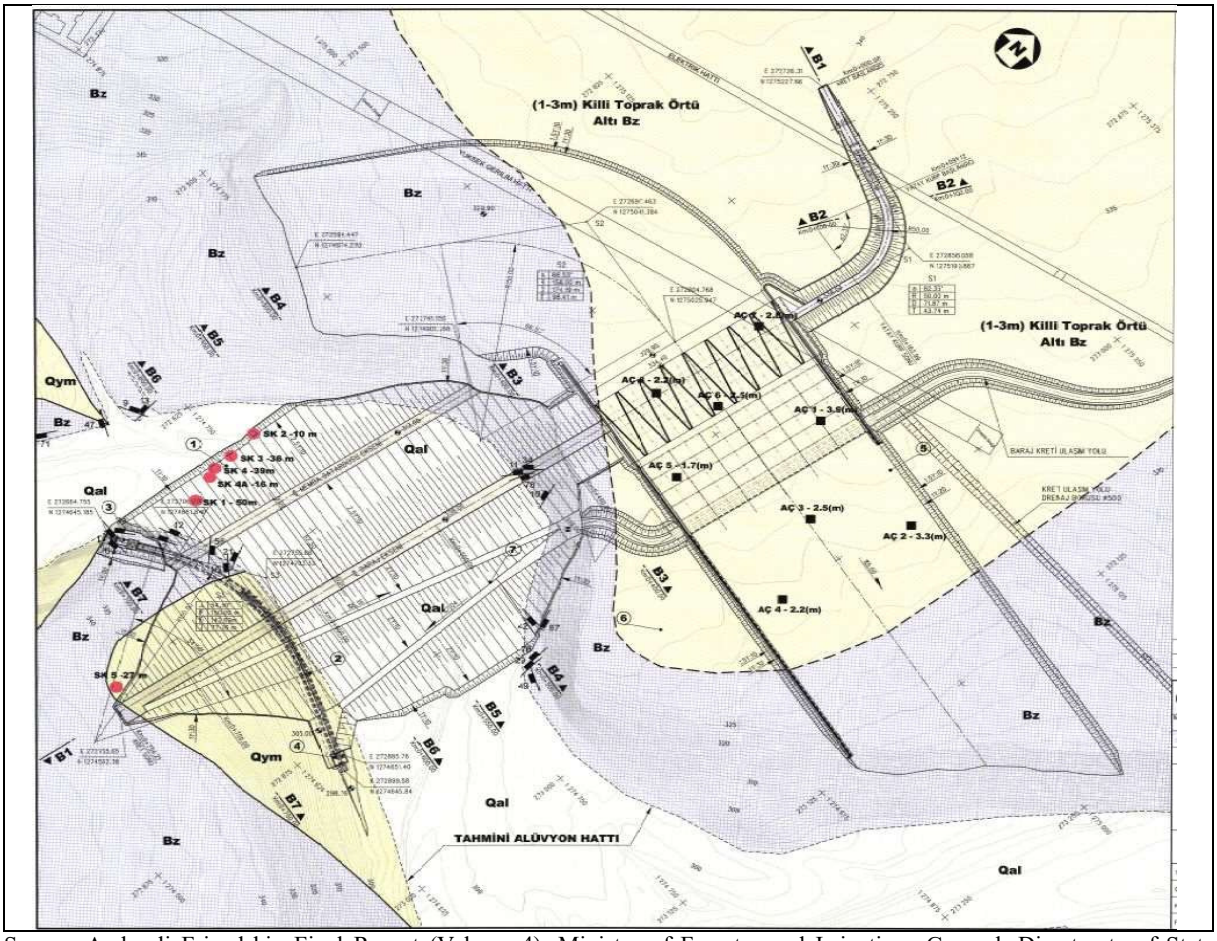
Source: Ambouli Friendship Final Report (Volume 1), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figures 2.4.3 to 2.4.9 show details of the dam, including an outline of the reservoir, plan view, a typical cross-section, a lateral profile.



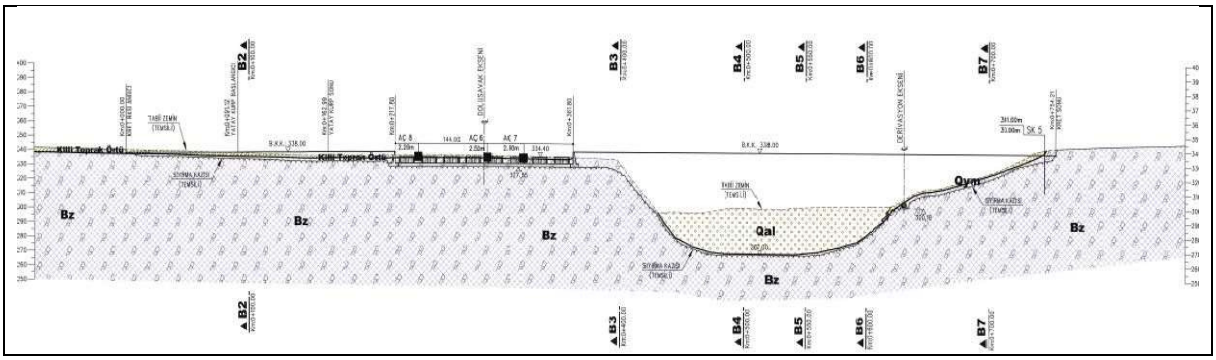
Source: Ambouli Friendship Final Report (Volume 1), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.3 Outline of the Reservoir of the Ambouli Friendship Dam (Completed in 2019)



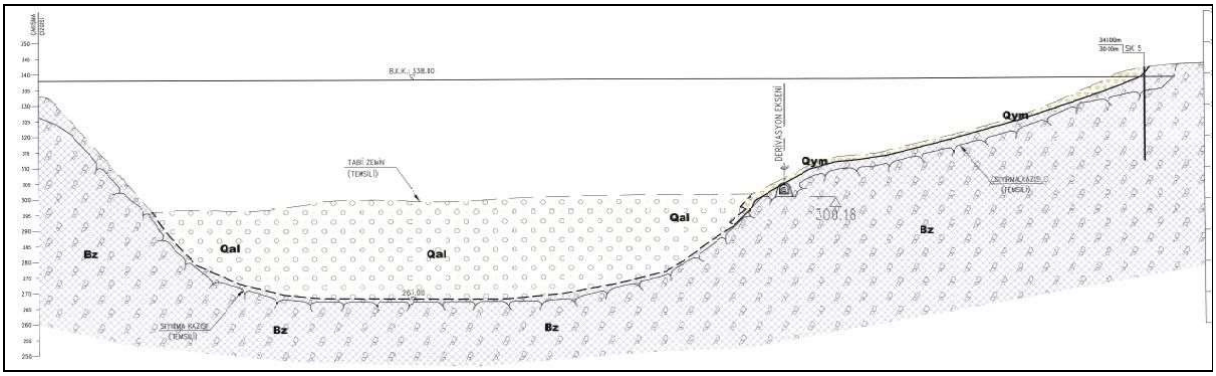
Source: Ambouli Friendship Final Report (Volume 4), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.4 Top View of the Ambouli Friendship Dam



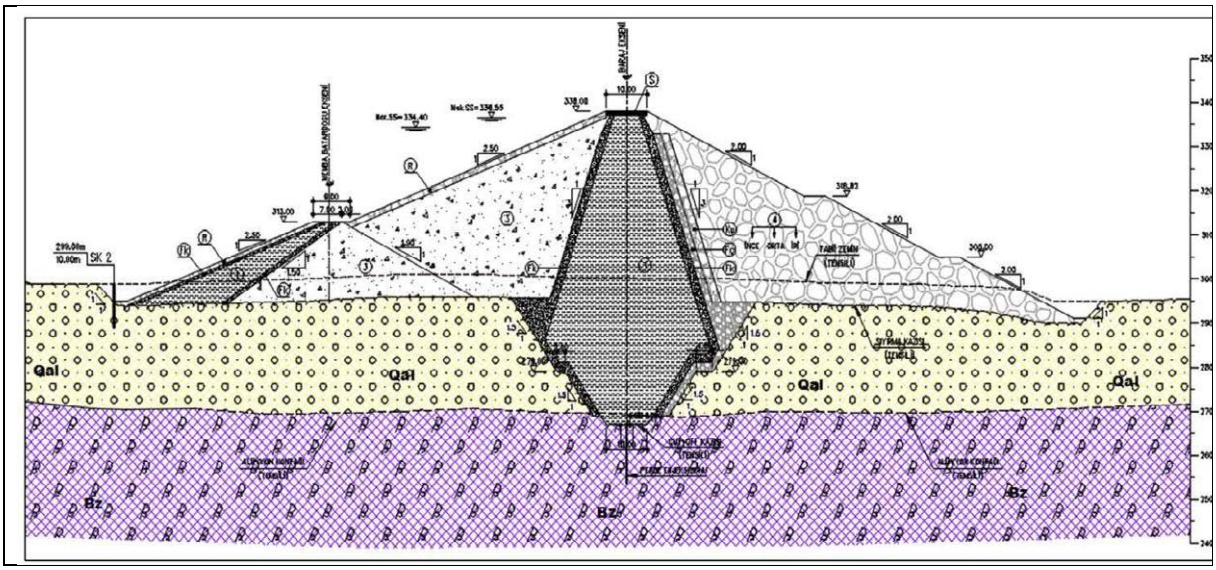
Source: Ambouli Friendship Final Report (Volume 4), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.5 Lateral Profile along the Axis of the Crestline of the Ambouli Friendship Dam



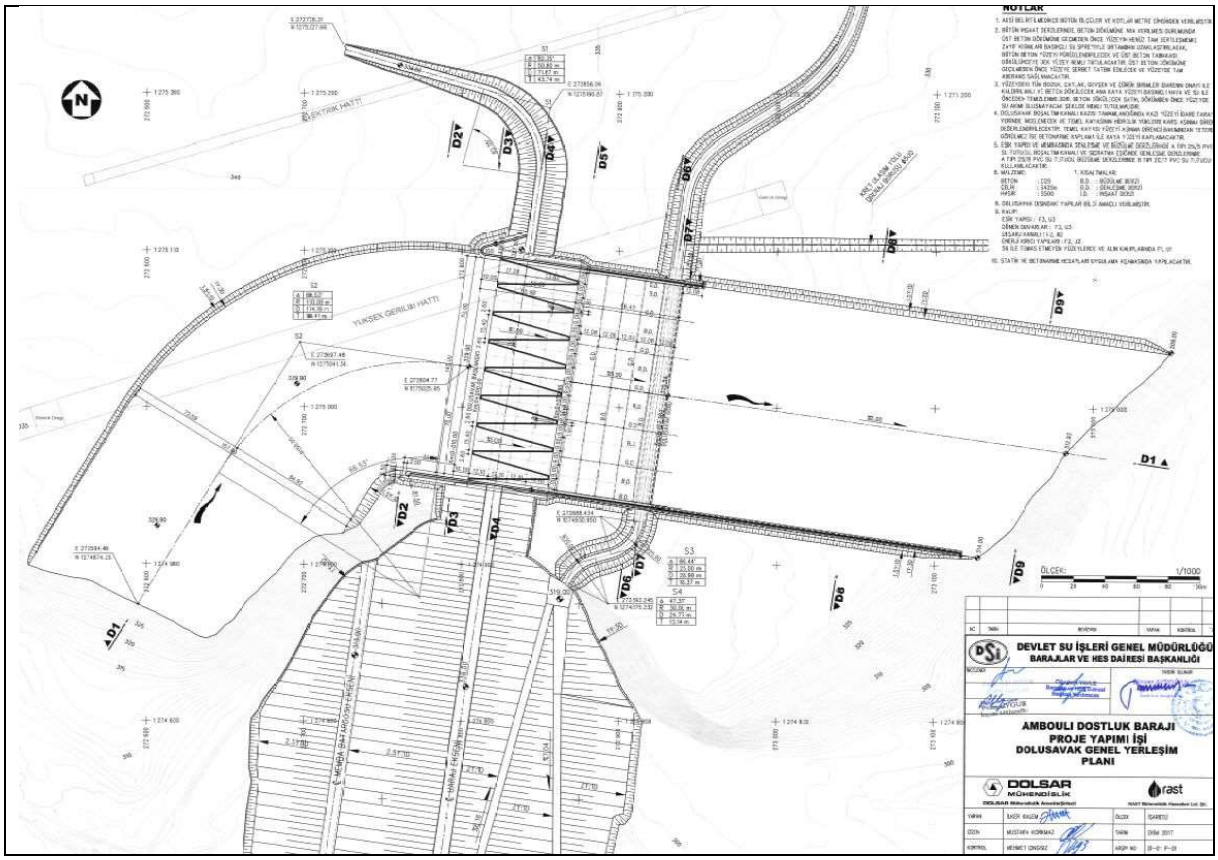
Source: Ambouli Friendship Final Report (Volume 4), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.6 Ambouli Friendship Dam (Enlarged Profile along the Crestline)



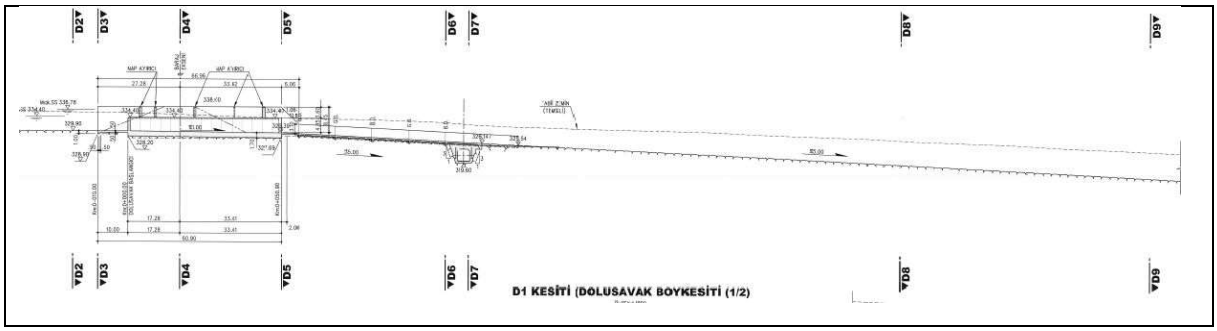
Source: Ambouli Friendship Final Report (Volume 4), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.7 Typical Cross-section of Ambouli Friendship Dam



Source: Ambouli Friendship Final Report (Volume 4), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.8 Top View of the Flood Spillway of the Ambouli Friendship Dam (design flow of 3,000m^3/sec)



Source: Ambouli Friendship Final Report (Volume 4), Ministry of Forestry and Irrigations General, Directorate of State Services of Dam Department (Ankara, 2017)

Figure 2.4.9 Vertical Profile of Flood Spillway of the Ambouli Friendship Dam

2.4.3 Countermeasures against Flood from the Ambouli River

In October 2004, an agreement was concluded between the World Bank (WB) and the local government concerning countermeasures against flood from the Ambouli River, and the implementation started in January 2005. The implementing agency was Agence Djiboutienne d'Exécution des Travaux d'Intérêt Public (ADETIP), or Public Service Project Implementation Agency, and the total project cost was 6.46 million US dollars, including a grand aid of 3.23 million US dollars.

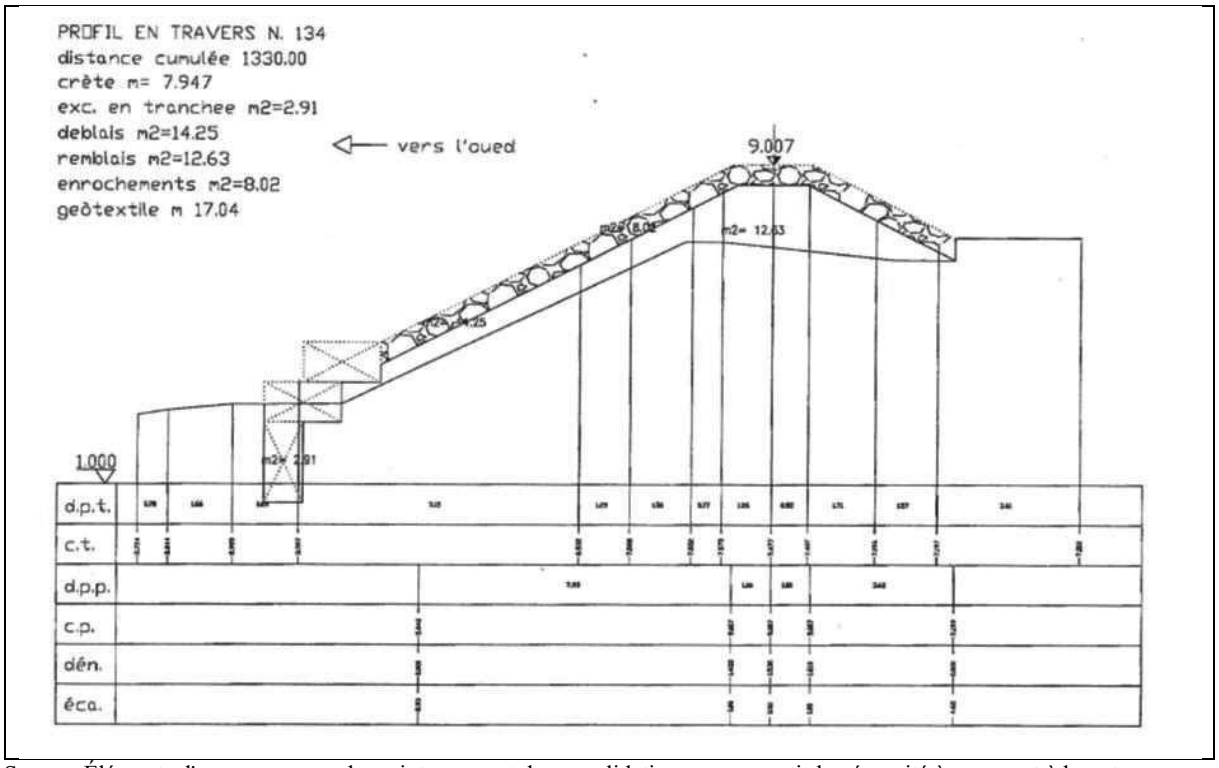
The outline of the project titled the Flood Emergency Rehabilitation Project (FERP) is shown below based on the WB's Project Information Document (PID).

Table 2.4.2 Outline of the Ambouli River Countermeasure Works Implemented following the 2004 Flood (FERP)

Project item	Description of project item
1. Rehabilitation of economic and social infrastructure (rehabilitation work)	a. Rehabilitation of flood protection structures: including 1) Rebuilding the destroyed flood protection dyke (embankment work) 2) Rehabilitating/widening the Oued river (river widening work)
	b. Rehabilitation of roads and drainage infrastructure 1) Reconstruction and repairs to the segments of the city roads (city road improvement) 2) Reconstruction and repairs to the segments of the regional/inter-city highways (highway improvement) 3) Repairing and cleaning up the storm water drainage channels (drainage channel improvement)
	c. Rehabilitation of schools: including replacement of damaged furniture, equipment and teaching material (school facilities rehabilitation)
	d. Rehabilitation of health centers (health center rehabilitation)
	e. Rehabilitation of water supply infrastructure (water supply facilities rehabilitation)
2. Delivery of basic infrastructure services to the resettlement zone in PK12 (support for relocated infrastructure procurement)	a. Providing basic access to potable water through the delivery of several appropriately located public standpipes (improvement of water supply facilities) b. Construction of septic tanks for the houses of the resettled population to improve sanitary conditions (sewerage facilities improvement)
3. Technical assistance and consultancy services for disaster prevention and management in the short- and long-term (technical support)	a. Consultancy services for construction supervision of rehabilitation activities (consulting service) b. Training and capacity building of the "Disaster Management Unit" (training and enhancement of disaster preventing control capability)
4. Project management and implementation assistance (project management and support)	ADETIP Assistance (support for ADETIP)

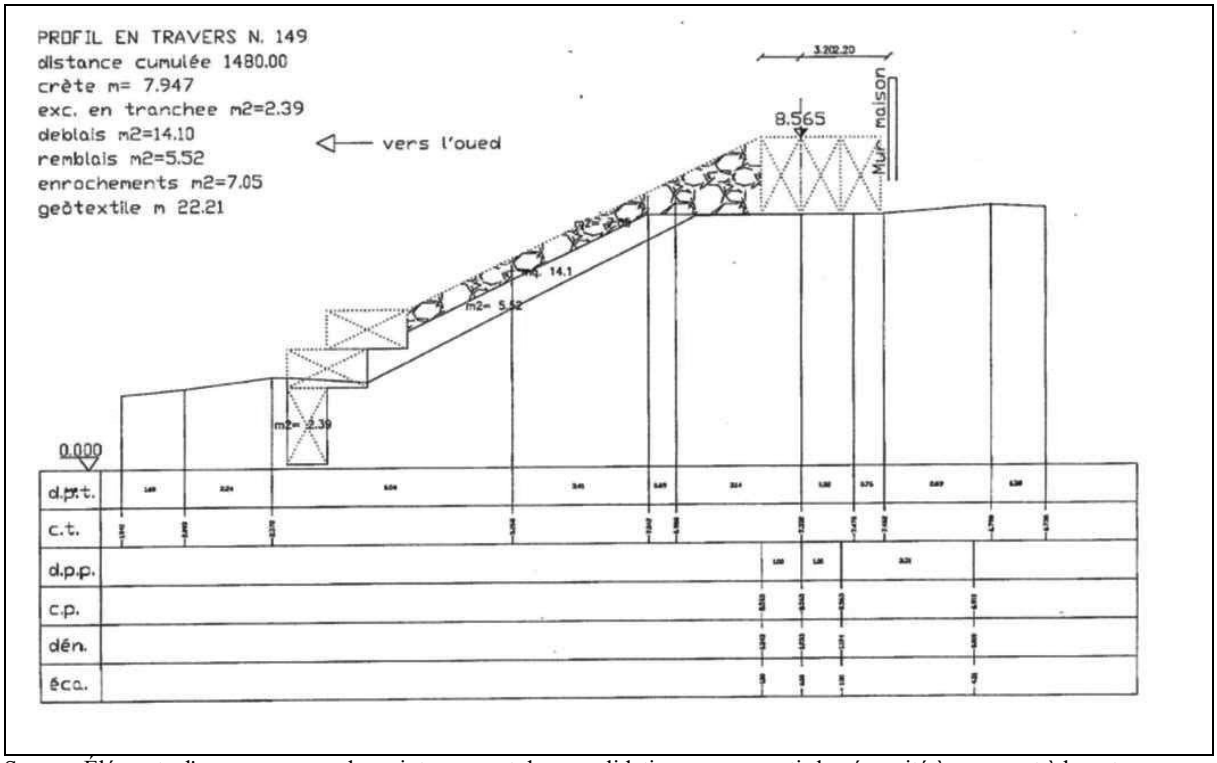
Source: Project Information Document (PID), P101454 Flood, Emergency Rehabilitation Project (Supplemental, WB)

In relation to the above listed project items, the cross-sectional profile of the right side embankment related to repair of the wadi is shown in Figures 2.4.10 and Figure 2.4.11. Basically, the foundation work for the dike is determined to be a gabion with the upper part covered with cobbled stone.



Source: Éléments d'un programme de maintenance et de consolidation pour garantir la pérennité à moven et à long terme de la protection contre les inondations de la Ville de Djibouti (2009.7)

Figure 2.4.10 Profile of the Right Side Embankment Repair Work of the Ambouli River (No.1)



Source: Éléments d'un programme de maintenance et de consolidation pour garantir la pérennité à moven et à long terme de la protection contre les inondations de la Ville de Djibouti (2009.7)

Figure 2.4.11 Profile of the Right Side Embankment Repair Work of the Ambouli River (No.2)

Chapter 3 Present Status and Issues of the Transport and Road Sector

3.1 Present Status of the Road Network of Djibouti City

In this section, the present status of the road network within Djibouti City is discussed based on existing materials and results of a road inventory survey implemented in this survey project to clarify problems and issues.

3.1.1 Present Status of the Road Network Development (Review of existing materials)

In the Republic of Djibouti, ADR is in charge of the operation of national roads and urban roads. The total road length amounts to 1,805km, of which 44% (785km) is paved with asphalt and the remaining 56% (1,011km) is unpaved (as of June 2021). Furthermore, the ratio of urban roads that are paved is low (30%), and therefore it is desirable that the trunk roads connecting to national roads be paved (See Table 3.1.1).

Table 3.1.1 Road Extension under ADR Management (as of June 2021)

Road type	Type of Pavement（km）			Pavement rate
	Paved	Unpaved	Total	
National Roads	606	587	1,193	51%
Urban Roads	179	424	603	30%
Total	785	1,011	1,805	44%

Source: Prepared by the survey team based on a hearing surveys to ADR.

Table 3.1.2 and Figure 3.1.1 show the pavement rate of national roads. The national roads that are completely paved include National Road Route 1(RN 1) connecting Djibouti and Ethiopia, National Road Route 2 running into Somaliland, National Road Routes 9 and 10 connecting Djibouti City and the Port of Tadjoura, and National Road Route 11 running from Tadjoura into the northern part of Ethiopia.

Table 3.1.2 Total Length of National Roads under the Ministry of Infrastructure and Facilities (as of June 2021)

Route Name	National Road (km)					
	Asphalt pavement			Unpaved	Total length	Paved road (%)
	Excellent	Good	Total			
RN 1	118.0	101.0	219.0	0.0	219.0	100.0%
RN 2	27.0	0.0	27.0	0.0	27.0	100.0%
RN 3	6.0	0.0	6.0	9.0	15.0	40.0%
RN 4	8.0	0.0	8.0	0.0	8.0	100.0%
RN 5	0.0	17.0	17.0	48.0	65.0	26.0%
RN 6	0.0	0.0	0.0	75.0	75.0	0.0%
RN 7	0.0	0.0	0.0	68.0	68.0	0.0%
RN 8	0.0	0.0	0.0	29.0	29.0	0.0%
RN 9	0.0	122.0	122.0	0.0	122.0	100.0%
RN 10	16.0	0.0	16.0	0.0	16.0	100.0%
RN 11	124.0	0.0	124.0	0.0	124.0	100.0%
RN 12	0.0	0.0	0.0	15.0	15.0	0.0%
RN 13	0.0	0.0	0.0	33.0	33.0	0.0%
RN 14	62.0	0.0	62.0	0.0	62.0	100.0%
RN 15	0.0	0.0	0.0	102.0	102.0	0.0%
RN 16	0.0	0.0	0.0	115.0	115.0	0.0%
RN 17	5.0	0.0	5.0	0.0	5.0	100.0%
RN 18	0.0	0.0	0.0	88.0	88.0	0.0%
RN 19	9.0	0.0	9.0	0.0	9.0	100.0%
Total	375.0	240.0	615.0	582.0	1193.0	51.3%

Source: ADR (Ministry of Infrastructure and Equipment)

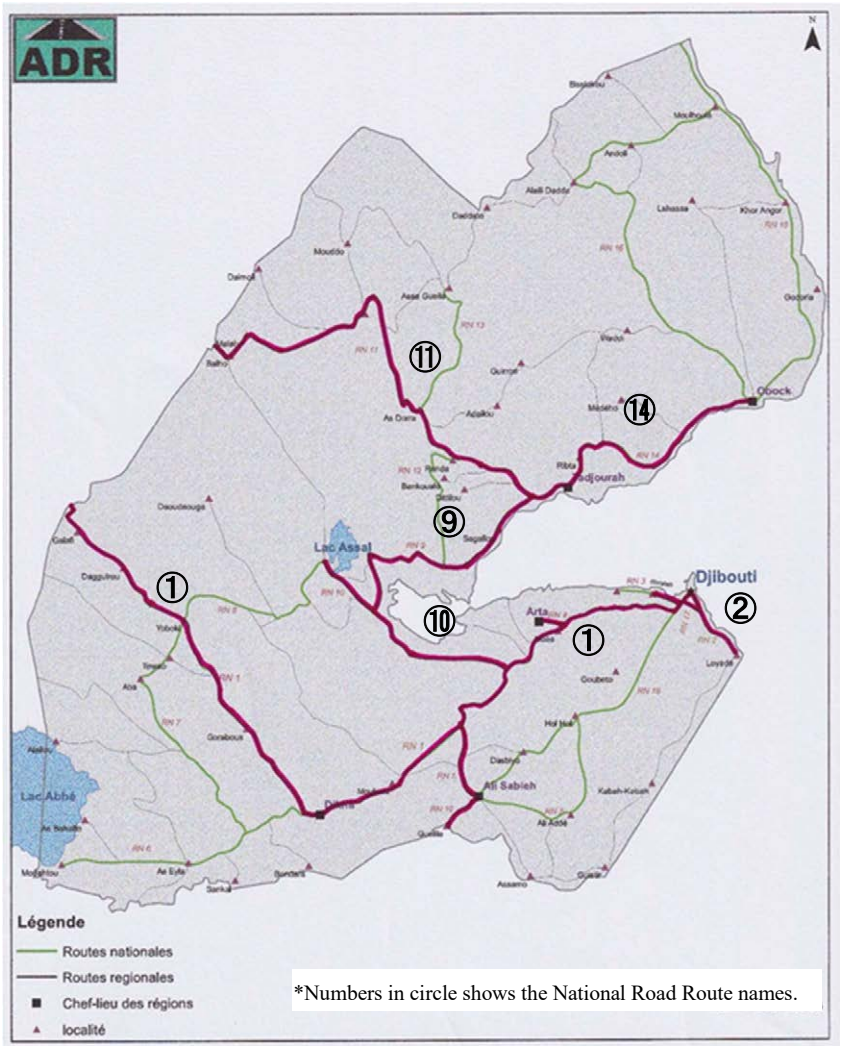


Figure 3.1.1 Completely National Roads where Pavement Work is Completed

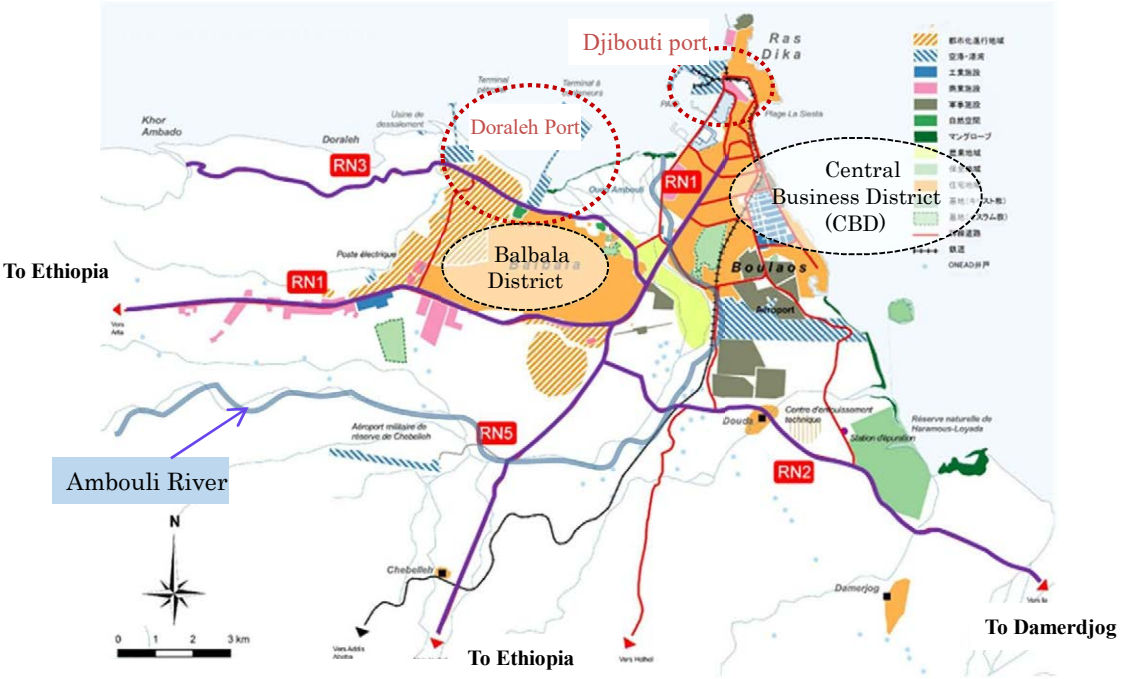
Table 3.1.3 shows how far urban roads are paved by district, and Djibouti City accounts for 90% of the total paved roads in terms of length. The pavement rate of roads in Djibouti City, however, varies from district to district, and while nearly 90% of the roads in the Ras-Dika district are paved, only 36.2% and 17.3% of roads in the Boulaos district and the Balbala district, respectively, are paved.

Table 3.1.3 Djibouti City Road Length in charge of the Ministry of Infrastructure and Equipment
(as of June 2021)

District		Inner-city Road (km)			
City	District	Asphalt pavement	Unpaved	Total	Pavement rate (%)
Djibouti	Ras-Dika	36.23	5.47	41.70	86.9%
	Boulaos	73.78	130.27	204.05	36.2%
	Balbala	54.11	258.48	312.59	17.3%
	Subtotal	164.12	394.22	558.34	29.4%
Ali-Sabieh		3.78	8.55	12.33	30.7%
Dikhil		0.81	6.67	7.48	10.8%
Arta		4.24	6.60	10.84	39.1%
Tadjourah		3.80	3.69	7.49	50.7%
Obock		2.83	4.88	7.71	36.7%
Districts outside of Djibouti City: Subtotal		15.46	30.39	45.85	33.7%
City Road: Total		179.58	424.61	604.19	29.7%

Source: ADR (Ministry of Infrastructure and Equipment)

The city's roads consist of four national roads and other arterial roads (see Figure 3.1.2). The most critical route is RN1 (National Road Route 1), and most of the freights for Ethiopia now utilize this route In December 2020, a renovation project supported by Japan was completed and a part of the route started operation. RN2 is a road connecting Damerjog Industrial Park with the city center and continues to Somalia. RN3 is a road connecting the city center with the Doraleh New Port. RN5 is also a road connecting Djibouti and Ethiopia as an alternative route to RN1. Currently the use of this routes is limited because the Ethiopian side of this route is unpaved and now in progress to be paved. However, when the paving of Ethiopian side is completed, this route will function as an alternative route to RN1.

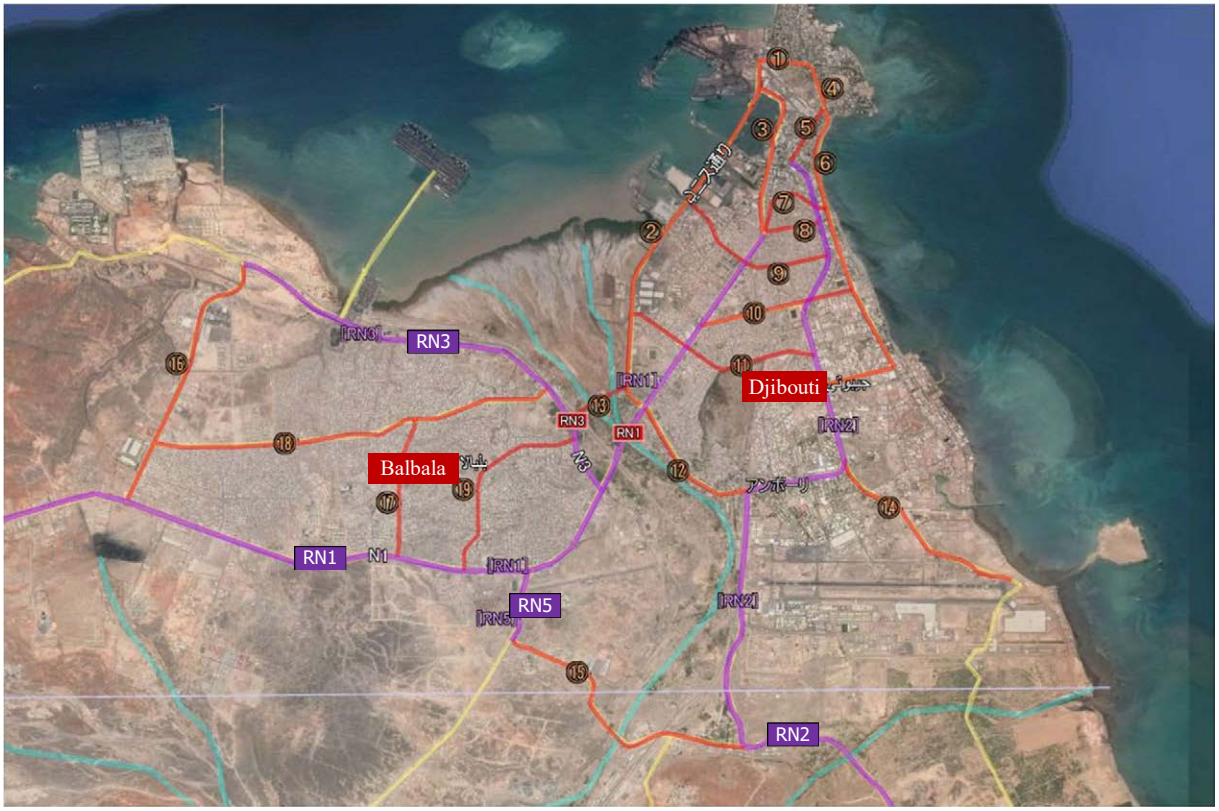


Source: Prepared by the survey team based on SDAU

Figure 3.1.2 Current Road Network in the City of Djibouti

3.1.2 Present Status of Road Development (Road inventory survey)

A road inventory survey was implemented on main routes of Djibouti City (23 routes including four national roads) to review the status of road facilities as mentioned above. The road facilities targeted in the review under this survey and the outline of the road inventory survey are shown in Table 3.1.4.



No.	Road Name	Length (km)	No.	Road Name	Length (km)
1	Avenue General Galleni	0.67	13	Cheikn Mohamed	0.85
2	Rue de Venice + Liaison Port-Rue de Venice	5.00	14	Route Nationale 2/2	2.72
3	Boulevard El Haj Hassan + Rue de Geneve	2.11	15	Voie Nagad	3.83
4	Avenue d'Esperey	0.55	16	voie 19	3.55
5	Boulevard de la République	0.81	17	Barwako - Hayabley + Avenue Ugass Hassan Xersi	3.66
6	Liaison Rue de Siesta-Route de l'Aéroport + Route de la Siesta	4.53	18	Ougass Hassan	3.43
7	Rue de Bender	1.18	19	Rue Abdi Hassan Liban	2.68
8	Avenue Cheik Houmad	0.71	20	Route National 1	13.1
9	Avenue 26 + Rue Venice-RN1 + Liaison Ouest-Est	2.20	21	Route National 2	20.46
10	Avenue Nasser (RN2) + Prolongement Avenue Nasser	2.00	22	Route National 3	5.94
11	Avenue type E	2.63	23	Route National 5	1.38
12	Boulevard Mandela	1.89			

Source: Prepared by the survey team.

*No. 14 is excluded from the target routes as it was under construction.
*Through discussions with ADR, No. 21 was excluded from the survey for a security reason.

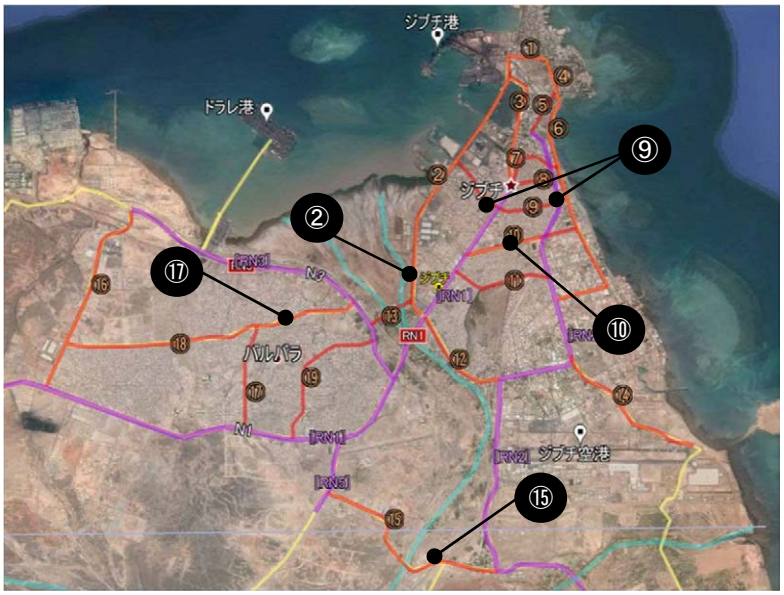
Figure 3.1.3 Routes Targeted in the Road Inventory Survey

Table 3.1.4 Contents of Road Inventory Survey

Subjects	Contents	Remarks
Road	Road width	RN1-RN3: about 400 m intervals Palmeraie Road (between east and west intersections): about 50 m intervals Other than above: about 200 m intervals
	Road shoulder facilities (type, dimensions)	
	Wastewater facilities (type, dimensions)	
	Conditions of pavement, drainage, and other facilities	
Ford structure	Position	Each structure
	Width, extension	
Transverse structure (ditch structure and railway structure)	Position, structural type	Each structure
	Inner diameter, extension, dimensions of elements	
	Appearance condition	
	Clearance with the current road	
Bridge structure	Position, structural type	Each structure
	Road width, sidewalk width, and ancillary objects	
	Bridge length, span length, and substructure dimensions	
	Appearance condition	
Traffic light facility	Location, type, and dimensions	Each facility
	Appearance condition	

Based on the inventory survey, the status of pavement, road drainage and structures is reviewed and the results are shown below.

(1) Outline of the Status of Pavement



The width of the road is reduced due to rutting on the shoulder.

Pavement is deteriorating significantly.

It is a main road in the Balbala district, but vehicles find it difficult to use when rain falls.

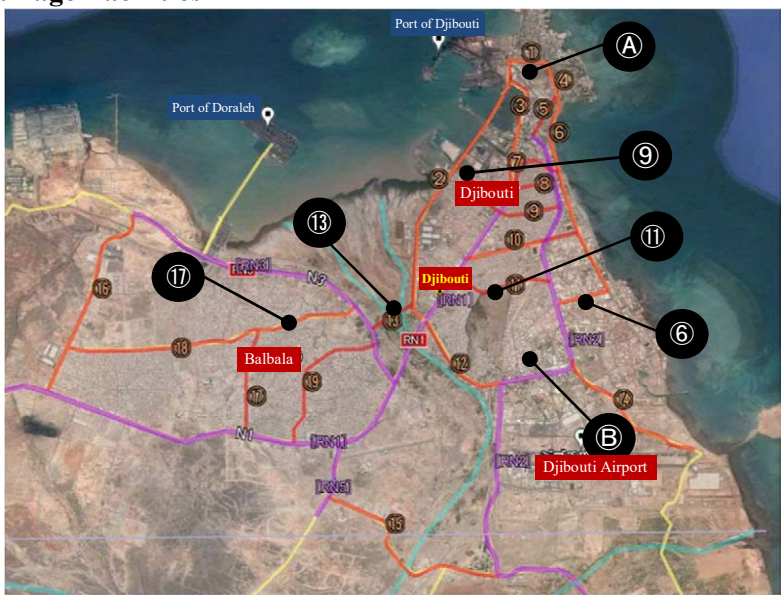
Ordinary cars cannot drive here.

It is a narrow railway underpass.

Driving on this lane (eastward) is impossible.

Figure 3.1.4 Overview of Pavement Condition in Djibouti City

(2) Outline of the Status of Drainage Facilities



Ford structure that is flooded and cannot be used by traffic when rain falls.

Flooded streets of the Heron district (photographed on Nov. 23, 2019)

Ford structure that is flooded and cannot be used by traffic when rain falls.

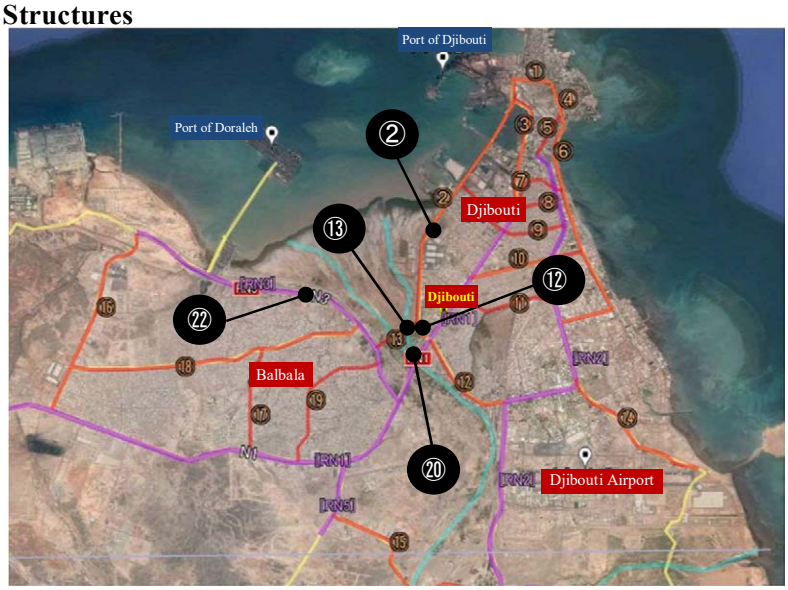
Flooded streets in the Boulaos district (photographed on Nov. 24, 2019)

A manhole in the city without cover.

An open channel with a width of nearly 10m that is covered.

Figure 3.1.5 Overview of Drainage Condition in Djibouti City

(3) Outline of the Status of Structures



This is the city's only one road bridge, Italy Bridge, constructed in 1993 and repaired in 2017 by a Chinese company. Currently, the passage of large vehicles is restricted due to durability concern.

Accumulated waste blocks the flow of water.

Damage due to corrosion of reinforcing bars is significant and it is assumed to be caused by salt and peeled-off concrete.

The entry/exit of the culvert is hidden by grown plants and trees.

Power switching facilities near Palmeraie Road. The transmission line crosses Palmeraie Road at a height of 18m.

Figure 3.1.6 Overview of Structure Condition in Djibouti City

Of the items to be surveyed, the following ones have already been reviewed in the preceding fiscal year report on road maintenance project requested by ADR, and the review of this survey was made based on the data of the report:

- Road width
- Existence of sidewalks and median strips
- Location and form of intersections
- Location and types of structures (road bridges, railroad bridges, culverts, fords and high-voltage cable towers)
- Existence and form of lighting system
- Pavement condition

In addition, photos taken on the site showing the road conditions of each route in a fixed survey interval and survey sheets to show measurements and external appearances of road bridges and culvert structures are included in the Appendix.

(1) Road Width

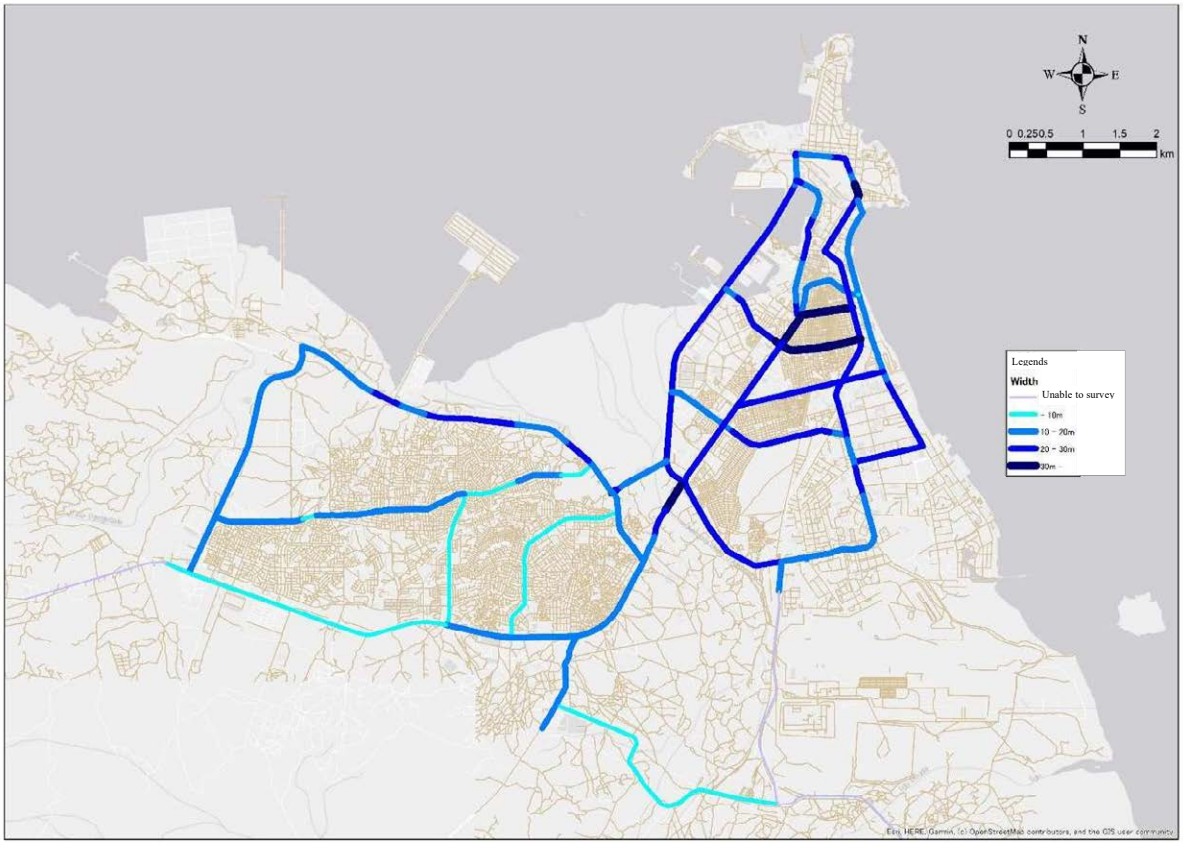


Figure 3.1.7 Arrangement of Road Conditions (Road Width)

(2) Sidewalk

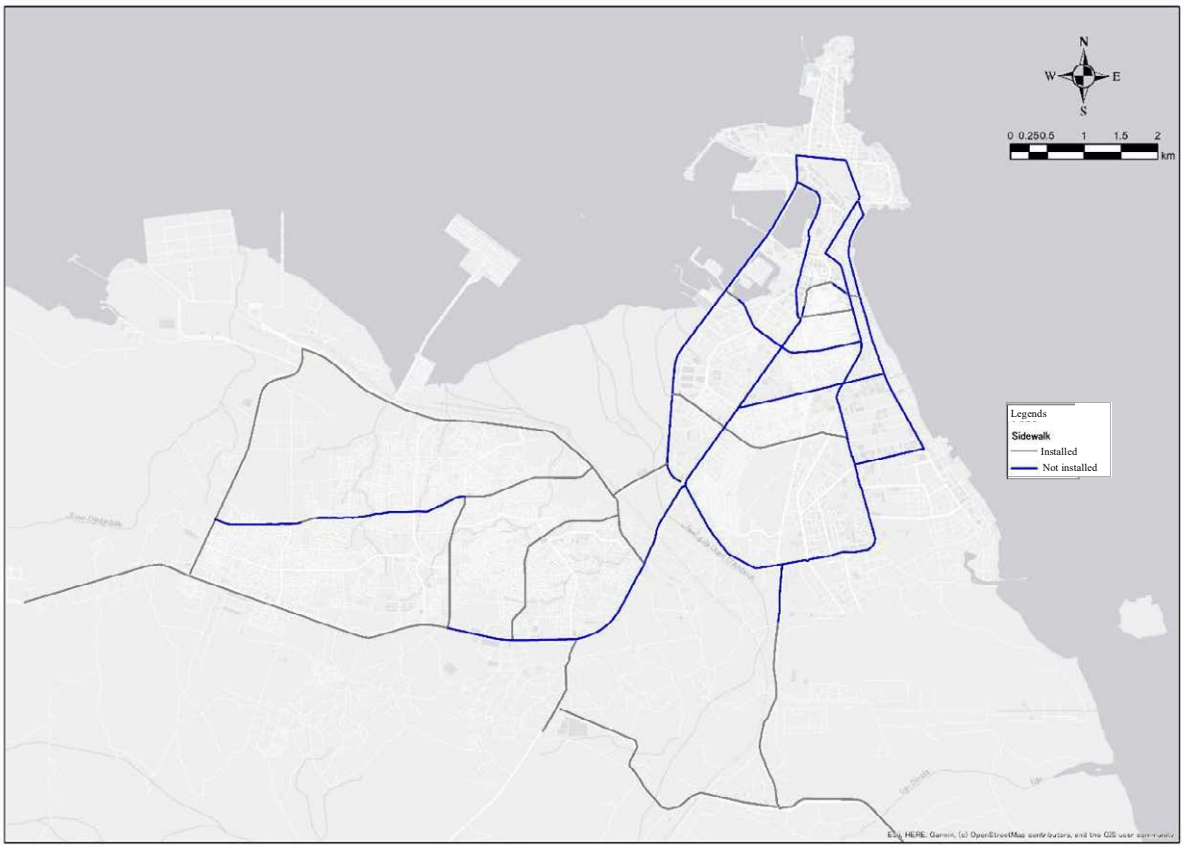


Figure 3.1.8 Arrangement of Road Conditions (Sidewalk)

(3) Median Strip

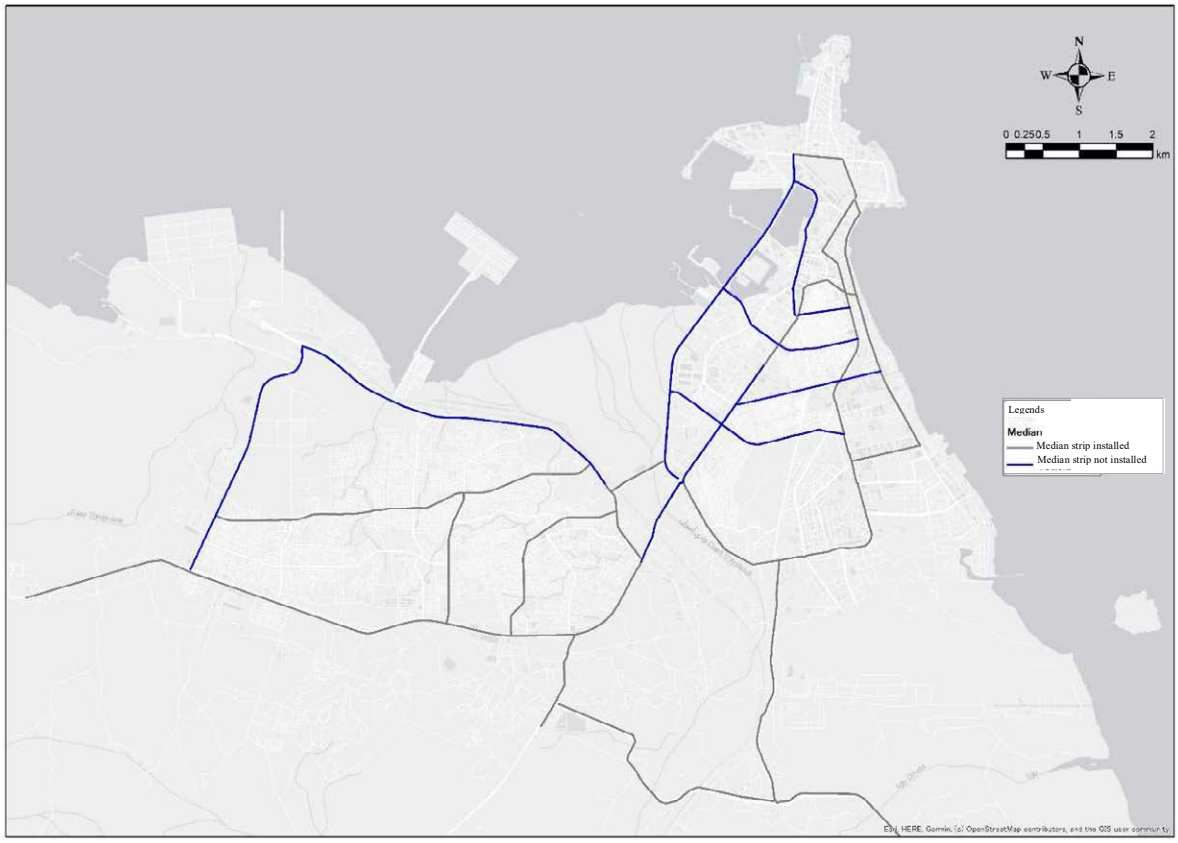


Figure 3.1.9 Arrangement of Road Conditions (Median)

(4) Form of Intersection

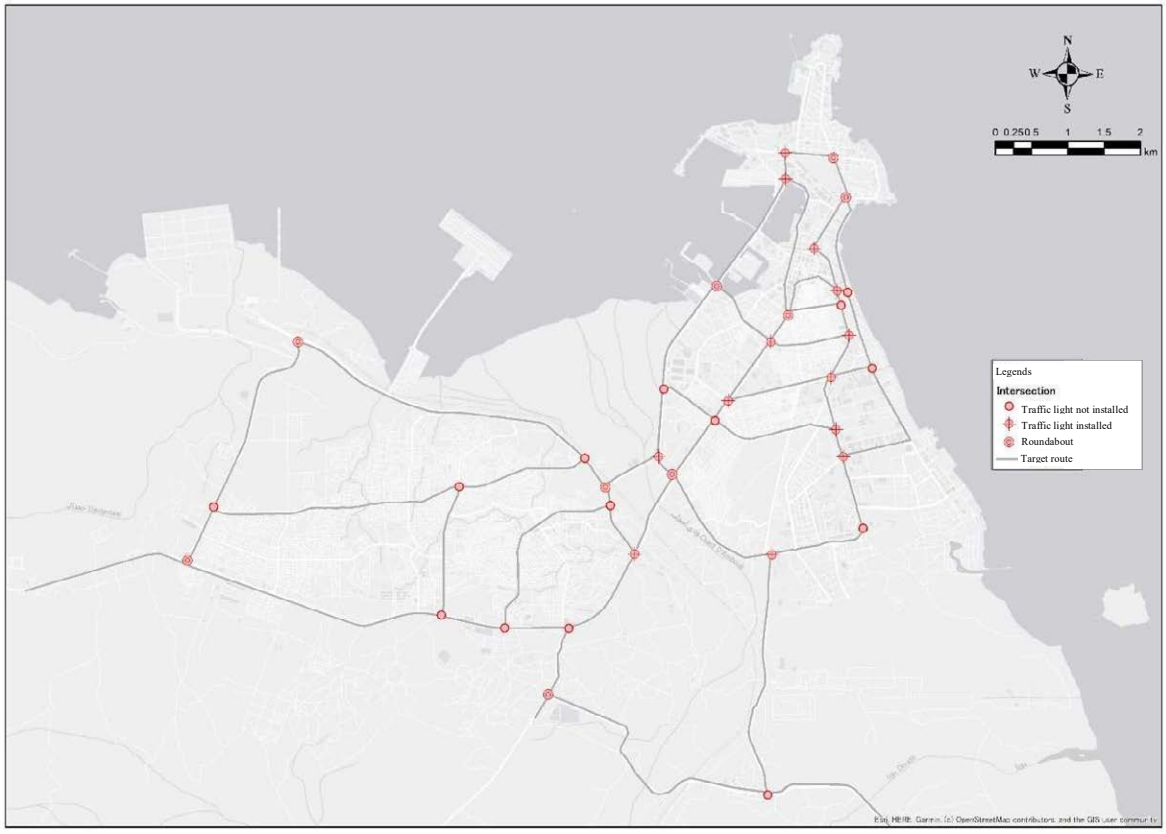


Figure 3.1.10 Arrangement of Road Conditions (Intersection)

(5) Location of Structures and Facilities (Culverts)

Figure 3.1.11 Arrangement of Road Conditions (Culverts)

(6) Survey of Structures (High-Voltage Cable Towers)

Figure 3.1.12 Arrangement of Road Conditions (High-Voltage Cable Towers)

(7) Survey of Structures (Road Bridges and Railroad Bridges)

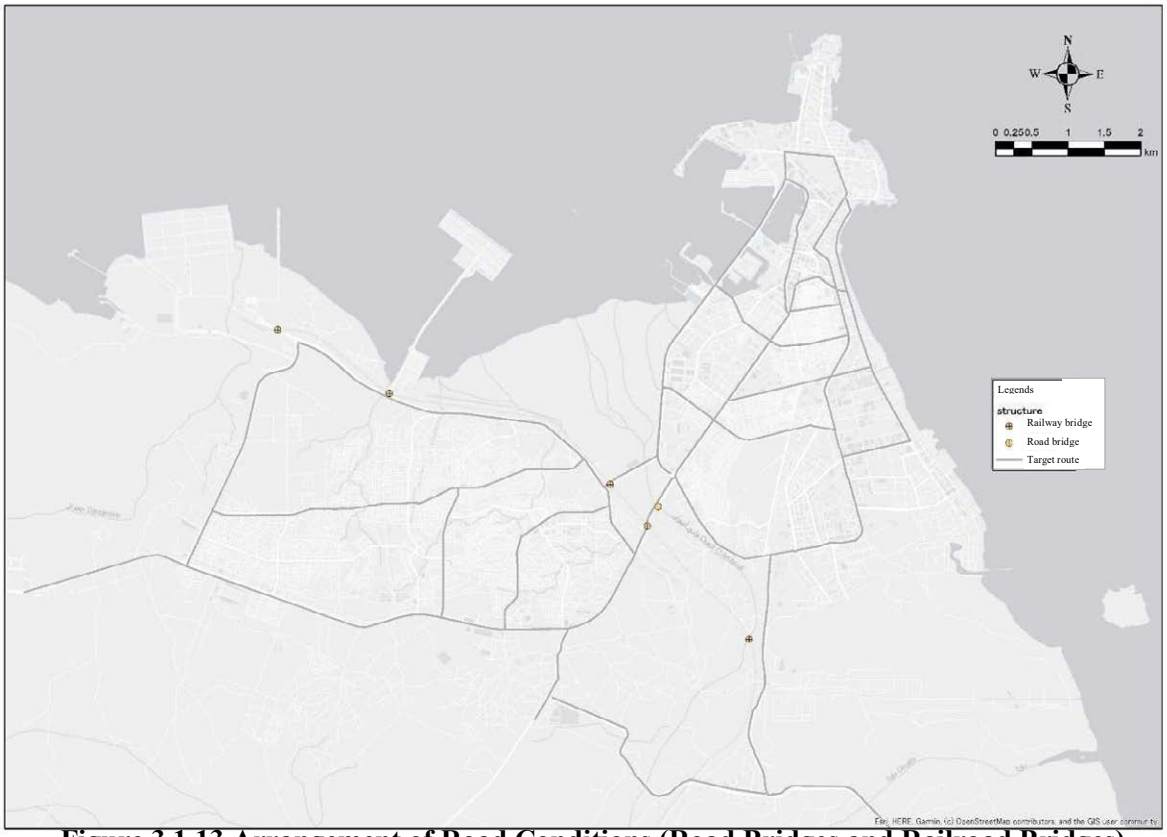


Figure 3.1.13 Arrangement of Road Conditions (Road Bridges and Railroad Bridges)

(8) Existence of Lighting System (Form)

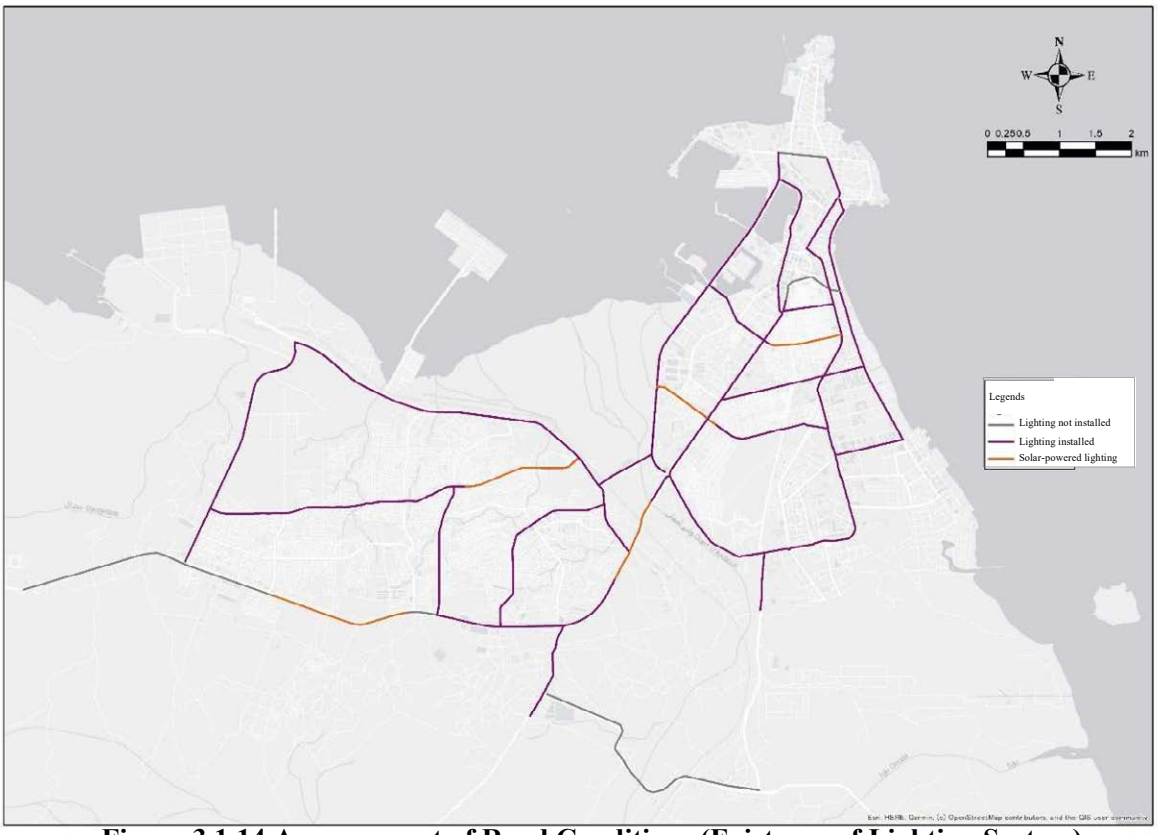


Figure 3.1.14 Arrangement of Road Conditions (Existence of Lighting System)

(9) Pavement Condition

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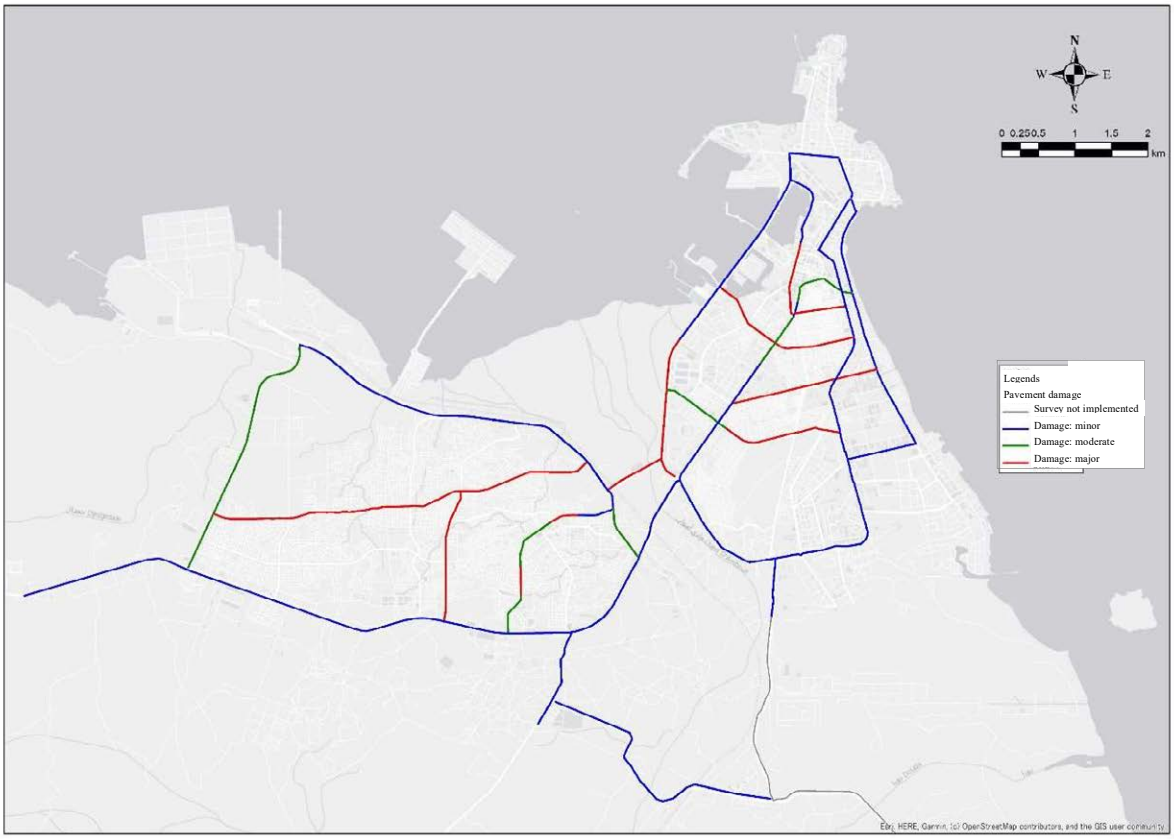


Figure 3.1.15 Arrangement of Road Conditions (Pavement Condition)

3.1.3 Status of Traffic Regulations

Different traffic regulations are in place in the city, some for traffic safety and other for smooth traffic flow or for both. In the central business district (CBD), where roads are relatively narrow and many vehicle and human traffic concentrate, parking restriction and one-way traffic are introduced. Although the road signs or markings for the traffic regulation are not easily visible, they are apparently known to the local people. Illegal parking creates congestion, especially during peak hours. Traffic officers, however, make efforts to enforce the law and prevent it.

Figure 3.1.16 Control of Illegal Parking Conducted by the Traffic Police (in CBD)

Speed limits are established on major roads in both the city and its suburban areas where motorists tend to drive at a high speed. Traffic police controls those who violate the speed limits using speed guns.

Figure 3.1.17 Examples of Traffic Regulation Signs in the City

Large trucks that use the Port of Djibouti enter and leave Djibouti City. There are no particular regulations on large trucks in the city except for the Italy Bridge.

Figure 3.1.18 Traffic Regulation Signs for Large-Sized Vehicles on the Italy Bridge

3.2 Present Status of Road Traffic in Djibouti City

3.2.1 Implementation of the Traffic Volume Survey

Although ADR conducted a traffic volume survey covering all districts of the city, it has already been six years since then and the traffic volume has changed during these six years. In this survey, therefore, a traffic volume is implemented on major sections and spots shown in Figure 3.2.1, besides using existing materials.

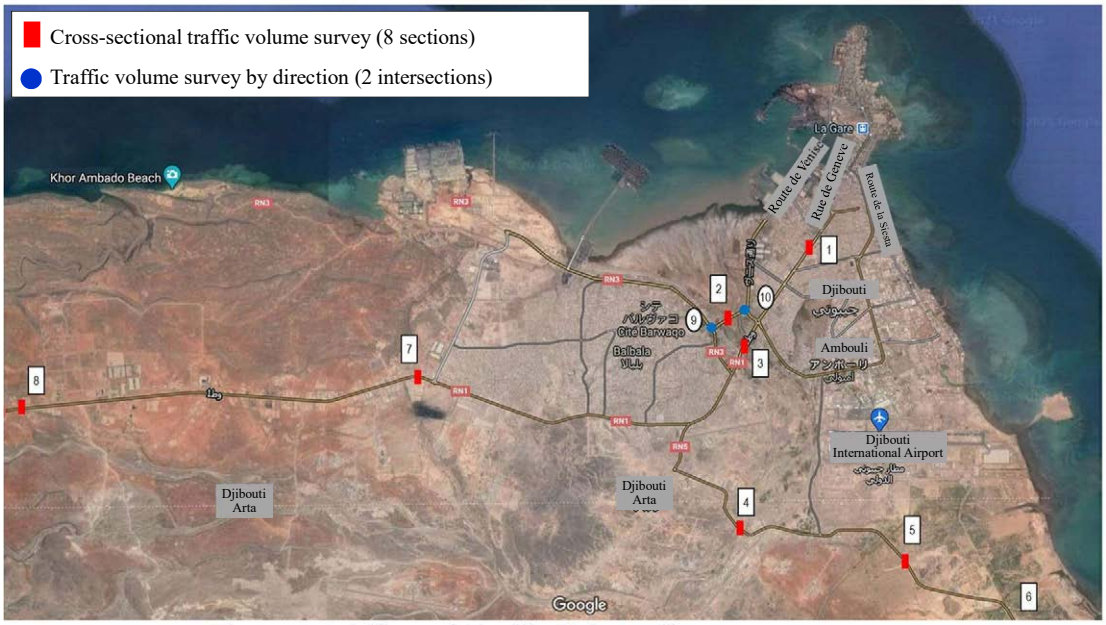


Figure 3.2.1 Sites of Traffic Volume Survey

Table 3.2.1 Contents of Traffic Volume Survey

Survey site	Contents of the survey	Survey date and time	Vehicle type classification (draft)
1	Cross-sectional traffic volume survey	14 hours on weekdays (6:00 AM to 8:00 PM)	Following nine vehicle categories (1) Motorcycle (2) Bajaj/Tuk tuk (3) Passenger car (4) Taxi (5) Minibus (6) Midibus (7) Light truck
2		24 hours on weekdays (6:00 AM to 6:00 AM)	
3			
4		14 hours on weekdays (6:00 AM to 8:00 PM)	
5			
6		24 hours on weekdays (6:00 AM to 6:00 AM)	

7		14 hours on weekdays (6:00 AM to 8:00 PM)	(8) Heavy truck (9) Trailer
8		24 hours on weekdays (6:00 AM to 6:00 AM)	
9	Traffic volume survey by direction	4 hours on weekdays (7:00 AM to 9:00 AM and 1:00 PM to 3:00 PM)	
10			

3.2.2 Road Traffic Volume

The results of the traffic volume survey are shown in Table 3.2.2. On the Palmeraie Road (No. 2), the daily traffic volume exceeds 30,000 vehicles, the largest volume found in this survey, followed by the Italy Bridge (No. 3) with daily traffic of 22,000 vehicles. The traffic volume of these two roads, which cross the Ambouli River, is very large, and this indicates that these two roads play the most important role in terms of the city traffic movement.

