Islamic Republic of Mauritania
Ministry of Land Use, Urbanization
and Habitation (MHUAT)
Urban Community of Nouakchott (CUN)

Nouakchott City Urban Master Plan Development Project In Islamic Republic of Mauritania

Final Report

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Japan International Cooperation Agency (JICA)

RECS International Inc.
CTI Engineering International Co., Ltd.
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Source: OANDA, https://www.oanda.com

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Abbreviations

AAGR	Annual Average Growth Rate
ACCVC	Climate Change Adaptation of Coastal Cities
ADU	Urban Development Agency
AFD	French Development Agency
AFESD	Arab Fund for Economic and Social Development
AMEXTIPE	Mauritanian Agency for the Execution of Works of Public Interest and Employment
AMU	Arab Maghreb Union
ANAC	National Agency of Civil Aviation
ANAT	National Agency for Land Development
AORTR	Authority of Organization and Regulation of Transport
ARE	Authority of Regulation
ARTOR	Authority for Regulation and Road Transport Organization
ATTM	Company of Sanitation of Works, Transport and Maintenance
BDR	Road Data Bank
BNT	National Office of Transport
BOP	Balance Of Payments
BRGM	Office of Geological and Mining Research
BRT	Bus Rapid Transit
CAD	Computer Aided Design
CCC	Communal Consultation Committee
CET	Landfill
CMC	Community Consultation Meetings
CON	Consultation and Coordination Meeting
COS	Floor Area Ratio
CPAN	Nouakchott City Sanitation Unit
CRED	Centre for Research on the Epidemiology of Disasters
CTCE	China Tiesiju Civil Engineering
CUF	Land Use Coefficient
CUN	Urban Community of Nouakchott
DCIG	Department of Mapping and Geographic Information
DEPAEC	Department of Studies, Projects and Planning of the Community Space
DFR	Draft Final Report
DGBEP	Department of Buildings and Public Facilities
DGDPE	General Directorate of State Property and Heritage
DGHU	General Department of Habitation and Urbanization
DGIT	General Department of Transport Infrastructures
DU	Department of Urbanism
DUT	Department of Urbanization and Topography
ECOWAS	Economic Community of West African States
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMDAT	Emergency Events Database
ENER	National Institution of Road Maintenance
ENRE	National Reference Survey on Employment and the Informal Sector
EPCV	Permanent Survey on the Living Conditions of Households
ERRT	Institution for the Rehabilitation and Renovation of the city of Tintane
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FISIM	Financial Intermediation Services Indirectly Measured
FR	Final Report
FTP	Technical and Vocational Training
GF	Ground Floor
GIZ	German Agency for International Cooperation
GMT	Greenwich Mean Time
GoM	Government of Mauritania
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
GRDR	Research and Development Group for Rural Development
GT	Taskforce
IADC	International Airport Development Core
ICD	Islamic Corporation for the Development
ICR	Inception Report
IDA	International Development Association
IEE	Initial Environmental Examination
IMF	International Monetary Fund
IMROP	Mauritanian Institute of Oceanographic and Fisheries Research
ISKAN	National Company for Land Development, Housing and Real Estate Management
ITR	Interim Report
ITS	Intelligent Transport System
JICA	Japan International Cooperation Agency
LRT	Light Rail Transit
LWF	Lutheran World Federation
MAD	Mean Absolute Difference
MDRE	Ministry of Rural Development and the Environment
MEDD	Ministry of Environment and Sustainable Development
MEF	Ministry of Economy and Finances
MEFPTIC	Ministry of Employment Vocational Training and Information and Communication Technologies
MET	Ministry of Equipment and Transport
MHA	Ministry of Hydraulics and Sanitation
MHUAT	Ministry of Land Use, Urbanization and Habitation
MIA	Ministry of Islamic Affairs
MLIT	Ministry of Land, Infrastructure and Transport

MNT	Non Communicable Disease
MOF	Ministry of Finance
MPI	Medical Professional Institute
MPN	Fish Market of Nouakchott
NADP	National Agricultural Development Plan
NCSI	Non Collective Sanitation Installation
NGO	Non Governmental Organization
NRPA	National Recreation and Park Association
OD	Origin Destination
OFDA	Office of Foreign Disaster Assistance
OJT	On the Job Training
OMRG	Mauritanian Office of Geological Research
OMVS	Organization for the Development of the Senegal River
ONAS	National Office of Sanitation
ONS	National Statistical Office
OSPUN	Observatory of Urban Services and Heritage of Nouakchott
PAD	Detailed Development Plan
PAN	Autonomous Port of Nouakchott
PANPA	Autonomous Port of Nouakchott aka Port of Friendship
PCU	Passenger Car Unit
PDALM	Mauritanian Coastal Master Plan
PDAN	Nouakchott Sanitation Master Plan
PDC	Communal Development Plan
PGR	Progress Report
PHPDT	Peak Hour Peak Direction Traffic
PIB	Gross Domestic Product
PIF	Land Intervention Perimeter
PL	Subdivision Plan
PLU	Local Urban Plan
PME	Small and Medium-sized Enterprises
PNDSE	National Program for the Development of the Education Sector
PPRI	Flood Risk Prevention Plan
R&D	Research and Development
RBU	Urban Land Consolidation Plan
RESEN	Status Report on the National Education System
RGPH	General Census of Population and Housing
RGU	General Urban Regulations
RU	Urban Renewal Plan
SCAPP	Strategy for Accelerated Growth and Shared Prosperity
SDAU	Urban Master Plan
SEA	Strategic Environmental Assessment
SEEI	Electrical and Industrial Equipment Company
SEZ	Special Economic Zone
SIG	Geographic Information System
SMH	Mauritanian Company of Hydrocarbons
SNDE	National Water Company
SNDT	National Tourism Development Strategy
SNIM	National Industrial and Mining Company
SOCOGIM	Real Estate Construction and Management Company
SOMELEC	Mauritanian Company of Electricity
SONELEC	National Water and Electricity Company
STP	Public Transport Company
STPN	Public Transport Company of Nouakchott
TBS	Gross Enrollment Ratio
TCR	Traffic Capacity Ratio
TDM	Traffic Demand Management
TFR	Total Fertility Rate
TIC	Information Technology
TNS	Net Enrollment Ratio
TOD	Transit Oriented Development
TVET	Technical and Vocational Education Training
TVZ	Tevragh Zeina
TWG	Technical Working Group
UDP	Urban Development Program
UNEP	United Nations Environment Program
USPR	Urban Services Penetration Rates
VAINCRE	Program of Valorization of the Fair Regional Growth Initiatives
VIH	Human Immunodeficiency Virus
WARCIP	West Africa Regional Communications Infrastructure Project
WHO	World Health Organization
WLC	Weighted Linear Combination
WWTP	Wastewater Treatment Plant
ZAC	Join Development Zone

INTRODUCTION

Background

Nouakchott City has been growing rapidly since the establishment of the city in 1960 as capital of Mauritania. According to the statistics by the National Statistical Office (OSN) of Mauritania the population of the City has grown from around 2,000 in 1957 to 558,195 in 2000, and 958,399 in 2013. The average annual growth rate was 4.61% from 2000 to 2013. This rapid growth of the city was driven not only by the "pull factors" such as commercial and economic center of the country, but also by some "push factors" such as serious poverty and scarcity of foods in the inland and rural areas caused by droughts and sandstorms took place in 1970's. The influx of the population resulted in formation of vast unplanned residential areas, or shanty towns, in the areas close to the central area, as well as in the outskirts of the City as ribbon type sprawl. Accordingly, the quality of lives of the citizens of Nouakchott was deteriorated considerably by severe shortage of access to infrastructure and social services, among others.

In order to overcome these urban problems of Nouakchot City, the Government of Mauritania (GOM) introduced necessary policies and projects, such as creation of the Urban Development Agency (ADU) to implement the Shanty Town Improvement Project which started in 2001, restructuring of central government ministries to enhance efficiency of the urban management, formulation of Urban Master Plan (Schéma Directeur d'Aménagement Urbain: hereinafter referred to as "SDAU") of Nouakchott in 2003 (hereinafter referred to as "SDAU 2003"), and creation of the Urban Planning Law (L*oi No 2008 - 07 portant Code de I'urbanisme*: hereinafter referred to as "Urban Planning Law 2008").

While shanty town problem has been gradually resolved by concerted efforts of above mentioned policies and projects, other urban problems gradually become prominent as Nouakchott grows to be a metropolis. Those problems include: inland inundation over built-up areas, occasional traffic jams, poor access to water and other urban services, coastal erosion, thread of sand dune against residential communities at urban fringe, etc.

Although the SDAU 2003 has been functioned as a fundamental policy to guide government activities related to urbanization, not all the decisions and public investments have followed its rules. The reason of these malfunctioning of the SDAU 2003 largely attributes to the luck of credibility, caused by existence of several factors which SDAU 2003 could not effectively address due largely to insufficient planning technology. Although the Ministry of Land use, Urbanization and Habitation (MHUAT) attempted to revise SDAU in 2013, it was abandoned because of the lack of capacity. In addition, the area of Nouakchott has expanded in 2015 to cover the new international airport and the new branch of Nouakchott University. Thus, there is no effective SDAU to guide the urbanization of the enlarged Nouakchott even though the long-term horizon of the SDAU 2003 was set to 2020.

Based on the above-mentioned circumstances, the Government of Mauritania submitted the official request of the Project to the Government of Japan for assistance to develop an SDAU for Nouakchott City. Responding to the request, Japan International Cooperation Agency (JICA) conducted necessary survey missions to confirm development needs related to the urbanization of Nouakchott City. As a result, JICA recognized that it is necessary to revise the SDAU 2003 as well as carrying out capacity development for urban planning and management. Consequently, the Record of Discussion was signed in May, 2016 and the Project was started in November, 2016.

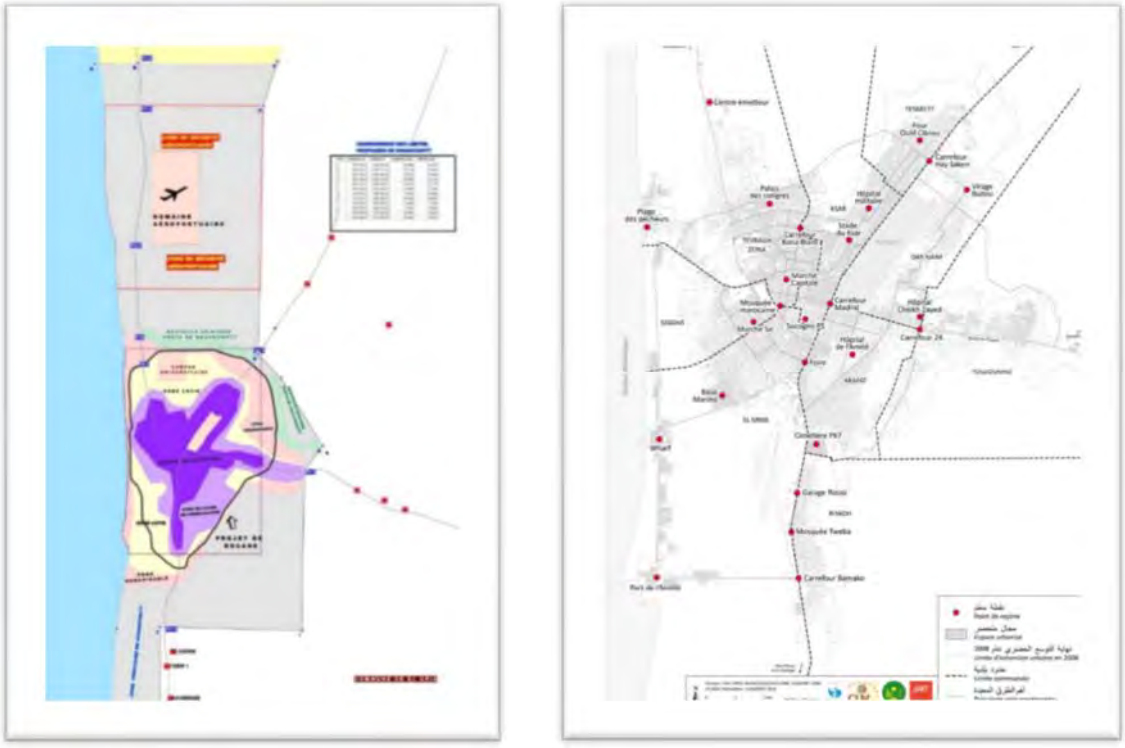
Objectives

The objectives of the Project consist of the following two items:

1) To formulate an SDAU for the entire administrative area of Nouakchott City and a PLU, a law binding plan to restrict regulations with more detailed drawing, for the administrative area of one Commune to be selected in the course of the Project; and
2) To enhance capacity of related agencies responsible for urban planning and realization.

Target Area

The target area of the SDAU covers the administrative area of Nouakchott City, which was expanded in 2015, with 1,129 km2 The target area for the PLU will be the administrative area of one Commune to be selected in the Project. It should be noted that the administrative area of Communes in Nouakchott has not been officialized yet. The new administrative areas of the Communes need to be defined by the Ministry of Interior and Decentralization, through consultation with the Ministry of Habitatt, Urbanization, and Land Use (MHUAT). Figure A shows the composition of administrative areas of Nouakchott City, before and after 2015.



Entire coverage of Nouakchott City after 2015 Composition of Communes before 2015

Figure A: Composition of Administrative Areas of Nouakchott City, before and after 2015

Target Year

The target year of both plans of the SDAU and the PLU are 2040, as described in the Record of Discussion signed in May. 2016.

Reports and Other Outputs

All the reports to be produced in the Project are listed below:

Name of the Report	Major Contents	Expected Time of Submission
Inception Report (ICR)	Outline of the Project, approach to the planning, work operation plan, assignment schedule, etc.	December, 2016
Progress Report (PR)	Results of analyses of the existing conditions, including the results of the social survey and GIS data development. Draft of major concepts of the SDAU, including theme/philosophy of development, future framework, expected position and role in wider context, targets for sustainable urban development, and strategies for realizing the targets.	June, 2017
Interim Report (ITR)	Conception works, land use plan, infrastructure development plan, framework of PLU planning, and results of project activities	March, 2018
Draft Final Report (DFR)	Results of all analyses works, concepts agreed through public consultation (SEA), draft of SDAU and PLU.	July, 2018
Final Report (FR)	All the results of the entire project activities.	October, 2018
Draft SDAU	Draft of the SDAU to be compiled in accordance with law requirement, aiming at smoother approval and enforcement. The document shall be prepared mainly by the hands of DU with necessary supports by the JICA Project Team.	Ditto
Draft PLU	Draft of the PLU for the selected Commune to be compiled in accordance with law requirement, aiming at smoother approval and enforcement. The document shall be prepared mainly by the hands of DU with necessary supports by the JICA Project Team.	Ditto
Leaflet of SDAU		Ditto
GIS data set		Ditto

Work Operation Structure

(1) Overall project management

The project was conducted under the ownership of the Government of Mauritania. The Project Team consisting of JICA experts and its Mauritanian counterpart (C/P) staff carried out the Project. The overall structure of the project management is illustrated in Figure B, followed by explanation on roles and assignment of relevant organizations.

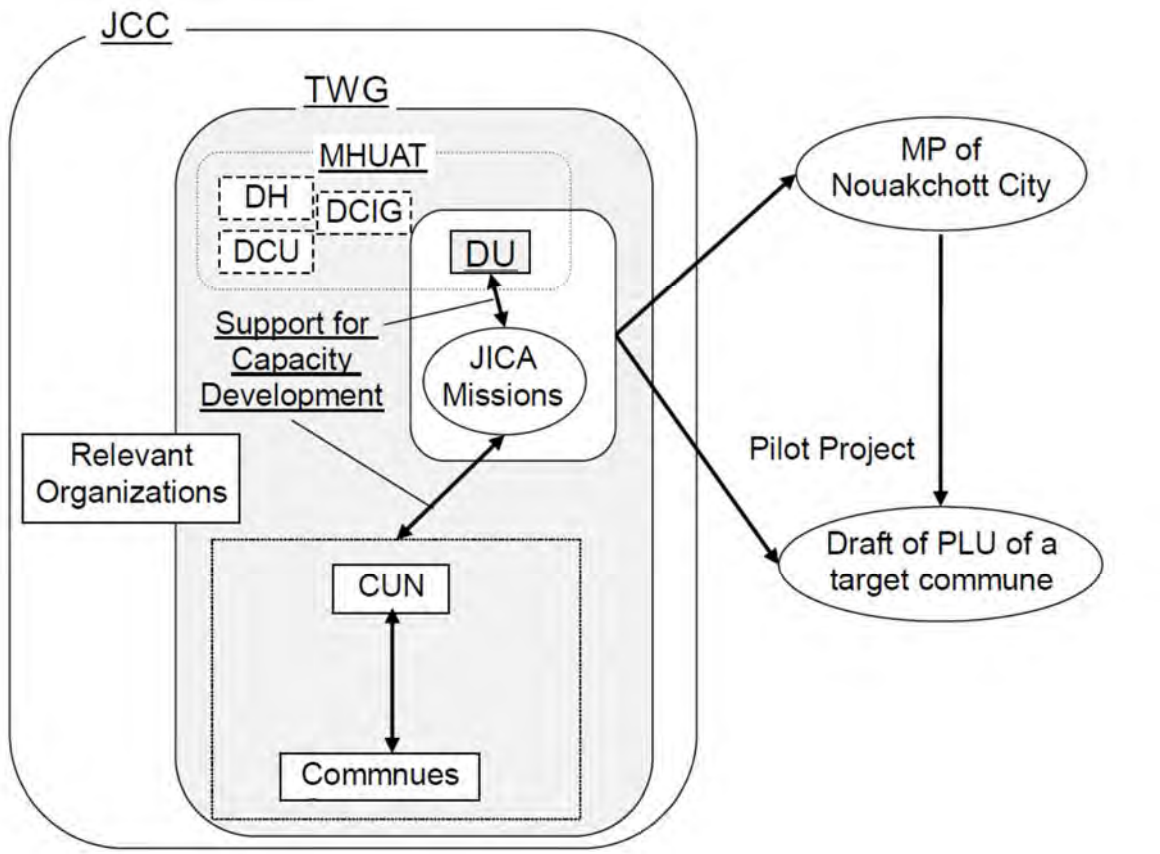


Figure B: Overall Project Management Structure

1) MHUAT

(a) Project Director
Secretary General of MHUAT was responsible for overall administration and implementation of the Project.

(b) Project Manager
Director of the Department of Urbanization and Topography (hereinafter referred to as "DUT"), MHUAT was responsible for smooth implementation and coordination of the Project.

(c) Assignment of counterpart personnel
MHUAT assigned counterpart personnel to formulate MP and the Model PLU together with JICA Team for capacity development.

2) CUN

(a) Project Coordinator at Commune level
Director of Department of Studies, Projects and Planning of Community Space (hereinafter referred as to "DEPAEC"), responsible for Observatory of Urban Services and Heritage of Nouakchott (hereinafter referred to as "OSPUN") of Urban Community of Nouakchott (hereinafter referred to as "CUN"), was responsible for coordination among CUN and all the communes.

(b) Assignment of counterpart personnel
CUN assigned counterpart personnel to cooperate on formulation of MP and the Model PLU and capacity development activities.

(c) Public Consultation
CUN is responsible for public consultation to local residents in all communes with collaboration with MHUAT and cooperation with JICA Team.

3) Joint Coordinating Committee

Joint Coordinating Committee (JCC) was established in order to facilitate inter-organizational coordination. JCC meetings were held at the beginning of the Project, and the time of discussion for each report in order to fulfill the following functions:

i. Approve work plan and review overall progress;
ii. Discuss and approve the reports;
iii. Conduct monitoring and evaluation of the Project; and
iv. Exchange opinions on major issues arising during the implementation of the Project.

4) Technical Working Group

Technical Working Group (TWG) was established in order to discuss technical issues and capacity development activities. TWG will be held whenever deemed necessary in order to fulfill the following functions:

i. Discuss and approve the technical matters;
ii. Conduct capacity development activities of relevant organizations; and
iii. Exchange opinions on technical issues arisen during the Project.

(2) The Project Team

Works for formulation of SDAU and PLU were carried out by the Project Team consisting of JICA Experts and C/P Staff assigned by MHUAT and CUN. The Project Team was composed of three Task Forces and two Units as illustrated in Figure C.

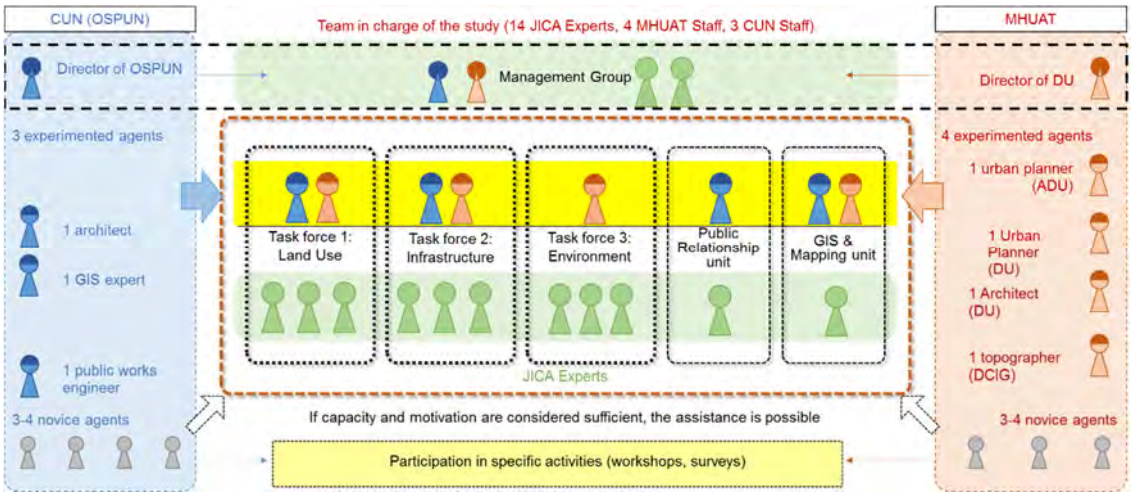


Figure C: Composition of the Project Team

The two units in the Project Team were in charge of 1) GIS and mapping, and 2) Public relationship, respectively. The GIS and mapping unit conducted development of GIS database, produced thematic maps for analyses, and finalized drawings of SDAU and PLU. The public relationship unit conducted preparation of public information systems, and carried out public consultations as a part of SEA. Role of the three Task Forces, on the other hand, were flexibly determined by work phases.

Operation of the Project Team is a major part of the CD activities. In the Analyses phase, the Task Forces concentrated on collection and analyses of information. This was done through internal discussion and creation of common understandings for necessity and usage of required information between JICA Expert and C/P staff. The Task Force jointly conducted data collection and analyses, and presented the results to the management group consisting of chief of DUT, chief of OSPUN and delegation from the JICA Expert in charge. In the planning phase, the Task Forces developed proposals and gave presentation in sector wise meetings of the Technical Working Groups. The TWG were held attended by members of related organizations in accordance with themes discussed. It should be noted that the core member of the TWG were appointed by MHUAT to attend all the TWG meetings.

PART I: SDAU

CHAPTER 1:
INTRODUCTION/SCOPE OF SDAU

1.1 General Characteristics and Objectives of SDAU

The SDAU can be described by the following characteristics.

- Coverage of the whole urban area and its neighborhoods, that is to say the whole territory to be urbanized or controlled in the long term;
- Consideration a long-term planning period, generally of about 10 to 20 years;
- Determination of general strategies for spatial development as a programming and planning document;
- No bidding force to private individuals but mandatory for the administration that must integrate its orientations and obligations to decisions and actions.

The SDAU determines the major orientations and enables the public authority to fulfill the following planning objectives.

- Planning of essential elements of urban development;
- Delineation of the urban growth boundary and setting of the surface areas to be open to urbanization, illustrating the consistence between the different types of land use;
- Planning of necessary land reserves for major structuring infrastructures;
- Information to the various stakeholders of its intentions in terms of urban development;
- Determination of the boundaries and content of future planning documents (PLU);
- Assessment of the compatibility of the big projects that will be submitted for approval having a permanent and known reference frame for all operators;
- Proposition of locations that are consistent with the SDAU for applications of newly decided projects.

1.2 SDAU as a Strategic Document for Coordination

Besides the direct function of SDAU as a control and urban planning tool, its role as a coordination instrument which can influence the decisions of public operators as well as private investors shall not be underestimated, as pointed out by the experience of the SDAU 2003. By the time the intentions of public authorities are known, the various stakeholders will try to make their projects comply with the SDAU, also in order to avoid troubles, delays and administrative difficulties. This anticipation will be translated in terms of implementation of activities and land acquisition.

However, this convergence of anticipations made possible by the SDAU requires the following conditions.

- Intentions and strategies expressed in the SDAU shall be clear and known by stakeholders; they shall be easy to understand for any stakeholder;
- Intentions shall be credible, in other words stakeholders shall be convinced that MHUAT can actually implement and achieve what the SDAU is planning;
- Urban development zones planned by the SDAU shall ensure enough land area for all categories of price and for all social groups.

1.3 Legal Framework

Urban Planning Law 2008 defines the contents of the SDAU as described in the Table below. This report covers all the necessary regulatory expectations contained in Mauritanian Law.

Table 1.1: Regulatory Expectations of the SDAU and Coverage by the Current Report

Theme	Regulatory expectations of the SDAU	Coverage by the Report
Urban growth	1. Delimit urban growth boundary for 10 years to 20 years horizon; 2. Indicate preferred areas of urban extension.	Chapter 2, Section 2.5

Transport and other network infrastructure	3. Define the layout of transport and other network infrastructure	Chapter 3, 4, and 5
Public facilities	4. Define the location of the major public facilities of the agglomeration	Chapter 7
Land use planning	5. Indicate land use planning of the different zones. - existing and future urban area for housing, commerce, activity, facilities or green space, specifying areas to be restructured, redeveloped or protected; - measures for the protection of water resources; - agricultural areas and construction prohibited natural areas; - sites of environmental, historical or archaeological interest to protect or enhance.	Chapter 4

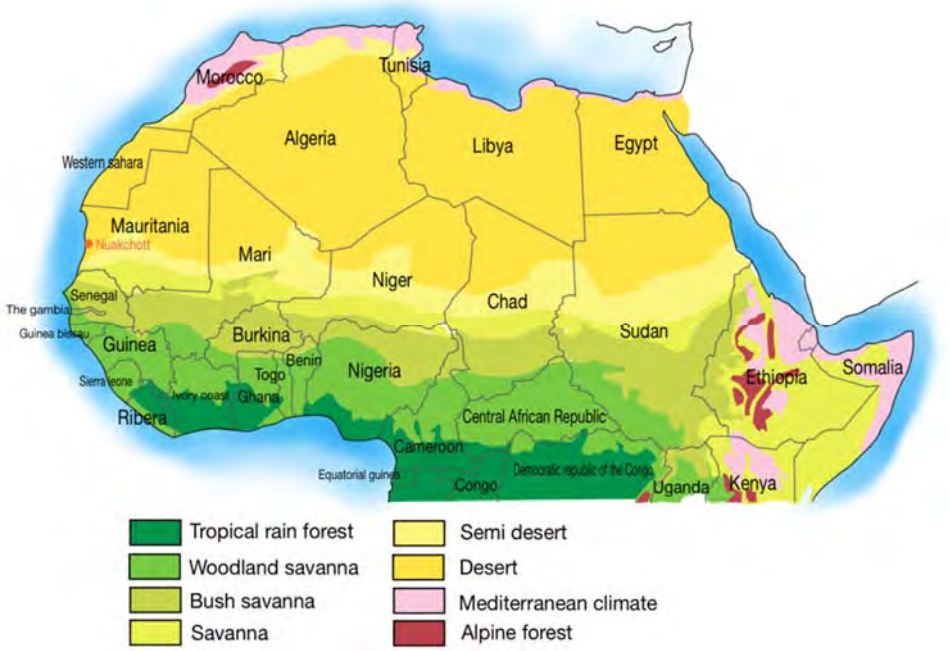
Source : Urban Planning Law 2008 and JICA Study Team

CHAPTER 2:
EXISTING CONDITIONS

2.1 Location and Geo-economic conditions

2.1.1 Location

Mauritania, officially the Islamic Republic of Mauritania, is a country in the Maghreb region of western Africa. It is the eleventh largest country in Africa and is bordered by the Atlantic Ocean to the west, Western Sahara in the north, Algeria in the northeast, Mali in the east and southeast, and Senegal in the southwest. At 1,030,000 square kilometers, 90% of which is desert, Mauritania is the world's 29th-largest country. It lies mostly between latitudes 14° and 26°N, and longitudes 5° and 17°W. Nouakchott is the capital and largest city of Mauritania. It is one of the largest cities in the Sahara. The city also serves as the administrative and economic center of Mauritania. Located on the Atlantic coast of the Sahara Desert, it lies on the west coast of Africa.



Source: http: //www.lib.utexas.edu/maps/africa/africa_veg_86.jpg

Figure 2.1: Location of Nouakchott

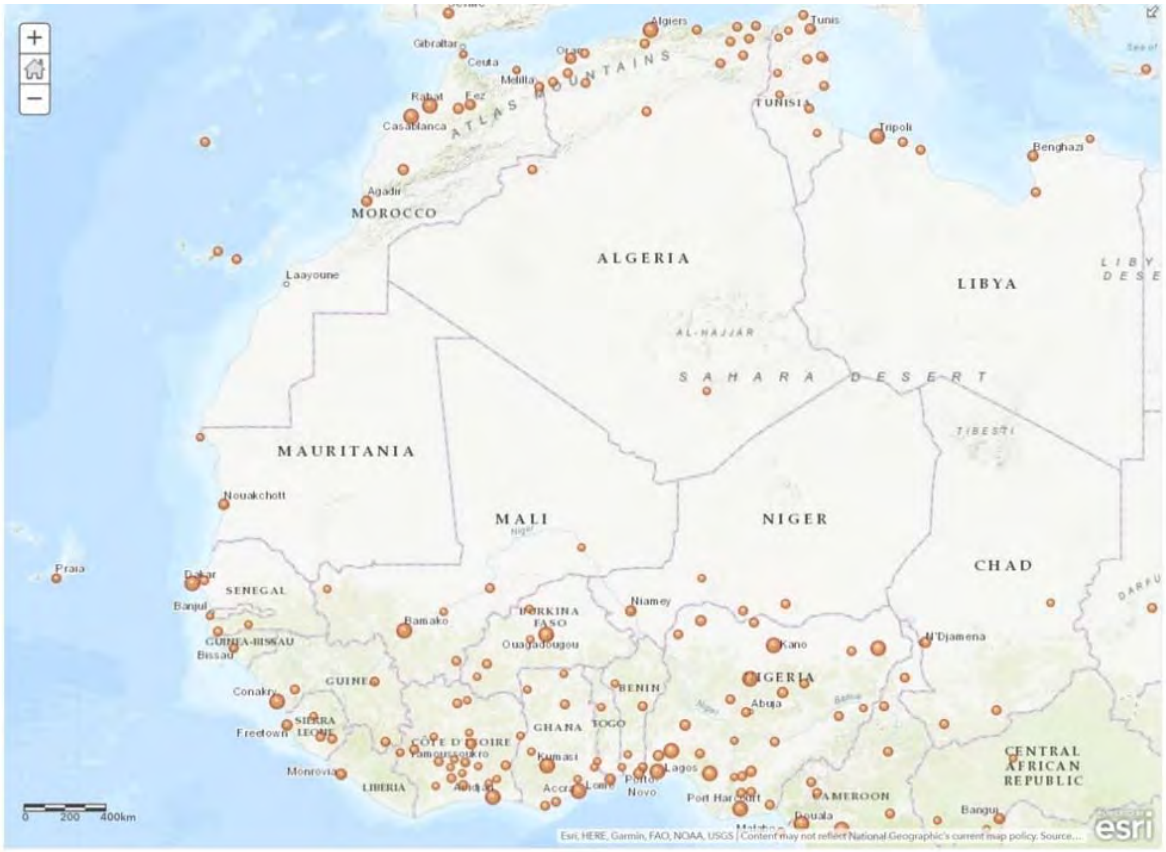
2.1.2 Position of Nouakchott in wider context

At the international and regional scale, Nouakchott has a secondary and relatively isolated position compared to other Northern African and West African capital cities, in geographic, demographic and economic terms.

Mauritania's external trade can be characterized by a high concentration of the export. The trade deficit remained at around 15 % of GDP. Performance regarding regional integration is very low. Mauritania is a member of the Arab Maghreb Union (AMU) from its establishment in 1989, but application to the signed cooperation treaties are very limited and intra-zone trade remains less than 3%. Exports to AMU member countries are very few (0.1% of total export value in 2013). Trade between Mauritania and member countries of the Economic Community of West African States (ECOWAS) is much more active (around 7% of total export in 2013), especially with the Senegal River Development Organization (OMVS) member countries (Guinea, Mali and Senegal).

Regarding the population importance, as testified in Figure 2.2 below showing the cities of more than 50,000 inhabitants, Nouakchott is isolated especially compared to the concentration of population of

Western Africa. Nouakchott is also outside the major transboundary commercial corridors, Dakar being the favorite access to the sea for land locked Mali. Inversely, given this isolated geographic location, Mauritania can be considered as a transit country. This gives to Nouakchott a comparative advantage in the region and a huge potential as a trade and integration platform.