In terms of vehicle type, motorbikes and public transport vehicles dominate the city center traffic (No. 1 to No. 3 of Table 3.2.2 below), while the number of trailers is the largest at No. 7 and No. 8 on the National Road Route 1, a major traffic route for logistics between Djibouti and Ethiopia. The number of trucks and trailers using the Palmeraie Road is relatively large, as it is an important road connecting the old Port of Djibouti.

Table 3.3.2 Results of Traffic Volume Survey (Sectional Traffic Volume)

№	Survey Location	Survey Duration	Traffic Volume by Vehicle Type					
			Motorbike	Car	Public	Truck	Trailer	Total
1	Arhiba	14hr	1,224	5,466	6,875	499	3	14,067
2	Palmeraie	24hr	3,502	17,436	8,047	1,565	1,000	31,550
3	Bridge	24hr	2,184	11,595	7,300	1,237	30	22,346
4	Nagad	14hr	155	1,264	570	479	118	2,586
5	RN2-Douda	24hr	214	1,507	323	392	70	2,506
6	RN2-Lawyade	14hr	7	199	26	51	24	307
7	RN1-PK20	14hr	58	1,412	997	683	1,820	4,970
8	RN1-PK24	24hr	31	999	239	283	2,122	3,674

Note: Nos. 2 and 3 survey data: May 19; Nos. 1, 7 and 8: May 20; Nos. 4 & 5: May 27; and No. 6: May 30

Table 3.2.3 shows a comparison with the results of the survey conducted by ADR in 2014 for the traffic of the three roads crossing the Ambouli River. The total daily traffic volume crossing Ambouli River in 2014 and 2021 was 39,946 and 51,079, respectively, showing an increase of 11,333 per day, or 28%. In terms of traffic volume, Italy Bridge was serving more traffic seven years back, but it is now overtaken by Palmeraie Road. In addition, the traffic volume of the Nagad Road is still small but the growth rate is significant showing that development along the road has been progressing.

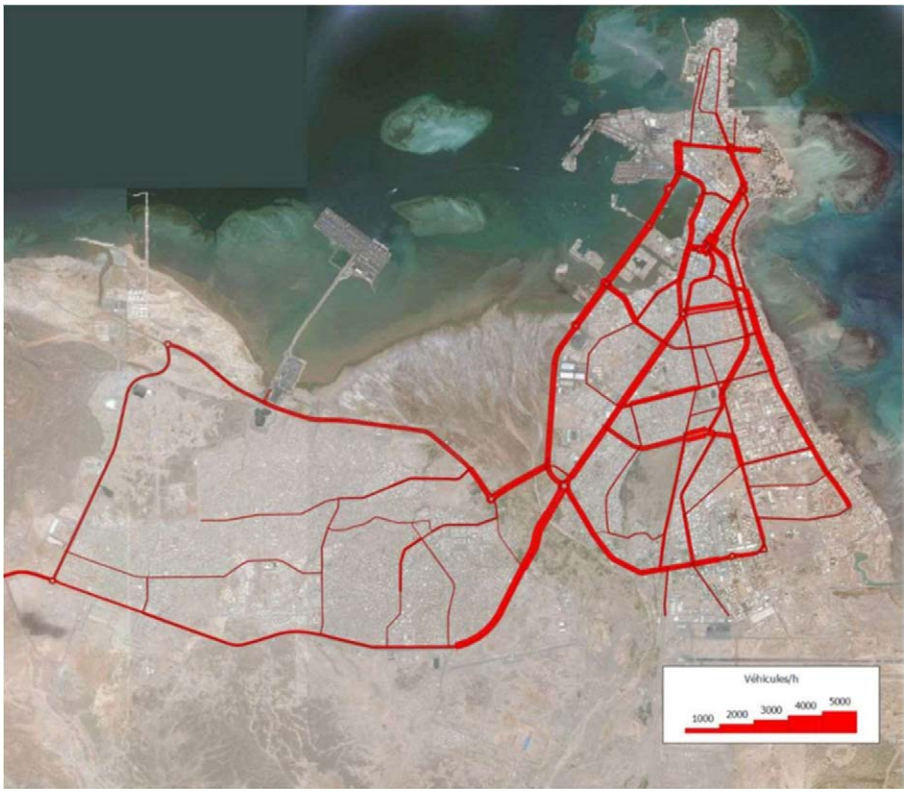
Table 3.2.3 Comparison of 2014 and 2021 Survey Results

№	Name of crossing	Traffic (veh./day)		(B-A)	(B/A)
		(A) 2014	(B) 2021		
2	Palmeraie	16,274	28,048	11,774	1.72
3	Italy Bridge	22,192	20,162	-2,030	0.91
4	Nagad	1,480	2,869	1,389	1.94
	Total	39,946	51,079	11,133	1.28

Source: 2014 survey data are provided by ADR.

Figure 3.2.2 shows road traffic of the city based on the survey conducted by ADR in 2014. Djibouti City is divided into two parts by Ambouli River: a commercial area (Ras-Dika and Boulaos) on the east side and a suburban area (Balbala) on the west side of the river. Both the east and west sides of the city are connected by two trunk roads (the Palmeraie Road, and the Italy Bridge located on the National Road Route 1). Specifically, the Palmeraie Road connects the old Port of Djibouti and the

northern part of Balbala (the new Port of Doraleh), and the National Road Route 1 (the Italy Bridge) connects the city center and the southern part of Balbala.



Source: 2014 ADR survey

Figure 3.2.2 City Road Traffic Volume

When the Ambouli River rises in accordance with heavy rain, traffic to the Palmeraie Road is blocked, resulting in a sharp increase in traffic to the Italian Bridge. At this time, Route 3, the road connecting the west intersection of Palmeraie Road to Route 1, has congested due to its poor pavement condition (Figure 3.2.3).

Date of Photo: November 26, 2020

Figure 3.2.3 Traffic Congestion during Flooding

3.3 Present Status of the Transport Sector of Djibouti City

3.3.1 Transport Administration

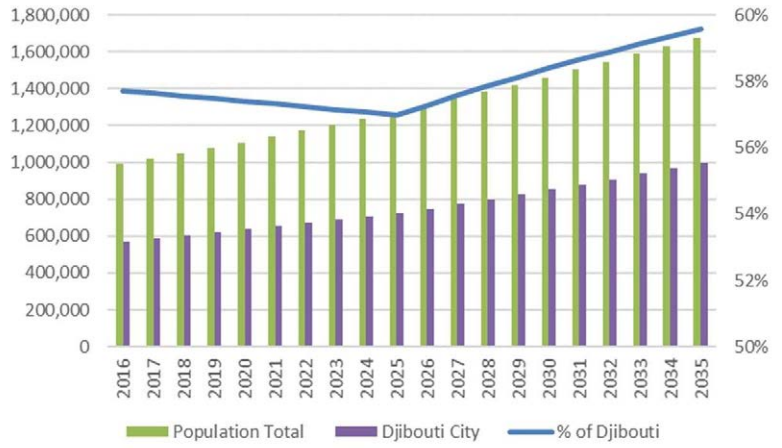
(1) Upper Plan

① Vision Djibouti 2035

Vision Djibouti 2035 is a national development plan established by the Ministry of Economy and Finance in 2014 setting the year of 2035 as its target year. The plan is to promote the country's growth and transformation with the following 5 pillar themes with the goal of "making Djibouti a lighthouse of the Red Sea and a hub of African Industries and Transport":

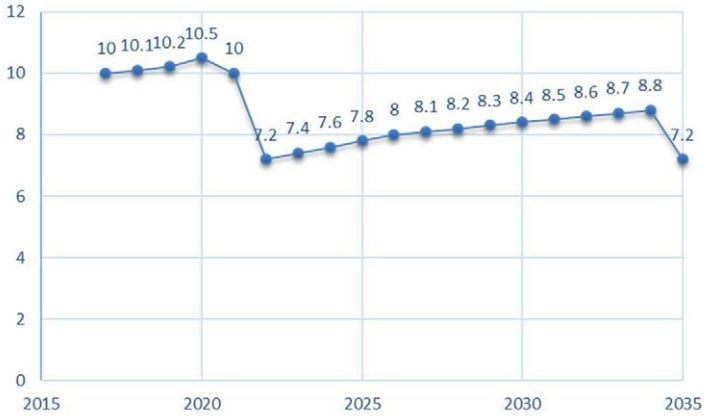
I. Peace and further integration as a nation
II. Diversification of the economy and strengthening of competitiveness utilizing private capital
III. Healthy national governance
IV. Regional integration
V. Consolidation and utilization of human resources

Figure 3.3.1 shows the population estimated in "Djibouti Vision 2035" and Figure 3.3.2 shows estimated GDP growth rates. As the population continues to concentrate in Djibouti City, the DGP of the Republic of Djibouti is estimated to grow at a high rate of 7 to 8% until 2035.



Source: Djibouti Vision 2035

Figure 3.3.1 Estimated Future Population of the Republic of Djibouti and Djibouti City



Source: Djibouti Vision 2035

Figure 3.3.2 Estimated GDP Growth of the Republic of Djibouti

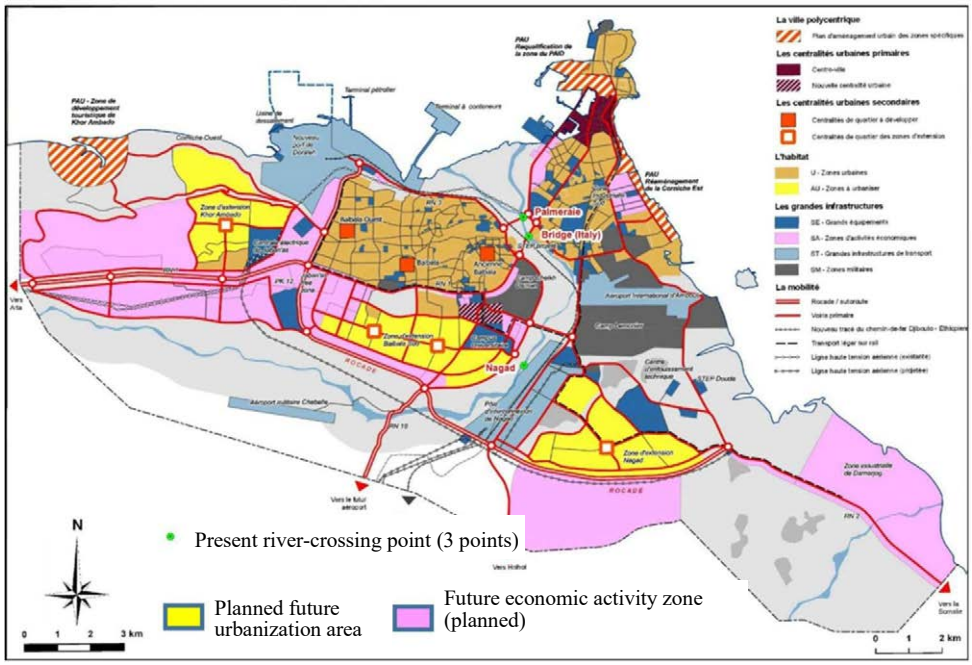
② SCAPE 2015-2019 (Strategy of Accelerated Growth and Employment, 2015, Ministry of Economy and Finance)

SCAPE 2015-2019 was developed as a strategy to define priority actions and goals to implement and achieve during five years from 2015, following the approval of Djibouti Vision 2035 by the Cabinet. The main goal of the development strategy for the transport sector is defined as "strengthening its function as a regional multimodal transport center in the Horn of Africa." The strategy underlines the need to ensure the country's status as a major and privileged port for Ethiopia by maintaining and strengthening the competitiveness of a logistics chain. At the same time, it points out the importance of developing the domestic transport system, i.e., roads, for a balanced development and growth, and for the diversification of the economy of the country. The following seven strategies are proposed for the transport sector:

I. Development of port infrastructure to strengthen the country's function as a regional hub
II. Development of free zones
III. Development of aerial transportation infrastructure and strengthening it
IV. Promotion of railway transport system for regional integration
V. Development of a national road network and regional corridors for domestic transportation meeting demand
VI. Development of an urban transportation network
VII. Strengthening the transport sector's institutional capacities

③ Master Plan for Urban Planning and Development of Djibouti City (SDAU[1])

This plan was decided by the Ministry of Housing, Urban Planning and Environment in accordance with "Vision Djibouti 2035", and it has set the goal of "balanced development and growth of both east and west districts" across the Ambouli River. Then, road improvement connecting east-west urban districts separated by the Ambouli River, widening of existing roads, ring roads, LRT, etc. have been proposed for smoothing road traffic in the city. Among them, four major routes are positioned as important to connect east and west districts to realize and promote the development of bases of the mentioned area (see Figure 3.3.3).



Source: SDAU

Figure 3.3.3 Future Land Use Plan of the City of Djibouti

[1] SDAU is an abbreviation of the French name, Schema Directeur d'Amenagement et d'Urbanisme.

(2) Concerned Organizations

Organizations related to the transport sector are shown in Table 3.3.1.

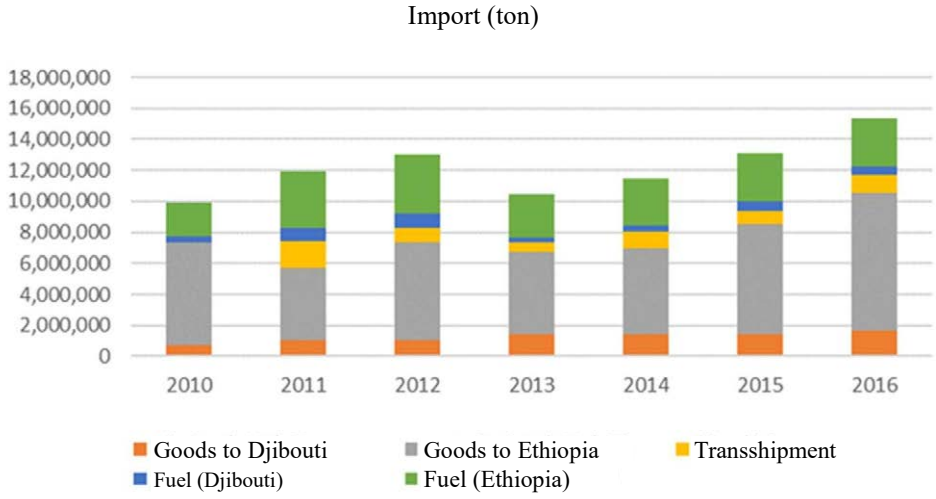
Table 3.3.1 Organizations Related to the Transport Sector

Transport Sector	Organization	Outline
Related to Road and Port	ADR	This organization is responsible for the planning, design, construction, and maintenance of national and local roads in Djibouti.
	DPFZA	This organization is responsible for the development and operation of ports and free zones. The Djibouti Ports Corridor Road (DPCR), a subordinate organization of this organization, is in charge of planning, maintenance and financing of the international corridor connecting Djibouti Port with neighboring countries.
Related to Transport, Logistics, and River	ADR	This organization is responsible for overall transport policy in Djibouti, and the agency in charge of the Djibouti side of the "Urban Mobility Improvement Study" conducted by the World Bank by May 2020.
	MAWFLFR	This organization is responsible for flood control in Djibouti and is the administrator of major rivers in the country. It is also the implementing organization of the Ambouli Friendship Dam Project which was implemented with Turkish assistance in the upper Ambouli River basin and completed in May 2019.

3.3.2 Present Status of the Transport Sector

(1) Marine Traffic

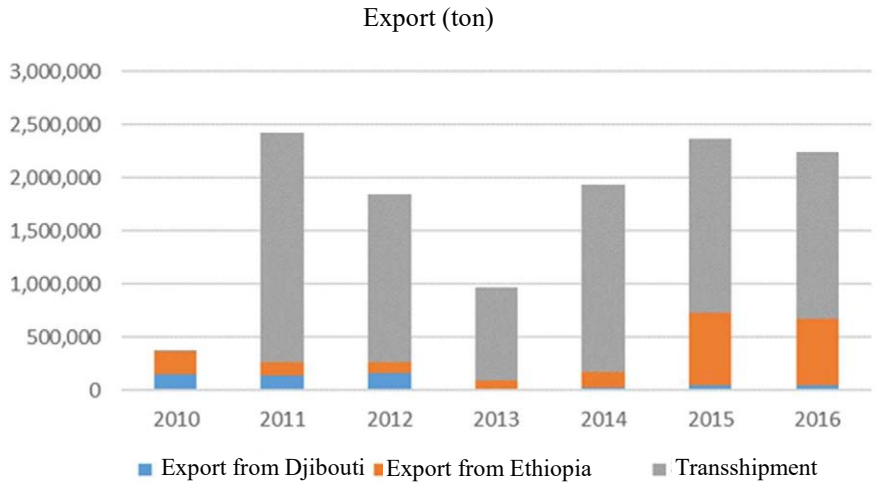
The Port of Djibouti handles large transshipment goods[2] because of its ideal geographical location. In addition, the port also functions as a gateway for Ethiopia and about 80% of import is bound for Ethiopia. The export volume is 1/10 to 1/5 of that of the import, of which about 70% is transshipped goods (see Figure 3.3.4 and Figure 3.3.5).



Source: PAID

Figure 3.3.4 Volume of Imports Handled at the Port of Djibouti

[2] This indicates that the transported cargo will be transhipped to another ship at a port on the way.



Source: PAID

Figure 3.3.5 Volume of Exports Handled at the Port of Djibouti

(2) Railway Traffic

The railway in the Republic of Djibouti was first constructed by a French company in 1917 as the Ethio-Djibouti Railway (connecting the Port of Djibouti and Addis Ababa). A new railway adjacent to the old one was constructed because of difference in the gauge width and the propulsion system. Regarding the financing of the new railway, 70% of the total investment of 3.4 billion dollars was supplied by the Export-Import Bank of China and the construction was completed in 2017. The railway is being operated by two Chinese companies under a six-year operation agreement with public railway corporations of Djibouti and Ethiopia. The train has to go up from the Port of Djibouti located 0m above the sea level to Addis Ababa located 2,300m above the sea level, in a distance of about 700km. Therefore, it requires a system with a strong propulsion, and it was decided to introduce an electrified railway system. The section connecting Sebeta and Adama via Addis Ababa was built with double tracks as a large demand was expected, and the remaining route between Adama and the Port of Djibouti was built with a single track.

Source: https://en.wikipedia.org/wiki/File:Bahnstrecke_Addis_Abeba%E2%80%93Dschibuti.png

Figure 3.3.6 New and Old Railway Routes between the Port of Djibouti and Addis Ababa

Freight transport between Djibouti and Ethiopia is carried out both by trucks and railway. The railway service started in 2018 and trains run to and from the Port of Djibouti and Addis Ababa, and currently the daily freight train frequency is limited to three in each direction. Railway freight has a share of about 13% of the entire freight (freight volume carried by one train is equivalent to that of 53 trucks).

The final goal is to increase the daily frequency of the freight trains to 19 in each direction (See Table 3.3.2).

Although there are short- and long-term plans for the frequency increase, it is already behind this schedule. In addition, how this service will grow in the future is unknown, making the estimation of the future modal split difficult. Therefore, the modal split between the train and truck is estimated based on the scenarios of the train service growth:

Scenario 1: The number of train operations per direction will increase up to five by 2023, and then remain so.

Scenario 2: The number will increase by one each year.

Scenario 3: The ultimate goal of daily freight trains of 19 per direction will be achieved by 2030.

Table 3.3.2 Rail Service Operation Plans

Study Year	Section	Pair of trains (pair/day)			
		Passenger train	Freight Train	Pick-up and drop train	Subtotal
Initial Stage	SEBETA ~ADAMA	5	5	1	11
	ADAMA~ AWASH	2	5	1	8
	AWASH~DIRE DAWA	2	5	1	8
	DIRE DAWA~NAGAD	1	5	1	7
Short Term Stage	SEBETA ~ADAMA	6	7	1	14
	ADAMA~ AWASH	2	8	1	11
	AWASH~DIRE DAWA	2	9	1	12
	DIRE DAWA~NAGAD	1	9	1	11
Long Term Stage	SEBETA ~ADAMA	10	16	1	27
	ADAMA~ AWASH	3	17	1	21
	AWASH~DIRE DAWA	3	19	1	23
	DIRE DAWA~NAGAD	2	19	1	22

Source: Ethiopian Railways Corporation

Figure 3.3.7 below show the modal split between trains and trucks for the above three scenarios. In Scenario 1, the train share would reach a maximum of 19%, and in Scenario 2 the share gradually increases until it reaches 34%. In the third and most optimistic scenario, the train share reaches a maximum of 48%, and the train share decreases after reaching its maximum frequency, as the freight volumes continue to increase.

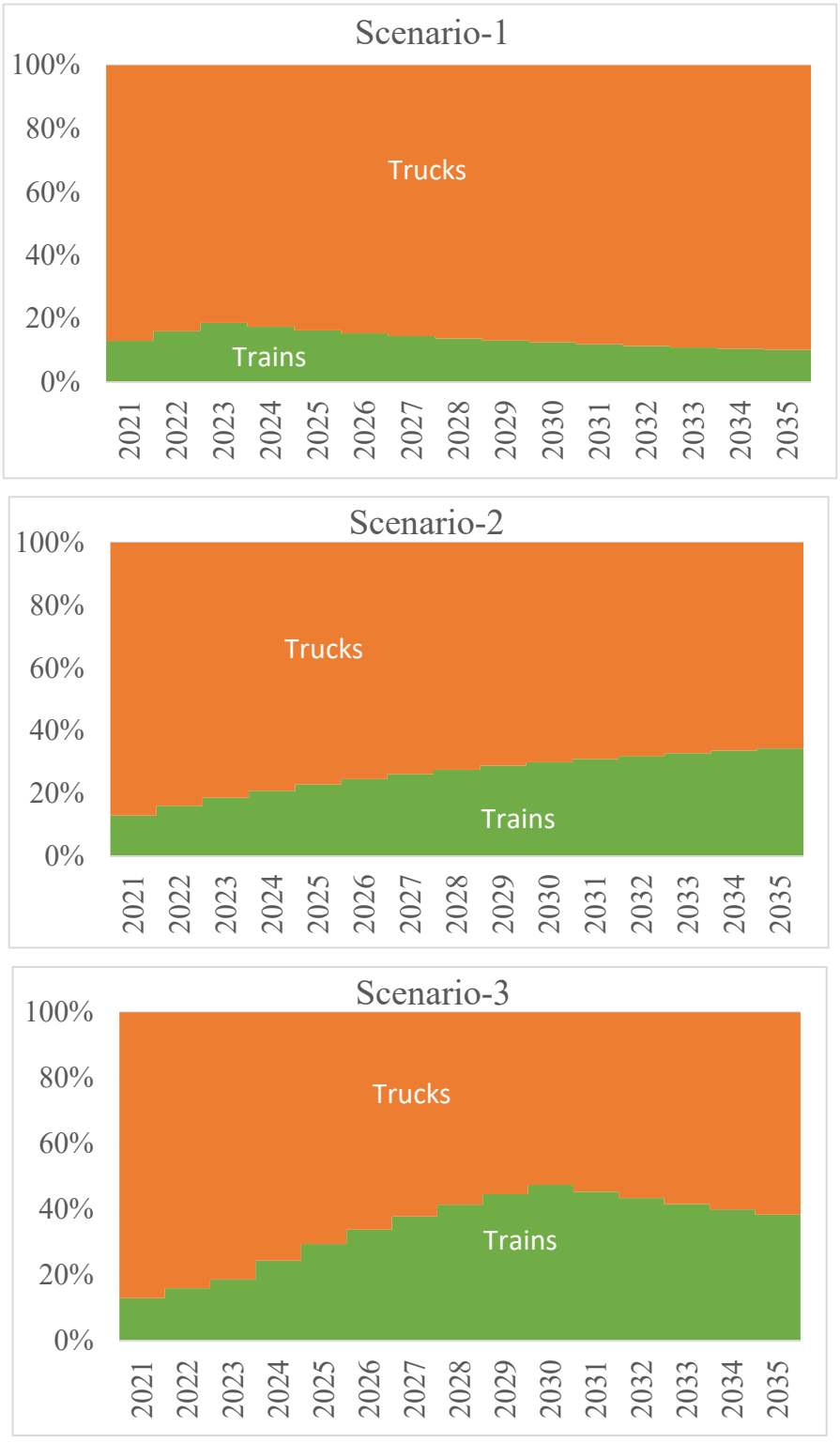


Figure 3.3.7 Transition of Rail/Truck Transportation Sharing Ratio by Scenario

(3) Urban Transport Service

The modal split in Djibouti City is as follows: 20% travel by public transport, 50% on foot, 3% by own car and remaining by taxi and company bus (survey of the World Bank). The city has no established bus routes or bus stops, and the bus driver chooses the route to serve depending on the demand, which means customers can get on and off the bus wherever they want. Although the bus routes are not established, buses mostly serve routes connecting the east and the west sides of the Ambouli River. There are a total of about 44 routes (See Figure 3.3.7). The bus fare is set at 40 FDJ

for the central part of the city and 50 FDJ between the central part and the Balbala district (no fare revision has been made since 1998). Different issues are pointed out including existence of districts in the peripheral areas with no service, poor safety and imbalance of service due to over-competition caused by lack of any regulation, besides poor working environment for drivers.

Source: Djibouti Technical Assistance for Urban Public Transport: Situational Analysis (World Bank)

Figure 3.3.8 Djibouti City Bus Routes

Table 3.3.2 shows the number of public transport vehicles using the two bus routes crossing the Ambouli River based on the current survey. The total traffic of the two routes exceeds 1,400 vehicles during the morning peak hour (i.e., one hour in the morning peak time). By multiplying the number of vehicles by average number of passengers by vehicles type[3], the largest number of the peak-hour peak-direction traffic volume of Palmeraie and Italy Bridge routes is found to be 6,164 people, and 5,300 people, respectively (See Table 3.3.3). Normally, the number of passengers that a bus can handle is said to be around 4,000 per hour (i.e., peak hour, per direction)[4]. Since the current passenger volume significantly exceeds the normal bus capacity, it can be said that it is the time to introduce a new urban transport system (articulated bus, BRT, LRT, etc.). If we assume that the peak rate of public transportation is about 10%, the daily traffic volume would be about 90,000 people on the Palmeraie Road and about 80,000 people on the Italian Bridge, for a total of about 170,000 people.[5]。

[3] Based on the capacity of each mode of transportation, we assumed that there would be 8 passengers for Bajaj, 2 passengers for Taxi, 12 passengers for Minibus, and 30 passengers for Midibus in the city canter direction. In the suburbs, the capacity was assumed to be half that. The capacity of each transportation type is as follows. Bajaj (8 seats), Minibus (12 to 14 seats), Midibus (30 to 35 seats), Taxi (4 seats)

[4] The capacity of a large bus is 45 to 60 people/vehicle. If we assume the maximum number of passengers is 60, and the operation interval is 1 minute (60 buses/hour), the hourly transportation volume would be 60 passenger's x 60 buses = 3,600 passengers/hour. Shorter service intervals will increase the transportation capacity, but considering the processing time at the bus stop, the increase will be about 10-20%, and the limit is said to be about 4,000 passengers.

[5] Palmeraie Road: 8,716 people/hour / 10% ≒ 90,000 people/day, Italian Bridge: 7,925 people/hour / 10% ≈ 80,000 people/day. The total number of people is 170,000, which is about 30% of the population of Djibouti City, which is about 570,000 people. This indicates that 15% of the total population crosses the Palmaret Road or the Italian Bridge every day.

Table 3.3.3 Number of Traffic through Ambouli River (morning peak 1 hour)

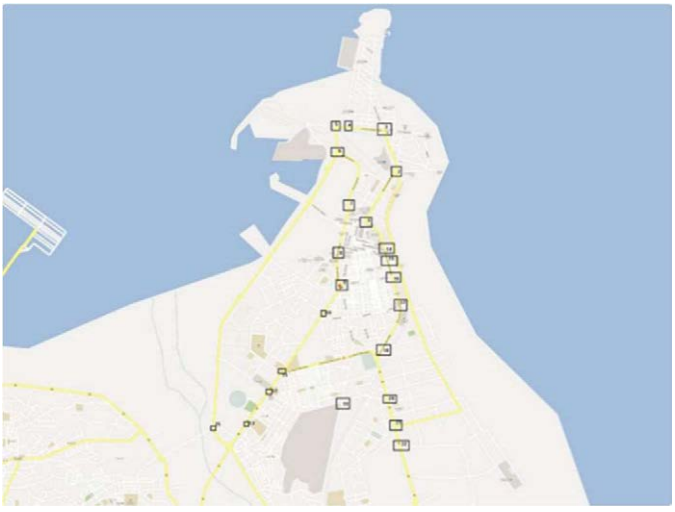
		Bajaj	Taxi	Minibus	Midibus	Total
Palmeraie Road	To City Center	0	169	93	157	419
	To Suberb	2	102	157	100	361
	Subtotal	2	271	250	257	780
Italy Bridge	To City Center	1	111	50	149	311
	To Suberb	2	79	143	112	336
	Subtotal	3	190	193	261	647
Total	To City Center	1	280	143	306	730
	To Suberb	4	181	300	212	697
	Subtotal	5	461	443	518	1,427

Table 3.3.4 Number of Traffic through Ambouli River (morning peak 1 hour)

		Bajaj	Taxi	Minibus	Midibus	Total
Palmeraie Road	To City Center	0	338	1,116	4,710	6,164
	To Suberb	8	102	942	1,500	2,552
	Subtotal	8	440	2,058	6,210	8,716
Italy Bridge	To City Center	8	222	600	4,470	5,300
	To Suberb	8	79	858	1,680	2,625
	Subtotal	16	301	1,458	6,150	7,925
Total	To City Center	8	560	1,716	9,180	11,464
	To Suberb	16	181	1,800	3,180	5,177
	Subtotal	24	741	3,516	12,360	16,641

(4) Traffic Lights

In August 2012, wireless solar traffic lights were installed at 25 locations of the city by a Chinese company, Zhong Jing Electric Engineering Co., Ltd. Since the signal timing is fixed and not optimized for peak hours, police officers control the traffic during the peak hours instead of the traffic lights to avoid congestion. With the increase of the traffic volume, it is becoming difficult to facilitate traffic using the existing traffic lights, and it is desirable to replace the lights with more advanced ones, which can change the timing with the change of the traffic. In addition, the existing traffic lights use solar-power batteries, and it is reported that some of the lights do not function at night as their run out of power.



Source: Zhong Jing Electric Engineering Co., Ltd. HP

Figure 3.3.9 Traffic Lights Installed in Djibouti City

3.3.3 Present Status of the Logistics Sector (Status of movement of goods, logistics business, etc.)

The volume of truck traffic on National Road Route 1, the main route for transporting goods between Ethiopia and Djibouti, is increasing every year, indicating the significance of logistics between the two countries (See Figure 3.3.9).

At present, Ethiopia uses the Port of Djibouti to import or export almost all goods. In July 2018, however, the leaders of the governments of Ethiopia and Eritrea signed an agreement to normalize the two countries' relations, and as the result, Ethiopia is expected to use the ports of Eritrea, for mainly freights to or from the northern part, which is geographically closer. Therefore, Djibouti needs to take necessary measures to ensure its competitiveness over Eritrea.

Source: ADR

Figure 3.3.10 Changes in the Truck Traffic Volume on the National Road Route 1

3.3.4 Aid of Other Donors

Table 3.3.2 shows donors engaged in the urban development and transport sectors in the Republic of Djibouti. In general, China is engaged in large-scale infrastructure developments related to strengthening logistics functions (ports, railways, free trade zones, etc.); and the World Bank is engaged in activities related to enhancement of livelihood and government capabilities, such as the strengthening of governance, poverty reduction, and public transport. Meanwhile, Japan's support is mainly concentrated in three areas: strengthening socioeconomic infrastructure, strengthening maritime security capacity, and improving basic education (see Table 3.3.3). At TICAD-V held in Yokohama in June 2013, five priority areas including the Djibouti Corridor were indicated, and it was stated that developments that promote integration such as infrastructural development, industrial development, social development, etc. in the concerned region would be supported. Then, in 2016, "The Data Collection Survey for Djibouti Corridor" was carried out to analyze the socioeconomic situation, infrastructure development, customs, immigration control, and international relationships in the region to grasp development issues and potentials (our company was in charge of this task). Furthermore, the "Country Assistance Policy for the Republic of Djibouti" formulated in September 2019 supports the development of industrial infrastructure and the improvement of the living environment of citizens, with a major goal of "Supporting sustainable socioeconomic development that contributes to regional stability", and three medium goals of "Strengthening the socioeconomic infrastructure that contributes to sustainable economic growth," "Development of human resources needed to support economic growth," and "Supporting efforts to stabilize the region."

Table 3.3.5 Donor Trends in Urban Development and Transport Sector in Djibouti

Donor	Project Name (abbreviation)	Project Phase	Outline
World Bank	Djibouti Urban Mobility Improvement Survey	Completed in May 2020	After investigating the actual conditions of public transportation in the City of Djibouti, a policy note which summarizes action plans for short and medium and long term was proposed.
Saudi Fund for Development	National Road Route 1 renovation project	Tender preparation	Two-lane asphalt pavement renovation project in 60km west of Djibouti's second city, Dikil.
China	Flower park maintenance	Under construction	A green park of about 70,000m^2 (7ha) is being constructed on the right bank of the Ambouli River (National Road Route 1 Italy Bridge to Palmeraie Road).
	Djibouti International Free Trade Zone (FTZ)	Test open	Total area 48km^2 (planned) is the largest in Africa. The completion is aimed at in 2028. 2.4km^2 was opened as a trial in July 2018.
	Djibouti-Addis Ababa Railway	In service	A railway route with a total length of 753km that connects Djibouti and Addis Ababa. Full-scale commercial operation started in 2018, but unstable operation due to insufficient power supply is considered to be a problem.
	Doraleh Port (New Port) Project	In service	It is located in the Balbala district in the City of Djibouti and is a multipurpose port with container terminals, oil terminals, etc. Chinese companies are involved in the development and operation of the railway, and can directly enter the above-mentioned Djibouti- Addis Ababa Railway from the port.
Others (Arab Fund for Economic and Social Development, etc.)	Development of the Damerjog Industrial Park	Under construction	Development of an industrial complex consisting of LNG terminals and piers, electric power bases, multi-purpose ports, shipyards, livestock terminals, and the Djibouti- Addis Ababa Railway route in the southeastern part of the City of Djibouti and the Damerjog district, about 1km ahead of the Somali border.

Table 3.3.6 Recent Grant Aid Projects to Djibouti

Project Name	Field	G/A, E/N Month/ Year
The Project for the Construction of Primary and Secondary School in Nassib in Balbala Quarter.	Education	Nov. / 2020
The Project for the Reinforcement of Maritime Transport Capacity at the Gulf of Tadjourah.	Transportation	Sep. / 2019
The Project for lmprovement of Road Management Equipment.	Transportation	May. / 2016
The Project for the Improvement of TV Programs of Radiodiffusion Television of Djibouti	Information and Communication Technology	Mar. / 2015
The Project for the Construction of Patrol Vessels for Enhancing the Ability to Secure Maritime Safety and Security.	Governance	Apr. / 2014
The Project for Improvement of Fire Fighting and Rescue Equipment of Djibouti City	Governance	Apr. / 2013
The Project for Provision of Waste Management Equipmen	Environmental Management	Dec. / 2012
The Project for Rural Water Supply in Southern Djibouti	Water resources and disaster prevention	May. / 2011
Elementary and secondary teacher training school construction project	Education	Feb. / 2010
The Project for Introduction of Clean Energy by Solar Electricity Generation System	Resources and Energy	Dec. / 2009
The Project for the Improvement of TV Programs of Radiodiffusion Television of Djibouti	Information and Communication Technology	May. / 2009
Basic Education Enhancement Program	Education	Aug. / 2003
Djibouti City Urban Water Supply Plan (Phase 2)	Water resources and disaster prevention	Aug. / 2002

Source：JICA

Chapter 4 Flood Risk Analysis in the Target Areas

4.1 Risks due to Flooding in Ambouli River

In March 2021, the risk of flooding in Djibouti City was assessed by AFD (French Development Agency) and the results were summarized in a report titled “Diagnostic et Recommandations pour une gestion intégrée du risque inondation sur l’agglomération de Djibouti (AFD, Sepia, 2021)”, or "Diagnosis and Recommendations for Integrated Flood Risk Management in Djibouti” (hereafter referred to as "AFD Report").

4.1.1 Probable Flood Inundation Areas

In the AFD report, Section 2.1.4, "Flooding due to overflowing of the Ambouli River", analyzed the flooding for different return periods. The results of the analysis including the relationship among the return period, the probable discharge, and the estimated inundation volume are shown below.

Table 4.1.1 Probable Discharge and Estimated Inundation Volume of Ambouli River (BCEOM)

Return Period (1/year)	Probable Discharge (m3/s)	Estimated Inundation Volume (Mm3)
2	430	3.9
5	870	7.1
10	1,160	9.1
20	1,440	11.1
30	1,600	12.2
50	1,800	13.6
100	**2.080**	**15.5**
1000	**2,970**	**21.9**

Source: Technical Assistance Study for the Establishment of an Analysis and Monitoring System for Risks Associated with Natural Disasters (Flood and Seismic) (2013)

The project titled “Plateforme pour d'Analyse Intégrée du Risques” (PAIR) or “Comprehensive Approach for Risk Assessment in Djibouti” (ARAD), conducted flood analysis for different return periods of discharges. In the flood risk assessment, floods with return periods of 100-year and 1,000-year were simulated (see the Figure below). In the case of 100-year return period, probable inundation areas are the downstream areas of the right bank embankment along National Road Route 1 (RN1).

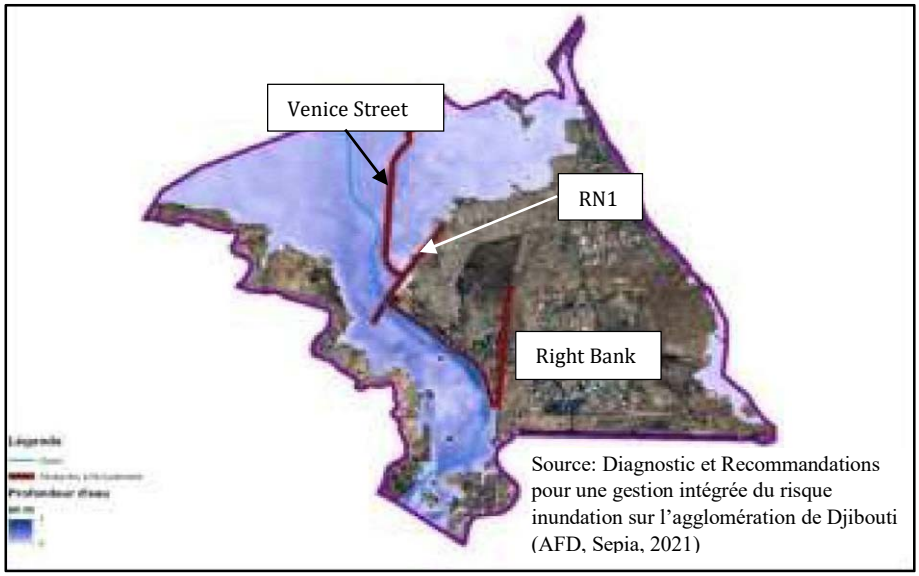


Figure 4.1.1 Probable Inundation Areas by Ambouli River Flooding
(100-year Return Period, 2080 m^3/sec)

In addition, in the case of the 1,000-year return period flood shown below, the probable flooding areas extend further to the northeast of Djibouti City and to the east of National Road Route 1 (RN1) in the right bank of the Ambouli River.

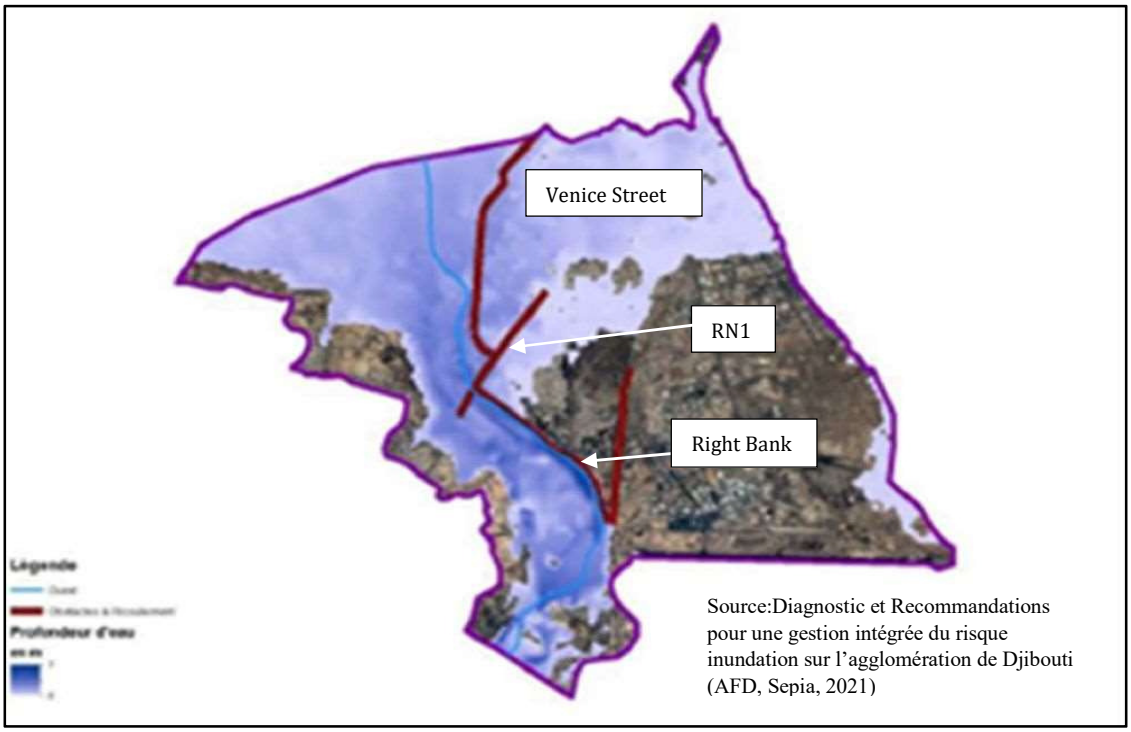


Figure 4.1.2 Probable Inundation Areas by Ambouli River Flooding
(1,000-year Return Period, 2,970 m^3/sec)

4.1.2 Identifying the Flood Risks of the Ambouli River

The major flood control facilities in the Ambouli River are the right bank embankment of the section near Djibouti City (2008), which was constructed after the 2004 flood, and the Ambouli Friendship Dam, which was completed in 2019 in Langobale in Ambouli River . The following issues related with these facilities from the perspective of flood control risk were identified based on the interviews with the Ministry of Agriculture by the Survey Team.

(1) Flood Control Plan for the Entire Ambouli River Basin is not Formulated

According to an interview with the Ministry of Agriculture, a flood control plan for the entire Ambouli River basin (600 km^2) has not been formulated. The discharges for the flood control measures by storage are calculated based on the past floods, but official design discharges do not exist. There is a lack of rainfall data in the basin, and no discharge observation is conducted in the Ambouli River. A consistent flood control master plan, from hydrological (rainfall) analysis to river hydraulic (water levels and discharges) analysis to flood control management also has not been formulated.

(2) Operational Rules for Flood and Irrigation Purposes are not yet Established for Ambouli Friendship Dam.

The Ambouli Friendship Dam was constructed for both flood control and irrigation water supply purposes at a location 35km upstream of Djibouti City. During the November 2019 flood, the peak flow of the Ambouli River was significantly reduced by the dam, which stored 10 million m^3 against a capacity of 14 million m^3, according to the UNDP report. The Ministry of Agriculture informed the Survey Team that the operation rules for the Ambouli Friendship Dam are yet to be decided.

The AFD report makes the following comments:

- The area of the dam, which accounts for about 45% of the total catchment area, has a flood control effect in downstream areas, but naturally has no effect on floods in the tributaries.

- When a major flood is expected, it is necessary to secure enough capacity by releasing water from the dam. However, the release of water for this purpose may cause damage downstream, and in such cases, appropriate reservoir operation such as stopping an operation for the release of storage water, and warning to downstream sections during the release of water are necessary.
- On the other hand, lowering the dam water for flood mitigation is expected not to be easy when the need of the water storage for irrigation purpose is considered. Therefore, the stakeholders concerned should closely coordinate on operation of the reservoir to meet the two purposes of the dam (irrigation and flood control), anticipating a situation like the one mentioned above.

The above points indicate the need to establish operation rules for the Ambouli Friendship Dam as soon as possible.

(3) Lack of Maintenance Measures for the Right Bank Embankment of the Ambouli River

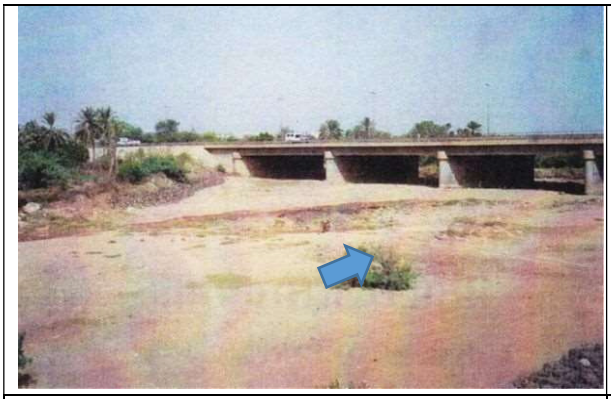
The right bank embankment of the Ambouli River is assessed to be inundated by the 100-year return period flood according to the results of the 2013 study. However, it is currently not well maintained, and if overflowed, the entire western and northern areas located of Djibouti City could be at a higher risk.

The effectiveness of embankment construction has been proven by simulations if it is properly managed. However, in the current situation, maintenance and river management are poor, and the foundation of the embankment is at a risk of being scoured and washed away. It is necessary to strengthen the maintenance and management of the embankments and river channels.

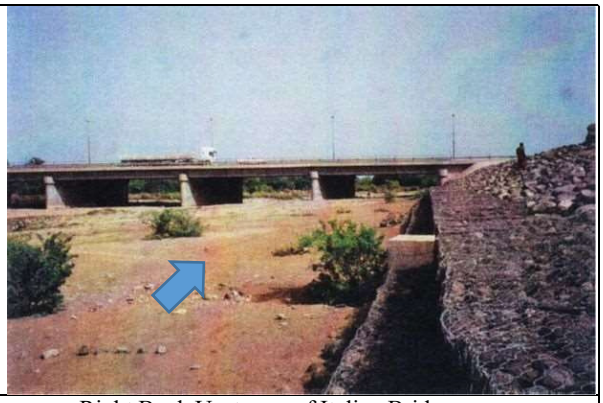
4.2 Channel Conditions and Changes in the Ambouli River

4.2.1 River Channel Conditions after Completion of the Rehabilitation Project

The following are the photos of the river after the rehabilitation project titled “Flood Emergency Rehabilitation Project” (FERP) was completed.



Left Bank Upstream of Italian Bridge



Right Bank Upstream of Italian Bridge

Source: Éléments d'un programme de maintenance et de consolidation pour garantir la pérennité à moven et à long terme de la protection contre les inondations de la Ville de Djibouti (2009.7)

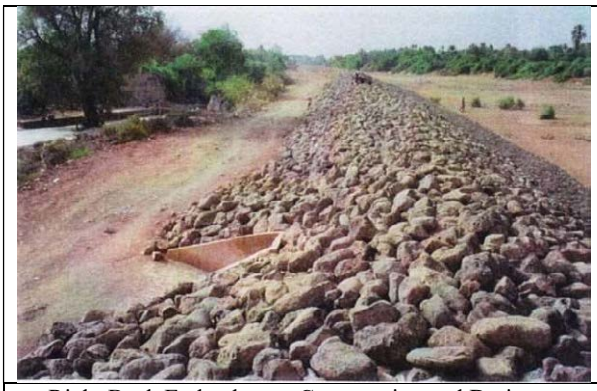
Figure 4.2.1 Photographs of the Ambouli River after Project (2009, No.1/3)

Right bank Upstream of Italian Bridge

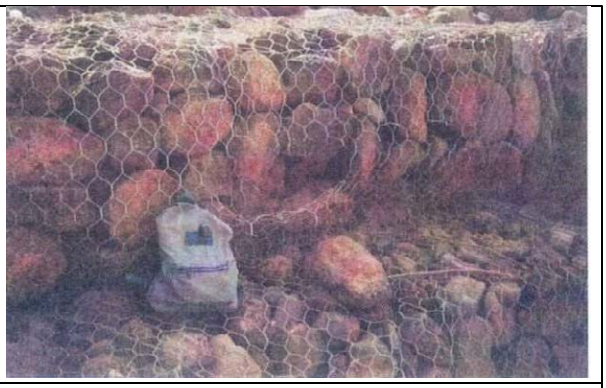
Left Bank Upstream of Italian Bridge

Source: Éléments d'un programme de maintenance et de consolidation pour garantir la pérennité à moven et à long terme de la protection contre les inondations de la Ville de Djibouti (2009.7)

Figure 4.2.2 Photographs of the Ambouli River after Project (2009, No.2/3)



Right Bank Embankment Construction and Drainage Channel for Inland Water



Foundation Work (Gabion Work)

Source: Éléments d'un programme de maintenance et de consolidation pour garantir la pérennité à moven et à long terme de la protection contre les inondations de la Ville de Djibouti (2009.7)

Figure 4.2.3 Photographs of the Ambouli River after Project (2009, No.3/3)

Although no other flood control measures other than the above World Bank works have been implemented on the Ambouli River, no floods overflowing the right bank of the Ambouli River have occurred since the works.

4.2.2 Changes in the River Channel after the Completion of the Rehabilitation Project

The changes in the Ambouli River after the rehabilitation were organized using Google Earth. The section upstream of the Italian Bridge and the section upstream of the riverbed road were selected for this purpose. The Figures below show the changes in the river channel for the period between March 2008 and March 2020.

Figure 4.2.4 Comparison of the Conditions after the Ambouli River Improvement in 2008 and the current one in 2020 (Upstream Section of Italian Bridge)

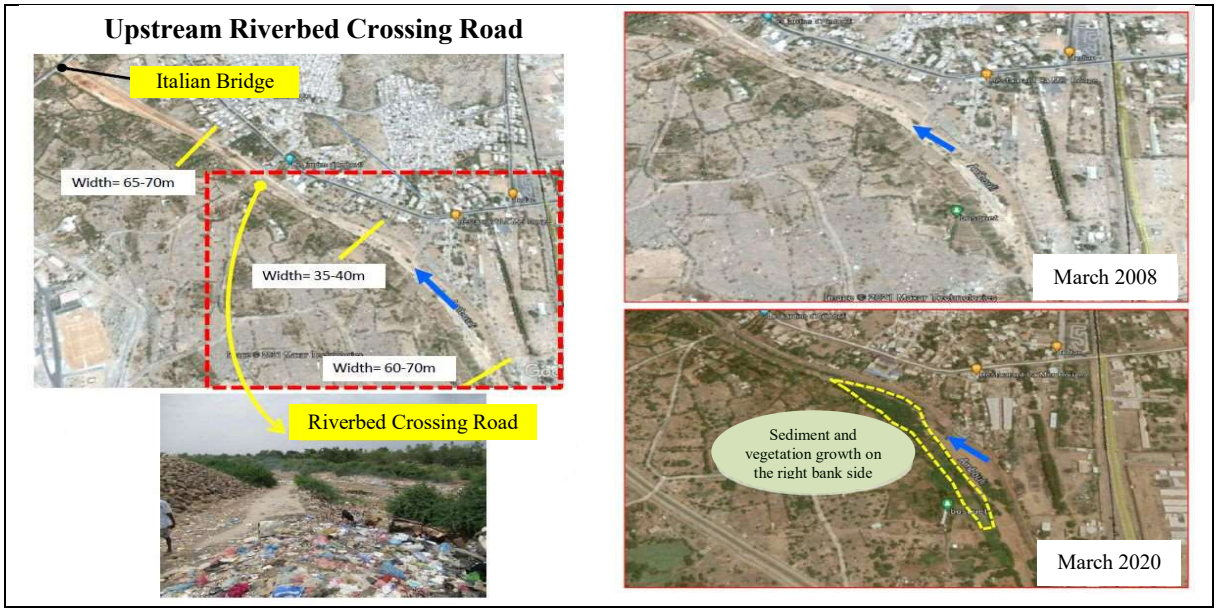


Figure 4.2.5 Comparison of the Conditions after the Ambouli River Improvement in 2008 and the Current one in 2020 (Upstream Section of Riverbed Crossing Road)

As can be seen from the above photos, the vegetation on the right bank of the upstream section of the Italian Bridge and the upstream section of the riverbed crossing road has become very thick, and sedimentation into the river channel is increasing.

4.2.3 Evaluation of the Discharge Capacity of the Existing River

Based on the results of the river topographic survey, the discharge capacity of the current river channel was calculated. The calculated section was from the survey starting point to about 4km upstream.

The discharge capacity was evaluated separately for the right bank "height" and the left bank "height". The discharge capacity of the right bank is approximately 500 - 1,000 m^3/sec, while that of the left bank is 100-300m^3/sec. At the time of the right bank embankment construction in 2008, the discharge capacity was to be 1,200 m3/sec, and the current discharge capacity has decreased significantly. Although the decrease in discharge capacity is a cause of flooding, no overflow of water has been recorded for these sections since the embankment was constructed in 2008.

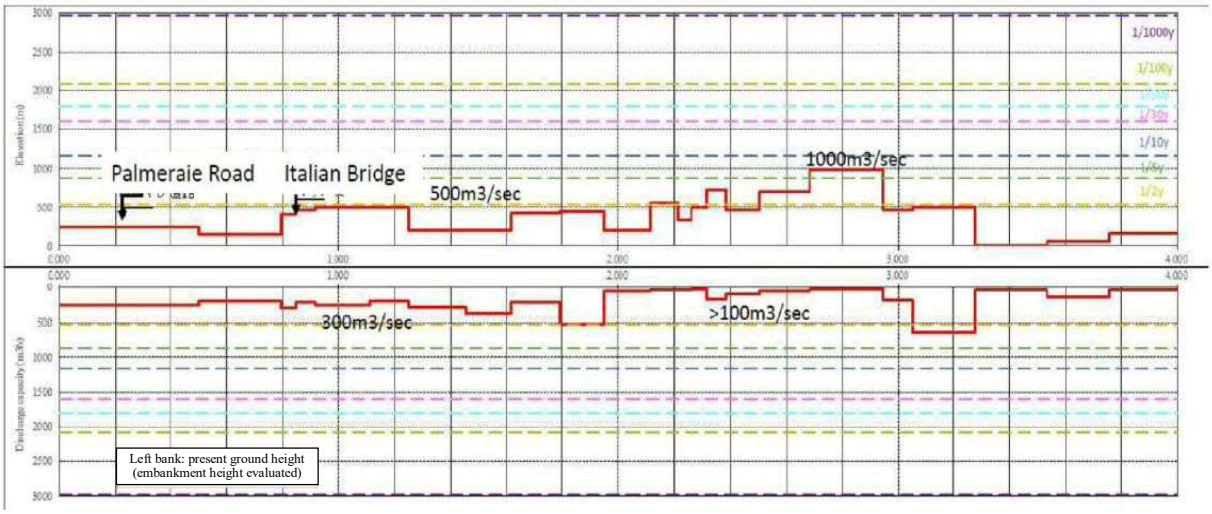


Figure 4.2.6 Current River Discharge Capacity of the Ambouli River

4.2.4 Land Use of the Floodplain in the Ambouli River

The land use of the floodplain of the Ambouli River was compared using Google Earth from 2008 and 2020, and the comparison results are shown below. The main difference in land use is the construction of the Ethiopian railroad on the left bank, and a slight increase in the number of houses. In general, the floodplain is mainly used for agricultural land.

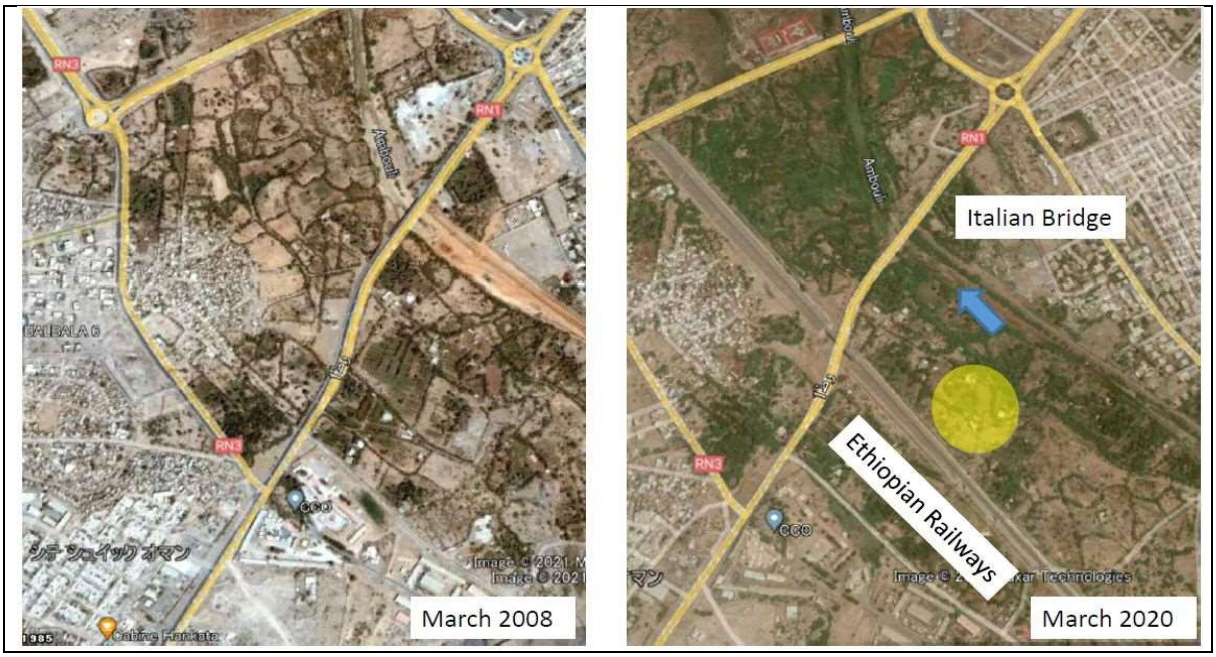
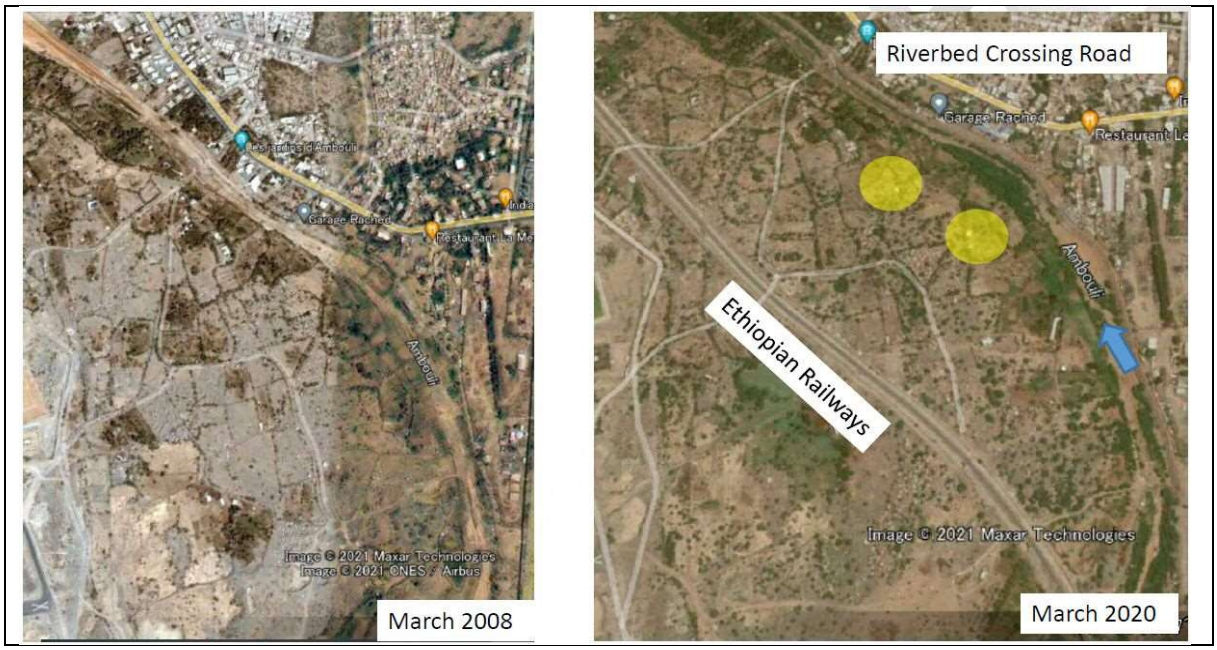


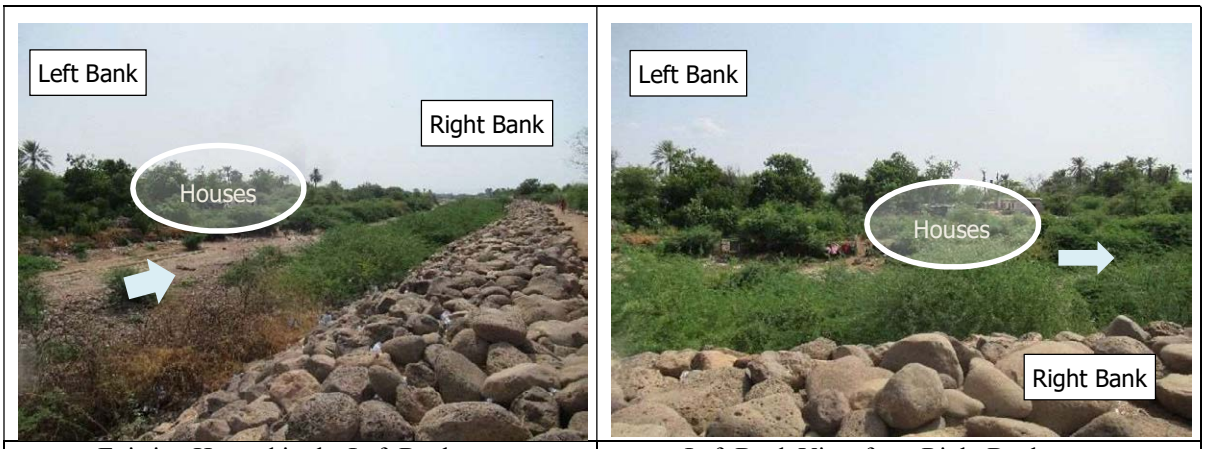
Figure 4.2.7 Comparison of Land Use in the Upstream Section of the Italian Bridge of the Ambouli River



Note: Prepared by JICA Survey Team based on Google Earth

Figure 4.2.8 Comparison of Land Use in the Upstream Section of Riverbed Crossing Road of the Ambouli River

In the upstream section of the Italian bridge where the field survey was conducted by JICA, the right bank consists of only roads and river slopes, so there are no houses or agricultural land as shown below. Since the flood plain in the left bank has flat terrains, there are houses in the area near the river channel. The land on the left bank side is mainly agricultural land.



Existing Housed in the Left Bank	Left Bank View from Right Bank

Figure 4.2.9 Current Conditions from Riverbed Crossing Road to Italian Bridge

According to an interview with the Ministry of Budget, Lands and Land Property Legislator, the land use conditions in the river areas (Italian Bridge-Palmeraie Road) in the lower sections from the Ambouli River is as follows.

- The flower park development project funded by the Saudi Arabian Government in the right bank in the Ambouli River is currently under construction by the Chinese Company, the river works is scheduled to be completed with embankment works, and there are no further expansion works.
- The left bank area of the Ambouli River was rented to the local residents as agricultural land in the past, but there is currently no development plans in the left bank area.

· A new urban development project by the Chinese Company (Touch Road) was signed with the Prime Minister of Djibouti in 2014. There is no business progress for development since then. Therefore, to date, the land title of the development area has not been transferred to the company.

	
Left Bank of Downstream Section from Italian Bridge	Right Bank of Downstream Section from Italian Bridge

Figure 4.2.10 Current Conditions of Downstream Section from the Italian Bridge

4.3 River Improvement Plan in Ambouli River

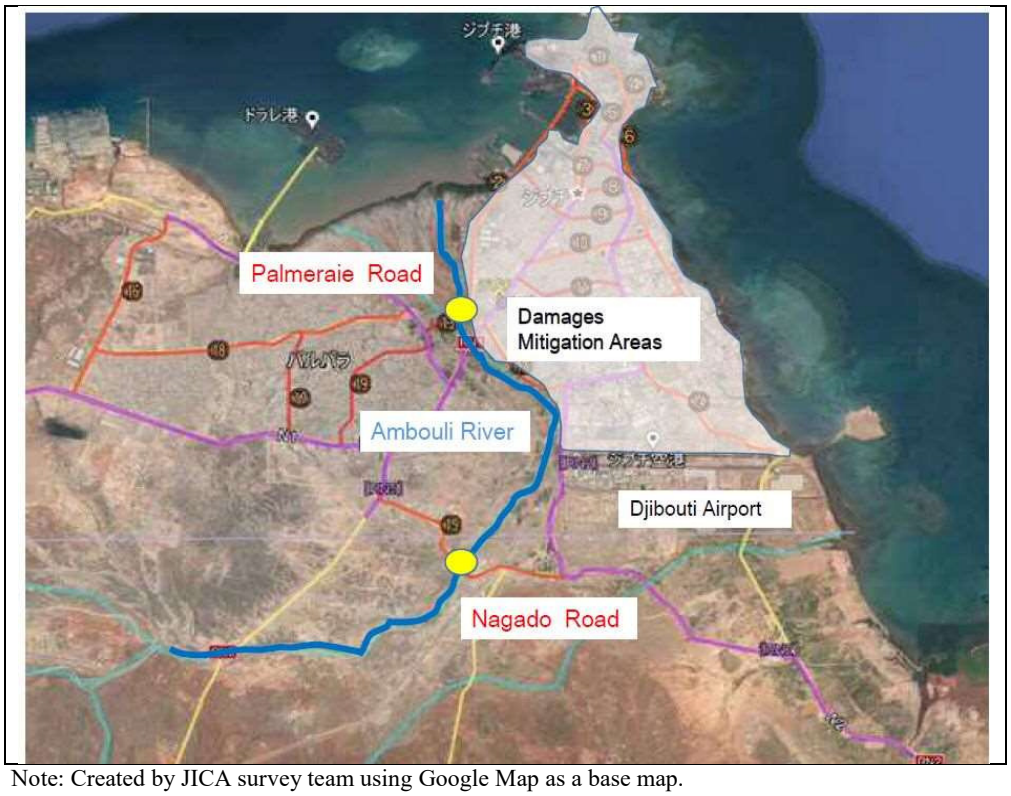
4.3.1 Current Condition of Ambouli River and Policy for River Improvement

Although there has been no overflow of the Ambouli River into the Djibouti City area since the completion of the right bank embankment work in 2008, there have been problems such as disruption of road traffic due to prolonged rainfall, prolonged stagnant water due to poor drainage in Djibouti City, and outbreaks of water-related diseases caused by the stagnant water, as seen during the 2019 flood.

The importance of maintenance and management of the Ambouli River after completion of the embankment has been also recognized, its maintenance and management has been limited by lack of budget and personnel. In addition, there is a riverbed crossing road 900m upstream of the Italian Bridge, and the dumping of garbage, construction wastes, and waste soils in the area around this road is remarkable, causing the riverbed to rise.

The discharge capacity of the river channel at the time of completion of the embankment in 2008 is not known, but based on previous reports, it is estimated to be around 1,200 m^3/sec. On page 18 of the "Éléments d'un programme de maintenance et de consolidation pour garantir la pérennité à moven et à long terme de la protection contre les inondations de la Ville de Djibouti (2009.7)", the discharge capacity that can be safely discharged is assumed to be between 1,000m^3/sec and 1,200m^3/s. In contrast, as summarized in the previous section, the current flow capacity of the Ambouli River is at most 500 m^3/sec, which is significantly lower than the capacity when completed.

Based on the current conditions described above, a river improvement plan for the Ambouli River will be developed. The target area of the river improvement plan is assumed to be Djibouti City, which is located on the right bank of the Ambouli River. The particular target area for flood damage mitigation is the east area of the Ambouli River and the north area of the Djibouti Airport, which is approximately 20 km^2.



Note: Created by JICA survey team using Google Map as a base map.

Figure 4.3.1 Flood Protection Areas and Ambouli River

Regarding the Ambouli River, there is no hourly rainfall data available for the flood control plan, and only daily rainfall data is available. In addition, since no hydrograph has been obtained, it is not possible to calculate the runoff discharges corresponding to rainfall, i.e. the runoff coefficient.

During the 2019 flood event, many photos and videos were taken, and the flood peak level mark at the Italian Bridge in the Ambouli River was also observed. In this study, the peak discharge generated by the flood peak level mark is estimated for the Ambouli River by performing non-uniform flow calculations. On the other hand, daily rainfall has been monitored for a long period of time at Djibouti Airport near the Ambouli River, which makes it possible to calculate the probable rainfalls. Although some major floods in the past have lasted for two to three days, the duration of rainfall that dominates inundation (flooding) for Djibouti City and the Ambouli River is evaluated on a daily basis. Therefore, the probability of rainfall evaluation is made on a daily rainfall basis.

The Ambouli Friendship Dam, constructed and began operation in 2019, has a flood control function, but the rules for its reservoir operation have not been formulated, as noted earlier. A flood control plan is a plan to determine the magnitude of rainfall (probable rainfall), calculate the discharges based on the probable rainfall (design discharges), and distribute the design discharges to rivers, dams, regulating reservoirs (ponds) and other facilities. In the case of the Ambouli River, however, it is not possible to carry out these series of operations. In particular, since it is not possible to specify the design discharge for flood control at the Ambouli Friendship Dam, it is planned that a predetermined flood discharge will flow down only the river channel.

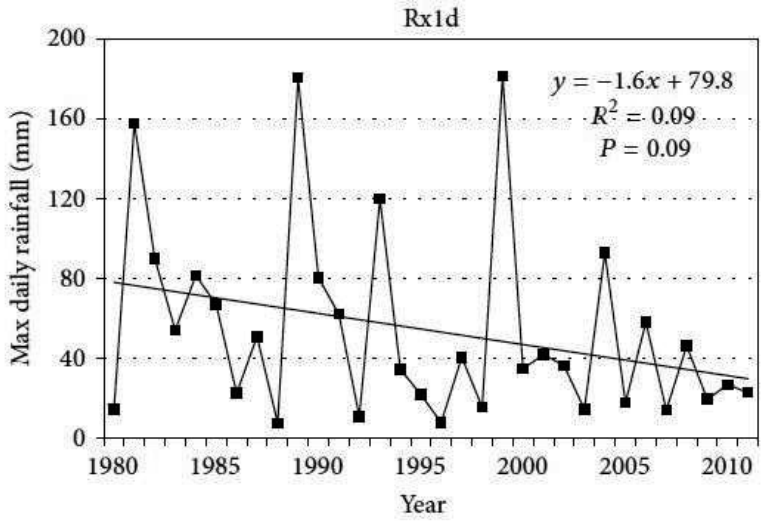
As for non-structural measures, land use regulations shall be implemented for areas with possible inundation areas to prevent human damage due to flooding in the upstream section of Italian Bridge.

4.3.2 Hydrological Data Arrangements for River Improvement Plan

(1) Probable Daily Rainfall Analysis at Djibouti Airport Station

The annual maximum rainfall was obtained from the Djibouti Airport Station under the National Meteorological Agency, but only for the five years starting from 2016. In addition, a document on a

climate obtained lists the maximum annual rainfall from 1981 to 2011, and the daily rainfall shown below was taken from this document. For the four years from 2012 to 2015, correlations between monthly rainfall and daily rainfall were determined based on the rainfall from 2016 to 2020, and calculations were made based on these correlations.



Source: "Recent Extreme Precipitation and Temperature Changes in Djibouti City (1966–2011)", Journal of Climatology, Volume 2013, Article ID 928501

Figure 4.3.2 Trend in Annual Maximum Rainfall (1980-2011)

Based on the above, the annual maximum daily rainfall arranged is shown below.

Table 4.3.1 Annual Maximum Daily Rainfall (1980-2020)

Maximum Daily Rainfall (mm) Occurrence year, maximum daily rainfall		Maximum Daily Rainfall (mm) Occurrence year, maximum daily rainfall	
Year	Max Rainfall (mm)	Year	Max Rainfall (mm)
1980	15.0	2001	40.0
1981	160.0	2002	39.0
1982	88.0	2003	20.0
1983	50.0	2004	90.0
1984	80.0	2005	25.0
1985	69.0	2006	50.0
1986	28.7	2007	24.0
1987	45.0	2008	44.0
1988	9.7	2009	25.0
1989	180.0	2010	30.0
1990	80.0	2011	27.0
1991	70.0	2012	46.7
1992	13.0	2013	33.3
1993	120.0	2014	14.0
1994	38.0	2015	57.4
1995	30.0	2016	306.0
1996	12.0	2017	162.0
1997	40.0	2018	110.7
1998	18.0	2019	170.0
1999	189.0	2020	80.0
2000	37.0		

Source: "Recent Extreme Precipitation and Temperature Changes in Djibouti City (1966–2011)", Journal of Climatology, Volume 2013, Article ID 928501

National Meteorological Agency (NMA) (2016-2020)

The results of the probability of the maximum daily rainfall for each year arranged are shown below. Eleven probability calculation methods were used, as described below. The reliability of the calculation methods is assessed based on the standard least squares value (i.e., method with SLSC ≤ 0.04). As a result, the "Iwai Method" is selected to be the most reliable method.

Table 4.3.2 Results of Probability Calculation of the Annual Maximum Daily Rainfall (1980-2020)

Correlation, return period		Exp	Gumbel	SqrtEt	Gev	LP3Rs	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM
X-COR(99%)		0.987	0.953	0.988	0.992	0.984	0.994	0.993	0.993	0.993	0.993	0.993
P-COR(99%)		0.994	0.973	0.995	0.997	0.992	0.997	0.997	0.998	0.997	0.997	0.997
SLSC(99%)		0.039	0.073	0.051	0.026	0.054	0.019	0.029	0.019	0.042	0.021	0.021
	Year	Exp	Gumbel	SqrtEt	Gev	LP3Rs	Iwai	IshiTaka	LN3Q	LN3PM	LN2LM	LN2PM
	2	46.9	56.0	48.0	45.9	47.9	45.6	47.4	44.5	47.2	46.4	46.4
	3	70.7	78.7	66.0	64.2	71.5	65.4	66.3	64.1	65.6	66.5	66.1
	5	100.8	104.1	88.6	89.0	101.1	92.6	91.7	91.9	90.5	93.8	92.6
	10	141.6	136.0	121.0	128.2	141.1	134.6	130.0	136.1	128.6	135.5	132.9
	20	182.4	166.5	156.0	176.7	180.6	183.7	173.6	189.1	172.5	183.7	179.1
Probability	30	206.2	184.1	177.9	210.5	203.4	216.1	202.0	224.6	201.2	215.1	209.2
	50	236.3	206.1	207.0	260.1	231.8	261.0	240.9	274.5	240.8	258.6	250.5
	80	264.0	226.2	235.4	313.9	257.3	306.8	280.0	326.0	280.9	302.5	292.3
	100	277.1	235.7	249.4	342.5	269.3	330.1	299.7	352.5	301.2	324.8	313.4
	150	301.0	253.0	275.7	400.6	290.7	375.2	337.6	404.0	340.3	367.7	354.0
	200	317.9	265.3	295.0	446.9	305.6	409.3	366.2	443.4	369.9	400.1	384.6
	400	358.7	294.7	344.1	579.2	340.7	499.8	441.0	548.8	447.8	485.5	465.0

The distributions (plotting positons) of daily rainfalls for each year and the regression equation for the above calculation results are shown below.

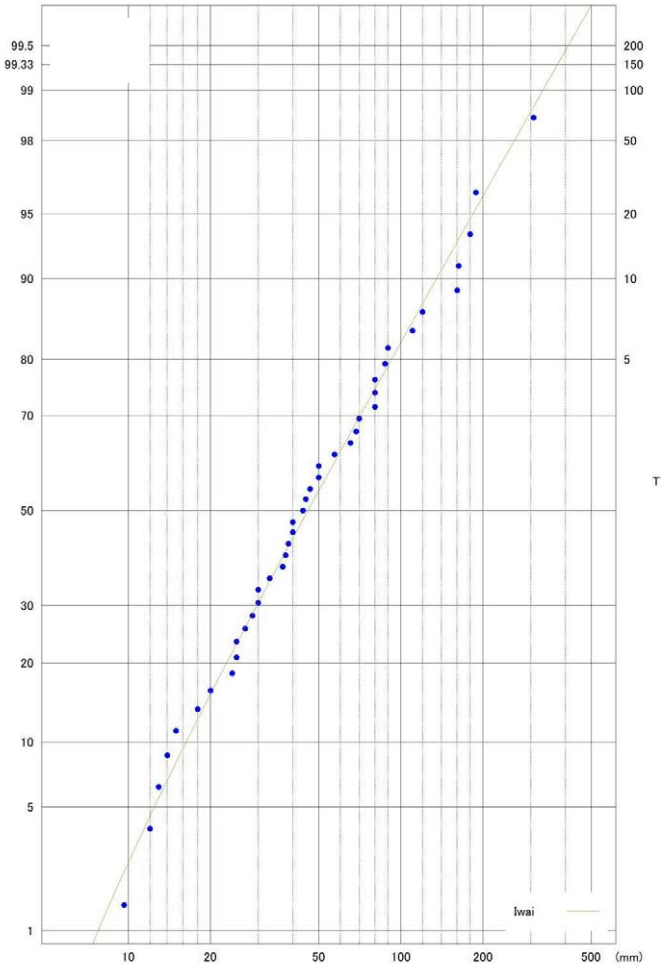


Figure 4.3.3 Distributions of Annual Maximum Rainfalls and Regression Curve

The probable rainfall can be summarized as follows.

Table 4.3.3 Return Period and Probable Daily Rainfall

Return period (1/year)	Probable daily rainfall (mm)
200	409.3
100	330.1
50	261.0
30	216.1
20	183.7
10	134.6
5	92.6
2	45.6

(2) Analysis of Tidal Level

The estuarine tidal level of the Ambouli River was arranged from the tidal level records collected from January 2016 to September 2018. Based on these tidal level records, the synodic monthly average tidal levels are calculated and shown below.

Table 4.3.4 Synodic Monthly Average Tidal Levels in the Flood Seasons

Year	Month	Date of New (Dark) Moon	Tidal Level (m)	Date of Full Moon	Tidal Level (m)	Average(m)	Year Average (m)
2016	1	10	2.79	24	2.63	2.71	
	2	8	2.91	23	2.65	2.78	
	3	9	2.99	23	2.68	2.84	
	4	7	3.05	22	2.71	2.88	
	5	7	3.05	22	2.72	2.89	
	11	29	2.63	14	2.96	2.80	
	12	29	2.66	14	2.96	2.81	2.81
2017	1	28	2.78	12	2.96	2.87	
	2	26	2.88	11	2.96	2.92	
	3	28	2.98	12	2.85	2.92	
	4	26	3.05	11	2.74	2.90	
	5	26	3.04	11	2.72	2.88	
	11	18	2.61	4	2.70	2.66	
	12	18	2.60	4	2.68	2.64	2.83
2018	1	17	2.63	2	2.95	2.79	
				31	2.86	2.86	
	2	16	2.76			2.76	
	3	17	2.86	2	2.86	2.86	
				31	2.85	2.85	
	4	16	2.94	30	2.81	2.88	
	5	15	2.99	29	2.71	2.85	2.84
Average			2.97		2.76		**2.83**

From the above Table, the synodic monthly average tidal level in the Ambouli River is set to 2.83m.

(3) Evaluating the Flood Occurrence Scale Based on the Daily Rainfall of Floods in the Past

Based on the results of the probable daily rainfall analysis, the return period of major floods is evaluated and shown as follows.

Table 4.3.5 Probability Evaluation for Major Floods and Rainfalls in Djibouti

SN	Period of Events	Total Amount of Rainfall (mm)	Daily Rainfall (mm)	Return Period (1/year)
1	1989.4.6-10	507	180	18
2	1994.11.22	360	38	3
3	2004.4.11-14	93	90	5
4	2013.3.25	-	33	2<
5	2018.5.19-21	181	111	7
6	2019.11.21-25	444	170	17
7	2020.4.20-21	80	80	4

Source: JICA Survey Team

From the above Table, the 1989 flood (180 mm) event is evaluated as the largest and is evaluated with a return period of 18 years, followed by the recent 2019 flood (170 mm with 17 years.

(4) Estimation of the Generated Peak Flow Rate During the 2019 Flood

The peak discharge observed in the November 2009 flood event was estimated based on the flood mark (estimated peak water level) during the flood. The peak water level is estimated at 4.7m (above sea level) based on the video recording and photograph records.

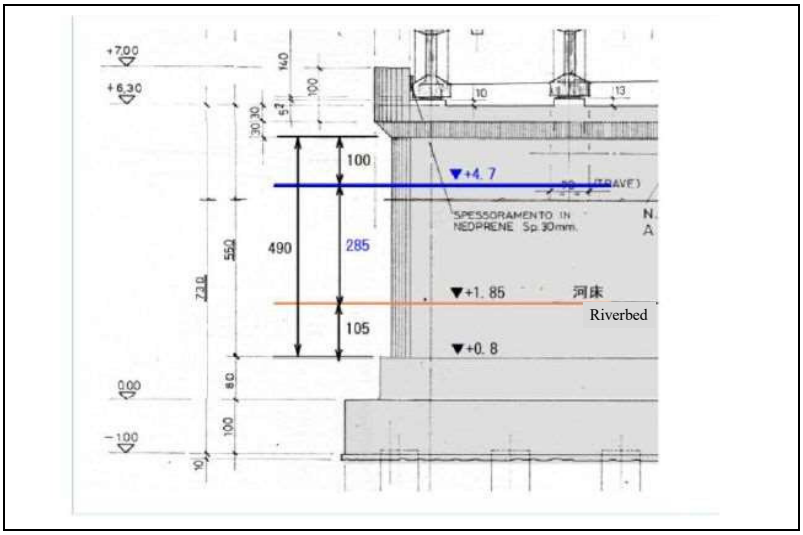


Figure 4.3.4 Peak Water Level for Flood Mark (4.7m) in 2019 Flood Event

For the above peak water level, a non-uniform flow calculation is performed and the elevation (H)-discharge (Q) curve is prepared. From the H-Q curve, the discharge corresponding to the water level mark (4.7m) was estimated to be about 500m^3/sec.

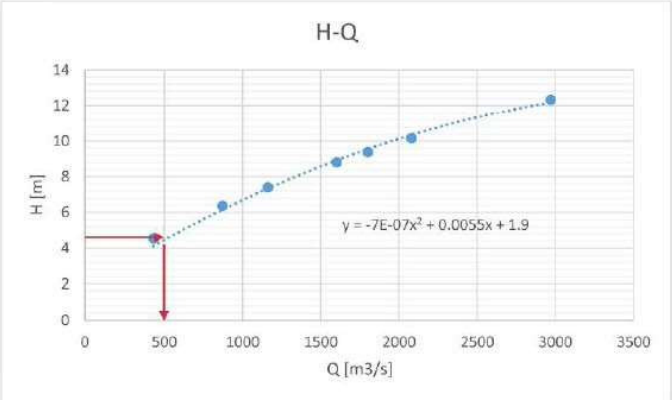


Figure 4.3.5 Elevation (H)-Discharge (Q) Curve and Estimated Peak Discharge based on Water Level

4.3.3 River Improvement Plan for Ambouli River

(1) Basic Specifications of the Improvement Plan

The basic policy of the Ambouli River improvement plan shall be as follows.

1) Design Scale and Design Discharge

The design discharge of the Ambouli River in the Palmaraie Road Plan is designated at 1,500 m^3/s, which is the same as the discharge capacity at the time of construction of the right bank done upstream of the Italian Bridge. However, the Study Team will also consider 1,800 m^3 s from the viewpoint making Djibouti resilient to future climate change and flood resilience as the capital Djibouti. The return periods of these planned discharges due to the basis of daily rainfall is about 25 years for the former and about 50 years for the latter (see Table 4.1.1).

2) Target Design Section

The target section designed for the river improvement plan is set from the Palmeraie Road to the vicinity (Djibouti Airport) designated as the flood mitigation Area (Figure 3.11). It is about 4km away from the Palmeraie Road, according to survey results.

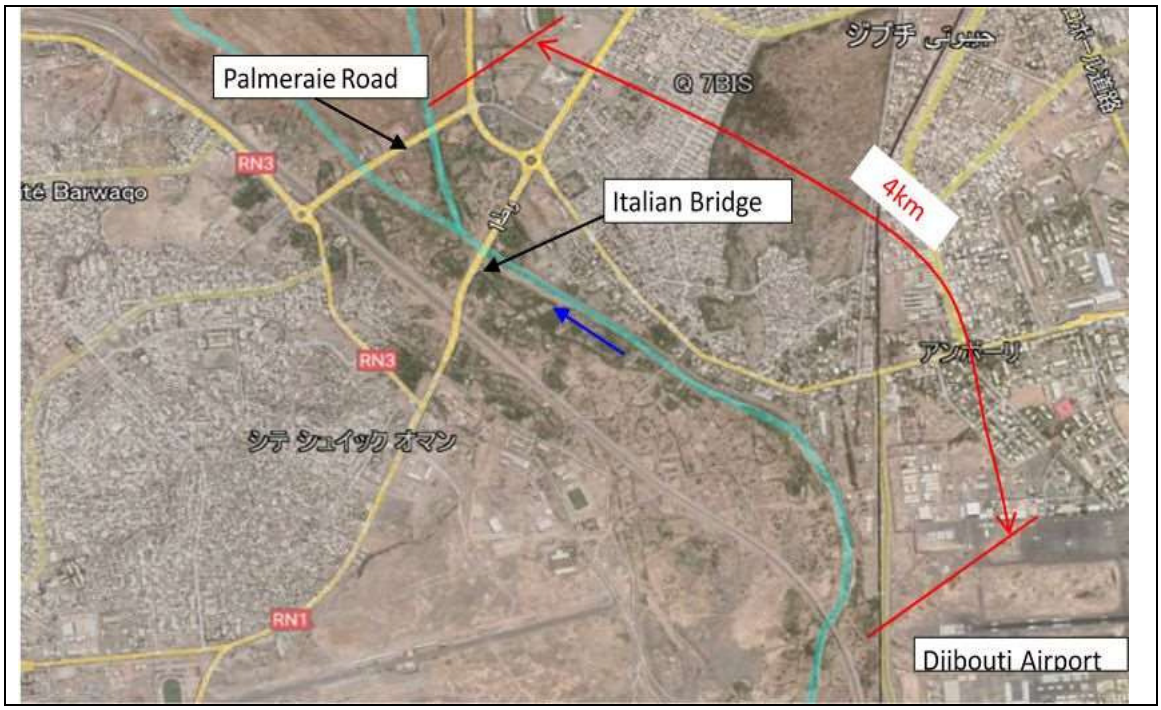


Figure 4.3.6 Target Section of River Improvement Plan (Section Length: 4km)

3) River Improvement Method and Design Cross Section

The river improvement method will be the same as that of the embankment with trapezoid cross section completed by the World Bank Project in 2008.

Regarding the longitudinal profiles, the design riverbed gradient is set as 1/700 based on the current riverbed gradient. Regarding the excavation of the riverbed, judging from the sedimentation conditions, an excavation depth of about 1m will be carried out up to the chainage of 0.3 km, but the upstream section will be gradually approached to the current riverbed height. Therefore, it is judged that the effect of saltwater intrusion due to river channel excavation is small. The design average high tidal level in the river improvement plan is set as 2.83m (Above Sea Level). The fluctuation of the low tide level varies from 0.90m to 1.90m.

(2) Consideration of Alternatives for the River Improvement Plan

Under the design policy, the following two (2) alternatives for the river improvement plan were considered based on the road plan explained in Chapter 6.

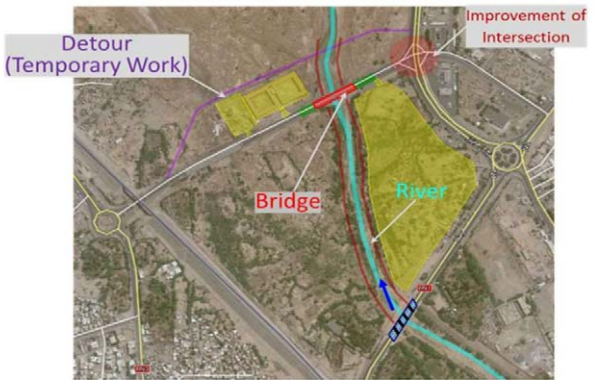
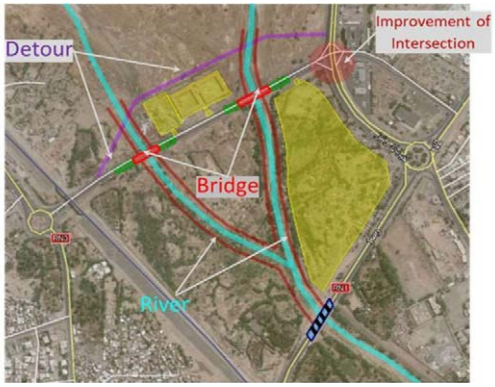
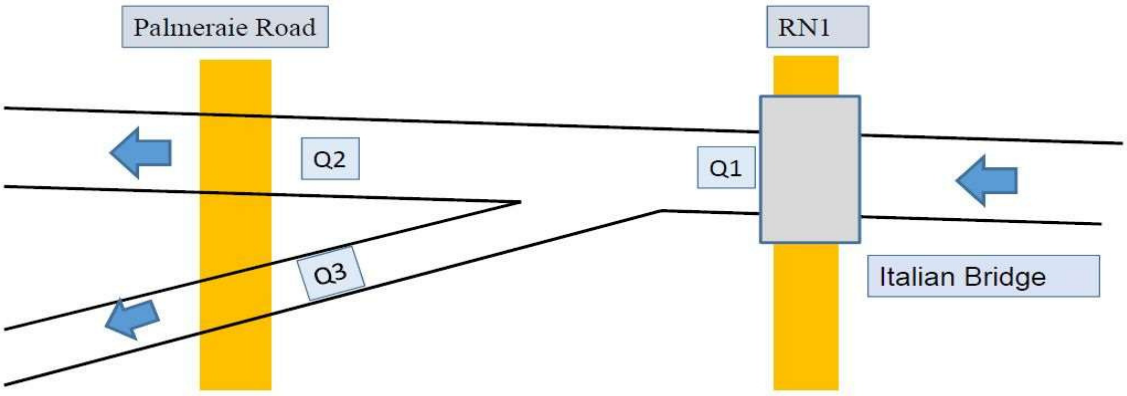
Alternative 1:Improvement Plan in Ambouli River	Alternative 2: Improvement Plan with Diversion of Ambouli River
	

Figure 4.3.7 Two (2) Alternatives Examined in River Improvement Plan



Design Discharges Distribution

Alternative	Probability (Year)	Design Discharge (Q1,m3/s)	Design Discharge (Q2,m3/s)	Design Discharge (Q3,m3/s)
Alternative 1A	1/25	1,500	1,500	
1B	1/50	1,800	1,800	
Alternative 2A	1/25	1,500	1,160	340
2B	1/50	1,800	1,160	640

Figure 4.3.8 Design Discharge Distribution Plan for Two (2) Alternatives

Based on the design discharges for alternatives, typical cross sections for alternative 1 and 2 are shown in Figures below.

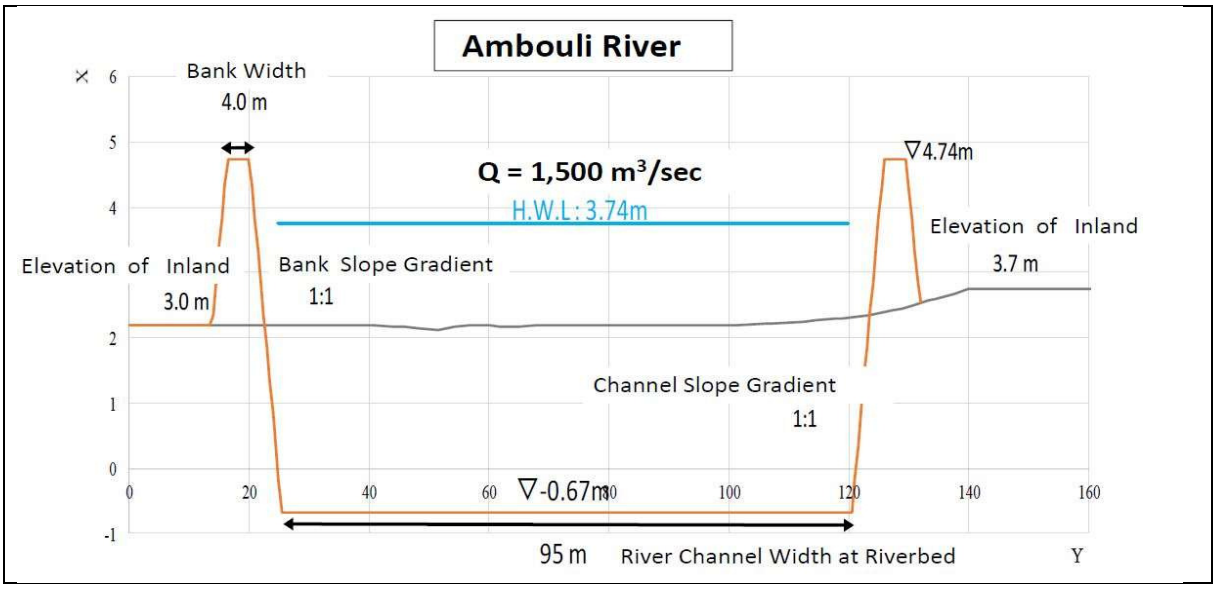


Figure 4.3.9 Typical Cross Section for Alternative 1 A (Q=1,500 m3/sec)

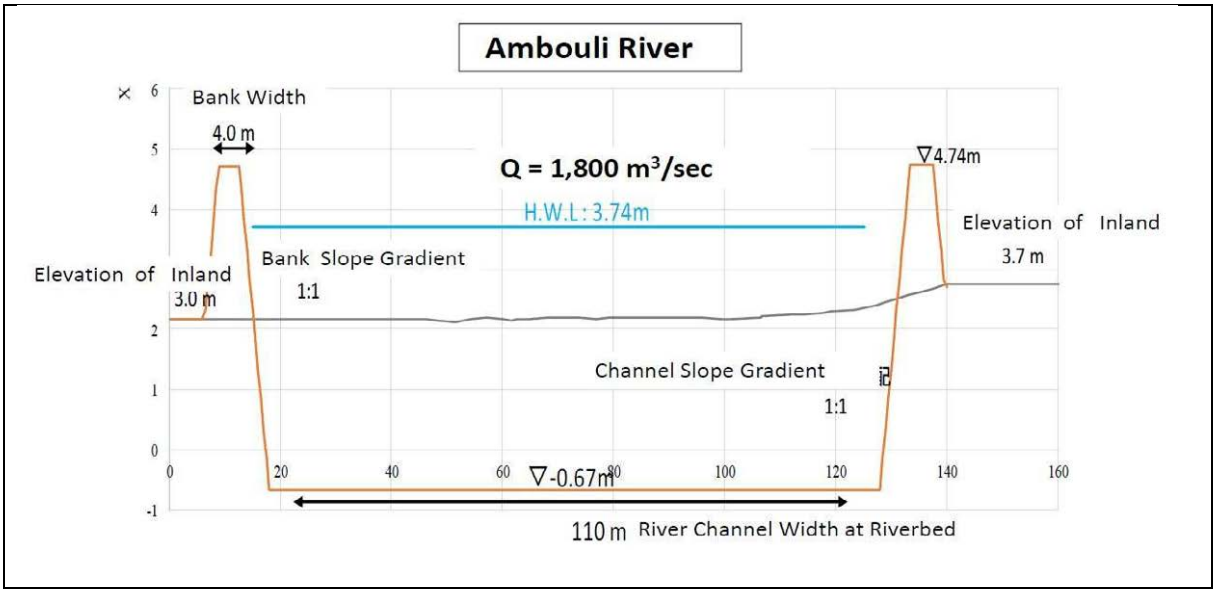
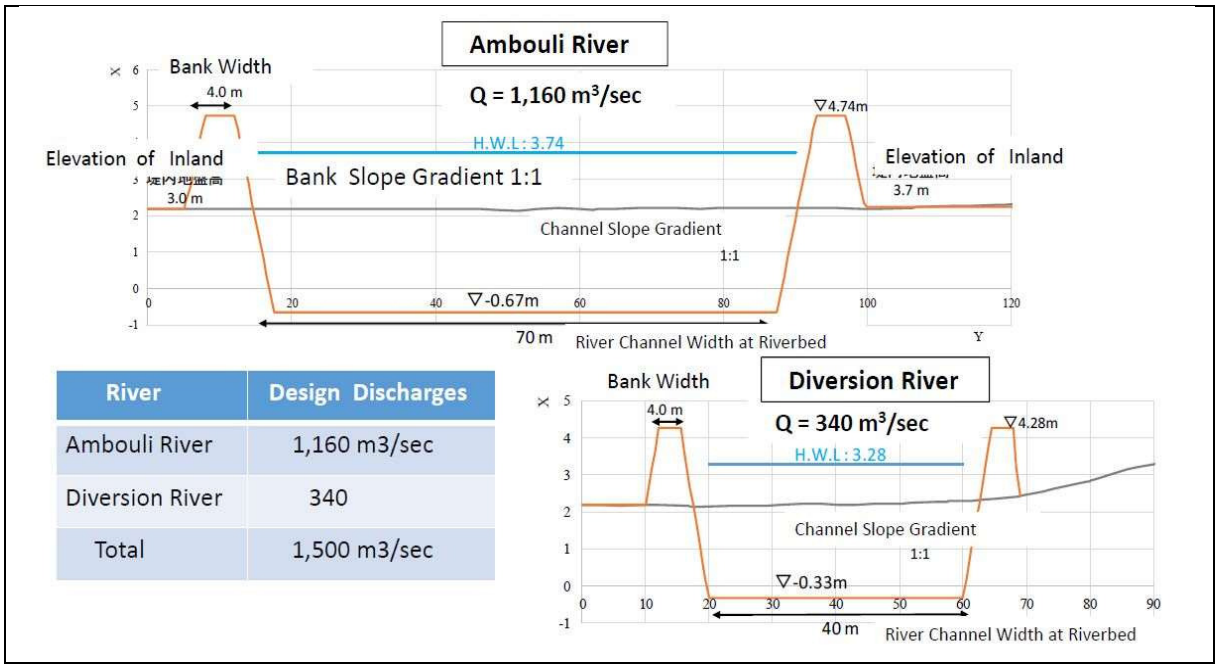
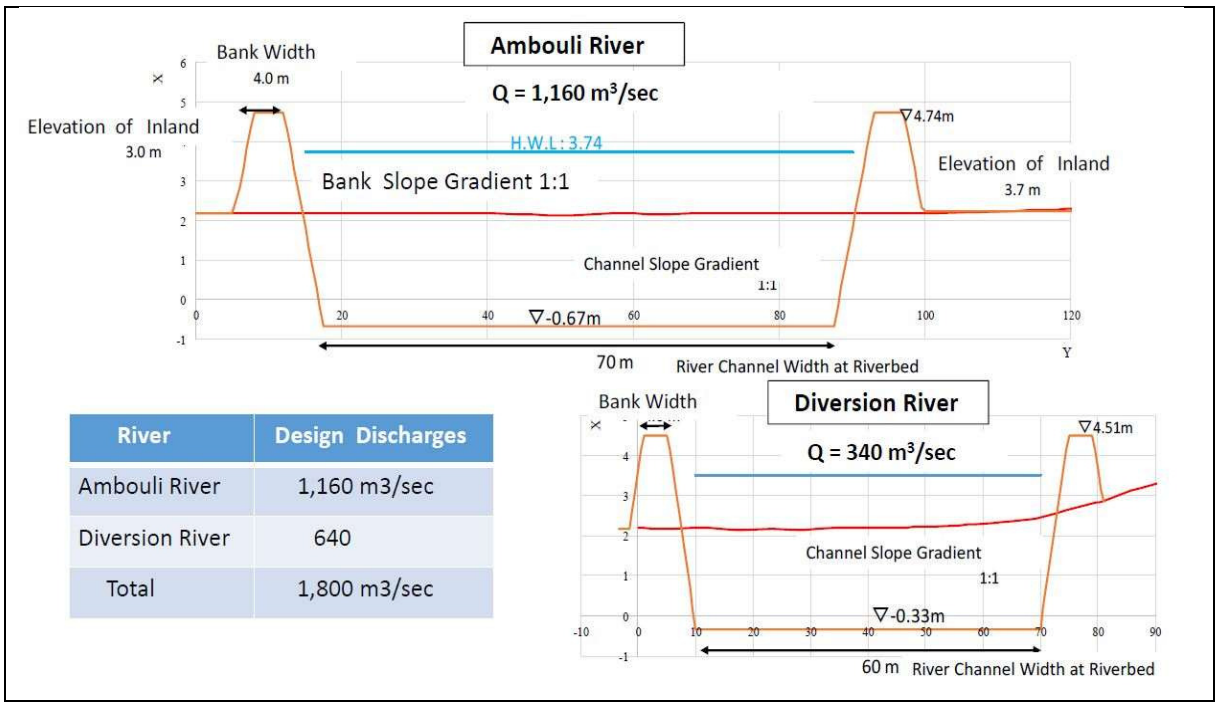


Figure 4.3.10 Typical Cross Section for Alternative 1B (Q=1,800 m3/sec)



River	Design Discharges
Ambouli River	1,160 m3/sec
Diversion River	340
Total	1,500 m3/sec

Figure 4.3.11 Typical Cross Section for Alternative 2 A (Q=1,160 + 360 m3/sec)



River	Design Discharges
Ambouli River	1,160 m3/sec
Diversion River	640
Total	1,800 m3/sec

Figure 4.3.12 Typical Cross Section for Alternative 2B (Q=1,160 + 640m3/sec)

The longitudinal water level profiles for the alternative plans based on the results of the hydraulic analysis using non-uniform flow analysis are shown as follows. The cross section that is critical (restricted) in the longitudinal section of the water level is located at the Italian Bridge, and the cross section was examined so that the water level at this bridge would be set at less than 5.3 m above sea level (with considering the freeboard). The Figures below show the longitudinal water level profiles based on the cross sections examined.

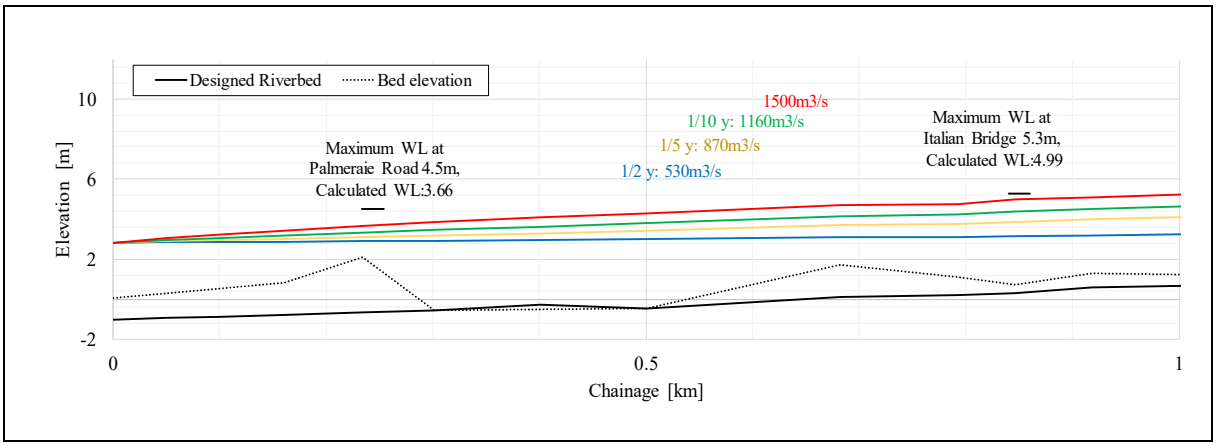


Figure 4.3.13 Longitudinal Water Level Profiles for Alternative 1A (Q=1,500m3/sec)

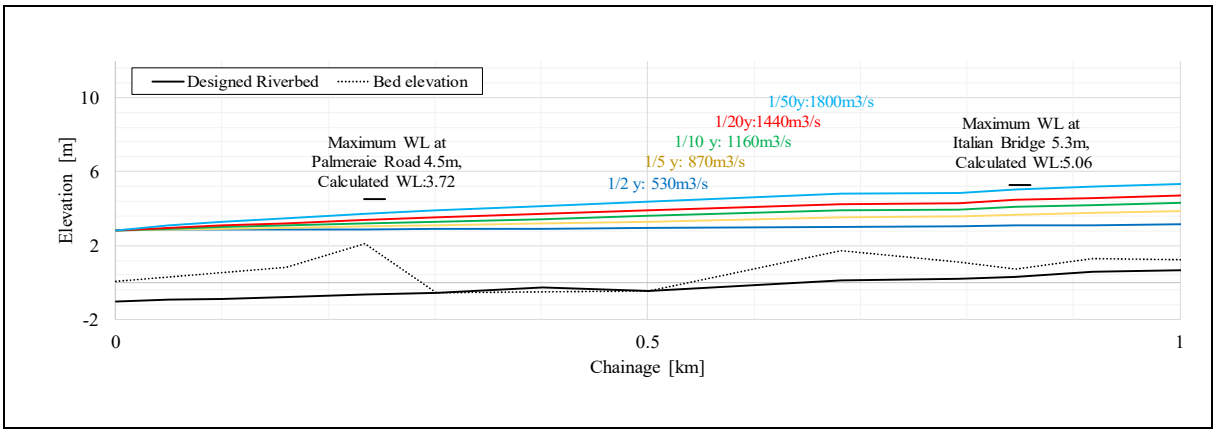


Figure 4.3.14 Longitudinal Water Level Profiles for Alternative 1B (Q=1,800m3/sec)

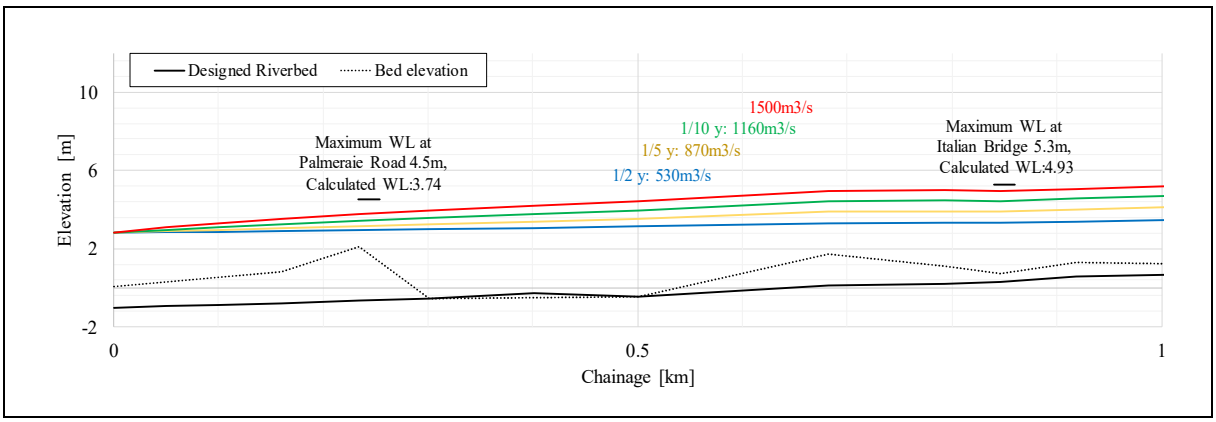


Figure 4.3.15 Longitudinal Water Level Profiles for Alternative 2A (Q=1,160 +340 m3/sec)

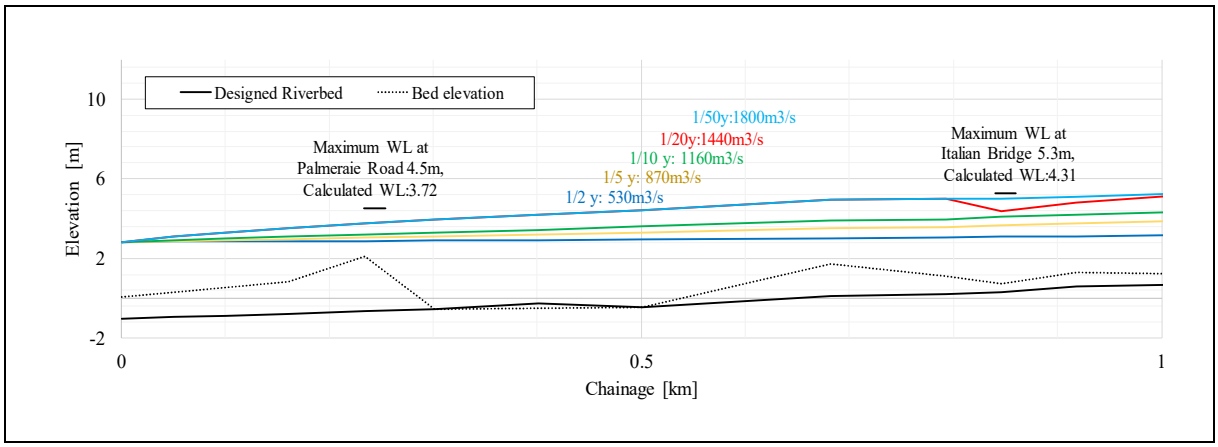


Figure 4.3.16 Longitudinal Water Level Profiles for Alternative 2B (Q=1,160 +640m3/sec)

(3) Land Use Regulation in Floodplain of Left Bank

In the examination of the alternative river improvement plans, a focus was made on the cross sections between the lower section of the Italian Bridge and the planned Palmaraie Bridge. This section is planned to be constructed with embankments on both banks.

On the other hand, in the section upstream of the Italian Bridge, 127 households were relocated in the 2008 World Bank funded rehabilitation project based on the census and socio-economic survey under the Settlement Action Plan (RAP), which was drafted and completed in June 2006. Compensation made at that time consisted of a plot of land for housing and construction of two-room housing units in the PK12 district of Balbala.

Agricultural lands are scattered even in the floodplain sections on the left bank side upstream of the current Italian Bridge, and there are houses in some areas. However, according to the information at the time of the field survey, the houses were built by people migrated from neighboring Ethiopia. Although the Djibouti government has restricted housing construction and regulated land use, its effects are limited. In future river improvement plans, the relevant ministries and agencies such as Ministry of Agriculture, Water, Fishery, Livestock and Marine Resources, Ministry of Budget, ADR, Ministry of Housing, Urban Planning and Environment and Djibouti City shall discuss strengthening the land use regulations in the floodplain on the left bank side of the Ambouli River and take measures against inundation.

CHAPTER 5 Identification of Problems and Investigation of Counter-Measures Related to Strengthening Logistics of Djibouti City

5.1 Forecast of Future Traffic Demand

5.1.1 Methodology for Traffic Demand Forecast

Changes in traffic volume are closely related to the country's socio-economic changes. Djibouti City has two distinct traffic: urban traffic and trans-border freight traffic. The urban traffic or domestic traffic in general is closely related to the socio-economic change of the city or the country, while that of the freight is mainly driven by the demand of the neighboring countries, particularly Ethiopia, a landlocked country which heavily depends on Djibouti. Therefore, the two kinds of traffic are forecasted separately as shown in Figure 5.1.1.

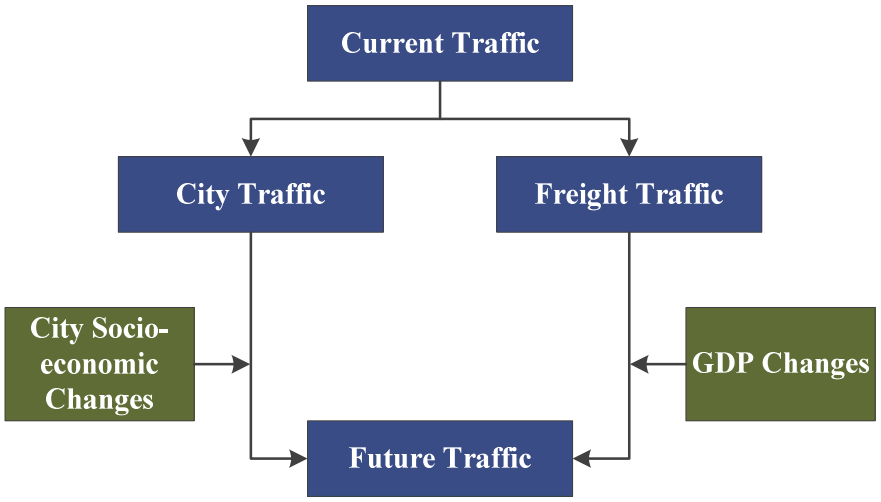


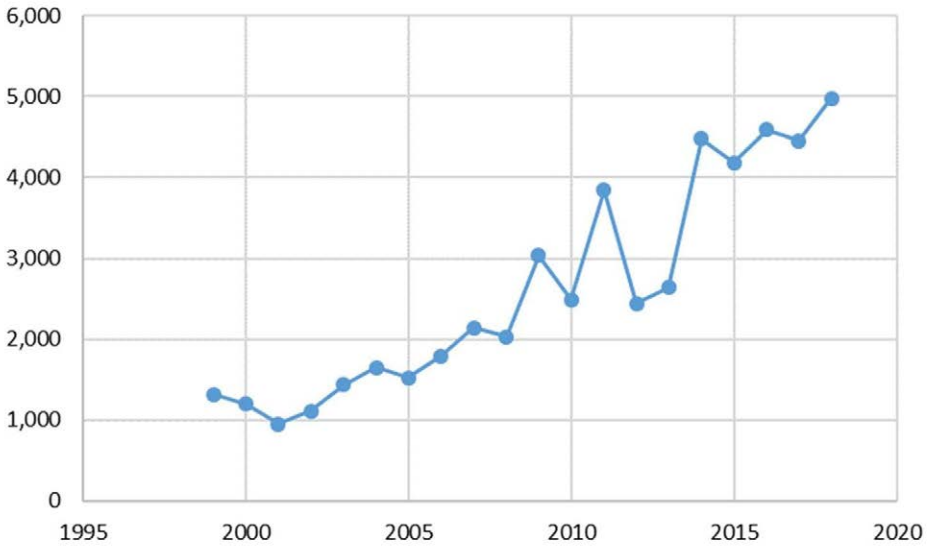
Figure 5.1.1 Procedure of Traffic Demand Forecast

(1) **Forecast of Urban Traffic Demand of Djibouti City**

Urban traffic changes with urbanization and motorization along with the socio-economic development. The city population was 475,322 in 2009 (2009 census data), and the Vision Djibouti estimate the current population at 653,264. Vision Djibouti also forecast the city population to grow at 2.7% annually until 2025, and then at 3.3% until 2030 followed by 3.2% until 2035.

Regarding development of motorization, the country is recently registering more than 4,500 new vehicles annually as shown in Figure 5.1.2. This is about three times as many as it was in the early 2000s. The cumulative number of newly registered vehicles since 1999 has exceeded 55,000, but there is no data on the total number of vehicles. As of 1999, the total number of registered vehicles was 46,210. In other words, the total number of vehicles has more than doubled in the last 20 years, and it is recently increasing at an annual rate of about 5%.[1]。

[1] Actually, some of the cars should be scrapped, so these are approximate figures.



Source: Statistical Yearbooks

Figure 5.1.2 Changes in the Number of Registered Veihcles

ADR conducted a traffic survey in the city in 2014, and forecast the future traffic volume by 2035. The above survey estimated the total traffic volume of the three roads crossing the Ambouli River (Palmeraie Road, Italy Bridge and Nagad Road) in 2014 at 39,946 PCU/day. The comparable current traffic from the 2021 traffic survey is 50,641 PCU/day, which indicates an annual growth rate of 3.45%, a rate slightly below the growth rate of 3.97% estimated by ADR.

The ADR growth rate is estimated based on future population growth, increase in the number of registered vehicles, and economic development such as GDP, which cannot be covered by this survey alone for reviewing it. It is also assumed that the growth of traffic volume has slowed down due to the recent COVID-19 pandemic. Therefore, although the actual growth rate of traffic volume across the Ambouli River is 3.45%, the ADR estimate of 3.97% was used to forecast the future traffic.

(2) Forecast of Freight Traffic

As mentioned above, freight traffic is mainly traffic related to the landlocked country Ethiopia . Freight traffic is closely related to GDP trends. In the preparatory survey for Upgrading National Road Route 1 conducted by JICA in 2018, it was confirmed that both freight vehicle traffic on National Road Route 1 and the GDP of Ethiopia were growing at a similar rate of around 10%. Therefore, the future growth of freight vehicle traffic is estimated based on the growth rate of Ethiopian GDP.

Freight vehicle traffic also depends on rail services between Djibouti and Ethiopia. The rail service started in 2018 with a round-trip service per day. According to DPFZA, the number of trains has now increased to three round trips a day. The long-term plan is to increase it gradually to 19 round trips a day. Each train is estimated to carry cargo equivalent to that of 53 trucks, and future freight traffic volume needs to take into account the increase in railroad transport service.

Currently, 2,122 trailers of two-way traffic are recorded by a 24-hour survey conducted at PK24 on National Road Route 1. In addition, there are three round-trips of freight train services as noted earlier. Table 5.1.1 shows the IMF's prediction of Ethiopian GDP, and it expects the GDP to grow at a rate of over 8% from 2022 to 2026, but in this survey, the average growth rate of 8.17% is adopted for forecasting the freight traffic.

Table 5.1.1 Forecast of Ethiopian GDP Growth Rate

Year	2022	2023	2024	2025	2026	Average
Growth rate (%)	8.67	8.19	8.00	8.00	8.00	8.17

Source: IMF

5.1.2 Prediction Results

Table 5.1.2 shows the results of the future traffic prediction for Palmeraie Road, Italy Bridge, and Nagad Road.

Traffic volume on the Palmeraie Road will increase by 1.429 times from the current level to reach 45,100 PCU/day by 2030. It will be difficult to handle this traffic with a 2-lane road, and it will be necessary to widen the road to 6 lanes. Italy Bridge traffic will also increase to 31,700 PCU/day by 2030 and 38,500 PCU/day by 2035, and widening it to 6 lanes should be considered by 2035. In addition, the Nagad Road traffic, which shows the highest growth rate of the three routes, will increase to 4,300 PCU/day by 2030 and 5,300 PCU/day by 2035, if a parallel road such as the outer ring road is not constructed.

Table 5.1.2 Results of the Future Traffic Forecast

	Traffic volume (Upper: vehicles/day , Lower: PCU/day)			Growth rate	
	(A) Current (Year 2021)	(B) Future (Year 2030)	(C) Future (Year 2035)	(B)/(A)	(C)/(A)
Palmeraie Road	31,550	45,100	54,800	1.429	1.737
	36,521	52,900	64,400	1.448	1.763
Italy Bridge	22,346	31,700	38,500	1.419	1.665
	25,652	36,400	44,200	1.419	1.723
Nagad Road	3,052	4,300	5,300	1.409	1.737
	4,047	5,700	7,000	1.408	1.730

Note: PCU exchange factors are as follows. Motorcycle: 0.5, Bajaj/Car/Taxi: 1.0, Midi bus: 1.2, Minibus/Light truck: 1.8, Heavy truck: 2.5, Trailers: 3.5

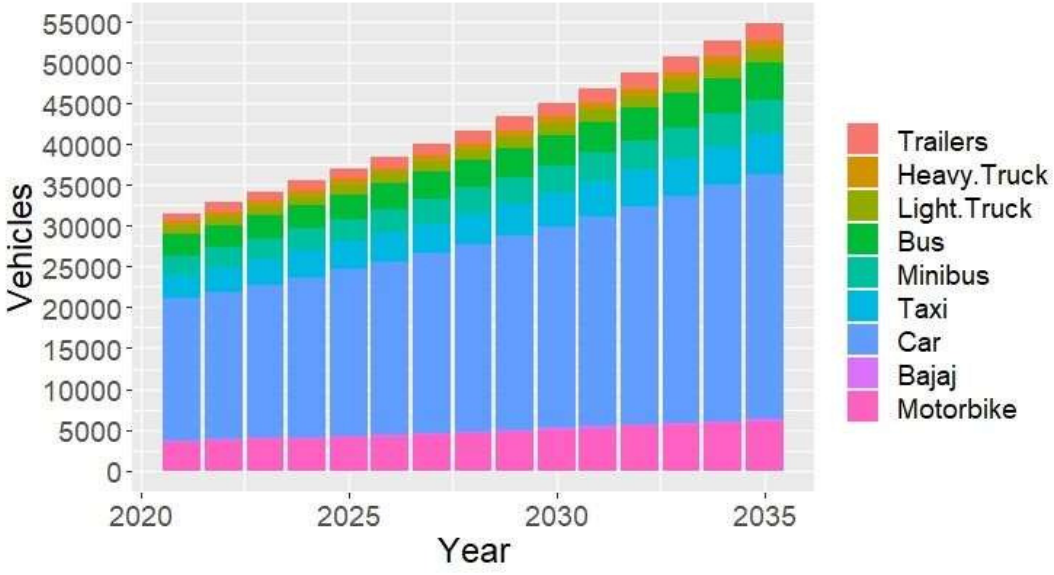


Figure 5.1.3 Palmeraie Traffic Forecast

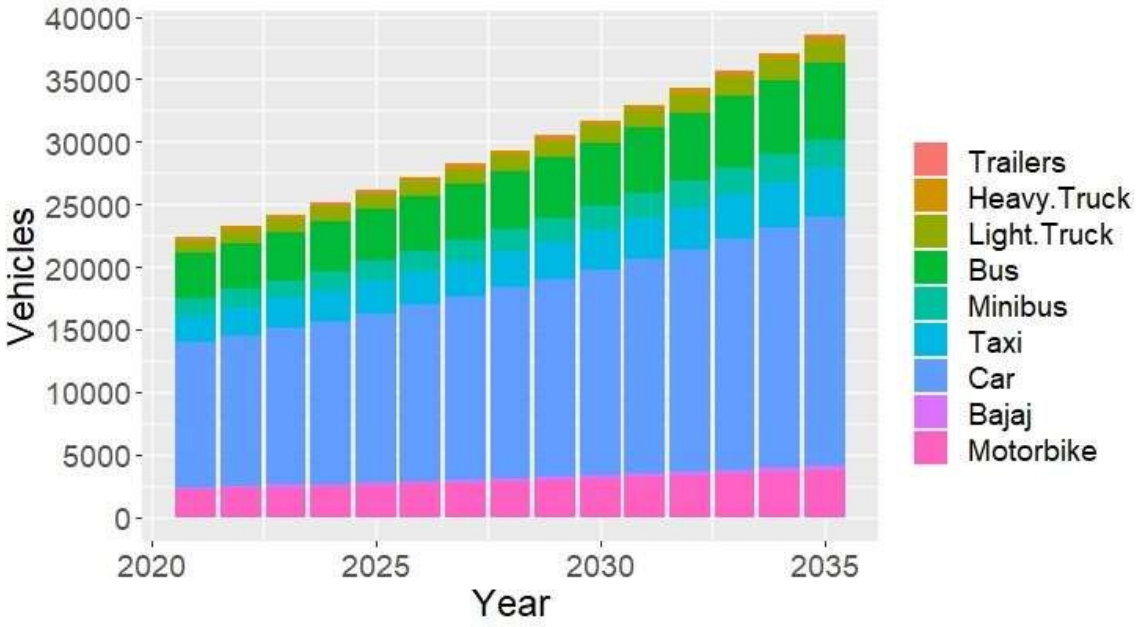


Figure 5.1.4 Italy Bridge Traffic Forecast

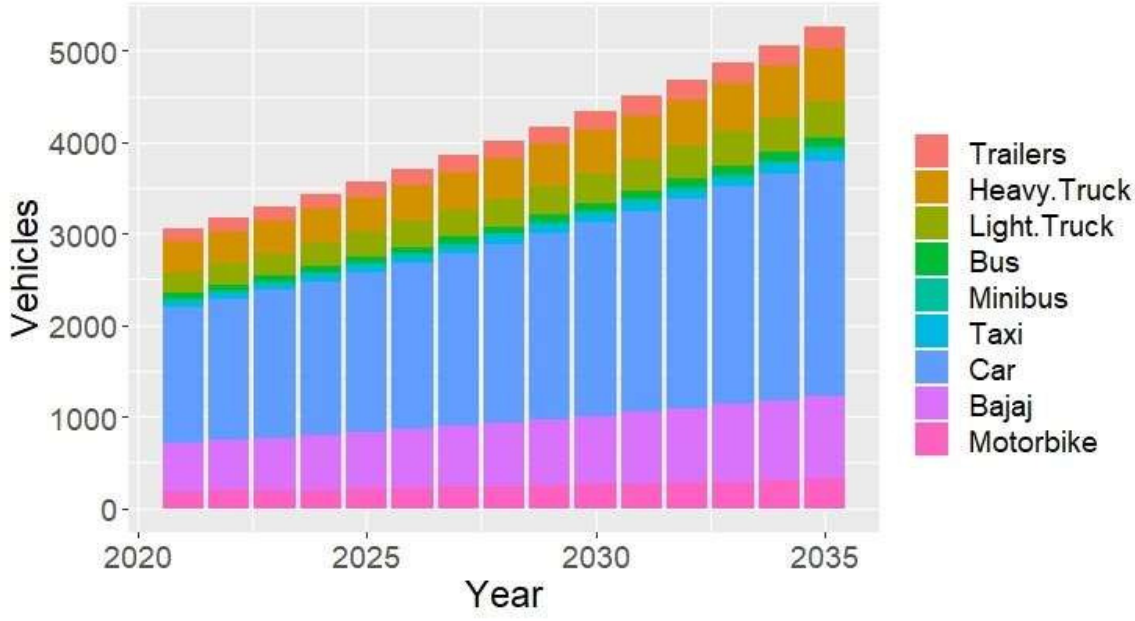


Figure 5.1.5 Nagad Traffic Forecast

5.2 Issues in the Transportation and Logistics Network of Djibouti

Based on the current situation analysis and future forecasts as described above, the issues in the transportation and logistics network in Djibouti are summarized in Table 5.2.1. These problems are further summarized into three issues: "Strengthening the logistics network", "Improving urban roads", and "Facilitating urban traffic".

Table 5.2 Issues in the Transportation and Logistics Network of Djibouti

Issues	Overview and Main Cause	Challenges
① Defectiveness on road network	❑ Division of the city by the Ambouli river (lack of crossing road) ❑ Division of the city by Djibouti－Ethiopian railway(lack of crossing road) ❑ Disconnected and bad alignment road network in the district	Stregthening the logistics network
② Unpaved and deteriorated pavement	❑ Deterioration of pavement due to lack of maintenance ability and inadequate system ❑ Many unpaved roads due to lack of budget	Improving urban roads
③ Deterioration of road structures	❑ Deterioration of road structures due to lack of maintenance ability and inadequate system	
④ Road flooding (outside water)	❑ Ford structure of roads that cross the Ambouli River (Parmeraie Road, Nagat Road) ❑ Sedimentation in rivers due to lack of maintenance	Facilitationg urban traffic
⑤ Road flooding (inland waters)	❑ Underdeveloped city drainage facilities and lack of maintenance	
⑥ Occurrence of road congestion	❑ Occurrence of traffic congestion due to insufficient capacity at intersections ❑ Deterioration of congestion due to street parking	Planning flood control
⑦ Lack of public transport	❑ Lack of public transport services and safety ❑ Concentration aof services on specific routes	

5.3 Measures to Strengthen the Logistics Network in Djibouti

For the three issues summarized in the previous section, the following three types of measures are proposed: "Structural measures" such as road maintenance and introduction of a new transportation system, "Non-structural measures" which are centered on traffic regulation and enhancement of traffic management, and "Flood-control measures" for the problems of river flooding and urban drainage, which hinder logistics and urban traffic (refer to Table 5.3.1).

5.3.1 Strengthening the Logistics Network

Improvement of the three trunk roads that cross the Ambouli River is desired along with the improvement of the Ambouli River. In addition, it will also be necessary to review the logistics system with Ethiopia, which is dominated by road transportation, by effective use of the Djibouti-Ethiopia railway. It is also desirable to review the logistics system in line with the future development plans in Damerjog and Nagad areas.

5.3.2 Improving Urban Roads

It is necessary to alleviate traffic congestion in the city, and to improve drainage facilities in the city. Measures to alleviate congestion in the city include eliminating unpaved sections, improving intersections, and improving access roads to newly developed areas.

5.3.3 Facilitating Urban Traffic

Public transportation is essential for the Djibouti City for the daily lives and economic activities of the citizens, but it is not properly managed currently. It is necessary to build a public management system and consider the introduction of new public transportation system. In addition, the enhancement of traffic management to alleviate traffic congestion in the city is also important.

5.3.4 Planning for flood control

The overflowing of the Amboli River and flooding of urban areas during the rainy season, which recurs every year, is directly caused by the lack of maintenance of river areas and inadequate drainage systems. However, there is a lack of a flood control plan to comprehensively plan, implement, and maintain these measures.

Table 5.3.1 Study of Countermeasures to Strengthen the Logistics Network in Djibouti City

	Structural measures	Non-structural measures
Strengthening the logistics network	・ Improvement of the roads crossing the Ambouli River (Palmeraie Road, Italy Bridge, and Nagad Road) ・ Road development in line with the planned development of the Damerjog and Nagad areas	・ Separation of trunk logistics and city routes (restriction of the movement of the large trucks in the city) ・ Installation of axle load gauge ・ Effective utilization of Djibouti-Ethiopian railway
Improving urban roads	・ Maintenance of trunk urban roads (especially in the east-west direction) ・ Intersection improvement (structural improvement, installation of advanced traffic lights) ・ Rehabilitation of the missing road (Vietnam Road) connecting Italy Bridge and Palmeraie Road ・ Balbala area road improvement (collector-distributor road improvement, pavement improvement) ・ Road development in the newly developed area	・ Planning of road maintenance ・ Strengthening of ADR implementation capacity ・ Securing funds for road maintenance
Facilitating urban traffic	・ Introduction of new public transportation (BRT, etc.) ・ Introduction of measures prioritizing public transportation (bus only, priority lane, bus priority signal, etc.))	・ Street parking regulations ・ Advanced city traffic management (introduction of advanced traffic lights, traffic control system, etc.)
Planning for flood control	・ River improvement of Ambouli River ・ Improvement of drainage facilities in the city ・ Installation of mobile pump vehicles	・ Flood Warning System

Chapter 6 Direction of Assistance by Japan

6.1 Direction of Assistance and Selection of Specific Measures

Direction of Assistance

Helping to solve various problems in the field of economic and social development of Djibouti, which is an important international partner for Japan, contributes to the stabilization of the East African region and the revitalization of the regional economy through the strengthening of Djibouti national infrastructure. Therefore, such aid would be highly valued and have quite significant impact. Since various aids from different organizations and countries including the World Bank, China, the Saudi Foundation, etc. are being provided in the area, as described in Section 3.3.4, identifying the role of the Japanese aid from other donors is needed. In other words, the support that shows Japan's concrete presence among other active donors, including China and the United States, is required.

As mentioned in Section 3.3.1, in its National Development Plan, the Djibouti government aims to "become a transport hub for African industries". In order to maintain and strengthen the competitiveness of the logistics chain(SCAPE2015-2019) and to achieve "balanced development and growth of both the east and west regions" of Djibouti City, it is proposed to build a road connecting the east and west urban areas across the Ambouli River.

The Government of Japan has set up 5 priority areas including the Djibouti corridor, and has announced aid centered on the development of the Djibouti corridor and regions around the corridor at TICAD IV held in Yokohama in June 2013. The Government of Japan has conducted the "Information Collection and Confirmation Study on Djibouti Corridor, Africa Region" in 2016, has organized the development issues and possibilities by organizing the socio-economic situation, infrastructure development, customs, immigration control, international affairs, etc. in the area, and has grasped the development issues and possibilities. Furthermore, in the "Country Assistance Policy for the Republic of Djibouti" formulated in September 2019, it has set up the basic policy of supporting the development of industrial infrastructure and of improving the living environment of the people with an ultimate goal of "Supporting sustainable economic and social development that contributes to regional stability" and three medium goals of "Strengthening the economic and social infrastructure that contributes to sustainable economic growth", "Developing human resources that support economic growth" and "Supporting regional stabilization efforts".

Considering the direction of the development policy of the Djibouti government and the basic policy of the Japanese government's support, it is desirable to provide "support related to the development of the corridor and regional development around the corridor" with the goal of "support for sustainable economic and social development that contributes to regional stabilization" to strengthen the logistics function of Djibouti and to achieve balanced development within Djibouti.

The specific directions of the support are summarized in the following four points.

(1) Strengthening the connectivity between the east and west urban areas that are divided by the Ambouli River.
(2) Development of a reliable international logistics network.
(3) Development of roads that contribute to urban and industrial development in the city.
(4) Development of a safe and comfortable road network in the city.

6.1.2 Selection of Specific Measures

Figure 6.1.1 shows the concrete measures (draft) for the directions of the support which have already been set.

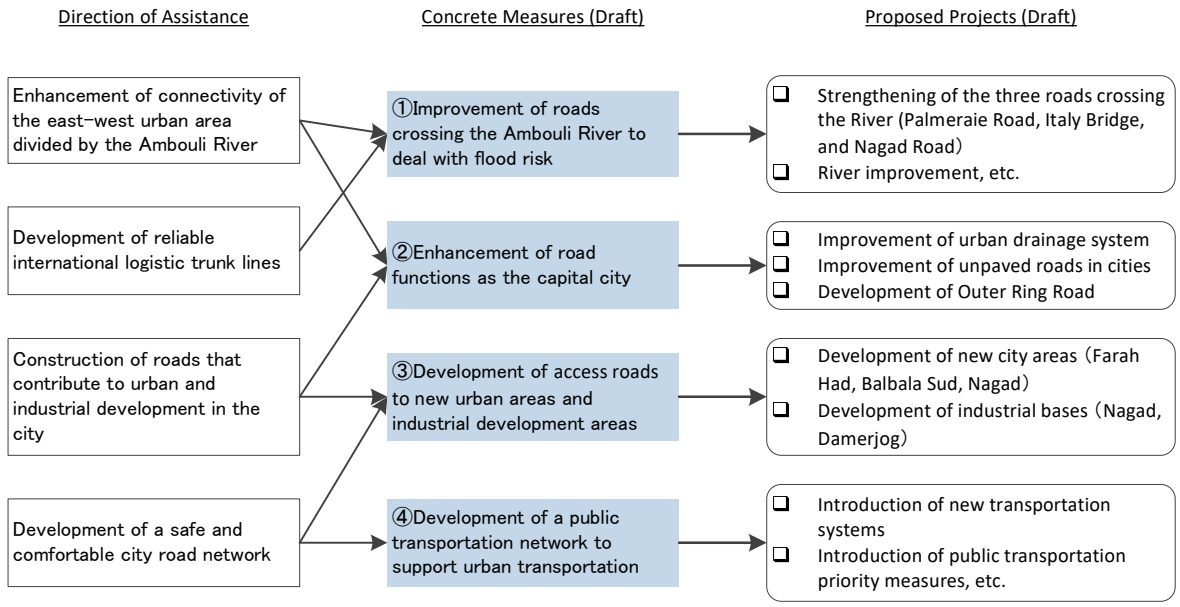


Figure 6.1.1 Identifying the Direction of Support and Concrete Measures (draft)

1. Improvement of three roads crossing the Ambouli River: this refers to Palmeraie Road, Italy Bridge, and Nagad Road. The Italy Bridge will be reinforced or replaced, while new bridges will be built at the remaining two crossings. River improvement will also be included.
2. Development of new urban area and development of access roads to industrial development areas: this consists of the construction of access roads to three new residential areas (Farah Had, Balbala Sud and Nagad) planned in SDAU, and the construction of access roads to industrial development areas in Nagad and Damerjog districts. It will support these developments in terms of road improvement.
3. Enhancement of road functions as the capital city: this supports the upgrading of vulnerable urban roads, drainage system and pavement of the capital city.
4. Development of a public transportation network to support urban transportation: this includes the consideration of the introduction of priority measures for existing public transportation and new transportation systems.

Table 6.1.1 shows the results of the evaluation of these measures from the following three perspectives:

- Urgency: Is it addressing issues that need to be addressed immediately?
- Validity: Is it appropriate as a Japanese grant aid project? Can it show Japan's presence?
- Feasibility: Are there any obstacles such as maturity of the plan, difficulty of the project, etc., to the implementation of the project?

Table 6.1.1 Evaluation of Concrete Measures (draft)

	Evaluation Items			Comprehensive evaluation	Remarks
	Urgency	Validity	Feasibility		
1. Improvement of roads crossing the Ambouli River to deal with flood risk	◎	◎	△	◎	
2. Development of new urban areas, and development of access roads to industrial development areas, etc.	△	△	○	△	
3. Enhancement of road functions as the capital city	◎	△	○	○	
4. Development of a public transportation network to support urban transportation	○	△	△	△	

Note) ◎ : Excellent, ○ : Good , △ : Average

According to the evaluation, (1) Improvement of roads crossing the Ambouli River received the highest rating.

Flooding of the Ambouli River, which divides Djibouti City into east and west, has been recurring every year and has had a significant impact on the lives of citizens and economic activities. There is no doubt that the development of roads that are resistant to flood damage is highly evaluated in terms of urgency and relevance. In addition, improvement of urban drainage systems and pavement condition to strengthen the functions of the capital city are also considered to be extremely important measures, but the scope of the project may be too wide and the project cost may be huge. Therefore, the evaluation was low in terms of their appropriateness as grant aid projects. The necessity and effectiveness of other measures are also recognized, but there are significant challenges in implementing them. As a result, it is thought that this should be further examined in the future.

6.1.3 Selection of Priority Road Improvement Projects

As shown in Table 6.1.2, there are three possible alternatives for the "Improvement of roads crossing the Ambouli River" that was selected as specific measures.

Italy Bridge was reinforced in 2017 and heavy vehicles are restricted from using it. However, the bridge itself was never flooded, and it is still serving as a trunk road. Since it also serves as an alternative to the Palmeraie Road when it is flooded, the need to reconstruct it prior to the improvement of the Palmeraie Road is low. However, in the future, six lanes will be necessary to handle the future traffic volume, and as it is also aging, the bridges will need to be replaced.

The traffic of Nagad Road is currently a low, but this may change and it could become an important route once the Damerjog area is developed. However, the SDAU is planning an outer ring road in the future, and this may diminish the role of the Nagad Road. Therefore, the direction of its development should be examined in response to the progress of future developments.

Palmeraie Road is the busiest and most important road crossing the Ambouli River. However, it is flooded and becomes impassible when heavy rainfall, resulting in a serious hindrance to logistics and daily life of the citizens. In particular, the loss of access to heavy trucks would be critical for Djibouti, so immediate action is needed.

Therefore, the Palmeraie Road improvement (widening and bridge) is selected here as the priority road improvement project.

Table 6.1.2 Alternatives for the Improvement Roads Crossing the Ambouli River

	Traffic volume (PCU/day)		Current	Improvement policy
	Current (2021)	Future (2035)		
Palmeraie Road (4-lane road)	31,550	54,800	• Highest traffic volume in the city • There is a lot of general traffic as well as logistics from Djibouti port. • Major bus routes	• Widening to 6 lanes • Reduce congestion at nearby intersections • Responding to increasing bus traffic • Improvement of the structure to prevent flooding even during floods
Italy Bridge (4-lane road)	22,346	38,500	• Second busiest road in terms of traffic volume, next to Palmeraie Road • Damage was discovered and repaired in 2017. Since then, large vehicles are restricted from using it.	• Widening to 6 lanes • Responding to increasing bus traffic • Reinforcement or replacement
Nagad Road (2-lane road)	2,586	5,300	• Traffic volume is low, but the ratio of large vehicles is high.	• Measures against flooding

6.2 Consideration of Priority Project Plans

6.2.1 Examination of Palmeraie Road Measures

(1) Study Flow of Countermeasures

There are many facilities along the Palmeraie Road, including those under construction, and the river conditions must meet the requirements necessary to plan the river crossing structures. Therefore, this study will be conducted according to the following flow.

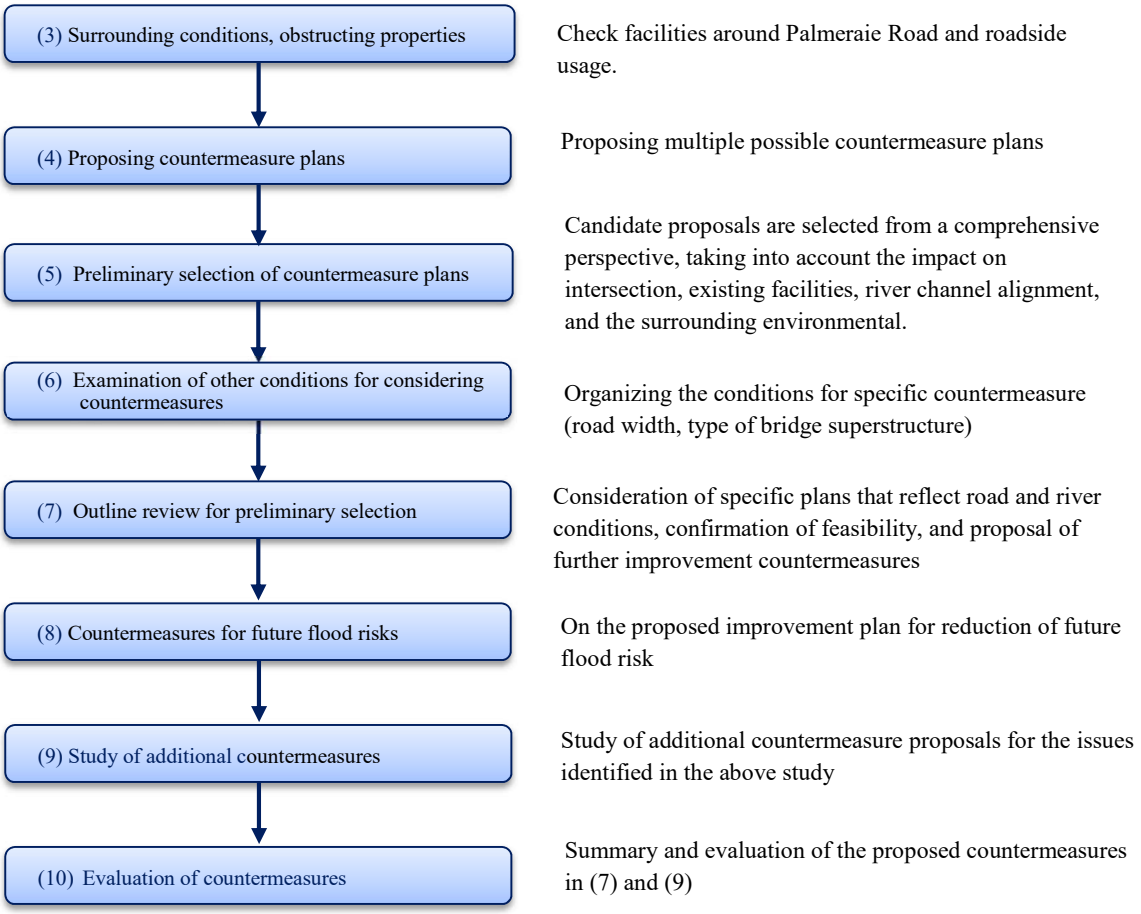


Figure 6.2.1 Study Flow of Palmeraie Road Countermeasure

(2) Basic Policy for Measures

The basic conditions for considering measures for the Palmeraie Road are shown below.

Table 6.2.1 Basic Conditions for Palmeraie Road Countermeasures

Item	Assumptions
1. Target year for planning	2035 (roughly 15 years from now)
2. Design traffic volume	2021: 31,550 vehicles/day (4 lanes) 2025: 37,000 vehicles/day (6 lanes) 2030: 45,100 vehicles/day (6 lanes) 2035: 54,800 vehicles/day (6 lanes)
3. Exclusive bus lane	Not considered at this time
4. Improvement of the Ambouli River	• In order to make the road passable in all weather conditions by installing a river crossing structure, river channel improvement will also be carried out. • A river cross-section enough for the design flood discharge should be secured (to be set separately). • The embankment will be constructed from the downstream side of Italy Bridge to about 100m downstream of the Palmeraie Road. In the downstream of the embankment, the river channel will be excavated.
5. Type of river crossing structure	• Since this is an important route and the Italy Bridge is located nearby upstream of the river, the structure will be basically the same as that of the Italy Bridge. Culvert type (multi-story structure) was judged unsuitable because the cross-sectional blocking ratio is not satisfactory and it has maintainability issues.
6. Main obstructing properties	• FTZ facility (owned by Chinese company, temporary and can be relocated) • Flower Park (under construction by a Chinese company) • High-voltage power line (63kV). • Railroad between Djibouti and Ethiopia.
7. Future plans	• Touch Road is a new urban planning project. An MOU was signed with the Djibouti government in 2014, but the progress of the project has not yet been determined. Land ownership has not been delegated, but care must be taken when planning permanent structures up to the river mouth.

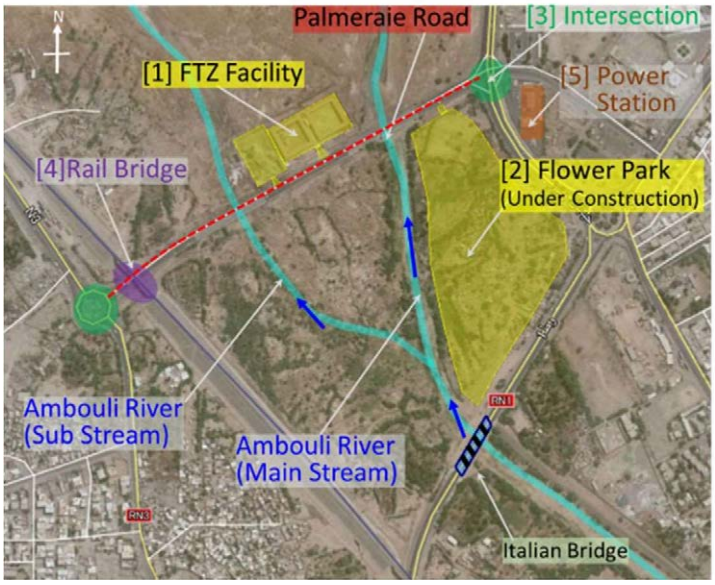
Source：https://human-village.org/spip.php?article153

Figure 6.2.2 New Urban Planning Project at the Mouth of the Ambouli River.