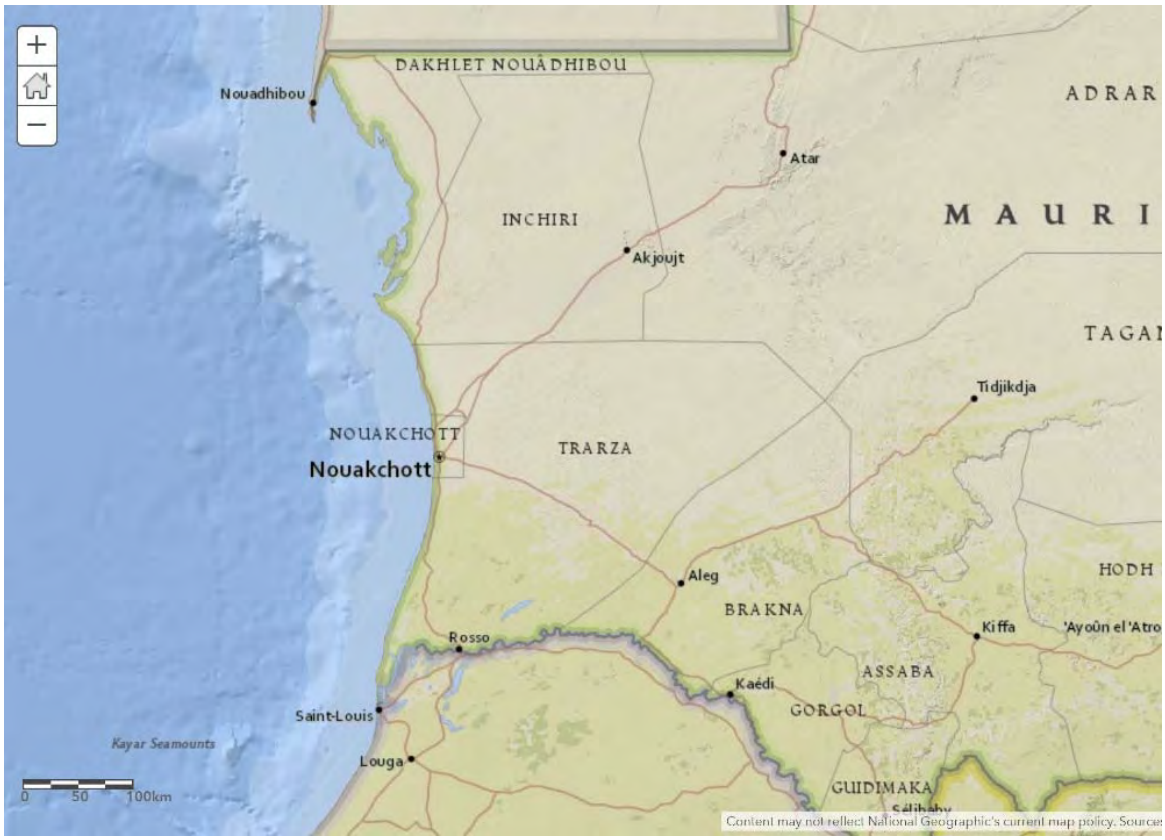


Source: ESRI

Figure 2.2: Regional Context of Nouakchott City

Regarding the position of Nouakchott City towards its national hinterland, as shown in Figure 2.3 below, the capital city has a central place in the country but is located far from any other important economic poles. Saint Louis in Senegal (approx. population 250,000) is distant of 250 km to the South and the second city of Mauritania, Nouadhibou (approx. population 120,000) is located 300 km in the North. The strengthening of the urban hierarchy of the whole country by relying on a few central poles to develop, such as Nouadhibou, Zouierate, Atar, Rosso, Kaedi, Kiffa or Nema, is a challenge for the future of the country.

Even though there is still a lack of major supporting urban pole in proximity of Nouakchott, there exists some smaller cities in the direct hinterland of the capital city, which are currently developing as bed towns for Nouakchott: Arya at 50 km in the South on the road of Rosso, Ouad Naga at 50 km in the East on the Hope road, and Tanit at 80 km in the North, which also will welcome a large-scale port development. However, those distant cities, which should be more compared to villages due to their lack of infrastructure and services, do not have any real supporting role to Nouakchott's development.



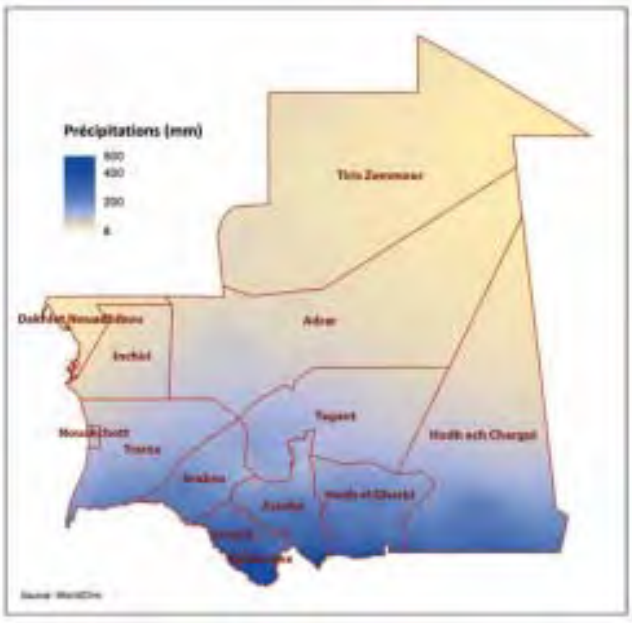
Source: ESRI

Figure 2.3: National Context of Nouakchott City

2.2 Natural Conditions

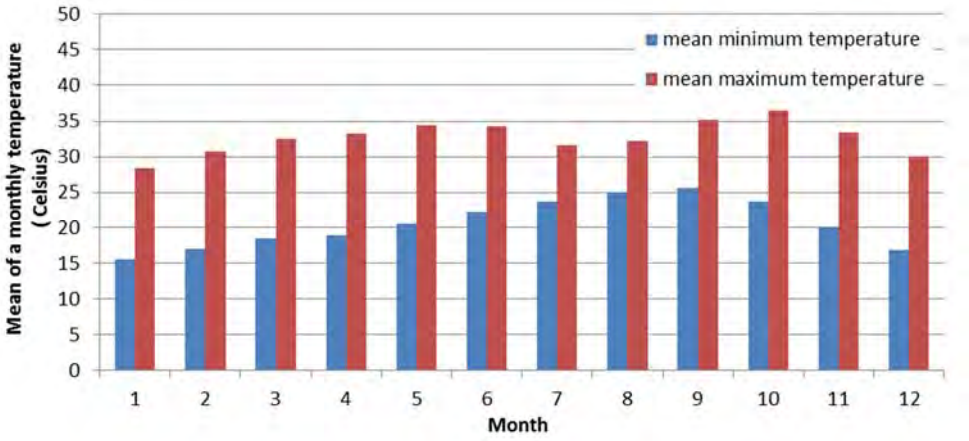
2.2.1 Climate

Nouakchott is characterized by a hot desert climate, having hot temperatures throughout the year. The average high temperatures are relatively constant at 33 °C, while average low temperatures range from 25 °C during the summer to 13 °C during the winter. The average rainfall in the city is 100 mm and sometimes less in a year as shown below:



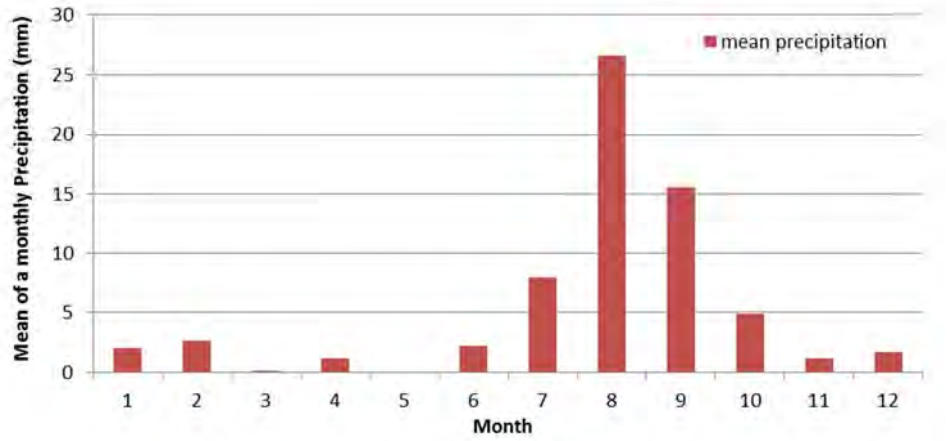
Source: WorldClim

Figure 2.4: Annual Rainfall Distribution in Mauritania（1950-2000）



Source: http: //www.meteofrance.com/

Figure 2.5: Monthly Mean minimum/maximum Temperature in Nouakchott (1981-2010)



Source: http: //www.meteofrance.com/

Figure 2.6: Mean Monthly Precipitation (1981-2010)

2.2.2 Geography

Nouakchott is a low-altitude coastal city. Situated in the desert climate. it is divided into coastal, lowland, urban and inland desert areas. Figure 2.7 shows the topographical overview of Nouakchott.

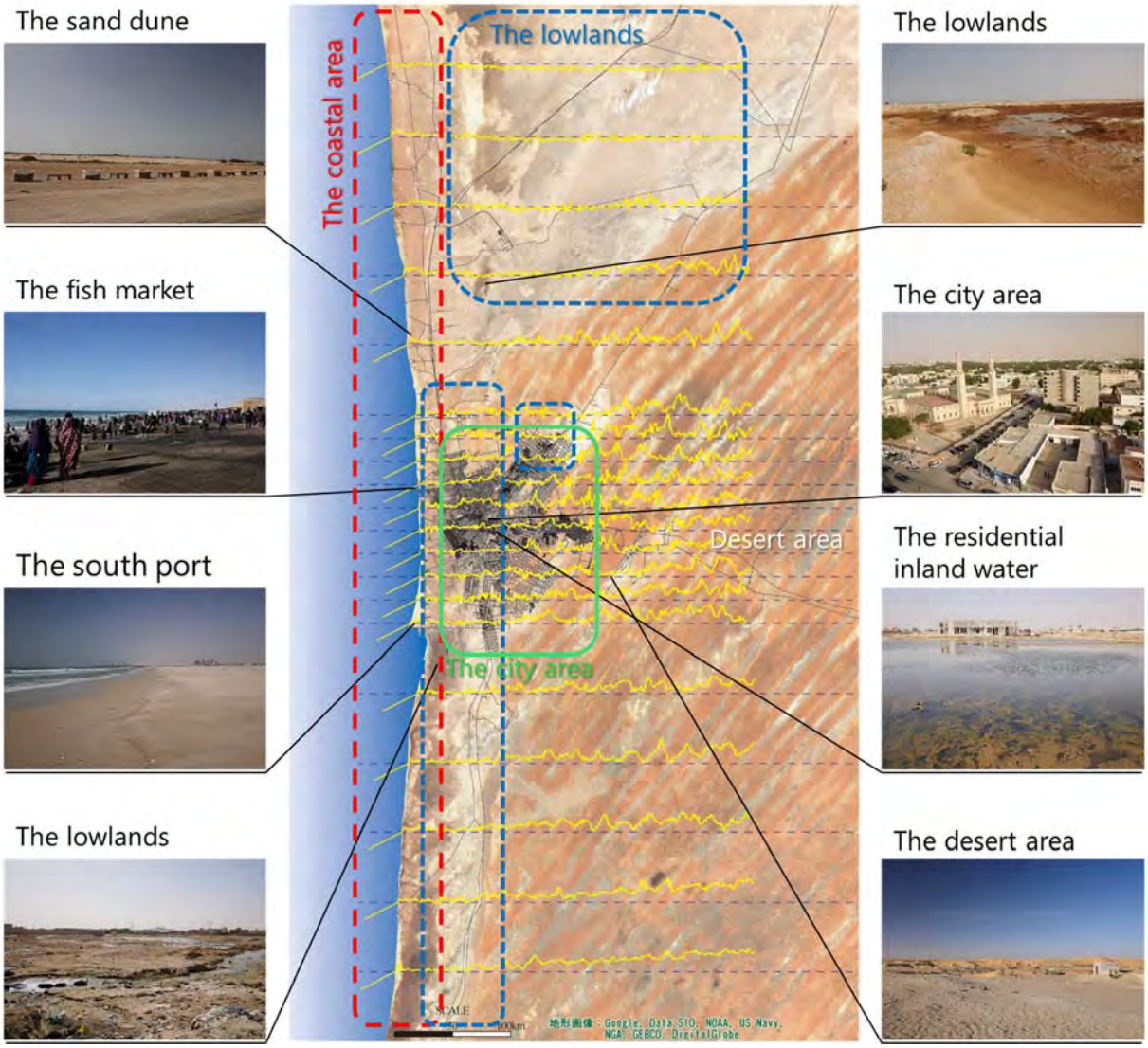


Figure 2.7: Geographical Features of Nouakchott

(1) Coastal Area

At the coastal side of Nouakchott, a sandy coastal line runs north to south and dunes with a height of 3 to 5 m are developed. In recent years, the dunes suffered loss due to illegal collection. Facilities such as fish market, industrial port, hotel and factory are seen in the coastal area. The industrial ports constructed with the aid of China has influenced the sand sedimentary environment and the coastline.

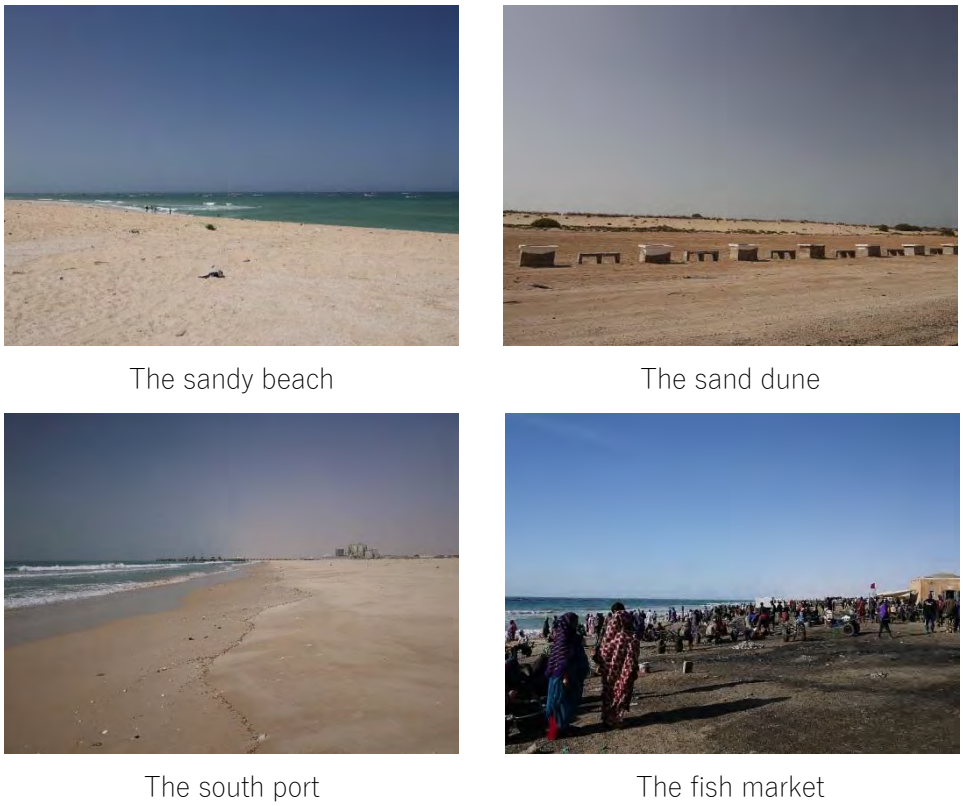


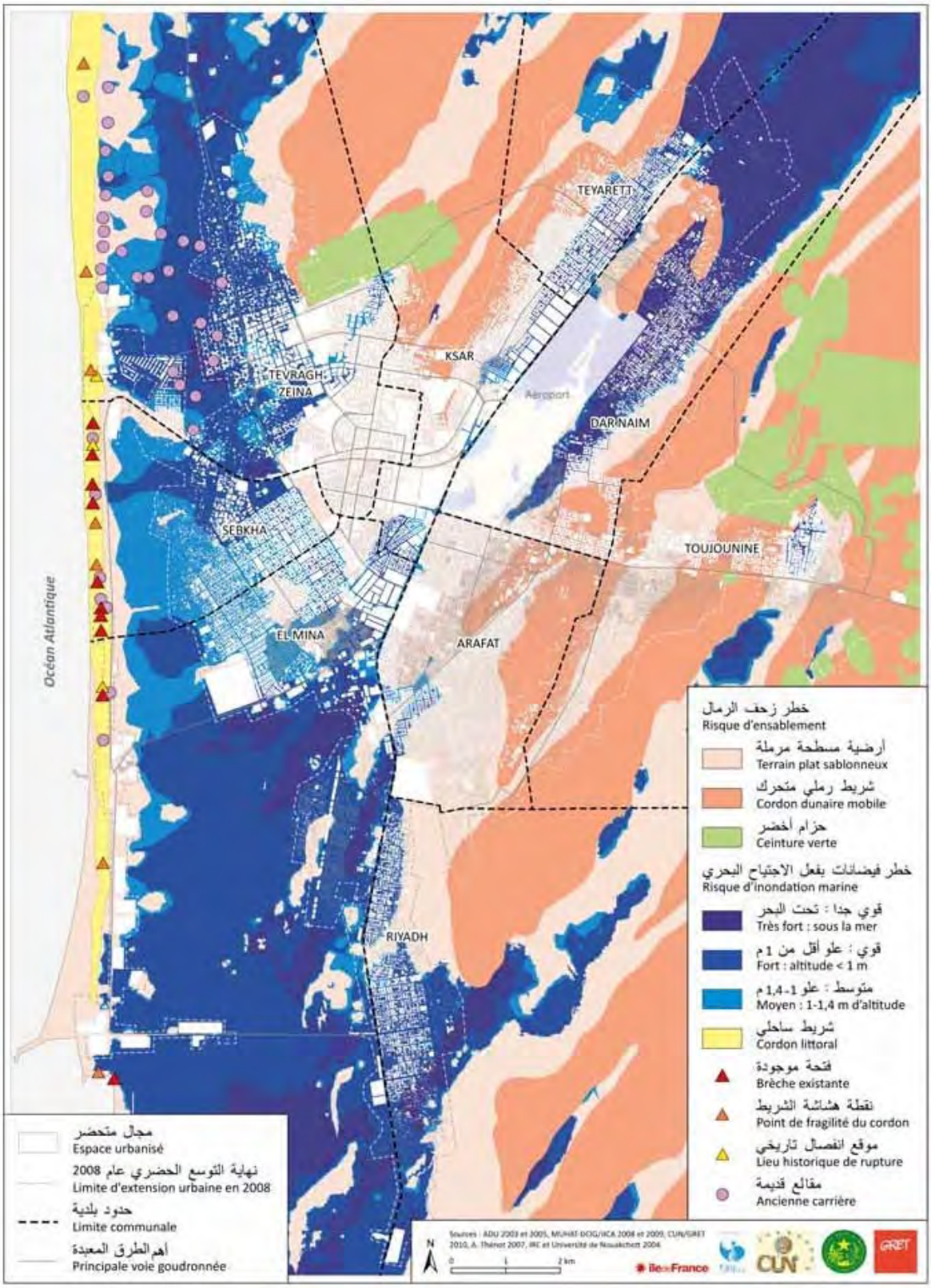
Figure 2.8: Coast Area

(2) Lowland

There are many areas which are below sea level in Nouakchott. These are places where flood damages are likely to occur. Main lowlands include: the northern part which are newly included in Nouakchott, the coastal lowland in the north-south, and the low parts extending from the northeast to the southwest on the northeast side of the city. Groundwater in Nouakchott is linked with sea water. The flood damage usually become sever when the high tide and rainfall overlaps, especially in coastal lowlands, where flooding frequently occurs. There are some simple drainage facilities, such as soil side grooves, provided run towards lower places such as depressions. Figure 2.9 shows the situation of the soil side groove.

Figure 2.9: View of Lowland Areas

Figure 2.10: Side Grooves at Coastal Lowlands



Source: ATLAS DE NOUAKCHOTT | Infrastructures et services urbains

Figure 2.11: Hazard Map of Inland Water

(3) Centre of city

The Nouadhibou Road running north to south on the western side of the city divides the city area into coastal lowland and the east side. The latter area is about 1 to 2 m higher than the coastal lowland (Figure 2.13). The altitude of east side area gradually rises towards the desert area.

Figure 2.12: View of the Central Area of Nouakchott

Figure 2.13: Section of the Central Area of Nouakchott

(4) Desert area

Since Nouakchott is a part of the desert area, desertification and movement of sand dunes are one of the major concerns caused by the natural condition. Tree planting have been practiced as a measure counter the movement of dunes. At the same time, the desert areas provide important recreation sites for citizens.

Desert at the continental side

Desert at the coastal side

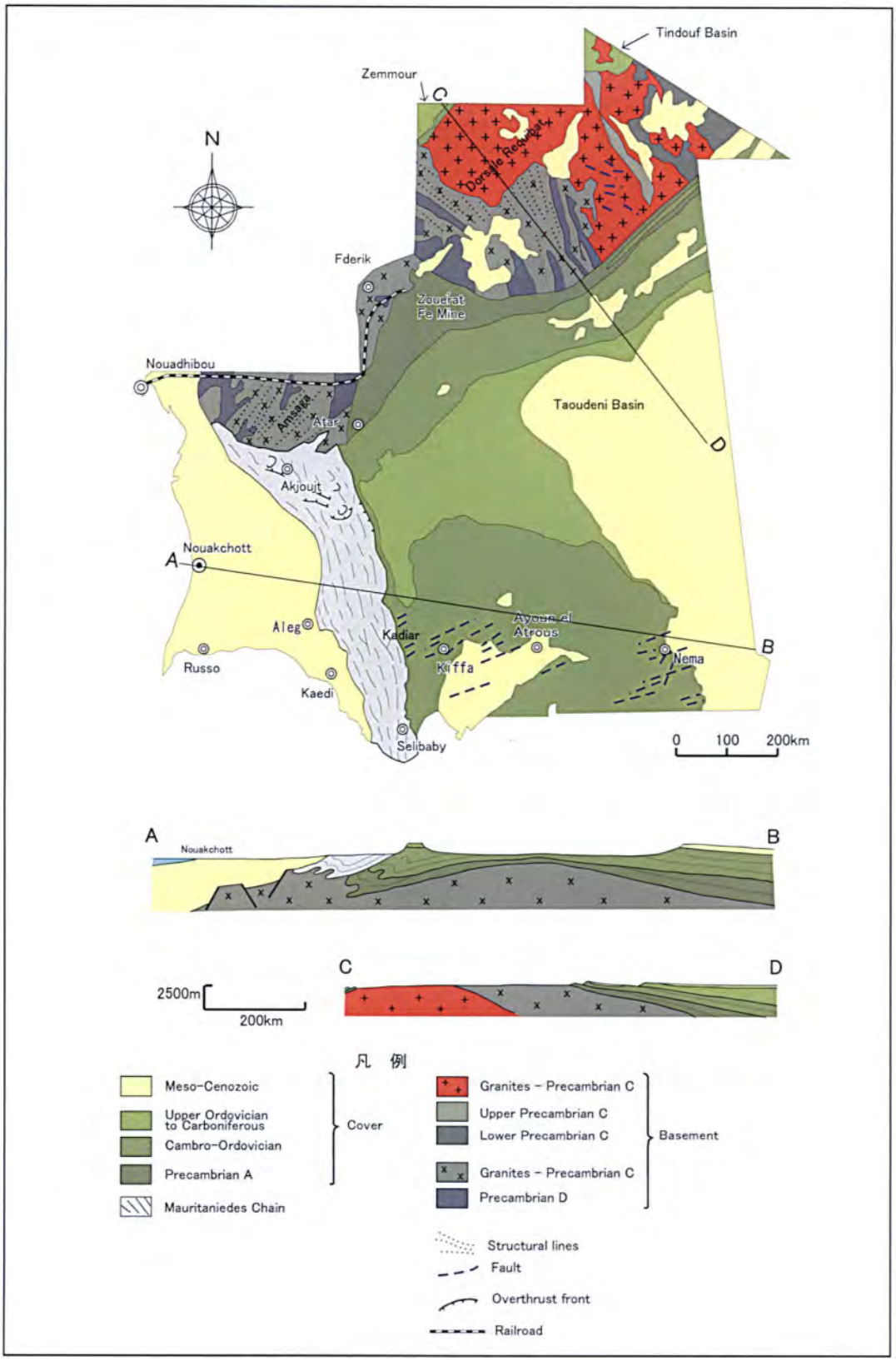
Tents for leisure

Tree planting

Figure 2.14: View of Desert Area

2.2.3 Geology

Mauritania consists of five geological zones as shown in Figure 2.15. Among them, Nouakchott is situated in the Atlantic coast basin consisting of Cenozoic sedimentary rocks. The Atlantic coast sedimentary basin is located west of the Mauritanian variability zone and is largely composed of the lower cretaceous to quaternary sedimentary rocks and sediments (BRGM, 1975). At the shallow level, the Nouakchott area is composed of sand and limestone layers which forms the first aquifer (MDRE, 2004). This aquifer reaches to the altitude of about 35m below sea level.

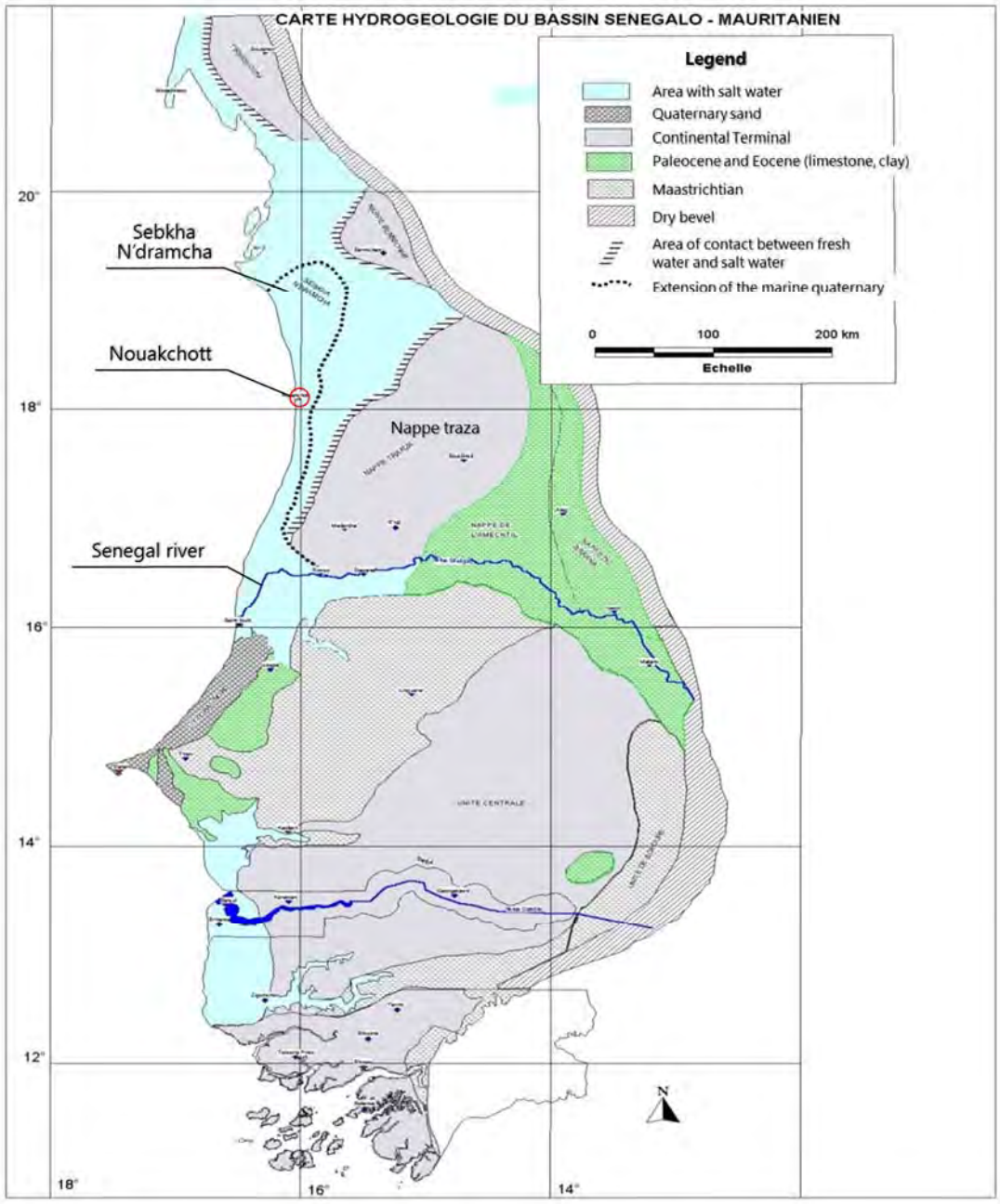


Source: BRGM (1975), Survey on mineral resource development strategy formulation Final Report (2006 JICA)

Figure 2.15: Geologic Map of Mauritania

2.2.4 Hydrological phenomena

There are no rivers in Nouakchott. The groundwater resource map of Mauritania is shown in Figure 2.16. Currently, groundwater of Nouakchott is not used for drinking nor agricultural purposes. Because the rainwater from the inner desert land is extremely limited, the sea water enters to the land area for about 50 km from the coastal line. The salt concentration of the groundwater in the Nouakchott is very high, leading to corrosion of the building foundation.



Source: LES RESSOURCES EN EAU En MAURITANIE (2007)

Figure 2.16: Water Resource Map of Nouakchott and Wider Region

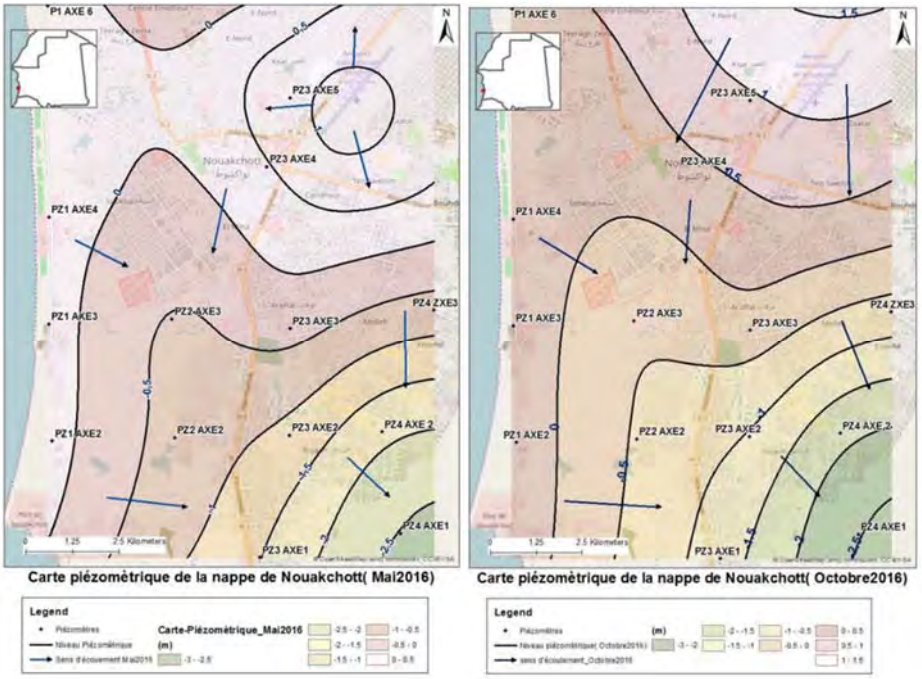
A large-scale survey was conducted to observe groundwater level and water quality in the city area by the Société National de l'Eau (SNDE) in 2015. By this survey, 20 observation wells were installed in the city area as shown in the Figures 2.17 below. According to the groundwater contour maps presented in Figure 2.18, it can be seen that the groundwater flows from the sea side to the land side.

Source: CNRE, Réalisation de 20 piézomètres carottés équipés d'enregistreurs automatiques et de deux forages (2015)

Figure 2.17: Location of Groundwater Monitoring Points

Source: Réalisation de 20 piézomètres carottés équipés d'enregistreurs automatiques et de deux forages (2015)

Figure 2.18: View of the Installed Monitoring Wells and Soil Samples



Source: CNRE, Hydrodynamique et origine des eaux souterraines de Nouakchott-Mauritanie (2016)

Figure 2.19: Groundwater Contour Maps

The hydrological system and its characteristics of Nouakchott is summarized in Figure 2.20.