* See 6.2.1(1) for the study flow of countermeasures

(3) Surrounding Conditions and Obstructing Properties

The main facility locations and as-built photos of them between the subject Palmeraie Road and the upstream Italy Bridge are shown below.



[1] FTZ Facility (Chinese)

[2] Flower Park

[3] Intersection

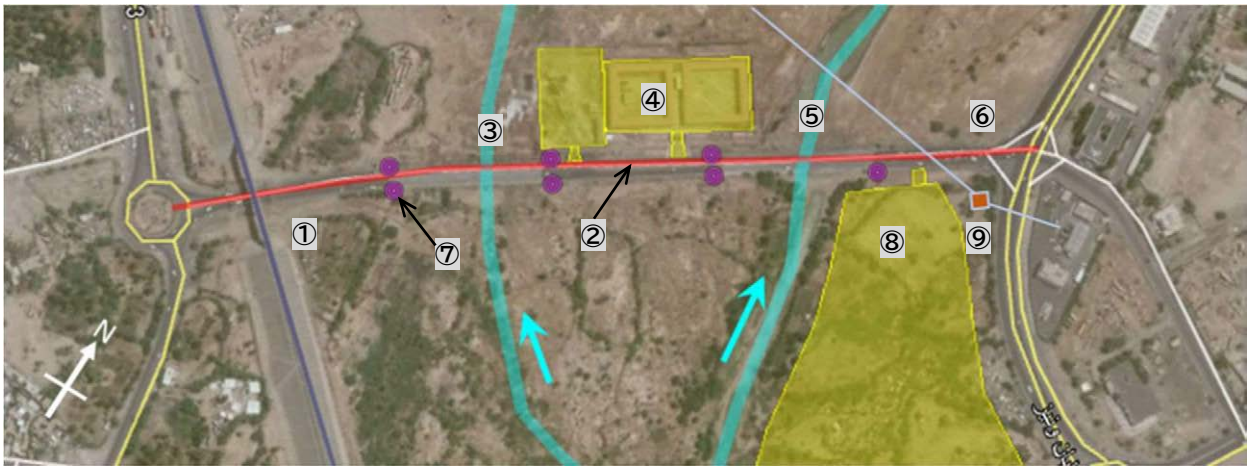
[4] Rail Bridge

[5] Power Station

The Palmeraie road is located parallel to National Road Route 1, about 600 meters downstream of the Ambouli River, with a width of about 19 meters and a distance of about 800 meters between the east and west intersections. The western part of the road passes under a railroad overpass, and there are FTZ facilities (Chinese company) and the Flower Park (under construction by a Chinese contractor) along the road. There is a high voltage power tower located east of the Flower Park and a switchyard for the main high voltage line across Fun City Road. The Ambouli River has its main stream on the east side, but it flows down to the sub stream on the west side when it is flooded by heavy rain. Therefore, ford structure is used at the intersections of the current road with the main stream and the sub stream.

Figure 6.2.3 Facilities around Palmeraie Road

In addition, the condition of the area around Palmeraie Road and obstructing properties are shown below. The status of the FTZ facilities and Flower Park, which are assumed to require special consideration in this measure, are shown on the following pages.



1. Railway bridge, gate (H=6m)

2. Palmeraie Road

3. Ambouli River (sub stream)

4. FTZ facilities (Chinese companies)

5. Ambouli River (main stream)

6. East side intersection (signalized)

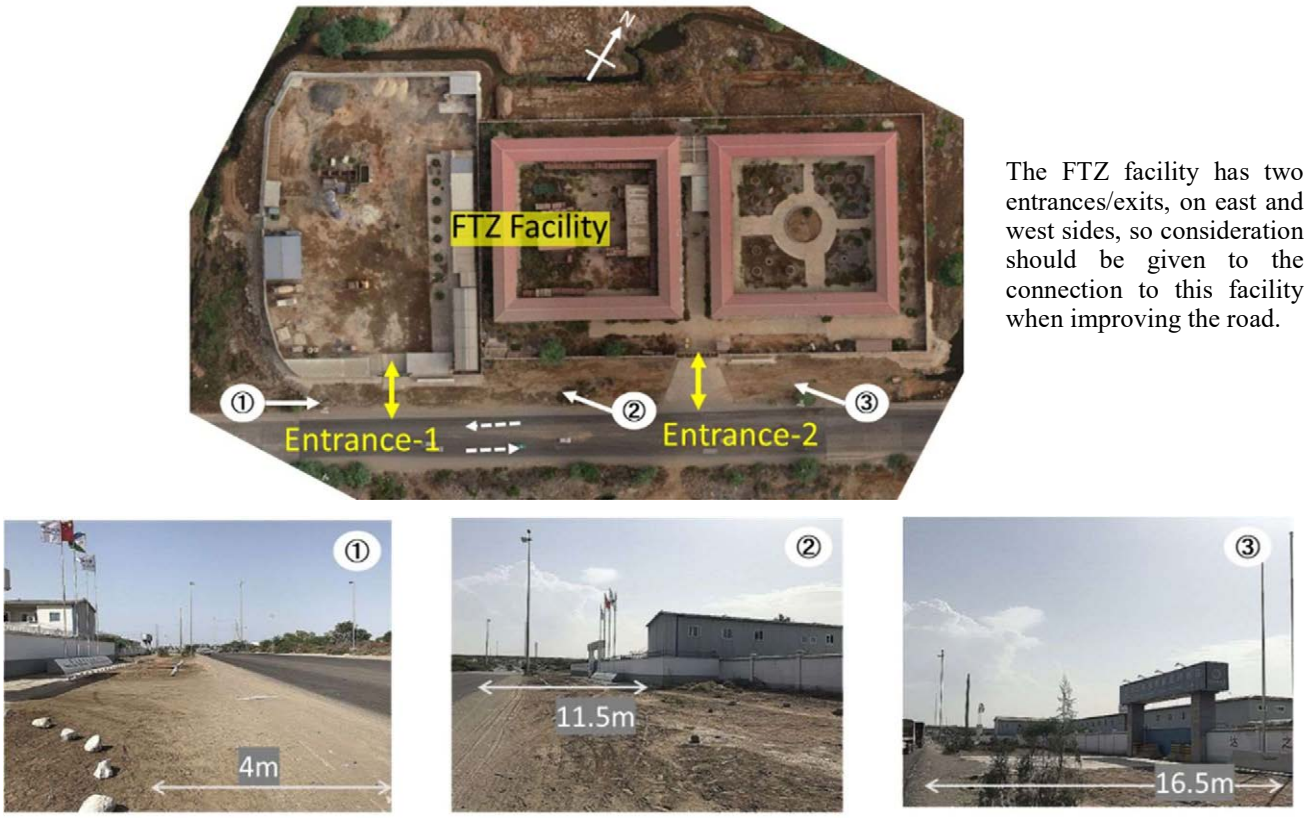
7. Streetlights (2 types: high and low)

8. Flower Park (under construction)

9. High-voltage power line tower (63kV)

Figure 6.2.4 Current Conditions around Palmeraie Road

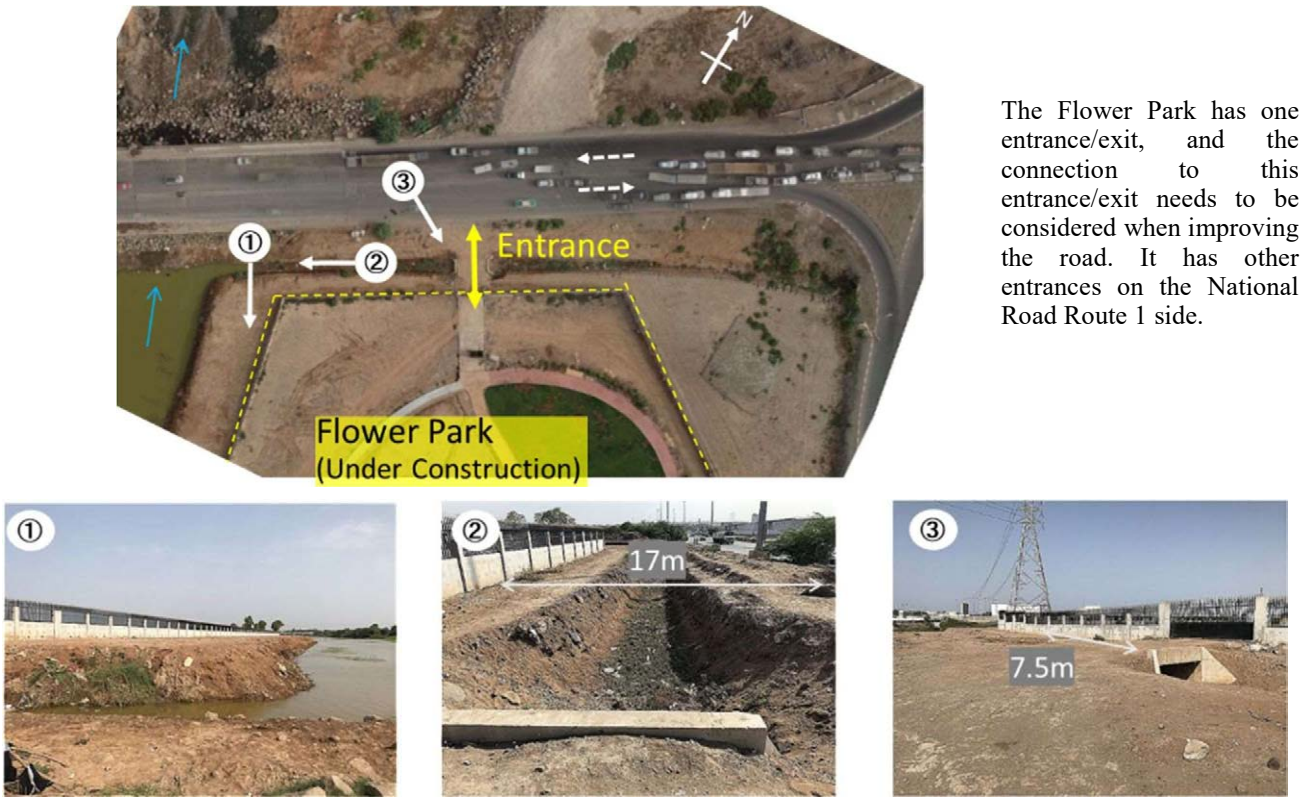
・ Detailed status of FTZ facilities



The FTZ facility has two entrances/exits, on east and west sides, so consideration should be given to the connection to this facility when improving the road.

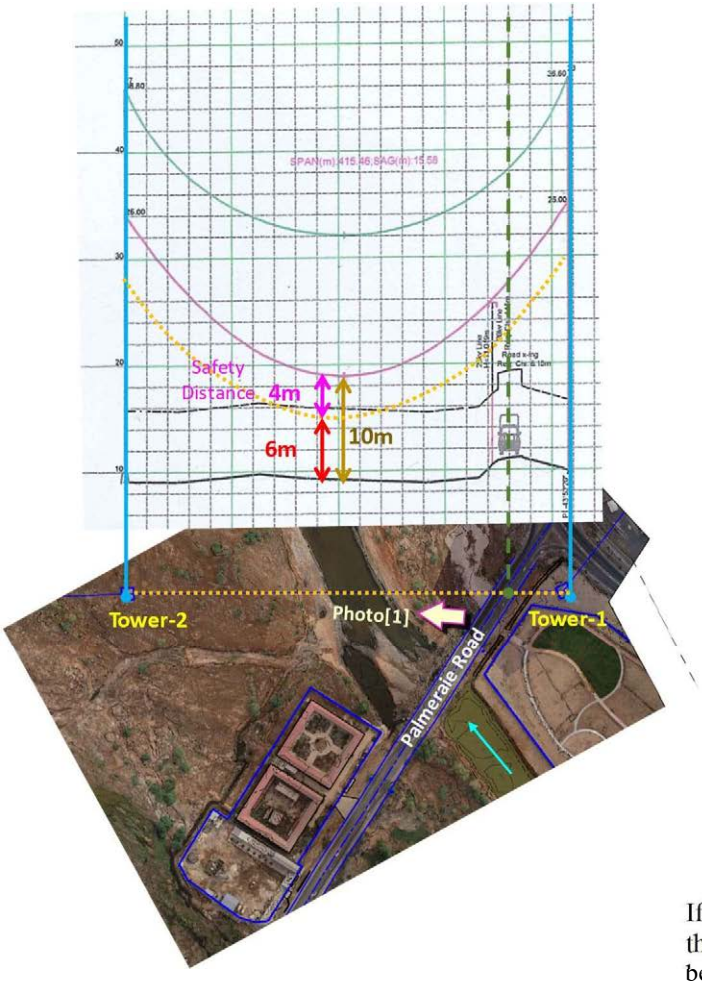
Figure 6.2.5 Detailed Status of FTZ Facilities

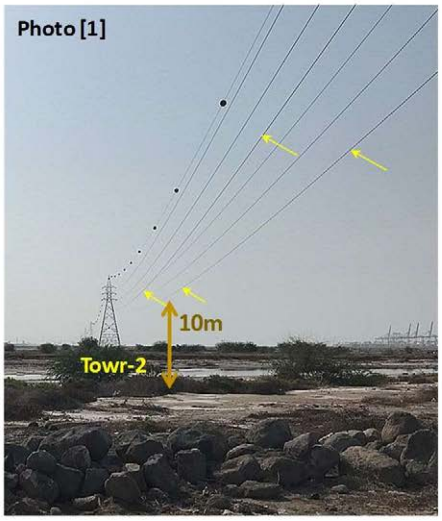
・ Detailed status of the Flower Park



The Flower Park has one entrance/exit, and the connection to this entrance/exit needs to be considered when improving the road. It has other entrances on the National Road Route 1 side.

Figure 6.2.6 Detailed Status of Flower Park





Source: Prepared by JICA survey team based on materials received from the EDD

If the road alignment is shifted to the east from the current road and a bridge is built, care should be taken to ensure the necessary distance from the voltage line.

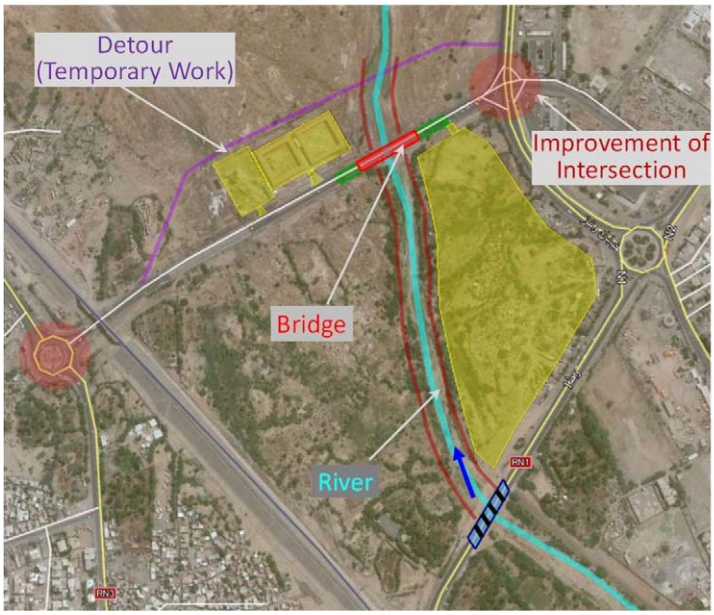
Figure 6.2.7 High-Voltage Line Layout

(4) Identifying Countermeasure Proposals

Based on the conditions outlined above, the following four possible countermeasure proposals are outlined.

Table 6.2.2 Proposed Palmeraie Road Countermeasures (1/2)

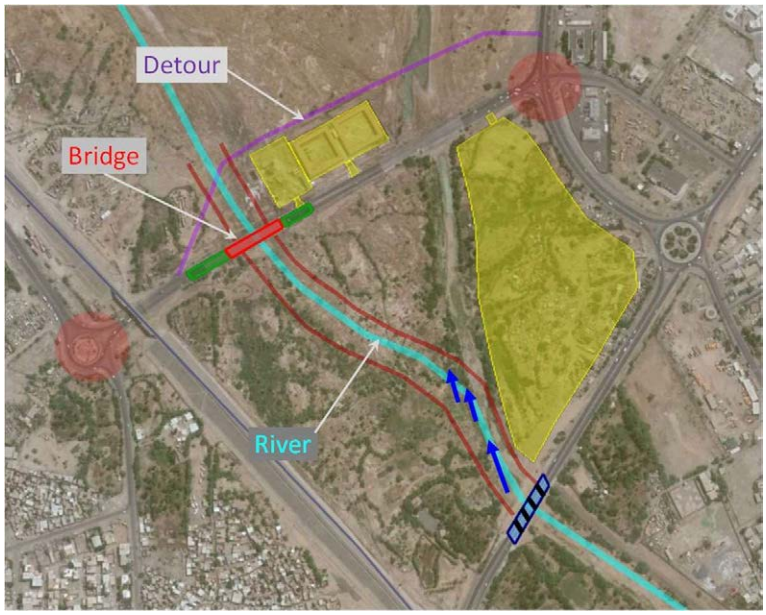
Alternative 1: River improvement on the main stream, installation of one bridge (partial relocation of FTZ facilities)



・Proposal to improve the main stream

・The alignment of the river channel will not change significantly from the current situation, but some of the FTZ facilities will need to be relocated in order to secure the river cross section.

Alternative 2: River improvement on the sub-stream* channel and installation of one bridge (without relocation of FTZ facilities) *In this chapter, diversion river is described as sub-stream.



・Proposal to improve the sub stream

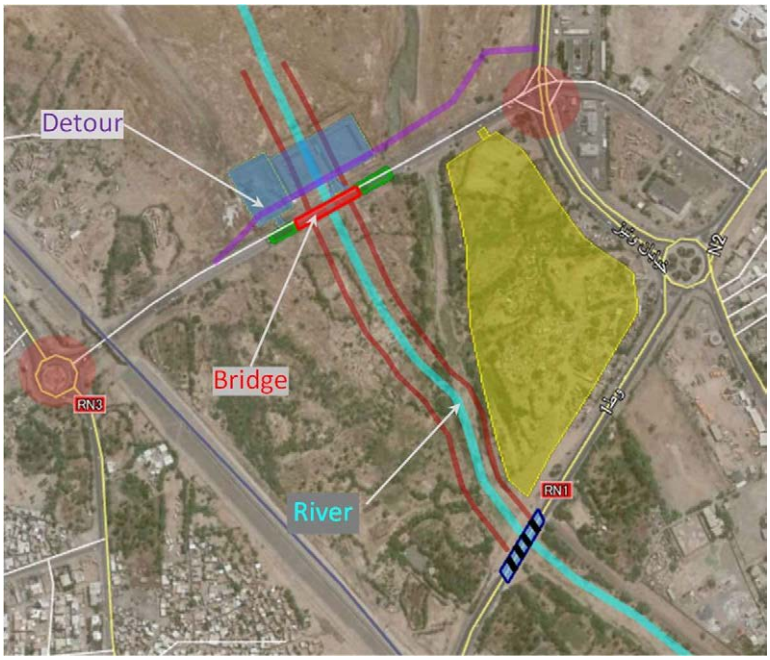
・No relocation of the FTZ facility is required, although the river channel alignment will be significantly changed from the current condition.

Table 6.2.3 Proposed Palmeraie Road Countermeasures (2/2)

Alterenative 3: River improvement of the main stream and sub-stream, and installation of two bridges (no relocation of FTZ facilities)

- Proposal to improve the river by dividing it into main stream and sub-stream
- Compared to the proposal 1, the river width and bridge length of the main stream flanked by the facilities can be reduced. The number of bridges and length of river channel are increased.

Alternative 4: River improvement between main stream and sub-stream, and Installation of one bridge (with relocation of FTZ facilities)



- Proposal to improve the river by relocating the FTZ facility (temporary)
- The impact on connections to surrounding facilities and intersections can be reduced. Need to treat the former river site along Flower Park.

(5) Preliminary Selection of Countermeasure Proposals

The results of the evaluation of the comparative proposals from the overall perspective of road connection, impact on the environment and facilities are shown below. As the result, From Alternative 1 to Alternative 3 were selected as preliminary proposals.

Table 6.2.4 Comparison of the Palmeraie Road Measures for Preliminary Selection

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Overview diagram				
FTZ facility	Partial relocation	No relocation	No relocation	Full relocation
River Improvement Alignment	○ Almost same as current condition	△ The Italian bridge substructure is located in the downstream direction of the main stream	○ Almost same as current condition	○ Curvature of the river alignment can be reduced
Cross section of river improvement	△ Subject to restrictions of both FTZ and park	○ Only coordination with FTZ side	○ Set cross-section under constraint on the main river side, and secure the shortage on the branch river side.	◎ No particular constraints
Connection to nearby facilities	△ Crossings are close to intersections and facilities, so connections need to be considered.	○ The distance from intersections and facilities is relatively secure.	△ Crossings are close to intersections and facilities, so connections need to be considered.	◎ Distance from intersections and facilities can be secured.
Impact on the surrounding environment	◎ Relatively small amount of excavation for river improvement.	△ Large amount of excavation for river improvement.	○ Large amount of excavation for river improvement is less than Alt.2.	▲ The most amount of excavation in river improvement.
Impact on surrounding houses and farmland	◎ There are no houses or farmland in the area to be improved.	◎ There are no houses or farmland in the area to be improved.	◎ There are no houses or farmland in the area to be improved.	◎ There are no houses or farmland in the area to be improved.
Coordination with surrounding facilities(Administrators)	△ Need to coordinate the relocation of some FTZ facilities	△ Need to coordinate on the treatment of river sites along the park	○ No need to coordinate with FTZ facilities and parks	▲ Requires most intensive coordination for overall relocation of FTZ facilities, treatment of river sites along the main river, etc.
Evaluation	Selected	Selected	Selected	

Note) ◎: Good , ○: Fair , △ : Poor, ▲: Very Poor

(6) Other Basic Conditions for Palmeraie Road measures

1) Road conditions (width)

- Road classification: Type 4, Class 1
- Design speed: 50 km/s
- Others:
  - The width of the roadway is 3.25m, which is the standard width of the road.
  - A median strip was placed to ensure safety of traffic.
  - The width of the shoulder is reduced so that traffic can be maintained even when a broken-down vehicle is stopped.
  - A sidewalk is secured for pedestrian use (same for the upstream Italian bridge).

Note: The actual final road width should be determined by considering the project cost through outline calculations.

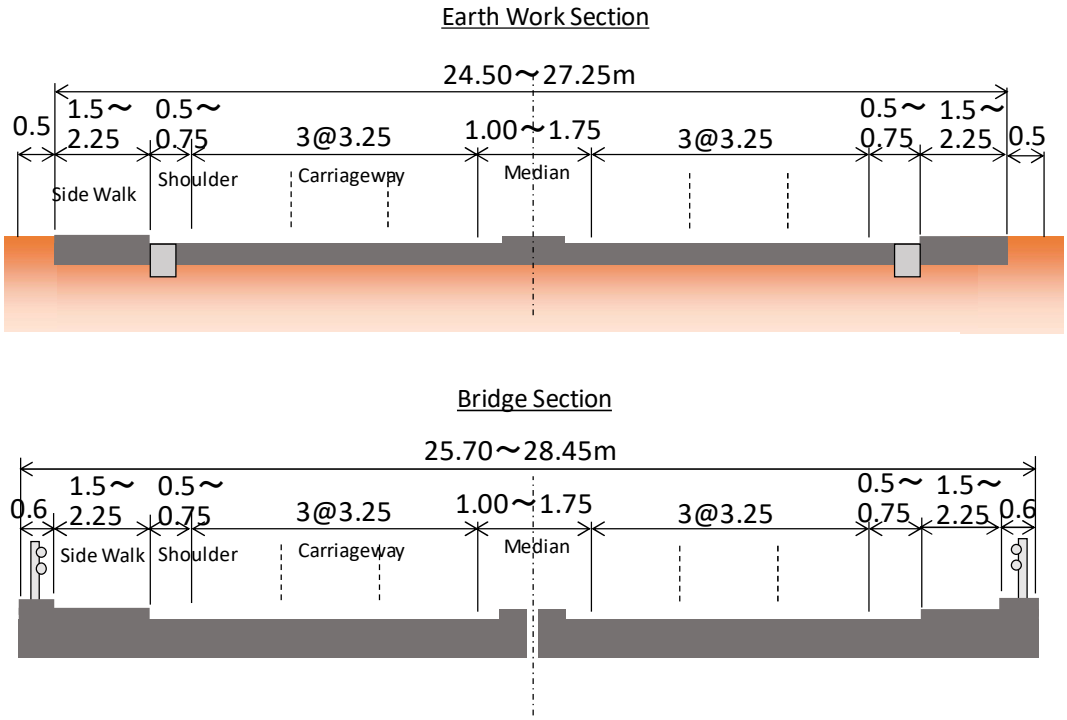


Figure 6.2.8 Typical Width of Planned Palmeraie Road

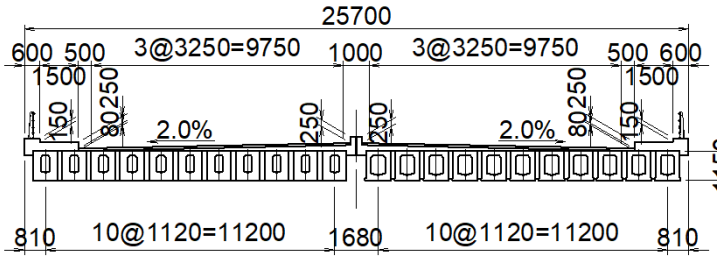
2) Bridge type (superstructure type)

The type of bridge superstructure for the river crossing is planned to be a "PC hollow slab bridge" in consideration of the surrounding environment and constraints of the bridge location.

Reasons for the selection:

- Steel bridge types were not used because of maintenance issues such as painting for rust prevention.
- Special bridges such as cable-stayed bridges and suspension bridges are not suitable for the scale of the bridge and require a large number of members. The number of members is large, and maintenance and management are inferior, so they should not be used.
- A concrete bridge was chosen as the basic structure to prevent salt damage, and a high strength prestressed concrete bridge was chosen as the basic structure.
- In order to minimize the changes in the longitudinal profile of the road, the girder height should be kept low and the type of bridge should be easy to maintain in the future.

* The final decision on the bridge type needs to be considered in the next design phase.



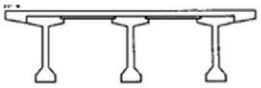
	Hollow Slab Girder	T- Girder
Cross Section		
Girder Bottom Condition	 Small surface area	 Large surface area
H/L H: Girder Height L: Span	H/L=1/25	H/L=1/15

Figure 6.2.9 Type of Bridge on the Palmeraie Road
(Typical cross-sectional drawing for comparison)

(7) Outline Review for the Preliminary Selection Proposal

The table below shows the results of the evaluation of the three proposals selected in the preliminary selection based on the outline study of the river improvement plan and the road and bridge plan, and the outline plan of each proposal is shown in the following pages.

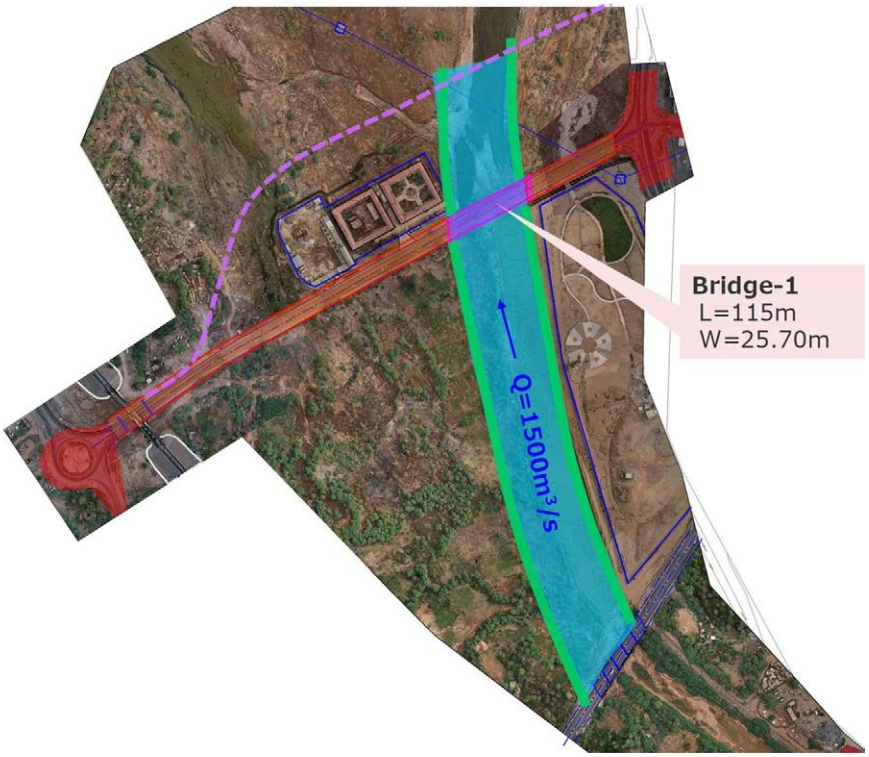
Table 6.2.5 Summary and Evaluation of the Alternatives for Palmeraie Road Countermeasures

Alternative 1	Main Stream Improvement				
	Assumptions	Partial relocation of FTZ facilities (The Flower Park is currently under construction, and demolition is expected to be difficult.)			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	115m	Earth work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Width of Lane	3.25m	Else	
		Side Walk	1.5m×2		
	Estimated Cost	4,600 million yen			
	Evaluation	- The river alignment will not change significantly. - In order to connect the road to the entrance/exit of the FTZ facility, the longitudinal length of the road needs to be about 6%. From the viewpoint of driving safety, it is desirable to keep it at about 2.5%. In this case, a separate side road arrangement will be required to connect to the FTZ facility. By raising the entire road, the road surface height is set higher than the HWL. - The partial relocation of the FTZ facility will take time to coordinate with the administrator, which may affect the progress of the project.			
Alternative 2	Sub-stream Improvement				
	Assumptions	Agreements with relevant organizations on the treatment of the main stream site along the park			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	108m	Earth work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Width of Lane	3.25m	Else	
		Side Walk	1.5m×2		
	Estimated Cost	4,300 million yen			
	Evaluation	- As there are no restrictions on the sub-stream side other than the FTZ facility, it can be crossed at right angles to the Palmeraie road. However, the excavation of the river bed will be the largest among the alternatives. - The location of the improved river is far from the Flower Park and the intersection on the east side, so the connection to these facilities is relatively easy. - The Park is planned and developed along the current alignment of the main river, and it is expected that it will take time to coordinate changes in the river channel and disposal of the site.			
Alternative 3	Main and Sub-stream Improvement				
	Assumptions	Detailed study of river diversion plan			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	87+51m	Earth work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Width of Lane	3.25m	Else	
		Side Walk	1.5m×2		
	Estimated Cost	5,200 million yen			
	Evaluation	- The total project cost will be the highest among the three proposals because the total bridge length will be the longest. - The overall project cost will be the highest among the three proposals because the total bridge length will be the longest, and the issue of the longitudinal alignment of the road to connect the entrance and exit of the FTZ facility is the same as in Alternative 1. The length of river improvement will be longer, and the burden of maintenance and management after improvement will be higher than other proposals.			

Note: Estimated cost includes detour construction, relocation of buried pipes such as power and communication pipes, consultant cost, and contingency cost.

Alternative-1:Main Stream Improvement（FTZ facility: Partial relocation）

[JICA Project] Design Flow Rate Q=1500m3/s



[Future Project] Design Flow Rate Q=1800m3/s

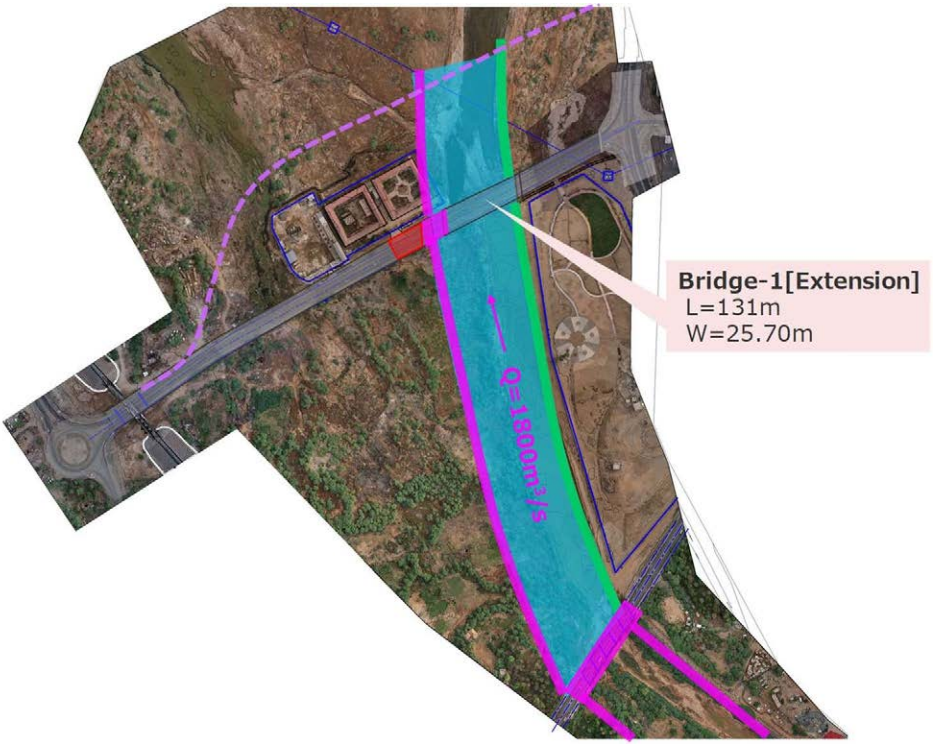
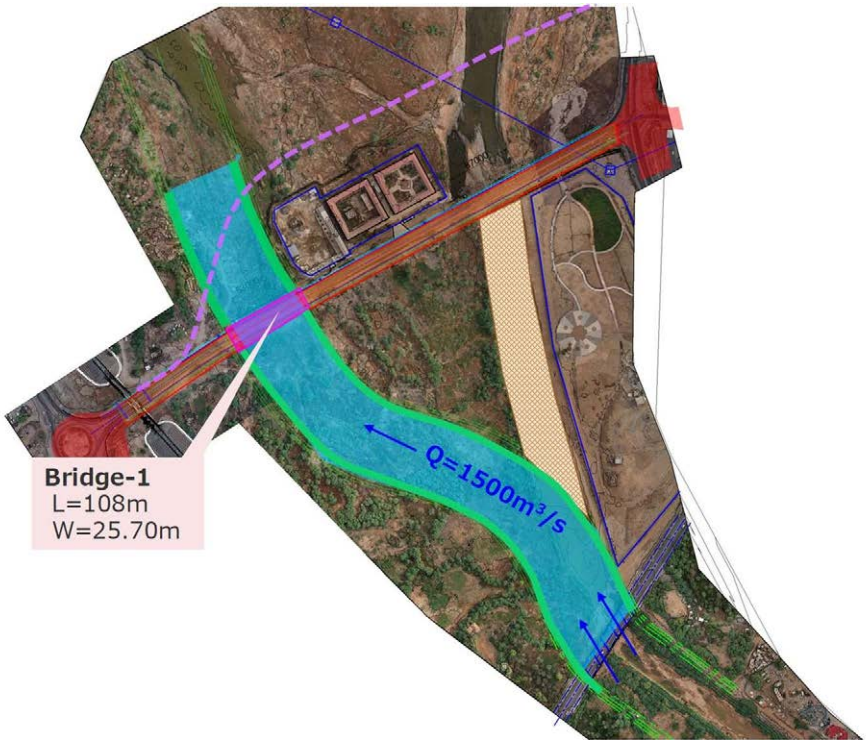


Figure 6.2.10 Outline of Plan（Alternative-1）

Alternative-2: Sub-Stream Improvement（FTZ facility: No relocation）

[JICA Project] Design Flow Rate Q=1500m3/s



[Future Project] Design Flow Rate Q=1800m3/s

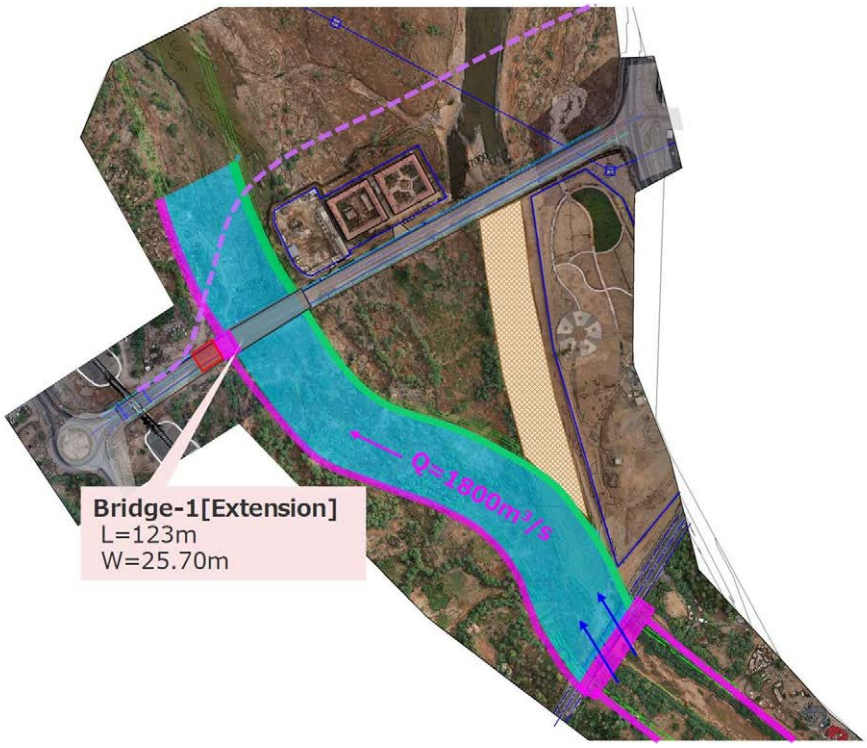
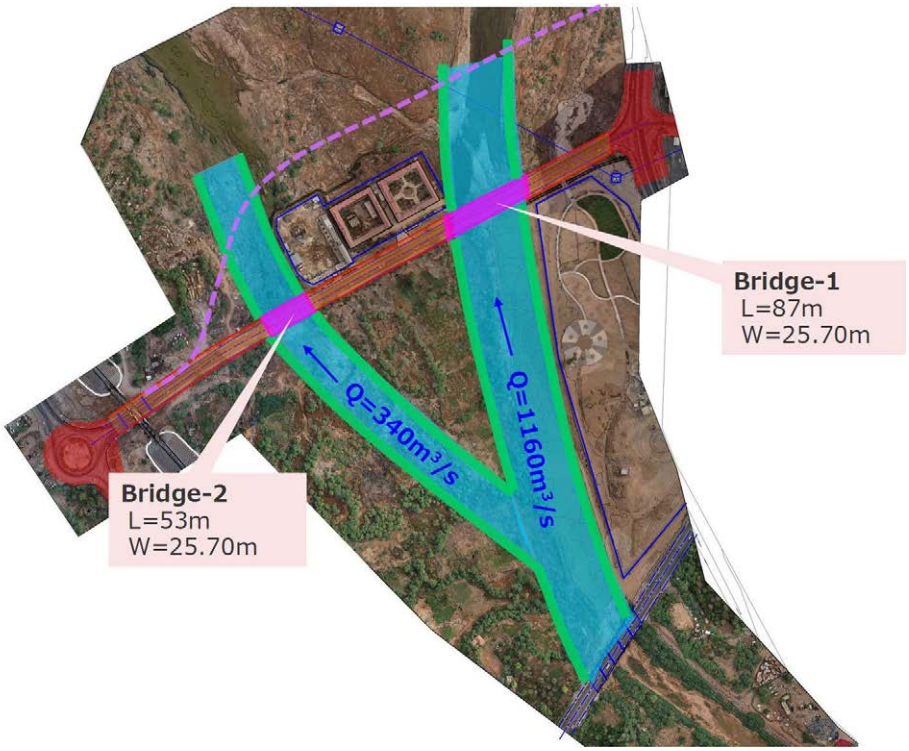


Figure 6.2.11 Outline of Plan（Alternative-2）

Alternative-3: Main and Sub-Stream Improvement（FTZ facility: No relocation）

[JICA Project] Design Flow Rate Q=1500m3/s



[Future Project] Design Flow Rate Q=1800m3/s

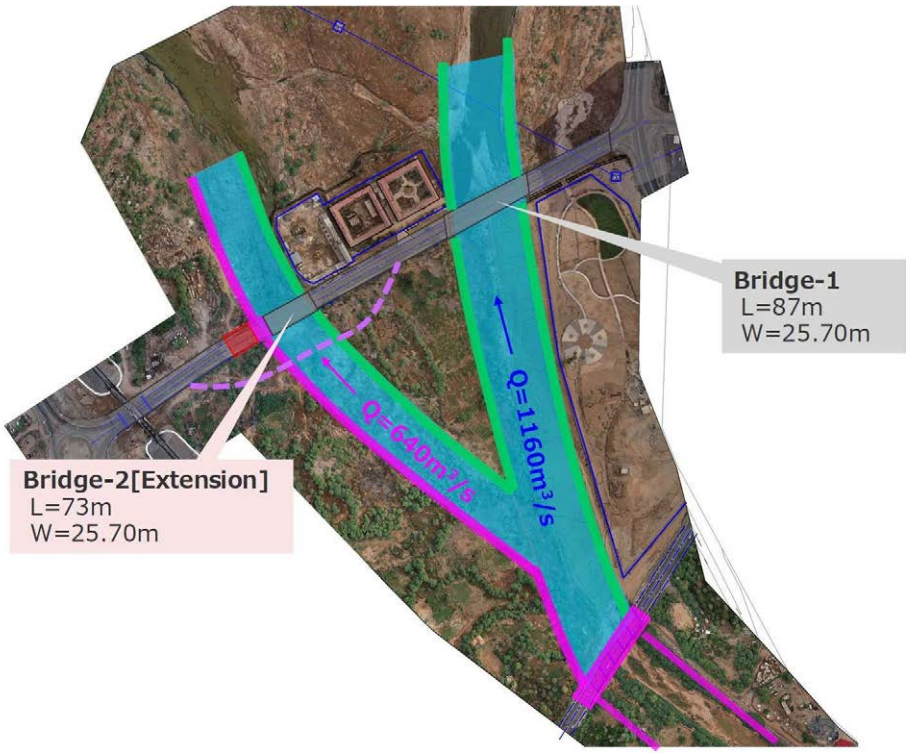


Figure 6.2.12 Outline of Plan（Alternative-3）

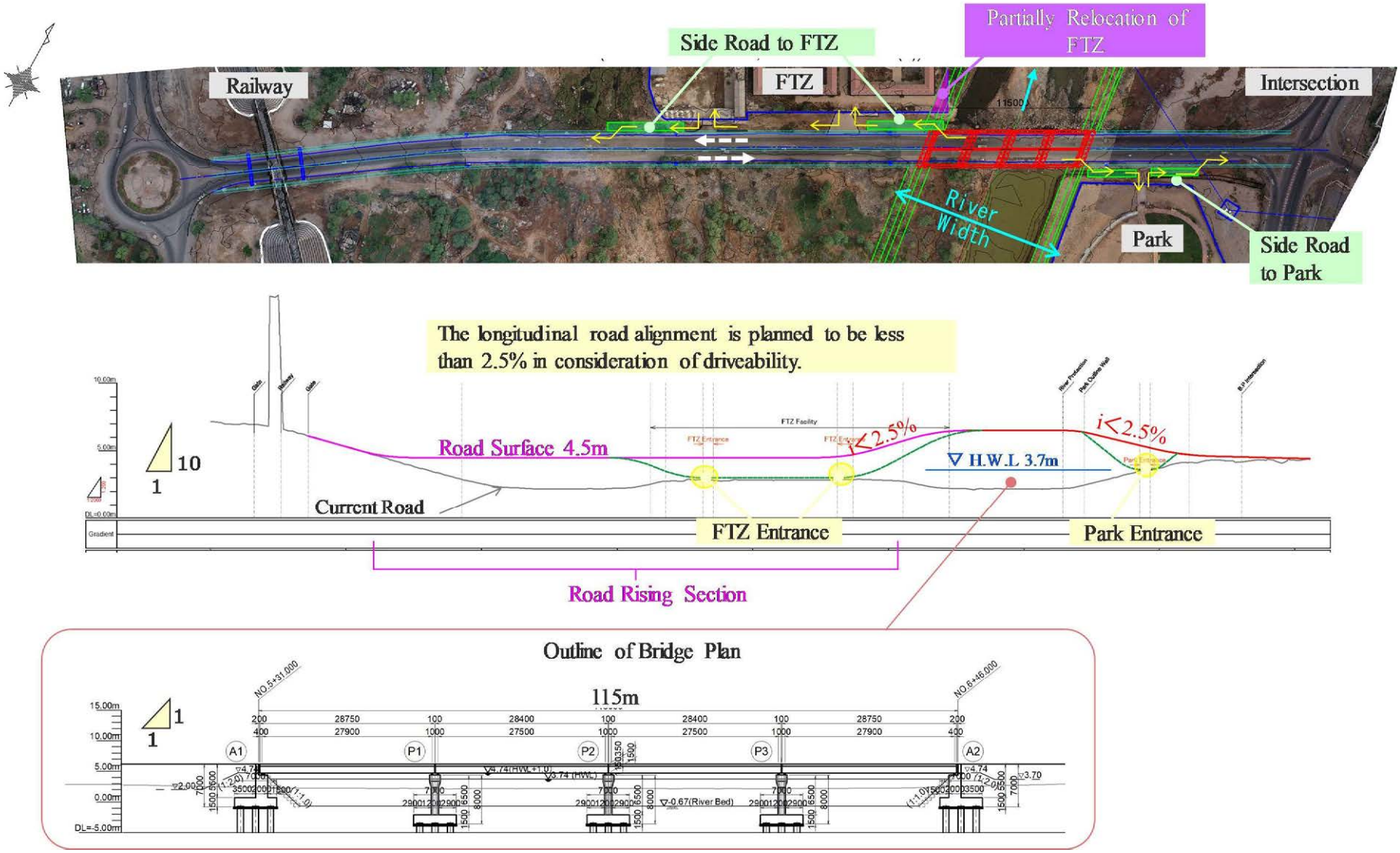


Figure 6.2.13 Outline Drawing of the Countermeasures (Alternative 1: Main Stream Improvement)

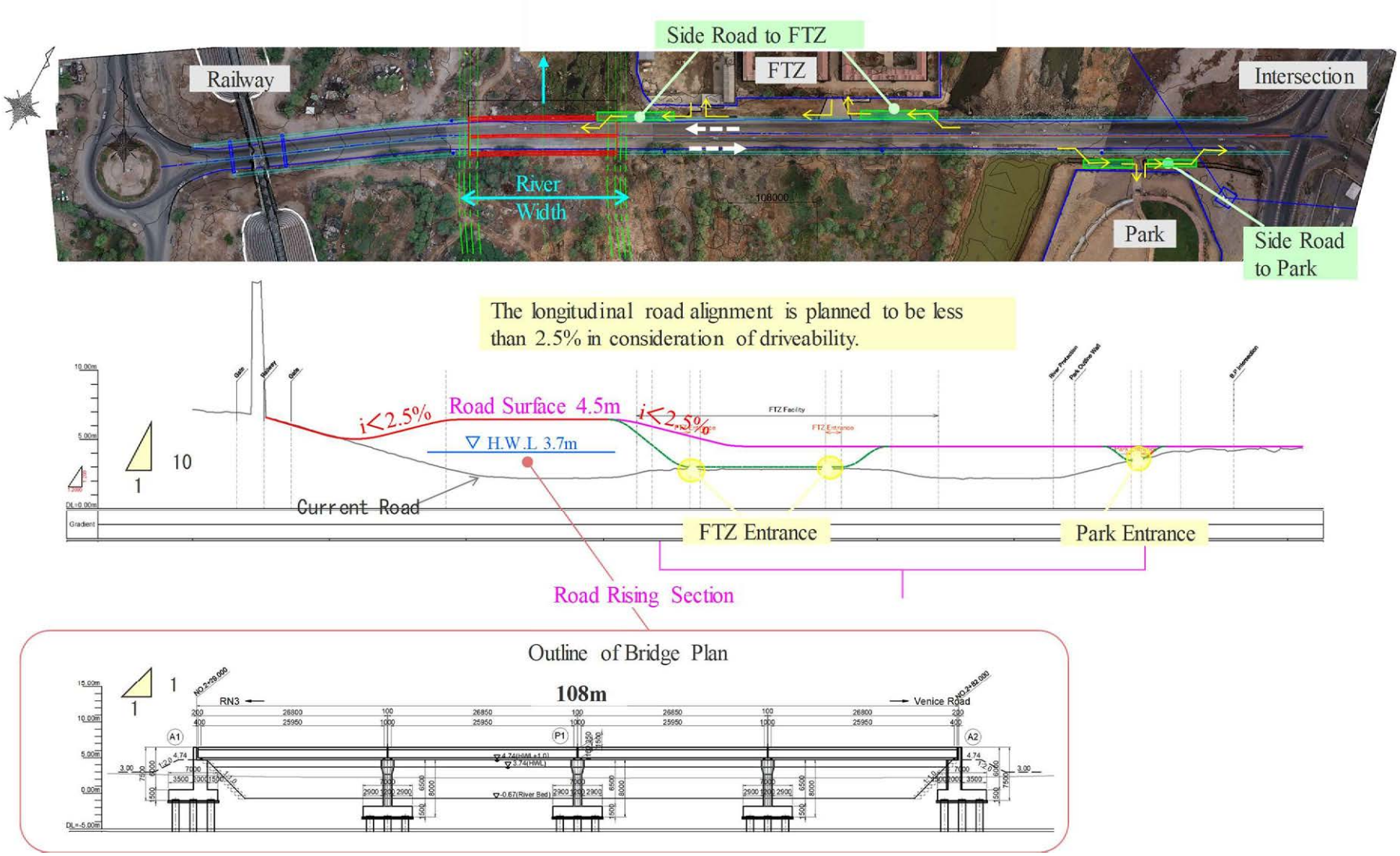


Figure 6.2.14 Outline Drawing of the Countermeasures (Alternative 2: Sub-stream Improvement)

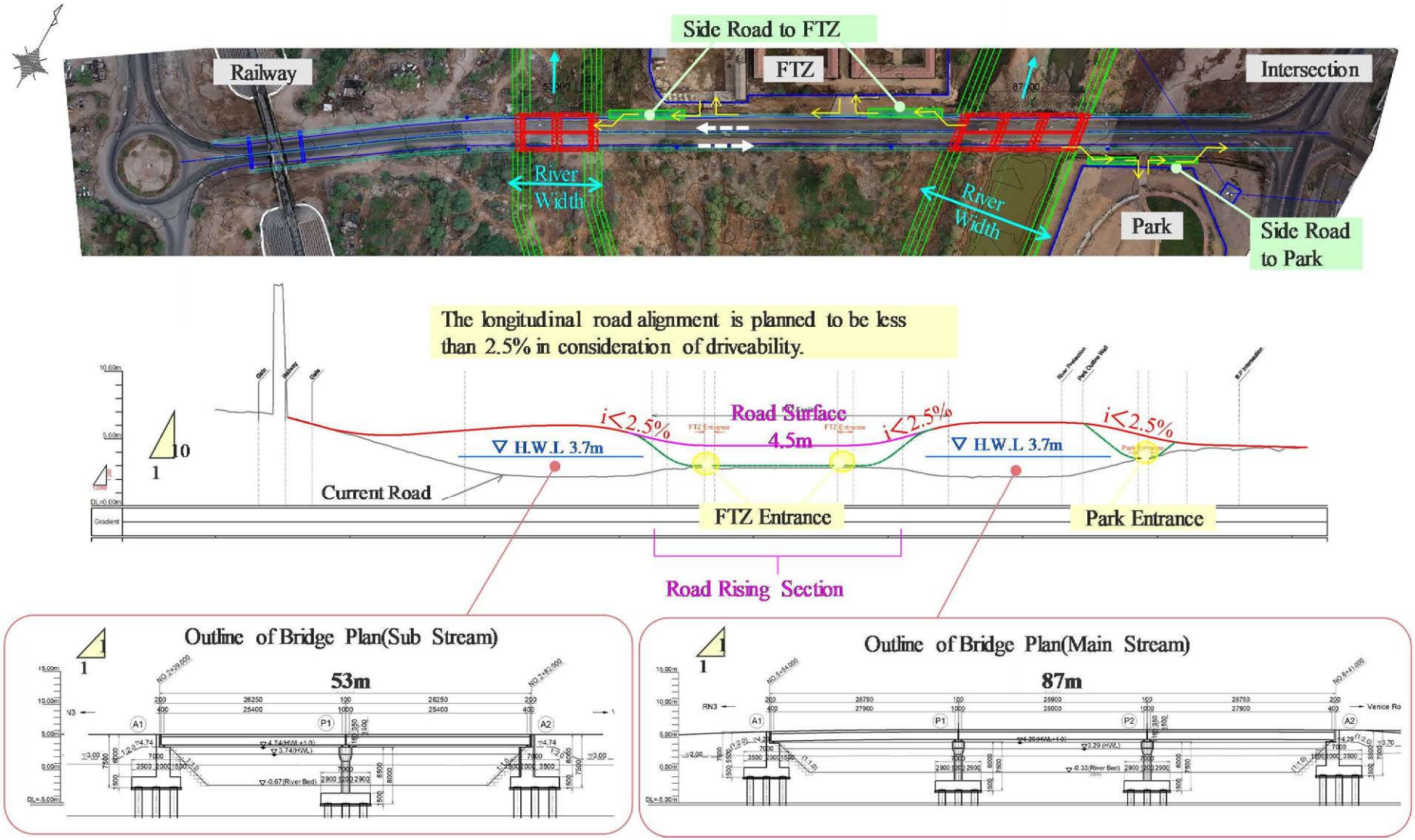


Figure 6.2.15 Outline Drawing of the Countermeasures (Alternative 3: Main+Sub-stream Improvement)

The followings are images of the completed form Alternatives 3 of Palmeraie Road.

Figure 6.2.16 Image of the Palmeraie Road Countermeasure (Alternative 3) [1/2]

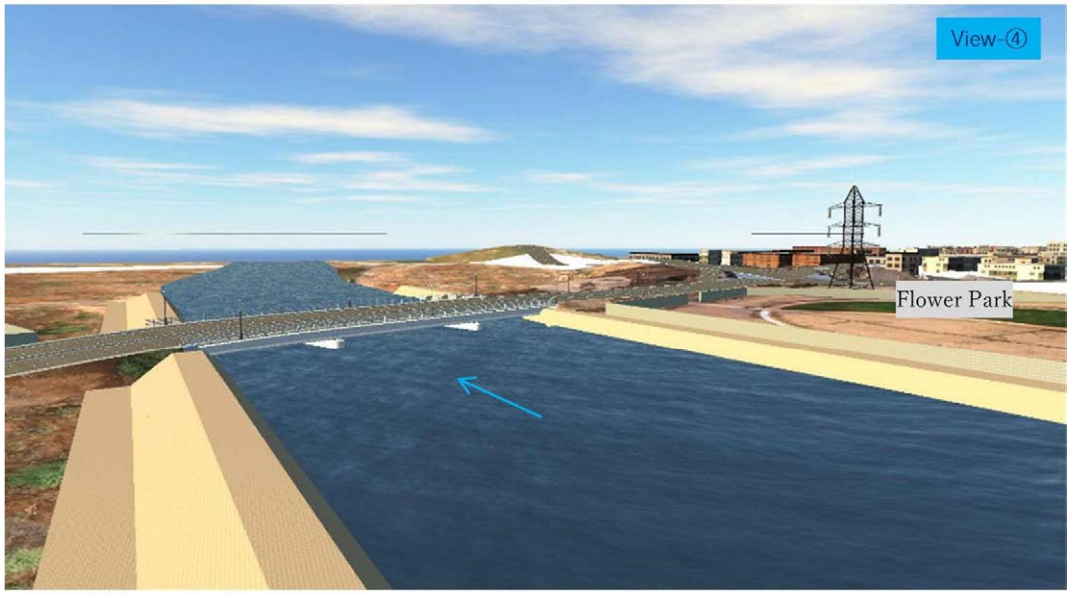


Figure 6.2.17 Image of the Palmeraie Road Countermeasure (Alternative 3) [2/2]

(8) Proposed Countermeasures Against Future Flood Risks

The planned flow rate of the Ambouli River in this study was set at 1,500 m3/sec based on the rainfall observation data for the past 40 years, taking into account the maintenance status upstream of the Italian Bridge and the scale of Japan's grant aid.

In addition, as shown in 4.3.3(1), the planned flow rate of 1,800 m3/sec (about 50-year probability) was set as the target, including the improvement of the area upstream of the Italian Bridge, in order to ensure resilience to climate change and floods in the future.

The following pages show the outline of each phase of the improvement described above, as well as the image of future improvement for the Alternative 1 and Alternative 3 described in (7) above.

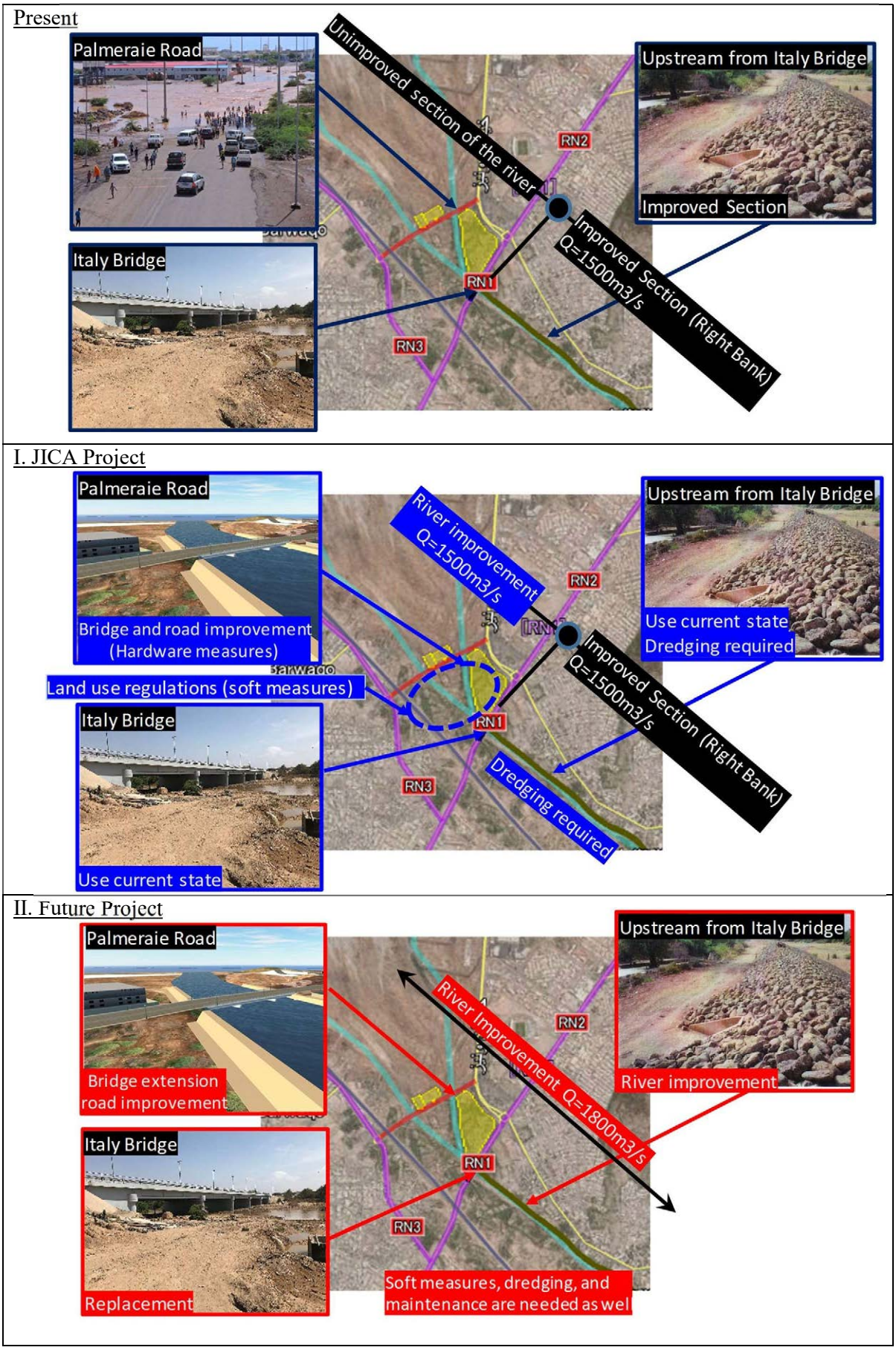
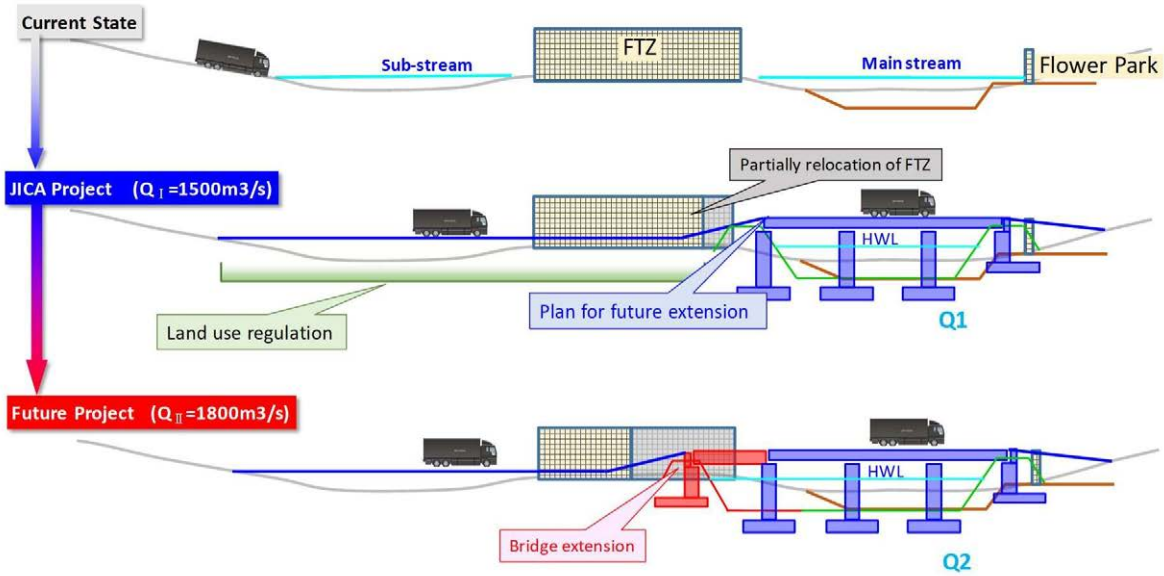


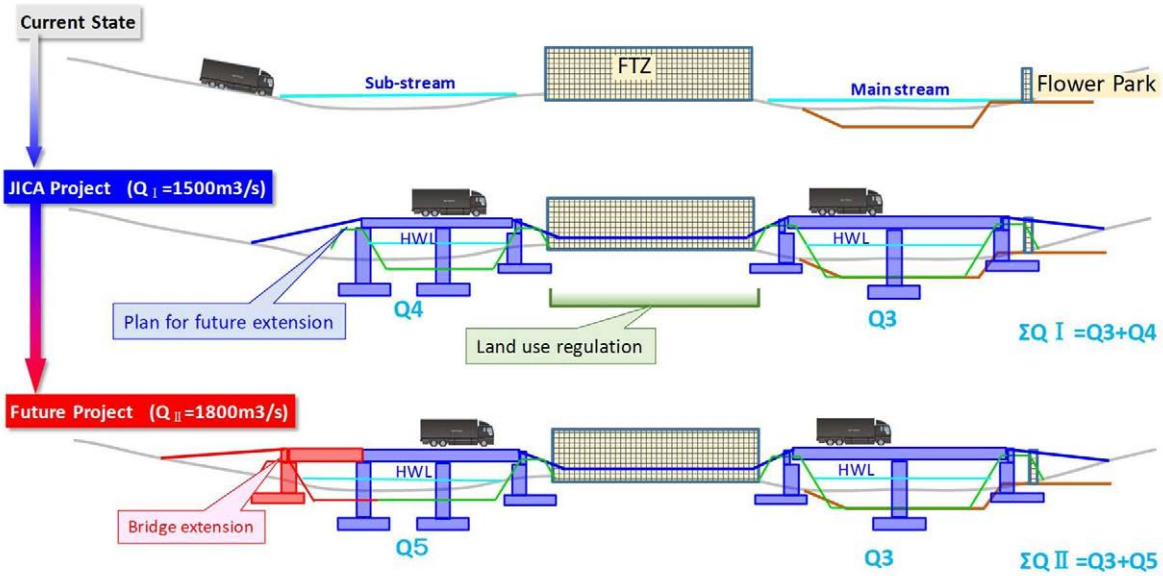
Figure6.2.18 Palmeraie Road Phased Improvement Plan (draft)

Alternative 1: Main Stream Improvement



- In the JICA project, the river will be improved and bridges will be constructed with the designed flow rate of Q1 (=1500m3/s).
- The planned future flow rate of Q2 (=1800m3/s) is to be met by widening the river channel and extending the bridges. In this case, it is necessary to planning for future extending at the JICA project stage.
- The Alternative 2 is basically the same policy, with the widening of the bridge on the sub-stream side.

Alternative 3 : Main + Sub-stream Improvement



- In the JICA project, river improvement and bridge construction will be carried out at the designed flow rates of Q3 and Q4 (1160m3/s and 340m3/s) for the main stream and the sub-stream, respectively.
- In the future, the river channel will be widened and the bridges will be extended to meet the flow rate of Q5 (640m3/s) on the sub-stream side (the bridge on the main stream side will not be extended).
- The bridge on the sub-stream side needs to be planned for future extending at the JICA project stage.

Figure 6.1.19 Proposed Phased Improvement of the Palmeraie Road and Structural Response (Alternative 1, Alternative 3)

(9) Study of Additional Countermeasures for Palmeraie road improvement

Each of the alternatives considered in the previous section (7) still has issues to be addressed in terms of consultation and coordination with the existing surrounding facilities (FTZ, Flower Park) and the scale of the project. Therefore, additional studies were conducted to meet these challenges.

Table 6.2.6 Palmeraie Road Improvement Issues and Additional Alternativess

Issue-1	[1] Coordination for partial FTZ relocation (Alternative 1)
Add. Alternative 1	・ To avoid relocation of the FTZ facilities, special retaining walls are applied to the river improvement sections that interfere with the FTZ facilities. ・ Future measures to be taken for the river improvement will be additional improvement on the sub-stream side to avoid relocation of the FTZ facilities. ・ (The basic policy for future correspondence is the same for other proposals)
Issue-2	[1] Coordination for partial FTZ relocation (Alternative 1), [2]Reduction of construction costs
Add. Alternative 2	• As for river improvement, as in the current situation upstream of the Italian Bridge, dikes will be built only on the right bank (city side), while the left bank will be improved simply.
Issue-3	[2]Reduction of construction costs
Add. Alternative 3	• The cost of construction will be reduced by constructing a road along the alignment of the detour route required for construction. As for the river improvement, the left bank is to be constructed only in a simplified manner as in Add. Alternative 2.

Note: The river improvement should be based on the main stream improvement (Alternative 1), which can reduce the coordination with surrounding facilities and the burden of maintenance and management.

A summary of the plan outline for the three additional Alternatives proposed above is shown in the Table 6.2.7, and a summary drawing for each plan is shown on the following pages.

Table 6.2.7 Summary and Evaluation of the Additional Alternatives for Palmeraie Road Countermeasures

Add. Alternative 1	Special Retaining Wall Arrangement				
	Assumptions	Partial relocation of FTZ facilities (The Flower Park is currently under construction, and demolition is expected to be difficult.)			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	115m	Earth Work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Lane Width	3.25m	Else	Special retaining wall
		Side Walk	1.5m×2		
	Estimated Cost	4,500 million yen			
	Evaluation	- A special retaining wall (assuming concrete sheet pile) will be placed on the left bank downstream from the Palmeraie Road, where the river cross section is close to the FTZ, to avoid relocating part of the FTZ facilities. - Construction cost will increase due to additional structures. - The longitudinal road plan to connect the FTZ facility and the park to the entrance/exit is the same as the Alternative 1 shown in (7).			
Add. Alternative 2	Simple Improvement of Left Bank Dike.				
	Assumptions	The dike on the left side of the river should be improved at the same simple level as upstream of the Italian bridge.			
	Outline of Plan	Item	Plan	Item	Plan
		Bridge Length	108m	Earth Work Width	24.5m
		Bridge Width	25.7m	Intersection	2 location
		Lane Width	3.25m	Else	Left side dike improved simply
		Side Walk	1.5m×2		
	Estimated Cost	4,300 million yen			

<table>
<tr><td></td><td>Evaluation</td><td colspan="4">- The improvement of the left bank of the river will be limited to a simple dike equivalent to the one upstream of the Italian Bridge to avoid countermeasures against the FTZ facility.
- Improvement of the left bank of the river will be carried out at the time of future planned flow in consideration of climate change. In this case, upstream improvements including the Italy Bridge are also necessary.
- It is possible to reduce investment in FTZs whose future existence is unclear.</td></tr>
<tr><td rowspan="8">Add.
Alternative 3</td><td colspan="5">Road Improvement with Detour Road Alignment</td></tr>
<tr><td>Assumptions</td><td colspan="4">Detailed study of river diversion plan</td></tr>
<tr><td rowspan="5">Outline of Plan</td><td>Item</td><td>Plan</td><td>Item</td><td>Plan</td></tr>
<tr><td>Bridge Length</td><td>108m</td><td>Earth Work Width</td><td>24.5m</td></tr>
<tr><td>Bridge Width</td><td>25.7m</td><td>Intersection</td><td>2 location</td></tr>
<tr><td>Lane Width</td><td>3.25m</td><td rowspan="2">Else</td><td rowspan="2">Simple dike(left bank)</td></tr>
<tr><td>Side Walk</td><td>1.5m×2</td></tr>
<tr><td>Estimated Cost</td><td colspan="4">4,500 million yen</td></tr>
<tr><td>Evaluation</td><td colspan="4">- It is the most economical among the alternatives due to the reduction of detour construction cost and the reduction of the scale of left bank river improvement.
- The construction cost for relocation and restoration of buried pipes can be reduced, and the construction period can be shortened accordingly.
- In the longitudinal road plan, coordination with FTZ facilities and park entrances and exits is unnecessary.
- The construction of the bridge is constrained by the presence of high voltage lines above the planned bridge site.</td></tr>
</table>

Note: Estimated cost includes detour construction, relocation of buried pipes such as power and communication pipes, consultant cost, and contingency cost.