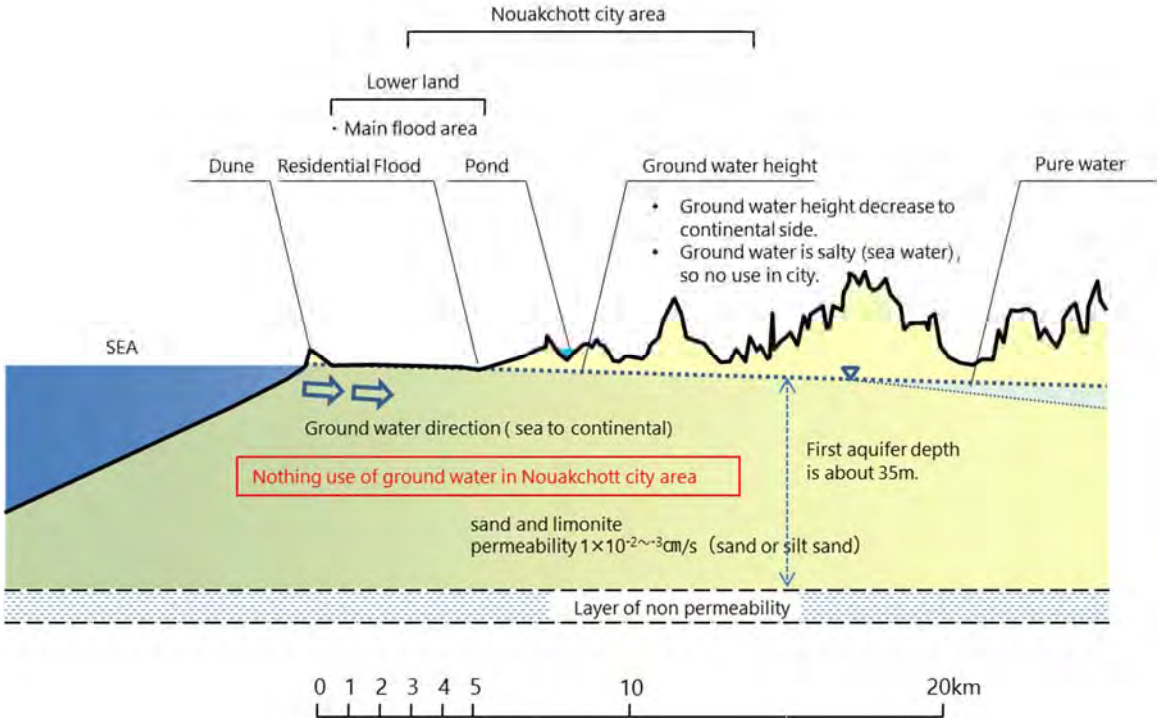
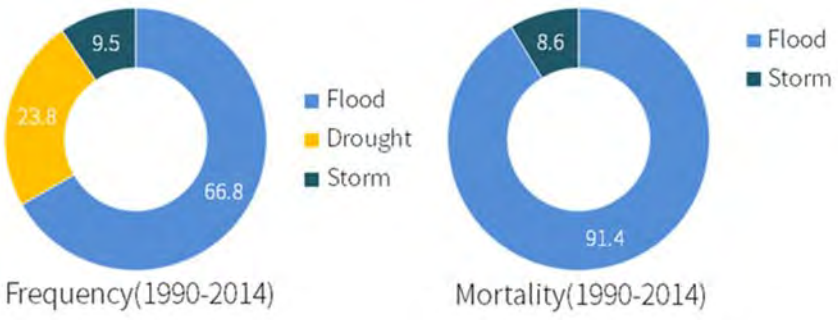


Figure 2.20: Geological and Hydrological Overview of Nouakchott

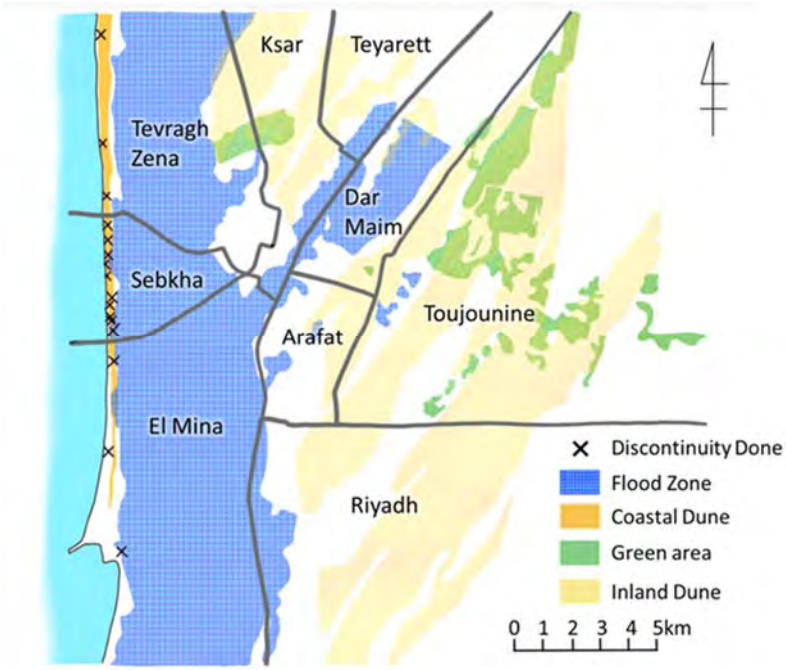
2.2.5 Natural environmental risks

Major natural disasters occurring in Nouakchott are inundation due to high waves, inland water damage, desertification (Figure 2.21). And, global climate change is expected to further increase the threat of natural disasters. Future urban planning needs to take mitigation and adaptation measures against these natural disasters. High wave inundation occurs in coastal low elevation areas. Coastal sand dunes have the role of breakwater. Inland water damage occurs during rainy season due to insufficient maintenance of urban drainage. Desertification is caused by the movement of sand from inland areas. Drought is expanding its damage. In Nouakchott, green belt is installed to prevent desertification and to prevent movement of sand from inland areas.



Source:
PreventionWebhttp: //www.preventionweb.net/countries/mrt/data/
Internationally Reported Losses 190-2014 EMDAT
CRED EM-DAT (Feb. 2015) : The OFDA/CRED - International Disaster Database www.emdat.be Université catholique de Louvain Brussels - Belgium.

Figure 2.21: Disaster Frequency and Number of Deaths in Mauritania (1990-2014)



Source: Vers une ECO ZAC pour la ville de Nouakchott

Figure 2.22: Map of Natural Disaster Risks in Nouakchott

(1) High wave inundation

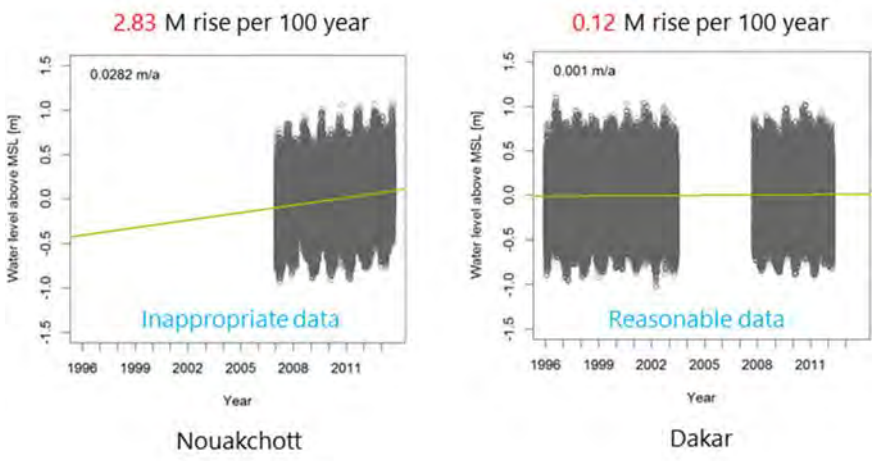
1) Introduction

High waves damage occur in coastal lowlands, causing frequent flooding and salt damage. For this reason, this area is not suitable as a residential area, and a large amount of expenses are required for improvement. In addition, the sand dunes existing in the coastal area have a role as a natural breakwater, but in recent years the sand dunes have been scaled down, and this conservation is an important issue.

2) Sea level rise due to global warming

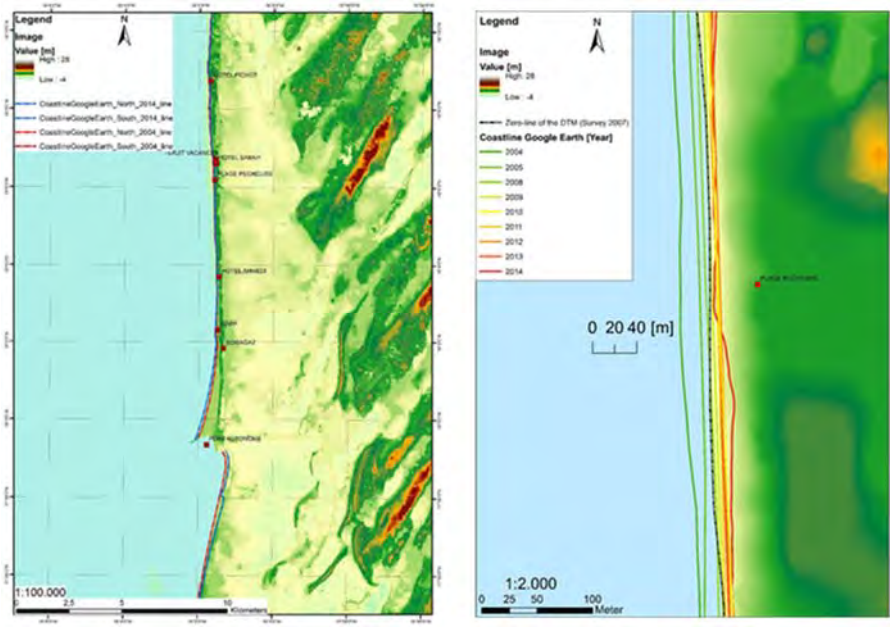
According to GIZ(2015), sea level rise in Nouakchott is expected to increase from 0.2 to 1.1m in the next 100 years. Floods and inland water damages are also expected to increase. In addition, GIZ reports that the change of the coastline is taking place due to erosion of sand beaches as well as recession. About 3 to 4 m per year of recession was observed from 2004 to 2014. With increasing rise of the sea level, further coastline erosion and flood damages are expected.

The coastal development has also caused change in the coastline. It has been observed that sediment accumulates on the northern side of the industrial seaport and a remarkable recession of the coastline on the south side is taking place.



Source: ACCVC, Changement climatique, érosion côtière et risques d'inondations à Nouakchott, Mauritanie (2015), GIZ

Figure 2.23: Hourly Sea Water Level in Nouakchott and Dakar

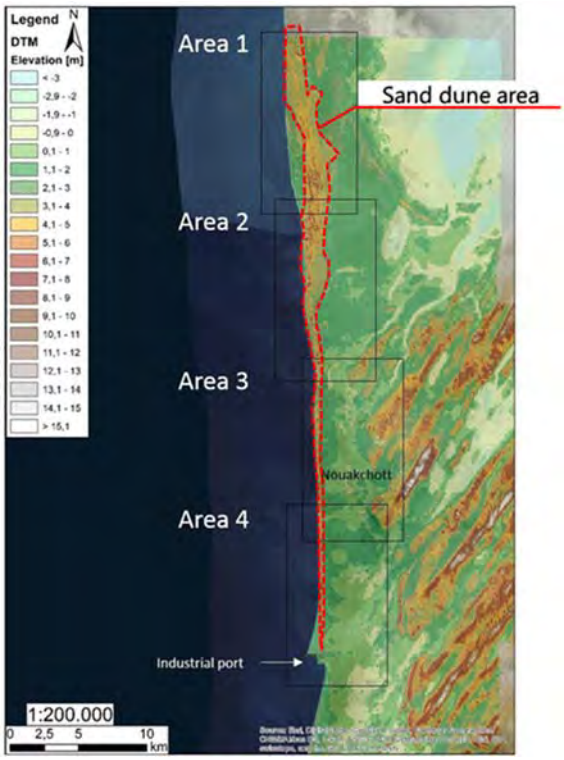


Source: ACCVC, Changement climatique, érosion côtière et risques d'inondations à Nouakchott, Mauritanie (2015), GIZ

Figure 2.24: Decline of Shoreline by Rising of Sea Level

3) Coastal dune preservation

The sand dunes with a height of 3 to 5 m naturally develop on the coastline and play a role as breakwater. However, in recent years, there has been a significant reduction in the sand dunes as people have been illegally collecting sand. GIZ implemented a project to rehabilitate the sand dunes in the framework of ACCVC. As this coastal dunes will be effective measures to reduce high wave harm, it is desirable to continue conservation activities.



Source: ACCVC, Changement climatique, érosion côtière et risques d'inondations à Nouakchott, Mauritanie (2015), GIZ

Figure 2.25: Distribution of Sand Dunes

Regarding the climate change, GIZ has been actively supporting the Mauritanian Government. Currently, the German-Mauritanian cooperation focuses on the sustainable natural resource management and adaptation to climate change. In light of this framework, several projects have been conducted as follows:

Adaptation to climate change in rural areas (2014-2018)

This project is supporting the MEDD and the other partner ministries and institutions in integrating the climate change adaptation more comprehensively into the national strategy and planning processes. The MEDD is in charge of ensuring that the National Adaptation Plan process is initiated, structured and implemented in an inclusive manner.

Helping Mauritanian coastal cities adapt to climate change (2012-2017)

GIZ is supporting relevant actors like the MEDD and municipalities to protect the city more effectively from the impacts of climate change.

The project is developing an information system (Adapt NKC) that gives all participating organisations access to the data they need to make sound decisions. At the same time, the municipal institutions are learning how to systematically integrate their project planning to climate change.

Management of Natural Resources (2014-2017)

The project is being implemented nationwide, its purpose is to strengthen MEDD's legal and human capacity on sustainable management of ecosystems and their natural resources. Pilot activities are taking place in the regions of Guidmakha, Hodh El Garbi and Gorgol in the south and in the Banc d'Arguin and Diawling coastal national parks.

Mauritanian coastal development Master Plan (PDALM: Plan directeur d'aménagement du littoral Mauritanien), officially validated by the Council of Ministers on April 12, 2018, consists of a national-level strategic document that the SDAU should observe and integrate. Indeed, the PDALM, initiated by the Ministry of Environment and Sustainable Development and financed by the World Bank, sets the

basic short and medium-term orientations for sustainable development, coastal enhancement and environmental protection. It is the first central, participative and consensual document which defines the appropriate framework for spatial development of the coastline in accordance with recognized standards in the field.

Table 2.1 below summarizes spatial recommendations and measures identified by the PDALM concerning the city of Nouakchott. Each of these measures is analyzed and its synergies with urban planning, its possibilities of integration into the SDAU are studied.

Table 2.1: Elements of the PDALM and integration levers in the SDAU

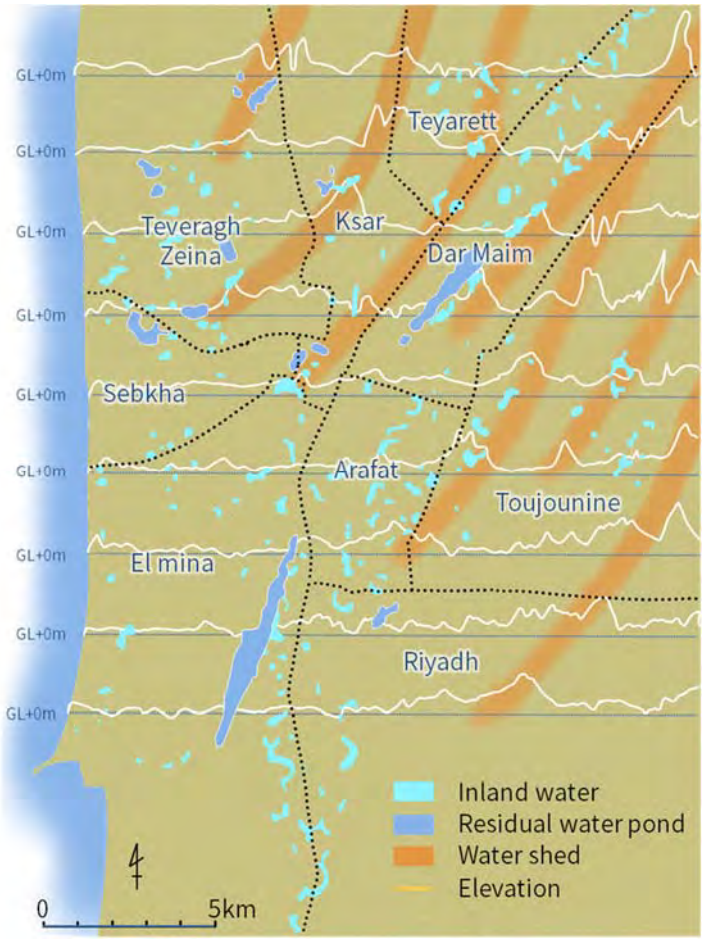
Description of the content	Integration levers in the SDAU
MEASURE A6: Restoration of the coastal dune	Not directly related to urban planning. Nevertheless, actions to be planned to requalify the coastal dune that will be specified during the formulation of Nouakchott Coastal Planning Directive (DAL: Directive d'Aménagement du Littoral) may influence existing buildings and coastal land.
MEASURE A7: Development of the coastal front	Not directly related to urban planning. Nevertheless, actions to be planned to develop the coastal front that will be specified during the formulation of the DAL may influence existing buildings and coastal land.
MEASURE B5: Hydrological functioning of the Nouakchott water table	Not directly related to urban planning. However, the results of the hydrological studies of the Nouakchott water table will serve as a basis for the formulation of the Flooding Risk Prevention Plan (PPRI: Plan de Prévention du Risque Inondation) and should therefore be carried out as a priority.
MEASURE A2: Nouakchott Coastal Planning Directive (DAL)	This is the measure that concerns the most urban planning, with MHUAT designated as executive agency of the study. Nouakchott DAL which will have the same value as a Coastal Risk Prevention Plan (PPRL: Plan de Prévention du Risque Côtier) is considered in the SDAU, along with the proposition of PPRI, in the planning principle of " Strongly prohibit construction in high flooding risk areas of sebkhas" of Strategic Orientation 1 (see Section 4.4.1). The Nouakchott DAL study is also included in the SDAU priority project proposals in the same terms as those stated in the PDALM, with the MHUAT as implementation agency.
MEASURE A10: Pilot resettlement of populations	This measure is contained in SDAU planning principle of "Ensure limited land consumption by operating densification, regeneration and polarization of the urban area: The Intense City" of Strategic Direction 1 (see Section 4.4.1) to set-up urban renewal zones. Areas for pilot resettlement of populations shall be specified in detail in the PLU of the concerned communes, on the basis of the technical zoning contained in the PPRI and the PPRL to be formulated.
MEASURE A15: Solutions for the restoration of sediment transit	Not directly related to urban planning.

Source: JICA Study Team and PDALM

(2) Inundation damage

1) Inland water damage situation

Inland water damage occurs when the daily precipitation amount is 30 mm or more, and roads and residential areas are flooded. In addition, due to lack of functional urban drainage system, contaminated water remain exposed on the ground surface, which is a cause of malodor and deteriorating sanitary conditions. Figure 2.26 shows the inland water distribution map and elevation lines. When it rains, many parts of the city temporarily flood. The rainwater gather further in low altitude areas and become residual inner water ponds. Although it is necessary to develop municipal drainage facilities in order to resolve the internal water damage, it is a particularly important task because it is closely related to sanitation problems. Furthermore, since water is valuable resource here, reuse to agriculture etc, is desired.



Source: CUN, Atras de Nouakchott(2011) ;ONAS;JICA study team

Figure 2.26: Inland Water Distribution Map

2) Drainage project

The residual pond drainage project is under way by Office National de l'Assainissement(ONAS). This wastewater is carried out by mobile pumping vehicles and draining from the urban area to the sea by forming the drainage network system.

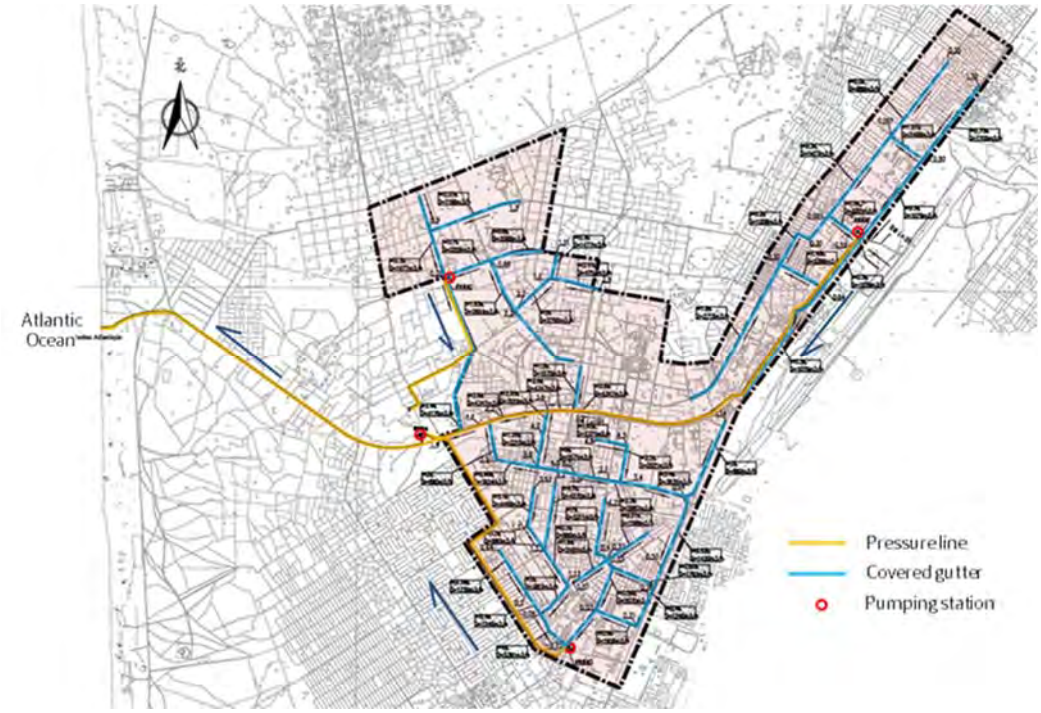
Source: ONAS, Raport de stage des étudiants sein de la Direction Technique de l'ONAS

Figure 2.27: Mobile Pumping Vehicle and Water Drainage

3) Urban drainage project

ONAS has also been implementing urban drainage projects with Chinese aid for 2 years based on Sanitation Master Plan from 2015. The area is highly urgent districts that are named Area-A in the master plan. The implementation of the project was decided on 17th December 2014. The total amount of assistance is USD 35 million. The outline of project is to discharge rainwater into the ocean with an extended 34 km concrete catchment network, four pump stations and a 14 km pipeline.

The drainage system also aims to counter groundwater contamination. According to the master plan, the collected groundwater is to be purified and partially sent back as irrigation water. The construction of drainage facilities is currently underway, but the purification facilities have not been constructed.



Source: Ministry of Hydraulic and Sanitation, Actualization of the Sanitation Master Plan of the City of Nouakchott in Mauritania(2014)

Figure 2.28: Urban Drainage Project by Chinese Assistance

(3) Desertification

1) Situation of desertification

Nouakchott is always exposed to encroachment of sand, and frequent droughts have been has accelerating the speed of sand encroachment. For this reason, the Mauritanian Government has spent time and financial resources on sand control measures such as Greenbelt projects. In city planning, it is desirable to actively utilize this asset. In addition, afforestation is also as an absorption source of carbon dioxide, which is a greenhouse gas. However, *Prosopis juliflora* species with strong desert resistance may disturb local ecosystems because of their vigorous reproductive capacity.

Source: OMRG; JICA study team

Figure 2.29: Map of the Green Belt

2) Green Belt projects

A Green Belt for anti-sand encroachment has been installed in the northwest part of Nouakchott. This Green Belt currently covers an area of about 800 ha and it was implemented by the Mauritania Government through overseas support. The Green belt was established through the following two projects:

- The Nouakchott Green Belt Project (1975-1992), financed by the Lutheran World Federation (LWF);
- The Support for the Rehabilitation and Extension of the Nouakchott Green Belt Project (2000-2007), with financing from the Walloon Region of Belgium and the support of Prince Laurent of Belgium.

The Green Belt is installed for the purpose of sand dune stabilization. The stabilization process uses two methods: mechanical stabilization and biological fixation.

Source: JICA study team

Figure 2.30: Sand Fence

The mechanical stabilization is a method of placing logs in a fence field (sand fence), and is installed in places where growth of vegetation is particularly difficult.

Biological fixation is carried out at places where mechanical fixation has been performed or plant growth is possible. The field for producing seedlings used for biological fixation was 400 square meters in Trarza province (*wilaya*) and has a production capacity of 25,000 seedlings per year. Tree planting is carried out after rain in the July-August rainy season. Sprinkling water of 10 L per strain at planting time will be carried out, after that it will be open-air cultivation. The successful rate of rooting depended on precipitation at that time.

Prosopis juliflora (the only woody species that has so far had any solid sustainable success on this type of soil) and *Aristida pungens* are planted on very mobile strip dunes. Regions with relatively little sand are planted with *Leptadenia pyrotechnica*、*Aristida pungens*、*Panicum turgidum*, while other slow-growing woody species such as Acacia raddiana and A.senegal are planted in more stable sandy zone.

The *Prosopis juliflora* (honey mesquite) used for the green belt has a strong desert resistance, but from its vigorous reproductive power, it is regarded as a harmful plant in other countries. Artificial management is necessary for using this plant.

Source: JICA study team

Figure 2.31: View of a Part of Green Belt

2.3 Demography and Macro Economic Conditions

2.3.1 Population

According to General Population and Housing Census 2013 (RGPH 2013), the total population of Mauritania was approximately 3,537,000, and that of Nouakchott City was approximately 958,000, accounting for 27% of the national population as shown in Table 2.2.

The population growth rate of Nouakchott City has been considerably higher than that of Mauritania. The average annual growth rate of Nouakchott City was 4.3% from the 2000 census to the 2013 census, while that of Mauritania was 2.7% in the same period.

Table 2.2: Population of Nouakchott in 2000 and 2013

Nouakchott and communes	2000	2013	Annual Average Growth Rate (%)
Nouakchott	***558,195***	***958,399***	***4.25***
Téyarett	46,351	78,828	4.17
Ksar	43,531	47,233	0.63
Tevragh-Zeina	48,093	46,336	-0.29
Toujounine	56,064	144,041	7.53
Sebkha	63,474	72,245	1.00

El Mina	95,011	132,674	2.60
Dar Naim	61,089	144,043	6.82
Arafat	102,169	175,969	4.27
Riyadh	42,413	117,030	8.12
Whole Country	***2,508,159***	***3,537,368***	***2.68***

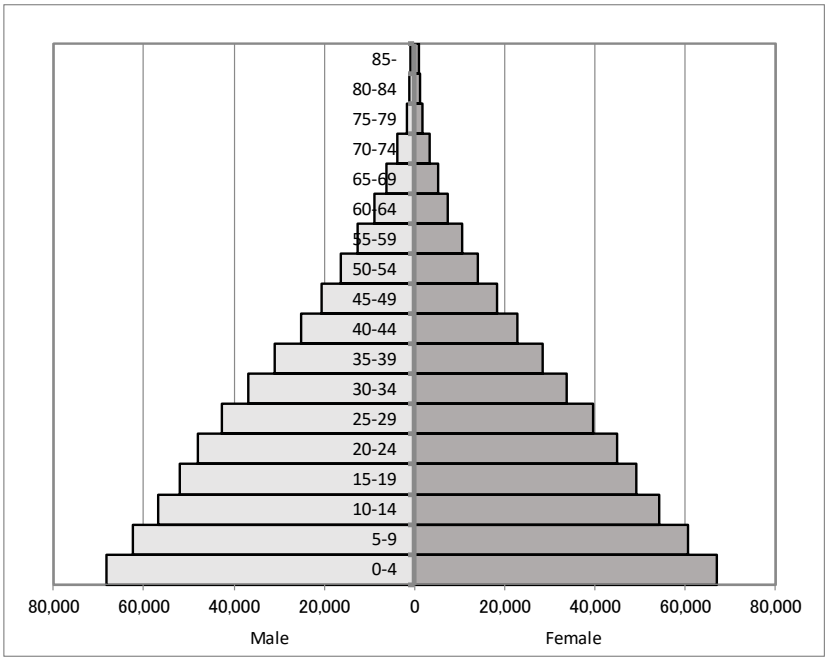
Sources: RGPH2000 and RGPH2013

The rapid population increase primarily due to a large number of in-migration from other regions (Wilayas) to Nouakchott from 1970s to date.

In the communes of Nouakchott, Riyadh has the highest growth from the 2000 census to the 2013 census at 8.1%, followed by Toujounine at 7.5% and Dar Naim at 6.8%, which are located in the eastern part of the city, while Tevragh-Zeina, Ksar and Sebkha, which are located in the western part of the City, have negative or low growth rates at -0.3%, 0.6% and 1.0%, respectively.

2.3.2 Age-group structure

As shown in Figure 2.32 and Table 2.3, the age structure of the population of Nouakchott in 2013 forms a typical pyramid, showing a demographic dividend with a large number of younger generations. This situation is the same as that of 1988 and 2000.



Source: RGPH 2013

Figure 2.32: Age Structure of Population of Nouakchott in 2013

Table 2.3: Population of Nouakchott by age-group in 1988, 2000 and 2013

Age Group	Male			Female			Total		
	1988	2000	2013	1988	2000	2013	1988	2000	2013
0 - 4	32,780	44,358	68,317	31,349	42,367	66,967	64,129	86,725	135,284
5 - 9	29,555	34,107	62,444	28,509	33,579	60,569	58,064	67,686	123,013
10 - 14	21,577	32,490	56,748	20,813	32,305	54,376	42,390	64,795	111,124
15 - 19	21,593	35,283	51,937	20,286	32,402	49,203	41,879	67,685	101,140
20 - 24	23,447	32,685	48,095	19,533	26,624	44,917	42,980	59,309	93,012
25 - 29	21,300	27,647	42,766	18,739	23,844	39,608	40,039	51,491	82,374
30 - 34	16,685	22,165	36,712	12,864	18,761	33,797	29,549	40,926	70,509
35 - 39	12,577	19,060	31,082	9,082	17,473	28,403	21,659	36,533	59,485
40 - 44	8,296	14,615	25,099	6,356	10,743	22,729	14,652	25,358	47,828
45 - 49	5,881	11,303	20,444	4,582	7,742	18,263	10,463	19,045	38,707
50 - 54	5,173	7,283	16,213	4,644	5,627	14,092	9,817	12,910	30,305
55 - 59	2,919	4,746	12,530	2,294	3,506	10,703	5,213	8,252	23,233
60 - 64	2,427	3,915	8,903	2,435	3,189	7,405	4,862	7,104	16,308
65 - 69	1,173	2,280	6,149	1,342	2,112	5,148	2,515	4,392	11,297
70 - 74	917	1,386	3,729	1,263	1,459	3,293	2,180	2,845	7,022
75+	1,217	1,363	3,717	1,717	1,776	4,041	2,934	3,139	7,758
Total	207,517	294,686	494,885	185,808	263,509	463,514	393,325	558,195	958,399

Source: ONS

The age structure of the population of Nine Communes of Nouakchott in 2013 are shown in Table 2.4 through Table 2.12.

Table 2.4: Population of Teyarett Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	5,367	5,253	10,620
5-9	4,686	4,600	9,286
10-14	4,349	4,085	8,434
15-19	4,135	4,032	8,167
20 - 24	3,924	3,689	7,613
25 - 29	3,577	3,418	6,995
30 - 34	3,039	2,911	5,950
35 - 39	2,640	2,502	5,142
40 - 44	2,288	2,091	4,379
45 - 49	1,855	1,623	3,478
50 - 54	1,280	1,257	2,537
55 - 59	1,079	1,090	2,169
60 - 64	701	703	1,404
65 - 69	551	519	1,070
70 - 74	374	349	723
75-79	181	170	351
80-84	152	141	293
85+	115	102	217
Total	40,293	38,535	78,828

Source: RGPH 2013

Table 2.5: Population of Ksar Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	2,778	2,737	5,515
5-9	2,576	2,488	5,064
10-14	2,537	2,337	4,874
15-19	2,639	2,285	4,924
20 - 24	2,635	2,277	4,912
25 - 29	2,485	2,042	4,527
30 - 34	2,001	1,744	3,745
35 - 39	1,643	1,572	3,215
40 - 44	1,328	1,261	2,589
45 - 49	1,215	1,076	2,291
50 - 54	918	722	1,640
55 - 59	768	622	1,390
60 - 64	523	398	921
65 - 69	393	368	761
70 - 74	228	174	402
75-79	100	117	217
80-84	85	67	152
85+	43	51	94
Total	24,895	22,338	47,233

Source: RGPH 2013

Table 2.6: Population of Tevragh-Zeina Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	2,735	2,725	5,460
5-9	2,469	2,393	4,862
10-14	2,446	2,200	4,646
15-19	2,602	2,153	4,755
20 - 24	2,633	2,165	4,798
25 - 29	2,476	2,045	4,521
30 - 34	2,008	1,678	3,686
35 - 39	1,655	1,589	3,244
40 - 44	1,405	1,224	2,629
45 - 49	1,260	1,024	2,284
50 - 54	993	640	1,633
55 - 59	855	622	1,477
60 - 64	525	392	917
65 - 69	429	246	675
70 - 74	203	142	345
75-79	91	94	185
80-84	63	66	129
85+	54	36	90
Total	24,902	21,434	46,336

Source: RGPH 2013

Table 2.7: Population of Toujounine Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	11,156	11,104	22,260
5-9	9,798	9,919	19,717
10-14	8,306	8,559	16,865
15-19	7,052	7,239	14,291
20 - 24	6,127	6,560	12,687
25 - 29	5,298	5,903	11,201
30 - 34	4,976	5,192	10,168
35 - 39	4,501	4,262	8,763
40 - 44	3,623	3,652	7,275
45 - 49	2,896	2,864	5,760
50 - 54	2,375	2,421	4,796
55 - 59	1,715	1,674	3,389
60 - 64	1,310	1,266	2,576
65 - 69	841	897	1,738
70 - 74	621	601	1,222
75-79	247	326	573
80-84	196	249	445
85+	135	180	315
Total	71,173	72,868	144,041

Source: RGPH 2013

Table 2.8: Population of Sebkha Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	4,588	4,541	9,129
5-9	4,311	4,102	8,413
10-14	4,196	3,797	7,993
15-19	4,353	3,529	7,882
20 - 24	4,485	3,589	8,074
25 - 29	4,301	3,129	7,430
30 - 34	3,363	2,604	5,967
35 - 39	2,804	2,063	4,867
40 - 44	1,967	1,567	3,534
45 - 49	1,590	1,271	2,861
50 - 54	1,130	786	1,916
55 - 59	952	705	1,657
60 - 64	609	418	1,027
65 - 69	429	292	721
70 - 74	232	143	375
75-79	114	75	189
80-84	63	53	116
85+	52	42	94
Total	39,539	32,706	72,245

Source: RGPH 2013

Table 2.9: Population of El Mina Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	9,909	9,741	19,650
5-9	9,162	8,951	18,113
10-14	8,138	7,892	16,030
15-19	7,102	6,736	13,838
20 - 24	6,939	6,124	13,063
25 - 29	6,205	5,108	11,313
30 - 34	5,423	4,598	10,021
35 - 39	4,494	3,659	8,153
40 - 44	3,645	2,769	6,414
45 - 49	2,786	2,084	4,870
50 - 54	2,212	1,574	3,786
55 - 59	1,627	1,158	2,785
60 - 64	1,183	764	1,947
65 - 69	710	500	1,210
70 - 74	442	284	726
75-79	179	139	318
80-84	119	87	206
85+	131	100	231
Total	70,406	62,268	132,674

Source: RGPH 2013

Table 2.10: Population of Dar Naim Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	10,810	10,672	21,482
5-9	9,901	9,486	19,387
10-14	8,696	8,424	17,120
15-19	7,701	7,359	15,060
20 - 24	6,963	6,680	13,643
25 - 29	6,075	5,917	11,992
30 - 34	5,394	4,949	10,343
35 - 39	4,585	4,223	8,808
40 - 44	3,855	3,235	7,090
45 - 49	2,963	2,515	5,478
50 - 54	2,266	2,043	4,309
55 - 59	1,750	1,547	3,297
60 - 64	1,228	1,083	2,311
65 - 69	880	746	1,626
70 - 74	498	482	980
75-79	238	304	542
80-84	148	188	336
85+	105	134	239
Total	74,056	69,987	144,043

Source: RGPH 2013

Table 2.11: Population of Arafat Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	11,750	11,197	22,947
5-9	10,887	10,249	21,136
10-14	10,284	9,817	20,101
15-19	10,276	9,664	19,940
20 - 24	9,173	8,499	17,672
25 - 29	7,965	7,182	15,147
30 - 34	6,489	6,098	12,587
35 - 39	5,307	5,258	10,565
40 - 44	4,258	4,432	8,690
45 - 49	3,717	3,830	7,547
50 - 54	3,134	3,133	6,267
55 - 59	2,398	2,207	4,605
60 - 64	1,717	1,535	3,252
65 - 69	1,211	1,103	2,314
70 - 74	730	813	1,543
75-79	309	439	748
80-84	246	278	524
85+	169	215	384
Total	90,020	85,949	175,969

Source: RGPH 2013

Table 2.12: Population of Riyadh Commune by age-group in 2013

Age Group	Male	Female	Total
0-4	9,223	8,997	18,220
5-9	8,653	8,382	17,035
10-14	7,795	7,266	15,061
15-19	6,077	6,207	12,284
20 - 24	5,216	5,335	10,551
25 - 29	4,384	4,863	9,247
30 - 34	4,020	4,023	8,043
35 - 39	3,454	3,274	6,728
40 - 44	2,729	2,499	5,228
45 - 49	2,162	1,976	4,138
50 - 54	1,904	1,516	3,420
55 - 59	1,388	1,077	2,465
60 - 64	1,107	845	1,952
65 - 69	704	478	1,182
70 - 74	401	306	707
75-79	183	173	356
80-84	102	123	225
85+	99	89	188
Total	59,601	57,429	117,030

Source: RGPH 2013

2.3.3 Number of households

As shown in Table 2.13, a total number of households in 2013 amounted to 575,678 in Mauritania and 160,842 in Nouakchott, respectively. The average size of household in Mauritania has increased between 2000 and 2013, i.e.; from 5.64 in 2000 to 6.14 in 2013. On the other hand, that in Nouakchott has increased from 5.46 to 5.96 between 2000 and 2013. The numbers of Nouakchott in both years are slightly smaller than the national average.

Table 2.13: Number of Households and Average Size of household in Mauritania and Nouakchott in 2000 and 2013

	RGPH 2000		RGPH 2013	
	Number of Households	Average Size of household	Number of Households	Average Size of household
Mauritania	444,577	5.64	575,678	6.14
Nouakchott	102,266	5.46	160,842	5.96

Sources: RGPH2000 and RGPH2013

2.3.4 Workforce and employment structure

The workforce and employment structure of Mauritania and Nouakchott are summarized in Table 2.14. The ratio of the economically active population or the labor participation ratio (the share of the economically active population divided by working age population) were between 44 and 47% in Mauritania and between 46 and 52% in Nouakchott, respectively. The ratio of the employed workforce or employment ratio (the share of employed workforce divided by the workforce) were between 73 and 90 percent in Mauritania and between 75 and 83 percent in Nouakchott, respectively.

As for the unemployment ratio, those of Nouakchott were much higher than those of the whole country in the National Reference Survey on Employment and the Informal Sector 2012 (ENRE 2012) and the Permanent Household Living Conditions Survey 2014 (EPCV 2014), while that of Nouakchott was slightly lower than that of the whole country in RGPH 2013.

Table 2.14: Workforce and Employment Structure of Mauritania and Nouakchott

Unit: Percent (%)

	RGPH 2013	ENRE 2012	EPCV 2014
1. Working Age Population (14-64) (WAP)			
Mauritania	54.0	52.0	-
Nouakchott	60.8	-	-
2. Workforce (Economically activity population) (WF)			
Share of WAP in Mauritania (Labor participation ratio)	44.1	44.3	46.6
Share of WAP in Nouakchott (Labor participation ratio)	51.4	45.9	52.2
Share of Nouakchott in the country	35.5	30.8	-
3. Employed Workforce			
Share of WAP in Mauritania	32.0	39.8	40.6
Share of WAP in Nouakchott	38.5	38.2	41.5
Share of WF in Mauritania (Employment ratio)	72.5	89.8	87.1
Share of WF in Nouakchott (Employment ratio)	75.1	83.2	79.5
Share of Nouakchott in the country	36.8	28.5	33.3
4. Unemployed Workforce			
Share of WAP in Mauritania	12.1	4.5	6.0
Share of WAP in Nouakchott	12.8	7.7	10.7
Share of WF in Mauritania (Unemployment ratio)	27.5	10.2	12.9
Share of WF in Nouakchott (Unemployment ratio)	24.9	16.8	20.5

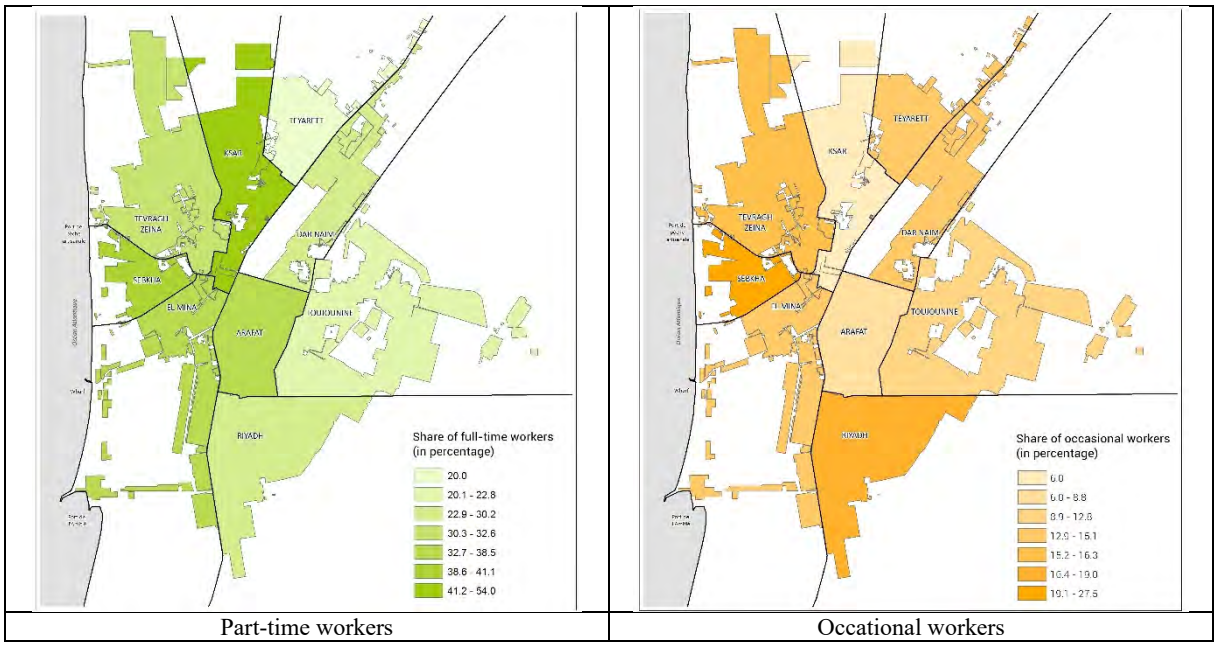
Sources:

RGPH 2013: Recensement Général de la Population et de l'Habitat 2013 (General Population and Housing Census 2013)

ENRE 2012: Situation de l'emploi et du secteur informel en Mauritanie en 2012 (National Reference Survey on Employment and the Informal Sector 2012)

EPCV 2014: Enquête Permanente sur les Conditions de Vie des ménages 2014 (Permanent Household Living Conditions Survey 2014)

Figure 2.33 shows distribution of full-time and occasional workers by commune, depicted based on the result of social survey conducted in the course of JICA SDAU Project. The "Share of full-time workers" are high in Ksar and Sebkha where factories are located in the official industrial area. "Share of occasional workers" reflects the importance of informal sector, especially in the commune of Sebkha, where various trading activities are occurring in the two big markets (marché Tieb-Tieb and marché cinquième).



Part-time workers | Occational workers

Figure 2.33: Spatial Distribution of Workers by Type

2.3.5 Poverty and inequality

EPCV 2014 shows the main features of poverty through the indices of poverty and inequality.

(1) Monetary poverty

In 2014, the proportion of the Mauritanian population defined as a poor level is at 31.0%. The poverty rate was estimated based on an estimated poverty line in real terms to MRO 169,445 harmonized in 2014. Poverty generally declined between 2008 and 2014 with an average annual national rate of 1.8%. This reduction was larger in the rural area with an average annual rate of 2.5% compared to only 0.7% in urban areas. In Nouakchott, this monetary poverty rate was less than 20% which is much lower than the national average.

(2) Extreme poverty

EPCV 2014 reveals that 16.6% of the country's population live below the extreme poverty set at MRO 126,035 threshold. It is noted that there were disparities between rural areas at 25.1% and urban area at 7.5%.

(3) Level and structure of household spending

The structure of total average expenditure per household across the country has changed significantly. Indeed, the share of food expenditure (including self-consumption) fell between 2008 and 2014 from 57.8% to 47.9%. This drop can be explained in part by the grant from the state. On the other hand, the share of spending allocated to the two social sectors, education and health, increased in 2014. These shares were respectively 5.4% and 4.8% in 2014.

(4) Inequality

The share of consumption of the bottom decile of the distribution represents 5.8% of total expenditure in 2014 against 2.5% in 2008. In contrast, the 10% richest of the population represented 17.4% of expenditure in 2014 compared to 28.1% in 2008. These results show the unequal situation of living standards for the poorest has improved. Corresponding to this result, as shown in Table 2.15, the GINI

indices in Mauritania between 2008 and 2014 have reduced, while those in Nouakchott have slightly increased.

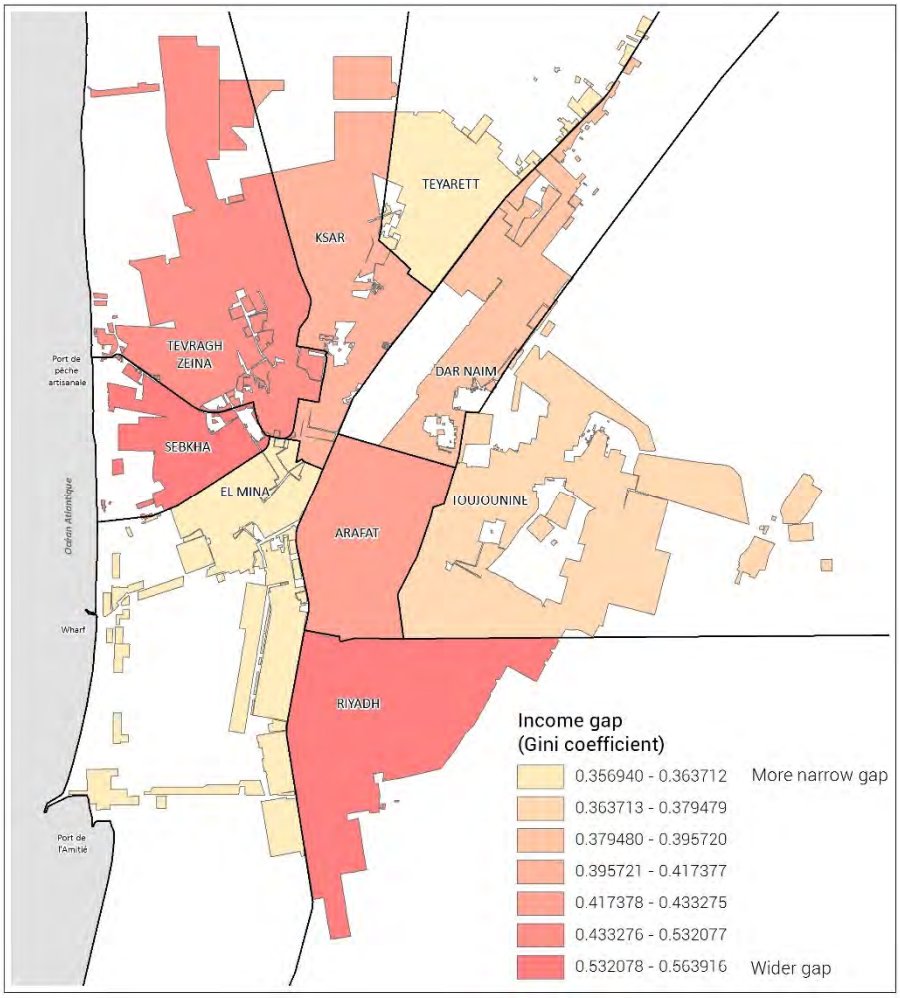
Table 2.15: Change of GINI indices of Mauritania and Nouakchott from 2008 to 2014

	2008	2014
Mauritania	0.38	0.34
Nouakchott	0.31	0.32

Source: EPCV 2014: Enquête Permanente sur les Conditions de Vie des ménages 2014 (Permanent Household Living Conditions Survey 2014)
Note: Closer to 0 means a more equal distribution of the income, closer to 1 means that the gap between rich and poor is wide.

Based on the results of the social survey, the "Gini coefficient" was calculated for each commune which reflects the spatial composition of the distribution of the inequality of income (see Figure 2.34). It can be seen that even though Riyad is the poorest commune with an average revenue of 125,799 MRO/month, Sebkha is the commune which has the wider gap of income with a small proportion of wealthier households (11.75% earn more than 500,000 MRO/month). It implys that the informal sector is also profitable.

The most equal distribution of income was observed in Teyaret and El Mina, which have almost the same Gini index (0.356 and 0.363 respectively), but Teyaret is generally wealthier than El Mina with an average income of 154,000 MRO/month against 139,036 MRO/month for El Mina. Indeed, Teyarett has a majority of inhabitants (32.5%) earning from 100,000 to 150,000 MRO/month whereas the vast majority living in El Mina (46.39%) only earn from 50,000 to 100,000 MRO/month.



Source: Social Survey, JICA Project Team

Figure 2.34: Gini Coefficient by Commune

2.3.6 Overall economic structure and national development strategy

(1) Overall economic structure

Overall economic structure by sector in Mauritania is shown in Table 2.16. The real GDP in Mauritania had increased steadily at an average annual growth rate of 4.4 % between 2010 and 2016. Currently, the secondary sector, such as construction and extractive activities, and the tertiary sectors, such as trade and transport & telecommunication, are the main drivers of economic growth. The shares of GDP in the primary sector have decreased from 32% to 29% between 2010 and 2016.

The data on the gross regional domestic product or gross domestic product in Nouakchott are not available.

Table 2.16: GDP and the shares by economic sector between 2000 and 2016 in Mauritania

1) Gross Domestic Product by economic sector

Unit: Million MRO at 2004 constant prices

Economic Sector	2010	2011	2012	2013	2014	2015	2016
Primary sector	216,576	211,895	227,811	225,493	233,639	244,016	255,734
1. Agriculture, fishing, logging	216,576	211,895	227,811	225,493	233,639	244,016	255,734
1.1Agriculture and Forestry	31,131	21,098	40,385	36,176	35,487	37,621	38,636
1.2 Livestock	167,578	171,022	166,030	169,849	171,887	180,307	189,283
1.3 Fishing	17,867	19,775	21,396	19,468	26,265	26,088	27,814
Secondary sector	191,398	198,474	204,521	227,067	247,795	230,016	233,408
2. Extractive activities	101,614	96,865	92,294	106,257	104,537	97,200	97,488
2.1 Extraction of petroleum products	33,306	29,354	22,878	28,742	25,680	23,721	21,152
2.2. Extractive industries other than petroleum products	68,308	67,511	69,416	77,515	78,857	73,479	76,336
2.2.1 Mining of metallic ores	66,253	65,209	66,798	74,361	75,217	69,237	71,929
Iron	45,193	44,372	41,298	45,565	48,343	42,178	49,056
Gold and Copper	21,060	20,838	25,499	28,796	26,874	27,059	22,873
2.2.2 Other Extractive Activities	2,055	2,302	2,618	3,154	3,640	4,242	4,407
3. Manufacturing	46,542	52,184	56,722	55,313	51,765	55,647	58,751
3.1 Manufacturing activities excluding Water-Electricity	44,820	50,435	55,532	56,870	50,385	54,142	57,120
3.2 Production and distribution of water and electricity	1,723	1,748	1,190	-1,557	1,380	1,505	1,631
4. Building and public works	43,242	49,425	55,505	65,497	91,493	77,169	77,169
Tertiary sector	232,945	247,418	265,928	274,882	292,207	305,582	314,146
5. Transport and telecommunications	42,693	48,785	63,176	65,699	70,560	71,747	73,283
5.1 Transportation	11,839	14,471	23,335	17,724	19,883	20,587	19,565
5.2 Telecommunications	30,854	34,314	39,842	47,975	50,677	51,160	53,719
6. Trade	51,795	54,578	58,683	58,123	62,760	67,175	69,454
7. Other services	88,803	94,187	93,153	99,908	107,082	114,023	119,345
FISIM Correction	-18,083	-20,054	-21,581	-18,916	-20,375	-20,781	-21,493
Total market activities	573,183	587,865	625,763	657,374	701,461	706,197	729,731
8. Government	49,654	49,868	50,915	51,152	51,805	52,636	52,063
GDP at the factor costs	622,836	637,732	676,678	708,526	753,266	758,834	781,795
Net taxes on products	55,311	64,788	81,416	84,300	89,358	94,719	97,930
GDP Adjusted factor (2011-13)		645,259	669,779	712,645			
GDP at market prices	678,147	710,047	751,195	796,945	842,624	853,553	879,725

Source: ONS

2) Shares of Gross Domestic Product by economic sector

Unit: percent (%)

Economic Sector	2010	2011	2012	2013	2014	2015	2016
Primary sector	31.9	29.8	30.3	28.3	27.7	28.6	29.1
1. Agriculture, fishing, logging	31.9	29.8	30.3	28.3	27.7	28.6	29.1
1.1Agriculture and Forestry	4.6	3.0	5.4	4.5	4.2	4.4	4.4
1.2 Livestock	24.7	24.1	22.1	21.3	20.4	21.1	21.5
1.3 Fishing	2.6	2.8	2.8	2.4	3.1	3.1	3.2
Secondary sector	28.2	28.0	27.2	28.5	29.4	26.9	26.5
2. Extractive activities	15.0	13.6	12.3	13.3	12.4	11.4	11.1
2.1 Extraction of petroleum products	4.9	4.1	3.0	3.6	3.0	2.8	2.4
2.2. Extractive industries other than petroleum products	10.1	9.5	9.2	9.7	9.4	8.6	8.7
2.2.1 Mining of metallic ores	9.8	9.2	8.9	9.3	8.9	8.1	8.2
Iron	6.7	6.2	5.5	5.7	5.7	4.9	5.6
Gold and Copper	3.1	2.9	3.4	3.6	3.2	3.2	2.6
2.2.2 Other Extractive Activities	0.3	0.3	0.3	0.4	0.4	0.5	0.5
3. Manufacturing	6.9	7.3	7.6	6.9	6.1	6.5	6.7
3.1 Manufacturing activities excluding Water-Electricity	6.6	7.1	7.4	7.1	6.0	6.3	6.5
3.2 Production and distribution of water and electricity	0.3	0.2	0.2	-0.2	0.2	0.2	0.2
4. Building and public works	6.4	7.0	7.4	8.2	10.9	9.0	8.8
Tertiary sector	34.4	34.8	35.4	34.5	34.7	35.8	35.7
5. Transport and telecommunications	6.3	6.9	8.4	8.2	8.4	8.4	8.3
5.1 Transportation	1.7	2.0	3.1	2.2	2.4	2.4	2.2
5.2 Telecommunications	4.5	4.8	5.3	6.0	6.0	6.0	6.1
6. Trade	7.6	7.7	7.8	7.3	7.4	7.9	7.9
7. Other services	13.1	13.3	12.4	12.5	12.7	13.4	13.6
FISIM Correction	-2.7	-2.8	-2.9	-2.4	-2.4	-2.4	-2.4

Economic Sector	2010	2011	2012	2013	2014	2015	2016
Total market activities	84.5	82.8	83.3	82.5	83.2	82.7	82.9
8. Government	7.3	7.0	6.8	6.4	6.1	6.2	5.9
GDP at the factor costs	91.8	89.8	90.1	88.9	89.4	88.9	88.9
Net taxes on products	8.2	9.1	10.8	10.6	10.6	11.1	11.1
GDP at market prices	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: ONS

(2) Balance of payment

1) Overview

Table 2.17 summarizes Mauritania's balance of payments between 2012 and 2016 as reported by the IMF. In the current account, Mauritania shows about US$700 million deficit in 2016. In 2016, as for the trade of goods, Mauritania's exports were US$1,401 million while imports totaled US$1,900 million resulting in a trade deficit of US$499 million. The services credit totaled US$270 million and service debit, which is composed of transport (passenger, freight and others), travel and other services, totaled US$605 million, respectively, resulting in a service deficit of US$335 million.

2) Remittances

The transactions recorded in the secondary income account pertain to those current transfers between residents and nonresidents including personal transfers and income from employment that directly affect the level of gross national disposable income and thus influence the economy's ability to consume goods and services.

Personal transfers consist of all current transfers in cash or in kind made or received by resident households to or from nonresident households including workers' remittances (e.g., Individual employed in the foreign country transfers part of his salary and income revenue to his account in home economy, namely, Mauritania). However, the data of the personal transfers is not specified in Table 2.17 due to a lack of statistical data.

Table 2.17: Balance of payment between 2012 and 2016 in Mauritania

Unit: US$ million

Component	2012	2013	2014	2015	2016
Current account	-1,226	-1,262	-1,473	-956	-707
Goods and services	-1,359	-1,206	-1,334	-954	-835
Credit	2,786	2,838	2,217	1,635	1,671
Debit	4,145	4,044	3,551	2,589	2,505
Goods	-488	-393	-712	-559	-499
Credit	2,641	2,651	1,938	1,389	1,401
General merchandise: export	2,641	2,651	1,938	1,389	1,112
Debit	3,129	3,044	2,650	1,948	1,900
General merchandise: import	3,129	3,044	2,650	1,948	1,900
Services	-872	-813	-622	-395	-335
Credit	145	186	279	246	270
Debit	1,017	999	900	641	605
Transport (Passenger, Freight and others), debit	349	331	329	233	191
Travel, debit	59	58	62	43	41
Other Services, debit	609	611	509	365	374
Primary income	-178	-196	-253	-180	-117
Credit	125	120	18	77	59
Debit	303	316	271	257	176
Secondary income	311	141	114	178	245
Credit	333	159	128	201	265
General government	272	87	64	110	176
Financial corporations, nonfinancial corporations, households, and NPISHs	61	72	64	91	89

Personal transfers	...	...	...	...	...
Other current transfers	61	...	...	...	...
Debit	22	18	14	22	20
General government	4	3	0	9	6
Financial corporations, nonfinancial corporations, households, and NPISHs	18	15	14	13	14
Personal transfers	...	...	...	...	...
Other current transfers	18	...	...	...	...
Capital account	41	5	16	31	8
Financial account	-1,325	-1,564	-1,516	-1,058	-531
Net errors and omissions	-139	-307	-59	-134	168

Source: IMF Database Warehouse April 2018

Notes: (1) The data in this table is based on the BOP Standard Presentation format as defined in the 6th Edition of the Balance of Payments Manual (BPM6).
(2) (...) Indicates a lack of statistical data
(3) NPISHs is an abbreviation of "non-profit institutions serving households."

According to the World Bank Bilateral Remittance Estimates for 2017 (April 2018 Version: http: //www.worldbank.org/en/topic/labormarkets/brief/migration-and-remittances), the migrant remittance inflows to Mauritania is not shown in the recent years, but the migrant remittance outflows from Mauritania is estimated at US$243.8 million comprising 130.4 million to Senegal, 48.0 million to Mali, 38.6 million to France, 3.6 million to Algeria, and 23.2 million to other countries in 2017.

In the IMF report titled Request for a three-year arrangement under the Extended Credit Facility - Debt Sustainability Analysis in November 2017, the gross annual inflows of workers' remittances to Mauritania is projected at about US$100 million in 2017 onwards.

(3) National Development Strategy

According to the National Strategy for Accelerated Growth and Shared Prosperity (SCAPP) 2016-2030 by the Ministry of Economy and Finance, the following strategies for the national development are stated.

Strategy 1: Promoting strong, sustainable and inclusive growth

Creating conditions for strong, sustainable and inclusive economic growth through structural changes; (a) strengthening of wealth-creating sectors and jobs capable of ensuring social inclusion and to meet internal demand, notably through private initiative and innovation, and (b) improving the export and attractiveness of foreign direct investment (FDI).

Strategy 2: Developing human capital and access to basic social services

Developing human capital through raising the quality of education and health, increasing access to other basic social services and strengthening social protection.

Strategy 3: Strengthening governance in all its dimensions

Strengthening the consolidation of the rule of law and democracy, social unity and equity, security and respect for human rights, efficient economic management, financial and environmental sustainability and the deepening of decentralization.

2.3.7 Agriculture and fishery

(1) Agriculture sector

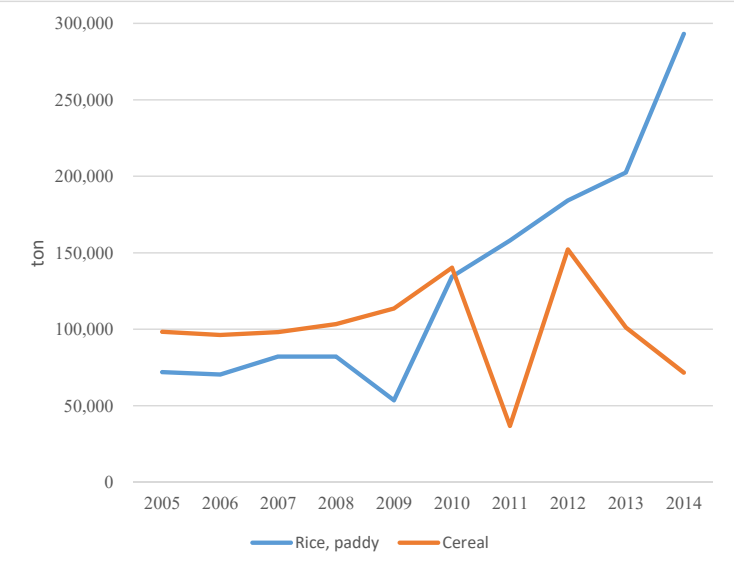
In Mauritania, the useful agricultural area is less than 0.5% of the national territory. According to the draft of the National Agricultural Development Plan (NADP) (2016-2025), a potential of agriculture land or the arable land is estimated at about 513,000 ha. However, less than half of this potential (220,000 ha) is made up of rainfed land and, therefore, highly dependent on rainfall.

Agricultural production in Mauritania was mainly designed to self-consumption, as the country has not yet reached food self-sufficiency. Domestic traditional cereal production in the country only meets about

one-third of the national food needs. Only gardening products and fruit trees are exported. The main products are rice, maize, millet, sorghum, and dates in the oasis zones.

In response to the development strategies of agriculture, efforts have focused on the development in the valley of the Senegal River towards the increase of production of rice. Also, several steps to support farmers with the establishment of credit mechanisms, agricultural inputs, and monitoring and supervision have been taken by the government. Based on these efforts, rice production has increased over the last 10 years from 72,000 tons in 2005 and 293,000 tons in 2014, as shown in Figure 2.35. On the other hand, traditional cereal production (total production of maize, millet and sorghum) were ups and downs due to change of rainfall. The contribution of agriculture to GDP at the constant prices was estimated at 4.2% in 2014.

The draft of NADP states that rice production will increase to about 414,000 ton in 2025 and that of traditional cereals will cover over 60% of food needs in the same year.



Source: Food and Agriculture Organization of the United Nations (FAO),
FAO. 2016. AQUASTAT Main Database

Figure 2.35: Production of Rice and Traditional Cereals in Mauritania between 2005 and 2014

As for horticulture sector, promotion of market gardening in peri-urban area is discussed in the draft of NADP, since producers in pri-urban areas play an important role in markets in major cities, namely, Nouakchott and Nouadhibou. In Nouakchott, the agricultural land development project for horticulture, where the farmers and producers in Dar Naim and Toujounine will be consolidated, is being promoted at PK17 with 310 ha in cooperation with Ministry of Agriculture, Ministry of Water & Sanitation and MHUAT.

In the livestock sector, Mauritania has a greater potential for breeding. The contribution of livestock to GDP, which is comprising milk, meat, skin and so on, was estimated at 20.4% in 2014. According to FAO, the herd is estimated at about 1,700,000 cattle, 1,400,000 camels, and 3,500,000 poultry in 2012.

As for issues and challenges in the agriculture sector, the followings are indicated in the draft of NADP.

1) Low level of yield of major crops,
2) Inefficiency and inadequate infrastructure for storage, processing and distribution,
3) Limitation of the availability and regularity of food supplies.

Also, the draft of NADP stresses that producers, especially women and young people as well as other actors involved in the production, processing and marketing process, encounter difficulties throughout the various links in the chain of values of the sectors.

Moreover, the followings are also indicated from the viewpoint of livestock and rural development.

1) Low levels of public and private investment in the livestock sector,
2) Weakness of the land management system in terms of rural development,
3) Weakness of the management of natural resources, especially water.

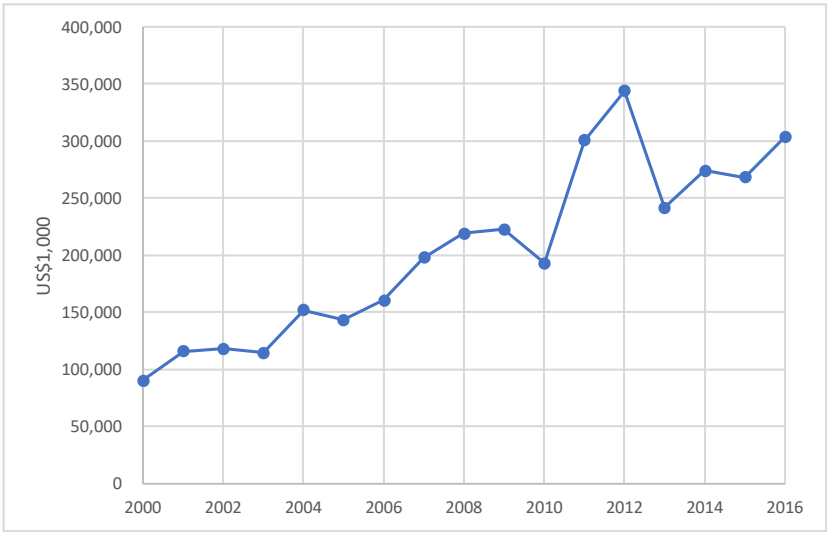
Regarding countermeasures for the development of agriculture sector, the draft of NADP stresses the following;

1) Promoting the intensification and diversification of agricultural production to meet national needs by 2025 (rice, wheat, horticulture, traditional cereals, oasis crops including dates, etc.),
2) Promoting the competitiveness of agricultural sectors (improvement of infrastructure, storage and processing facilities, etc.),
3) Promoting the sustainable and participatory management of natural resources,
4) Improving the quality of agricultural services including institutional capacity building.