Add. Alternative-1: Special Retaining Wall Arrangement

[JICA Project] Design Flow Rate Q=1500m3/s

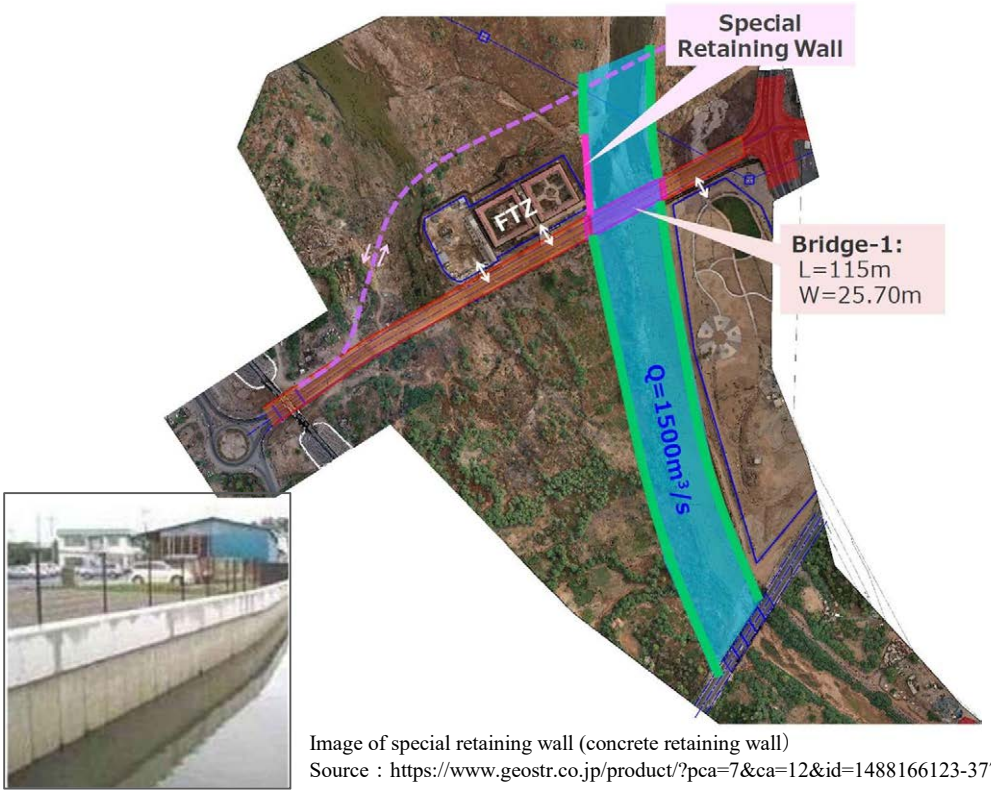


Image of special retaining wall (concrete retaining wall)
Source：https://www.geostr.co.jp/product/?pca=7&ca=12&id=1488166123-377633

[Future Plan] Design Flow Rate Q=1800m3/s

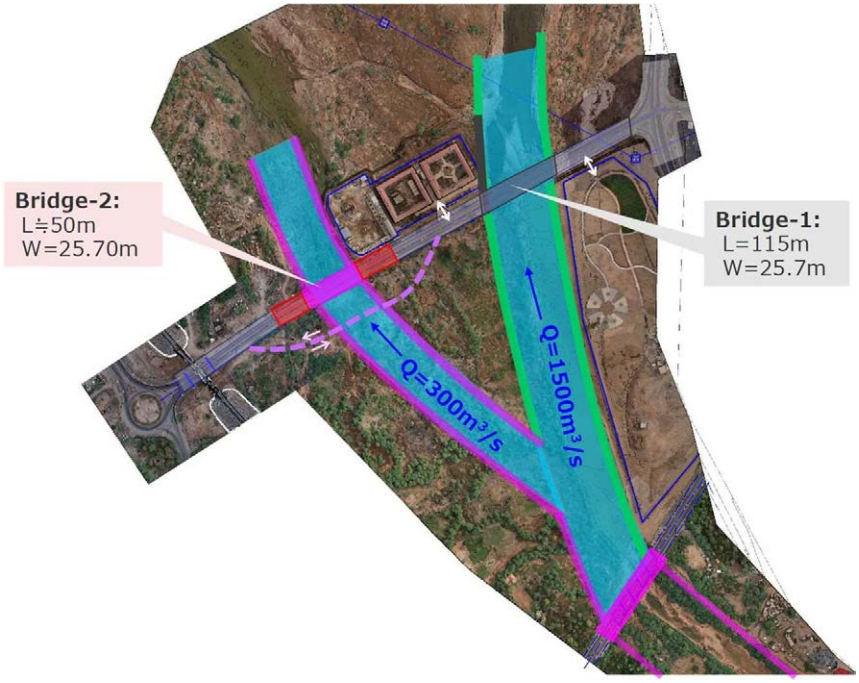
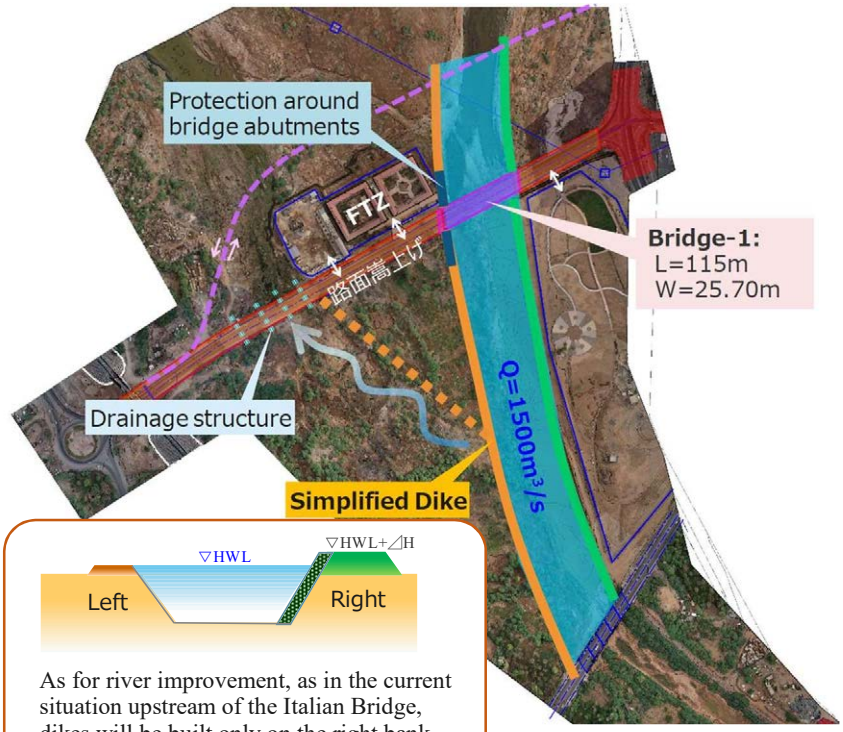


Figure 6.2.20 Outline of Plan（Add. Alternative-1）

Add. Alternative-2: Simplified Improvement of Left Bank Dike

[JICA Project] Design Flow Rate Q=1500m3/s



As for river improvement, as in the current situation upstream of the Italian Bridge, dikes will be built only on the right bank (city side), while the left bank will be improved simply.

[Future Plan] Design Flow Rate Q=1800m3/s

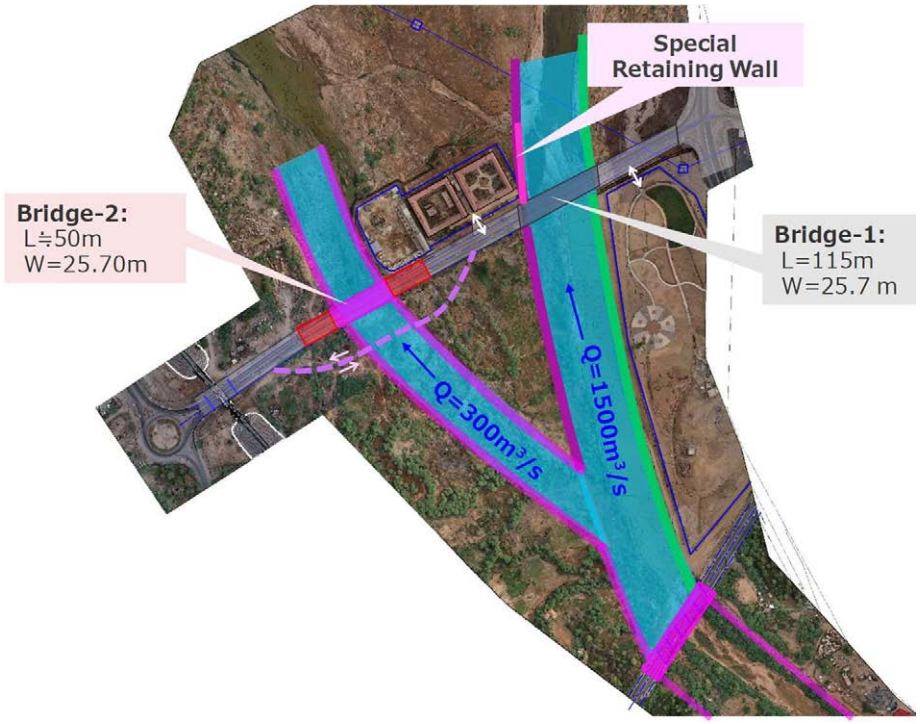
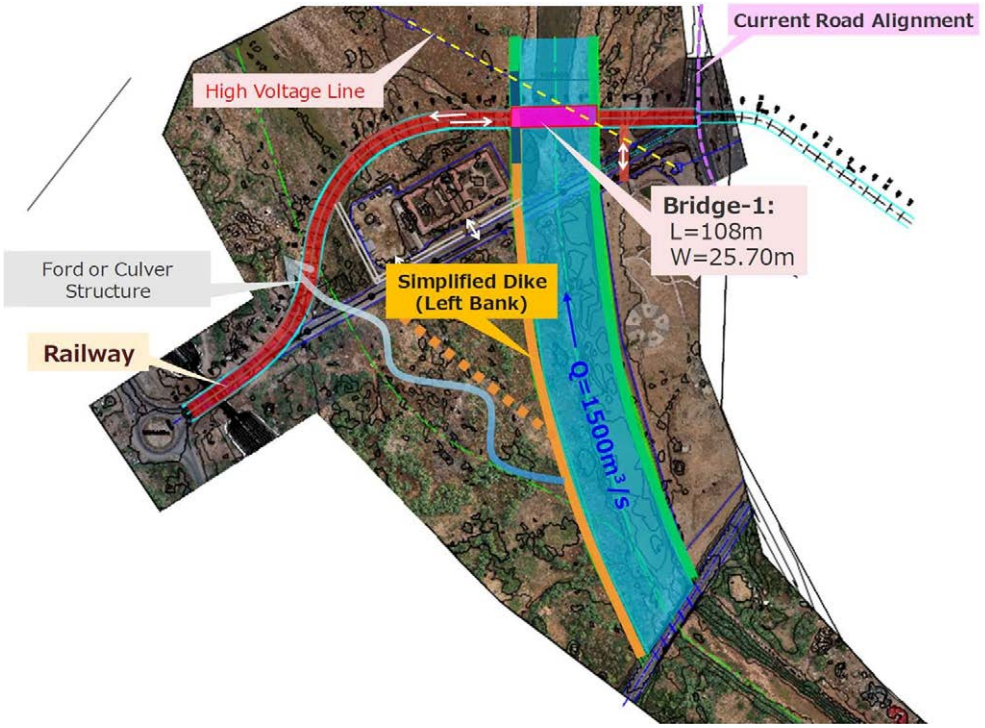


Figure 6.2.21 Outline of Plan（Add. Alternative-2）

Add. Alternative-3: Road Improvement with Detour Road Alignment

[JICA Project] Design Flow Rate Q=1500m3/s



[Future Project] Design Flow Rate Q=1800m3/s

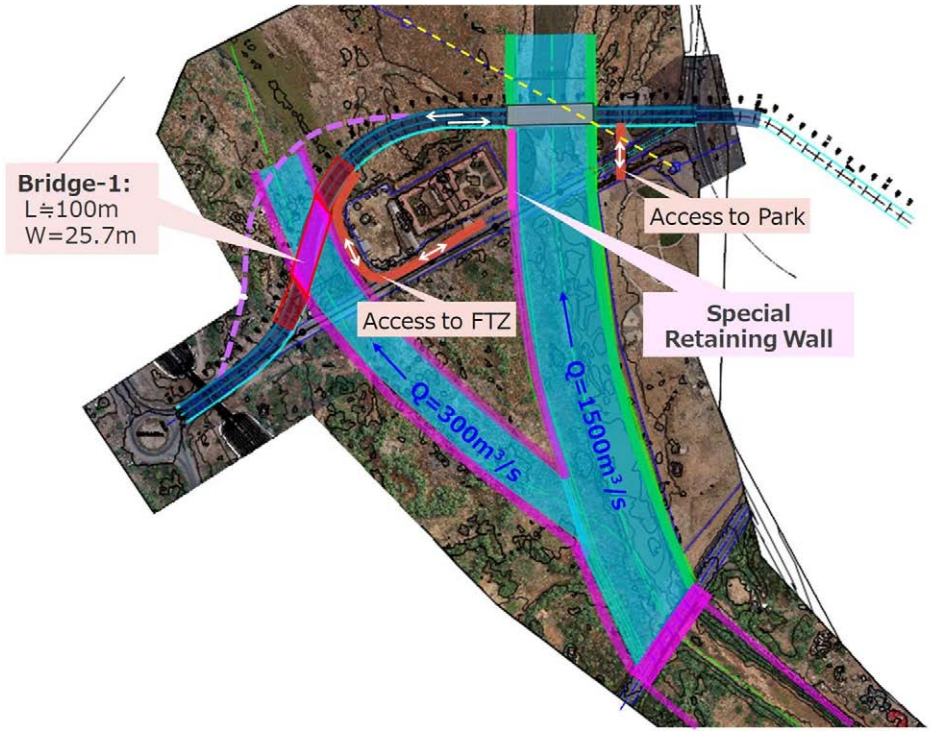


Figure 6.2.22 Outline of Plan（Add. Alternative-3）

(10) Summary of Palmeraie Road Improvement Contermeasures

- A summary of the results of each of the studies shown in (7) to (9) above is shown below.
- - The relocation of the FTZ and the modification of the Ambouli River alignment are likely to require time for negotiation and coordination with the relevant ministries and agencies, and are likely to be obstacles to early implementation of the measures (*Alternative 1, Alternative 2*).
- The alternative that divides the Ambouli River into a main stream and a branch stream can address the above issues, but it will increase the length of river maintenance of the Ambouli River. Considering the current maintenance and management system in Djibouti, the suitability of this alternative for the local region remains an issue. In addition, this alternative requires two bridges, which results in the highest project cost among the comparative proposals (*Alternative 3*).
- The following are among the additional alternatives that changed the level of river improvement and the alignment of road improvement based on the basic conditions of avoiding relocation of FTZ facilities and the current alignment of the Ambouli River;
  - The use of special retaining walls should be avoided as much as possible due to the uncertainty of future plans for the FTZ facility, and the high cost of construction (*Additional Alternative 1*).
  - The improvement of the road in the form of a detour route is expected to be constrained during construction due to the close distance of the bridge to the high voltage lines above, and it also remains an issue as a road alignment with heavy traffic (*Additional Alternative 3*).

Based on the above results, the Palmeraie Road improvement plan is considered to be superior to the "Additional Alternative 2" among the comparison Alternativess. However, since no consultations with related facilities were conducted in this study, and the topographical survey and buried object survey were limited, it is necessary to conduct these surveys and collect such information in future studies, and reconsider the suitability of this alternative.

(11) Calculation of Estimated Project Cost

The estimated project cost assuming a Japanese grant aid project is shown below.

In addition to calculating the project cost of the alternative judged to be superior in Section 6.2.1 (10), the advantages and disadvantages of this alternative were summarized.

Table 6.2.8 Estimated Project Cost（Palmeraie Road）

Project Policy	Scope of Work	Cost (million yen)
(1) River improvement corresponding to the planned flow rate of 1,500 m3/s (equivalent to the upstream of Italy Bridge) (2) River improvement on the right bank side where the urban area is located (same as upstream of the Italy Bridge) (3) Bridge construction according to the river cross section in (1) (4) Improvement of Palmeraie Road and intersection	Additional Alternative 2: (1) River Improvement River channel width: 95m (2) Bridge Construction Bridge length: 115m Width: 25.7 m (six lanes of traffic, 1.5 m sidewalk on each side) Bridge type: 4 span PC hollow slab bridge Foundation type: Pile foundation (3) Road and Intersection Improvement Length: 1,000m Width: 24.50m (roadway 3.25m x 6 lanes, sidewalk 1.5m on each side) Signalized intersection: 1, Roundabout right turn added: 1	Total Cost: 4,300 Breakdown of Main Construction Cost (1) River Improvement; 100 (2) Bridge Construction; 2,540 (3) Road, Intersection; 520 (4) Relocation of Utility Pipes; 400 (5) Other Works; 210 (6) Consultant Cost; 337 (7) Contingency Cost; 207 * (5) includes detour cost

■ Advantages
-The planned flow rate and channel improvement are consistent with the upstream plan.
-Maintenance and management (dredging, etc.) after completion of the project is easy because the river is integrated into the mainstream.

■ Challenges
-It is necessary to understand the detailed location and shape of buried objects such as power pipes and communication pipes.
-When the water level rises beyond the planned level, the water will flow to the tributary side, so it is necessary to consider measures to ensure the flow and the Palmeraie Road crossing.

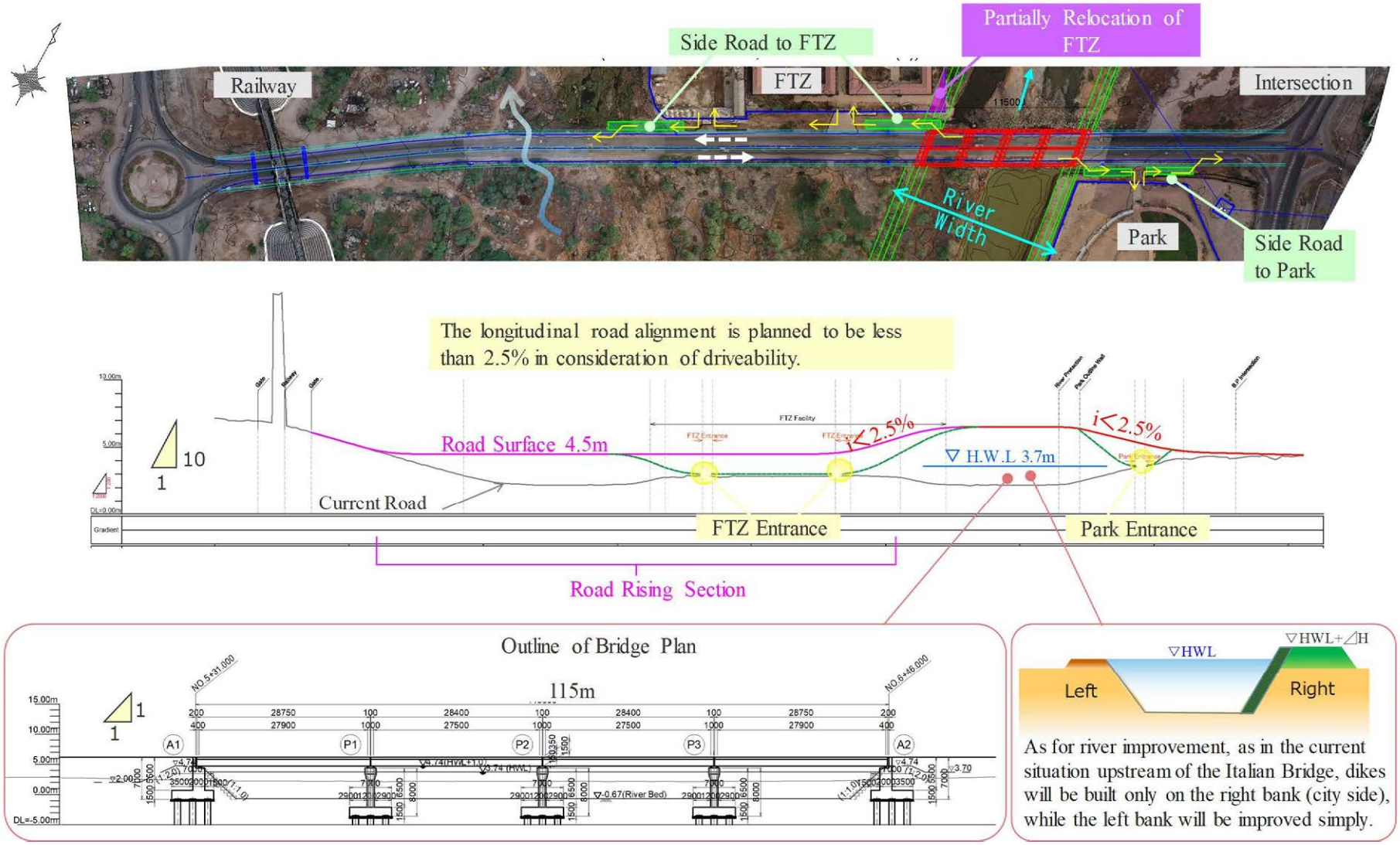


Figure 6.2.23 Outline Drawing of the Countermeasures (Additional Alternative 2)

6.2.2 Examination of Related Improvement Plan (Intersection Improvement)

Palmeraie Road intersects with other roads at both ends. As shown in the figure below, the eastside intersection is signalized and the west side one is roundabout.

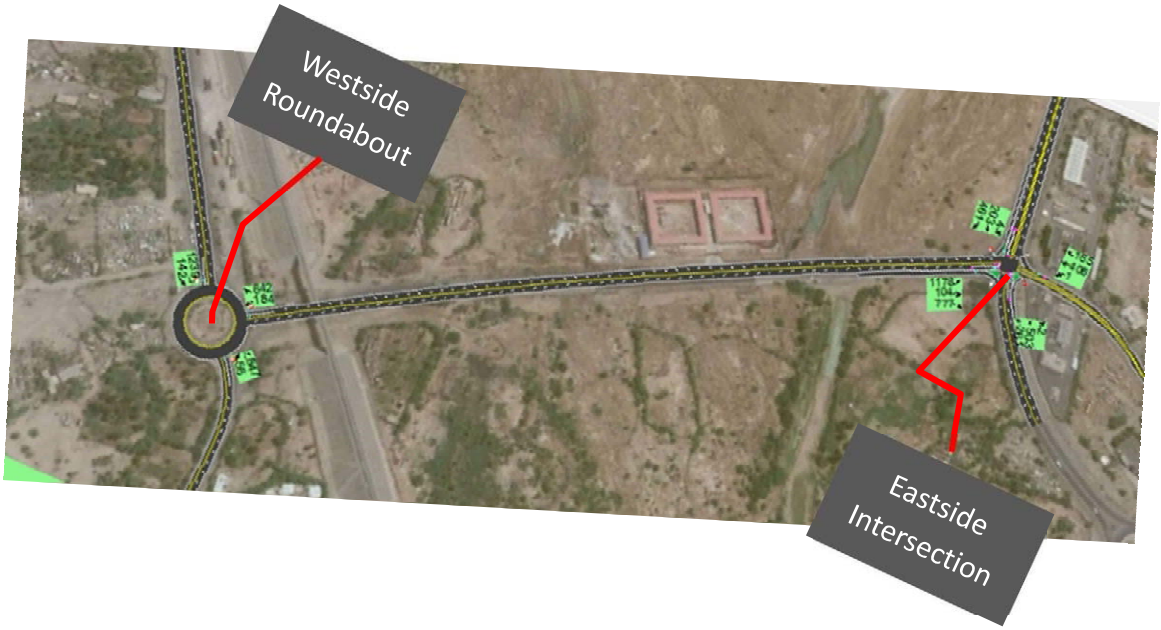


Figure 6.2.24 Palmeraie Road Intersection and Roundabout

The current morning peak traffic volume of the eastside intersection is 3,423 vehicles (4,065 PCU per hour), and that of the roundabout is 2,565 vehicles (3,110 PCU per hour). The east side intersection is more critical because of its proximity to the river and the high volume of traffic. An overview of the intersections is given below.

(1) Eastside Intersection

Current Status Analysis

As shown in Figure 6.2.25, the eastside intersection has heavy traffic from the direction of Balbala to the city center during the morning peak hours. This is especially noticeable for the traffic turning left onto Venice Road at the intersection. During the afternoon peak hours, the traffic in the opposite direction turning right from Venice Road and turning left from Fun City toward Palmeraie Road is high. Furthermore, the inbound EDD approach has only one lane, and although the traffic volume is low and is almost all through traffic towards Palmeraie Road, the efficiency of this intersection depends largely on the treatment of this traffic.

Table 6.2.9 shows the calculation of intersection saturation and congestion by each approach using traffic volumes and signal plan in the morning peak when the traffic of the intersection is highest. The current intersection saturation is 1.011, which is above the standard (less than 0.9), and some countermeasures are needed even in the current situation. In addition, the congestion level of Palmeraie Road and EDD approaches is high.

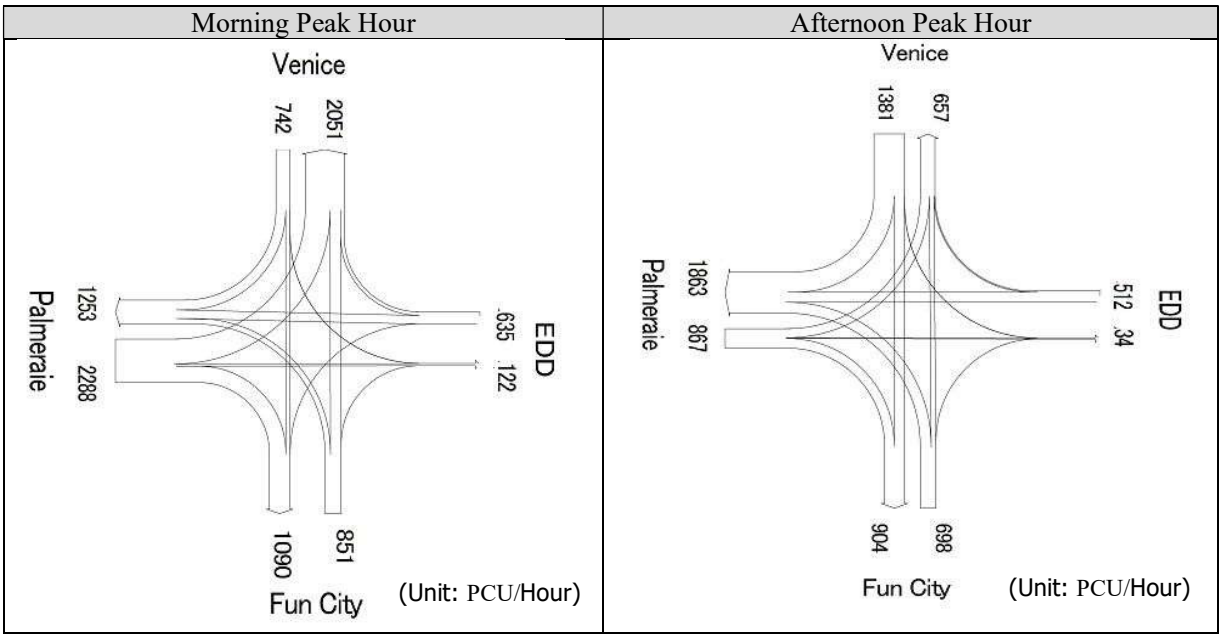


Figure 6.2.25 Volume of the Traffic Passing Through the Intersection on the East Side of Palmeraie Road

Table 6.2.9 Results of the Calculation of the Saturation at Intersection (current situation)

	Entrance		Palmeraie	Venice	EDD	Fun City
Demand rate of the intersections	Cycle length (seconds)		140			
	Loss time (seconds)		16			
	Signal phase demand ratio	1ϕ	0.353			
		2ϕ		0.111		
		3ϕ			0,295	
		4ϕ				0.252
	Degree of saturation of intersection			1.011	≥	0.9
Congestion by	Saturation flow rate		3,640	4,000	1,940	3,800
	Green ratio		0.19	0.26	0.19	0.26
	Design capacity (PCU/h)		692	1,040	369	988
	Demand (PCU/h)		1282	207	572	764
	Degree of congestion		1.85	0.20	1.55	0.77

Current existing layout

Examination of countermeasures

There are two ways to reduce congestion at intersections: structural measures, such as addition of new lanes and grade separation, and non-structural measures, such as the review of traffic regulations and signal timing. Figure 6.2.26 shows 3 at-grade and 1 grade-separated intersection alternatives.

In addition to widening the Palmeraie Road (left-turn lanes from 2 to 3, and total lanes from three), Proposal A-1 improves Fun City approach (right-turn lane to shared / right turn lane), Proposal A-2 improves EDD approach(shared through/left-turn lane to right-turn lane), and Proposal A-3 combines the above two improvements (widening Palmeraie approach and improving Fun City and EDD approaches). Proposal A-4 is a grade-separated alternative elevating two left-turn lanes from Palmeraie Road to Venice Road, and this requires widening Venice from its current three lanes to four lanes.

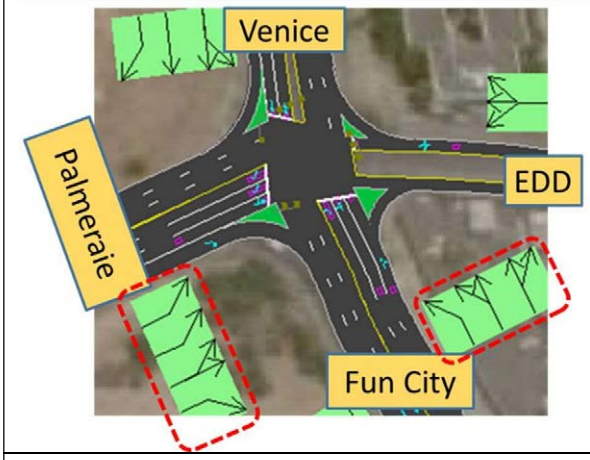
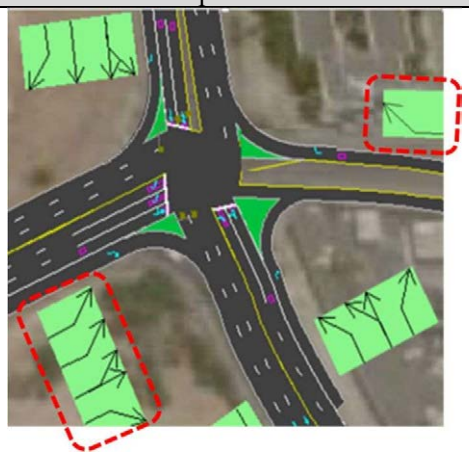
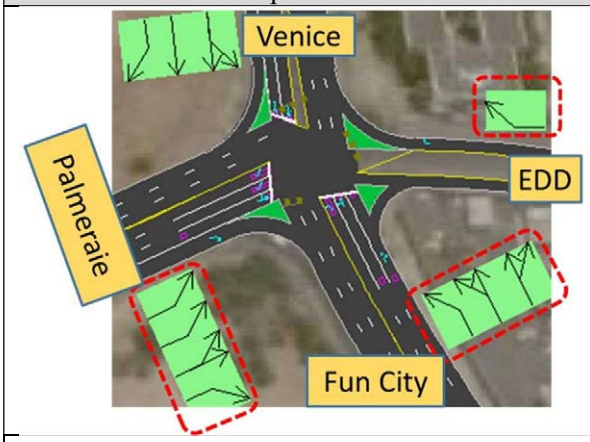
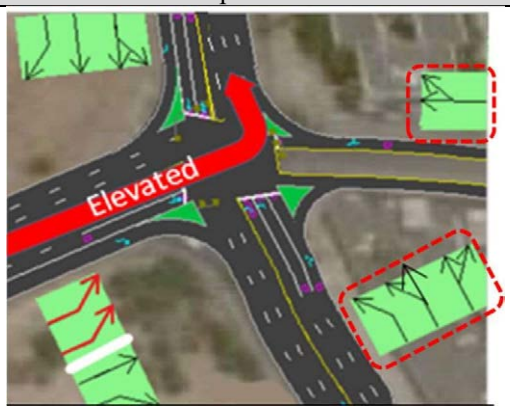
<table>
<tr><th>Proposal A-1</th><th>Proposal A-2</th></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td>• Palmeraie approach: A left turn lane added (from one lane to two lanes)
• Fun City approach: Right-turn lane⇒Through-right lane</td><td>• Palmeraie approach: A left turn lane added (from one lane to two lanes)
• EDD approach: Left-through lane ⇒ Right-turn lane</td></tr>
<tr><th>Proposal A-3</th><th>Proposal A-4</th></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>• Palmeraie approach: A left turn lane added (from one lane to two lanes)
• Fun City approach: Right-turn lane ⇒ Through-right lane
• EDD approach: Left-through lane ⇒ Right turn lane</td><td>• Palmeraie approach: Left-turn lane elevated (two lanes)
• Fun City approach: Right-turn lane ⇒ Through-right lane
• Exit side of Venice Road: 1 lane added (from 3 to 4 lanes)
• EDD approach: Left- through-right lane ⇒ Through-right lane</td></tr>
</table>

Figure 6.2.26 Improvement Alternatives for the Eastside Intersection of Palmeraie Road.

Table 6.2.10 shows the degree of saturation for each of the above alternative intersection plans for the years 2025, 2030, and 2035. The degree of saturation level of Proposal A-1 exceeds 0.9 except for the current condition and it will not able to handle the future traffic volume. Proposal A-2 can be handle the traffic until 2030, while Proposals A-3 and A-4 can handle until 2035.

The grade-separated intersection will ensure smooth flow of the left-turn traffic from Palmeraie Road to Venice, but the degree of saturation will be the same as that of Proposal A-3. In addition, the cost will be large, and there are still physical challenges, as the project may be affected by the high-voltage power lines that cross the Palmeraie Road. Therefore, Proposal A-3 is recommended in this study.

Table 6.2.10 Proposed Improvement Measures for the Eastside Intersection of Palmeraie Road

Measures		Saturation rate (AM peak)			
		2021	2025	2030	2035
Basic	Do nothing	1.011	1.180	1.434	1.742
A-1	Palmeraie: L-LT-R>>L-L-LT-R	0.834	0.974	1.182	1.438
A-2	Palmeraie: L-LT-R>>L-L-LT-R + EDD: LTR>>R	0.598	0.700	0.849	1.032
A-3	Palmeraie: L-LT-R>>L-L-LT-R + EDD: LTR>>R + Fun City: L-TL-R>>L-TL-TR	0.494	0.578	0.702	0.853
A-4	Elevated Palmeraie left turn + Fun City: L-TL-R>>L-TL-TR + Restriction of EDD left turn	0.513	0.599	0.727	0.884

Figure 6.2.28 shows the intersection plan drawing for Proposal A-3. Its basic concept is as follows:

- Since the entrance to the Flower Park and the intersection are close to each other, there is a need to locate the entrance road to the park outside the right turn lane of the intersection.
- The storage length at each approach was set as follows based on the traffic volume per signal cycle.

Table 6.2.11 Storage Length at Each Approach

AM		Palmeraie		Venice		EDD	Fun City
		Straight left	Right	Straight left	Right	Right	Left Straight right
Traffic volume per hour	Q0	2.211	1.340	357	795	285	2,021
Number of lanes	n	3	1	2	1	1	3
Traffic volume per lane (Q0/n)	Qn	737,0	-	178,5	-	285.0	673.7
Traffic volume per signal cycle (Qn/Cn)	Qc	28,7	-	6,9	-	11.1	26.2
Storage length (Qc ×6m)	L	172	-	42	-	67	157

PM		Palmeraie		Venice		EDD	Fun City
		Straight left	Right	Straight left	Right	Right	Left Straight right
Traffic volume per hour	Q0	745	750	816	1.566	81	2,006
Number of lanes	n	3	1	2	1	1	3
Traffic volume per lane (Q0/n)	Qn	248,3	-	408,0	-	81.0	668.7
Traffic volume per signal cycle (Qn/Cn)	Qc	9,7	-	15,9	-	3.2	26.0
Storage length (Qc ×6m)	L	58	-	96	-	19	156

(2) Westside Intersection

The west side roundabout is not problematic in its current state, but when left-turning traffic from the direction of Doralee onto Palmeraie Road increases in the future, it will be difficult to enter from the south. This will require a separate right-turn lane on Palmeraie Road from the south (see Figure 6.2.27).

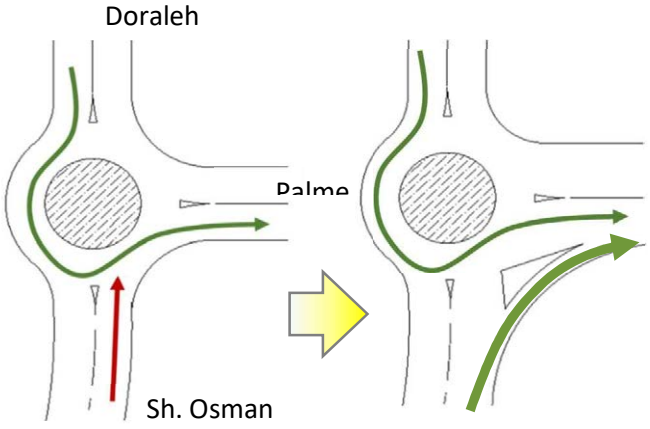


Figure 6.2.27 Proposed Palmeraie Road Westside Intersection Improvement

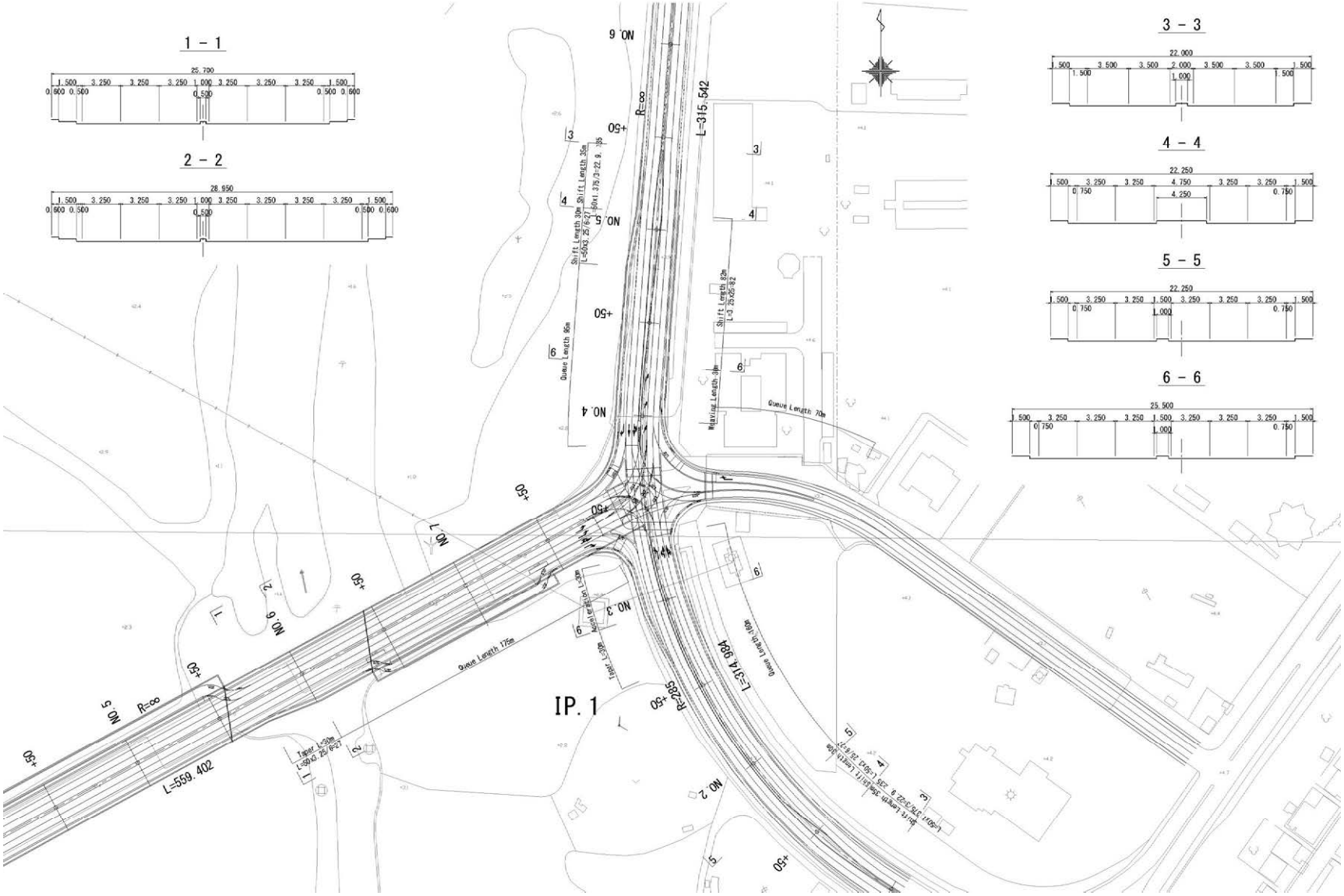


Figure 6.2.28 Improvement Plan Drawing for the Eastside Intersection of Palmeraie Road

6.2.3 Examination of Cost Reduction

Based on discussions with the Government of Japan based on the "Additional Alternative-2", which was judged to be superior among the alternatives, the following policy was presented regarding the content of support for the improvement of the Palmeraie Road.

- The measures should be aimed at strengthening against natural disasters.
- Further reduction of project costs should be pursued.

The largest part of the project cost is for bridge construction. However, bridge maintenance is the sole means of resilience against natural disasters, and it cannot be eliminated, so cost reduction measures in other portions of the project were considered. The outline of each proposal and the breakdown of the project cost are shown below.

Table 6.2.12 List of Cost Reduction Alternatives

	Support Contents					
	Scope of Work	Number of lane	Road Width	River Improvement	Bridge Construction	Intersection Improvement*1
Basic Plan	All	6 Lane	Standard	○	○	○
CR. Alternative-1	East Side	6 Lane	Standard	○	○	○ (East Side)
CR. Alternative-2	East Side	4 Lane	Standard	○	○ (4Lane)	—
CR. Alternative-3	All	6 Lane	Roadway-Reduction Sidewalk-One side *2	○	○	○ (East Side)

*1 Reduce the amount of pavement replacement and signal replacement at intersections.
*2 Standard width: 25.7m (guard fence 0.6m×2, walkway 1.5m×2, shoulder 0.5m×2, lane 3.25m×6, median 1.0m)
Reduction width: 22.2m (guard fence 0.6m×2, walkway 1.5m×1, shoulder 0.5m×2, lane 3.00m×6, median 0.5m)

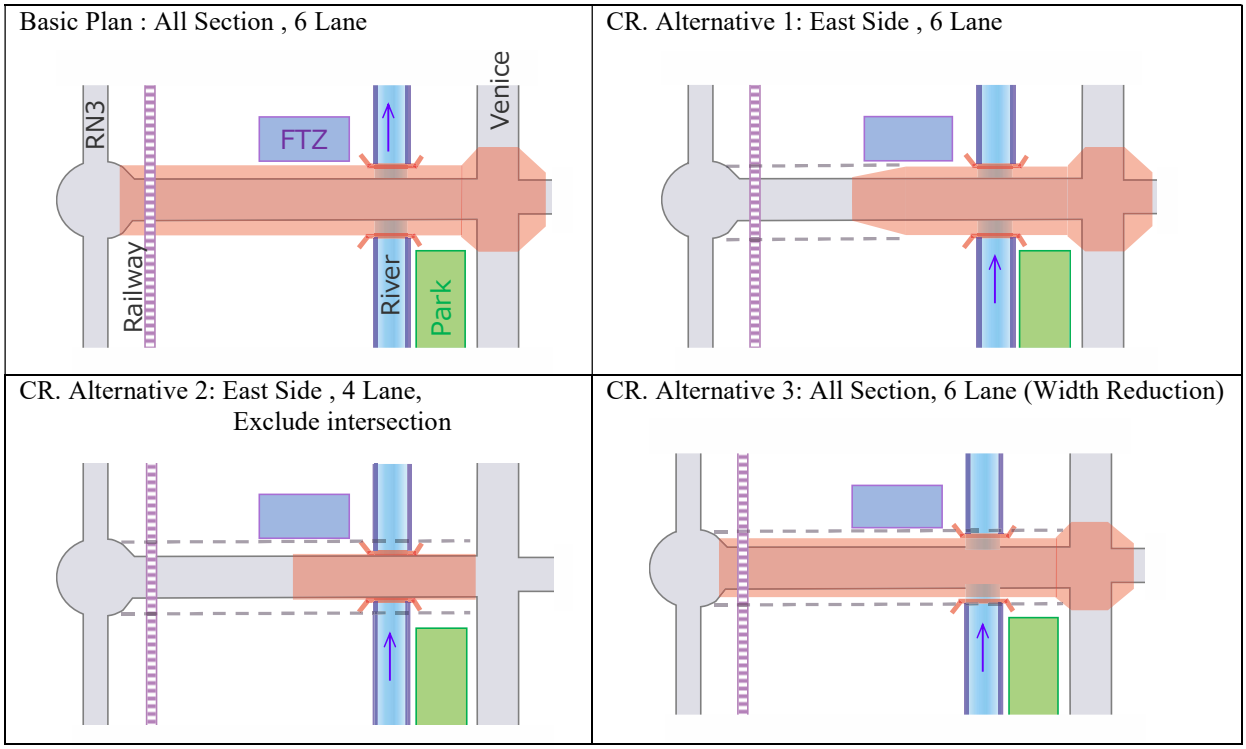


Figure 6.2.29 Outline of Cost Reduction Alternatives

Table 6.2.13 Cost Breakdown of Cost Reduction Alternatives

	Summary	Scope of Work	Estimated Cost（million yen）	
Basic Plan	All six lanes between the east intersection and the west intersection will be improved.	Bridge Length: 115m Bridge Width: 25.70m Lane Width: 3.25m Side Walk: 1.5m×2 Earth Work Width: 24.50m Intersection: 2 Location	River Improvement: Bridge: Road, Intersection: Relocation utilities: Others: Consultant Cost: Contingency Cost: Total	100 2,540 520 400 210 337 185 **4,300**
CR. Alternative 1	Six lanes between the east intersection and bridge will be improved	Bridge Length: 115m Bridge Width: 25.70m Lane Width: 3.25m Side Walk: 1.5m×2 Earth Work Width: 24.50m Intersection: 1 Location (East Side)	River Improvement: Bridge: Road, Intersection: Relocation utilities: Others: Consultant Cost: Contingency Cost: Total	100 2,540 210 300 180 292 160 **3,800**
CR. Alternative 2	Four lanes for only bridge will be improved	Bridge Length: 115m Bridge Width: 19.20m Lane Width: 3.25m Side Walk: 1.5m×2 Earth Work Width: 18.00m Intersection: ---	River Improvement: Bridge: Road, Intersection: Relocation utilities: Others: Consultant Cost: Contingency Cost: Total	100 2,000 80 300 180 236 130 **3,100**
CR. Alternative 3	All six lanes with reduced road width between the east intersection and the west intersection will be improved.	Bridge Length: 115m Bridge Width: 22.20m Lane Width: 3.00m Side Walk: 1.5m×1 Earth Work Width: 21.00m Intersection: 2 Location	River Improvement: Bridge: Road, Intersection: Relocation utilities: Others: Consultant Cost: Contingency Cost: Total	100 2,370 470 400 210 315 174 **4,100**

6.2.4 Project Evaluation

(1) Necessity of the Project

Floods in the Ambouli River, which divides Djibouti City into east and west, have occurred repeatedly every year and have had a great impact on the lives of citizens and economic activities. The development of roads that are flood-resistant is an urgent and important subject for Djibouti. In particular, the Palmeraie Road is the most heavily trafficked road crossing the Ambouli River and is an important route. In addition, it would be critical for Djibouti if large trucks used for logistics could not pass through, so immediate countermeasures are required. The validity of implementing this project as Japan's grant aid is evaluated from the following two points.

Securing highly reliable logistics functions

In the Horn of Africa region, Ethiopia has become the economic center of the region. However, Ethiopia is a landlocked country, and any maritime trade with the world requires passage through another country.

Ethiopia's relationship with Eritrea is poor, and the country is rarely used as a gateway for cargo to and from Ethiopia. Somalia, on the other hand, is not being used as a gateway for cargo to and from

Ethiopia because of the lack of security and the resulting slow infrastructure development. Therefore, most of the cargo going to Ethiopia and exported from Ethiopia uses Djibouti as a gateway[1].

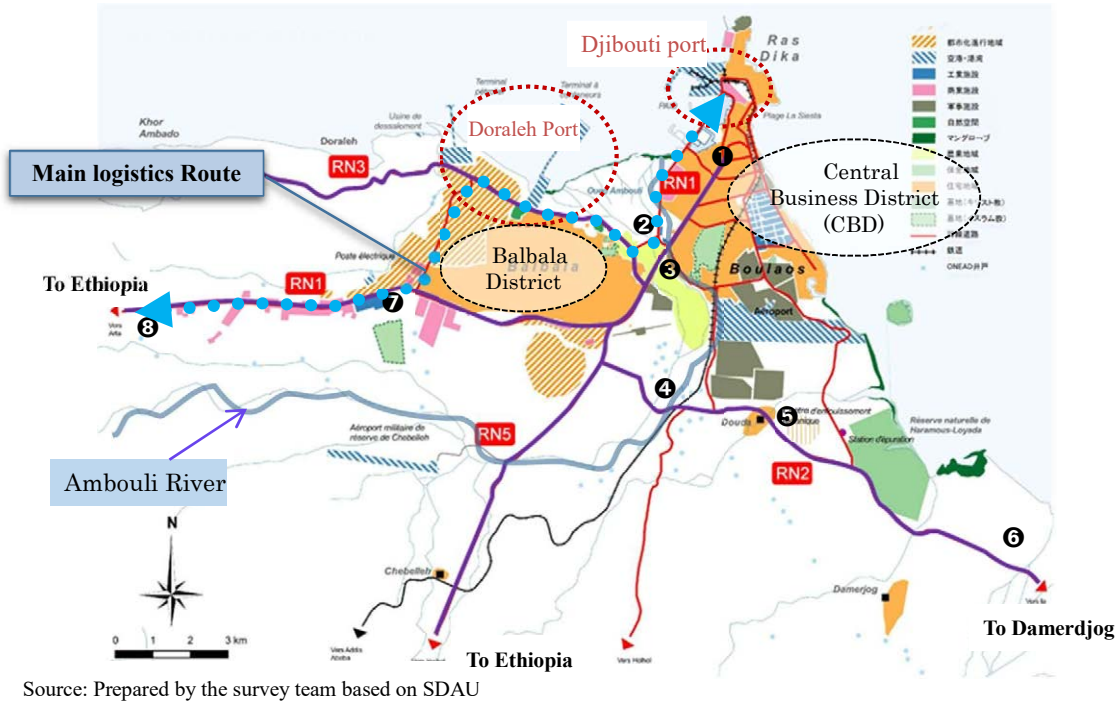
There is no industry in Djibouti, and the main industry is the port and logistics industry.Djibouti's GDP per capita is $3,310 (World Bank, 2019), compared to less than $1,000 per capita in Eritrea and Ethiopia. Logistics between Djibouti and Ethiopia is via the Port of Djibouti on the east bank of the Ambouli River - Palmeraie Road - Port of Doraleh - National Route 1 (see Figure 6.2.29). As shown in Table 6.2.14, the total volume of freight vehicle traffic on the Palmeraie Road is 1,565 trucks/day and 1,000 trailers/day (corresponding to point № 2), and compared to other points on the goods flow line (№ 7 and 8), the total volume of freight vehicle traffic is the highest.

Table 6.2.14 Results of Traffic Volume Survey on Logistics Main Road

№	Survey Site	Survey Duration	Traffic Volume by Vehicle Type						
			Motor-bike	Car	Public	Truck	Trailer	Total	Truck + Trailer
2	Palmeraie	24hr	3,502	17,436	8,047	1,565	1,000	31,550	2,565
7	RN1-PK20	14hr	58	1,412	997	683	1,820	4,970	2,503
8	RN1-PK24	24hr	31	999	239	283	2,122	3,674	2,405

Note: Survey date №2: May 19 2021, №7, 8: May 20 2021

In addition, upstream of the Palmeraie Road, there is the Italy Bridge, which was built in 1980, but since its damage was discovered in 2017, the passage of large cargo vehicles has been restricted, and cargo vehicles from the Port of Djibouti, located in the eastern urban area, must pass through the Palmeraie Road. In addition, there are only three roads crossing the Ambouli River, including the Palmeraie Road, and the only one that is barely passable even during floods is the Italian Bridge. It is impossible for the Italian bridge alone to handle all the automobile traffic, which is nearly 60,000 vehicles per day in cross-sectional traffic volume, resulting in a citywide traffic congestion. As described above, the development of the Palmeraie road is extremely important to secure a reliable logistics function.



Source: Prepared by the survey team based on SDAU

Figure 6.2.30 Logistics Lines and Traffic Survey Points in Djibouti City

[1] About 80% of the import cargo at the Port of Djibouti is destined for Ethiopia. In addition, exports from Ethiopia have been increasing in recent years, rising to about 30% of total volume (refer to Chapter 3).

Strengthen Connectivity between East and West Urban Areas

There have been seven major natural disasters in the Ambouli River basin in the past, from 1989 to the present. In particular, in recent years, floods have occurred three years in a row, which is assumed to be related to climate change. The duration of floods ranges from one to five days, during which time it is difficult to cross the Ambouli River. Since major urban functions are concentrated on the east side of the Ambouli River and many citizens usually cross the river to commute to work or school, economic activities and the lives of citizens will be significantly affected. In addition, the transportation sharing ratio in Djibouti is 20% for public transportation, 50% for walking, 3% for private cars, and the rest for cabs and corporate buses (World Bank survey). In other words, excluding walking, more than 90% of the total population uses some form of public transportation, including buses, which shows the importance of public transportation in Djibouti. Most of the bus routes connect the east and west sides of the Ambouli River, with the Palmeraie Road and the Italian Bridge being the routes (World Bank survey results). Based on the results of the traffic survey conducted this study, the number of people using public transportation on the Palmeraies Road and the Italian Bridge crossing the Ambouli River was estimated to exceed 100,000 per day for both Palmeraie Road and the Italian Bridge, indicating the importance of both roads as bus routes. This indicates the importance of both roads as bus routes. In other words, the strengthening of the Palmeraie Road, which has the function of connecting the east and west urban areas, is highly appropriate for the improvement of the roads in order to maintain a smooth life of citizens.

(2) Estimation of the Amount of Economic Benefits and Economic Internal Rate of Return

The following benefits will accrue from widening the Palmeraie road to 6lanes and making it passable even during floods

a) Eliminate time loss due to the closure of the Palmeraie Road during floods (Palmeraie Road, Italy Bridge)
   If the Palmeraie Road becomes impassable, the Italy Bridge upstream is the only alternative. The time loss of detouring to the Italy Bridge and the time loss of congestion on the Italy Bridge due to this detour will be calculated as a benefit.

b) Benefits associated with reduced travel time due to 6-lane widening on Palmeraie Road and intersection improvement
   The improvements of the Palmeraie Road and the eastern intersection will increase the travel speed and shorten the travel time. In addition, the improvement of the Palmeraie Road will reduce the traffic load on the parallel Italy Bridge, and the time required to pass through the Italy Bridge will also be reduced.

c) Eliminating economic losses in the logistics industry due to the closure of the Palmeraie Road during floods
   As the Port of Djibouti functions as the only port for Ethiopia's import and export, Djibouti's logistics-related industry is established. And the foreign currency it earns contributes to raising GDP of Djibouti. The Palmeraie Road is located at the center of the Djibouti-Ethiopia logistics corridor, and the impact of the closure of the Palmeraie Road on Djibouti's logistics industry is calculated as a benefit.

The preconditions and results for the calculation of the benefits of the above3 points are shown below.

Time loss due to road closure

Assumptions for the calculation:

- National income per capita: 3,594 US$[2] (as of 2021)
- Labor share:0.7 (set value)
- Employment rate: 43.0% (% of total population, as of 2019, UNDP)
- Average income per worker (yen): 3,594 x 111.364 yen[3] x 0.7 / 0.43 / 260 days = 2,506 yen/day
- Number of people passing through Palmeraie Road: 126,000 people[4] (as of 2021, excluding cargo vehicles)
- Number of people passing through the Italy Bridge: 105,000 people (as of 2021, excluding freight vehicles)
- Number of days closed per year: 3.3 days[5]
- Lost time due to road closure: 2 hours for Palmeraie Road, 1 hour for Italy Bridge)
- Percentage of the population contributing to economic activity: 35 %.

Result of calculation of benefit amount:

- 2,506 yen x (126,000 x 2/8 +105,000 x 1/8) x 3.3 days x 260/365 x 0.35 = 92,007,000 yen

Time-saving benefits from the Palmeraie Road improvement

Assumptions for the calculation:

- Time evaluation value: 2,506 yen / 8 hour = 313 yen / person / hour
- Reduction in time (peak hour) due to Palmeraie Road improvement: 2.0 minutes (road section: 1.0 minute, intersection: 1.0 minute)
- Reduction in travel time on the Italy Bridge due to the Palmeraie Road improvement (peak hours): 1.0 minute
- Peak hour traffic ratio: 30% of current level (as of 2021) to be increased annually in proportion to the growth in traffic volume (4.02%)[6]
- Percentage of the population contributing to economic activity: 35 %.

Result of calculation of benefit amount:

- 313 yen x (126,000 x 2/60 +105,000 x 1/60) x 260 day x 0.35 x 0.3 = 50,842,000 yen

Economic loss in the logistics industry

Assumptions for the calculation:

- Djibouti Corridor (Djibouti - Addis Ababa) transportation cost[7]: (export) 160,000 ETB / vehicle (= 372,800 yen/vehicle) for export 210,700 yen/vehicle for import.
- Number[8] of days required: 8.00 days (192hours), for export(import) 3.96 days (95hours) for import.

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[2] Based on World Bank data as of 2019 (3,310 US$), converted to 2021value using real GDP growth rate (4.2%/year).

[3] JICA Settlement Rate as of October 2021

[4] The daily number of passengers for public transport converted from the peak-hour number of passengers estimated in the Chapter 4 based on the peak rate (10%) per day, plus the number of passengers passing by car (average number of passengers: 2.0) and motorcycle (same number of passengers: 1.1).
Palmeraie Road: 8,716 / 0.1 + 2.0 x 17,436 + 1.1 x 3,502 =125,884 ≈ 126,000 people
Italy Bridge: 7,925 / 0.1 + 2.0 x 11,595 + 1.1 x 2,184 =104,842 ≈ 105,000 people

[5] Annual average of total traffic closure days (10days) per 3 year through 2018 - 2020

[6] Average traffic growth rate from 2021 to 2035 on Palmeraie Road (as analyzed in this study)

[7] Results of interviews with Ethiopian Transporters

[8] Source: National Logistics Strategy, Marine Affairs Authority

- Number[9] of trailers passing through the Djibouti Corridor: 480 trailers for export, 520 trailers for import.
- Vehicle occupied ratio: 96% for export, 27% for import (calculated from ADR and JICA survey results)
- Number of days Palmeraie Road is closed per year: 3.3 days
- Standby cost due to road closure: 50% (set value)

Result of calculation of benefit amount:

- 372,800 yen / 8.00 days x 480 units x 0.96 = 21,473,000 yen/day
- 210,700 yen / 3.96 days x 520 units x 0.27 = 7,470,000 yen/day
- (21,473,000 yen + 7,470,000 yen) x 3.3days x 0.5 = 47,756,000 yen

Estimating the Economic Internal Rate of Return

Assumptions for the calculation:

- Project cost: 3,100~4,300 million yen (as of 2021 price)
- Conversion rate from financial cost to economic cost: 0.85 (removal of taxes (value added tax), etc.)
- Price escalation rate during construction: 4% annually
- Maintenance and operational costs: 10 million yen is allocated each year for the base case. Other cases are set based on the ratio of the project cost to the base case.
- Increase in time-saving benefits due to increased traffic volume: 4.02% (set value)
- Discount rate: 8%

The project cost was calculated for each fiscal year with the construction period of 3years (10%, 30% and 60%). The project cost is converted to economic cost by multiplying the project cost by 0.85. On the other hand, the benefits are calculated for the aforementioned benefits a) to c) per 20year from the start of its operation.

Table 6.2.15 shows the results of calculating B/C and EIRR when the discount rate is set at 8%. The B/C of the basic case and Alt-3: All 6-lanes with reduced width exceeded 1.0, indicating that they are economically feasible. However, the project costs for these two cases are still large, and there are still concerns about traffic safety for Alt-3. Thus the evaluation from a comprehensive perspective is necessary.

Table 6.2.15 List of Economic Analysis Results

	Project Cost (billion yen)	B/C	EIRR (%)	NPV (billion yen)
Base case	4.3	1.138	9.29	0.526
Alt-1: Bridge and east intersection	3.8	0.825	6.07	-0.590
Alt-2: 4-lanes bridge only	3.1	0.703	4.30	-0.819
Alt-3: All 6-lanes with reduced width	4.1	1.193	9.78	0.704

6.2.5 Summary of Measures for Other Projects

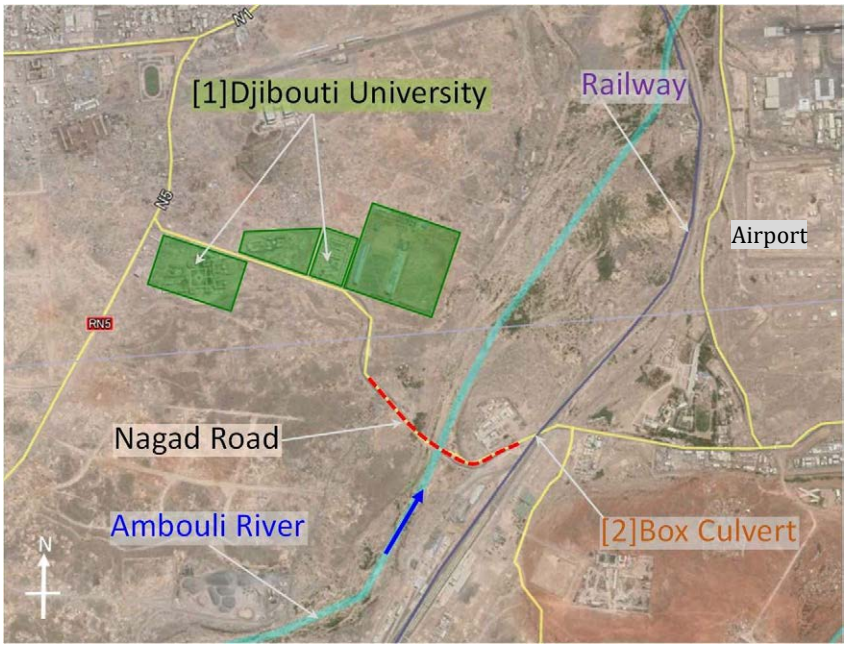
This section provides a summary of measures for the following two projects that were not ultimately selected as priority projects in Section 6.1.3.

- Nagad Road
- Italy Bridge (Route 1)

[9] Source: Results of traffic volume survey in this study

(1) Nagad Road Measures

1) Local situation

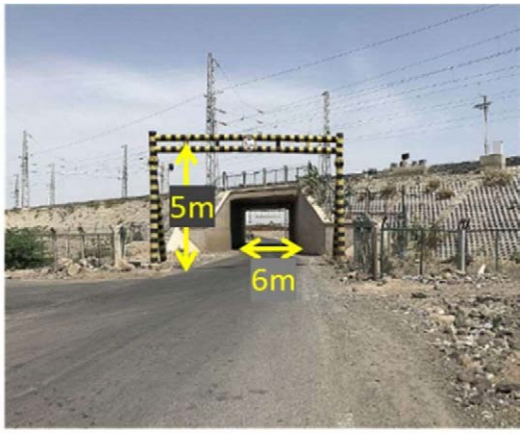


The road intersects the Palmeraie Road at about 5 km upstream of the Ambouli River, and it has currently two lanes with a road width of about 9 meters. The road crosses the river with a ford, and it has a vertical alignment with a steep slope of over 7%. The University of Djibouti is located in the west, and the eastern part of the road passes through a culvert under the railroad and connects to National Road Route 2, the road towards Damerjog.

Nagad Road (1)

Nagad Road (2)

[1] Djibouti University



[2] Box Culvert

Figure 6.2.31 Situation Around Nagad Road

2) Road Conditions (width)

- Road classification: Type 3, Class 2
- Design speed: 50km/s
- Others : The width of the roadway is 3.5m due to heavy traffic of large vehicles
  Since the number of lanes will be limited by the width of the box culvert under the railway on the east side, the current two lanes should be used.
  The width of the road shoulder should be set so that two lanes can be secured even when a broken-down vehicle is stopped.
  Sidewalks should be provided because it is close to railroad station and university facilities.

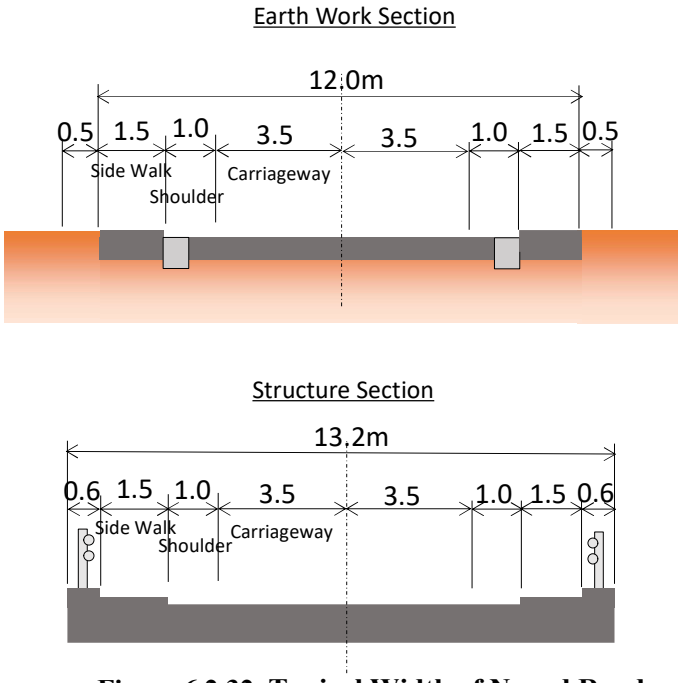


Figure 6.2.32 Typical Width of Nagad Road

3) Outline of Plan and, Estimated Project Cost

Table 6.2.16 Estimated Project Cost（Nagad Road）

Project Policy	Scope of Work	Cost (million yen)
(1) River improvement corresponding to the planned flow rate of 1,500 m3/s (equivalent to the Palmeraie Road) (2) Bridge construction according to the river cross section in (1) (3) Nagad road improvement	(1) River Improvement River channel width: 60m (2) Bridge Construction Bridge length: 62m Width: 13.2 m (two lanes of traffic, 1.5 m sidewalk on each side) Bridge type: 2 span PC hollow slab bridge Foundation type: Direct foundation (3) Road Improvement Length: 400m Width: 12.00m (roadway 3.5m x 2lanes, sidewalk 1.5m on each side)	Total Cost: 1,200 Breakdown of Main Construction Cost (1) River Improvement; 3 (2) Bridge Construction; 900 (3) Road, Intersection; 100 (4) Consultant Cost; 100 (5) Contingency Cost; 55

Outline of the project: The Nagad Road, as well as the Palmeraie Road, will be flooded and traffic will be blocked when the water level rises, so a bridge should be constructed to secure traffic. The current road has a steep gradient of more than 7%, and the following road alignment was planned in consideration of securing traffic during construction. Although there are no records of past floods, the cross-section of the road is planned to be equivalent to the planned flow rate of the Palmeraie Road downstream. A certain section (about 10m) upstream and downstream of the bridge abutment is planned to be protected by gabions.

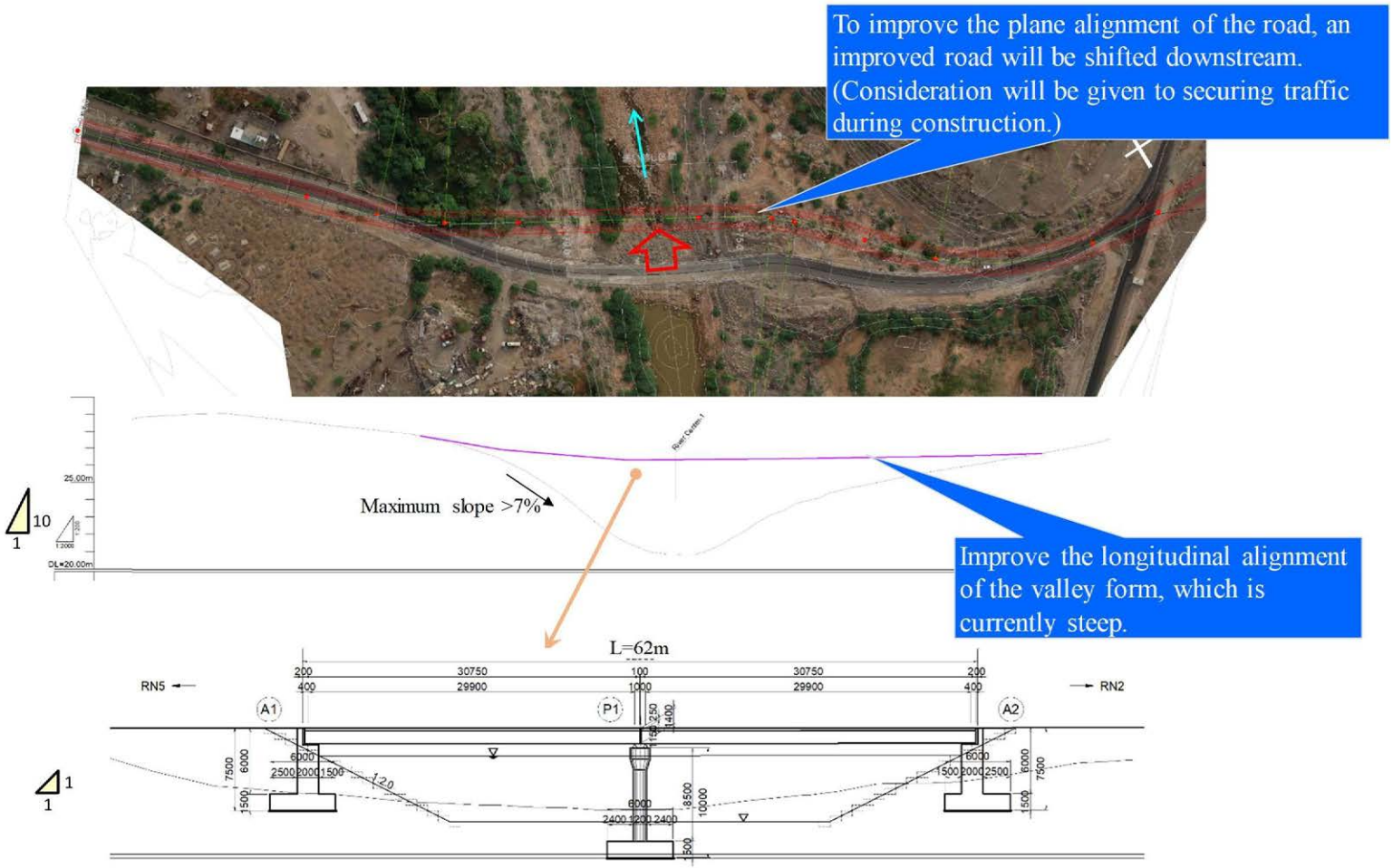


Figure 6.2.33 Outline of the Nagad Road Countermeasure Plan

(2) Italy Bridge (Route 1) Measures

1) Local situation

Italy Bridge is a 109-meter-long PC post-tensioned T-girder bridge built in 1993 at the point where National Road Route 1 crosses the Ambouli River. In 2017, repair work was carried out by a Chinese company, but due to safety issues, heavy vehicle traffic is currently restricted. Almost nothing related to the repair work exists, and the materials used and details of the repair work could not be confirmed.

Bridge deck conditions of the Italy Bridge

Condition under the girder of the Italy Bridge

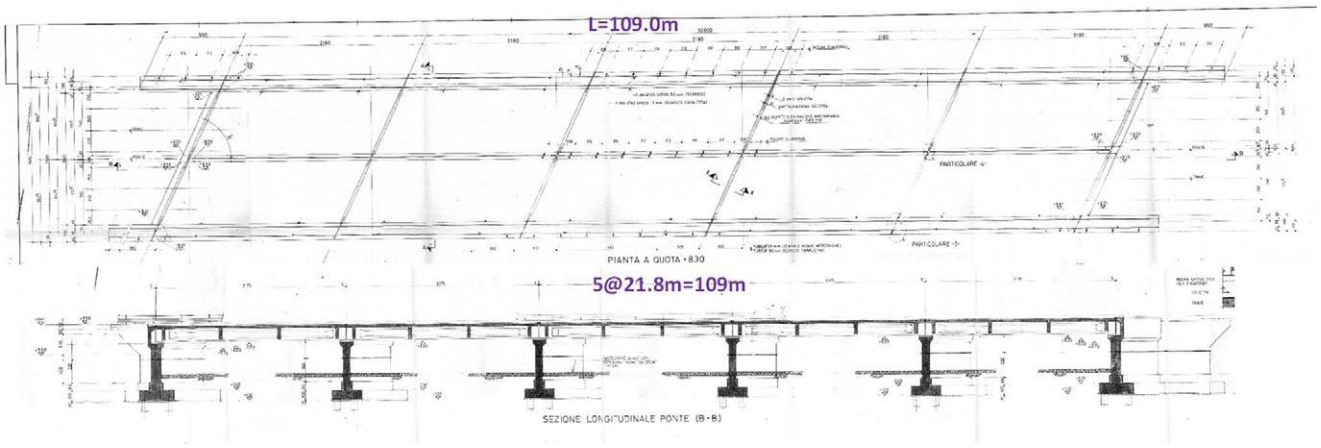
Condition of the Flower Park on the left bank of the Ambouli River

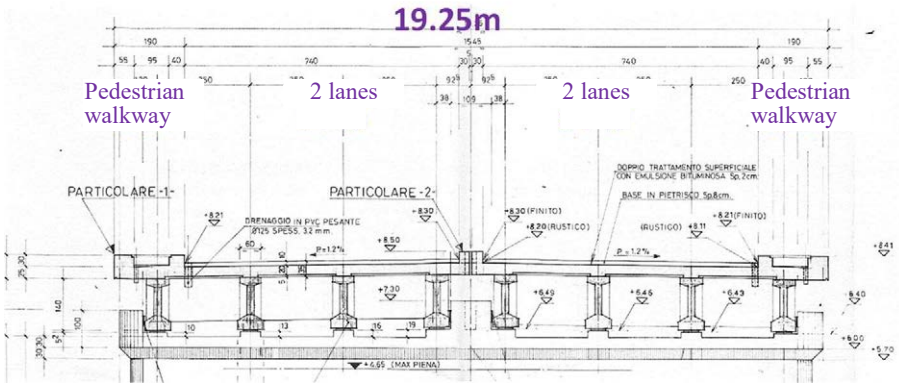
Southside railroad intersection status

Figure 6.2.34 Situation Around Italy Bridge

3) Collected materials on the Italy Bridge

The following are the construction documents obtained from the local contractor involved in the construction of the Italy bridge (detailed drawings and repair documents are not available)





Basic Specifications of Italy Bridge:

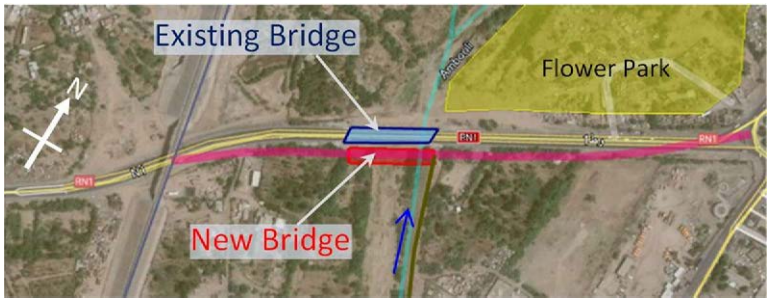
- Bridge length: 109.0m
- Width: 19.25m (4 lanes in total, with sidewalks)
- Number of spans: 5
- Superstructure: PC I-girder bridge (post-tensioned)
- Substructure: RC wall type pier
- Foundation structure: Pile foundation
  (Cast-in-place pile - presumed)
- Skew angle: Yes (65°)
- Construction: 1993
- Repair Work: 2017

Figure 6.2.35 Italy Bridge Construction Documents, Construction Photos, and Specifications

3) Basic policy on measures for Italy Bridge

In order to keep the current Italy Bridge in a sound condition for vehicular traffic, two proposed measures are shown in the table below. Considering the contents of the measures of each proposal, Alternative 2, the construction of a new bridge, which has fewer issues, is considered preferable if it is to be implemented with the assistance of Japan.

Table 6.2.17 Comparison of Basic Countermeasure Plans for Italy Bridge

	Alternative 1: Repair (reinforcement) of existing bridge	Alternative 2: Construction of a new bridge
Outline	・Carry out necessary repairs and reinforcement to existing bridges. ・Various surveys will be carried out in the field for evaluating the strength of the current bridge, and reinforcements will be carried where necessary based on the field study.  Field survey image (core sampling rebar confirmation)	・Construction of a new bridge separate from the current one. ・Construct a new bridge on the upstream side of the existing bridge, considering the local conditions, securing the flow of current traffic, and early completion. (It is impossible to build a new bridge on downstream side because this affects the access to the park.) 
Traffic during construction	Construct a detour (temporary bridge) upstream to secure traffic.	The current bridge will be used until the new bridge is completed.
Issues	・The scale of repair and reinforcement cannot be determined without a detailed survey. (If reinforcement, including the foundation, is required, the construction period and cost may increase.) ・When the reinforcement work is done, setting the scope of liability for damage would be an issue.	No specific issues are expected since the survey will be implemented anew.
Evaluation	▲	◎

Note) ◎: Good, ○: Fair , △ : Poor, ▲: Very Poor

On the downstream side of the Italian bridge, a flower park is under construction on the right bank and RC panels are being installed between the bridge and the national highway. The new bridge is planned to be located upstream because the upstream side is more advantageous than the downstream side in terms of road plan alignment. The detailed location of the new bridge should be set in consideration of the impact on the current bridge during the construction period as well as the completion status.

Figure 6.2.36 Overview of Measures for the Italy Bridge (New Bridge Construction)

6.3 Strategies for Project Implementation

6.3.1 Consideration of the Project Scheme

The following is a draft of the items of undertakings by both countries under Japan's grant aid scheme assumed for this project.

Undertakings by Japan side

Main work parts including the construction of roads, bridges, or river improvement work that are eligible for grant aid

Undertakings by Djibouti side

The implementing agencies of the Djibouti side will implement the works listed in the table below in cooperation with the relevant organizations.

Table 6.3.1 Items of Undertakings by Djibouti Side on Each Project Phase

No.	Burden items	Project phase		
		Before implementation (Before bidding)	During Implementation (During construction)	After implementation (After construction)
1	Project approval for the implementation of this plan (environment, road occupancy, etc.)	✓		
2	Briefing residents and holding stakeholder meetings in the vicinity of the planned facility construction site	✓	✓	
3	Securing land for construction under appropriate legal procedures	✓		
4	Relocation or removal of obstructions (power cables, communication cables, water and sewage pipes, etc.)	✓*		
5	Provision of land for installation of temporary facilities (site office, warehouse, batcher plant, access road, construction yard, temporary bridge, etc.)	✓		
6	Construction, maintenance and management of detours for general vehicles required for the construction.	✓*	✓*	
7	Provision of disposal facilities and locations for the disposal of construction waste	✓	✓	
8	Notifying residents, passing vehicles, and passing vessels about traffic restrictions	✓	✓	
9	Guidance of general vehicles to detour routes and traffic control in the vicinity during the construction period, etc.		✓*	
10	Legal measures and work permits necessary for Japanese and third-country personnel engaged in construction to enter and stay in Djibouti	✓	✓	
11	Process for exemption of corporate income tax, customs duties, internal taxes, and other taxes imposed in Djibouti on those using Japanese grant funds.	✓	✓	
12	Process for issuing Authorization for Payment (A/P) required for payment to Japanese consultants and contractors, and bearing the issuing and payment fees	✓	✓	
13	Appropriate operation, maintenance, and management of facilities (roads, bridges, and river facilities) constructed through the project			✓
14	Appropriate maintenance and management of river facilities (dredging work, etc.)	✓	✓	✓
15	All costs not included in grant assistance that are incurred in the implementation of this project.	✓	✓	✓

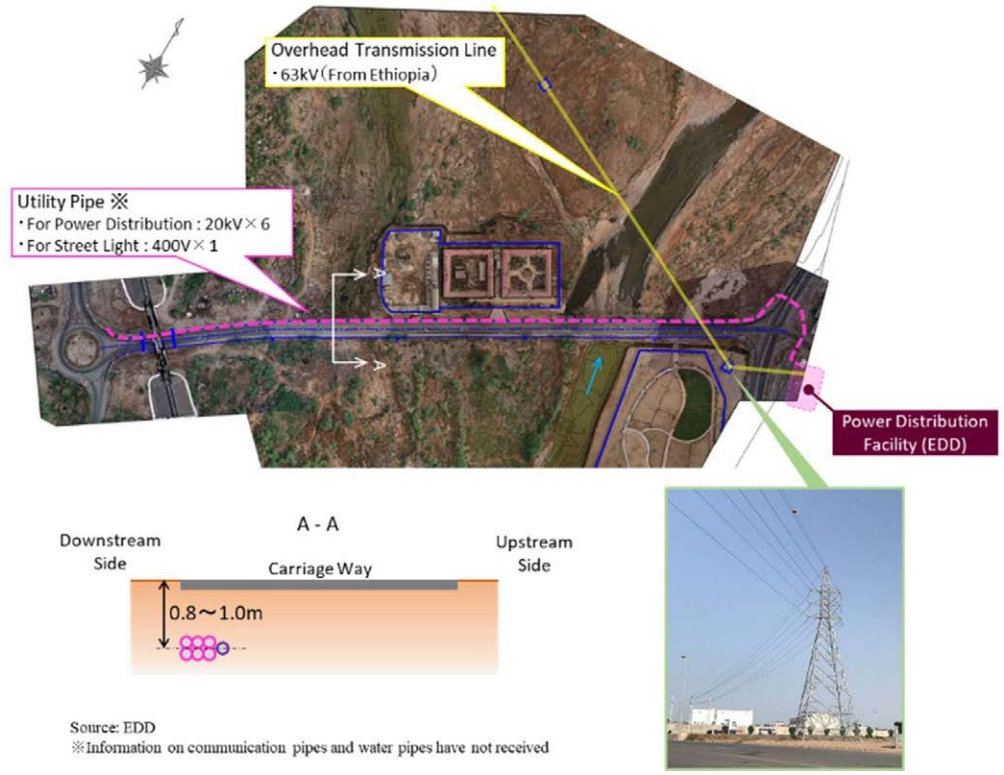


Figure 6.3.1 Buried or Underground Obstructions

6.3.2 Schedule for Project Implementation

Table 6.3.2 is a draft schedule for project implementation, assuming Japan's grant aid project scheme.

Table 6.3.2 Draft Schedule for Project Implementation

■ In the case of preliminary work to be carried out by the Japanese side

Year	1 year				2 years				3 years				4 years				5 years			
Quarter of a Year	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.Outline design and cost estimation																				
2. cabinet approval																				
3. E/N, G/A																				
4. Detailed design																				
5. Preparation and approval of bidding documents																				
6. Pre-qualification, bidding																				
7. Evaluation of bids																				
8. Signing of vendor contracts																				
9. Preparation works																				
10. Preliminary work (Detour, Relocation of utilities)																				
11. Main Work																				
12. Project Completion																				

■ In the case of preliminary work to be carried out by the Djibouti side

Year	1 year				2 years				3 years				4 years				5 years			
Quarter of a Year	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1.Outline design and cost estimation																				
2. cabinet approval																				
3. E/N, G/A																				
4. Detailed design																				
5. Preparation and approval of bidding documents																				
6. Pre-qualification, bidding																				
7. Evaluation of bids																				
8. Signing of vendor contracts																				
9. Preparation works																				
10. Preliminary work （Detour、Relocation of utilities）																				
11. Main Work																				
12. Project Completion																				

Work of Djibouti Side

- It is difficult to complete the project within 24 months after the G/A is concluded.
- If the detour route and relocation of obstacles are to be undertaken by the Djibouti side, the completion of these works is assumed to be a necessary condition for the commencement of the pre-qualification.
- The period required for the preliminary works and the main works should be carefully reviewed in future studies.

6.3.3 Project Implementation Issues

The following is a list of issues that may be faced in the implementation of the project as a grant aid project:

- Grasping the latest trends of development projects around the target area (in the planning stage or under implementation), and reflecting them in the grant aid plan as appropriate
- Consultation and coordination with relevant organizations in Djibouti (body in charge of the Ambouli River management, electricity authority, ONEAD, Djibouti Telecom, police, etc.) during the planning stage of the grant aid assistance program
- Clarification of the roles of relevant organizations in Djibouti (body in charge of the Ambouli River management, Electric Power Authority, police, etc.) and establishment of an operation system for appropriate operation and maintenance of the cooperation targeted facilities (roads, bridges, intersections, rivers) subject to cooperation.

Chapter 7 Conclusion and Future Tasks

7.1 Conclusions

1) Assisting Djibouti, which is an important international partner for Japan, in solving its various economic and social development problems through strengthening Djibouti national infrastructure contributes to the stabilization of the East African region and the revitalization of the regional economy. The World Bank, China, the Saudi Arabian Fund, and other donors are providing supports in the region, and there is a need to coordinate these supports with that of Japan. In other words, it can be said that Japan's specific support to Djibouti needs to be identifies in the midst of active support from various countries.

2) In this study, we identified four directions for Japan's assistance: (1) strengthening the connectivity between the east and west urban areas divided by the Ambouli River, (2) developing a reliable international logistics trunk line, (3) developing roads that contribute to urban and industrial development in the city, and (4) developing a safe and comfortable network of roads in the city, and specific measures corresponding to each of them were examined. Among the proposed measures, "Improvement of the Road Crossing the Ambouli River to cope with flood risk" was proposed as a priority project in consideration of its urgency, relevance, and feasibility.

3) At present, there are three roads crossing the Ambouli River (Palmeraie Road, Italy Bridge (NR1), Nagat Road). The Italian Bridge was reinforced in 2017, but the traffic of large vehicles is restricted. However, the bridge itself will not be flooded and can function as a main road for the time being. It also functions as an alternative to the Palmeraie Road when it is flooded, and there is little need for maintenance prior to the improvement of the Palmeraie Road. However, the road needs to be widened to six lanes in the future. The Nagat Road may become an important route with the development of the Damerjog district. However, the direction of development of the Nagat Road should be reconfirmed as the SDAU is planning an outer ring road in the future. The Palmeraie Road has the highest traffic of all the three roads crossing the Ambouli River, and it is an important route that requires six lanes in the future. However, the road is submerged in water during floods, causing significant disruption to logistics and the daily life activities of citizens. In particular, the fact that large trucks cannot pass through is critical for Djibouti, and urgent measures are needed. Therefore, the improvement of the Palmeraie Road (widening and bridging project) was selected as a priority maintenance project.

4) Based on the improvement plan of the Palmeraie Road and the planned flow rate of 1,500 m3/s upstream of the Italy Bridge, the cross-section of the river improvement and the plan of the road bridge were analyzed. Based on the surrounding obstacles (FTZ facilities, Flower Park, etc.), the main stream improvement, the sub-stream improvement, and the improvement plan to divide the main stream were studied, and the bridge plan in each case was also studied. In addition, additional studies were conducted to reduce the project cost and avoid the impact on the surrounding facilities, which were identified in the study process. The standard main stream improvement would interfere with FTZ facilities and require consultation on partial removal of the facilities. The project cost for the river improvement by dividing the river would be relatively high because the river management length would be longer and two bridges would be required. As a result, it was recommended that the left bank of the river on the opposite side of the city be simplified (the same as upstream of the current Italian bridge) and that roads and bridges be constructed, based on the main stream improvement.

5) The river improvement plan is planned for a flow rate of 1,500 m3 /s, which is the improvement condition for the Italy Bridge located upstream. According to the flood probability calculated from the maximum daily rainfall of the past 40 years, a flood exceeding the planned flow may occur approximately once every 25 years. There was an argument that an even lower probability (about 1/50) should be a targeted, taking into account future climate change and the need to strengthen the functions of the capital city, but in that case, it has to be a large scale project, and a plan that leaves room for future expansion is proposed.

6) A signal intersection is located on the east side of Palmeraie Road and a roundabout on the west side. The signalized intersection on the east side is already experiencing traffic congestion, and it was determined that the intersection needs to be upgraded to meet the future traffic demand. Different alternative including at grade and grade-separated plans are compared, and it was confirmed that at grade intersection can handle the traffic until 2035 with appropriate traffic control plan. It was also determined that a grade-separated intersection would be difficult due the high-voltage power lines crossing over Palmeraie Road and the high cost of the project. As for the roundabout on the west side, it was confirmed that adding a right-turn lane connecting the south side approach to Palmeraie Road would enable it to handle the future traffic volume.

7) If these projects are to be implemented as Japanese grant aid projects, it is necessary to clarify the scope of the projects and the items to be covered by the Djibouti side. In other words, the scope of the project includes the widening of the Palmeraie Road, a bridge across the Ambouli River, improvement of the east and west side intersections, and river improvement and dike construction from the Italy Bridge to about 100 meters downstream of the Palmeraie Road. Because of the importance of this route, it is also important to construct alternative roads and control traffic during construction. It is also necessary to relocate underground utilities such as electricity and telecommunications that use the Palmeraie Road. In addition, it is necessary to clarify the responsibilities of the Japanese and Djiboutian sides.

7.2 Future Tasks

1) Each proposal for the improvement of the Palmeraie Road and the Ambouli River was examined, but the final decision should be made through consultation between Japan and Djibouti. The possibility of relocating the FTZ facility near the Ambouli River, the possibility of changing the plan of the Flower Park should be assessed, and the latest trends of other development projects should be monitored and reflected in the contents of the grant aid.

2) In the future preparatory study, the following matters that were not considered in this study should be discussed with the relevant organizations and their details should be finalized:
   - Discussions on the construction, operation, and maintenance of alternative roads during construction
   - Investigation of underground structures that may obstruct the construction, and consultation on their relocation and removal
   - Discussions on revising traffic control of the east side intersection
   - Discussions on the timing and frequency of channel dredging and maintenance management
   - Establishment of a system to regulate land use in the river area
   - Confirmation of connection with urban drainage channel downstream of Italy Bridge and future management plan

3) As mentioned above, the undertakings by the Djibouti side for this project varies widely. In the preparatory survey, it will be important to identify and classify these undertakings by stage of the project, i.e., before implementation (before bidding), during implementation, and after implementation, and to confirm the implementation system and budgetary measures of the Djibouti side for appropriate operation and maintenance.

Appendix

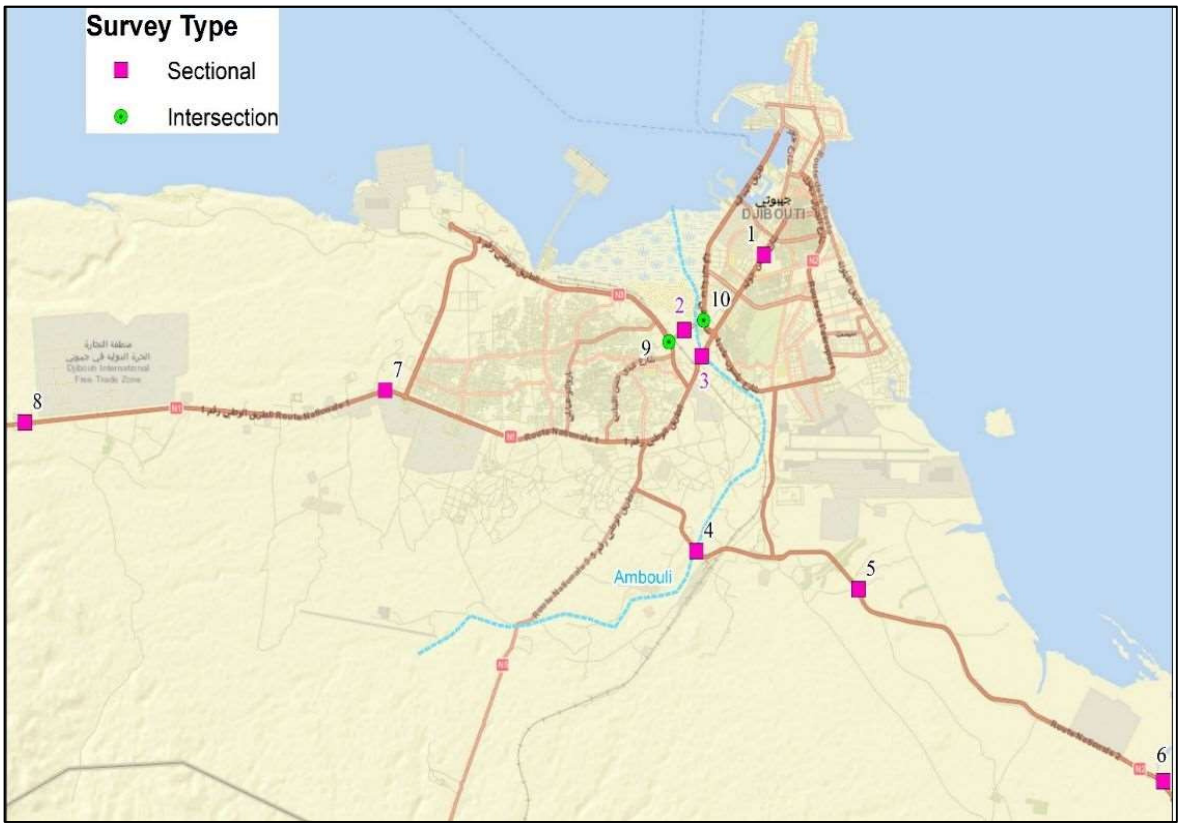
1. Traffic Survey Data

2. Road Inventory Survey Data

3. Geological Survey Data

4. Basic Plan Drawing

1. Traffic Survey Data



Survey Locations

SECTIONAL DATA

Vehicle Classification (Sectional Survey)

Class	Typical vehicles included	Examples
Motorbike	Motorbike	
Bajaj	Tuktuk/Bajaj	 
Car	Passenger Car / Pick-up	  
Taxi	Taxi	
Minibus	Minibus	
Bus	Bus	
Light Truck	Light Truck (Rigid 2-Axle Trucks)	
Heavy Truck	Heavy Truck (Rigid 3-Axle Trucks)	 
Trailer	Trailer (Articulated trucks, with more than 3 Axles)	 

Table 1 Location 1 (Arhiba) Traffic

Time	To City									
	Motorbike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
6:00-7:00	24	1	91	27	98	122	24	2	0	389
7:00-8:00	64	4	209	59	103	136	15	6	0	596
8:00-9:00	61	3	255	60	98	138	21	2	0	638
9:00-10:00	62	4	249	66	105	144	13	3	0	646
10:00-11:00	73	3	243	89	89	99	20	8	0	624
11:00-12:00	50	1	218	72	71	81	13	0	0	506
12:00-13:00	54	0	192	69	109	121	21	3	0	569
13:00-14:00	57	1	277	60	89	83	11	4	1	583
14:00-15:00	41	1	223	42	81	80	10	0	0	478
15:00-16:00	37	1	180	32	65	85	16	0	0	416
16:00-17:00	35	1	238	58	108	145	21	2	0	608
17:00-18:00	51	2	246	100	128	163	13	4	0	707
18:00-19:00	48	1	216	70	92	138	22	2	0	589
19:00-20:00	63	3	202	71	100	131	9	0	0	579
To Balbala										
6:00-7:00	9	1	56	25	70	84	10	0	1	256
7:00-8:00	37	2	129	26	78	87	12	2	0	373
8:00-9:00	39	1	222	48	67	99	25	3	0	504
9:00-10:00	42	3	170	39	80	99	21	2	0	456
10:00-11:00	47	0	157	66	75	85	15	1	0	446
11:00-12:00	56	0	244	57	76	69	16	1	1	520
12:00-13:00	49	0	227	93	93	80	29	0	0	571
13:00-14:00	39	1	223	56	71	63	14	2	0	469
14:00-15:00	32	0	165	43	68	72	8	2	0	390
15:00-16:00	19	0	123	33	65	55	13	0	0	308
16:00-17:00	20	1	127	41	66	82	19	0	0	356
17:00-18:00	25	2	185	69	84	106	10	1	0	482
18:00-19:00	37	3	207	65	97	105	12	0	0	526
19:00-20:00	53	1	192	59	70	91	15	1	0	482
Both Directions										
6:00-7:00	33	2	147	52	168	206	34	2	1	645
7:00-8:00	101	6	338	85	181	223	27	8	0	969
8:00-9:00	100	4	477	108	165	237	46	5	0	1142
9:00-10:00	104	7	419	105	185	243	34	5	0	1102
10:00-11:00	120	3	400	155	164	184	35	9	0	1070
11:00-12:00	106	1	462	129	147	150	29	1	1	1026
12:00-13:00	103	0	419	162	202	201	50	3	0	1140
13:00-14:00	96	2	500	116	160	146	25	6	1	1052
14:00-15:00	73	1	388	85	149	152	18	2	0	868
15:00-16:00	56	1	303	65	130	140	29	0	0	724

16:00-17:00	55	2	365	99	174	227	40	2	0	964
17:00-18:00	76	4	431	169	212	269	23	5	0	1189
18:00-19:00	85	4	423	135	189	243	34	2	0	1115
19:00-20:00	116	4	394	130	170	222	24	1	0	1061

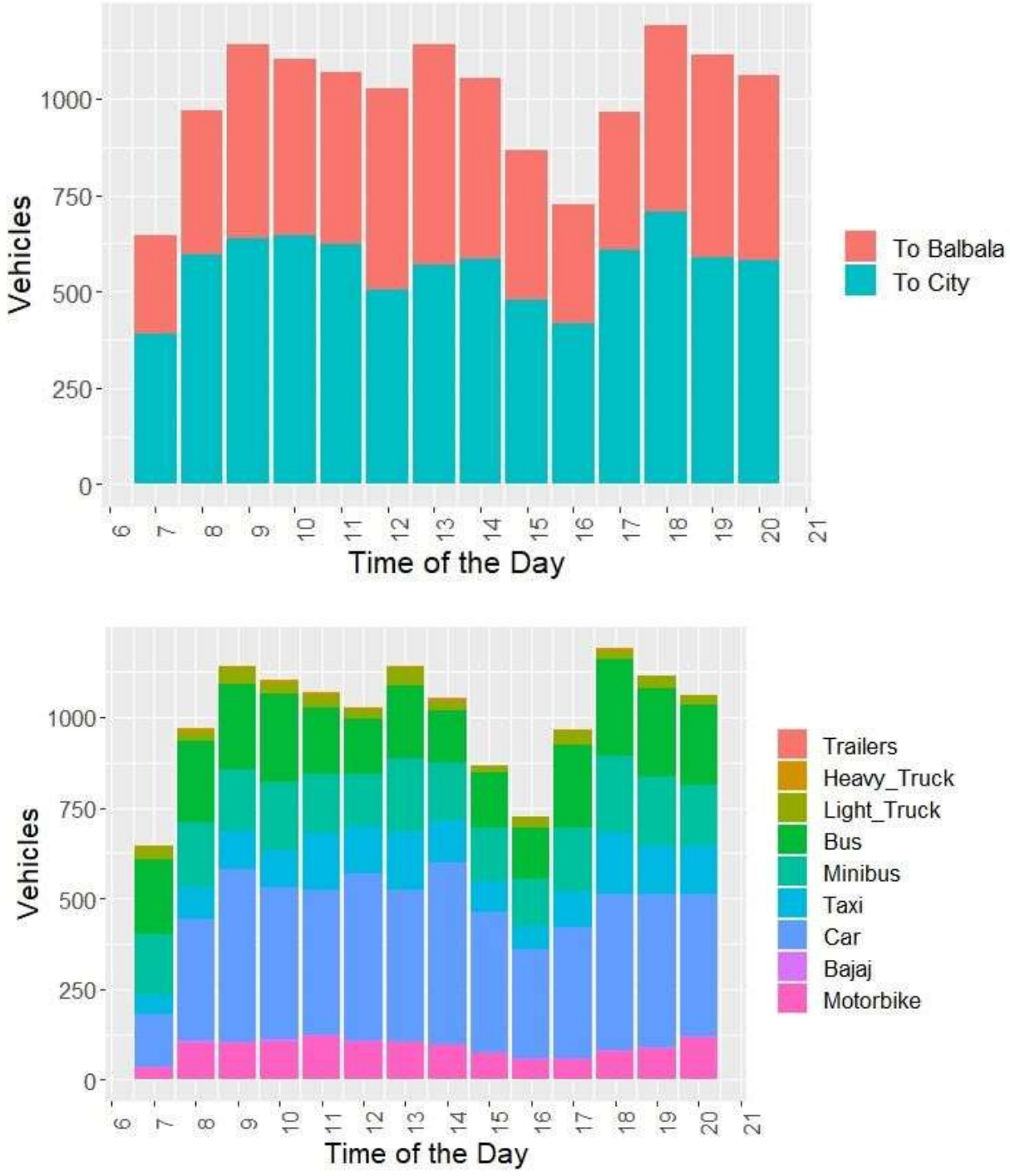


Figure 1 Arhiba Traffic by Time of Day

Table 2 Location 2 (Palmeraie) Traffic

Time	To City									
	Motorbike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
0:00-1:00	23	3	90	34	13	7	2	0	10	182
1:00-2:00	6	6	50	22	3	4	0	1	9	101
2:00-3:00	9	3	23	10	3	2	0	0	2	52
3:00-4:00	10	7	20	5	5	4	2	1	2	56
4:00-5:00	5	2	27	6	8	11	3	2	0	64
5:00-6:00	58	2	126	31	50	55	10	0	10	342
6:00-7:00	108	1	395	74	86	135	20	7	4	830
7:00-8:00	237	0	1133	169	93	157	33	19	24	1865
8:00-9:00	190	3	740	134	85	100	32	21	37	1342
9:00-10:00	106	1	546	83	53	48	40	34	34	945
10:00-11:00	85	3	488	79	59	45	36	33	40	868
11:00-12:00	71	5	443	73	51	66	28	27	34	798
12:00-13:00	91	2	501	76	59	65	35	17	47	893
13:00-14:00	84	2	443	74	59	50	16	39	39	806
14:00-15:00	77	7	478	52	55	53	26	25	23	796
15:00-16:00	81	6	475	45	56	49	43	19	45	819
16:00-17:00	96	10	529	62	81	69	28	13	29	917
17:00-18:00	87	4	495	67	57	72	37	8	32	859
18:00-19:00	100	5	452	67	66	58	33	4	29	814
19:00-20:00	66	2	447	62	68	56	25	3	18	747
20:00-21:00	45	2	419	49	64	69	13	2	17	680
21:00-22:00	70	7	368	58	57	53	17	6	19	655
22:00-23:00	49	5	249	61	36	47	10	1	9	467
23:00-0:00	32	3	156	39	22	15	7	1	7	282
To Balbala										
0:00-1:00	41	3	132	53	17	15	6	0	4	271
1:00-2:00	23	2	58	33	5	6	4	0	11	142
2:00-3:00	11	2	38	15	4	0	0	0	1	71
3:00-4:00	8	6	28	10	3	2	1	0	3	61
4:00-5:00	6	6	26	9	7	8	6	2	7	77
5:00-6:00	11	1	66	13	31	57	9	0	2	190
6:00-7:00	19	1	113	18	53	81	16	6	21	328
7:00-8:00	27	2	344	45	57	100	15	18	37	645
8:00-9:00	45	2	404	69	71	96	23	16	22	748
9:00-10:00	77	5	348	98	91	84	47	38	39	827
10:00-11:00	76	2	426	85	92	79	54	42	38	894
11:00-12:00	94	3	404	81	54	62	43	20	18	779
12:00-13:00	164	6	850	120	61	81	31	23	45	1381
13:00-14:00	119	5	1177	106	68	82	47	23	34	1661
14:00-15:00	78	2	384	47	43	40	14	14	24	646

15:00-16:00	52	2	313	30	48	32	16	18	25	536
16:00-17:00	76	1	341	41	47	33	17	17	13	586
17:00-18:00	137	1	534	65	80	115	48	16	22	1018
18:00-19:00	131	4	396	71	75	60	30	20	31	818
19:00-20:00	109	1	330	65	63	63	24	5	14	674
20:00-21:00	127	2	427	65	60	63	24	1	34	803
21:00-22:00	106	0	432	123	67	79	7	0	29	843
22:00-23:00	111	4	532	122	57	64	15	0	4	909
23:00-0:00	68	5	240	69	36	32	8	2	2	462
Both Directions										
0:00-1:00	64	6	222	87	30	22	8	0	14	453
1:00-2:00	29	8	108	55	8	10	4	1	20	243
2:00-3:00	20	5	61	25	7	2	0	0	3	123
3:00-4:00	18	13	48	15	8	6	3	1	5	117
4:00-5:00	11	8	53	15	15	19	9	4	7	141
5:00-6:00	69	3	192	44	81	112	19	0	12	532
6:00-7:00	127	2	508	92	139	216	36	13	25	1158
7:00-8:00	264	2	1477	214	150	257	48	37	61	2510
8:00-9:00	235	5	1144	203	156	196	55	37	59	2090
9:00-10:00	183	6	894	181	144	132	87	72	73	1772
10:00-11:00	161	5	914	164	151	124	90	75	78	1762
11:00-12:00	165	8	847	154	105	128	71	47	52	1577
12:00-13:00	255	8	1351	196	120	146	66	40	92	2274
13:00-14:00	203	7	1620	180	127	132	63	62	73	2467
14:00-15:00	155	9	862	99	98	93	40	39	47	1442
15:00-16:00	133	8	788	75	104	81	59	37	70	1355
16:00-17:00	172	11	870	103	128	102	45	30	42	1503
17:00-18:00	224	5	1029	132	137	187	85	24	54	1877
18:00-19:00	231	9	848	138	141	118	63	24	60	1632
19:00-20:00	175	3	777	127	131	119	49	8	32	1421
20:00-21:00	172	4	846	114	124	132	37	3	51	1483
21:00-22:00	176	7	800	181	124	132	24	6	48	1498
22:00-23:00	160	9	781	183	93	111	25	1	13	1376
23:00-0:00	100	8	396	108	58	47	15	3	9	744

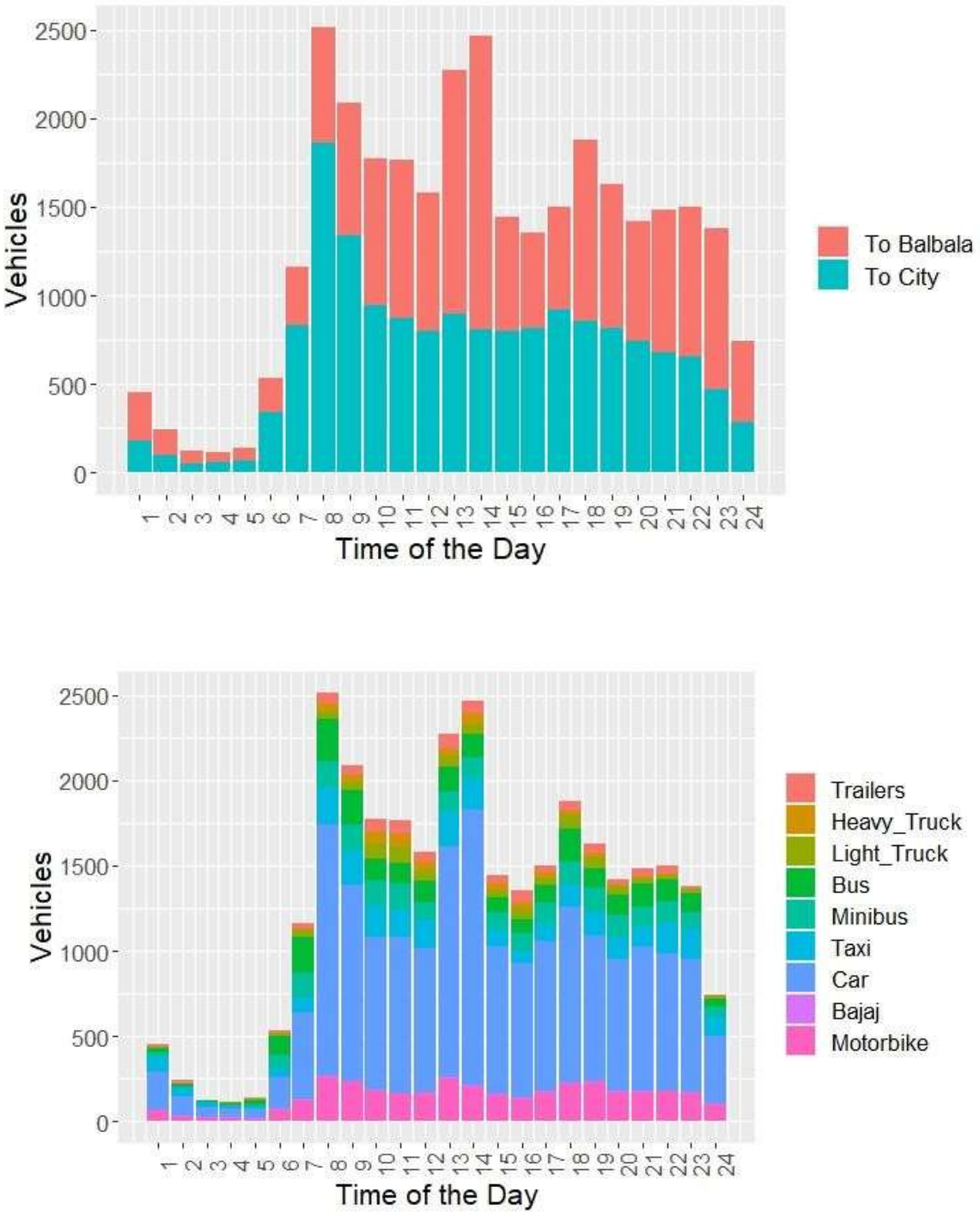


Figure 2 Palmeraie Traffic by Time of Day

Table 3 Location 3 (Bridge) Traffic

Time	To City									
	Motor bike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
0:00-1:00	12	3	88	20	10	15	9	0	3	160
1:00-2:00	10	11	38	12	4	6	2	3	0	86
2:00-3:00	11	5	26	13	1	4	2	1	2	65
3:00-4:00	6	4	13	6	2	2	3	1	0	37
4:00-5:00	4	3	28	11	16	19	5	0	0	86
5:00-6:00	32	4	94	15	39	77	10	4	4	279
6:00-7:00	42	2	200	45	44	119	15	4	2	473
7:00-8:00	109	1	721	111	50	149	34	9	0	1184
8:00-9:00	92	5	418	89	39	119	25	10	0	797
9:00-10:00	63	7	310	72	34	103	33	11	1	634
10:00-11:00	54	4	267	69	28	64	23	9	0	518
11:00-12:00	37	2	256	58	29	84	31	16	1	514
12:00-13:00	37	1	316	42	34	115	23	17	0	585
13:00-14:00	41	2	247	60	21	75	21	13	0	480
14:00-15:00	59	3	352	55	40	66	27	12	1	615
15:00-16:00	53	5	340	62	51	94	40	12	2	659
16:00-17:00	61	6	313	56	51	123	27	5	0	642
17:00-18:00	71	2	355	65	48	114	36	8	2	701
18:00-19:00	56	4	314	48	48	113	20	5	0	608
19:00-20:00	54	1	318	47	46	128	27	5	0	626
20:00-21:00	67	3	264	73	46	116	10	2	0	581
21:00-22:00	41	0	223	34	30	66	12	2	0	408
22:00-23:00	48	3	174	39	19	52	8	2	0	345
23:00-0:00	33	6	96	34	20	33	6	1	1	230
To Balbala										
0:00-1:00	22	4	111	32	7	17	8	1	0	202
1:00-2:00	14	10	43	25	4	5	4	3	1	109
2:00-3:00	6	5	27	13	2	2	7	0	0	62
3:00-4:00	4	2	19	9	4	2	4	0	0	44
4:00-5:00	6	4	21	11	10	12	12	0	0	76
5:00-6:00	6	3	60	11	21	54	9	0	1	165
6:00-7:00	19	5	88	21	33	98	19	5	0	288
7:00-8:00	33	2	267	48	31	112	11	9	0	513
8:00-9:00	37	3	230	43	34	135	16	11	1	510
9:00-10:00	40	6	247	61	31	97	29	12	2	525
10:00-11:00	45	4	237	59	38	97	41	23	0	544
11:00-12:00	55	4	284	53	16	85	25	11	0	533
12:00-13:00	80	4	557	84	49	122	46	13	3	958
13:00-14:00	93	6	640	100	45	100	29	5	0	1018
14:00-15:00	43	0	281	51	24	46	18	8	0	471

15:00-16:00	42	0	247	29	23	62	15	12	0	430
16:00-17:00	39	2	240	38	24	66	37	6	1	453
17:00-18:00	59	2	388	48	38	119	41	6	0	701
18:00-19:00	84	2	328	46	36	101	34	3	0	634
19:00-20:00	67	2	274	56	33	97	27	5	0	561
20:00-21:00	92	2	318	58	28	82	23	5	1	609
21:00-22:00	88	4	361	51	19	80	19	2	0	624
22:00-23:00	67	1	338	76	23	76	13	2	1	597
23:00-0:00	50	4	218	52	26	49	7	0	0	406
Both Directions										
0:00-1:00	34	7	199	52	17	32	17	1	3	362
1:00-2:00	24	21	81	37	8	11	6	6	1	195
2:00-3:00	17	10	53	26	3	6	9	1	2	127
3:00-4:00	10	6	32	15	6	4	7	1	0	81
4:00-5:00	10	7	49	22	26	31	17	0	0	162
5:00-6:00	38	7	154	26	60	131	19	4	5	444
6:00-7:00	61	7	288	66	77	217	34	9	2	761
7:00-8:00	142	3	988	159	81	261	45	18	0	1697
8:00-9:00	129	8	648	132	73	254	41	21	1	1307
9:00-10:00	103	13	557	133	65	200	62	23	3	1159
10:00-11:00	99	8	504	128	66	161	64	32	0	1062
11:00-12:00	92	6	540	111	45	169	56	27	1	1047
12:00-13:00	117	5	873	126	83	237	69	30	3	1543
13:00-14:00	134	8	887	160	66	175	50	18	0	1498
14:00-15:00	102	3	633	106	64	112	45	20	1	1086
15:00-16:00	95	5	587	91	74	156	55	24	2	1089
16:00-17:00	100	8	553	94	75	189	64	11	1	1095
17:00-18:00	130	4	743	113	86	233	77	14	2	1402
18:00-19:00	140	6	642	94	84	214	54	8	0	1242
19:00-20:00	121	3	592	103	79	225	54	10	0	1187
20:00-21:00	159	5	582	131	74	198	33	7	1	1190
21:00-22:00	129	4	584	85	49	146	31	4	0	1032
22:00-23:00	115	4	512	115	42	128	21	4	1	942
23:00-0:00	83	10	314	86	46	82	13	1	1	636

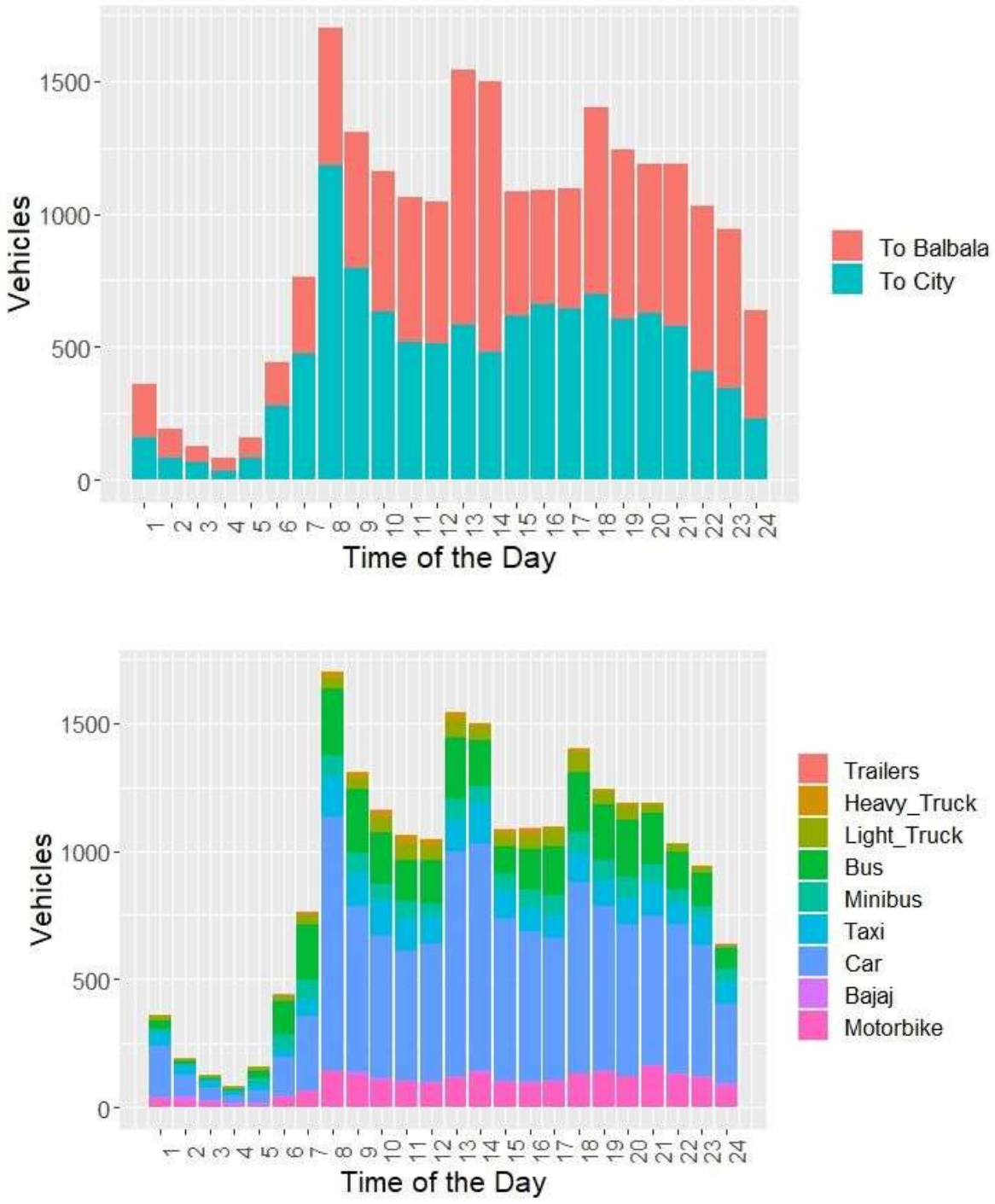
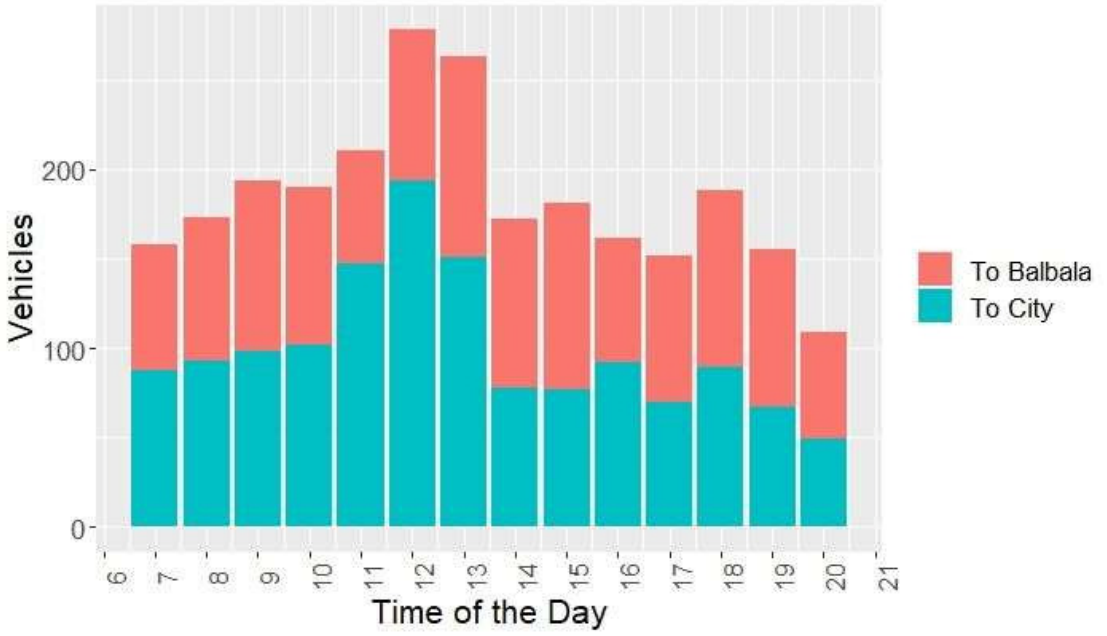


Figure 3 Italy Bridge Traffic by Time of Day

Table 4 Location 4 (Nagad) Traffic

Time	To City									
	Motorbike	Baja j	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
6:00-7:00	12	27	25	1	2	2	4	8	7	88
7:00-8:00	8	15	44	2	2	3	2	14	3	93
8:00-9:00	6	20	45	2	3	1	5	16	0	98
9:00-10:00	1	25	37	0	1	0	4	11	23	102
10:00-11:00	4	26	60	1	0	0	0	36	20	147
11:00-12:00	10	24	96	9	0	4	10	22	19	194
12:00-13:00	5	33	71	2	1	1	10	12	16	151
13:00-14:00	4	18	31	2	0	2	17	3	1	78
14:00-15:00	8	10	39	1	2	2	10	5	0	77
15:00-16:00	6	7	50	3	1	4	12	7	2	92
16:00-17:00	4	12	37	1	0	2	9	5	0	70
17:00-18:00	3	16	46	4	2	1	8	9	0	89
18:00-19:00	9	11	30	1	0	2	9	4	1	67
19:00-20:00	2	6	29	0	0	2	6	4	0	49
To Balbala										
6:00-7:00	6	30	23	0	0	3	2	6	0	70
7:00-8:00	4	16	43	1	2	1	0	13	0	80
8:00-9:00	1	19	49	1	0	1	3	18	4	96
9:00-10:00	5	15	37	3	0	0	7	16	5	88
10:00-11:00	2	8	37	1	0	2	2	10	2	64
11:00-12:00	7	12	45	3	1	0	1	15	0	84
12:00-13:00	9	12	77	2	0	3	1	6	2	112
13:00-14:00	7	10	52	2	1	5	9	5	3	94
14:00-15:00	4	18	54	4	1	2	12	6	3	104
15:00-16:00	3	11	33	1	2	1	9	8	2	70
16:00-17:00	6	10	44	0	1	3	9	8	1	82
17:00-18:00	9	15	45	1	1	2	21	5	0	99
18:00-19:00	7	12	46	1	0	2	10	8	2	88
19:00-20:00	3	9	39	0	0	0	6	1	2	60
Both Directions										
6:00-7:00	18	57	48	1	2	5	6	14	7	158
7:00-8:00	12	31	87	3	4	4	2	27	3	173
8:00-9:00	7	39	94	3	3	2	8	34	4	194
9:00-10:00	6	40	74	3	1	0	11	27	28	190
10:00-11:00	6	34	97	2	0	2	2	46	22	211
11:00-12:00	17	36	141	12	1	4	11	37	19	278
12:00-13:00	14	45	148	4	1	4	11	18	18	263
13:00-14:00	11	28	83	4	1	7	26	8	4	172

14:00-15:00	12	28	93	5	3	4	22	11	3	181
15:00-16:00	9	18	83	4	3	5	21	15	4	162
16:00-17:00	10	22	81	1	1	5	18	13	1	152
17:00-18:00	12	31	91	5	3	3	29	14	0	188
18:00-19:00	16	23	76	2	0	4	19	12	3	155
19:00-20:00	5	15	68	0	0	2	12	5	2	109



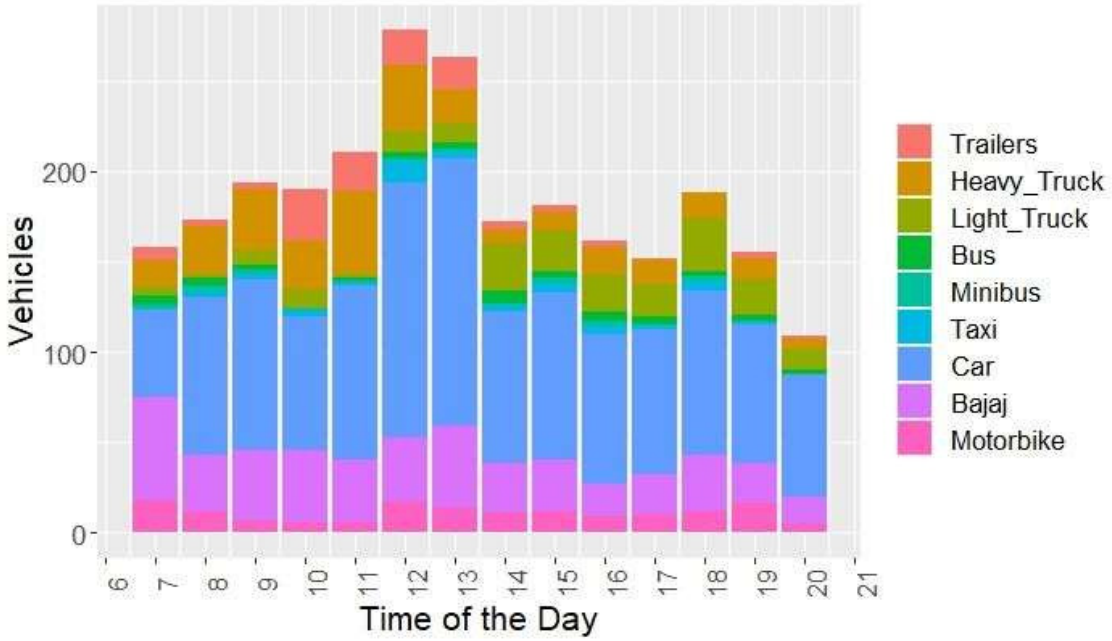


Figure 4 Nagad Traffic by Time of Day

Table 5 Location 5 (Douda) Traffic

Time	To City									
	Motorbike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
0:00-1:00	1	0	10	0	0	0	0	0	0	11
1:00-2:00	1	0	5	1	1	0	0	0	0	8
2:00-3:00	1	0	9	0	1	0	1	0	0	12
3:00-4:00	0	0	1	1	0	0	0	1	1	4
4:00-5:00	2	0	5	1	0	1	0	0	0	9
5:00-6:00	2	0	8	3	1	1	1	1	0	17
6:00-7:00	10	11	23	4	4	2	1	4	2	61
7:00-8:00	8	1	25	8	1	3	5	5	1	57
8:00-9:00	7	1	37	9	2	2	2	9	1	70
9:00-10:00	5	0	51	4	2	1	4	12	2	81
10:00-11:00	6	2	45	3	1	0	5	10	5	77
11:00-12:00	2	0	36	1	1	2	4	5	2	53
12:00-13:00	4	0	37	6	1	0	6	7	3	64
13:00-14:00	5	1	33	4	2	6	3	6	1	61
14:00-15:00	4	1	38	2	0	2	6	9	2	64
15:00-16:00	2	2	33	4	2	0	9	7	0	59
16:00-17:00	7	4	46	10	3	3	7	7	1	88
17:00-18:00	5	2	61	4	3	3	10	3	4	95
18:00-19:00	8	0	78	7	2	2	15	8	5	125
19:00-20:00	6	0	64	1	0	1	4	1	6	83
20:00-21:00	7	1	27	3	1	0	1	5	1	46
21:00-22:00	3	0	25	2	0	0	3	2	1	36
22:00-23:00	2	1	18	1	2	1	2	3	0	30
23:00-0:00	2	0	8	1	0	0	0	1	0	12
To Damerjog										
0:00-1:00	1	0	12	3	0	0	1	0	0	17
1:00-2:00	2	0	3	3	0	0	1	0	0	9
2:00-3:00	1	0	3	0	0	0	0	0	0	4
3:00-4:00	1	0	2	3	0	0	0	0	1	7
4:00-5:00	0	0	1	4	0	0	0	2	0	7
5:00-6:00	2	0	9	0	2	2	0	2	0	17
6:00-7:00	6	0	25	0	0	0	3	4	0	38
7:00-8:00	1	0	32	3	2	2	2	9	0	51
8:00-9:00	2	1	48	2	4	2	1	9	0	69
9:00-10:00	2	0	39	3	1	2	0	13	1	61
10:00-11:00	5	2	56	3	1	1	5	10	2	85
11:00-12:00	10	0	41	4	0	3	2	12	2	74
12:00-13:00	11	1	64	8	1	2	4	13	2	106
13:00-14:00	10	1	54	2	2	1	3	9	15	97

14:00-15:00	6	0	47	4	0	2	3	10	0	72
15:00-16:00	10	1	50	8	2	2	5	13	3	94
16:00-17:00	3	2	82	8	3	0	7	8	2	115
17:00-18:00	14	1	74	4	4	3	5	4	1	110
18:00-19:00	8	0	39	3	1	6	11	1	3	72
19:00-20:00	3	0	22	5	1	2	3	2	0	38
20:00-21:00	8	0	21	4	1	0	3	0	0	37
21:00-22:00	2	1	24	1	2	2	5	3	0	40
22:00-23:00	3	0	20	3	1	2	5	0	0	34
23:00-0:00	3	0	16	3	0	3	1	3	0	29
Both Directions										
0:00-1:00	2	0	22	3	0	0	1	0	0	28
1:00-2:00	3	0	8	4	1	0	1	0	0	17
2:00-3:00	2	0	12	0	1	0	1	0	0	16
3:00-4:00	1	0	3	4	0	0	0	1	2	11
4:00-5:00	2	0	6	5	0	1	0	2	0	16
5:00-6:00	4	0	17	3	3	3	1	3	0	34
6:00-7:00	16	11	48	4	4	2	4	8	2	99
7:00-8:00	9	1	57	11	3	5	7	14	1	108
8:00-9:00	9	2	85	11	6	4	3	18	1	139
9:00-10:00	7	0	90	7	3	3	4	25	3	142
10:00-11:00	11	4	101	6	2	1	10	20	7	162
11:00-12:00	12	0	77	5	1	5	6	17	4	127
12:00-13:00	15	1	101	14	2	2	10	20	5	170
13:00-14:00	15	2	87	6	4	7	6	15	16	158
14:00-15:00	10	1	85	6	0	4	9	19	2	136
15:00-16:00	12	3	83	12	4	2	14	20	3	153
16:00-17:00	10	6	128	18	6	3	14	15	3	203
17:00-18:00	19	3	135	8	7	6	15	7	5	205
18:00-19:00	16	0	117	10	3	8	26	9	8	197
19:00-20:00	9	0	86	6	1	3	7	3	6	121
20:00-21:00	15	1	48	7	2	0	4	5	1	83
21:00-22:00	5	1	49	3	2	2	8	5	1	76
22:00-23:00	5	1	38	4	3	3	7	3	0	64
23:00-0:00	5	0	24	4	0	3	1	4	0	41

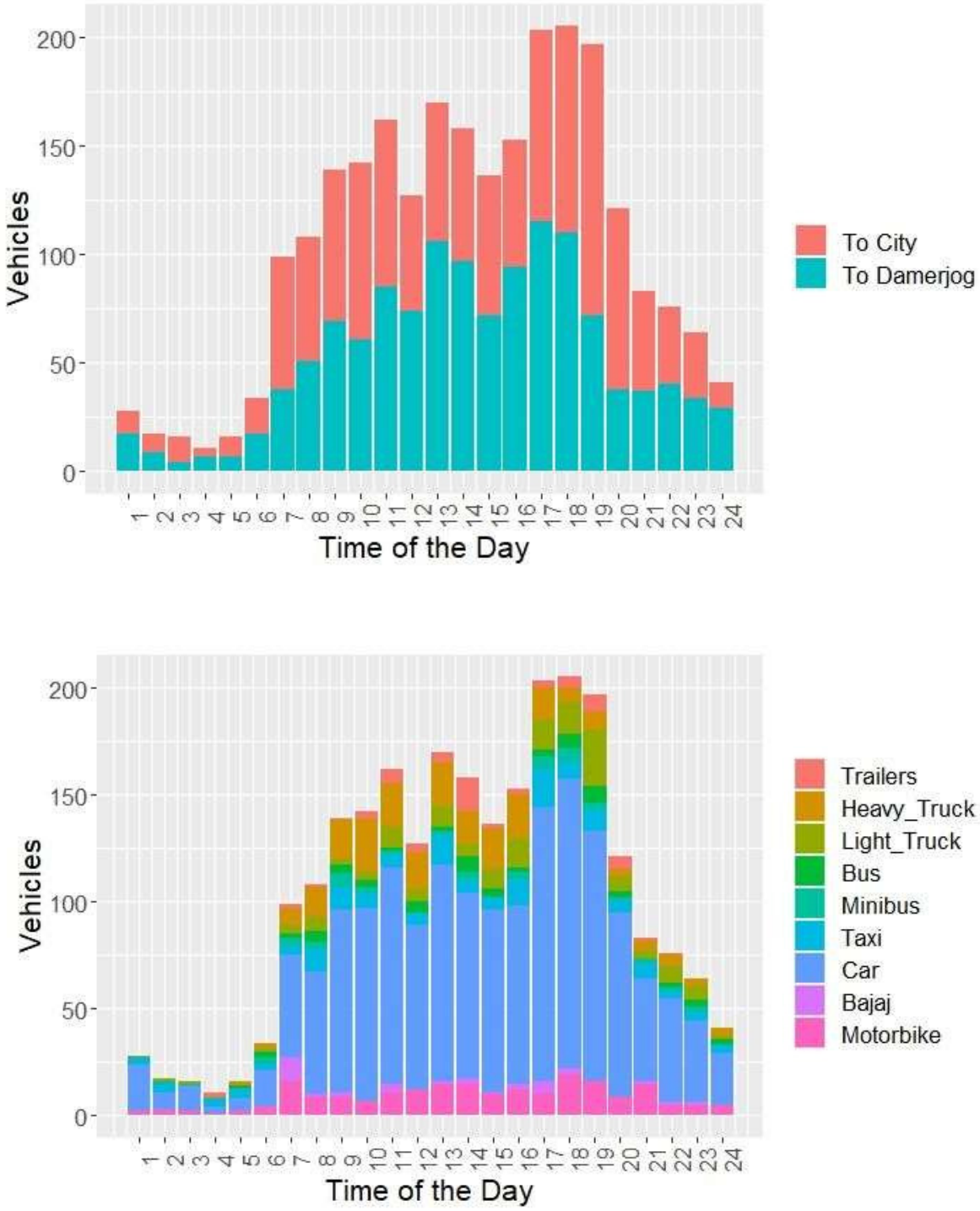


Figure 5 Douda (Location 5) Traffic by Time of Day

Table 6 Location 6 (Loyada Crossing) Traffic

Time	Motorbike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
To Damerjog										
6:00-7:00	0	0	1	0	0	0	0	0	0	1
7:00-8:00	0	0	2	0	0	0	0	0	0	2
8:00-9:00	0	0	2	0	0	0	0	2	0	4
9:00-10:00	1	0	12	0	0	0	0	1	0	14
10:00-11:00	0	0	22	1	0	0	3	0	0	26
11:00-12:00	0	0	7	0	0	0	1	0	0	8
12:00-13:00	1	0	2	0	0	0	2	0	0	5
13:00-14:00	1	0	9	0	0	0	2	0	0	12
14:00-15:00	0	0	7	0	0	0	0	6	0	13
15:00-16:00	0	1	5	1	0	0	0	1	0	8
16:00-17:00	0	1	5	0	0	0	1	5	4	16
17:00-18:00	0	0	11	0	1	0	3	1	3	19
18:00-19:00	0	0	8	0	0	0	1	0	3	12
19:00-20:00	0	2	6	1	0	5	0	0	0	14
To Somalia										
6:00-7:00	0	0	0	0	0	0	0	0	0	0
7:00-8:00	0	0	2	0	0	0	0	0	0	2
8:00-9:00	1	1	3	0	1	0	0	2	0	8
9:00-10:00	1	0	13	0	0	0	3	0	0	17
10:00-11:00	0	0	24	0	0	0	1	1	0	26
11:00-12:00	0	0	2	0	0	0	1	1	1	5
12:00-13:00	2	0	8	0	0	0	0	0	3	13
13:00-14:00	0	0	6	1	0	0	2	2	6	17
14:00-15:00	0	0	1	0	0	0	0	0	0	1
15:00-16:00	0	0	9	0	0	0	1	0	2	12
16:00-17:00	0	1	3	0	0	0	3	3	1	11
17:00-18:00	0	0	14	0	0	0	2	0	1	17
18:00-19:00	0	1	9	1	0	4	0	0	0	15
19:00-20:00	0	3	6	0	0	0	0	0	0	9
Both Directions										
6:00-7:00	0	0	1	0	0	0	0	0	0	1
7:00-8:00	0	0	4	0	0	0	0	0	0	4
8:00-9:00	1	1	5	0	1	0	0	4	0	12
9:00-10:00	2	0	25	0	0	0	3	1	0	31
10:00-11:00	0	0	46	1	0	0	4	1	0	52
11:00-12:00	0	0	9	0	0	0	2	1	1	13
12:00-13:00	3	0	10	0	0	0	2	0	3	18
13:00-14:00	1	0	15	1	0	0	4	2	6	29
14:00-15:00	0	0	8	0	0	0	0	6	0	14
15:00-16:00	0	1	14	1	0	0	1	1	2	20

16:00-17:00	0	2	8	0	0	0	4	8	5	27
17:00-18:00	0	0	25	0	1	0	5	1	4	36
18:00-19:00	0	1	17	1	0	4	1	0	3	27
19:00-20:00	0	5	12	1	0	5	0	0	0	23

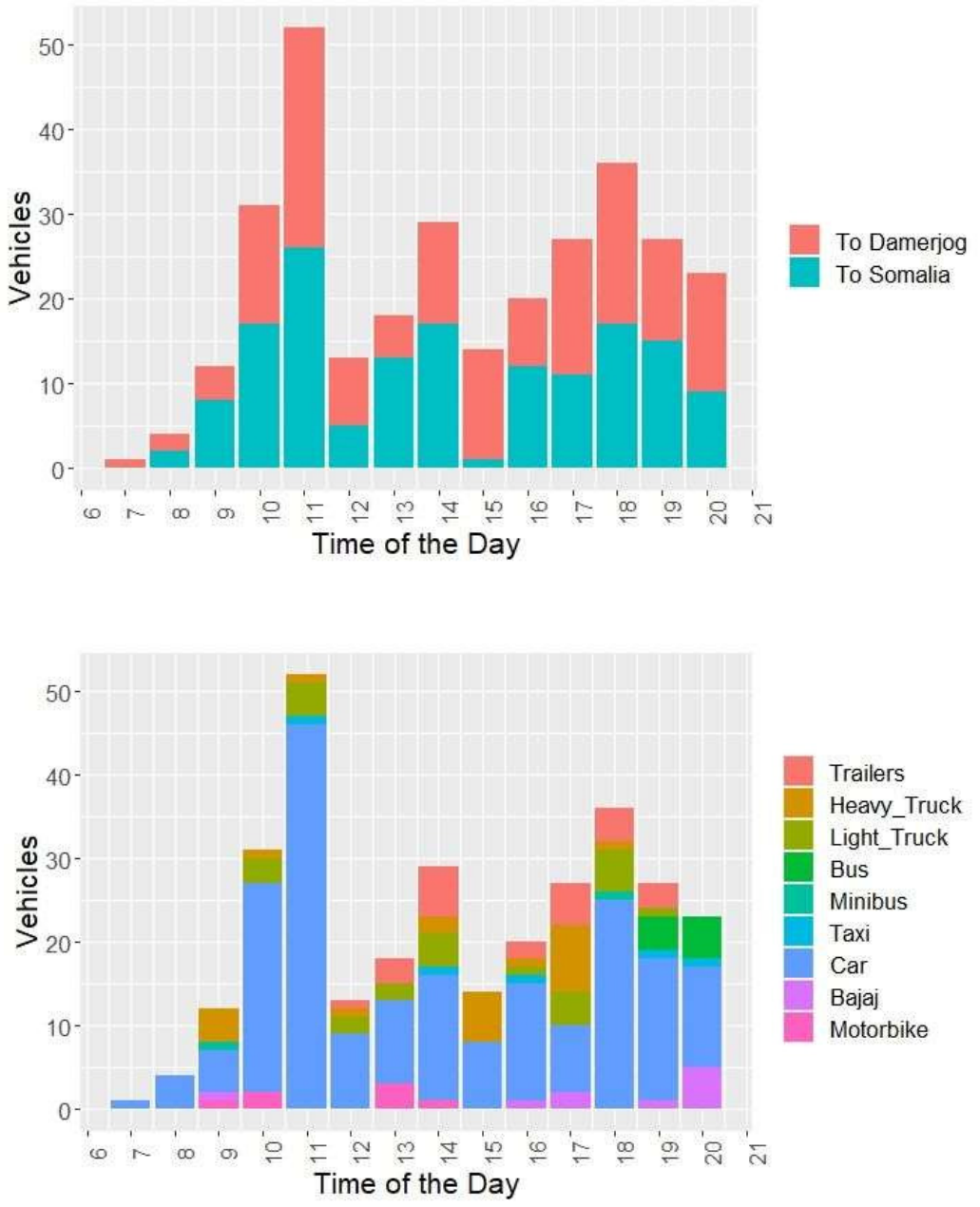
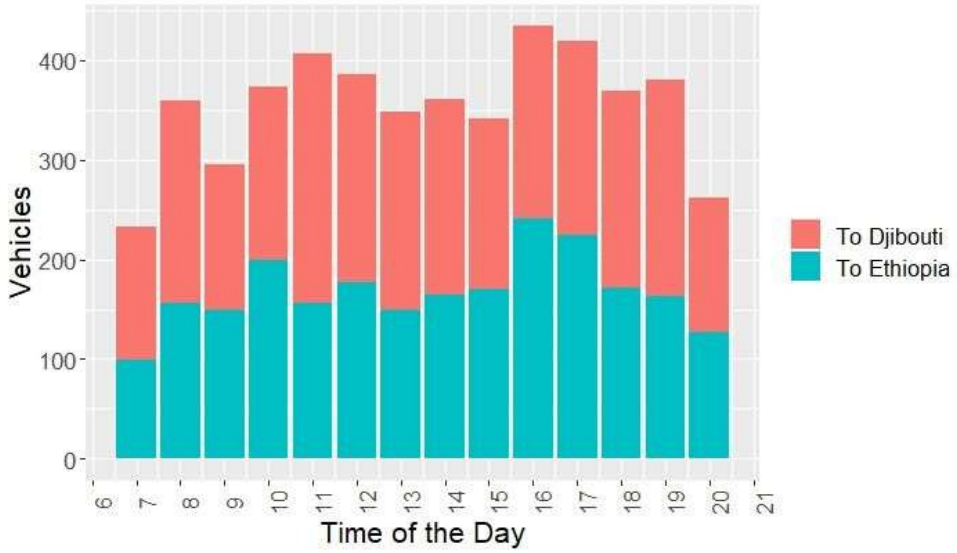


Figure 6 Loyada Crossing Traffic by Time of Day

Table 7 Location 7 (PK20) Traffic

Time	To Ethiopia									
	Motorbike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
6:00-7:00	3	25	23	1	1	3	1	2	40	99
7:00-8:00	3	39	41	1	1	6	3	19	43	156
8:00-9:00	2	34	45	1	1	7	1	8	50	149
9:00-10:00	2	33	72	0	1	4	6	19	63	200
10:00-11:00	5	23	56	1	5	4	5	9	48	156
11:00-12:00	1	27	62	1	1	5	8	6	66	177
12:00-13:00	2	24	42	0	4	3	3	12	60	150
13:00-14:00	3	19	50	0	4	4	11	24	50	165
14:00-15:00	2	16	63	0	4	3	7	13	62	170
15:00-16:00	0	30	73	1	3	4	10	34	86	241
16:00-17:00	0	17	53	0	2	8	16	33	95	224
17:00-18:00	1	28	44	1	3	4	9	16	66	172
18:00-19:00	2	31	31	0	3	2	2	30	62	163
19:00-20:00	2	26	28	1	0	3	3	18	46	127
To Djibouti										
6:00-7:00	1	36	17	3	3	3	1	3	67	134
7:00-8:00	2	40	36	1	1	2	10	22	90	204
8:00-9:00	3	38	29	0	6	6	9	9	47	147
9:00-10:00	3	33	47	2	4	3	5	10	66	173
10:00-11:00	3	29	68	1	3	6	10	14	117	251
11:00-12:00	1	22	72	1	1	7	7	13	85	209
12:00-13:00	3	25	67	1	3	5	5	13	76	198
13:00-14:00	2	20	49	2	4	3	5	39	72	196
14:00-15:00	1	14	46	1	1	5	8	13	83	172
15:00-16:00	2	24	51	1	4	7	15	22	67	193
16:00-17:00	1	24	53	0	1	9	12	34	61	195
17:00-18:00	3	27	80	0	3	5	7	16	56	197
18:00-19:00	2	37	67	0	2	11	7	23	68	217
19:00-20:00	3	29	47	0	2	3	1	22	28	135
Both Directions										
6:00-7:00	4	61	40	4	4	6	2	5	107	233
7:00-8:00	5	79	77	2	2	8	13	41	133	360
8:00-9:00	5	72	74	1	7	13	10	17	97	296
9:00-10:00	5	66	119	2	5	7	11	29	129	373
10:00-11:00	8	52	124	2	8	10	15	23	165	407
11:00-12:00	2	49	134	2	2	12	15	19	151	386
12:00-13:00	5	49	109	1	7	8	8	25	136	348
13:00-14:00	5	39	99	2	8	7	16	63	122	361
14:00-15:00	3	30	109	1	5	8	15	26	145	342
15:00-16:00	2	54	124	2	7	11	25	56	153	434

16:00-17:00	1	41	106	0	3	17	28	67	156	419
17:00-18:00	4	55	124	1	6	9	16	32	122	369
18:00-19:00	4	68	98	0	5	13	9	53	130	380
19:00-20:00	5	55	75	1	2	6	4	40	74	262



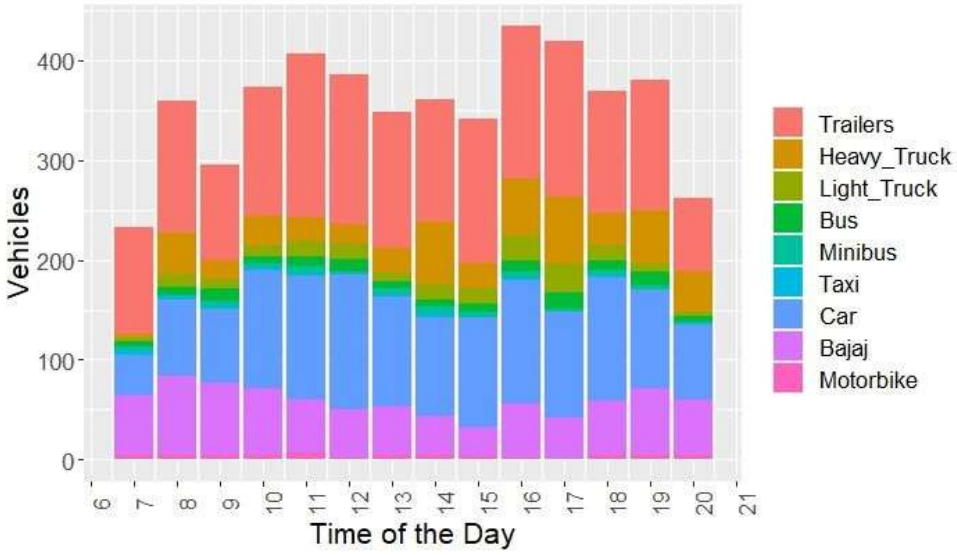


Figure 7 PK20 Traffic by Time of Day

Table 8 Location 8 (PK24) Traffic

Time	Motorbike	Bajaj	Car	Taxi	Minibus	Bus	Light Truck	Heavy Truck	Trailer	Total
To Ethiopia										
0:00-1:00	0	1	5	1	0	1	1	0	37	46
1:00-2:00	1	0	2	0	0	0	2	5	10	20
2:00-3:00	0	0	2	0	0	0	0	1	1	4
3:00-4:00	0	0	2	0	0	0	3	0	12	17
4:00-5:00	0	0	2	1	0	0	2	1	33	39
5:00-6:00	0	0	14	1	0	0	1	1	62	79
6:00-7:00	3	1	16	4	1	1	0	1	66	93
7:00-8:00	1	1	31	1	0	6	5	5	47	97
8:00-9:00	2	0	26	1	0	0	0	5	65	99
9:00-10:00	2	3	29	0	0	4	2	5	60	105
10:00-11:00	1	1	30	2	3	4	0	6	56	103
11:00-12:00	0	1	32	3	1	2	5	4	72	120
12:00-13:00	1	3	29	1	3	5	4	2	52	100
13:00-14:00	2	0	21	0	1	1	3	4	25	57
14:00-15:00	0	1	37	0	2	3	4	10	52	109
15:00-16:00	0	5	47	0	0	3	5	2	68	130
16:00-17:00	0	0	43	0	2	2	5	4	85	141
17:00-18:00	0	2	28	0	3	7	9	0	58	107
18:00-19:00	1	1	21	0	1	2	1	2	55	84
19:00-20:00	0	0	12	0	0	3	0	1	34	50
20:00-21:00	2	2	21	0	0	3	6	3	40	77
21:00-22:00	0	1	11	0	0	2	3	3	63	83
22:00-23:00	0	1	18	0	0	2	6	2	58	87
23:00-0:00	0	0	13	0	0	2	3	1	67	86
To Djibouti										
0:00-1:00	0	0	7	0	0	0	2	0	15	24
1:00-2:00	0	0	5	0	1	0	0	0	8	14
2:00-3:00	0	0	5	0	0	0	0	1	11	17
3:00-4:00	0	0	0	0	0	0	1	1	2	4
4:00-5:00	1	0	2	0	0	0	1	1	3	8
5:00-6:00	1	1	4	0	0	1	4	0	11	22
6:00-7:00	0	1	18	2	1	2	1	3	80	108
7:00-8:00	2	0	23	3	1	2	8	2	71	112
8:00-9:00	2	1	19	2	4	2	3	2	35	70
9:00-10:00	1	1	26	2	3	2	5	2	59	101
10:00-11:00	1	2	35	1	1	3	5	8	83	139
11:00-12:00	1	0	43	1	0	9	4	4	82	144
12:00-13:00	1	3	47	2	1	4	2	4	75	139
13:00-14:00	1	6	19	2	1	1	1	7	63	101