(2) Fishery sector

The fishery sector remains one of the strategic sectors of the national economy in various views: wealth creation or GDP, job creation, a source of fiscal revenue and foreign exchange, improvement of trade balance and food security. The fishing sector's contribution to GDP is about 2 to 3 percent since 2010. However, this excludes consideration of indirect economic effects: upstream and downstream (post-catches or processing). Economic studies by Institut Mauritanien de Recherches Océanographiques et des Pêches (Mauritanian Institute of Oceanographic and Fisheries Research) (IMROP) revealed that the fishery sector as a whole contributed around 4.8% to the national GDP in 2009 and a nearly 6% in 2013, respectively.

Over the period 2000 to 2016, exports of fishery products have increased from US$ 100 million to US$ 300 million as shown in Figure 2.36. For contribution to jobs, the fishery sector directly employed between 42 000 and 43 000 people in 2014. Around 80% of jobs come from the artisanal fisheries. In addition to about 13 000 jobs indirectly generated by fisheries-related activities, particularly in the post-catch sector, the fisheries sector provides almost 55 000 jobs in total.



Source: Ministry of Fisheries and Maritime Economy

Figure 2.36: Exports of Fisheries Products between 2010 and 2016

According to the Strategy for the Sustainable Development of Fisheries and the Maritime Economy 2015-2019, the number of canues for artisanal fisheries amounted to 4,000 in 2007 to more than 7,000 in 2013 for the entire coastline. On the other hand, industrial fishing fleet operating in the Mauritanian Exclusive Economic Zone (EEZ) has decreased between 2002 and 2013, from 380 to 137 active vessels.

In Nouakchott, less than 30% of fish products processing units of the country are located, while 70% of them are in Nouadhibou. Fishmeal production unit is located at PK28 (the pole point from 28 km distance from Nouakchott).

As for issues and challenges for fishery sector relating to Nouakchott, the followings are stated in the Strategy.

1) Lack of storage spaces in the processing units
2) Scarcity and high price of electric power,
3) Difficulties in access to credit,
4) Inadequacy of the training in the value chain sectors

Regarding countermeasures for the development of fishery sector, the Strategy stresses to strengthen the processing of fishery products by the construction of pole development at Nouakchott, PK 28, Legweichich (PK93), NDAMECH (PK144) and N'Diago. Also, it states that it is needed to rehabilitate the Fish Market at Nouakchott (MPN).

2.3.8 Industry

It is not easy to obtain statistics on the industry in Mauritania and Nouakchott. The available data references, basically, to the publications of the ministry responsible for Industry, Surveys of the National Statistical Office (ONS) and the Development Strategy of the private sector adopted by the government in 2014.

It appears from these data that extractive industries (iron, gold, copper, oil, gypsum, and so on) have been the backbone of the national economy, which accounts for more than 15% of GDP in 2014.

The formal manufacturing sector, which is composed of less than two hundred SMEs, is mainly located in Nouakchott and Nouadhibou. Their products, mainly agro-processing products and food, accounted for about 7% of GDP in 2014. Manufactured products are weakly diversified, quality and technological content is limited and sometimes below standards.

In addition to the formal sector, the manufacturing industry also includes a thousand of micro and small enterprises covering many industrial, artisanal and services such as artisanal brickyard, carpentry, mechanical workshops, bakery and pastry, metalwork and so on. Businesses in the manufacturing sector represent about 1.4% of all the 70,000 informal enterprises in the country and 3% of informal jobs. The formal and informal manufacturing enterprises are, in general, uncompetitive.

Industrial activities in Nouakchott City have been mainly concentrated in Communes of EL Mina, Sebkha, Ksar and Teyarett as shown in Table 2.18. The major types of industries are food, plastic, metallic product, paper and packaging, leathers, textiles and construction materials. Table 2.19 shows the list of industrial companies by type and location in Nouakchott.

Table 2.18: Type and Location of Major Industries in Nouakchott

Type of Industry	Location	Numbers
Food	El Mina	27
	Sebkha	2
	Toujounine	1
	Teyarett	1
	Sub-total	***31***
Chemistry and Plastic product	El Mina	10
	Sebkha	5
	Ksar	3
	Teyarett	1
	Tevragh-Zeina	1
	Sub-total	***20***
Metallic product	El Mina	1
	Sebkha	1
	Dal Naim	1
	Sub-total	***3***
Paper and Packaging	El Mina	2
	Sub-total	***2***
Leather, Skins, Textiles and Leather Goods	El Mina	4
	Ksar	2
	Toujounine	1
	Sub-total	***7***

Construction materials	El Mina ***Sub-total***	11 ***11***
Total		***74***

Source: Ministry of Commerce, Industry and Tourism

Table 2.19: List of Industrial Companies by Type and Location in Nouakchott

1) Food

No.	Company	Major products	Location	Employment
1	TOP MILK	Milk and dairy products	El Mina	45
2	SLAM	Milk and dairy products	El Mina	-
3	TIVISKI	Milk and dairy products	El Mina	-
4	EL WATANIA	Milk and milk products	Toujounine	65
5	SAVA	Milk and milk products	El Mina	52
6	Maurilait	Yogurt	El Mina	-
7	COGITREM	Candy	El Mina	18
8	GMN	Wheat flour	El Mina	85
9	Biscuiterie Hamoud	Biscuits	El Mina	42
10	Mauritanian biscuit company	Biscuits	El Mina	25
11	ANDI-AGRO	Flour for children	El Mina	-
12	SOBOMA	Soft drink	Sebkha	85
13	Selsabil Foods	Soft drink	El Mina	26
14	SBAO SARL	Juice	Sebkha	18
15	MPA	Pasta, Couscous	El Mina	67
16	FAMO	Pasta, Couscous	El Mina	95
17	MISEL	Salt	El Mina	-
18	ROCK SALT	Salt	El Mina	35
19	MINAL	Biscuits	El Mina	-
20	IBS	Biscuits	El Mina	84
21	Ets MOUBAH	Biscuits	El Mina	-
22	SBAB	Biscuits	El Mina	29
23	SOMAICO	Biscuits	Teyarett	42
24	GMM	Milling, Livestock feed	El Mina	80
25	Moulins of Sahel	Milling, Livestock feed	El Mina	59
26	Moulins of Stars	Milling	El Mina	45
27	Moulins Atlas	Milling	El Mina	39
28	Mills of NKC	Milling	El Mina	-
29	Moulin Chinguitty	Milling	El Mina	15
30	Modern Moulin	Flour	El Mina	-
31	Mauritanian Society Mills	Flour	El Mina	-

2) Chemistry and Plastics

No.	Company	Major products	Location	Employment
1	Polyethylene from Mauritania	HD bags and packaging films	Ksar	15
2	PLAST RIM	Seals of bathtubs and others	El Mina	24
3	Chinguit plast	Plastic mats	Tevragh-Zeina	28
4	Saada	Mattress	El Mina	-
5	ETS MOUBAH	Mattress	El Mina	19
6	MAUCIT	Mattress	El Mina	-
7	MCI	Mattress	El Mina	-
8	MIP	Polystyrene case	Sebka	35
9	SOFAPOP	Pots of octopus	Sebka	-
10	SEMAP	Polystyrene canoes	Sebka	-
11	SOMACOGIR	Candles	Ksar	-
12	NKTT SOAP	Household soap	Teyarett	32
13	SOMIGEM	Household soap	Sebka	45
14	Sonafos	Household soap	El Mina	21
15	Smci- sotunol	Painting	Ksar	52
16	COMACIP	Paintings	El Mina	15
17	CIPROCHIME	Detergents, pesticides, insecticides	Sebka	45
18	MIP NAVAL	Canoes	Sebka	-
19	SOPROCHIM	Polystyrene bleach	El Mina	-
20	Ets Mauritanien hygiene products	Bleach	El Mina	-
21	Ets Ahmedbedy	PVC hoses	El Mina	25

3) Metallic

No.	Company	Major products	Location	Employment
1	Steel of the north	Concrete Iron	El Mina	-
2	ETS M'BAREK	Boiler	Sebkha	18
3	Ets BEDER	Mounting of semi-trailers	Dar NAIM	8

4) Paper and Packaging

No.	Company	Major products	Location	Employment
1	SIPE CARTON	Cardboard packaging	El Mina	32
2	MAURISAC	Kraft bag	El Mina	17

5) Leather and Skins, Textiles and Leather Goods

No.	Company	Major products	Location	Employment
1	SMPCP	Leather skins	Toujounine	39
2	GTM	Leather skins	El Mina	32
3	Ets Boye Atap	Tannery	El Mina	-
4	ETS DRAME	Leather goods	Ksar	15
5	MATIS	Woven carpet, mat	Ksar	75
6	ARWA Group	Tannery	El Mina	30
7	Ets AKID	Tannery	El Mina	54

6) Construction Materials

No.	Company	Major products	Location	Employment
1	MAFCI	Cement (Grinding of clinker)	El Mina	125
2	Cement of Mauritania	Cement (Grinding of clinker)	El Mina	158
3	Concrete of Mauritania	Concrete elements	El Mina	52
4	BSA Cement	Cement	El Mina	98
5	MAFCI Concrete	Concrete elements	El Mina	56
6	Cement Chinguitty	Cement packing	El Mina	85
7	SAMIA	Plaster	El Mina	-
8	Cement of Sahel	Cement	El Mina	In progress
9	SOMIP	Plaster	El Mina	45
10	Concrete and Quarries of the North	Concrete elements	El Mina	52
11	Carmeuse trading and services	Hydrated lime	El Mina	65

Source: Ministry of Commerce, Industry and Tourism

As the constraints and issues, the National Strategy for the Private Sector Development 2015-2020 by Directorate General for the Promotion of Private Sector, Ministry of Economy and Finance, states that the industrial sector, with rare exceptions, is characterized by insufficient raw materials and financial resources, marketing difficulties due to competition from imports as well as low-skilled human resources. These issues are mainly coming from the informal nature of industries, although the importance of the informal private sector is undeniable in terms of production, employment and creation of new businesses.

Despite many benefits of formal work such as better access to finance and public procurement, access to incentives by the public system, and legal protection, several obstacles such as taxation, paperwork and legislation costs, and labor regulations discourage people from going out of informality.

As for countermeasures for issues and challenges, the Strategy proposes as follows;

1) Integration of a thousand micro-enterprises in the formal sector
2) Development of Agro-Food industry
3) Development of Fishery products processing industry
4) Development of local procurement for mining and large industries
5) Development of entrepreneurship and innovation within companies
6) Strengthening of vocational training

2.3.9 Tourism and services

(1) Tourism sector

The tourism sector in Mauritania remains at an early stage of development, with adverse security picture (the "red zone" of the East in particular), which is paralyzing investment and development of the sector.

Based on the Provisional Report of Operational Diagnosis for Tourism Sector 2017, there would be less than 3,000 leisure tourists and about 60,000 business travelers visiting the country annually from 2009 to 2015.

According to Stratégie Nationale de Développement du Tourisme (National Tourism Development Strategy) (SNDT), the majority of accommodation establishments is located in Nouakchott (26 hotels in 1020 rooms) followed by Nouadhibou (11 hotels for 213 rooms). Apart from these cities, most accommodations are either urban apartments for long stays or hostels. Bivouac tents are the most widely used and required by the desert tourists.

It is estimated by the Mauritanian Federation of Tourism that there are (i) 700 restaurants, (ii) 170 travel agencies, (iii) 50 car rental companies and (iv) 30 hotels in Nouakchott.

As shown in Table 2.20, the number of passenger arrivals at Nouakchott airport amounted to about 123,000 in 2014. In Mauritania, there are two international airports (Nouakchott and Nouadhibou), seven secondary airports and 10 airfields.

Table 2.20: Airlines serving Nouakchott airport in 2014

Airlines	Number of passenger arrivals	Share (%)
Royal Air Morocco	33,979	27.7 %
Mauritania Airlines	27,385	22.3 %
Tunis Air	21,557	17.5 %
Air France	13,436	11.0 %
Turkish Airlines	10,141	8.3 %
Air Algeria	5,887	4.8 %
Senegal Airlines	4,267	3.5 %
Nas Air	2,073	1.7 %
Binter Canarias	1,996	1.6 %
Iberia	1,599	1.3 %
Canary Fly	391	0.3 %
Total	122,711	100.0%

Source: Agence Nationale de l'Aviation Civile

Entries by land are carried out mainly on two points; (i) the Moroccan border where tourist flows have developed from southern Morocco thanks to the road linking Morocco to Senegal and (ii) the Senegalese border at Rosso connecting with Saint Louis, Senegal.

As for issues and challenges for the tourism sector, the followings are discussed in the Provisional Report of Operational Diagnosis for Tourism Sector 2017.

1) Lack of accommodations
2) Seasonality and spatial concentration (e.g.. Saharan desert tour in Adrar)
3) Slow development of domestic tourism and low purchasing power of population
4) Environmental degradation of the tourism spots
5) Lack of qualified or trained staff for tourism sector
6) Poor condition of secondary access roads to attracts tourists
7) Limited websites for tourists and lack of information on the destinations
8) Less linkage between industry players

The Provisional Report states the following countermeasures to diversify the tourism activities to meet different market expectations.

1) Business and conference tourism in Nouakchott and Nouadhibou,
2) Ecotourism in the protected areas of the National Parks,
3) Extensions of tourism and culture in Adrar Desert to Tagant and Hodhs especially in the 4 ancient cities classified as World Heritage and Archaeological Sites,

4) River tourism including cruises, rural activities, fishing, biking and hiking,
5) Coastal tourism including health tourism, sports, festivals, youth activities

In October 2016, a Qatari company released a plan to build a huge residential tourism complex in Nouakchott, which will cover 25 hectares comprising two hotels, 386 residences, malls and game rooms. Also, the construction of a 5-star hotel with 127 rooms by the National Industrial and Mining Company (SNIM) is planned in Nouakchott. It is estimated to open in 2020.

(2) Services

Based on the One Stop Shop of the Department of Private Sector Promotion, Ministry of Economy and Finance, the registered number of companies amounted to 6,950 in Nouakchott since 2014 as shown in Table 2.21. Among the registered companies, trade sector is predominant at 62.5%, followed by agriculture (5.6%), construction (4.2%), transportation and warehousing (2.8%), fishing (2.6%), information & communication (1.9%), accommodation & catering (1.3%), and manufacturing (1.0%).

Table 2.21: Registered Companies by Type of Sector in Nouakchott since 2014

Sector	Number	share (%)
Trade	4,343	62.5
Agriculture, Breeding, Hunting	390	5.6
Construction	293	4.2
Transportation and Warehousing	195	2.8
Fishing, Fish and Aquaculture	178	2.6
Information and Communication	132	1.9
Accommodation and Catering	91	1.3
Manufacturing	67	1.0
Activities for Human Health	31	0.4
Education	29	0.4
Arts & Entertainment	18	0.3
Finance	17	0.2
Production and Distribution of Energy/Utility	16	0.2
Publishing Activities	15	0.2
Real Estate	7	0.1
Extractive Activities	6	0.1
Other Services Activities	1,122	16.1
Total	6,950	100.0

Source: One Stop Shop of the Department of Private Sector Promotion, Ministry of Economy and Finance

2.3.10 Economic activities by commune

The features of services and industrial activities for nine (9) communes in Nouakchott are summarized as shown in Table 2.22.

Table 2.22: Features of Services and Industrial Activities for Nine Communes

Commune	Features of Services and Industrial Activities
Arafat	• The small private businesses, both formal and informal, have been developed particularly in the services and trade sector. Among them, typical type of businesses is gas stations, bakeries, grain mills, hardware, deposits of bricks, mechanical workshops, restaurants and others. The total number of jobs provided by these companies is more than 2,400.
Dar Naim	• The economic activities in Dar Naim are diversified such as general and informal trade, the work of building, sewing, restoration, garages, mechanical workshops, and peri-urban agriculture. Among them, trade, which is handling food products and building materials, plays a prominent role in economic activities. A total number of stores is more than 500 and most of them are retailers. The total number of jobs provided by these businesses amounted to more than 2,000. • In the Commune, there are eight markets, which do not generally have the essential services such as water and electricity and latrines. With the installation of the agriculture produce market, gardening or relatively small-scale production of fruits, vegetables and so on has been activated. However, this agriculture is facing multiple constraints linked in particular to urban growth such as the land tenure and water supply. In Dar Naim, there are 19 gardening cooperatives in 2012.
El Mina	• The local economy in El Mina is based on a very large variety of activities: trade, industry, handicraft, garages, workshops, transport and so on. Most of these activities are taken place in an informal manner. • Also, the economy of the commune is closely linked to port activities and fishing since there are two major ports. The approximate number of persons employed in the fishery sector are more than

Commune	Features of Services and Industrial Activities
	3,000. Existing industrial processing businesses are bakery, carpentry, manufacturing of ice, foodstuffs and so on. El Mina has the largest livestock market in Nouakchott as well as a slaughterhouse with an area of 2,500 m2.
Ksar	• The commune of Ksar seems to be very dynamic from the economic point of view since • it has a large industrial area and the number of markets. Along the roads, there are classically known activities such as mechanical garages and spare parts, but also new activities such as supermarkets and metalwork. The industrial zone in Ksar is one of the most important in the country, which is composed of factories of candles, soap, plastics, food and beverages, and so on. There are 5 markets in the commune.
Riyad	• Riyadh has ten markets including six public markets and four private markets. These are not specialized and diversified goods are traded. The central market consists of 34 large shops, 10 small shops, 44 canteens, 122 vegetable places and so on. • The economic activities are little developed; This is shown by the low level of employment generated by local micro-enterprises. The rest of the working population moves to Tevragh Zeina, Arafat, and Ksar to work.
Sabkh	• The local economy of Sebkha is characterized by different activities. One of the major activities is trade sector. Sabkh has five large markets, which are well served and close to consumers. The fishery is active in Sebkha since most of the traditional fishermen are from this commune. The sale of fish and its processing is conducted by the population of Sebkha. There are two types of handicrafts practiced in Sebkha: traditional crafts and modern crafts. Traditional crafts such as braiding, shoes and musical instruments are conducted by artisans. On the other hand, modern crafts are mainly practiced by young people who are interested in sewing, mechanics, welding, hairdressing, weaving, and carpentry. As for processing, the main local products are smoked or dried fish, donut, starch from cassava, non-wood forest products and gardening products.
Tyarett	• Many mechanical garages are located since Teyaret has several road axes. The industrial zone in Teyaret is in fact only a small part of the Industrial zone dedicated to the Ksar. There are 7 markets in the commune with the number of 1690 businesses. Food-related businesses including meat stalls and food shops account for three-quarters of all businesses and textiles account for one-tenth of all businesses.
Toujounine	• The local economy of Toujounine is based on trade, which is composed of retailers and semi-wholesalers, mainly handling food and building materials. The trade sector is dominated by informal activities. The Commune has seven markets including livestock market at the national level. Urban agriculture contributes to the fight against poverty through the creation of employment and income. The market of the Commune has about 800 farmers, which are not grouped in a structured organization. • The number of artisanal cooperatives at the commune level is 52. The main artisanal products are scarves, turbans, key rings, clothing and so on. This commune has only one milk production company.
Tevragh Zeina	• In Tevragh Zeina, the private sector, both formal and informal, evolves through the creation of new businesses and local businesses, particularly in the services and trade sector. The commune has five municipal markets including the fish market.

Sources: Plan De Développement Communal-PDC 2013-2017 (2012); Community Development Plan-PDC 2013-2017 (2012) for Nine (9) Communes

As the constraints and issues, the services sector is characterized by insufficient sales products and lack of financial resources, keen competition as well as low-skilled human resources. These issues are mainly coming from the informal nature of this sector, which is also discussed in the preceding section of industry.

2.4 Socioeconomic Issues and Cultural Characteristics

The socioeconomics issues have been analyzed based on the best available data. However, because of the lack of relevant source of information, except for health and security, which are covered by international organizations, the household survey carried out by JICA Study Team, has been used as the main source of information for understanding Nouakchott socioeconomic realities.

The results of the household survey, accompanied with specific analysis will be submitted as a separate report at the occasion of the submission of FR.

Cultural aspects of Mauritanian urban society have been observed and commented by many national and international observers during several years, but those observations were not relying on a scientific basis. It is important to note that the household survey carried out by the JICA Study Team is the most important scientific social study that has ever happened on Nouakchott City. Survey components, sampling, methodology, language and even the way of asking question to households has been discussed

and commonly agreed with the Mauritanian side taskforce. To that extent, the exploration of the results of the household survey can help to bring light to hypothetic statements that are sometimes contained in technical literature. However, it is necessary to warn that this work cannot replace a population census and only present trends that might be better followed-up in an indicative way.

2.4.1 Overview of household survey

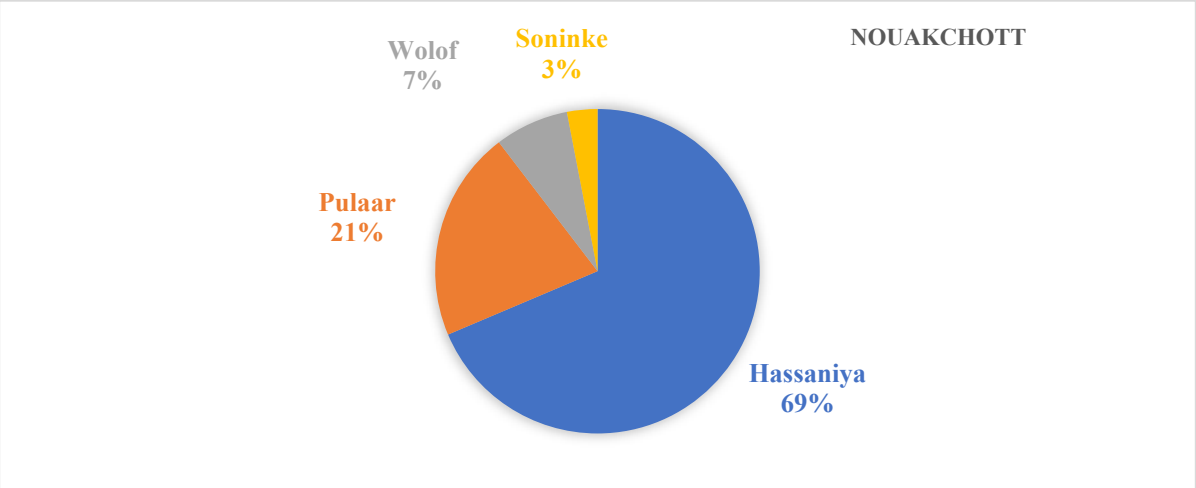
The household survey mentioned above was carried out through the following process.

- Sampling size and zoning: The number of samples was 1,000. This is the minimum number of samples corresponding to a confidence level of 95% that is judged statistically significant for cities with a population of less than 1 million. Samples were extracted by random sampling at multiple stages;
- Survey objectives and items: The main objective of the household survey was to inform about (1) socio-economic situation, (2) degree of satisfaction and perception on existing conditions and urban services and (3) mobility of Nouakchott population. Those three themes were covered by 140 survey items;
- Sampling method: In order to avoid gaps in the representativeness of the sampling, the selected sampling unit was the neighborhood. 100 landmarks were set according to the population of the neighborhood on the basis of a GIS analysis of current population density. On the field, a surveyor threw a pen from the landmark and visited 10 households in the direction of the pen tip;
- Survey implementation methodology: The survey was implemented through a dedicated smartphone application. The use of this application especially allowed the integration of nested questions that would appear according to the specific answers of the previous question;
- Data analysis: It was checked whether samples collected by the application were answered without misunderstanding and corrected if an error was found. The work of editing and analysis was done in cooperation between the local consultants and JICA Study Team.

2.4.2 Native language

While the official language of Mauritania is Arabic, the country has four national languages: Hassaniya (variant of Arabic), Pulaar, Wolof and Soninke. The last three were originally spoken in the Southern part of the country in the Senegal River's valley. Share of each language among the surveyed household respondents is shown in Figure 2.37. Hassaniya dominated at 69%, followed by Pulaar (21%), Wolof (7%), and Soninke (3%)

Over the years, Nouakchott has spread out along the four axes which link the city with the rest of the country. Historically, the incoming population has settled in the vicinity of these four main axes, respecting a certain demographic reason. For example, those who have familial ties in the southern part settles at the south end of the city. Indeed, it is observed that languages other than Hassaniya are more present in southern municipalities, namely: El Mina, Riyadh and Sebkha.



Source: Social Survey, JICA Study Team

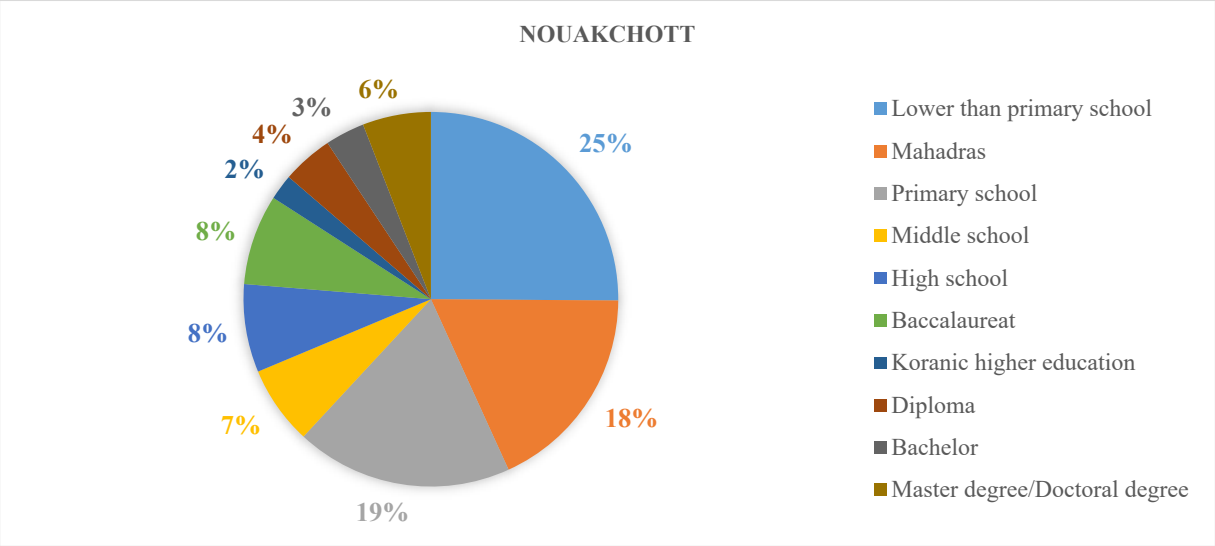
Figure 2.37: Share of Population by Native Language

2.4.3 Religion

Mauritania declared itself an Islamic Republic after its independence in 1960. The Mauritanian Constitution of 2006 states in article 5 that "Islam is the religion of the people and of the State" (Constitution of the Islamic Republic of Mauritania, 2006). Thus, responses to religious affiliation were predictable. Among the respondents, 99.70% of were Muslims, while only three respondents were of Christian came from foreign countries.

2.4.4 Educational level

The largest share of the population regarding the educational level was "lower than primary school (25.10%)", followed by “primary school” (18.70%), Mahadoras (18.10%). On the other hand, 23.70% of people have higher educational background than high school graduation.



Source: Social Survey, JICA Study Team

Figure 2.38: Share of Population by Educational Level

2.4.5 Health

Based on the World Health Organization (WHO) World Health Statistics (2017), the health situation of Mauritanian population can be summarized in the following Table 2.23.

Table 2.23: Health Situation of Mauritania

	Mauritania		African average		Worldwide average	
	Men	Women	Men	Women	Men	Women
Prevalence of hypertension (in adults 25 years and above)	38.4%	33.9%	38.5%	35.5%	29.2%	24.8%
Obesity (in adults 20 years old and above)	4.3%	23.3%	5.3%	11.1%	10.0%	14.0%
Prevalence of diabetes (raised fasting blood glucose ≥ 7.0 mmol/L or on medication)	6.2%	7.3%	4.9%	5.2%	8.8%	8.2%
Risk of premature death from the four NCDs* (in adults 30 to 70-year-old)	18.3%	18.0%	21.1%	20.1%	21.1%	15.0%
Daily smoking (in adults 15 to 64-year-old)	32.7%	4.8%	24.2%	2.4%	36.1%	6.8%
Insufficient physical activity (in adults 15 to 64-year-old)	47.6%	53.0%	17.3%	24.4%	19.8%	26.8%

Source: WHO
Note: (*) Non-Communicable Diseases: cardiovascular disease, cancer, diabetes or chronic respiratory disease

If most of the indicators are within regional or worldwide averages, prevalence of hypertension and insufficiency of physical activity are particularly high in Mauritania compared to other countries. Also, in addition to the mentioned problems, it is likely that Mauritanian women are more affected by obesity and risk of premature death from NDCs, even exceeding worldwide averages whereas Mauritanian men are below worldwide averages in both categories.

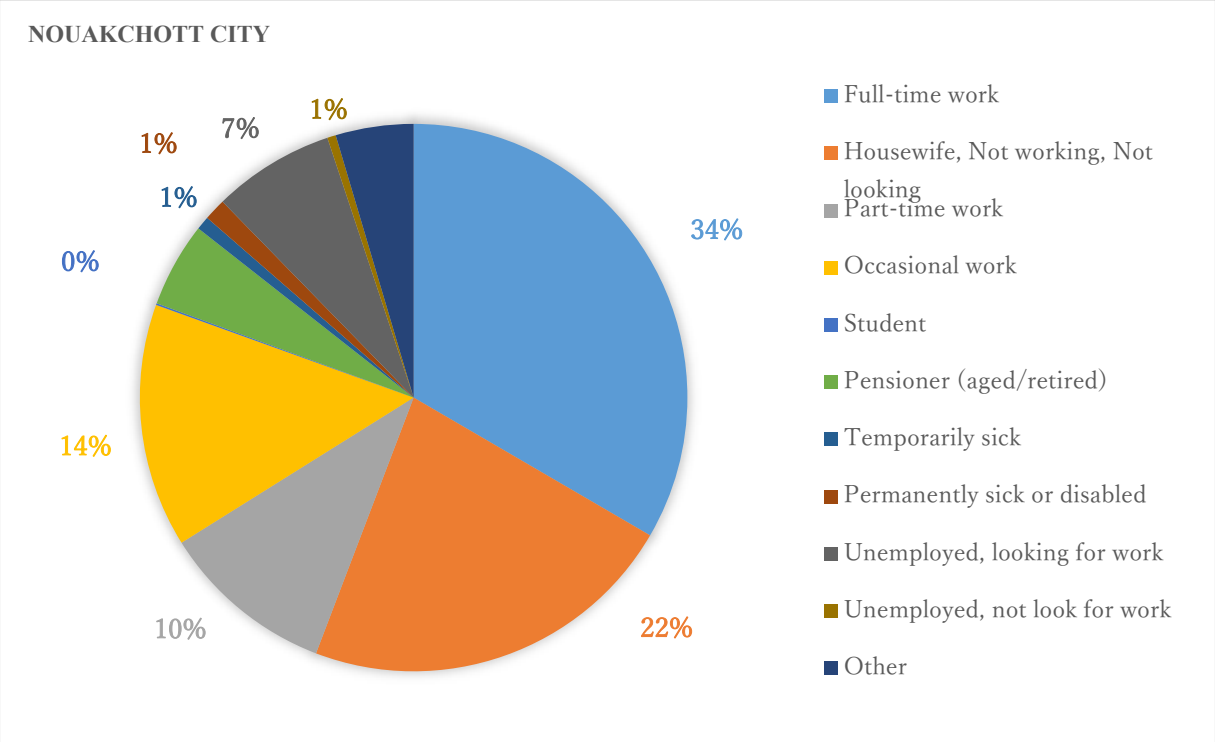
This shall be directly linked with new consumption habits and usage of the city principally centered on private car transportation with a severe lack of walking and cycling activities in daily life. Indeed, as pointed out by the global status report on noncommunicable diseases (WHO, 2014), many factors, including the type of urbanization of a city and the transportation policies contribute to the high prevalence rates of hypertension leading to cardiovascular illness.

There is a necessity for urban planning and design to define urbanization patterns, transportations models and places that would promote physical activity, especially towards women, in order to reduce obesity, risk of hypertension, and prevalence of diabetes and NDCs. This strategy necessitates a strong political will and the understanding of the highest levels of administration.

2.4.6 Employent

(1) Employment status

The majority of respondents in the whole Nouakchott city (33.40%) work full-time, while one segment (14.40%) said they work occasionally, and a small percentage (10.30%) said they work part-time. About one-fifth (22.40%) work as a housewife and they do not look for work outside.