14:00-15:00	0	2	23	1	0	2	3	6	84	121
15:00-16:00	1	1	22	0	1	5	5	4	50	89
16:00-17:00	1	4	24	0	1	6	5	8	41	90
17:00-18:00	1	2	44	0	2	2	3	3	46	103
18:00-19:00	0	0	38	0	0	11	13	3	49	114
19:00-20:00	0	1	30	0	3	2	2	0	21	59
20:00-21:00	0	2	23	0	0	5	0	4	13	47
21:00-22:00	0	0	28	0	0	1	6	5	19	59
22:00-23:00	1	4	14	0	1	1	1	0	14	36
23:00-0:00	0	0	8	0	0	1	1	1	9	20
Both Directions										
0:00-1:00	0	1	12	1	0	1	3	0	52	70
1:00-2:00	1	0	7	0	1	0	2	5	18	34
2:00-3:00	0	0	7	0	0	0	0	2	12	21
3:00-4:00	0	0	2	0	0	0	4	1	14	21
4:00-5:00	1	0	4	1	0	0	3	2	36	47
5:00-6:00	1	1	18	1	0	1	5	1	73	101
6:00-7:00	3	2	34	6	2	3	1	4	146	201
7:00-8:00	3	1	54	4	1	8	13	7	118	209
8:00-9:00	4	1	45	3	4	2	3	7	100	169
9:00-10:00	3	4	55	2	3	6	7	7	119	206
10:00-11:00	2	3	65	3	4	7	5	14	139	242
11:00-12:00	1	1	75	4	1	11	9	8	154	264
12:00-13:00	2	6	76	3	4	9	6	6	127	239
13:00-14:00	3	6	40	2	2	2	4	11	88	158
14:00-15:00	0	3	60	1	2	5	7	16	136	230
15:00-16:00	1	6	69	0	1	8	10	6	118	219
16:00-17:00	1	4	67	0	3	8	10	12	126	231
17:00-18:00	1	4	72	0	5	9	12	3	104	210
18:00-19:00	1	1	59	0	1	13	14	5	104	198
19:00-20:00	0	1	42	0	3	5	2	1	55	109
20:00-21:00	2	4	44	0	0	8	6	7	53	124
21:00-22:00	0	1	39	0	0	3	9	8	82	142
22:00-23:00	1	5	32	0	1	3	7	2	72	123
23:00-0:00	0	0	21	0	0	3	4	2	76	106

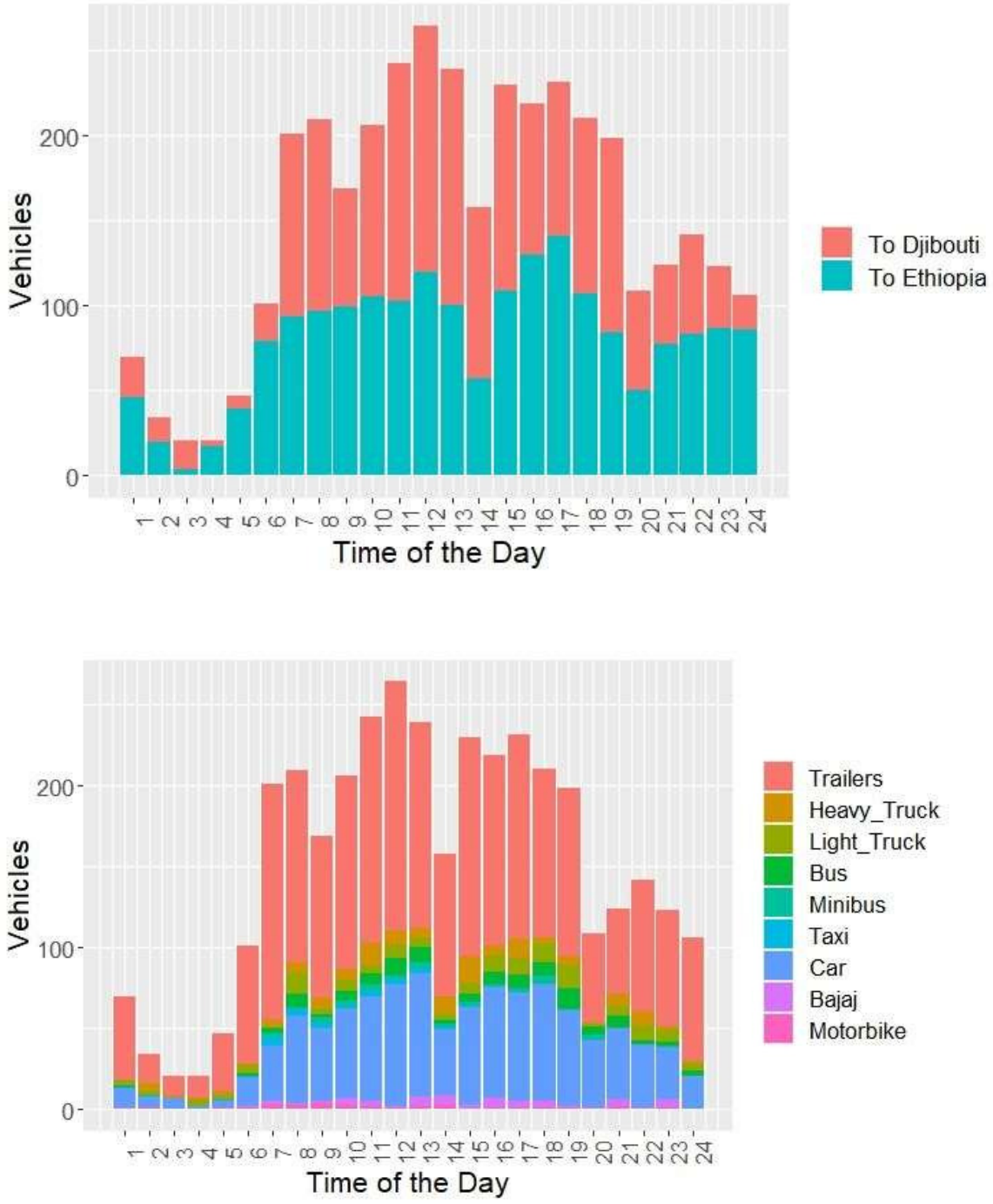
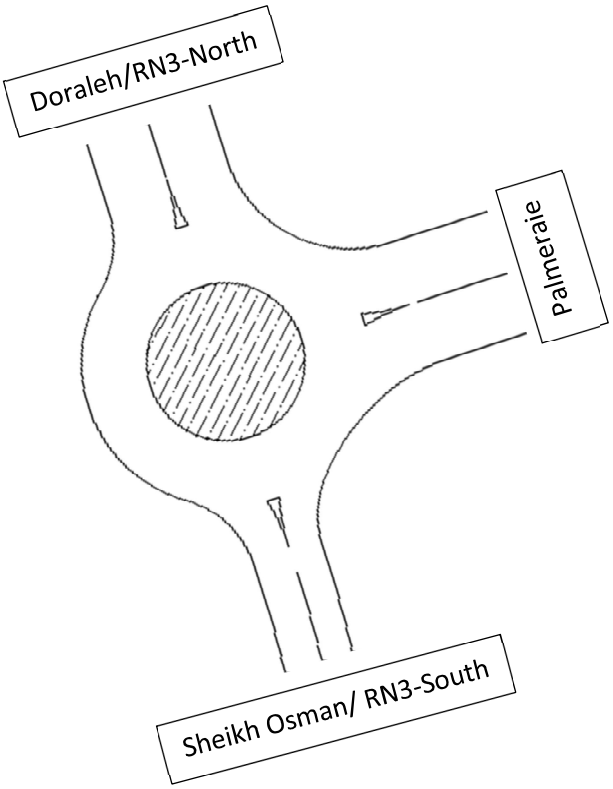


Figure 8 PK24Traffic by Time of Day

INTERSECTION DATA

Vehicle Classification for Intersections

Category	Typical vehicles included	Examples
Car	Cars/taxis/minibus/pick-ups	
Bus/Truck	Single unit trucks/midi-buses (2-3 axles)	
Trailer	Trailer (>3 axles)	



Palmeraie Roundabout (Location 9) Layout

Table 9-1 Location 9 Palmeraie Roundabout, Palmeraie Approach (AM)

Palmeraie or Westbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
6:30 - 6:45	25	0	0	25
6:45 - 7:00	24	5	0	29
7:00 - 7:15	20	7	0	27
7:15 - 7:30	45	8	0	53
7:30 - 7:45	34	8	0	42
7:45 - 8:00	31	4	0	35
8:00 - 8:15	33	1	0	34
8:15 - 8:30	56	4	0	60
8:30 - 8:45	31	2	0	33
8:45 - 9:00	35	6	0	41
Right Turn				
6:30 - 6:45	43	25	8	76
6:45 - 7:00	39	24	8	71
7:00 - 7:15	48	24	9	81
7:15 - 7:30	84	28	10	122
7:30 - 7:45	72	40	7	119
7:45 - 8:00	108	20	4	132
8:00 - 8:15	77	37	7	121
8:15 - 8:30	103	34	8	145
8:30 - 8:45	68	35	8	111
8:45 - 9:00	80	25	9	114

Table 9-2 Location 9 Palmeraie Roundabout, Sheikh Osman Approach (AM)

Sheikh Osman or Northbound Approach				
Time	Through			
	Car	Truck/Bus	Trailer	Total
6:30 - 6:45	4	1	0	5
6:45 - 7:00	9	2	0	11
7:00 - 7:15	2	9	0	11
7:15 - 7:30	2	5	0	7
7:30 - 7:45	5	5	0	10
7:45 - 8:00	5	2	0	7
8:00 - 8:15	8	2	0	10
8:15 - 8:30	5	1	0	6

8:30	- 8:45	5	2	0	7
8:45	- 9:00	7	2	0	9
Right Turn					
6:30	- 6:45	70	7	0	77
6:45	- 7:00	115	10	0	125
7:00	- 7:15	167	8	0	175
7:15	- 7:30	210	8	0	218
7:30	- 7:45	165	15	0	180
7:45	- 8:00	191	26	0	217
8:00	- 8:15	153	10	0	163
8:15	- 8:30	103	7	0	110
8:30	- 8:45	113	4	2	119
8:45	- 9:00	110	3	0	113

Table 9-3 Location 9 Palmeraie Roundabout, Doraleh Approach (AM)

Doraleh or Southbound Approach					
Time		Through			
		Car	Truck/Bus	Trailer	Total
6:30	- 6:45	1	4	0	5
6:45	- 7:00	1	4	0	5
7:00	- 7:15	15	8	0	23
7:15	- 7:30	5	10	0	15
7:30	- 7:45	25	5	0	30
7:45	- 8:00	39	6	0	45
8:00	- 8:15	0	3	0	3
8:15	- 8:30	0	6	0	6
8:30	- 8:45	9	3	0	12
8:45	- 9:00	11	2	0	13
Left Turn					
6:30	- 6:45	69	37	9	115
6:45	- 7:00	135	32	5	172
7:00	- 7:15	187	37	7	231
7:15	- 7:30	326	18	9	353
7:30	- 7:45	195	50	7	252
7:45	- 8:00	135	36	9	180
8:00	- 8:15	152	30	5	187
8:15	- 8:30	140	20	7	167

8:30	- 8:45	106	23	4	133
8:45	- 9:00	69	31	12	112

Table 9-4 Location 9 Palmeraie Roundabout, Palmeraie Approach (PM)

Palmeraie or Westbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	83	10	0	93
12:45 - 13:00	104	4	2	110
13:00 - 13:15	120	10	4	134
13:15 - 13:30	95	8	2	105
13:30 - 13:45	115	14	0	129
13:45 - 14:00	39	8	1	48
14:00 - 14:15	28	11	2	41
14:15 - 14:30	24	5	0	29
14:30 - 14:45	30	6	1	37
14:45 - 15:00	32	4	0	36
Right Turn				
12:30 - 12:45	115	32	10	157
12:45 - 13:00	195	22	7	224
13:00 - 13:15	240	30	7	277
13:15 - 13:30	215	34	10	259
13:30 - 13:45	200	38	14	252
13:45 - 14:00	110	20	6	136
14:00 - 14:15	90	18	8	116
14:15 - 14:30	74	12	3	89
14:30 - 14:45	75	12	4	91
14:45 - 15:00	68	8	5	81

Table 9-5 Location 9 Palmeraie Roundabout, Sheikh Osman Approach (PM)

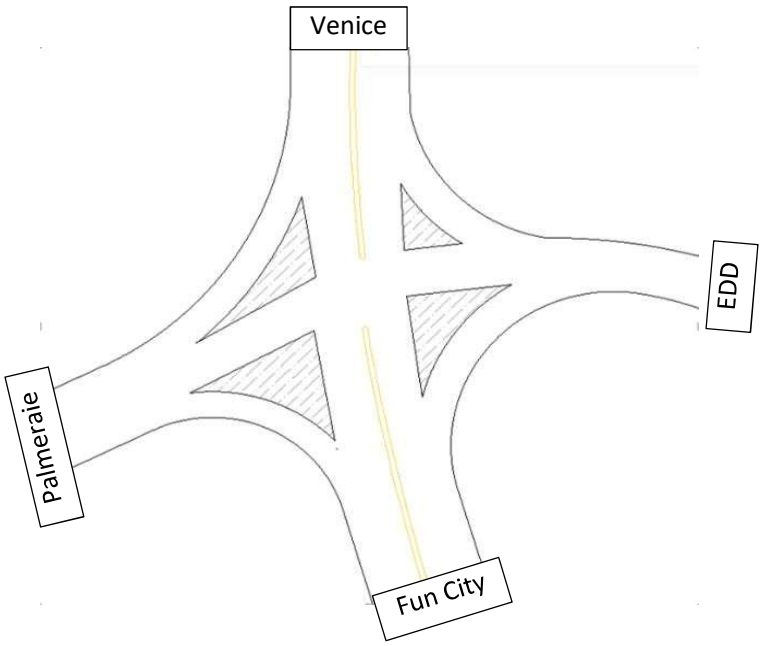
Sheikh Osman or Northbound Approach				
Time	Through			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	7	0	0	7
12:45 - 13:00	18	3	1	22
13:00 - 13:15	10	0	0	10

13:15	- 13:30	14	5	0	19
13:30	- 13:45	10	4	0	14
13:45	- 14:00	11	1	0	12
14:00	- 14:15	9	3	0	12
14:15	- 14:30	8	2	0	10
14:30	- 14:45	10	2	0	12
14:45	- 15:00	4	3	1	8
Right Turn					
12:30	- 12:45	61	3	0	64
12:45	- 13:00	68	3	1	72
13:00	- 13:15	67	2	0	69
13:15	- 13:30	52	4	0	56
13:30	- 13:45	61	6	0	67
13:45	- 14:00	81	2	0	83
14:00	- 14:15	83	2	0	85
14:15	- 14:30	85	3	0	88
14:30	- 14:45	66	5	0	71
14:45	- 15:00	80	4	0	84

Table 9-6 Location 9 Palmeraie Roundabout, Doraleh Approach (PM)

Doraleh or Southbound Approach				
Time	Through			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	0	1	1	2
12:45 - 13:00	9	13	0	22
13:00 - 13:15	24	2	0	26
13:15 - 13:30	36	0	0	36
13:30 - 13:45	8	0	0	8
13:45 - 14:00	29	0	0	29
14:00 - 14:15	28	0	0	28
14:15 - 14:30	43	0	0	43
14:30 - 14:45	20	3	0	23
14:45 - 15:00	19	0	0	19
Left Turn				
12:30 - 12:45	91	30	10	131
12:45 - 13:00	87	17	10	114
13:00 - 13:15	46	19	28	93

13:15 - 13:30	49	15	17	81
13:30 - 13:45	77	26	12	115
13:45 - 14:00	58	22	10	90
14:00 - 14:15	80	18	21	119
14:15 - 14:30	71	28	10	109
14:30 - 14:45	60	16	26	102
14:45 - 15:00	72	31	15	118



Palmeraie Intersection (Location 10) Layout

Table 10-1 Location 10 Palmeraie Intersection, Palmeraie Approach (AM)

Palmeraie or Eastbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
6:30 - 6:45	58	15	4	77
6:45 - 7:00	100	20	0	120
7:00 - 7:15	160	15	3	178
7:15 - 7:30	276	16	2	294
7:30 - 7:45	199	25	5	229
7:45 - 8:00	165	40	5	210
8:00 - 8:15	247	34	5	286
8:15 - 8:30	212	16	5	233
8:30 - 8:45	121	18	5	144
8:45 - 9:00	105	14	15	134
Through				
6:30 - 6:45	3	0	0	3
6:45 - 7:00	8	5	0	13
7:00 - 7:15	20	1	0	21
7:15 - 7:30	45	0	0	45

7:30 - 7:45	30	3	0	33
7:45 - 8:00	11	1	0	12
8:00 - 8:15	10	0	0	10
8:15 - 8:30	10	1	0	11
8:30 - 8:45	13	0	0	13
8:45 - 9:00	8	0	0	8
Right Turn				
6:30 - 6:45	61	21	0	82
6:45 - 7:00	87	27	1	115
7:00 - 7:15	149	31	3	183
7:15 - 7:30	180	23	5	208
7:30 - 7:45	156	23	0	179
7:45 - 8:00	126	15	3	144
8:00 - 8:15	113	20	3	136
8:15 - 8:30	111	26	0	137
8:30 - 8:45	65	20	1	86
8:45 - 9:00	84	22	3	109

Table 10-2 Location 10 Palmeraie Intersection, Venice Approach (AM)

Venice or Southbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
6:30 - 6:45	0	0	0	0
6:45 - 7:00	0	0	0	0
7:00 - 7:15	1	0	0	1
7:15 - 7:30	0	0	0	0
7:30 - 7:45	1	0	0	1
7:45 - 8:00	1	0	0	1
8:00 - 8:15	2	0	0	2
8:15 - 8:30	1	0	0	1
8:30 - 8:45	0	0	0	0
8:45 - 9:00	1	0	0	1
Through				
6:30 - 6:45	8	4	1	13
6:45 - 7:00	17	5	0	22
7:00 - 7:15	22	3	1	26
7:15 - 7:30	31	5	0	36

7:30	- 7:45	35	0	0	35
7:45	- 8:00	35	8	0	43
8:00	- 8:15	50	13	0	63
8:15	- 8:30	37	19	0	56
8:30	- 8:45	25	3	0	28
8:45	- 9:00	37	4	0	41
Right Turn					
6:30	- 6:45	15	8	5	28
6:45	- 7:00	15	8	7	30
7:00	- 7:15	39	26	2	67
7:15	- 7:30	35	23	8	66
7:30	- 7:45	55	16	12	83
7:45	- 8:00	46	19	7	72
8:00	- 8:15	68	16	4	88
8:15	- 8:30	58	26	4	88
8:30	- 8:45	32	13	3	48
8:45	- 9:00	49	28	3	80

Table 10-3 Location 10 Palmeraie Intersection, EDD Approach (AM)

EDD or Westbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
6:30 - 6:45	7	2	1	10
6:45 - 7:00	0	0	0	0
7:00 - 7:15	0	0	0	0
7:15 - 7:30	0	0	0	0
7:30 - 7:45	0	0	0	0
7:45 - 8:00	1	0	0	1
8:00 - 8:15	0	0	0	0
8:15 - 8:30	0	0	0	0
8:30 - 8:45	0	0	0	0
8:45 - 9:00	0	0	0	0
Through				
6:30 - 6:45	25	30	3	58
6:45 - 7:00	18	25	0	43
7:00 - 7:15	35	28	0	63
7:15 - 7:30	53	36	0	89

7:30	- 7:45	46	21	1	68
7:45	- 8:00	40	31	2	73
8:00	- 8:15	21	26	2	49
8:15	- 8:30	43	23	1	67
8:30	- 8:45	26	18	1	45
8:45	- 9:00	45	25	2	72
Right Turn					
6:30	- 6:45	3	2	0	5
6:45	- 7:00	8	0	0	8
7:00	- 7:15	10	0	0	10
7:15	- 7:30	36	2	0	38
7:30	- 7:45	38	1	0	39
7:45	- 8:00	43	5	0	48
8:00	- 8:15	18	7	0	25
8:15	- 8:30	25	0	0	25
8:30	- 8:45	10	1	0	11
8:45	- 9:00	22	1	0	23

Table 10-4 Location 10 Palmeraie Intersection, Fun Coty Approach (AM)

Fun City or Northbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
6:30 - 6:45	27	5	0	32
6:45 - 7:00	24	8	0	32
7:00 - 7:15	25	3	2	30
7:15 - 7:30	41	6	0	47
7:30 - 7:45	50	9	0	59
7:45 - 8:00	47	5	1	53
8:00 - 8:15	73	4	0	77
8:15 - 8:30	52	3	0	55
8:30 - 8:45	48	5	1	54
8:45 - 9:00	35	4	2	41
Through				
6:30 - 6:45	20	3	0	23
6:45 - 7:00	55	4	4	63
7:00 - 7:15	55	5	1	61
7:15 - 7:30	109	5	2	116

7:30	- 7:45	115	8	1	124
7:45	- 8:00	112	3	0	115
8:00	- 8:15	119	5	0	124
8:15	- 8:30	99	4	1	104
8:30	- 8:45	101	4	2	107
8:45	- 9:00	103	2	3	108
Right Turn					
6:30	- 6:45	0	1	0	1
6:45	- 7:00	0	0	0	0
7:00	- 7:15	0	0	0	0
7:15	- 7:30	0	0	0	0
7:30	- 7:45	0	0	0	0
7:45	- 8:00	1	0	0	1
8:00	- 8:15	1	0	0	1
8:15	- 8:30	0	0	0	0
8:30	- 8:45	0	0	0	0
8:45	- 9:00	0	0	0	0

Table 10-5 Location 10 Palmeraie Intersection, Palmeraie Approach (PM)

Palmeraie or Eastbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	81	3	5	89
12:45 - 13:00	58	6	12	76
13:00 - 13:15	54	4	8	66
13:15 - 13:30	50	2	12	64
13:30 - 13:45	53	7	13	73
13:45 - 14:00	69	9	4	82
14:00 - 14:15	86	8	5	99
14:15 - 14:30	70	8	6	84
14:30 - 14:45	87	11	3	101
14:45 - 15:00	62	6	3	71
Through				
12:30 - 12:45	13		0	13
12:45 - 13:00	4	0	0	4
13:00 - 13:15	6	1	0	7
13:15 - 13:30	4	0	0	4

13:30	- 13:45	5	0	0	5
13:45	- 14:00	7	0	0	7
14:00	- 14:15	6	2	0	8
14:15	- 14:30	4	0	0	4
14:30	- 14:45	6	0	0	6
14:45	- 15:00	3	0	0	3
Right Turn					
12:30	- 12:45	85	13	0	98
12:45	- 13:00	71	16	3	90
13:00	- 13:15	65	23	0	88
13:15	- 13:30	67	16	0	83
13:30	- 13:45	65	18	1	84
13:45	- 14:00	67	21	0	88
14:00	- 14:15	67	14	1	82
14:15	- 14:30	56	20	2	78
14:30	- 14:45	67	19	2	88
14:45	- 15:00	47	12	0	59

Table 10-6 Location 10 Palmeraie Intersection, Venice Approach (PM)

Venice or Southbound Approach				
Time	Left Turn			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	2	0	0	2
12:45 - 13:00	0	0	0	0
13:00 - 13:15	1	0	0	1
13:15 - 13:30	1	0	0	1
13:30 - 13:45	1	0	0	1
13:45 - 14:00	0	0	0	0
14:00 - 14:15	1	0	0	1
14:15 - 14:30	1	0	0	1
14:30 - 14:45	0	0	0	0
14:45 - 15:00	0	0	0	0
Through				
12:30 - 12:45	117	8	1	126
12:45 - 13:00	127	6	0	133
13:00 - 13:15	95	3	0	98
13:15 - 13:30	76	8	0	84

13:30	- 13:45	74	6	1	81
13:45	- 14:00	37	3	0	40
14:00	- 14:15	50	10	0	60
14:15	- 14:30	35	2	0	37
14:30	- 14:45	42	3	0	45
14:45	- 15:00	39	12	0	51
Right Turn					
12:30	- 12:45	129	23	6	158
12:45	- 13:00	148	17	7	172
13:00	- 13:15	183	20	9	212
13:15	- 13:30	181	31	2	214
13:30	- 13:45	168	23	9	200
13:45	- 14:00	58	5	3	66
14:00	- 14:15	78	10	3	91
14:15	- 14:30	64	8	2	74
14:30	- 14:45	46	7	3	56
14:45	- 15:00	45	6	7	58

Table 10-7 Location 10 Palmeraie Intersection, EDD Approach (PM)

EDD or Westbound Approach				
Time	Left turn			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	0	0	0	0
12:45 - 13:00	0	0	0	0
13:00 - 13:15	0	0	0	0
13:15 - 13:30	0	0	0	0
13:30 - 13:45	0	0	0	0
13:45 - 14:00	0	0	0	0
14:00 - 14:15	0	0	0	0
14:15 - 14:30	0	0	0	0
14:30 - 14:45	0	0	0	0
14:45 - 15:00	0	0	0	0
Through				
12:30 - 12:45	62	17	2	81
12:45 - 13:00	60	15	1	76
13:00 - 13:15	66	22	3	91
13:15 - 13:30	60	40	2	102

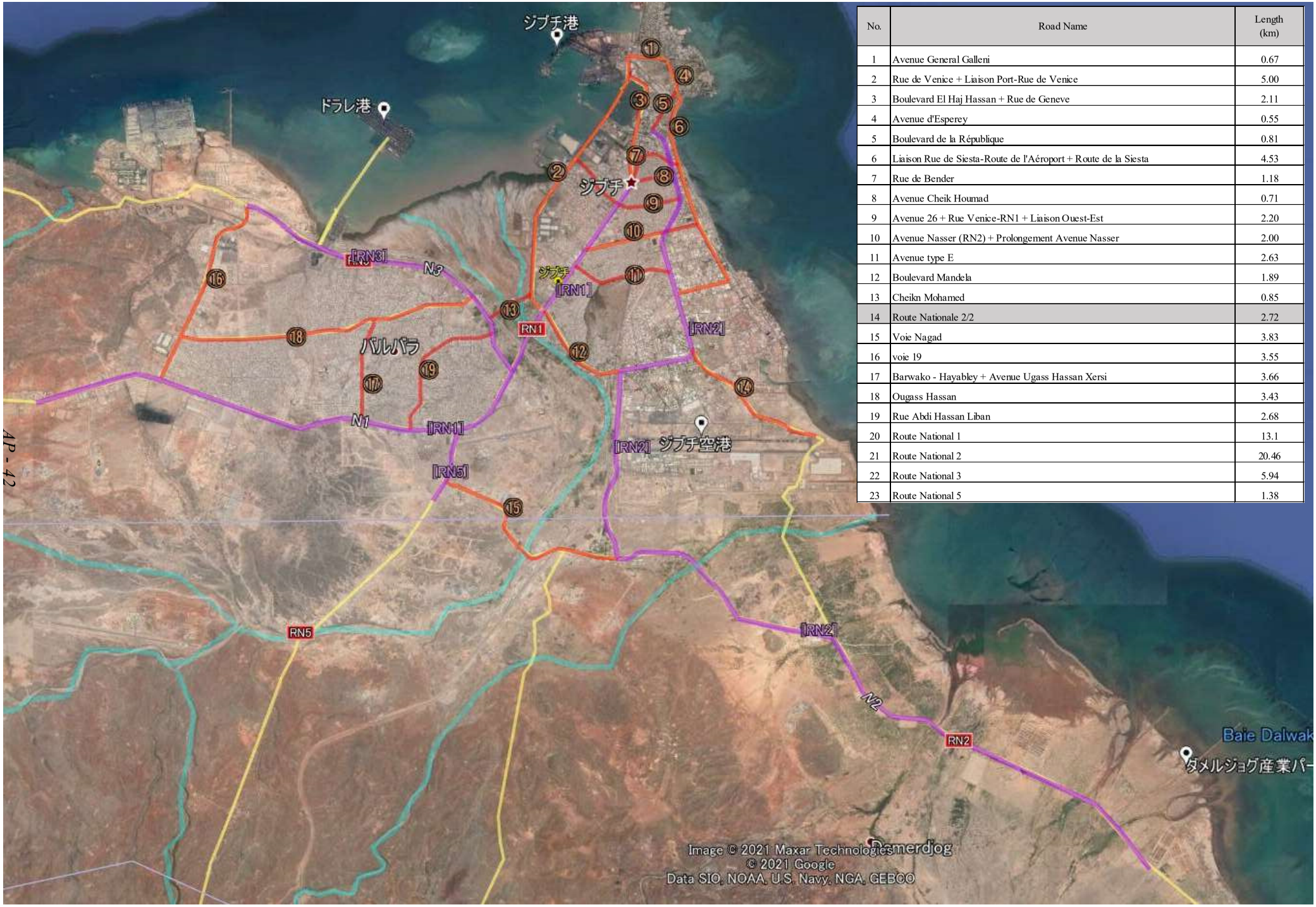
13:30 - 13:45	35	22	1	58
13:45 - 14:00	42	6	1	49
14:00 - 14:15	61	3	1	65
14:15 - 14:30	27	5	0	32
14:30 - 14:45	40	3	0	43
14:45 - 15:00	35	3	1	39
Right turn				
12:30 - 12:45	17	1	0	18
12:45 - 13:00	5	0	0	5
13:00 - 13:15	8	0	0	8
13:15 - 13:30	13	1	0	14
13:30 - 13:45	3	0	0	3
13:45 - 14:00	6	1	0	7
14:00 - 14:15	7	0	0	7
14:15 - 14:30	7	0	0	7
14:30 - 14:45	12	0	0	12
14:45 - 15:00	7	1	0	8

Table 10-8 Location 10 Palmeraie Intersection, Fun Coty Approach (PM)

Fun City or Northbound Approach				
Time	Left turn			
	Car	Truck/Bus	Trailer	Total
12:30 - 12:45	58	9	2	58
12:45 - 13:00	105	3	1	105
13:00 - 13:15	126	1	0	126
13:15 - 13:30	132	14	1	132
13:30 - 13:45	91	17	1	91
13:45 - 14:00	47	7	2	47
14:00 - 14:15	37	4	1	37
14:15 - 14:30	38	3	2	38
14:30 - 14:45	40	2	4	40
14:45 - 15:00	39	3	0	39
Through				
12:30 - 12:45	45	6	1	45
12:45 - 13:00	43	5	1	43
13:00 - 13:15	34	3	2	34
13:15 - 13:30	32	5	0	32

13:30 - 13:45	47	4	1	47
13:45 - 14:00	63	4	0	63
14:00 - 14:15	40	5	0	40
14:15 - 14:30	51	8	0	51
14:30 - 14:45	61	7	0	61
14:45 - 15:00	41	3	0	41
Right turn				
12:30 - 12:45	0	0	0	0
12:45 - 13:00	1	0	0	1
13:00 - 13:15	0	0	0	0
13:15 - 13:30	0	0	0	0
13:30 - 13:45	0	0	0	0
13:45 - 14:00	0	0	0	0
14:00 - 14:15	0	0	0	0
14:15 - 14:30	0	0	0	0
14:30 - 14:45	0	0	0	0
14:45 - 15:00	0	0	0	0

2. Road Inventory Survey Data



No.	Road Name	Length (km)
1	Avenue General Galleni	0.67
2	Rue de Venice + Liaison Port-Rue de Venice	5.00
3	Boulevard El Haj Hassan + Rue de Geneve	2.11
4	Avenue d'Esperey	0.55
5	Boulevard de la République	0.81
6	Liaison Rue de Siesta-Route de l'Aéroport + Route de la Siesta	4.53
7	Rue de Bender	1.18
8	Avenue Cheik Houmad	0.71
9	Avenue 26 + Rue Venice-RN1 + Liaison Ouest-Est	2.20
10	Avenue Nasser (RN2) + Prolongement Avenue Nasser	2.00
11	Avenue type E	2.63
12	Boulevard Mandela	1.89
13	Cheikn Mohamed	0.85
14	Route Nationale 2/2	2.72
15	Voie Nagad	3.83
16	voie 19	3.55
17	Barwako - Hayabley + Avenue Ugass Hassan Xersi	3.66
18	Ougass Hassan	3.43
19	Rue Abdi Hassan Liban	2.68
20	Route National 1	13.1
21	Route National 2	20.46
22	Route National 3	5.94
23	Route National 5	1.38

BRIDGE SURVEY & REORD SHEET

Sheet No.	1 - 1

Date:	June 27 , 2021	Suveyer Name:	M.Murata, I.Takahashi		latitude	longitude
Route Name:	RN1	Weather:	Sunny	Location:	11°33'50.40"N	43° 7'42.48"E

No. / Name	No. 1				Itarian Bridge					
Total Length	L = 109.0				Number of Spans			5		
Span Length	L' = 5	@	21.8	=	109.0					
Width	Total 19.25	Carriageway	7.4	Footpath	1.35	Median	0.65	Curb	0.55	
Structure Type and Dimension	Superstructure	PC I-Girder		Number of Girder		8		Height	1.4	
	Substructure	RC pier, RC Abutment		Width		Axial -	0.7	Lateral -	18.35	
	Foundation	Pile Foundation				Type-2	---			
Bearing Type	Rubber			Guard fence Type		Concrete				
Joint Type	Asphalt			Drainage Type		Steal Pipe				
Pavement Type	Asphalt			Attached Pipes, Cables		————				
Year of Construction	June, 1993	History of repairs		YES	2017	Reair or Reconstruction Plan			No	

Status Photo

Deck Surface

Side Veiw

Superstructure

Substructure

Accessory(1)

Accessory(2)

Memo

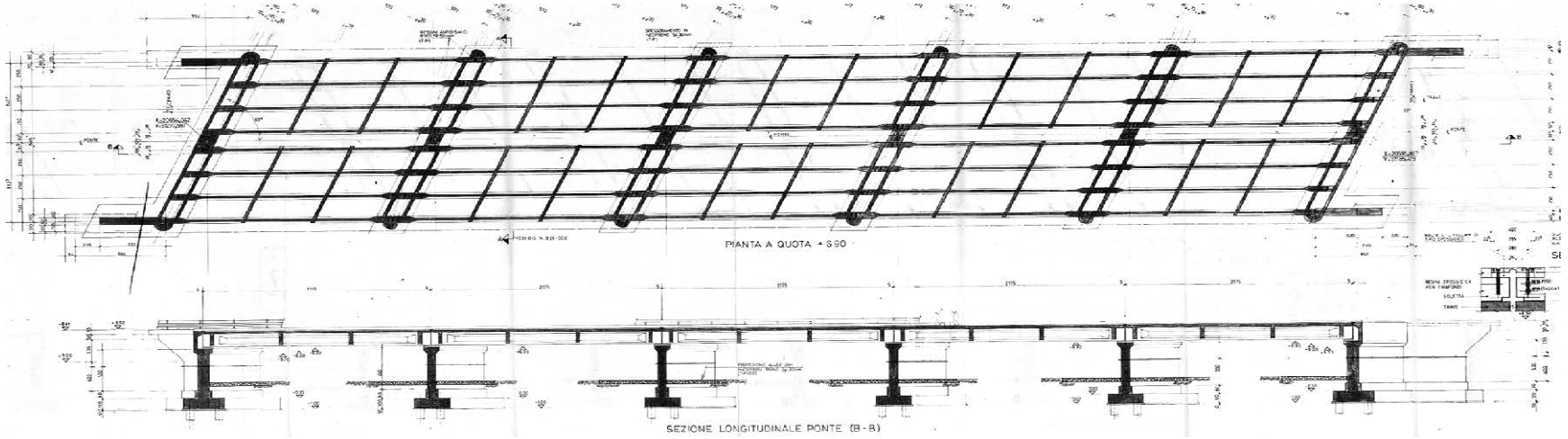
- The repair work was carried out about 24 years after the initial construction.
- There are no detailed drawings of the repair work at the time of construction (some drawings from the time of construction are available).
- Although the repair work was carried out, the traffic of large vehicles is restricted due to the lack of reliability.
- The concrete surface was covered with repair material, making it difficult to check for cracks, but horizontal cracks (less than 0.1mm) were found on some of the piers.
- A large deformation was observed on the guardrail of the bridge, which is dangerous.
- A cover was placed on the surface of the sidewalk, and it seems that a pipeline is located inside.
- The width of the substructure is 90 cm, and judging from the drawings at the time of construction, it is assumed that the width of the substructure has been increased during repair work.
- The outer surface of the main girder has a stripe pattern, but it is difficult to evaluate the soundness of the girder from the visual inspection.

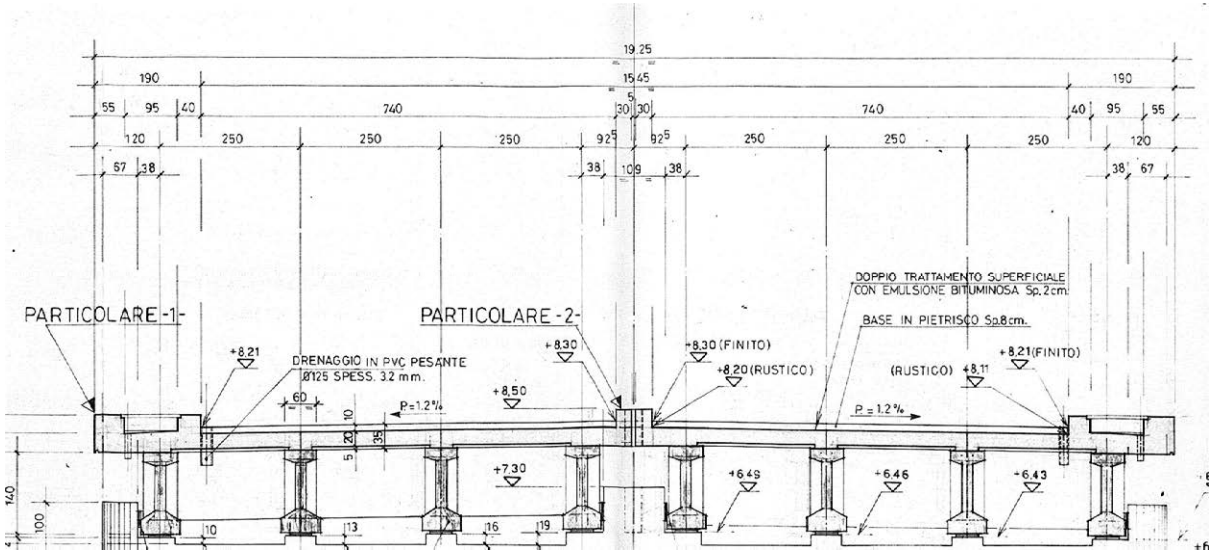
BRIDGE SURVEY & REORD SHEET

Sheet No.	1 - 2

Date:	June 27 , 2021	Suveyer Name:	M.Murata, I.Takahashi		latitude	longitude
Route Name:	RN1	Weather:	Sunny	Location:	11°33'50.40"N	43° 7'42.48"E

Drwaing and Photo (Initial Construction)





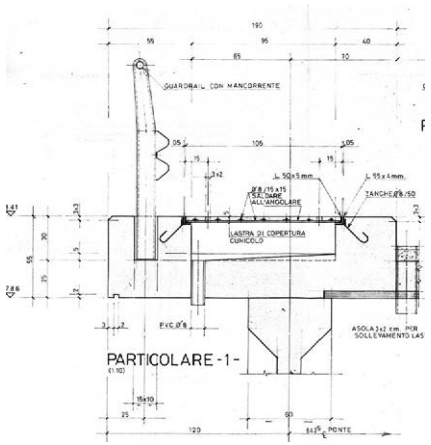
Source : Local Contractor (Cosmezz)

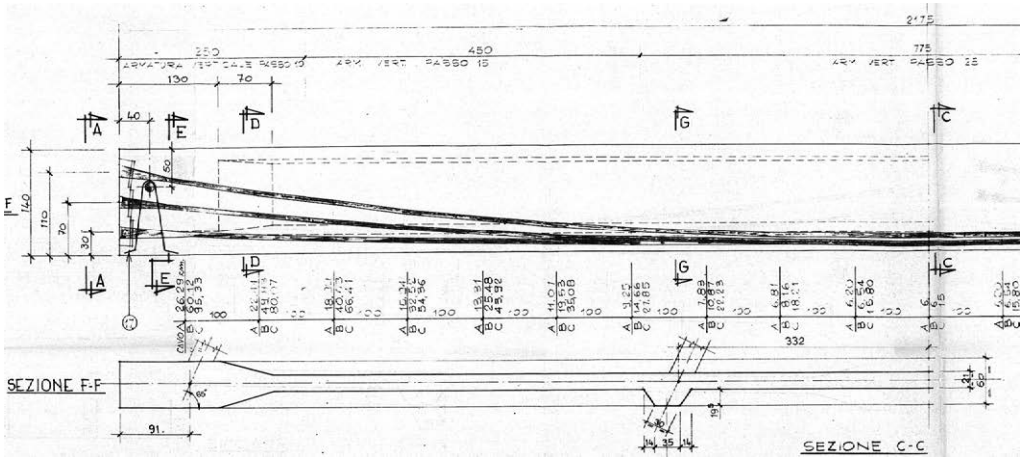
BRIDGE SURVEY & REORD SHEET

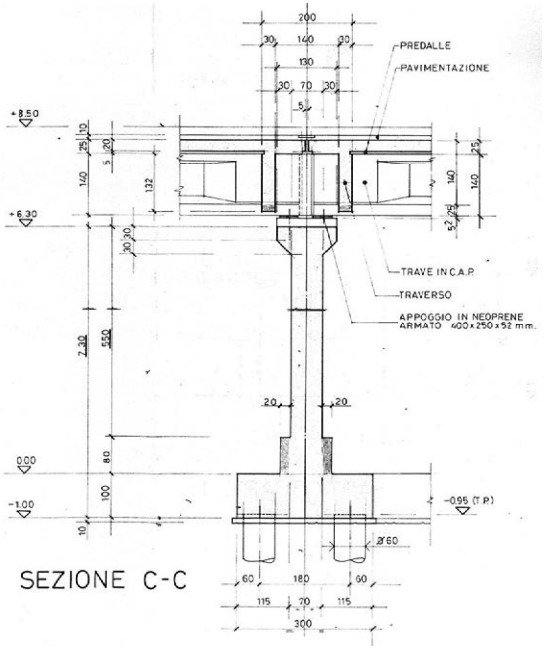
Sheet No.	1 - 3

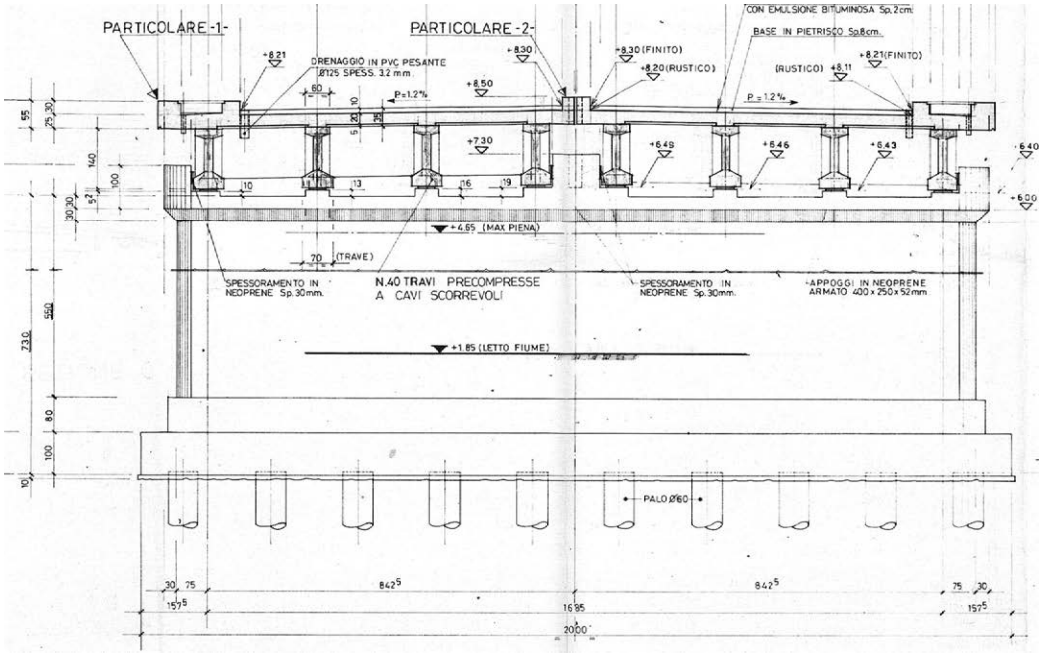
Date:	June 27 , 2021	Suveyer Name:	M.Murata, I.Takahashi		latitude	longitude
Route Name:	RN1	Weather:	Sunny	Location:	11°33'50.40"N	43° 7'42.48"E

Drwaing and Photo (Initial Construction)









Source : Local Contractor (Cosmezz)

BRIDGE and Culvert SURVEY & REORD SHEET

Sheet No.	1 - 2

Date:	June 27 , 2021	Suveyer Name:	M.Murata, I.Takahashi
Route Name:	RN1	Weather:	Sunny

Structure / Rute Nam	Rail Road			Cheikn Mohamed			Rail Road Bridge (2)			National Route 1		
Location:	11°34'1.63"N			43° 7'21.68"E			11°33'42.81"N			43° 7'38.75"E		
Total Length	L = 110.0			Number of Spans		3	L = 113.0			Number of Spans		3
Structure Type	Superstructure	PC I-Girder		Substructure	RC pier, RC Abutment		Superstructure	PC I-Girder		Substructure	RC pier, RC Abutment	
Year of Construction	2016	History of repairs	No	—	Reair or Reconstruction Plan	No	2016	History of repairs	No	—	Reair or Reconstruction Plan	No

AP - 45

Status Photo

Memo

From the road surface to the bottom of the girder : 6.0m

From the road surface to the bottom of the girder : 6.0m

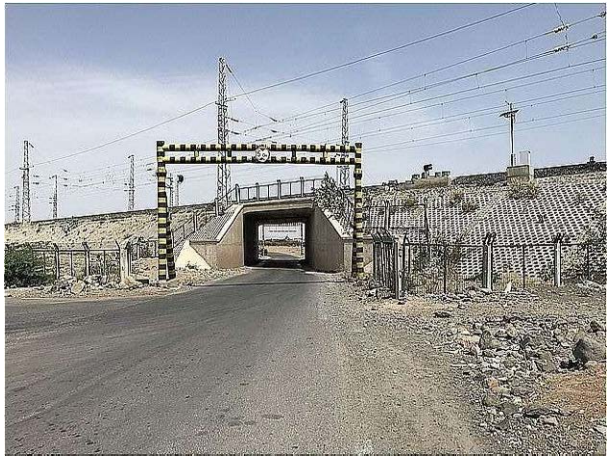
BRIDGE and Culvert SURVEY & REORD SHEET

Sheet No.	2 - 2

Date:	June 27 , 2021	**Suveyer Name:**	M.Murata, I.Takahashi
Route Name:	RN1	**Weather:**	Sunny

Structure / Rute Nam	**Box Culvert**			**Cheikn Mohamed**							
Location:	11°31'47.65"N			43° 7'58.22"E							
Total Length	L = 32.0			**Number of Spans**	-		L =		**Number of Spans**		
Structure Type	**Superstructure**	— (RC Culvert)		**Substructure**	— (RC Culvert)		**Superstructure**		**Substructure**		
Year of Construction	2016	**History of repairs**	No	—	**Reair or Reconstruction Plan**	No		**History of repairs**		—	**Reair or Reconstruction Plan**	

Status Photo



Memo

From the road surface to the bottom of the girder : 5.0m

AP - 4

FORD SURVEY & REORD SHEET

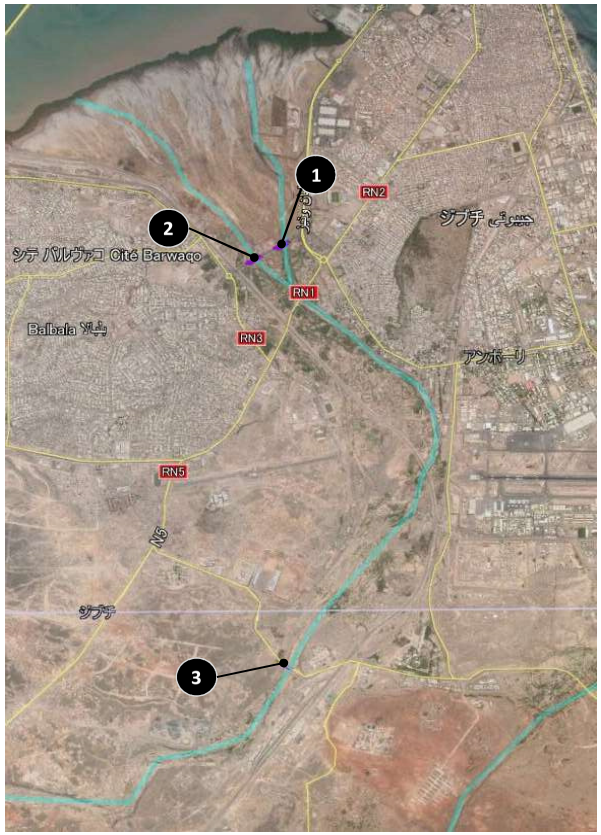
Sheet No.	1 - 1

Date:	June 27 , 2021	Suveyer Name:	M.Murata, I.Takahashi
Route Name:	RN1	Weather:	Sunny

No. / Rute Name	1	Cheikn Mohamed	2	Cheikn Mohamed
Location:	11°34'1.63"N	43° 7'21.68"E	11°34'1.63"N	43° 7'21.68"E
No. / Rute Name	3	Voie Nagad		
Location:	11°34'1.63"N	43° 7'21.68"E		

AP - 8

Status Photo



No.1 W=19m L=150m

No.2 W=19m L=150m

No.3 W= 10m L=100m

CULVERT INVENTORY SURVEY FIELD SHEET

Date:	June 27 ,2021	**Suveyer Name:**	M.Murata, I.Takahashi		**latitude**	**longitude**
Route Name:	Rue de Venice + Liaison Port-Rue de Venice	**Weather:**	Sunny	**Beginning Point(B.P)**	11°34'5.92"N	43° 7'49.89"E

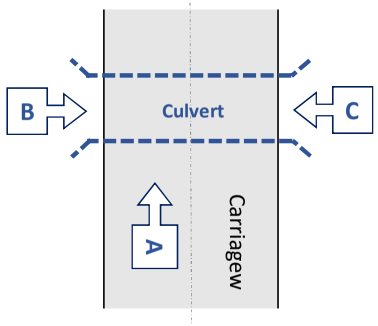
No. / Location	2 / 1	Location	latitude	longitude	/	Location	latitude	longitude
Length	L = 23 (m)		11°34'5.92"N	43° 7'49.89"E	L = (m)			
Condition	☐ Good ■ Crack ■ Broken ☐ Sediment				Good Crack Broken Sediment			

Culvert Type and Dimension

☐ Pipe	■ Box ※5-BOX	☐ Arch	(m) D = ---- W = 9.6 H = 1.2	Pipe	Box	Arch	(m) D = W = H =

Status Photo

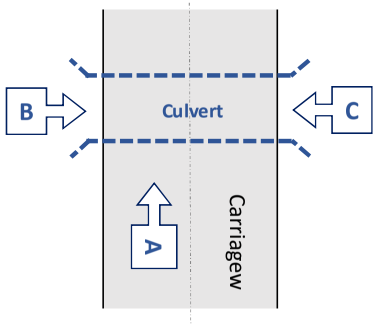
To Balbala



To Djibouti Port

[A]

To



To

[A]

[B]

■ Inlet ☐ Outlet ☐ Unknown

[C]

☐ Inlet ■ Outlet ☐ Unknown

[B]

[C]

Memo

・Rusting of steel bars and spalling of concrete due to salt damage have been observed.

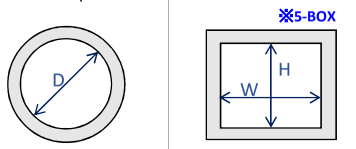
CULVERT INVENTORY SURVEY FIELD SHEET

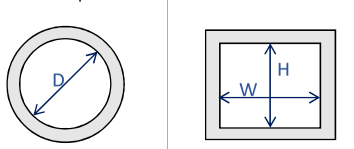
Date:	June 27 ,2021	**Suveyer Name:**	M.Murata, I.Takahashi		**latitude**	**longitude**
Route Name:	Cheikn Mohamed	**Weather:**	Sunny	**Beginning Point(B.P)**	11°34'0.08"N	43° 7'19.77"E

No. / Location	13 / 1	Location	latitude	longitude	13 / 2	Location	latitude	longitude
Length	L = 26 (m)		11°34'12.55"N	43° 7'43.53"E	L = 19 (m)		11°34'12.99"N	43° 7'43.53"E
Condition	☐ Good ■ Crack ☐ Broken ☐ Sediment				☐ Good ■ Crack ☐ Broken ☐ Sediment			

Culvert Type and Dimension

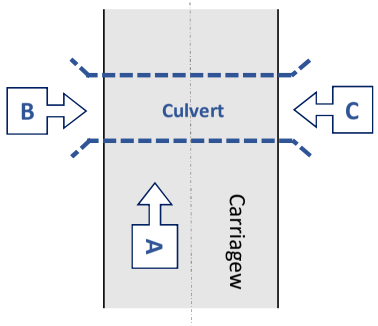
☐ Pipe	■ Box ※5-BOX	☐ Arch	(m) D = ---- W = 1.4 H = 1.4		■ Pipe	☐ Box	☐ Arch	(m) D = 0.3 W = ---- H = ----	





Status Photo

To Djibouti Port



To Fun City

[A]

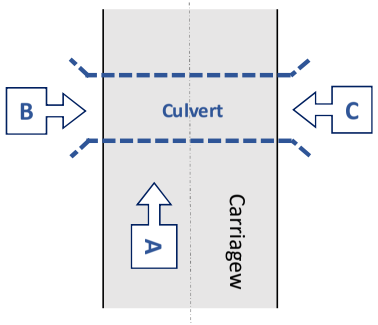
[B]

☐ Inlet ☐ Outlet ■ Unknown

[C]

☐ Inlet ☐ Outlet ■ Unknown

To Djibouti Port



To Balbala

[A]

[B]

☐ Inlet ☐ Outlet ■ Unknown

[C]

☐ Inlet ☐ Outlet ■ Unknown

Memo

- Concrete is relatively sound, but sediment and weeds have accumulated.

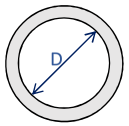
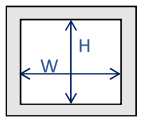
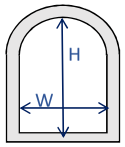
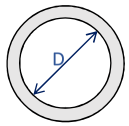
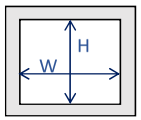
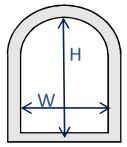
- Concrete is relatively sound, but sediment and weeds have accumulated.

CULVERT INVENTORY SURVEY FIELD SHEET

Date:	June 27 ,2021	Suveyer Name:	M.Murata, I.Takahashi		latitude	longitude
Route Name:	Route National 3	Weather:	Sunny	Beginning Point(B.P)	11°33'29.86"N	43° 7'32.96"E

No. / Location	22 / 1	Location	latitude	longitude	22 / 2	Location	latitude	longitude
Length	L = 23 (m)		11°34'23.77"N	43° 6'57.13"E	L = 16 (m)		11°33'35.14"N	43° 6'57.13"E
Condition	☐ Good ■ Crack ■ Broken ☐ Sediment				☐ Good ■ Crack ■ Broken ■ Sediment			

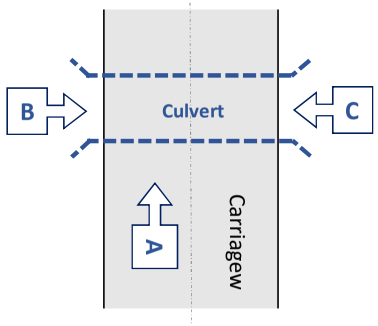
Culvert Type and Dimension

☐ Pipe	■ Box ※3-BOX	☐ Arch	(m)	☐ Pipe	■ Box	☐ Arch	(m)
			D = --- W = 7.3 H = 1.6				D = --- W = 3.0 H = 3.0

*Dimensions depend on the hearing.

Status Photo

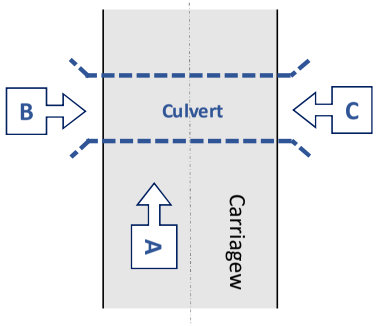
To RN3



To RN1

[A]

To RN3



To RN1

[A]

[B]

■ Inlet ☐ Outlet ☐ Unknown

[C]

☐ Inlet ■ Outlet ☐ Unknown

[B]

■ Inlet ☐ Outlet ☐ Unknown

[C]

☐ Inlet ■ Outlet ☐ Unknown

Memo

・Rusting of steel bars and spalling of concrete due to salt damage have been observed.

・There seems to be a box culvert under the road, but it cannot be confirmed because it is covered with sediment and garbage.
・During heavy rains, the water level rises to about 1m above the road, making it impossible to pass.
・The topographical conditions are such that the surface water in the Barbara area eventually collects in this river.

3. Geological Survey Data

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Ministère de l'Equipement et des Transport

LCBE
LABORATOIRE CENTRAL
DU BÂTIMENT ET DE L'EQUIPEMENT

GEOTECHNICAL STUDY REPORT

SOIL IDENTIFICATION CAMPAIGN

FILE N°144-2021 – Réf n°176-21-LCBE

SITE: NAGAD AND PALMERAIE

PROJECT: PRELEMIRY STUDY FOR INFRASTRUTURE

CLIENT: YACHIYO ENGINEERING Co. Ltd

Version	Dated	Nature modification
A	29/06/2021	Original Version– Factual report
B	02/08/2021	Original Version– Factual report

GEOTECHNICAL MISSION

PRELIMINARY STUDIES - GEOTECHNICAL

Included in this document:

1. A geotechnical report
2. Annex 1: Lithology of boreholes
3. Annex 2: SPT
4. Annex 4: Laboratory results
5. Annex 5: Survey crate pictures
6. Annex 6: Site Project pictures
7. Annex 7: Logging of the drilling holes
8. Annex 8 : Définitions des missions U.S.G., norme NF P 94-500

Table of content

GEOTECHNICAL MISSION 2

PRELIMINARY STUDIES - GEOTECHNICAL 2

I. PRESENTATION 4

1.1 Mission Definition 4

1.2 Regulation used 4

II. SOIL IDENTIFICATION 5

2.1 Identification program 5

2.2 Identification synthesis 5

♦ **Surveying procedures** 5

♦ **Synthesis of laboratory tests** 7

♦ **Hydrogeological synthesis** 8

No tablecloth was encountered. It has been noted during field operations areas of high water loss probably related to the presence of fracturing network of rock formations 8

However, we cannot exclude the presence of anarchic traffic, linked to preferential flow channels. The surface hydrological regime is likely to vary, depending on the season and rainfall 8

III. CONCLUSIONS 9

I. PRESENTATION

1.1 Mission Definition

♦ Mission

At the request of **Yachiyo Engineering Co.**, the **CENTRAL BUILDING AND EQUIPMENT LABORATORY (LCBE)** moved to the site of **NAGAD AND PALMERAIE**, to carry out a **SERIE OF IDENTIFICATION OF SOIL** of the ground. This mission should allow:

1. Determine the lithological nature of the formations crossed
2. To identify the geotechnical nature of the samples taken from the section
3. Provide the results of the laboratory tests performed on the samples taken.

.

1.2 Regulation used

The various tests performed (in situ and laboratory tests) comply with AFNOR standards

.

II. SOIL IDENTIFICATION

2.1 Identification program:

For this study, the investigation program initially planned was modified to take into account the difficulties of access to the site.

.

The table below gives a summary of the work performed:

Lieu	Ech N°	Coordonnée des points		Prélèvement (m)	Observations
		Abscisse	Ordonnée		
	SC01	0295815	1275193	10	Difficulty of advancement. Non-cohesive, non-homogeneous sample. Mixture of weathered rock and silty clay /
	SC02	0295445	1279512	10	No problem encountered.
	SC03	0295766	1279599	10	Tubing up to 6m deep.

In addition to the core drilling and manual sampling of soil samples, the following test has been realized on the site:

1. Laboratory tests to identify and characterize soils in place, including:

- 10 Sieve analysis [NF EN 933-1 & NF EN 933-2],
- 10 Atterberg Limits [NF P 94-051],
- 10 Water content [NF P 94-050],
- 5 Compressive strength tests [NF P 94-420],
- 5 Physical properties [NF P 94-410],

The results of all the tests are presented in the appendices to this report.

2.2 Identification synthesis

♦ Surveying procedures

1. <u>Boreholes drilling with Standard penetration test :</u>

For these types of machines, drillings are carried out by the method of rotation by means of a drill string provided at its base with a perforating tool which rotates in the borehole. Bentonite-based slurry injected into the circuit allows the drill string to be cooled down, the wall to be shielded and the borehole to be cleaned. Tungsten carbide crowns, carbonites and diamond crowns are used depending on the formations encountered.Drilling was carried out by rotation and washing.

The Standard Penetration Test is carried out following a battering of a 450 mm penetration of the split sampler, using a hammer weighing 63.5 kg and falling in free fall from a height of 760 mm on the head of a drill string.

The split sampler used has an outside diameter of 51 mm and does not have a liner inside. The standard penetration tests were performed using an automatic hammer, providing effective energy to the rod train of about 80% of the theoretical potential free fall energy.

This test, carried out in accordance with the French Standard (NF P 94-116), makes it possible to provide information on the nature of the soil and to take samples of remodeled material for carrying out physical tests in the laboratory.

Lieu	Ech N°	Coordonnée des points		Prélèvement (m)
		Abscisse	Ordonnée	
	SC01	0295815	1275193	10
	SC02	0295445	1279512	10
	SC03	0295766	1279599	10

NB: the reference zero level for the depths is the natural terrain.

All the depths above are given to the right of our recognitions (Survey point).

♦ **Site plan of Survey points:**

The different survey points made are materialized on the ground plan below.

♦ **Synthesis of laboratory tests:**

The results of the laboratory tests carried out on the soil samples taken from the holes are presented in appendices.

♦ Hydrogeological synthesis

No tablecloth was encountered. It has been noted during field operations areas of high water loss probably related to the presence of fracturing network of rock formations.

However, we cannot exclude the presence of anarchic traffic, linked to preferential flow channels. The surface hydrological regime is likely to vary, depending on the season and rainfall.

WATER LEVEL SURVEY (m)				
Date	**24h**	**48h**	**72h**	**5J**
Points	**SC01**			
Depth	**x**	**x**	**x**	**x**
Points	**SC02**			
Depth	**0***	**0***	**0***	**0***
Points	**SC03**			
Depth	**1,23**	**1,25**	**1,3**	**-**

* On the surface, swampy area

III. CONCLUSIONS

The laboratory tests were carried out on the samples taken, the results obtained are inserted in the report and attached.