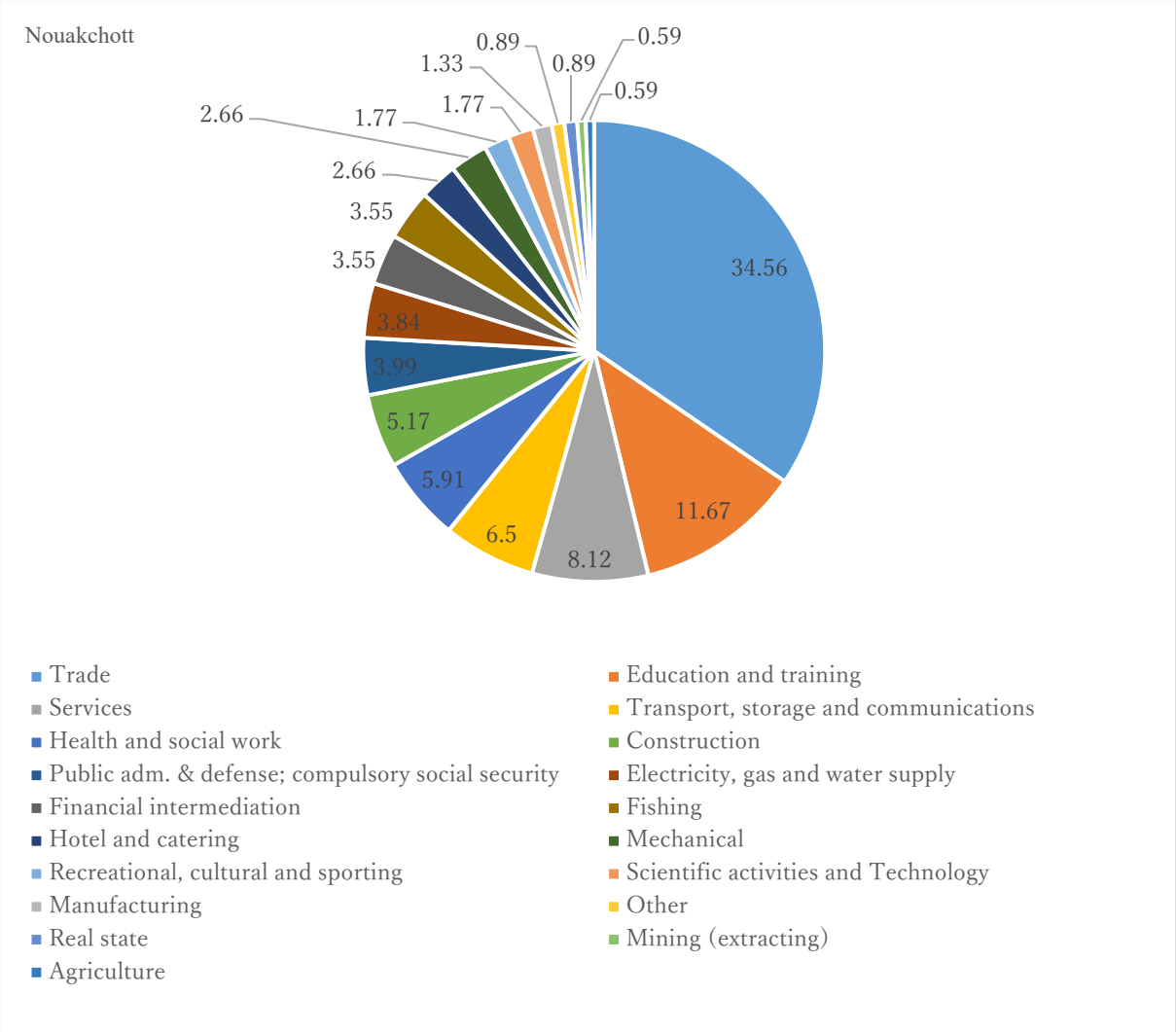


Source: Social Survey, JICA Study Team

Figure 2.39: Share of Population by Occupancy

(2) Employment sector

With a remarkable difference in respect to other profiles, the majority of the respondents (34.56%) works in the trade sector, implying significance in number of informal sector jobs.

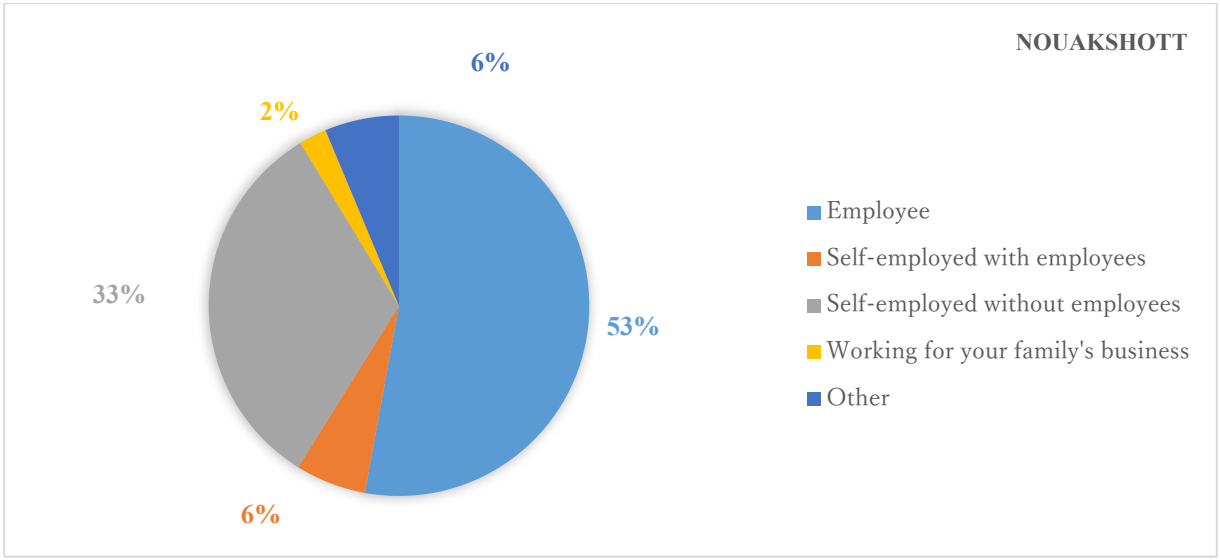


Source: Social Survey, JICA Study Team

Figure 2.40: Share of Workers by Sector

(3) Employment / self-employment

Most people who work or have worked (52.86%) were employees, while about one-third (32.45%) answered “Self-employed without employees”.



Source: Social Survey, JICA Study Team

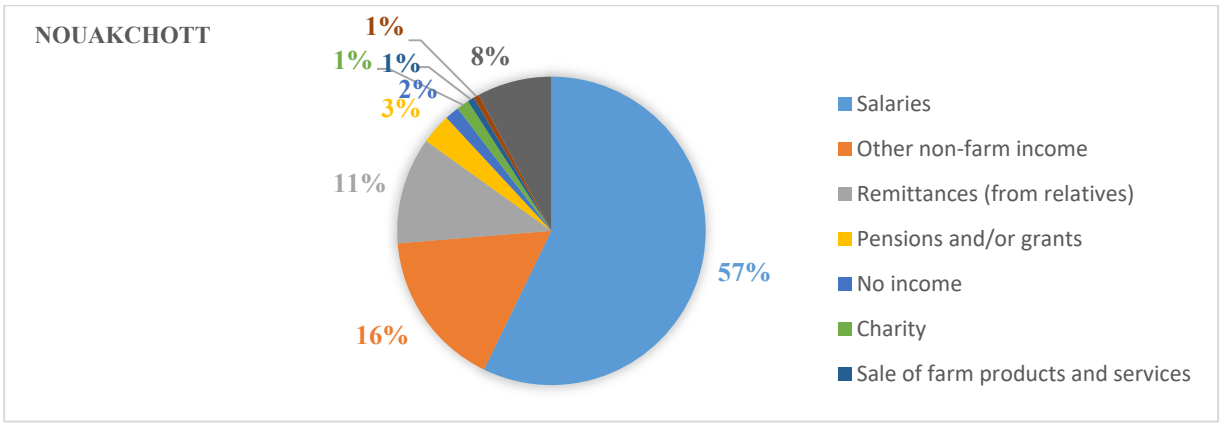
Figure 2.41: Share of Workers by Type of Employment

2.4.7 Income

(1) Main source of income

More than half of households in Nouakchott city (57.20%) acquired main income from salary, followed by non-farm income (16.50%) and remittance from relatives (11.20%).

The main household income sources are mainly salaries, but there is a big difference for each commune. Salaries were the main source of income in Trvrag Zeina (73.47%), El Mina (68.67%), Sebkha (68.63%), Riyadh (67.35%), Ksar (66.00%), and Arafat (60.42%), while Toujounine has the smallest proportion of households where salary is the main source of income (35.00%). Toujounine is also characterized by dependence on remittance from relatives (23.57%).

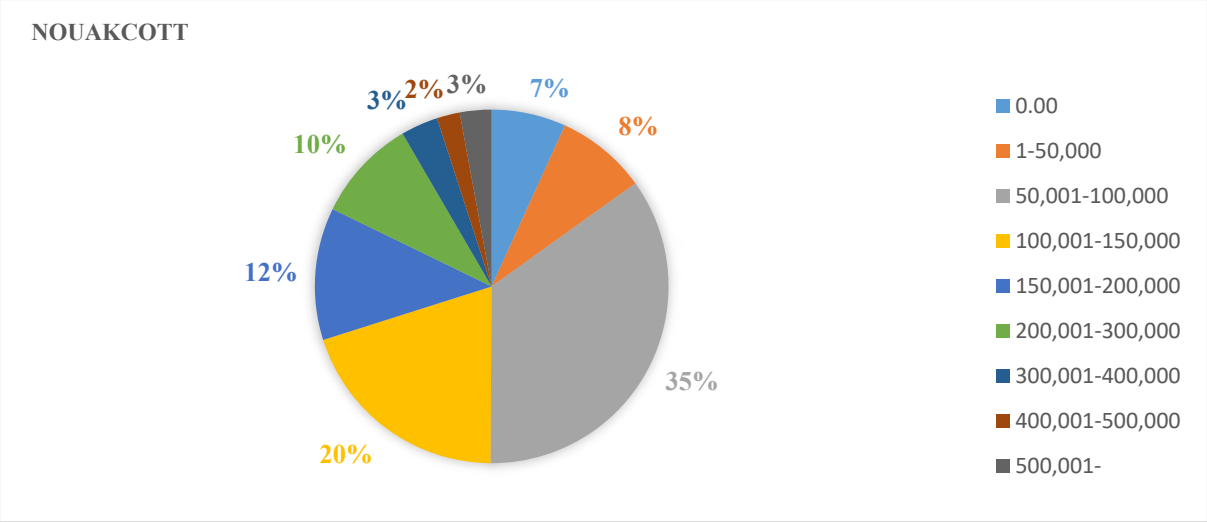


Source: Social Survey, JICA Study Team

Figure 2.42: Share of Household Income Source

(2) Total monthly household income (MRO)

About half (50.10%) of the responded households lived with monthly income of 100,000MRO or less. There were households living without any income (6.80%). This percentage indicates there are households who have never received any charity wervices. About 8.40% of the responded households had income of 300,001 MRO or more.

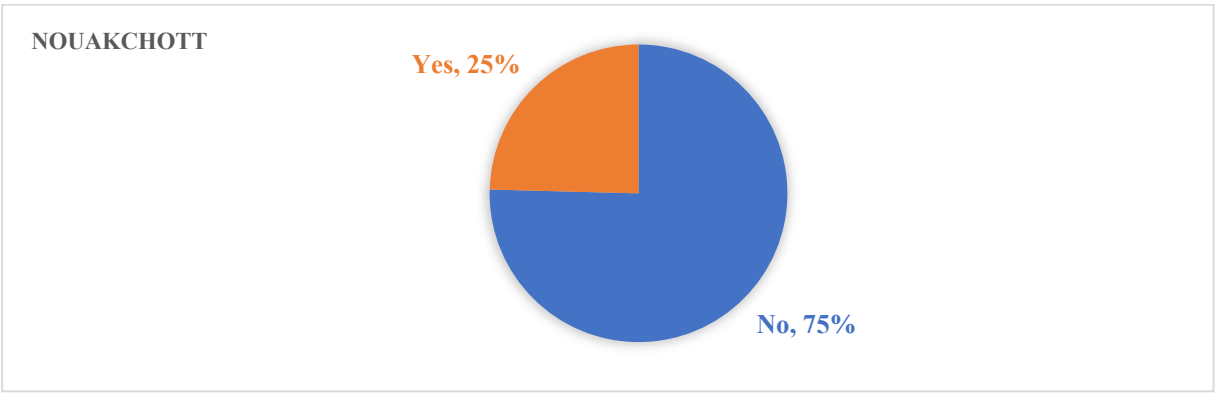


Source: Social Survey, JICA Study Team

Figure 2.43: Share of Monthly Household Income

(3) Participation in common funds

A majority of respondents (75.40%) said they did not participate in a solidarity fund. The percentage difference in the municipalities is trivial. The proportion of participation in solidarity funds was different by commune. Ksar was lowest at 14%, while Sebkha was highest at 33.82%.



Source: Social Survey, JICA Study Team

Figure 2.44: Share of Participation in Common Funds

2.4.8 Security

Security issues in urban areas cover the three major aspects of terrorism risk, common delinquency and feeling of insecurity.

(1) Terrorism risk

Mauritania has for many years been confronted with Islamic terrorism and organized crime. Al Qaeda in the Islamic Maghreb (AQIM) is very present in the Sahel region and this presence continues to grow. As the Sahel region has become an instable zone, where all types of trafficking are taking place (weapons, drugs, etc.), the climate in the country continues to deteriorate. This situation also prevents foreign investors from considering settling in Mauritania. In addition, geostrategic stakes (security, energy) make this region a space of confrontation of big foreign powers.

Even though the Global Terrorism Index (GTI), published by the Institute for Economics and Peace, which quantifies and ranks worldwide terrorism impact has decreased in Mauritania from 0.067 in 2016 to 0.0 (no impact from terrorism) in 2017, the risk of future terrorist act is important. Indeed, Mauritania is classified with “medium risk” by the Terrorism Risk Index (TRI) elaborated by global risks advisory firm Maplecroft,

Within this national and transnational context, it shall be observed that Nouakchott has always been preserved by any major terrorist attack, mostly due to his distance far from any foreign borders, but also thanks to its internal land use pattern. Indeed, even though administrative power, including embassies, are all concentrated in the traditional central district of Tevragh Zeina, this area also contains large-scale military sites and security forces, ensuring the general safety. In addition, this area has been designed with large roads carrying low traffic, and with low presence of residential and commercial land use, this area can be well controlled.

(2) Common delinquency

There is a lack of information and quantitative data related to ordinary crime in Nouakchott and its distribution throughout the different neighbourhoods. Nevertheless, it seems that criminality is traditionally higher is shantytowns, as it was pointed out by the Social Impact Assessment study of El Mina Kebbe Redevelopment Project.

(3) Feeling of insecurity

Alongside actual facts about crime or terrorist phenomenon, the feeling of insecurity is also an important factor to consider to be able to create inclusive spaces for everyone to feel comfortable. According to Gallup Global Law and Order report (2017), Mauritania is classified in the top 12 of the least likely country to feel safe. Indeed, only 39% of the surveyed people answered that they “feel safe walking alone at night” against 97% of Singaporean, 87% of Norwegians and 83% of Spanish who do not feel any stress going in the city alone at night.

As studied in the essay called West African City: Urban space and models of urban planning (2013), press articles from Mauritanian newspapers also give a glimpse of the important feeling of insecurity of Nouakchott citizens. The expression of the feeling of insecurity shall be taken carefully, since it sometimes leads to the perpetuation of the discrimination of certain neighborhood not necessarily based on observed crimes.

2.4.9 Social characteristics by spatial distribution

(1) Origins of Nouakchott population

The analysis of the origin of the citizens who made the rural exodus from the interior of the country to the capital city reveals an important diversity and mixing of regional identities. As confirmed by Figure 2.45 below, the population coming from Northern regions of the country settles more in the Northern part of the city, and similarly the population coming from Eastern regions settles more in the Eastern part of the city. Historically, the incoming population has settled, and continues to do so, alongside the four main roads entering Nouakchott, according to their origin. Nowadays, a person who have familial ties in a certain part of the city will plausibly settle near his community, at least in the beginning of his residential course.

Even though it is known that the city has historically expanded spatially from the center along the four national roads as explained before, the question of “which generation settled first in Nouakchott?” has been asked to the citizens. Without a surprise, as shown on Figure 2.46 below, the settlement of household has been carried out progressively by the generation of the grand-parents in the center, by the parents in the close surroundings of the center, and by the respondents themselves (average age 45 years old) in the periphery of the city. However, two phenomena are interesting to analyze from this information. Firstly, the fact that there are other places far from the center that have been occupied by the generation of grand-fathers, especially on the road of Boutilimit and on the road of Rosso, at the current limit of the city. This can testify of the settlement in the first historical gazras. Secondly, even the newer generation continue to settle near central areas, which means that there is an ongoing process of densification of urban areas and of regeneration of urban fabric in Nouakchott.

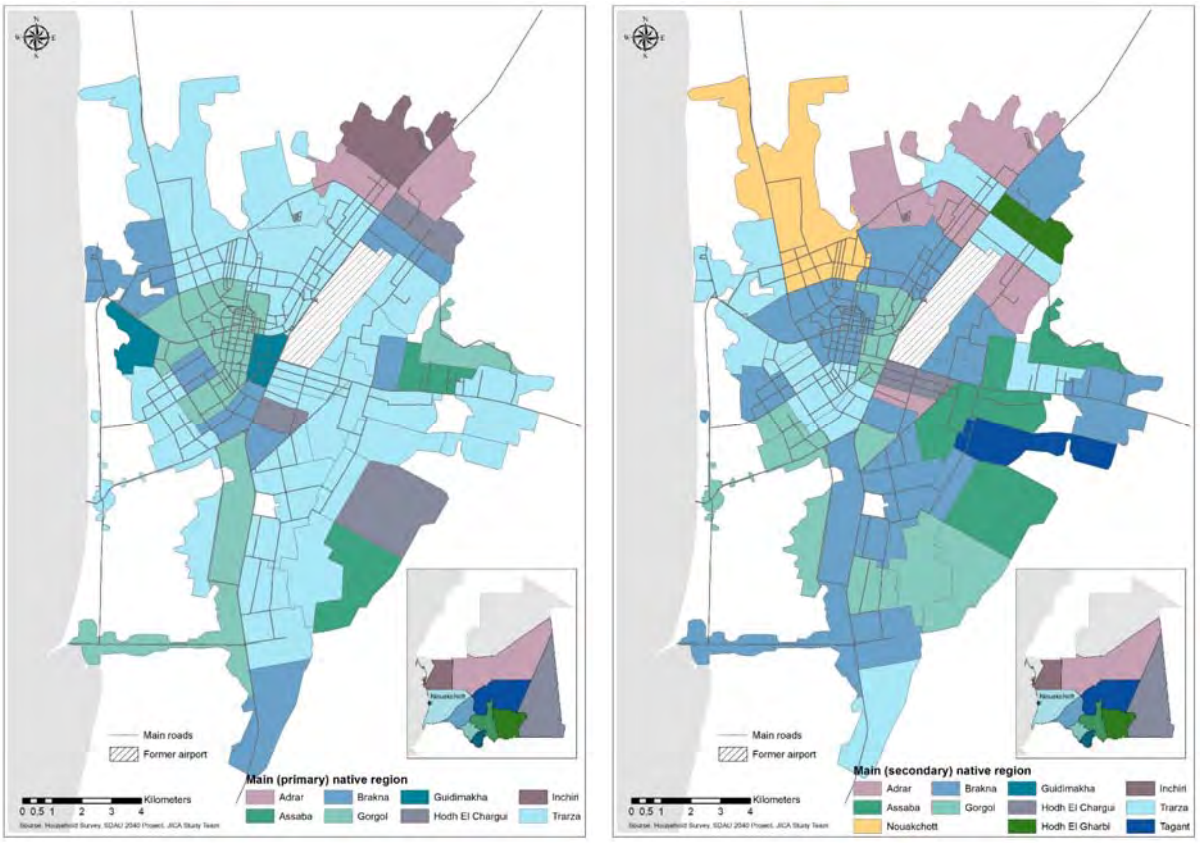
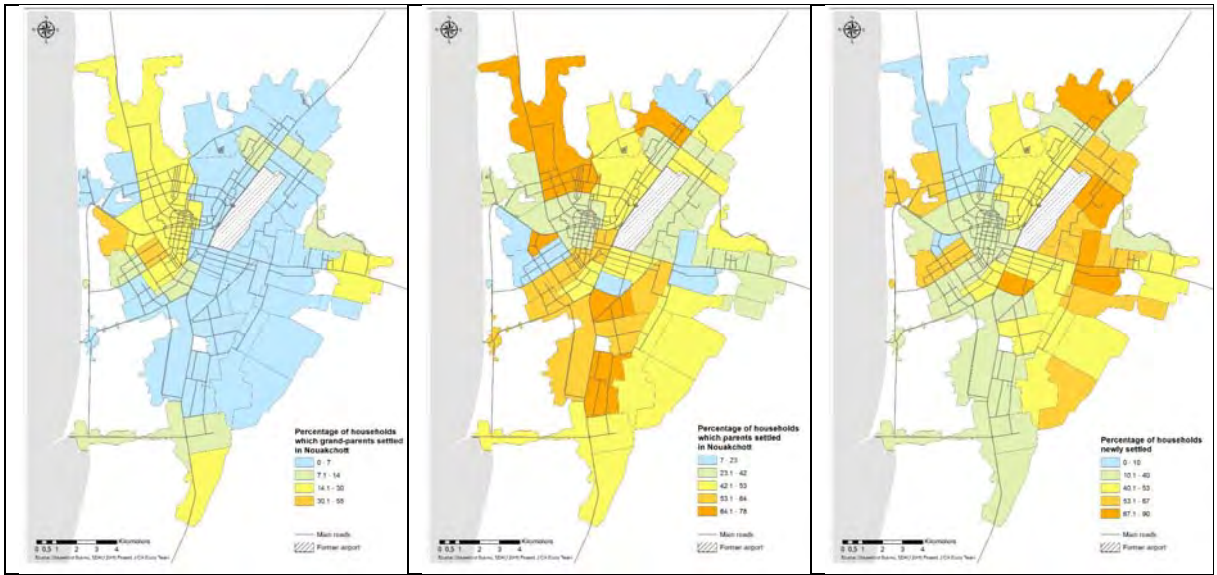


Figure 2.45: Main Native Region of Nouakchott Inhabitants (left: primary; right: secondary)



■=0.0-7.0, ■=7.1-14.0, ■14.1-30.0, ■30.1-55.0 (%)	■=7.0-23.0, ■=23.1-42.0, ■42.1-53.0, ■53.1-64.0, ■64.1-78.0 (%)	■=0.0-10.0, ■=10.1-40.0, ■40.1-53.0, ■53.1-67.0, ■67.1-90.0 (%)

Figure 2.46: Generation of Settlement (left: grand-parents; center: parents; right: respondents)

Implication to land use planning: As mentioned above, the results of household survey proved that a densification process of existing urban fabric is ongoing, especially through the building of unoccupied parcels. This conclusion was utilized to calculate the occupancy growth of existing urban areas in land use planning.

Translation to city planning: The question of the expansion of the city and of the origin of Nouakchott population is complex shall be studied more specifically in terms of migration at the scale of the whole country. Indeed, if previous historical drought in the interior of the country has provoked fast influx of population in Nouakchott, the same type of natural or human crisis phenomenon in the country can

precipitate the spatial expansion of the city. As mentioned above, since the specific direction of urban expansion of the city is largely linked to the region of origin of the immigration, studying and understanding demographic trends and socioeconomic risks for the stability of each region of the interior of the country can greatly help to plan the urban expansion of the capital city. Bridges shall be found between large-scale national and regional planning and urban development planning. The recent activity of an international NGO called GRDR (Groupe de Recherche et de Réalisation pour le Développement Rural dans le Tiers Monde: Research and Development Group for Rural Development in the Third World) in Mauritania shall be enhanced and linked to the efforts of planning by ONS and MHUAT.

(2) Social disparities and concentration of fragilities

Having grown and evolved in an unplanned way but supplied by successive waves of population exodus which find some spatial cohesion, as explained above, Nouakchott expresses its social characteristics in both homogeneous and concentrated way, but also sometimes in a heterogeneous and nested way. Indeed, if some areas of the city might cumulate all kinds of social difficulties, some other areas might gather extremely opposed social situations on the same ground, like in the famous case of the slums (kebbe) that are settled in the middle of high standing villa zone in Tevragh Zeina.

In terms of employment and income generation of the households, the situation is characterized be large discrepancies in terms of volume, source and spatial distribution of the income. The distribution of average monthly income, as shown on Figure 2.47 shows importance differences between a northern crescent starting from fisherman port to the former airport, that seems globally wealthy (average of more than 175,000 MRO/month), a vast uniform area surrounding the center of the city of middle income (125,000 to 175,000 MRO/month), and urban fringes in the periphery that have globally the lowest income of the capital (around 80,000 to 125,000 MRO/month). The latter category of income represents the population living below the extreme poverty threshold, as defined by the Permanent Household Living Conditions Survey 2014 (EPCV 2014) of Mauritania.

In order to have a more precise idea of spatial representation of the inequality of income, Gini index was calculated, as shown in Figure 2.48. It can be seen that the gap of income is wide in the wealthy areas. Obviously, those areas gather a small proportion of very wealthy households living in villas mixed with low income households and even scattered slums on the same area. Both population are supplying each other's with various types of economic services.

Implication to strategic orientations: As it was revealed by household survey, the coexistence of wealthy and deprived households in the same area is historically important in Nouakchott. That is why the achievement of social mix through social housing policies shall be introduced as a key objective for the future planning of the city, as proposed in the strategic orientations of the SDAU.

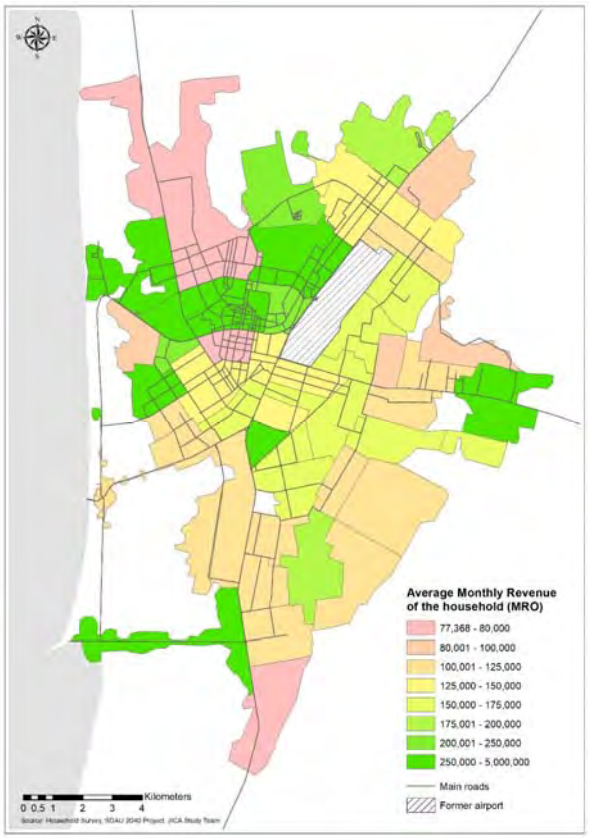


Figure 2.47: Average Monthly Income

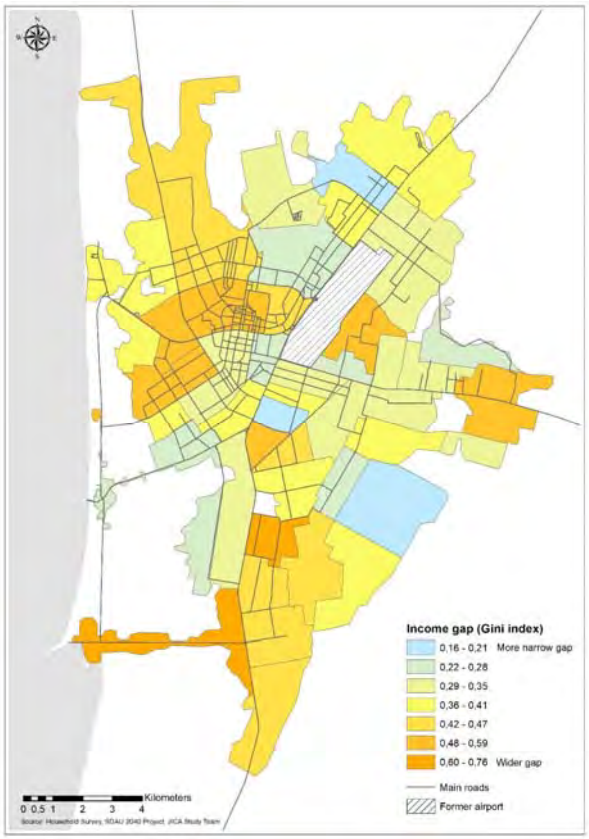


Figure 2.48: Income Gap (Gini Index)

(3) Housing conditions and household structure

House is the primary living environment for human beings. Housing conditions are thus a crucial indicator of the sustainability of a human society. In their residential courses, 62.3% of citizens have moved from their previous address to find "better housing conditions" (ranked 1st).

The Research on Sustainable Cities in Developing Countries by JICA has put the emphasis on this issue in its proposed urban scope for inclusiveness (poverty reduction/ disparity correction) and with the following indicators.

- Percentage of slum population / share of population in slum areas;
- Urban service penetration rate (water supply, sewerage, electricity);
- Average living area.

Even though the three indicators mentioned above can be informed by analysis of GIS data, answers from households in the social survey can be used in a more qualitative way.

During the past decades, slums could be found in vast areas in Nouakchott, but thanks to the efforts of ADU, kebbe and gazra have almost disappear. Still, even though parcels have been arranged by the public authorities and settlement have been legally formalized, the presence of precarious housing conditions (tents, shack or hangar) is still important. According to the household survey, which has a random sampling methodology (thus precarious housing areas have also been surveyed), around 7% of the population is living in precarious housing, which is distributed spatially mostly in the eastern far periphery, Tarhil area, and Northwest of the city, as shown in Figure 2.49.

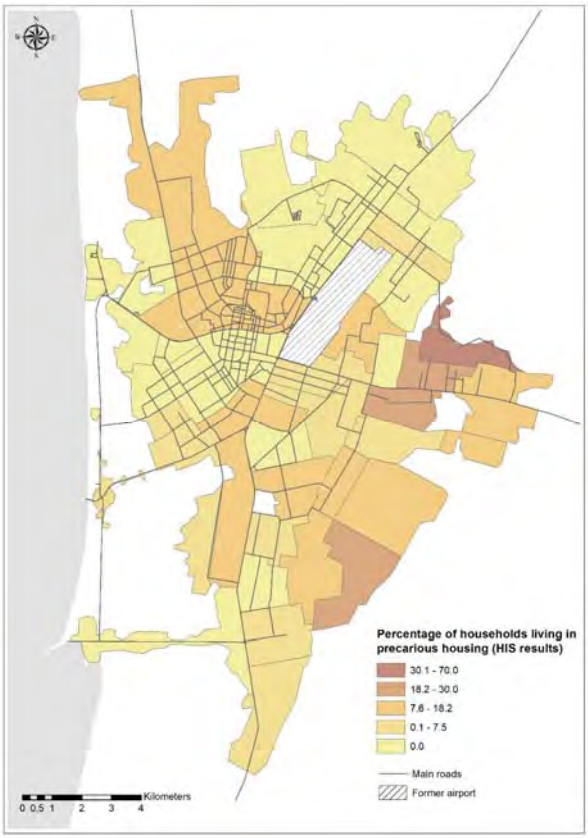


Figure 2.49: Precarious Housing

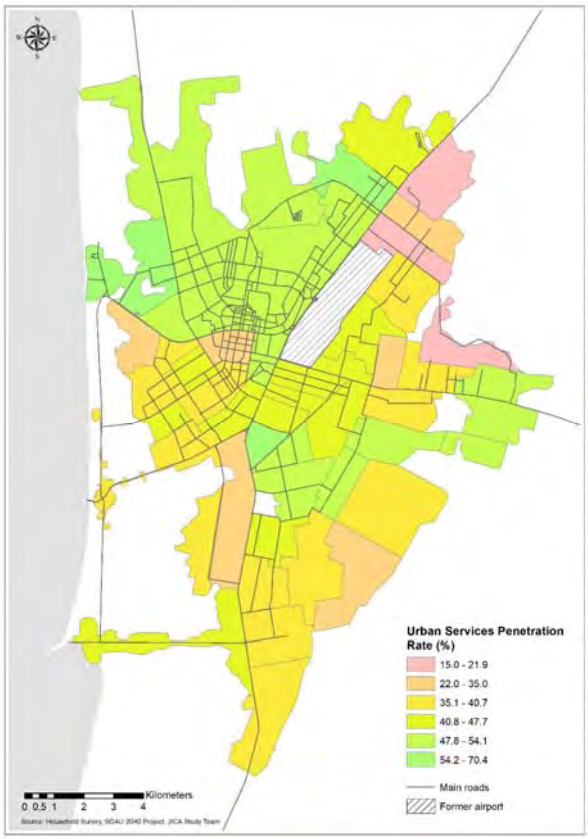


Figure 2.50: Urban Services Penetration

Average of connection rate to electricity (91.7%), water supply by piping (53.4%), sewage service (3.9%) and solid waste collection service (24.3%) has been calculated to give an overall urban services penetration rate (USPR), shown in Figure 2.50 above. Average USPR in Nouakchott is 43,3%, and varies from 15,% for the lowest penetrated areas, especially in the new extensions along road of Adrar and in precarious residential areas along road of Boutilimit, to 70,4% in the newest extensions in the North of the commune.

Asked what would make housing condition ideal, respondents answered firstly with an outstanding majority: living surface (78%), followed by aeration (17%) and very far by cheapness of the price (only 1%). As presumed, the largeness of houses is a key factor for Mauritanian dwellers. According to the household survey, the average housing living area in Nouakchott is 130.3 m^2. For comparison, average housing living per dwelling is of 91,2m^2 in France, and 130,1m^2 in United States, which is quite close to the situation of Nouakchott, except the fact that household size is much more important in Mauritania. The indicator would be better to be average living area per capita, which would take into account the problem of overcrowding. Average living area is distributed spatially as shown on Figure 2.51 below.

Naturally, since the living surface is most value for a dwelling, the ideal housing type is the individual house for a large majority of citizens (87%), with a preference for detached house (50%) over attached house (37%). Nevertheless, relatively important portion of respondents is willing to live in an apartment (12%), as shown on Figure 2.52 below. Obviously, the category of population which expressed this wish is the one which is already settled in dense urban areas.

In order to understand more precisely the needs in terms of housing, household size and composition has been analyzed. According to the household survey, the average household size is 5.5 persons/dwelling, and varies according to the housing typology: 6.1 persons/dwelling in individual housing, 5.7 in precarious housing, and 4.7 in collective housing. The spatial distribution of household size is shown in Figure 2.53 below. Alongside household size, an important factor is the number of generation living together in the same dwelling, shown in Figure 2.54 below. A large majority (84.4%) of households are composed of two generations. Households composed of grand-parents, parents and

children can be found mostly in the outskirts of the city, while single-generation (couple without child) are present in an not negligible proportion in downtown area (14.3% in Tevragh Zeina).

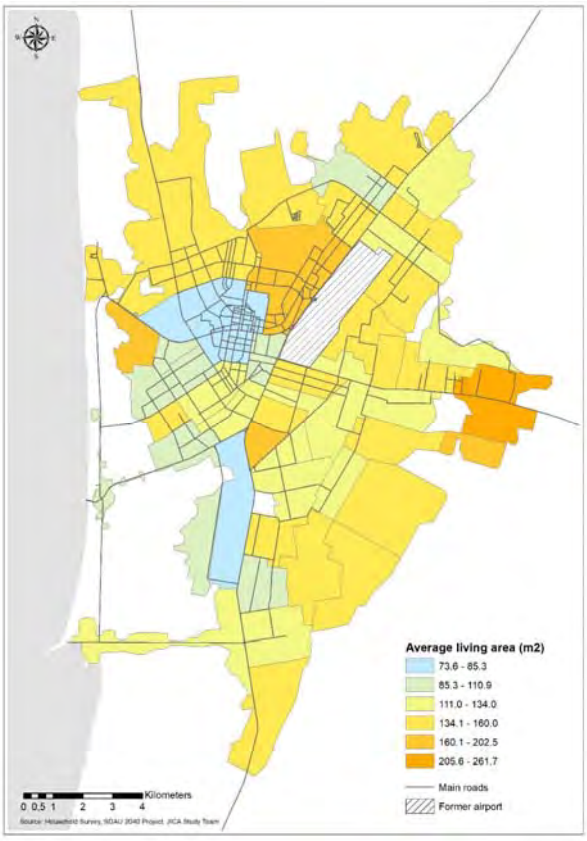


Figure 2.51: Average Living Area

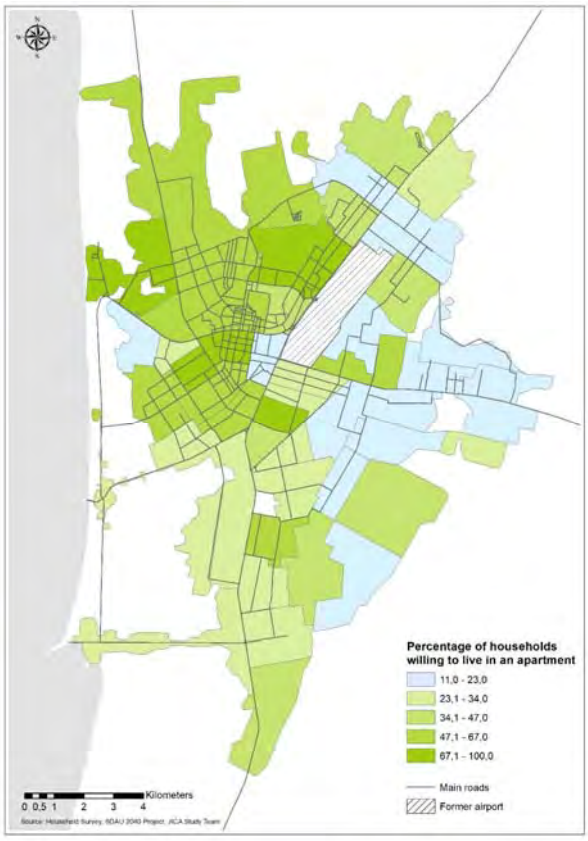


Figure 2.52: Willingness to Live in Apartment

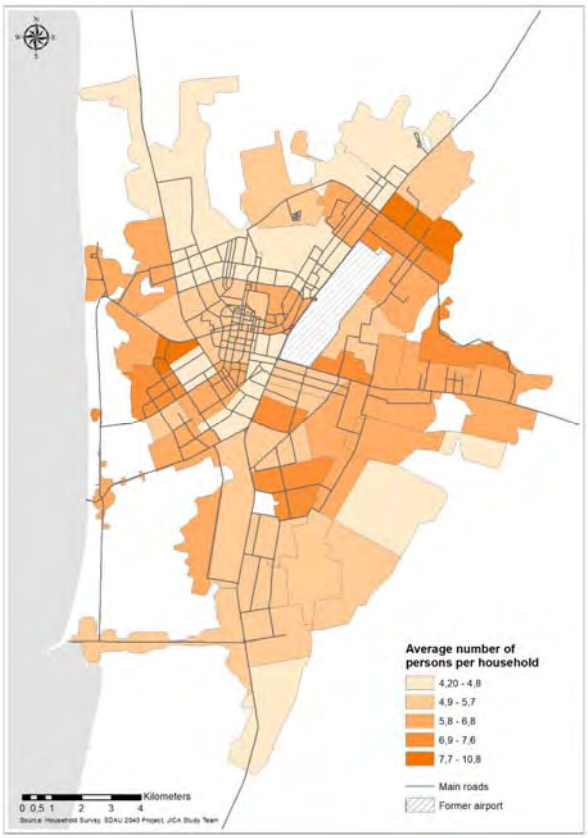


Figure 2.53: Number of Person per Household

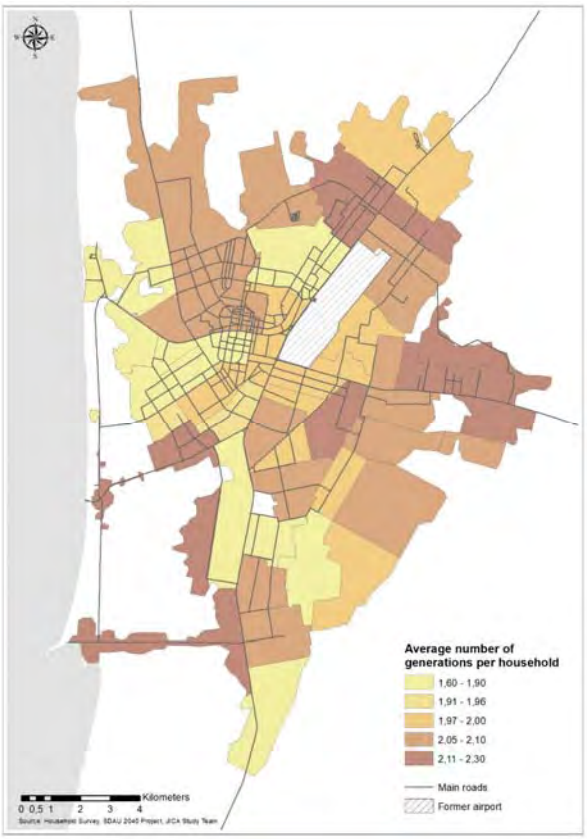


Figure 2.54: Number of Generation Living Together

(4) Social peace and religion as main pillars of Nouakchott society

Several indicators show that the citizens of Nouakchott are considering social link and religion as key factors for the stability of their society. Far ahead the need for modernization of economy, the wish to achieve a stronger economy or a better individual financial situation, that would be understandably important in a developing country, the value that respondents have prioritize as the most important for Nouakchott are the conservation of social link and the quest for spirituality.

Indeed, asked about what they "like" in Nouakchott (the question mentioned that the answer could be "a place, a feeling, or a thing"), the citizens have placed in first the "Social relationships" with 17% of answers. Similarly, the benevolent idea of maintaining and enhancing social link is strongly present in other answer such as the following.

- "Peace" in Nouakchott is appreciated by 13% of the respondents (ranked 2nd) and is considered by 15% of the citizens as a pride of the city (ranked 3rd),
- "Solidarity" of Nouakchott people is appreciated by 11% of the respondents (ranked 3nd) and is considered by 10% of the citizens as a pride of the city (ranked 4th);
- "Personal relationships", "hospitality" or "neighbors" are considered as a pride of Nouakchott.

Alongside the idea of social peace, religion has been prioritized highly as a key component of Mauritanian urban identity. The importance of religion can be interpreted as both a personal quest for spirituality, but also as a mean to enhance social link between people. Indeed, mosques have been identified as the second most important spaces of sociability in Nouakchott (24% of answers to the question "spaces of sociability: in your neighborhood, what are the places where people randomly gather or can have a chat?").

Another indicator of the importance of social peace and solidarity as a central value for Mauritanian urban society is the fact that 25% of the citizens participate in solidarity funds such as tontine or lawha. This creates a social safety net which helps the most vulnerable households.

Translation to city planning: The strong wish to maintain and enhance social peace, religion and solidarity, that is clearly expressed in the household survey, shall be translated in spatial terms through urban planning and other tools.

- A first step to social peace and solidarity would be, at the level of urban structure, to federate all the neighborhoods of the city and to make sure there is not a strong spatial and social disconnection;
- In the case the city is evolving through a spatial and social disconnection, like it seems to be with the proposition of airport city in the North of Nouakchott, then adaptation measures such as the linking of neighborhoods with performant affordable public transportation, or mitigation measures such as the introduction of solidarity financial mechanisms (a part of the revenue of land taxes of wealthy areas is allocated to poorest areas) shall be introduced;
- Diversity of housing offers (mix of rental/ home ownership, social housing/ high standing) is thus an important theme to strengthen. It would enhance cultural diversity and mixing of populations;
- Local democracy and participation of citizens to local political life is a condition to the realization of common understanding and social peace. Thus, city planning documents shall as much as possible to elaborated and implemented in close collaboration with local communities.

2.4.10 Summary of socioeconomic characteristics and implication to planning

Based on the analysis of the results of household survey, the following socioeconomic characteristics and trends of Nouakchott citizens as well as related implication to planning have been found out, as shown in Table 2.24 below. Those characteristics will be used further to identify development issues to elaborate the planning orientations of the SDAU.

Table 2.24: Summary of socioeconomic characteristics and implication to planning

Theme	Socioeconomic characteristic and trends	Implication to planning
Settlement and housing patterns	New settlements not only in suburbs but also within existing urban area	Support ongoing densification of existing urban area
	Wealthy households coexist with poorest households (slum existing within the villa area)	Promote social mix and affordable housing
	Precarious settlements are still existing	Pursue restructuration and relocation
Access to urban services	Inequality regarding access to social services	Promote equal access to social services
	Inequality regarding access to urban infrastructure	Promote equal access to urban infrastructure
	Inequality regarding mobility (low motorization rate and lack of public transportation)	Promote equal access to mobility
Symbols of society	Social peace, solidarity and religion as main pillars of Nouakchott society	Unify urban structure, link neighborhoods, propose a diverse housing offer, promote participation of citizen in urban planning

Source: JICA Study Team

2.5 Urbanization

2.5.1 Urbanization history

The urbanization history of Nouakchott, in terms of growth of population and of built-up area, is summarized in Table 2.25 and Figure 2.55, 2.56 and 2.5' below.

Table 2.25: Evolution of Population and Built-up Area Growth in Nouakchott

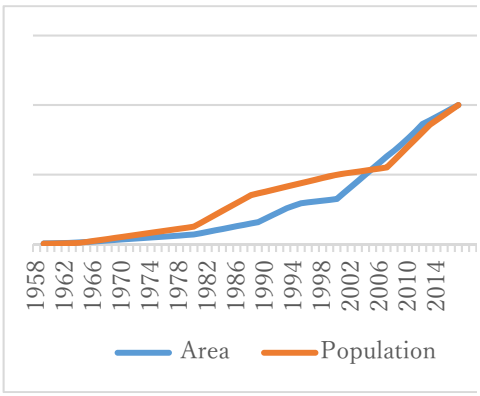
Year	Popu-lation	Annual growth rate (%)	Built-up area (km^2)	Annual growth rate (%)	Average density (pop/ha)	Elements of Context
1958	1,995	-	0.5	-	39.9	Foundation of the city. Free distribution of land to encourage officials located St. Louis to settle in Nouakchott.
1964	9,100	15.0%	2.4	15.2%	37.8	Two urban cores, designed in 1959 by the French architect André Leconte, are established: one around the fort called "Capital" which hosts public institutions; the other around the Ksar Mosque, the first residential core.

1980	140,000	6.2%	14.1	5.5%	99.4	The tow cores merge. Demographic and spatial growth of the city is continuing at a rapid pace as a result of a high birth rate and drought-related rural exodus (1968-1973) from the interior of the country. Shantytown (*kebbe*) of Sebkha and El Mina are born.
1989	407,064	3.5%	32.4	6.7%	125.7	In the 80's, first efforts of land management and distribution of land to stop progression of shantytown. This strategy and the second wave of drought will lead to intense irregular urbanization and starting of land speculation (*gazra*) in the new districts of Arafat, Dar Naim and Riyadh.
1995	489,499	2.9%	60.2	6.9%	81.3	The city extends mainly along major axis and especially towards the South.
2000	558,195	2.5%	66.4	2.0%	84.1	In the second half of the 1990's, demographic and urban growth slow down, even if it remains one of the highest in Africa.
2008	672,539	9.3%	137.4	6.7%	49.0	In 2001, ADU is created and launches the first major program of shantytown restructuration. In 2003, beginning of the requalification of El Mina *kebbe* under the PDU. Urban sprawl continues in urban fringes at a steady pace.
2012	901,227	4.3%	176.7	3.8%	51.0	Creation in 2009 of the large resettlement district of Tarhile. Shantytowns are resorbed and densified.
2017	1,116,738	3.7%	204.5	2.8%	54.6	Urban growth pressure slows down relatively, even though a town of villas is growing on the urban front of Sukuk in the North of Nouakchott, and scattered urbanization in the East on the roads of Boutilimit and Adrar is getting more intense.
Average on 2000-2017 period		**4.1%**		**6.6%**		

Source: JICA Study Team based on ADU, CUN, Ateliers de Cergy, interpretation of 2012 and 2017 satellite images

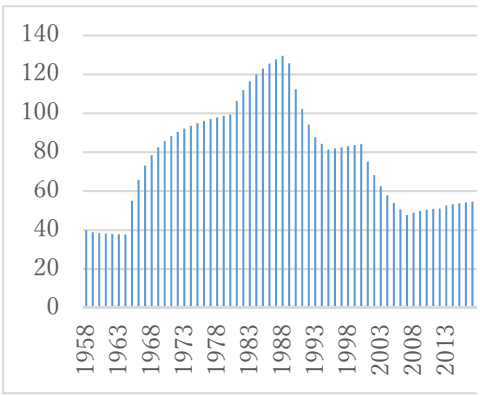
Source: JICA Study Team based on ADU, Ateliers de Cergy, interpretation of 2012 and 2016 satellite images

Figure 2.55: Urbanization History of Nouakchott City (1958 to 2017)



Source: JICA Study Team

Figure 2.56: Evolution of population and built-up area in Nouakchott City throughout history



Source: JICA Study Team

Figure 2.57: Evolution of average gross density in Nouakchott City throughout history

As explained below, Nouakchott has experienced a rapid growth in a few decades. The urban growth of the capital city of Mauritania can be characterized by two factors: the importance of irregular urbanization, and the de-densification trend.

Just after its foundation, the city of Nouakchott has been influenced by large-scale influx of population from the interior of the country. Those people started to settle irregularly in temporary housing in suburb areas. Since then, formation of these unplanned settlement become common, and have given the shape of the whole city evolution.

As shown in the figures above, the evolution of population and built-up area in Nouakchott city has been inverted during history. During the first period, from the foundation of the city in 1958 to the mid 1990's, the population has evolved faster than the built-up area. Oppositely, from the late 1990's to nowadays, the built-up area has extended faster than the population, leading to the de-densification tendency that is characterizing Nouakchott. Those two historical trends of urbanization can be explained by two types of unplanned urbanization: *kebbe* and *gazra* (see Section 2.5.4 (4)).

In recent years, on the 2000-2017 period, the average population growth rate is lower than the built-up area growth rate, 4.1% and 6.6% respectively, which means that Nouakchott city has kept de-densifying from the last two decades.

2.5.2 Existing land use of Nouakchott City

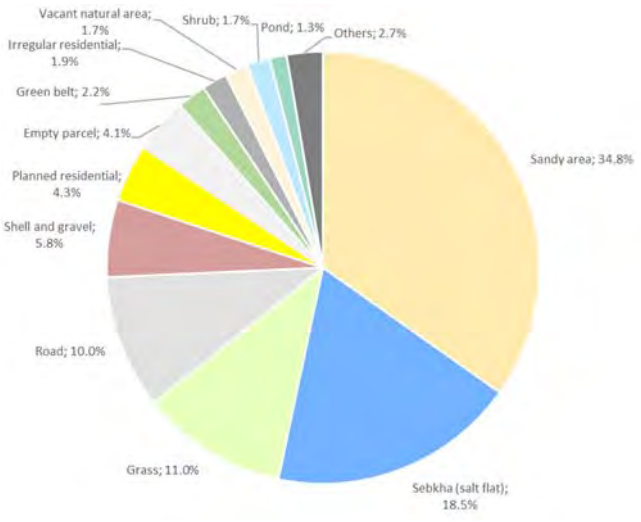
Under the situation of absence of cadaster map or other available land use information in the city, the existing land use map was computed based on different GIS works carried out by JICA Survey Team, including (1) the collection and correction of available official subdivision parcel data from MHUAT and Ministry of Domains, (2) the digitalization of non-available parcel data on the basis of satellite image, (3) the qualification of built-up land use from field survey (100% of parcels in PLU area and sample survey in the remaining areas of SDAU), and (4) the identification of land uses others than built-up areas based on satellite image interpretation.

Existing land use map of Nouakchott City, the target area of the Study, has thus been created as shown in Figure 2.58 below. As reflected by the area shown in Table 2.26 and Figure 2.59 below, sandy area and *sebkha* area (salt flats) are the dominant land use, representing a little bit more than half (53.3%) of the whole area of Nouakchott City. Inversely, green areas including wooded areas or agricultural farm lands are extremely few (0,3%), testifying of the arid nature of the land cover. The built-up area stands for 8.7% of the whole area of Nouakchott City.

Table 2.26: Area of Existing Land Use of Nouakchott City

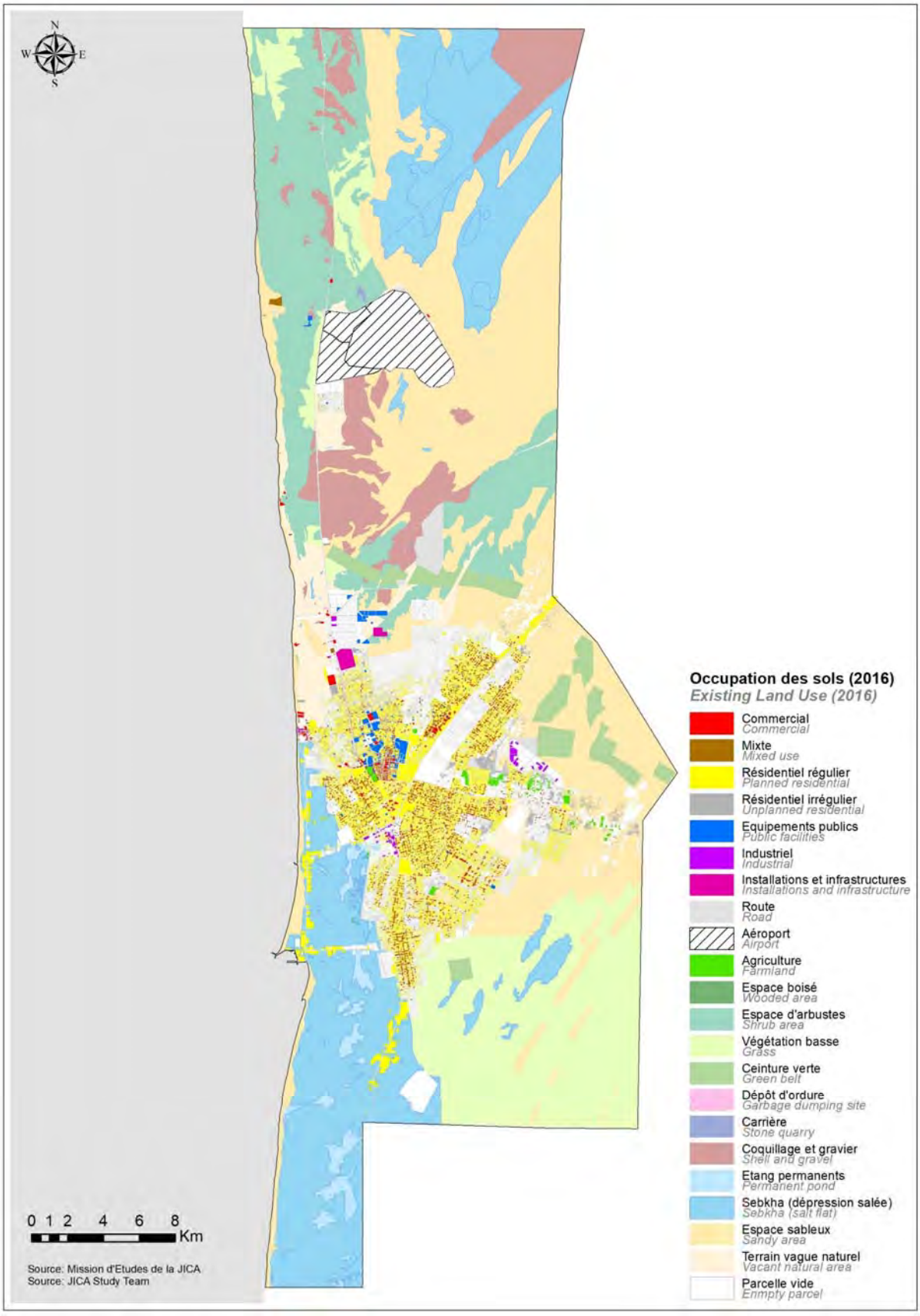
Land Use Category	Area (ha)	(%)
Sandy area	39,276	34.8
Sebkha (salt flat)	20,905	18.5
Grass	12,380	11.0
Road	11,303	10.0
Shell and gravel	6,530	5.8
Planned residential	4,852	4.3
Empty parcel	4,661	4.1
Green belt	2,448	2.2
Irregular residential	2,134	1.9
Vacant natural area	1,972	1.7
Shrub area	1,928	1.7
Permanent pond	1,436	1.3
Mixed use	1,270	1.1
Commercial	952	0.8
Public facilities	536	0.5
Farm land	210	0.2
Industrial	108	0.1
Wooded area	5	0.0
TOTAL	**112,906**	**100.0**

Source: JICA Study Team



Source: JICA Study Team

Figure 2.58: Area of Existing Land Use of Nouakchott City



Source: JICA Study Team

Figure 2.59: Existing Land Use of Nouakchott City

2.5.3 Occupancy rate of parcels in residential subdivisions

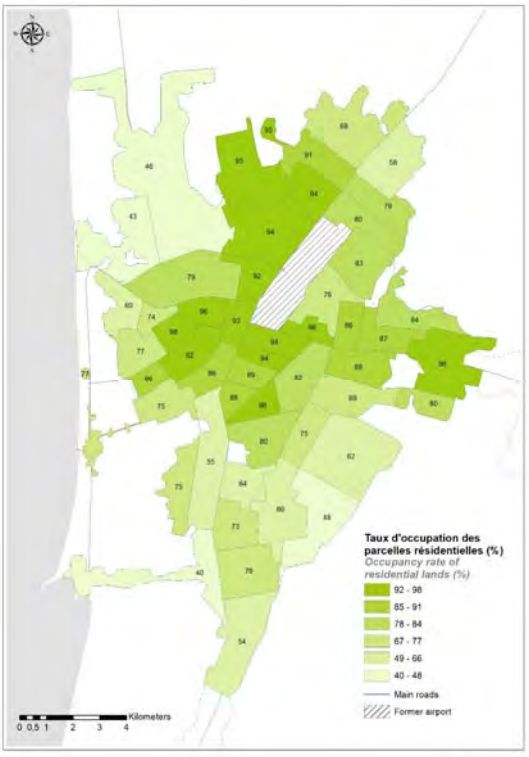
As mentioned in previous parts, public administration has previously carried out massive campaigns of distribution of free parcels in order to limit the proliferation of informal settlements. The government habit of supplying great number of parcels in large subdivision operations had then begun, leading to the spatial expansion of planned neighborhoods. With the local culture of owning several parcels with not necessarily equip them or construct a house on it, the subdivision generally takes a long time to get fully occupied. As a result, the average occupancy rate of residential parcels is quite low, 75% at the scale of Nouakchott as shown in Table 2.27. The occupancy rate distributed geographically as shown in Figure 2.60 below, is still far from being full even in quite central neighborhoods that have been developed decades ago.

The filling-up of empty parcels in subdivisions alone would accommodate a decent amount of population in the near future (roughly, if the 287,611 parcels occupied in 2017 equals to a population of 1,116,738, then the filling-up of the 94,663 empty parcels would allow to accommodate 367,558 people).

Table 2.27: Occupancy of residential parcels in Nouakchott

	Parcels located in PLU target zone	Official parcels	Digitized parcels	**TOTAL**
Method of identification of occupancy	Field confirmation	Sample field survey + satellite image	Sample field survey + satellite image	
Total number of parcels	22,970	311,869	47,435	**382,274**
Occupied parcels	12,384	236,336	38,891	**287,611**
Empty parcels	10,586	75,533	8,544	**94,663**
Occupancy rate	54%	76%	82%	**75%**

Source: JICA Study Team

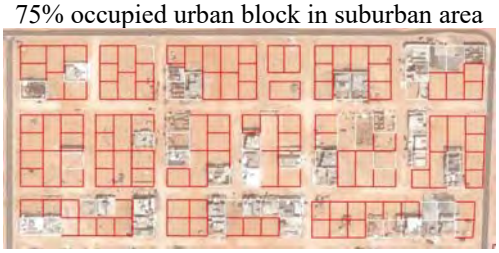


Source: JICA Study Team

Figure 2.60: Occupancy rate of residential lands

Fully occupied urban block in central area

75% occupied urban block in suburban area

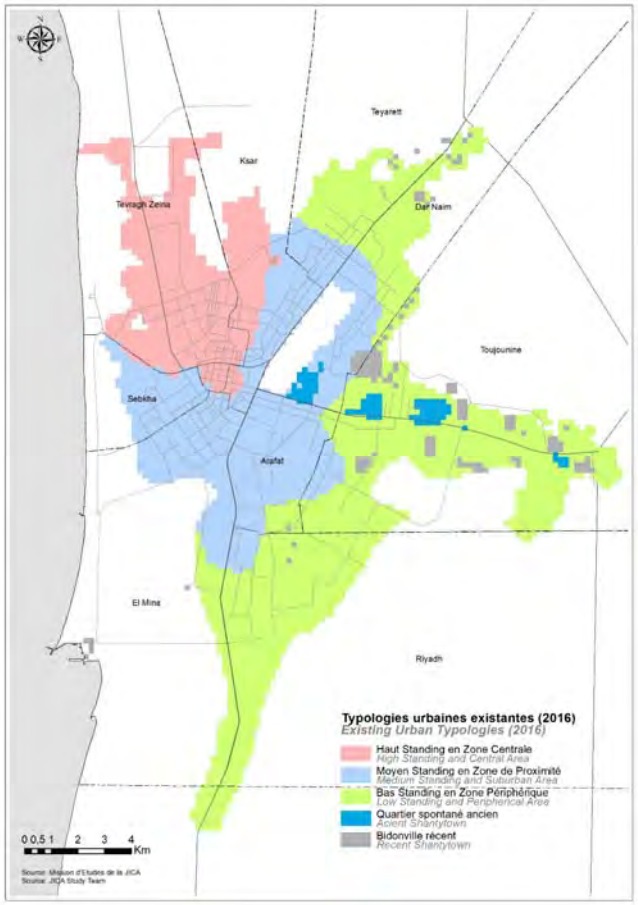


34% occupied urban block in new villa area

Figure 2.61: Residential occupancy rate examples

2.5.4 Typologies of built-up areas

Based on the existing land use analyzed through GIS data, the density and on the housing characteristics, built-up areas in Nouakchott can be categorized roughly into the following categories, distributed geographically as shown in Figure 2.62 below.



Source: JICA Study Team

Figure 2.62: Existing Urban Typologies (2016)

(1) High standing and central area

In the oldest and central parts of the city, mostly in the communes of Tevragh Zeina and Ksar, a typology of high standing built-up area can be found. It designates an urban fabric made of commercial and mixed land use alongside large roads, and of wealthy villas and well-equipped large houses in the inside the urban blocks, as shown in Figures 2.63 and 2.64 below.

Source: en Haut!

Figure 2.63: Typical Landscape of High Standing and Central Area

Source: JICA Study Team

Figure 2.64: Typical Land Use Pattern of High Standing and Central Area

The average density in the high standard and central area is quite low: around 4 to 10 dwelling units (DU) per ha, i.e. approximately 25 to 50 inhabitants /ha. This low density comes from the low intensity of land use, as explained in sample analysis below. It is coming from the fact that houses are built on relatively large parcels (from 700 to 2,000 m2), that occupancy rate which is still low due to the phenomenon of land keeping (gazra) in those areas, and from the large sizing of roads and interstitial spaces.

Taking advantage of the availability of full land use and building data on Tevragh Zeina, a typical sample area has been taken as shown in Figure 2.65 below in order to verify the assumptions about the characteristics of high standing and central area. In this 8.4 ha urban block containing 80 parcels, 51 residential parcels are occupied, leading to an average of 6 DU / ha (around 30 inhabitants/ha). 13 parcels are unoccupied (in white) and 3 parcels are occupied by precarious settlements, obviously gazra (in grey). Thus, the occupancy of parcel is relatively high (76%). The standard area of the parcels of this type of subdivision is 700 m2. Average living area of buildings is 267 m2. Finally, large roads and unused interstitial spaces (in light grey) represent a substantial part of the area (37%). As a result, despite the quite high occupancy of the area, the land use intensity of built-up area is low (27%).

Sample Area: 84,370 m2; Built-Up Area: 22,539 m2; Land Use Intensity Ratio: 27%
Source: JICA Study Team based on 2016 satellite image and produced GIS data

Figure 2.65: Sample of Land Use Intensity in High Standing and Central Area

(2) Medium standing and suburban area

The most populous suburbs of the city, mostly in the communes of Sebkha, El Mina, Arafat and Teyarett, a typology of medium standing built-up area can be found. This typology designates an urban fabric composed of a dense residential area dotted with small boutiques, most of the times organized surrounding a market, from which are starting commercial and mixed use corridors, as shown in Figures 2.66 and 2.67 below (example of central market of Teyarett).

Source: en Haut!

Figure 2.66: Typical Landscape of Medium Standing and Suburban Area

Source: JICA Study Team

Figure 2.67: Typical Land Use Pattern of Medium Standing and Suburban Area

The average density in the medium standard and suburban area is relatively high: around 20 to 40 dwelling units (DU) per ha, i.e. approximately 100 to 200 inhabitants /ha. This high density comes from the high rationalization and intensity of this populous and commercial areas.

A typical sample area has been taken as shown in Figure 2.68 below in order to verify the assumptions about the characteristics of medium standard and suburban area. In this 3.4 ha urban block containing 100 parcels, 87 residential parcels are occupied, leading to an average of 26 DU / ha (around 120 inhabitants/ha). Only 1 parcel is unoccupied, and 1 parcel is occupied by precarious settlement. Thus, the occupancy of parcel is extremely high (98%). The standard area of the parcels of this type of subdivision is 225 m2. Living area of buildings is relatively small, with an average of 102 m2. Finally, large roads and unused interstitial spaces represent a substantial part of the area (33%). As a result, the land use intensity of built-up area is relatively high (38%) for Nouakchott.

Sample Area: 33,814 m2; Built-Up Area: 12,401 m2; Land Use Intensity Ratio: 38%
Source: JICA Study Team based on 2016 satellite image and produced GIS data

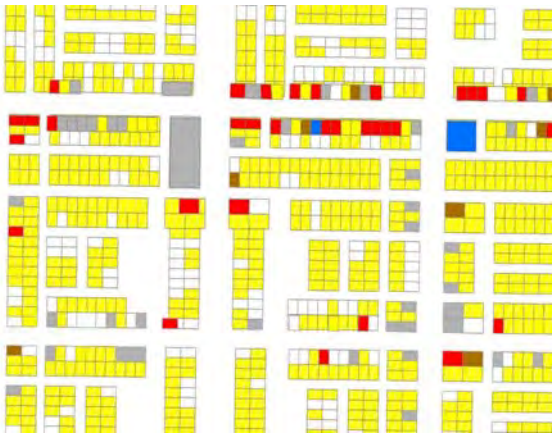
Figure 2.68: Sample of Land Use Intensity in Medium Standing and Suburban Area

(3) Low standing and peripherical area

The low standing of housing can be found in the peripheries surrounding the city, namely in the North part of Dar Naim, East of Toujounine and Riyadh. This typology designates isolated neighborhoods far from major urban axis, composed by small houses built with modest materials (zinc roofs), organized around a small traditional courtyard left unused. The parcel is constantly densifying according to the growth of the household. Alongside asphalt roads, scattered and small-scale local commercial activity can be found. Low standing and peripherical area is shown in Figures 2.69 and 2.70 below.