Done in Djibouti, the *02/08/2021*

Head of service Laboratory P.I

Idriss Mohamed Ahmed

Head of service building and structures

Arbba Mohamed Dileita

GENERAL MANADGER OF LCBE

RAHIMAN AHMED MOUSSA

LCBE
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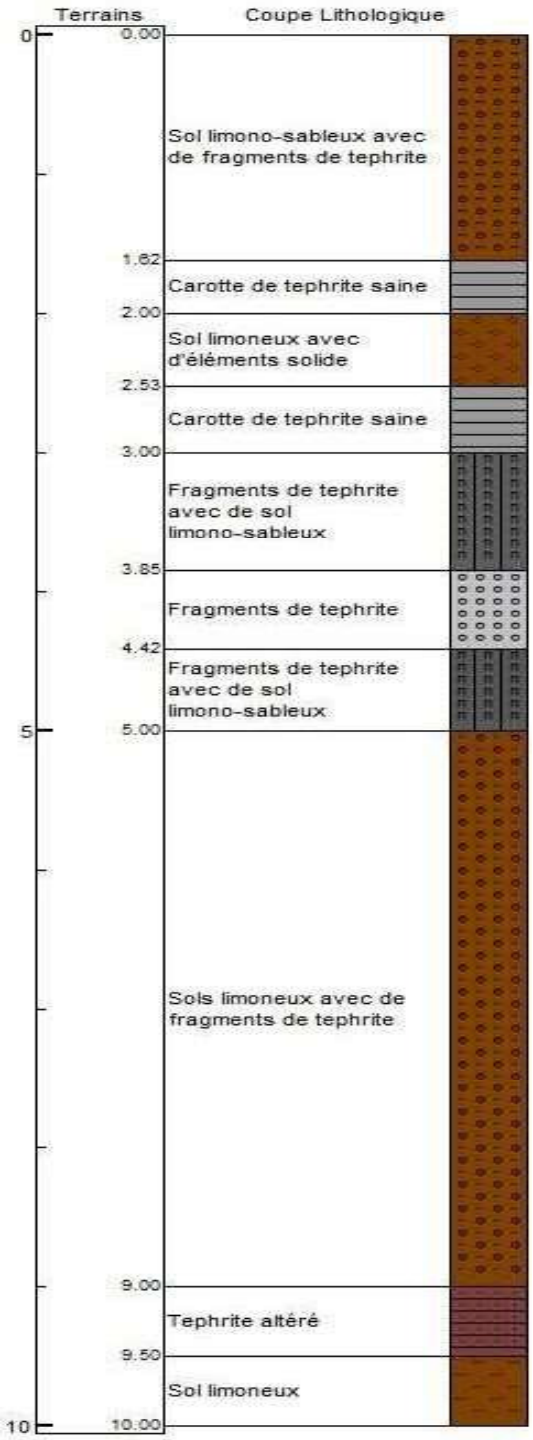
ANNEX:

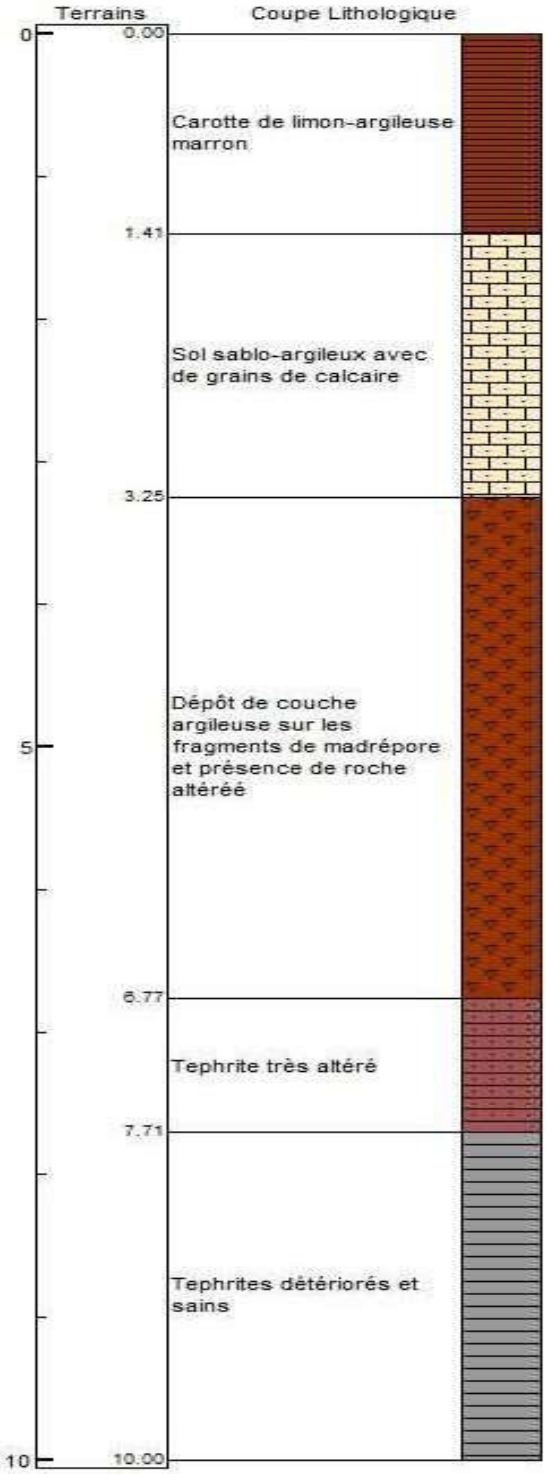
Annex 1: Lithology cut of Boreholes 10
Annex 2: SPT 12
Annex 3: Laboratory Test Results 13
SIEVE ANALYSIS 13
ATTERBERG LIMITS 23
WATER CONTENT 33
COMPRESSION TEST 34
Annex4: Survey crates pictures 36
Annex 5: Pictures of rocks 39
Annex 6: Site Project pictures 40
Annex 7: Logging of the drilling holes 42
ANNEXE 8 : DEFINITIONS DES MISSIONS U.S.G., NORME NF P 94-500 45

Annex 1: Lithology cut of Boreholes

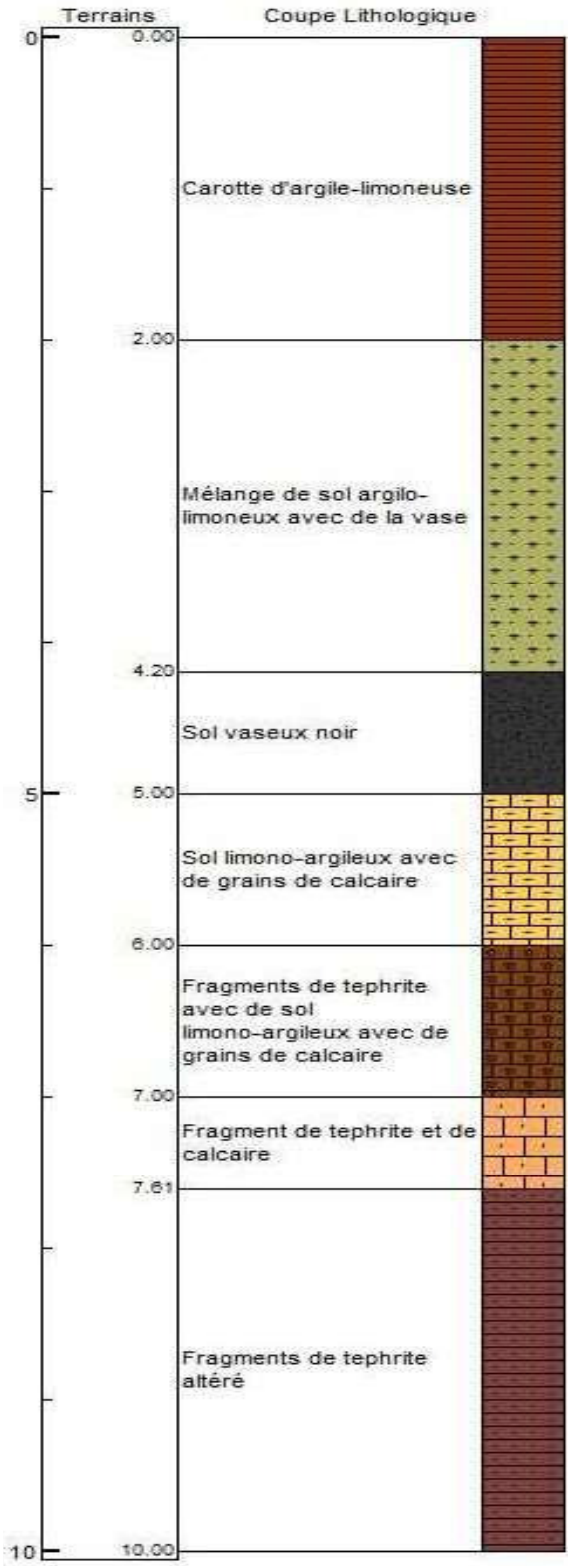
SC01



SC02



SC03


Terrains
Coupe Lithologique
0
5
10
0.00
2.00
4.20
5.00
6.00
7.00
7.61
10.00
Carotte d'argile-limoneuse
Mélange de sol argilo-limoneux avec de la vase
Sol vaseux noir
Sol limono-argileux avec de grains de calcaire
Fragments de tephrite avec de sol limono-argileux avec de grains de calcaire
Fragment de tephrite et de calcaire
Fragments de tephrite altéré

Annex 2: SPT

Standard Penetration Test (SPT)				
Depth (m)	15 cm	15cm	15cm	SPT Value (N)
SC01				
1.20-1.65	>55	-	-	-
2.00-2.45	48	>55	-	-
3.15-3.60	>55	-	-	-
4.00-4.45	2	>55	-	-
5.30-5.75	7	3	>55	-
6.35-6.85	>55	-	-	-
7.05-7.50	>55	-	-	-
8.10-8.55	>55	-	-	-
9.50-9.95	>55	-	-	-
10.00-10.45	-	-	-	-
SC02				
1.00-1.45	7	7	10	17
2.00-2.45	10	12	18	30
3.00-3.45	4	12	50	62
4.00-4.45	19	44	>55	-
5.00-5.45	27	>55	-	-
6.00-6.45	>55	-	-	-
7.00-7.45	-	-	-	-
8.00-8.45	-	-	-	-
9.00-9.45	-	-	-	-
10.00-10.45	-	-	-	-
SC03				
1.00-1.45	2	3	3	6
2.00-2.45	3	5	3	8
3.00-3.45	2	1	1	2
4.00-4.45	1	1	1	2
5.00-5.45	7	7	9	16
6.00-6.45	>55	-	-	-
7.00-7.45	-	-	-	-
8.00-8.45	-	-	-	-
9.00-9.45	-	-	-	-
10.00-10.45	-	-	-	-

Annex 3: Laboratory Test Results

SIEVE ANALYSIS

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LCBE
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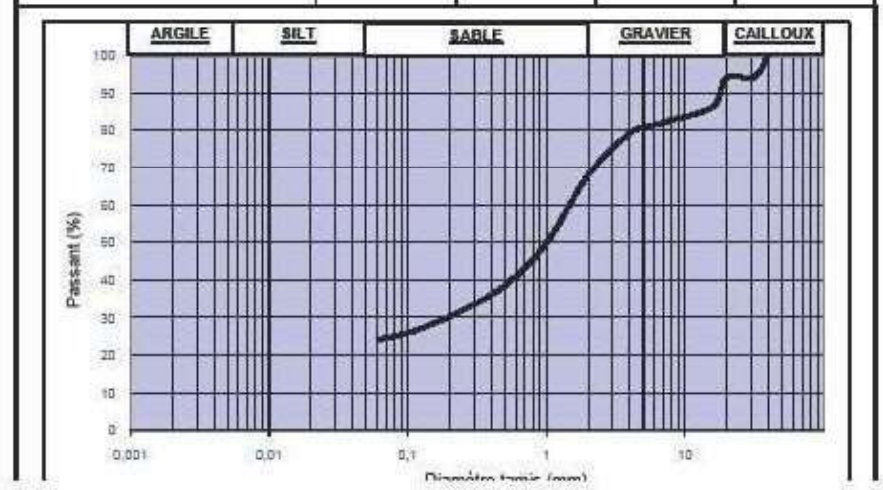
المختبر المركزي للبناء

ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC01 (1,0-1,63 m)

Poids Initial (gr): **1108,9**

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		64	5,77	94,23
20		64	5,77	94,23
16		150	13,53	86,47
8		191	17,22	82,78
5		213	19,21	80,79
4		228	20,56	79,44
2		355	32,01	67,99
1		557	50,23	49,77
0,5		682	61,50	38,50
0,25		754	68,00	32,00
0,125		808	72,87	27,13
0,08		832	75,03	24,97
0,063		839	75,66	24,34



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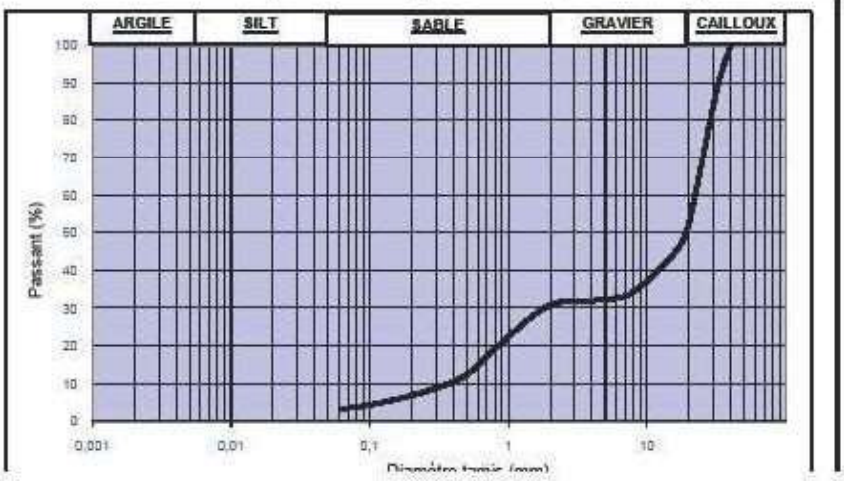
ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC01 (4,42-5,0 m)

Poids Initial (gr): 1251,0

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		159	12,71	87,29
20		596	47,64	52,36
16		690	55,16	44,84
8		822	65,71	34,29
5		847	67,71	32,29
4		851	68,03	31,97
2		866	69,23	30,77
1		970	77,54	22,46
0,5		1096	87,61	12,39
0,25		1153	92,17	7,83
0,125		1188	94,97	5,03
0,08		1204	96,25	3,75
0,063		1210	96,72	3,28



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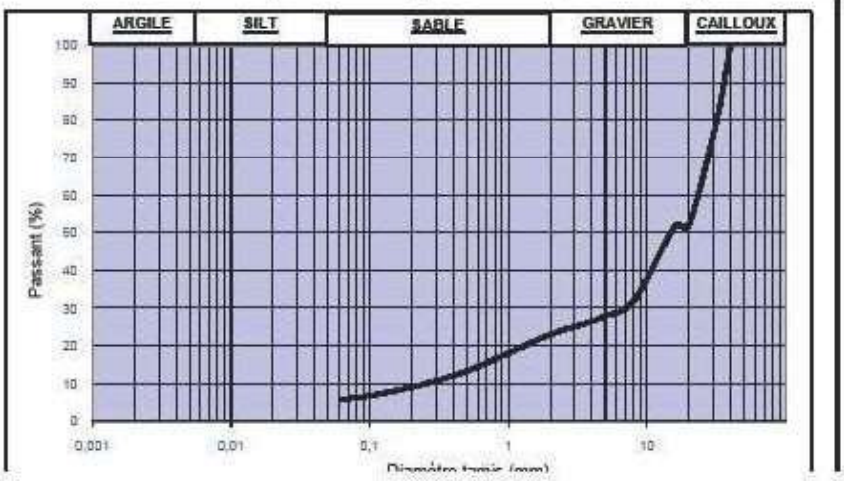
LABORATOIRE CENTRAL
المختبر المركزي للبناء

ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC01 (6,0-7,0 m)

Poids Initial (gr): 2436,3

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		505	20,73	79,27
20		1174	48,19	51,81
16		1174	48,19	51,81
8		1661	68,18	31,82
5		1757	72,12	27,88
4		1791	73,51	26,49
2		1877	77,04	22,96
1		1996	81,93	18,07
0,5		2113	86,73	13,27
0,25		2196	90,14	9,86
0,125		2256	92,60	7,40
0,08		2286	93,83	6,17
0,063		2289	93,95	6,05



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Ministère de l'Equipement et des Transports

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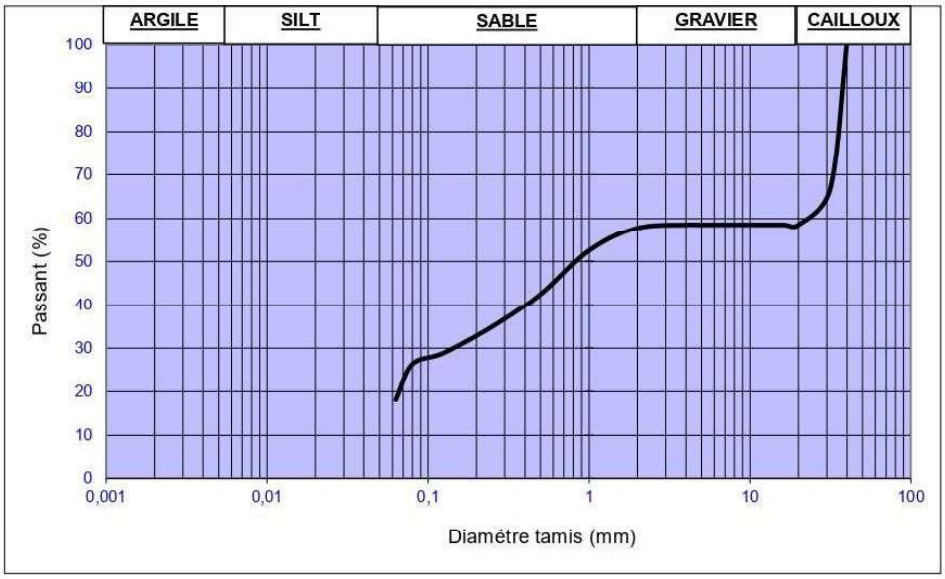
LABORATOIRE CENTRAL DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ANALYSE GRANULOMETRIQUE - NORME NF EN 933-1 & EN 933-2

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co, Ltd
Échantillon : SC01 (9,5-10,0 m)

Poids Initial (gr): 807,3

Tamis(mm)	Refus partiels	Refus Cumules (gr)	Refus Cumules (%)	Passant (%)
40		0	0,00	100,00
31,5		269	33,32	66,68
20		335	41,50	58,50
16		335	41,50	58,50
8		335	41,50	58,50
5		335	41,50	58,50
4		335	41,50	58,50
2		341	42,24	57,76
1		383	47,44	52,56
0,5		464	57,48	42,52
0,25		525	65,03	34,97
0,125		574	71,10	28,90
0,08		595	73,70	26,30
0,063		661	81,88	18,12



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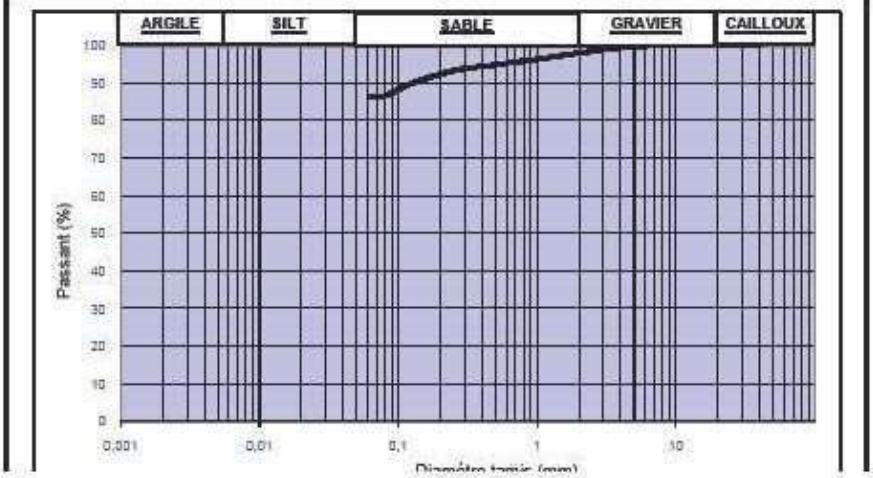
LABORATOIRE CENTRAL
المختبر المركزي للبناء

ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC02 (0,0-1,0 m)

Poids Initial (gr): 1215,4

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		0	0,00	100,00
20		0	0,00	100,00
16		0	0,00	100,00
8		0	0,00	100,00
5		5	0,41	99,59
4		8	0,66	99,34
2		24	1,97	98,03
1		45	3,70	96,30
0,5		63	5,18	94,82
0,25		82	6,75	93,25
0,125		123	10,12	89,88
0,08		163	13,41	86,59
0,063		167	13,74	86,26



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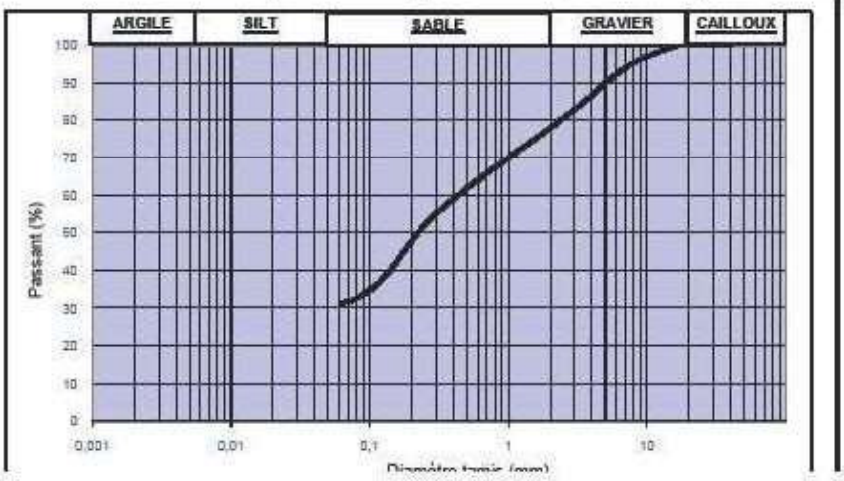
LABORATOIRE CENTRAL
المختبر المركزي للبناء

ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC02 (2,0-3,0 m)

Poids Initial (gr): 1477,9

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		0	0,00	100,00
20		0	0,00	100,00
16		4	0,27	99,73
8		69	4,67	95,33
5		149	10,08	89,92
4		198	13,40	86,60
2		326	22,06	77,94
1		443	29,98	70,02
0,5		566	38,30	61,70
0,25		707	47,84	52,16
0,125		920	62,25	37,75
0,08		997	67,48	32,54
0,063		1015	68,68	31,32



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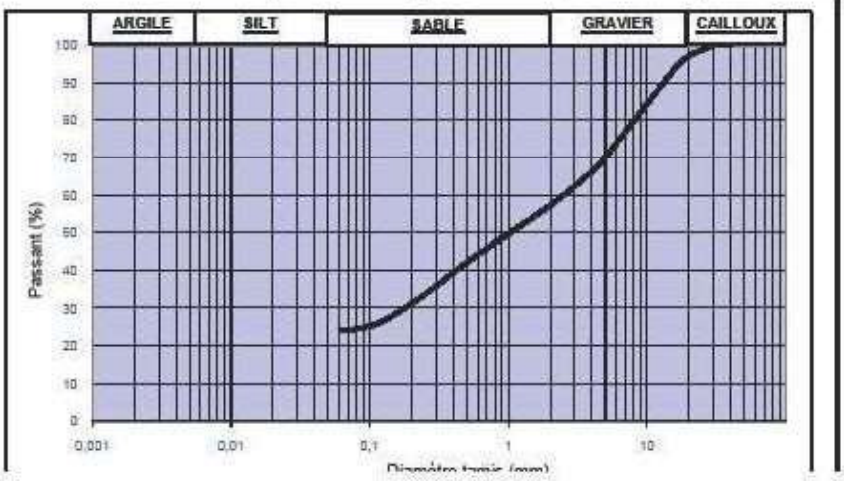
المختبر المركزي للبناء

ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC02 (5,0-6,0 m)

Poids Initial (gr): 1168,8

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		0	0,00	100,00
20		33	2,82	97,18
16		71	6,07	93,93
8		236	20,19	79,81
5		349	29,86	70,14
4		395	33,80	66,20
2		500	42,78	57,22
1		588	50,31	49,69
0,5		677	57,92	42,08
0,25		776	66,40	33,60
0,125		858	73,41	26,59
0,08		883	75,55	24,45
0,063		888	75,98	24,02



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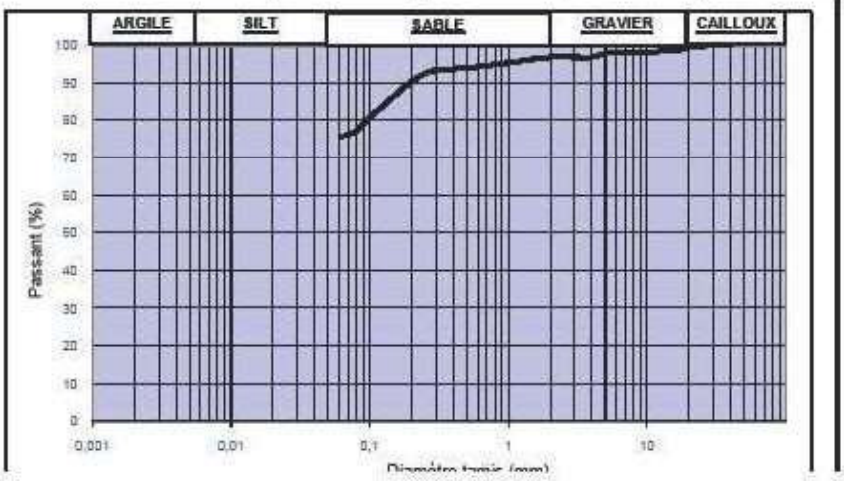
ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC03 (1,0-2,0 m)

Poids Initial (gr): 1153,3

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		0	0,00	100,00
20		7	0,61	99,39
16		16	1,39	98,61
8		23	1,99	98,01
5		26	2,25	97,75
4		37	3,21	96,79
2		37	3,21	96,79
1		54	4,68	95,32
0,5		70	6,07	93,93
0,25		87	7,54	92,46
0,125		185	16,04	83,96
0,08		262	22,72	77,28
0,063		280	24,28	75,72



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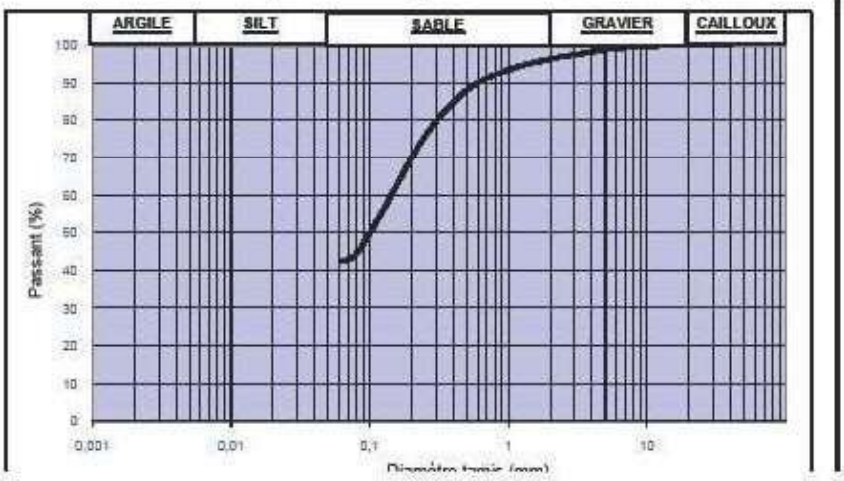
ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC03 (4,2-5,0 m)

Poids Initial (gr): **1143,6**

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		0	0,00	100,00
20		0	0,00	100,00
16		0	0,00	100,00
8		5	0,44	99,56
5		14	1,22	98,78
4		21	1,84	98,16
2		42	3,67	96,33
1		75	6,56	93,44
0,5		136	11,89	88,11
0,25		278	24,31	75,69
0,125		504	44,07	55,93
0,08		636	55,62	44,38
0,063		660	57,72	42,28



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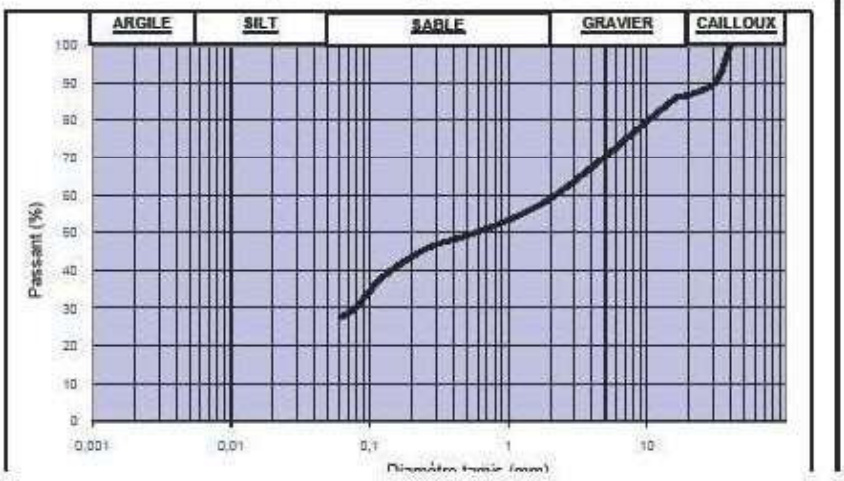
ANALYSE GRANULOMETRIQUE - NORME

Chantier : Construction de la bretelle de Nagad et voie Palmeraie
Client : Yachiyo Engineering Co.Ltd
Échantillon : SC03 (5,0-6,0 m)

Poids Initial (gr): 1381,3

Tamis(mm)	Refus partiels	Refus Cumulés (gr)	Refus Cumulés (%)	Passant (%)
40		0	0,00	100,00
31,5		133	9,63	90,37
20		183	13,25	86,75
16		196	14,19	85,81
8		321	23,24	76,76
5		410	29,68	70,32
4		452	32,72	67,28
2		567	41,05	58,95
1		645	46,70	53,30
0,5		702	50,82	49,18
0,25		752	54,44	45,56
0,125		853	61,76	38,24
0,08		963	69,72	30,28
0,063		1000	72,40	27,60



ATTERBERG LIMITS

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LABORATOIRE CENTRAL
DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

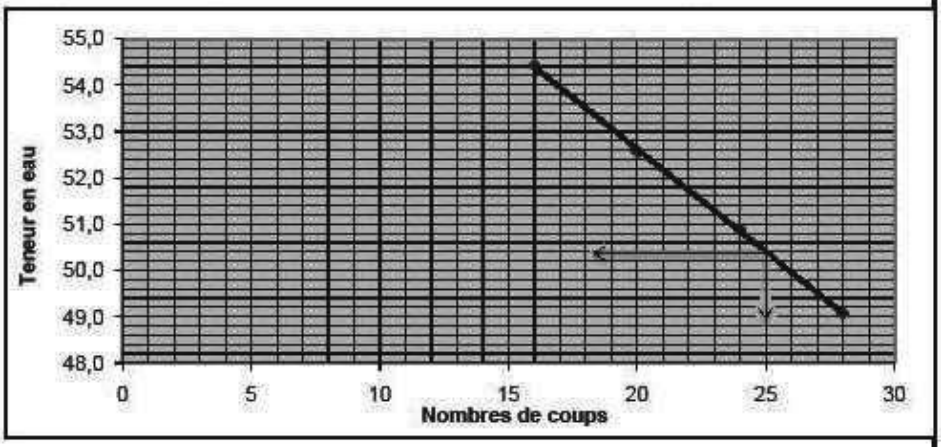
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC01 (1,0-1,65 m)

LL: 50,4 **LP: 29,5** **IP: 20,9**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	16	20	24	28	Test n°1	Test n°2
NUMERO DE LA TARE	10	2	KI	LO	M	B
POIDS TOTAL HUMIDE (g)	32,44	30,10	28,67	28,08	13,45	13,73
POIDS TOTAL SEC (g)	28,89	27,53	26,63	26,23	12,50	12,73
POIDS DE LA TARE (g)	21,80	22,64	22,62	22,46	9,32	9,30
POIDS D'EAU (g)	3,8	2,6	2,0	1,9	0,9	1,0
POIDS NET SEC (g)	6,9	4,9	4,0	3,8	3,2	3,4
TENEUR EN EAU (%)	54,4	52,6	50,9	49,1	29,9	29,2
TOTAL (%)	51,7				29,5	



Observation : **L'indice de plasticité de ce matériau est de 20,9**

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DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

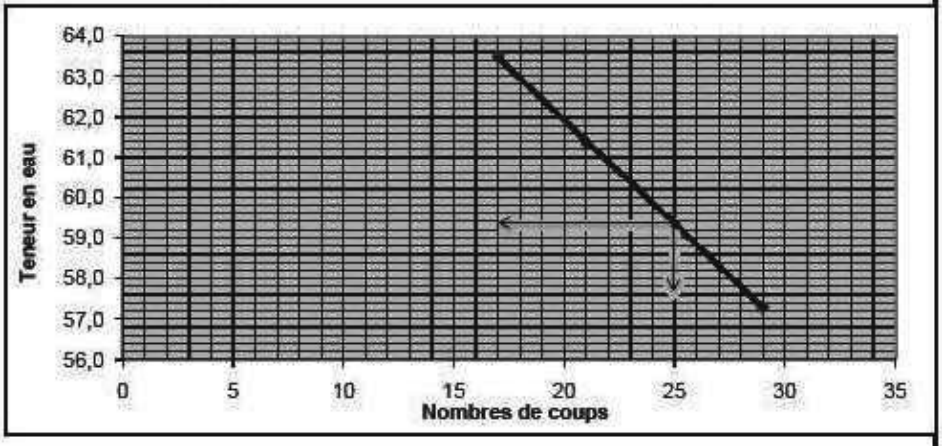
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC01 (4,42-5,0 m)

LL: 59,4 **LP: 26,6** **IP: 32,8**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	17	21	25	29	Test n°1	Test n°2
NUMERO DE LA TARE	10	O	13	Z	15	M
POIDS TOTAL HUMIDE (g)	27,80	27,79	30,96	32,69	15,67	15,12
POIDS TOTAL SEC (g)	25,47	25,68	27,69	28,92	14,25	14,00
POIDS DE LA TARE (g)	21,80	22,19	22,18	22,34	9,39	9,33
POIDS D'EAU (g)	2,3	2,1	3,3	3,8	1,4	1,1
POIDS NET SEC (g)	3,7	3,5	5,5	6,6	4,9	4,7
TENEUR EN EAU (%)	63,5	61,4	59,3	57,3	29,2	24,0
TOTAL (%)	60,4				26,6	



Observation : **L'indice de plasticité de ce matériau est de 32,8**

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DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

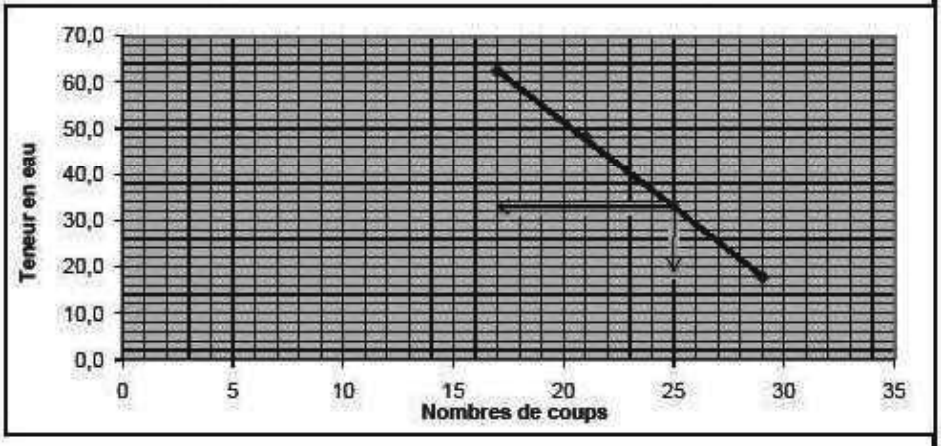
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC01 (6,0-7,0 m)

LL: 30,3 **LP: 26,9** **IP: 3,4**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	17	21	25	29	Test n°1	Test n°2
NUMERO DE LA TARE	1	15	0	LO	B	4
POIDS TOTAL HUMIDE (g)	17,48	18,84	31,00	31,14	13,25	12,61
POIDS TOTAL SEC (g)	14,35	15,75	28,87	29,79	12,42	11,91
POIDS DE LA TARE (g)	9,32	9,32	22,41	22,18	9,31	9,32
POIDS D'EAU (g)	3,1	3,1	2,1	1,4	0,8	0,7
POIDS NET SEC (g)	5,0	6,4	6,5	7,6	3,1	2,6
TENEUR EN EAU (%)	62,2	48,1	33,0	17,7	26,7	27,0
TOTAL (%)	40,2				26,9	



Observation : L'indice de plasticité de ce matériau est de 3,4

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LABORATOIRE CENTRAL
DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

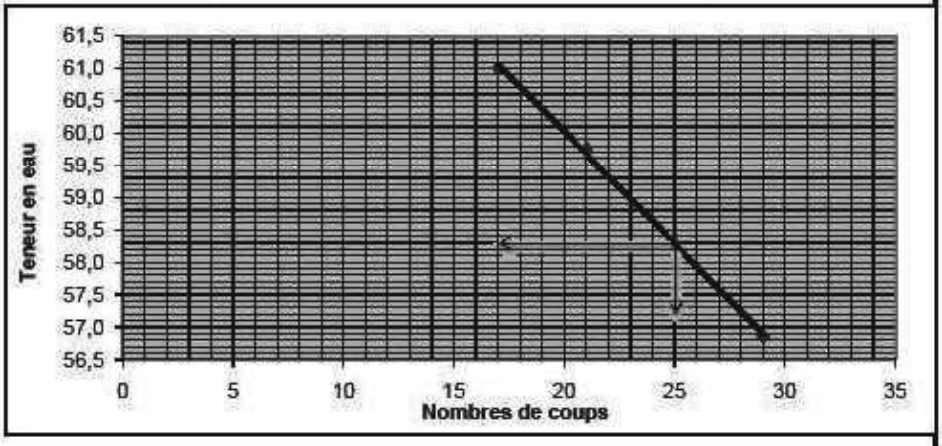
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC01 (9,5-10,0 m)

LL: 58,3 **LP: 41,2** **IP: 17,1**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	17	21	25	29	Test n°1	Test n°2
NUMERO DE LA TARE	Z	2	NI	KI	15	I
POIDS TOTAL HUMIDE (g)	31,64	29,12	28,60	30,30	14,12	13,91
POIDS TOTAL SEC (g)	28,12	26,55	26,21	27,52	12,70	12,60
POIDS DE LA TARE (g)	22,35	22,25	22,11	22,63	9,33	9,34
POIDS D'EAU (g)	3,5	2,6	2,4	2,8	1,4	1,3
POIDS NET SEC (g)	5,8	4,3	4,1	4,9	3,4	3,3
TENEUR EN EAU (%)	61,0	59,8	58,3	56,9	42,1	40,2
TOTAL (%)	59,0				41,2	



Observation : L'indice de plasticité de ce matériau est de 17,1

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LABORATOIRE CENTRAL
DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

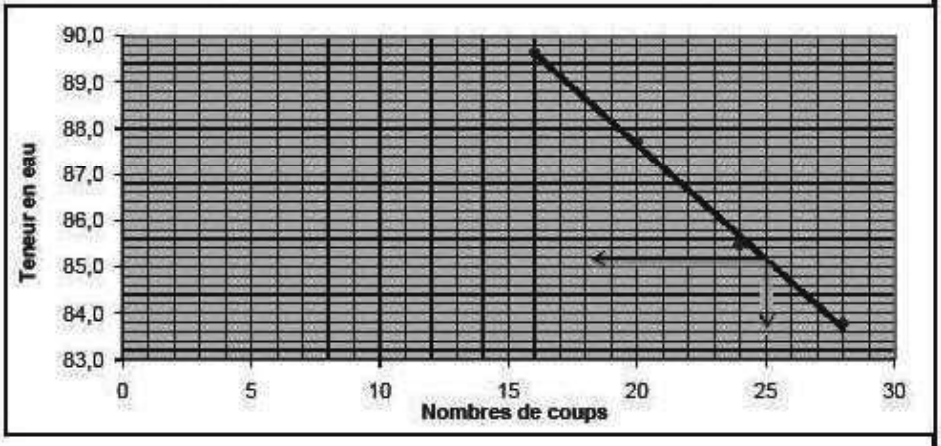
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC02 (0,0-1,0 m)

LL: 85,2 **LP: 50,7** **IP: 34,5**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	16	20	24	28	Test n°1	Test n°2
NUMERO DE LA TARE	LO	L	O	B	R	KI
POIDS TOTAL HUMIDE (g)	28,27	27,65	27,68	31,15	15,75	15,65
POIDS TOTAL SEC (g)	25,50	25,08	25,15	27,07	13,62	13,50
POIDS DE LA TARE (g)	22,41	22,15	22,19	22,20	9,34	9,34
POIDS D'EAU (g)	2,8	2,6	2,5	4,1	2,1	2,2
POIDS NET SEC (g)	3,1	2,9	3,0	4,9	4,3	4,2
TENEUR EN EAU (%)	89,6	87,7	85,5	83,8	49,8	51,7
TOTAL (%)	86,7				50,7	



Observation : L'indice de plasticité de ce matériau est de 34,5

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DU BÂTIMENT ET DE L'EQUIPEMENT
المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

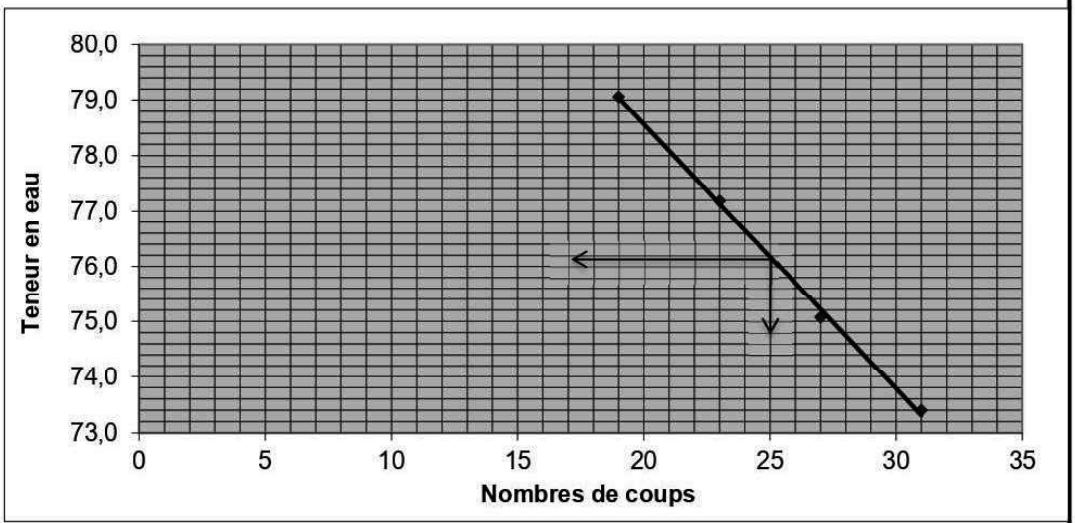
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co, Ltd

Échantillon : SC02 (5,0-6,0 m)

LL: 76,1 **LP: 47,9** **IP: 28,2**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	19	23	27	31	Test n°1	Test n°2
NUMERO DE LA TARE	Z	13	LO	O	15	H
POIDS TOTAL HUMIDE (g)	31,82	30,50	28,95	31,37	14,26	15,70
POIDS TOTAL SEC (g)	27,63	26,88	26,15	27,48	12,68	13,62
POIDS DE LA TARE (g)	22,33	22,19	22,42	22,18	9,33	9,34
POIDS D'EAU (g)	4,2	3,6	2,8	3,9	1,6	2,1
POIDS NET SEC (g)	5,3	4,7	3,7	5,3	3,4	4,3
TENEUR EN EAU (%)	79,1	77,2	75,1	73,4	47,2	48,6
TOTAL (%)	76,2				47,9	



Observation : L'indice de plasticité de ce matériau est de 28,2

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LABORATOIRE CENTRAL
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ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

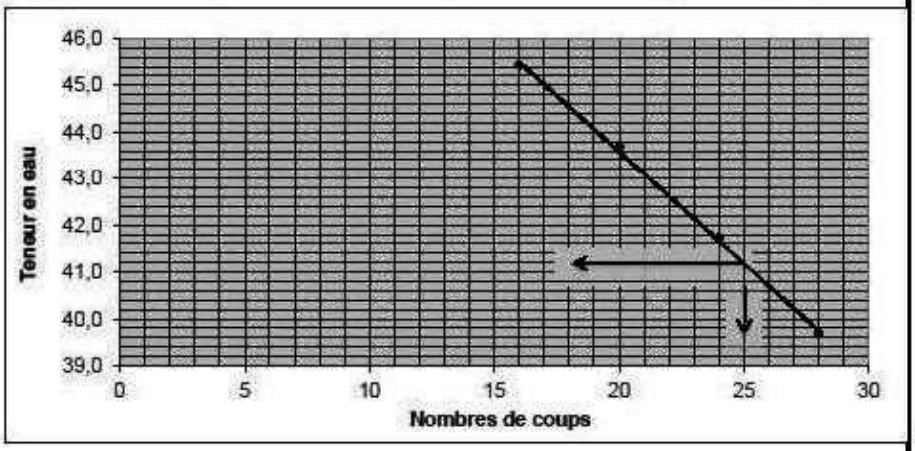
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC02 (2,0-3,0 m)

LL: 41,2 **LP: 25,1** **IP: 16,1**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	16	20	24	28	Test n°1	Test n°2
NUMERO DE LA TARE	NI	2	KI	10	M	B
POIDS TOTAL HUMIDE (g)	33,08	31,64	30,40	28,99	15,31	15,66
POIDS TOTAL SEC (g)	29,65	28,78	28,11	26,95	14,10	14,40
POIDS DE LA TARE (g)	22,10	22,23	22,62	21,81	9,33	9,34
POIDS D'EAU (g)	3,4	2,9	2,3	2,0	1,2	1,3
POIDS NET SEC (g)	7,6	6,6	5,5	5,1	4,8	5,1
TENEUR EN EAU (%)	45,4	43,7	41,7	39,7	25,4	24,9
TOTAL (%)	42,6				25,1	



Observation : L'indice de plasticité de ce matériau est de 16,1

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المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

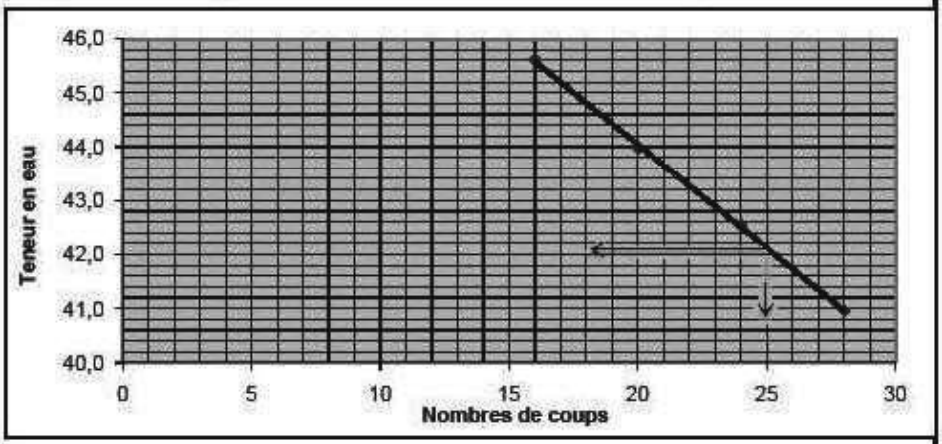
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC03 (1,0-2,0 m)

LL: 42,1 **LP: 24,3** **IP: 17,8**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	16	20	24	28	Test n°1	Test n°2
NUMERO DE LA TARE	L	13	R	M	1	13
POIDS TOTAL HUMIDE (g)	31,45	32,47	16,13	20,08	25,89	27,40
POIDS TOTAL SEC (g)	28,54	29,33	14,11	16,95	25,18	26,35
POIDS DE LA TARE (g)	22,16	22,19	9,36	9,31	22,13	22,19
POIDS D'EAU (g)	2,9	3,1	2,0	3,1	0,7	1,1
POIDS NET SEC (g)	6,4	7,1	4,8	7,6	3,1	4,2
TENEUR EN EAU (%)	45,6	44,0	42,5	41,0	23,3	25,2
TOTAL (%)	43,3				24,3	



Observation : L'indice de plasticité de ce matériau est de 17,8

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المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

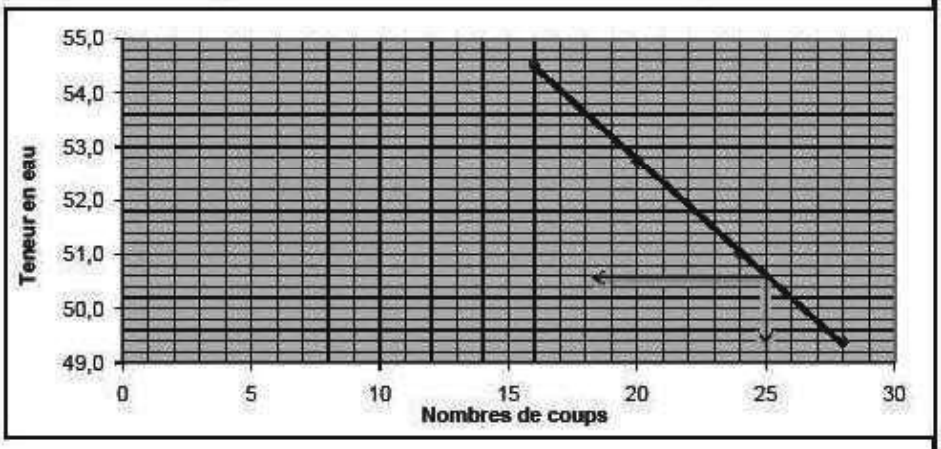
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC03 (4,2-5,0 m)

LL: 50,6 **LP: 29,2** **IP: 21,4**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	16	20	24	28	Test n°1	Test n°2
NUMERO DE LA TARE	B	H	E	O	B	H
POIDS TOTAL HUMIDE (g)	22,47	21,95	21,27	21,13	14,02	14,35
POIDS TOTAL SEC (g)	17,83	17,60	17,24	17,22	12,94	13,23
POIDS DE LA TARE (g)	9,32	9,35	9,34	9,30	9,31	9,32
POIDS D'EAU (g)	4,6	4,4	4,0	3,9	1,1	1,1
POIDS NET SEC (g)	8,5	8,3	7,9	7,9	3,6	3,9
TENEUR EN EAU (%)	54,5	52,7	51,0	49,4	29,8	28,6
TOTAL (%)	51,9				29,2	



Observation : L'indice de plasticité de ce matériau est de 21,4

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المختبر المركزي للبناء والتجهيز

ESSAI DE LIMITE D'ATTERBERG
NORME NF P 94 - 051

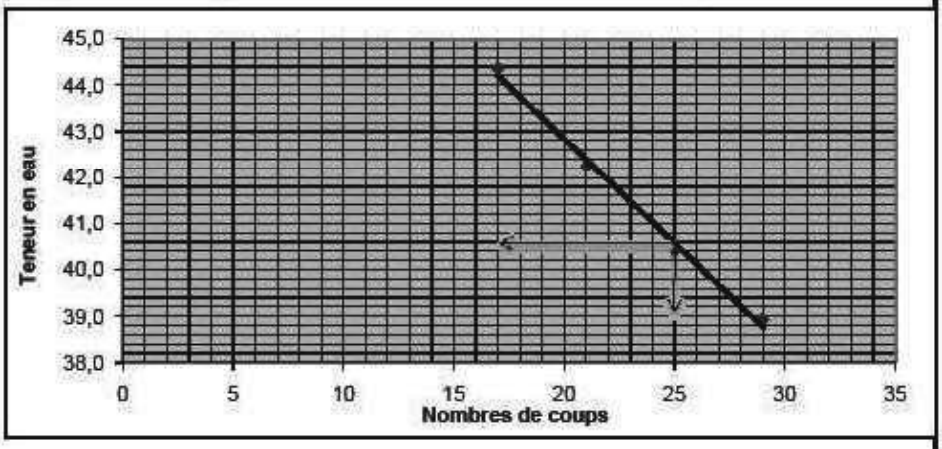
Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

Échantillon : SC03 (5,0-6,0 m)

LL: 40,6 **LP: 27,5** **IP: 13,1**

	LIMITE DE LIQUIDITE				LIMITE DE PLASTICITE	
NOMBRE DE COUPS	17	21	25	29	Test n°1	Test n°2
NUMERO DE LA TARE	10	1	O	3	R	M
POIDS TOTAL HUMIDE (g)	20,20	19,94	20,84	19,76	14,43	14,25
POIDS TOTAL SEC (g)	16,86	16,78	17,52	16,84	13,32	13,20
POIDS DE LA TARE (g)	9,33	9,30	9,30	9,34	9,36	9,31
POIDS D'EAU (g)	3,3	3,2	3,3	2,9	1,1	1,1
POIDS NET SEC (g)	7,5	7,5	8,2	7,5	4,0	3,9
TENEUR EN EAU (%)	44,4	42,2	40,4	38,9	28,0	27,0
TOTAL (%)	41,5				27,5	



Observation : L'indice de plasticité de ce matériau est de 13,1

WATER CONTENT

REPUBLIQUE DE DJIBOUTI
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ESSAI DE TENEUR EN EAU
Norme NF P 94-050

Chantier : Construction de la bretelle de Nagad et voie Palmeraie

Client : Yachiyo Engineering Co.Ltd

SC01

Provenance (m) :	1,0-1,3	4.42-5,0	6,0-7,0	9,5-10,0
NUMERO DE LA TARE	DOU	FI	YA	14/21
POIDS TOTAL HUMIDE (g)	660	502	517	478
POIDS TOTAL SEC (g)	526	406	412	336
POIDS DE LA TARE (g)	59	59	61	52
POIDS D'EAU (g)	134	96	105	142
POIDS NET SEC (g)	467	347	351	284
TENEUR EN EAU (%)	28,69	27,67	29,91	50,00

SC02

Provenance (m) :	0,0-1,0	2,0-3,0	5,0-6,0
NUMERO DE LA TARE	KK	8	V
POIDS TOTAL HUMIDE (g)	659	765	527
POIDS TOTAL SEC (g)	545	649	413
POIDS DE LA TARE (g)	53	52	57
POIDS D'EAU (g)	114	116	114
POIDS NET SEC (g)	492	597	356
TENEUR EN EAU (%)	23,17	19,43	32,02

SC03

Provenance (m) :	1,0-2,0	4,2-5,0	5,0-6,0
NUMERO DE LA TARE	TO	N-A	N-C
POIDS TOTAL HUMIDE (g)	372	468	522
POIDS TOTAL SEC (g)	299	380	428
POIDS DE LA TARE (g)	61	59	61
POIDS D'EAU (g)	73	88	94
POIDS NET SEC (g)	238	321	367
TENEUR EN EAU (%)	30,67	27,41	25,61

COMPRESSION TEST

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TEST REPORT

Compressive Strength (Tests on rocks)

STANDARD :
NF P94-420

FOLDER :

Client : *Yachiyo Engineering Co. Ltd* ***Test :*** *Control*
Site: *Construction de la bretelle de Nagad et voie Palmeraie* ***Part :*** *Geotechnical study*

SAMPLE REFERENCE :

N° of samples: *1 à 5*
From: *Site*

TESTS :

N° Rocks	Depths (m)		Depths (m)		Weight	Volume	Section	Density	Twinge	Force	Résistance		Correction
	From	To	From	To	(g)	(cm³)	(cm²)	(g/cm³)		(KN)	Mpa	Bar	Bar
SC01													
1	1	2	1,63	2,64	1779	716,8	47,8	2,5	2	210	44,0	440	440
2	2	3	2,53	2,73	1898	692,9	47,8	2,7	2	219	45,9	459	459
SC02													
3	8	9	8,64	8,87	2105	778,9	47,8	2,7	2	579	121,2	1212	1212
SC03													
4	8	9	8,47	8,80	2183	783,7	47,8	2,8	2	94	19,6	196	196
5	9	10	9,28	9,74	2226	788,4	47,8	2,8	2	565	118,2	1182	1182

OBSERVATION :

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TEST REPORT

Physical Properties (Tests on rocks)

STANDARD :
NF P94-410

FOLDER :

Client : *Yachiyo Engineering Co. Ltd* ***Test :*** *Control*
Site: *Construction de la bretelle de Nagad et voie Palmeraie* ***Part :*** *Geotechnical study*

SAMPLE REFERENCE :

N° of samples: *1 à 5*
From: *Site*

TESTS :

Rocks	Depth (m)		Depth (m)		Dry density	Saturated density	Absorption	Porosity (%)
	from	to	from	to				
SC01								
1	1	2	1,63	2,64	2,51	2,52	0,35	1%
2	2	3	2,53	2,73	2,72	2,73	0,43	2%
SC02								
3	8	9	8,64	8,87	2,72	2,72	0,13	1%
SC03								
4	8	9	8,47	8,80	2,77	2,77	0,12	1%
5	9	10	9,28	9,74	2,78	2,78	0,09	0%

OBSERVATION :

Annex4: Survey crates pictures

SC01 0 à 5 m

SC01 5 à 10 m

SC02 0 à 5 m

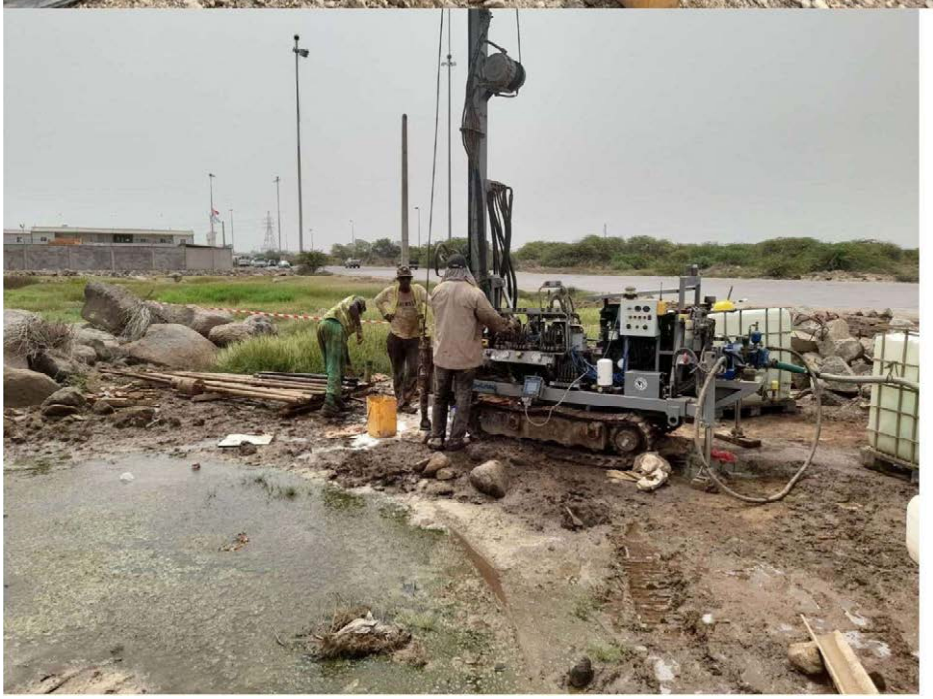
SC02 5 à 10 m

SC03 0 à 5 m

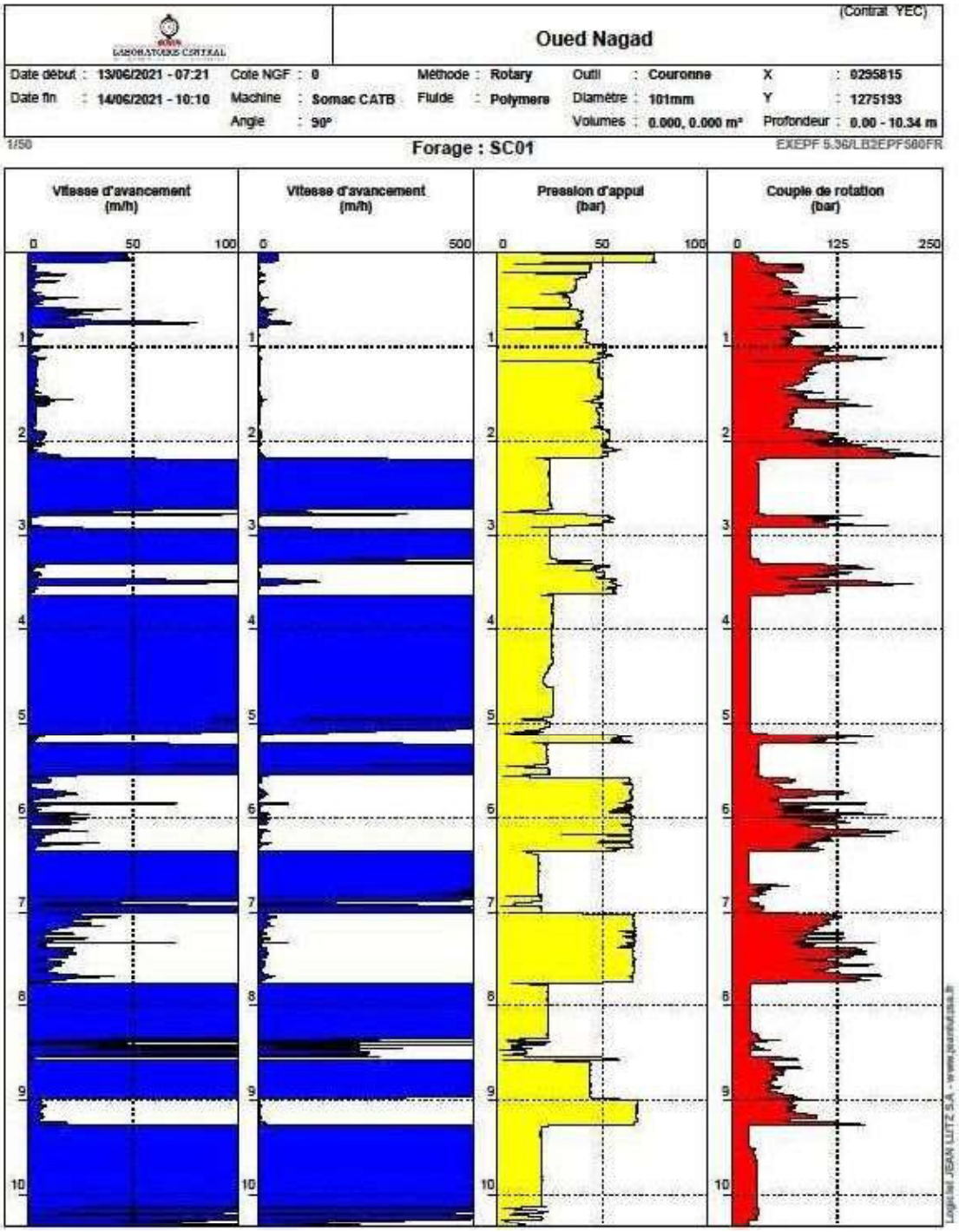
SC03 5 à 10 m

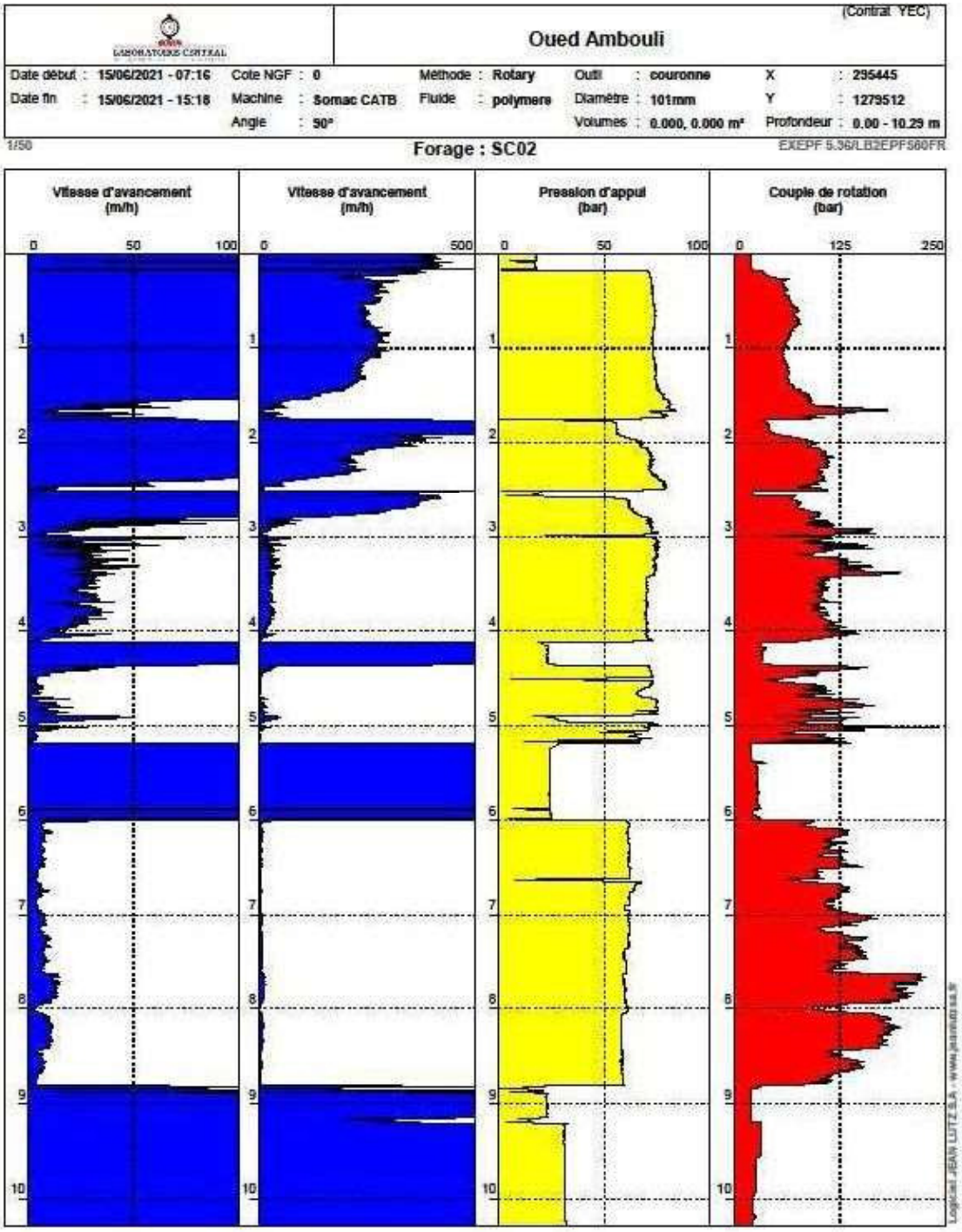
Annex 5: Pictures of rocks

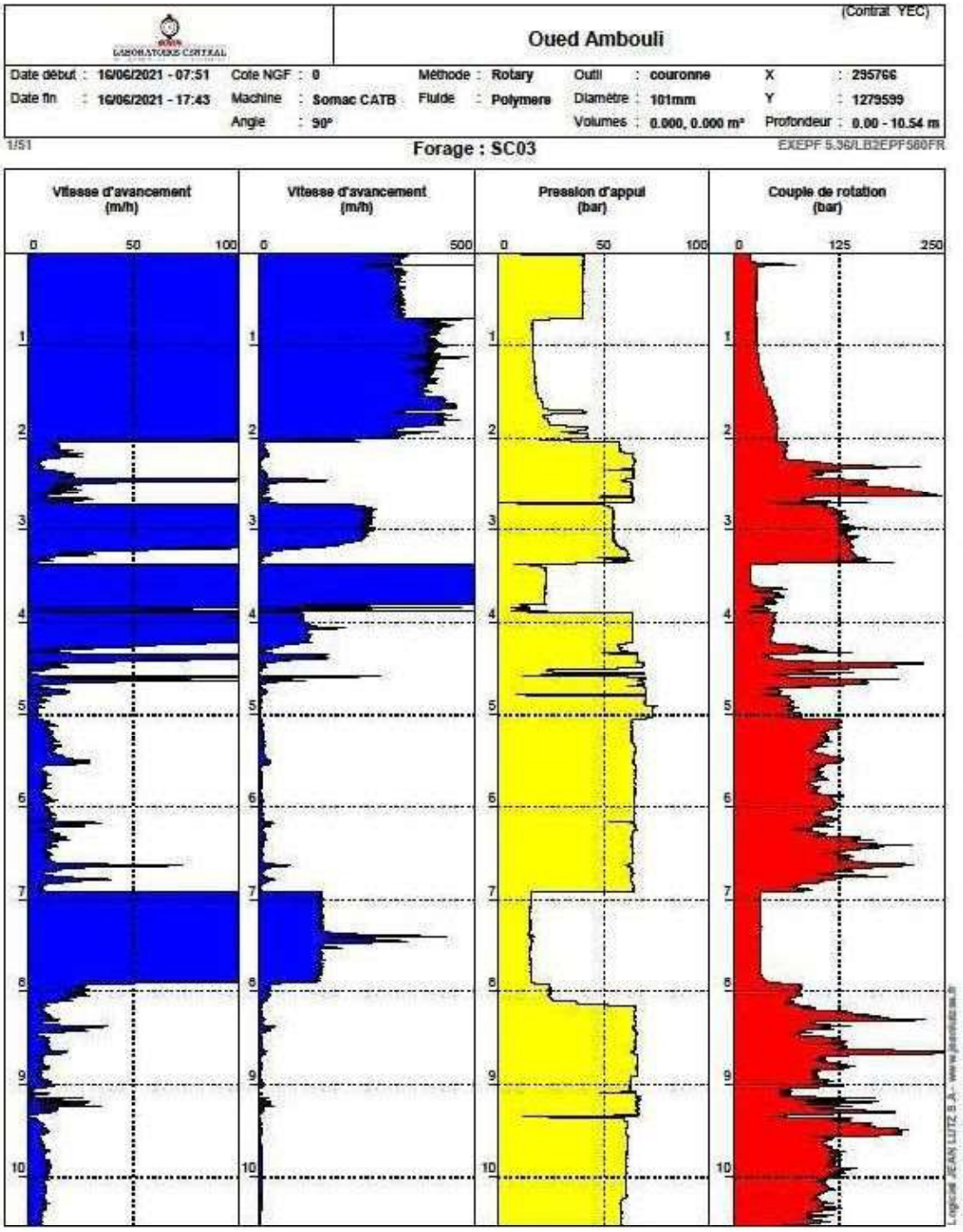
Annex 6: Site Project pictures



Annex 7: Logging of the drilling holes




(Contrat YEC)
Oued Ambouli
Date début : 15/06/2021 - 07:16
Date fin : 15/06/2021 - 15:18
Cote NGF : 0
Machine : Somac CATB
Angle : 90°
Méthode : Rotary
Fluide : polymere
Outil : couronne
Diamètre : 101mm
Volumes : 0.000, 0.000 m³
X : 295445
Y : 1279512
Profondeur : 0.00 - 10.29 m
1/50
Forage : SC02
EXEPF 5.36/LB2EPF560FR
Vitesse d'avancement (m/h)
0 50 100
Vitesse d'avancement (m/h)
0 500
Pression d'appui (bar)
0 50 100
Couple de rotation (bar)
0 125 250
1
2
3
4
5
6
7
8
9
10


(Contrat YEC)
Oued Ambouli
Date début : 16/06/2021 - 07:51
Date fin : 16/06/2021 - 17:43
Cote NGF : 0
Machine : Somac CATB
Angle : 90°
Méthode : Rotary
Fluide : Polymers
Outil : couronne
Diamètre : 101mm
Volumes : 0.000, 0.000 m³
X : 295766
Y : 1279599
Profondeur : 0.00 - 10.54 m
1/51
Forage : SC03
EXEPF 5.36/LB2EPF560FR
Vitesse d'avancement (m/h)
0 50 100
Vitesse d'avancement (m/h)
0 500
Pression d'appui (bar)
0 50 100
Couple de rotation (bar)
0 125 250
1
2
3
4
5
6
7
8
9
10

ANNEXE 8 : DEFINITIONS DES MISSIONS U.S.G., NORME NF P 94-500

CONDITIONS GENERALES DES MISSIONS GEOTECHNIQUES

1. Cadre de la mission

Par référence à la CLASSIFICATION DES MISSIONS GEOTECHNIQUES TYPES (Norme NFP 94-500 de décembre 2006), il appartient au maître d'ouvrage et à son maître d'œuvre de veiller à ce que toutes les missions géotechniques nécessaires à la conception puis à l'exécution de l'ouvrage soient engagées avec les moyens opportuns et confiées à des hommes de l'Art.

L'enchaînement des missions géotechniques suit la succession des phases d'élaboration du projet, chacune de ces missions ne couvrant qu'un domaine spécifique de la conception ou de l'exécution. En particulier :

1. les missions G1, G2, G3, G4 sont réalisées dans l'ordre successif ;
2. une mission confiée à notre société peut ne contenir qu'une partie des prestations décrites dans la mission type correspondante ;
3. les investigations géotechniques engagent notre société uniquement sur la conformité des travaux exécutés à ceux contractuellement commandés et l'exactitude des résultats qu'elle fournit ;
4. une mission type G1 à G5 n'engage notre société sur son devoir de conseil que dans le cadre strict, d'une part, des objectifs explicitement définis dans notre proposition technique sur la base de laquelle la commande et ses avenants éventuels ont été établis, d'autre part, du projet du client décrit par les documents graphiques ou plans cités dans le rapport ;
5. une mission type G1 ou G5 exclut tout engagement de notre société sur les quantités, coûts et délais d'exécution des futurs ouvrages géotechniques ;
6. une mission type G2 engage notre société en tant qu'assistant technique à la maîtrise d'œuvre dans les limites du contrat fixant l'étendue de la mission et la (ou les) partie(s) d'ouvrage(s) concerné(s).

La responsabilité de notre société ne saurait être engagée en dehors du cadre de la mission géotechnique objet du rapport. En particulier, toute modification apportée au projet ou à son environnement nécessite la réactualisation du rapport géotechnique dans le cadre d'une nouvelle mission.

2. Recommandations

Il est précisé que l'étude géotechnique repose sur une reconnaissance du sol dont la maille ne permet pas de lever la totalité des aléas toujours possibles en milieu naturel. En effet, des hétérogénéités,

naturelles ou du fait de l'homme, des discontinuités et des aléas d'exécution peuvent apparaître compte tenu du rapport entre le volume échantillonné ou testé et le volume sollicité par l'ouvrage, et ce d'autant plus que ces singularités éventuelles peuvent être limité en extension.

Les éléments géotechniques nouveaux mis en évidence lors de l'exécution, pouvant avoir une influence sur les conclusions du rapport, doivent immédiatement être signalés au géotechnicien chargé de la supervision du suivi géotechnique d'exécution (mission G4) afin qu'il en analyse les conséquences sur les conditions d'exécution voire la conception de l'ouvrage géotechnique.

Si un caractère évolutif particulier a été mis en lumière (notamment glissement, érosion, dissolution, remblais évolutifs, tourbe), l'application des recommandations du rapport nécessite une validation à chaque étape suivante de la conception ou de l'exécution. En effet, un tel caractère évolutif peut remettre en cause ces recommandations notamment s'il s'écoule un laps de temps important avant leur mise en œuvre.

3. Rapport de la mission

Le rapport géotechnique constitue le compte-rendu de la mission géotechnique définie par la commande au titre de laquelle il a été établi et dont les références sont rappelées en tête. A défaut de clauses spécifiques contractuelles, la remise du rapport géotechnique fixe la fin de la mission.

Un rapport géotechnique et toutes ses annexes identifiées constituent un ensemble indissociable. Les deux exemplaires de référence en sont les deux originaux conservés : un par le client et le second par notre société. Dans ce cadre, toute autre interprétation qui pourrait être faite d'une communication ou reproduction partielle ne saurait engager la responsabilité de notre société. En particulier l'utilisation même partielle de ces résultats et conclusions par un autre maître d'ouvrage ou par un autre constructeur ou pour un autre ouvrage que celui objet de la mission confiée ne pourra en aucun cas engager la responsabilité de notre société et pourra entraîner des poursuites judiciaires.

CLASSIFICATION DES MISSIONS TYPES D'INGENIERIE GEOTECHNIQUE

L'enchaînement des missions d'ingénierie géotechnique doit suivre les étapes d'élaboration et de réalisation de tout projet pour contribuer à la maîtrise des risques géologiques. Chaque mission s'appuie sur des investigations géotechniques spécifiques.

Il appartient au maître d'ouvrage ou à son mandataire de veiller à la réalisation successive de toutes ces missions par une ingénierie géotechnique.

Etape 1 : Etudes Géotechniques préalables (G1)

Ces missions excluent toute approche des quantités, délais et coûts d'exécution des ouvrages géotechniques qui entre dans le cadre d'une mission d'étude géotechnique de projet (étape 2). Elles sont normalement à la charge du maître d'ouvrage.

Etude Géotechnique préliminaire de site (G11)

Elle est réalisée au stade d'une étude préliminaire ou d'esquisse et permet une première identification des risques géologiques d'un site :

7. faire une enquête documentaire sur le cadre géotechnique du site et l'existence d'avoisinants avec visite du site et des alentours ;
8. définir un programme d'investigations géotechniques spécifique, le réaliser ou en assurer le suivi technique, en exploiter les résultats ;
9. fournir un rapport avec un modèle géologique préliminaire, certains principes généraux d'adaptation du projet au site et une première identification des risques.

Etude Géotechnique d'avant-projet (G12)

Elle est réalisée au stade de l'avant-projet et permet de réduire les conséquences des risques géologiques majeurs identifiés :

10. définir un programme d'investigations géotechniques spécifique, le réaliser ou en assurer le suivi technique, en exploiter les résultats ;
11. fournir un rapport donnant les hypothèses géotechniques à prendre en compte au stade de l'avant-projet, certains principes généraux de construction (notamment terrassements, soutènements, fondations, risques de déformation des terrains, dispositions générales vis-à-vis des nappes et avoisinants).

Cette étude sera obligatoirement complétée lors de l'étude géotechnique de projet (étape 2).

Etape 2 : Etudes Géotechniques de projet (G2)

Elle est réalisée pour définir le projet des ouvrages géotechniques et permet de réduire les conséquences des risques géologiques importants identifiés. Elle est normalement à la charge du maître d'ouvrage et peut être intégrée à la mission de maîtrise d'œuvre générale.

Phase Projet

12. définir un programme d'investigations géotechniques spécifique, le réaliser ou en assurer le suivi technique, en exploiter les résultats ;
13. fournir une synthèse actualisée du site et les notes techniques donnant les méthodes d'exécution proposées pour les ouvrages géotechniques (notamment terrassements, soutènements, fondations dispositions vis-à-vis des nappes et avoisinants) et les valeurs seuils associées, certaines notes de calcul de dimensionnement niveau projet ;
14. fournir une approche des quantités/détails/coûts d'exécution de ces ouvrages géotechniques et une identification des conséquences des risques géologiques résiduels.

Phase Assistance aux Contrats de Travaux

15. établir les documents nécessaires à la consultation des entreprises pour l'exécution des ouvrages géotechniques (plans, notices techniques, cadre de bordereau des prix et d'estimatif, planning prévisionnel) ;
16. assister le client pour la sélection des entreprises et l'analyse technique des offres.

Etape 3 : Exécution des Ouvrages Géotechniques (G3 et G4, distinctes et simultanées)

Etude et Suivi Géotechniques d'Exécution (G3)

Se déroulant en 2 phases interactives et indissociables, elle permet de réduire les risques résiduels par la mise en œuvre à temps de mesures d'adaptation ou d'optimisation. Elle est normalement confiée à l'entrepreneur.

Phase Etude

17. définir un programme d'investigations géotechniques spécifique, le réaliser ou en assurer le suivi technique, en exploiter les résultats ;
18. étudier dans le détail les ouvrages géotechniques, notamment validation des hypothèses géotechniques, définition et dimensionnement (calculs justificatifs), méthodes et conditions d'exécution (phasages, suivis, contrôles, auscultations en fonction des valeurs seuils associées, dispositions constructives complémentaires éventuelles), élaborer le dossier géotechnique d'exécution.

Phase Suivi

19. suivre le programme d'auscultation et l'exécution des ouvrages géotechniques, déclencher si nécessaire les dispositions constructives prédéfinies en phase étude ;
20. vérifier les données géotechniques par relevés lors des excavations et par un programme d'investigations géotechniques complémentaire si nécessaire (le réaliser ou en assurer le suivi technique, en exploiter les résultats) ;
21. participer à l'établissement du dossier de fin de travaux et des recommandations de maintenance des ouvrages géotechniques.

Supervision géotechniques d'exécution (G4)

Elle permet de vérifier la conformité aux objectifs du projet, de l'étude et du suivi géotechniques d'exécution. Elle est normalement à la charge du maître d'ouvrage.

Phase Supervision de l'étude d'exécution

22. avis sur l'étude géotechnique d'exécution, sur les adaptations ou optimisations potentielles des ouvrages géotechniques proposées par l'entrepreneur, sur le programme d'auscultation et les valeurs seuils associées.

Phase Supervision du suivi d'exécution

23. avis, par interventions ponctuelles sur le chantier, sur le contexte géotechnique tel qu'observé par l'entrepreneur, sur le comportement observé de l'ouvrage et des avoisinants concernés et sur l'adaptation ou l'optimisation de l'ouvrage géotechnique proposée par l'entrepreneur.

Diagnostic Géotechnique (G5)

Pendant le déroulement d'un projet ou au cours de la vie d'un ouvrage, il peut être nécessaire de procéder, de façon strictement limitative, à l'étude d'un ou plusieurs éléments géotechniques spécifiques, dans le cadre d'une mission ponctuelle.

24. définir, après enquête documentaire, un programme d'investigations géotechniques spécifique, le réaliser ou en assurer le suivi technique, en exploiter les résultats ;
25. étudier un ou plusieurs éléments géotechniques spécifiques (par exemple soutènement, rabattement, causes géotechniques d'un désordre) dans le cadre de ce diagnostic, mais sans aucune implication dans d'autres éléments géotechniques.

Des études géotechniques de projet et/ou d'exécution, de suivi et supervision, doivent être réalisées ultérieurement, conformément à l'enchaînement des missions d'ingénierie géotechnique, si ce diagnostic conduit à modifier ou réaliser des travaux.