Source: en Haut!

Figure 2.69: Typical Landscape of Low Standing and Peripherical Area



Source: JICA Study Team

Figure 2.70: Typical Land Use Pattern of Low Standing and Peripherical Area

The average density in the low standard and peripherical area is average: around 10 to 30 dwelling units (DU) per ha, i.e. approximately 50 to 150 inhabitants /ha depending on the extremely variable occupation situation. This high population density is contrasting with the low intensity of land use.

A typical sample area has been taken as shown in Figure 2.71 below in order to verify the assumptions about the characteristics of low standard and peripherical area. In this 2.8 ha urban block containing 100 parcels, 82 residential parcels are occupied, leading to an average of 29 DU / ha (around 150 inhabitants/ha). 18 parcels are unoccupied, and 7 parcels are occupied by precarious settlement. Thus, the occupancy of parcel is relatively high (82%). The standard areas of the parcels of this type of subdivision are 150 m2 for the smallest parcels, and 300m2 for the biggest. Living area of buildings is relatively small, with an average of 60 m2 by barrack. Finally, sand access roads and unused interstitial spaces represent a substantial part of the area (38%). As a result, the land use intensity of built-up area is very low (9%).

Sample Area: 84,370 m2; Built-Up Area: 22,539 m2; Land Use Intensity Ratio: 27%
Source: JICA Study Team based on 2016 satellite image and produced GIS data

Figure 2.71: Sample of Land Use Intensity in Low Standing and Peripherical Area

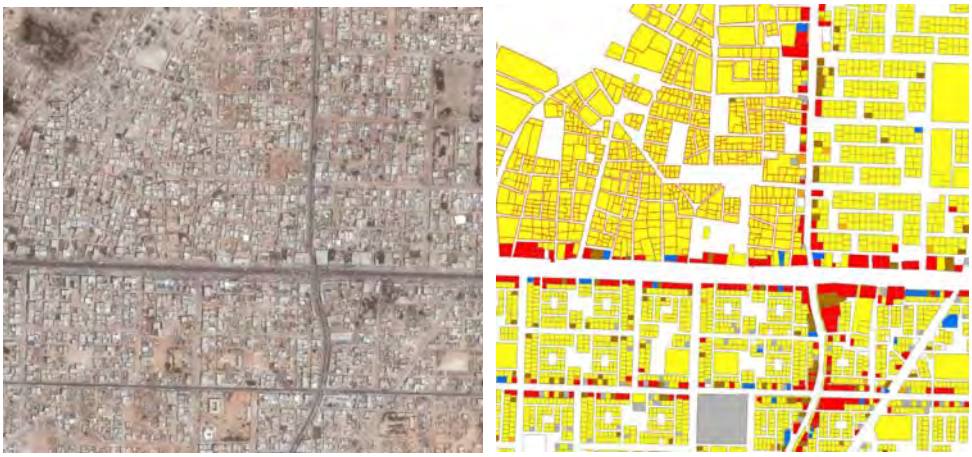
(4) Shantytowns and slum pockets

Based on the history of urbanization discussed above, currently three major types of irregular occupancy are remaining in Nouakchott: ancient shantytowns, recent shantytowns, and slum pockets.

1) Ancient shantytowns

Even though most of the shantytowns formed in the first decades of urban expansion of Nouakchott have been resettled and requalified through the action of ADU, some of them have evolved as dense urban blocks, and have been formalized on-site by the administration. In the urban fabric, ancient shantytowns can be identified by a more organic shape, by the irregularity of parcel size and orientation, as shown in Figure 2.72. Ancient shantytowns generally gather vigorous commercial activity and are now fully integrated to the city, even though their level of equipment in urban services and infrastructure is still not sufficient.

In terms of density, ancient shantytowns have the same characteristics than medium standing and suburban area explained above.



Source: JICA Study Team

Figure 2.72: Example of Typical Ancient Shantytown Land Use Pattern

2) Recent shantytowns

Even after the massive intervention of ADU, the phenomenon of kebbe has continued, and shantytowns established from the 2000's are still visible in the extreme outskirt of the city, especially alongside major roads to the East and Northeast. Recent shantytowns have established in the continuity of the urban sfringe, generally of low standing and peripherical areas, as shown in Figure 2.73. However, a major characteristic of recent shantytowns is that they settled in the direct proximity of their livelihood source, as the famous kebbe installed recently on the site of the Port of Wharf, as shown in Figure 2.74.

Source: JICA Study Team

Figure 2.73: Example of Recent Shantytown Formed in the Continuity of Urban Fringe (Dar Naim)

Source: JICA Study Team

Figure 2.74: Example of Recent Shantytown Formed Near Livelihood Source (Wharf Port)

3) Slum pockets

Another representation of irregular urbanization in Nouakchott is the presence of small slum pockets within the formal subdivisions, and especially in the wealthiest parts of Nouakchott, as shown in Figure 2.75 below. It can be analyzed that the presence of slum pockets in more intense along the main commercial axis and in the developing parts where there are still vacant parcels.

Source: JICA Study Team

Figure 2.75: Important Presence of Slum Pockets in the Wealthiest Part of Nouakchott (Tevragh Zeina)

As discussed earlier about historical formation of kebbe and gazra phenomenon, the presence of slum pockets in the formal city can be of two natures, as shown in Figure 2.76 below: (1) the keeping of lands by the servants of wealthy households in the perspective of land speculation (gazra), testified in general by the presence of a unique tent or barrack in a large parcel closed by walls; (2) the presence of poor population packed in interstitial spaces in precarious housing (kebbe), generally giving service (construction, food cooking, security) to wealthy households.

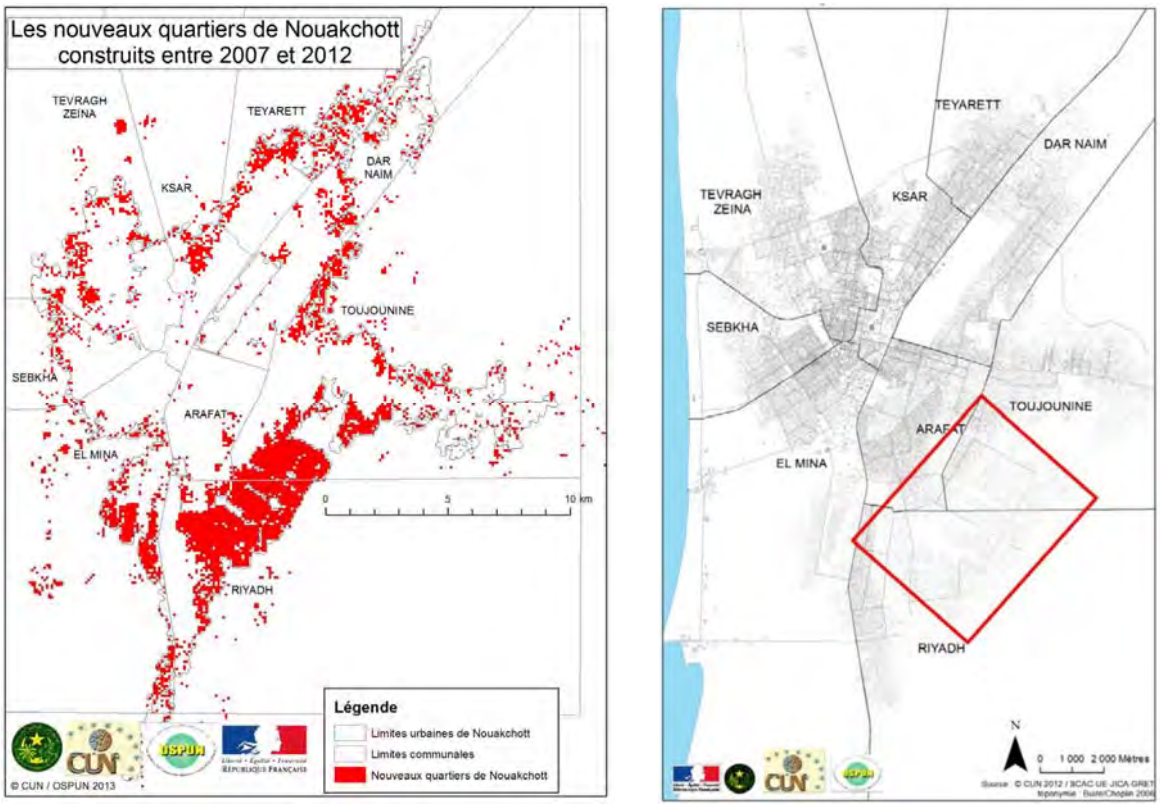
Source: JICA Study Team

Figure 2.76: Two Types of Slum Pockets: Gazra (left) and Kebbe (right)

(5) Outline and current status of ADU project

The Mauritanian Government has started full-scale improvement projects in unplanned residential areas since 2001, and has established ADU (Agence de Dévelopment Urbain: Urban Development Corporation) to as an implementing body for the series of projects. Since 2003, ADU has been carrying out large-scale residential development with installation of public facilities, supported by the World Bank finance. At the initial stage, around 85% of the project cost was funded by the World Bank, and the remaining 15% was funded by the government of Mauritania. This initial stage project targeted about 16,000 households, of which approximately 10,000 households remained in the original area that was rebuilt within the unplanned residential districts, while 6,000 households were subject to relocation. This project has successfully ended in 2007.

Since then, in 2009 Phase-2 was initiated with 100% government funds. This covers approximately 105,000 households. Assuming each household is consisting of 3 to 5 people, roughly 400,000 people were involved in the Phase-2 of the project. The project developed large-scale residential areas in three communes, namely; Dar Naim, Arafat, and Toujounine. At present, almost 90% of the Phase-2 has already completed. This includes a huge new district development for the purpose of distributing land parcels to households relocated from the unplanned districts. This new development area is locally called "Tarhile". Figure 2.77 shows the major development from 2007 to 2012, showing the location of the Tarhile.



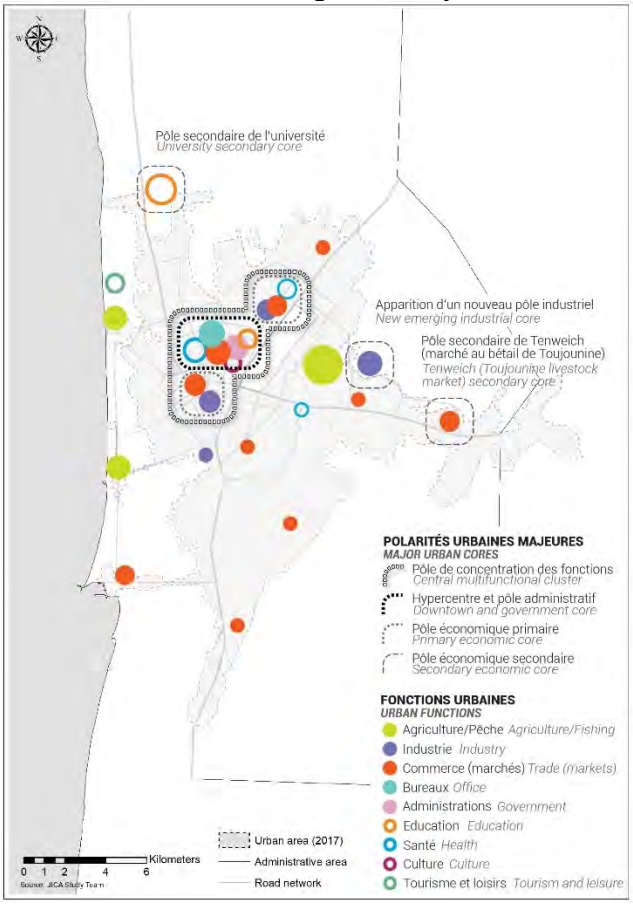
Newly Built-up Areas from 2007 to 2012 — Location of Tarhile Developed in the Suburbs

Figure 2.77: Newly Built-up Areas from 2007 to 2012 and the Location of Tarhile

2.5.5 Existing urban structure

Having been developed in an unplanned manner, Nouakchott has grown with a macrocephalic, unipolar structure. Historic downtown area concentrates all the urban functions, and thus is saturated. In the detail, the existing urban structure of Nouakchott City, as shown in Figure 2.78 below, can be characterized by the following:

- The overwhelming dominance of the historical downtown core of Ksar-Capital, which concentrates most of the urban functions: economic activities, administration and services;
- The downtown core is supported by two primary economic cores located in its vicinity: Marché Cinquième of Sebkha-El Mine in the South, and Ksar-Teyarett in the North;
- The agglomeration of the three cores mentioned above forms the biggest multifunctional cluster of the city of Nouakchott;
- Outside the multifunctional cluster, the rest of the city can be considered having low multifunctionality, consisting mostly in residential areas;
- The relatively small markets, which are a structuring element of Nouakchott city life, are mostly located alongside major roads, except for the one in Tarhil, which has an off-center position;
- At the outskirt of the city, two secondary poles are getting more and more importance: the university pole on Nouadhibou road in the North, and Tenweich market on Boutilimit road in the East;
- A relatively new industrial core is structuring the nearby outskirt in the Eastern direction.

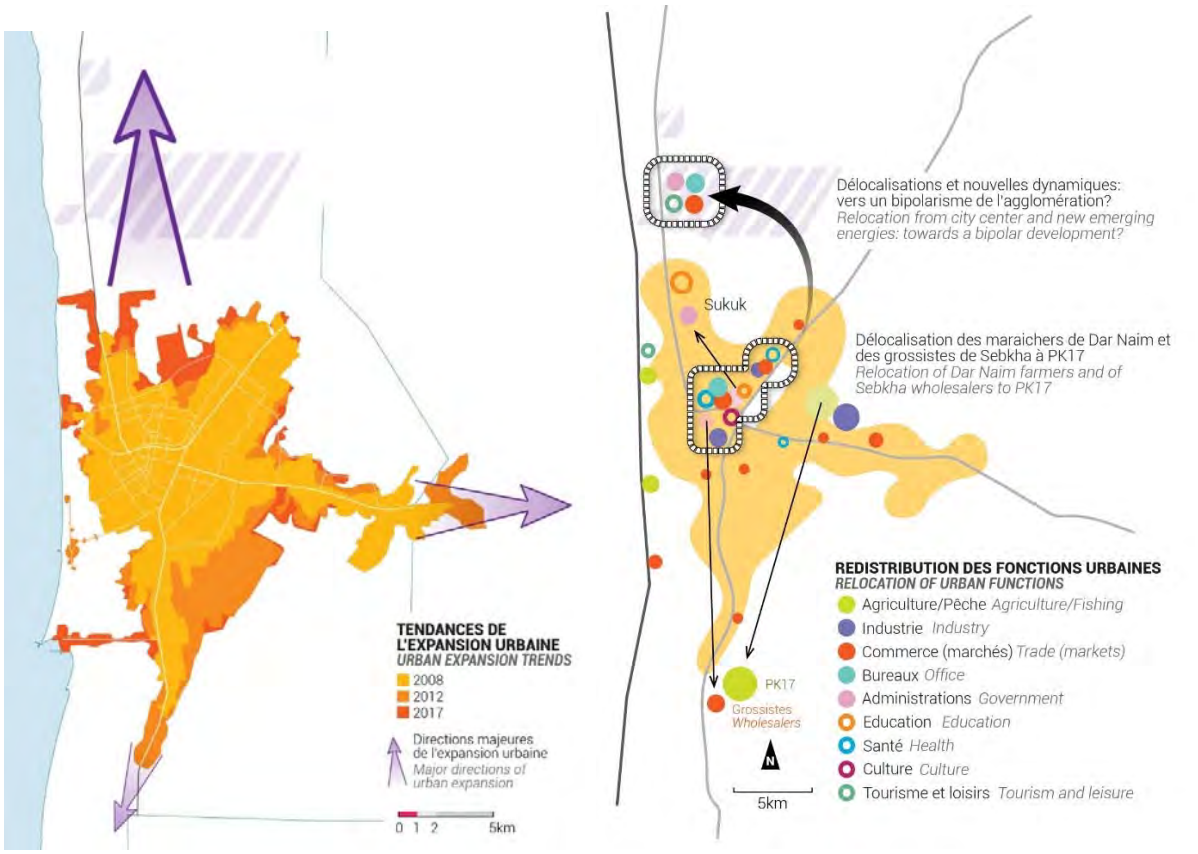


Source: JICA Study Team

Figure 2.78: Existing Urban Structure of Nouakchott (2017)

2.5.6 Development trends and projects affecting urban structure transformation

The following emerging phenomena are considered having an influence on the transformation of the existing urban structure. They will be considered as structuring factors in the elaboration of the different urban expansion scenario and development alternatives. Figure 2.79 below illustrates the development trends that influence the urban structure the most significantly.



Source: JICA Study Team

Figure 2.79: Urban expansion trends and relocation of urban functions

(1) Urban development in airport and coastal zone of Tevragh Zeina

Although urban pressure is lower than during the previous decades, it should be noted that a strong development towards the north of the agglomeration is ongoing. It is a largely a qualitative urbanization, symbolized particularly by the following projects.

- Construction of an international congress center, currently under completion, which should be ready to host the 30th Summit of African Union Heads of State in Mauritania in 2018;
- Expansion of luxury villas from Sukuk under progress;
- Private tourism and residential investments represented by Ribat Bahar project and the future airport city currently under consideration;
- Relocation of some central administrations to Sukuk, etc.

A detailed presentation of these projects is available in Part II of this report.

Nouakchott city, traditionally unipolar as described above, evolves in the direction of a bipolarity: the traditional downtown core (Ksar-Capital) in one hand / the new city established around the airport to the north in the other hand. It is likely that mostly administrative, office, tourist and luxury residential functions that will be relocated and attracted to this new airport city.

This evolution can be interpreted as a sort of new quest for a new urban modernity. It is necessary to take the measure of the real geographical consequences of this type of urban expansion. As was previously the creation of the university in a peripheral exclave, this type of expansion is disconnected from the existing city. It is contrary to the principle of urban continuity, which shall be strengthened in Mauritania.

(2) Large-scale linear expansion towards east alongside hope road

To the east, alongside the hope route (route de l'espoir) to Boutilimit, a linear urban expansion over an extremely long distance is in progress. It seems that most of the land alongside this road to Ouad Naga (50km from Nouakchott) is already subdivided and allocated. This presupposes a colossal built-up

expansion in the near future. The urban typology that characterizes this expansion is of two radically different types: high standard large secondary villas on one hand, but also a precarious habitat built by people who cannot afford to stay in Nouakchott on the other hand.

The social dimension of this new urban growth must be taken into consideration. Public authorities should be able to propose affordable parcels or even housing (social housing policy) within the city of Nouakchott, in order to limit urban sprawl.

(3) Relocation and specialization of urban functions at the metropolitan scale

The Mauritanian government has started to implement a policy of relocating major urban functions, particularly from the center to the periphery of the agglomeration. This redistribution aims at the rationalization of the metropolitan area, as well as the decongestion of the city center. The rationalization of the urban space is based on an objective pursued of functional specialization of certain peripheral cores. For example, the PK17 project, including agricultural, commercial and livestock components, will find synergies with the Port Autonome of Nouakchott, particularly in terms of freight forwarding.

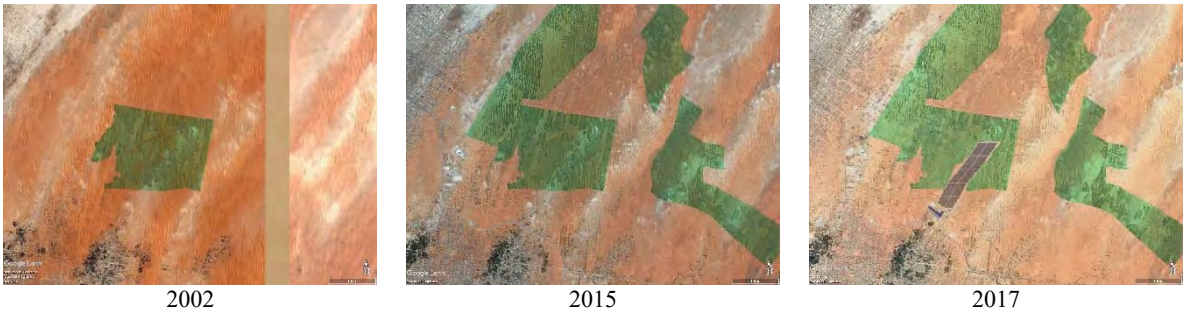
The following projects, shown in Figure 2.79 above, can be cited as examples illustrating the efforts of relocation and specialization by Mauritanian government.

- Relocation to PK17 of fruit and vegetable wholesalers, traditionally located at the Sebkha Fifth Market, which will still keep the retail market. This project will reduce the number of trucks entering downtown;
- Relocation to PK17 of Dar Naim vegetable gardens farmers. Even if the project is quite ancient, nothing has been implemented yet. Many issues remain unresolved, such as the problem of accommodation of farmer near their workplace. The vegetable gardens, located very close to city center, represent a major added value for the city of Nouakchott: that of proposing a close-distance urban agriculture which is allowing to establish short food circuits which distribute quickly the agricultural production. Once relocated to PK17, agricultural production will have to keep its urban character by proposing a rapid diffusion of its products in the urban space;
- The emergence of the Resistance industrial zone, which is welcoming more and more companies, is occupying a significant surface on the urban continuity of the Toujounine neighborhoods. The steel foundry under construction or the recently completed solar power plant are two symbolic achievements of this industrial area. The proximity of the industrial area to the dwellings should be well considered, and the appearance of slums should especially be avoided since different types of pollution and nuisances can be generated by the industries.

(4) Nouakchott green belt: between success and fragmentation

The green belt, whose initial objective is the stabilization of dunes, has also a significant effect on the urban structure of the city of Nouakchott. Indeed, it allows to set a physical limit to the city and to contain inside the urban expansion. As such, the successes in creating this green belt over the long term should be encouraged.

However, as shown in Figure 2.80 below, although the green belt has expanded significantly in recent years, its integrity is threatened, as some projects could encroach on its area, such as the solar power station built in the neighboring industrial area. The building prohibition that will be prescribed in the SDAU must be followed by a political conviction not to derogate from it.



2002 2015 2017

Source: JICA Study Team on Google Earth data

Figure 2.80: The green belt of Nouakchott between success and fragmentation (zone of the Resistance)

2.5.7 Major policies established by SDAU 2003

The *Schéma Directeur d'Aménagement Urbain de Nouakchott*, Horizon 2010-2020 (SDAU 2003) has been established by the Decree nº 2003-034 of May 22nd 2003, through the following five articles.

- Article 1 "approves and declares the SDAU to be of public utility at the horizons 2010 and 2020";
- Article 2 defines the content of the document: "The SDAU contains strategic orientations and planning principles that define the framework for the development of the city. It also includes maps which fix ring roads by its different horizons and delimit the areas to be urbanized ". This article gives an idea of the strategic nature of this document, which only gives the main orientations of urban development without going into details;
- Article 3 indicates the further steps of the city planning by explaining that "this SDAU will be supplemented by land use plans with their specifications in accordance with the regulations in force", that is to say binding urban planning documents effective on third parties;
- Article 4 informs, however, that "this decree repeals and replaces Decree No. 87.226 of 27 August 1987 approving the urban planning regulation of Nouakchott". It should be pointed out that a non-binding and general strategical plan as the SDAU replaces the only biding regulation;
- Article 5 recalls that the following ministries are responsible for the implementation of the SDAU: "The Ministry of Equipment and Transport, the Ministry of Interior, Posts and Telecommunications and the Ministry of Finance". The general strategic orientations contained in the SDAU will therefore have to be implemented by these ministries. However, the decree does not specify any precision in terms of decision-making process or responsibility.

Although this decree gives a legal status to the SDAU, it is clear from its articles that it is not complete enough to impose the SDAU as a key element in the hierarchy of urban planning norms.

There is no legal mecanism for verification of compliance of lower plan like PLU (for example) to SDAU. When a lower planning document (PLU for example) is formulated, there should be a strict mecanism that obliges the PLU plan to be in compliance with SDAU orientations. For example. if a PLU plans the opening to urban development at a place where SDAU was planning protection of farmland, there is a problem of conformity. But the conformity control is not planned in Urban Code. As a conclusion, it can be said that without this conformity control, it will be hard to implement the SDAU.

(1) Densification of formal residential area

Among the existing urban area, it is promoted to achieve higher density with respect to the formally developed areas. This aims to prevent the endress expansion of the built-up areas as well as to increase efficiency of movement within the city. The concrete method of densification is to promote the utilization of unused land parcels as shown in Figure 2.81 below. It did not promoted the higher stratification to achieve densification. The idea of trying to form a compact urban area with an appropriate density is widely shared by various stakeholders, and thus, is still an important theme in urban planning of Nouakchott.

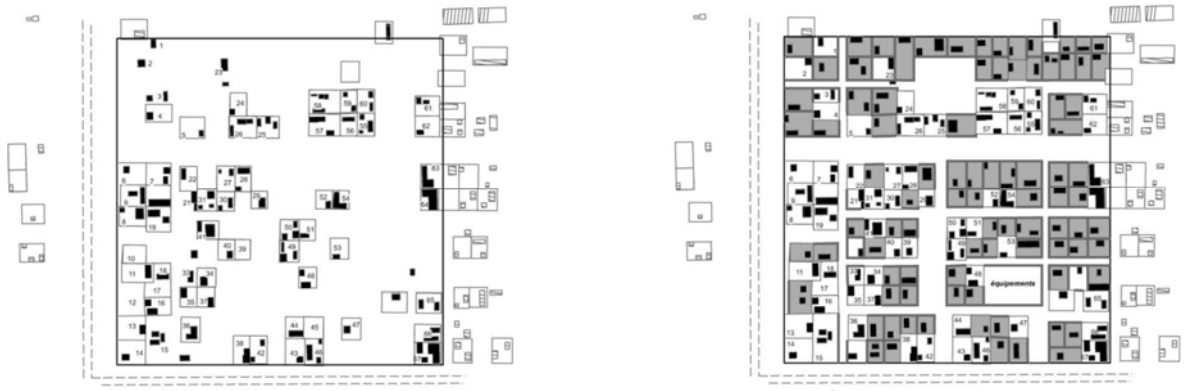


Figure 2.81: Concept of Densification Method

(2) Prevention of radial development

Based on the fact that the urban area has been formed radially along the intercity road so far, the SDAU developed the concept of Radioconcentric model which is to link stretched and separated urban areas as shown below.

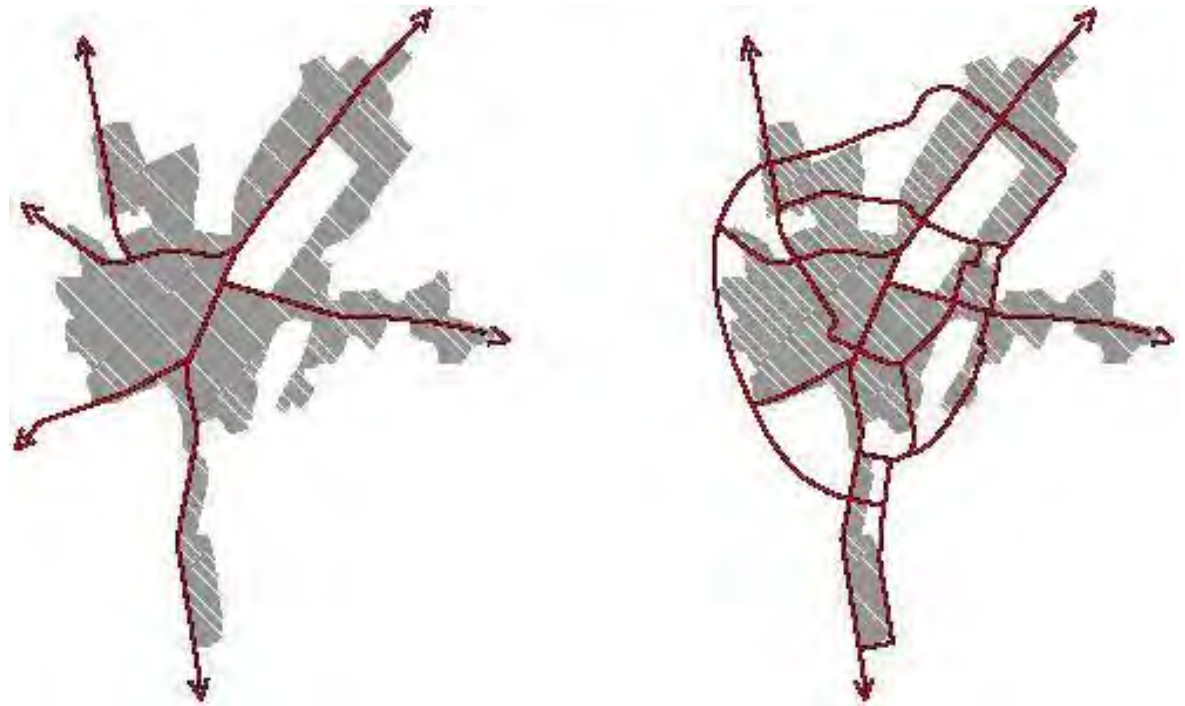


Figure 2.82: Concept of Radioconcentric Model

(3) Prevention of the formation of unplanned residence

About 100 thousand people lived in unplanned residences of the form such as Kebba and Gazra at the time but focused on preventing the formation of these residences beforehand and gradually resolving existing ones.

(4) Introduction of prohibited area for land use

A policy was set to prohibit utilization of land in areas where risk of natural disaster such as floods is high and if the existing situation is low density use. In addition, some areas are designate for environmental protection, aiming to realize the following:

- Conservation of urban agricultural districts
- Securing recreational areas
- Protection of coast
- Prevention of urbanization in districts not suitable for residence

(5) Support for promoting economic development

As a measure to support the promotion of economic development from the viewpoint of urban planning, the SDAU 2003 stated policies to secure lands suitable for economic activity by preventing illegal occupation. It also conceived projects such as construction of large-scale livestock market, improvement of fish market, development of industrial area, realization of road between Nuadibou and Nouakchott, construction of the new airport, and expansion of Nouakchott University.

In Part 3 of the SDAU 2003, it presented a map showing a framework of land use to be achieved by 2010, as shown in Figure 2.83. Apart from SDAU for 2010, concepts of planning for 2020 is also presented based on the above-mentioned basic policy of SDAU for 2010. It shows some land use categories to be expanded to sertain directions, as depicted in Figure 2.84.

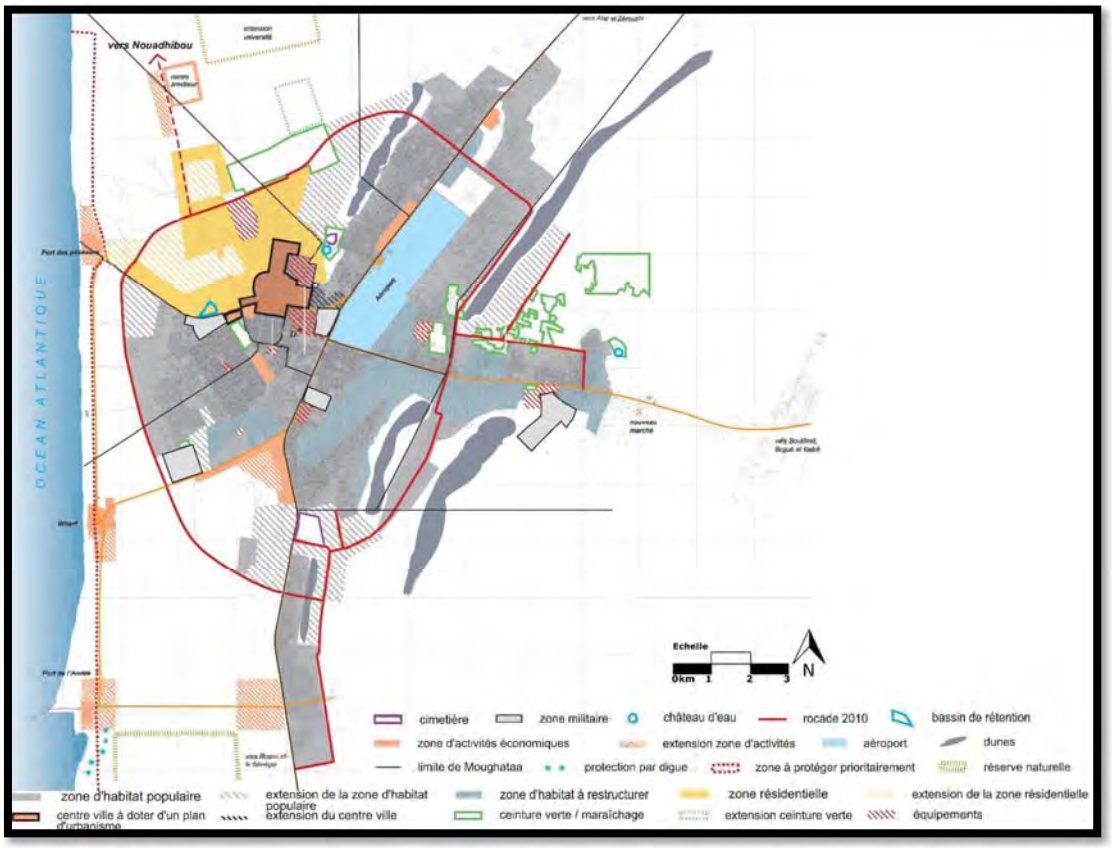


Figure 2.83: Proposed Drawing of SDAU for 2010

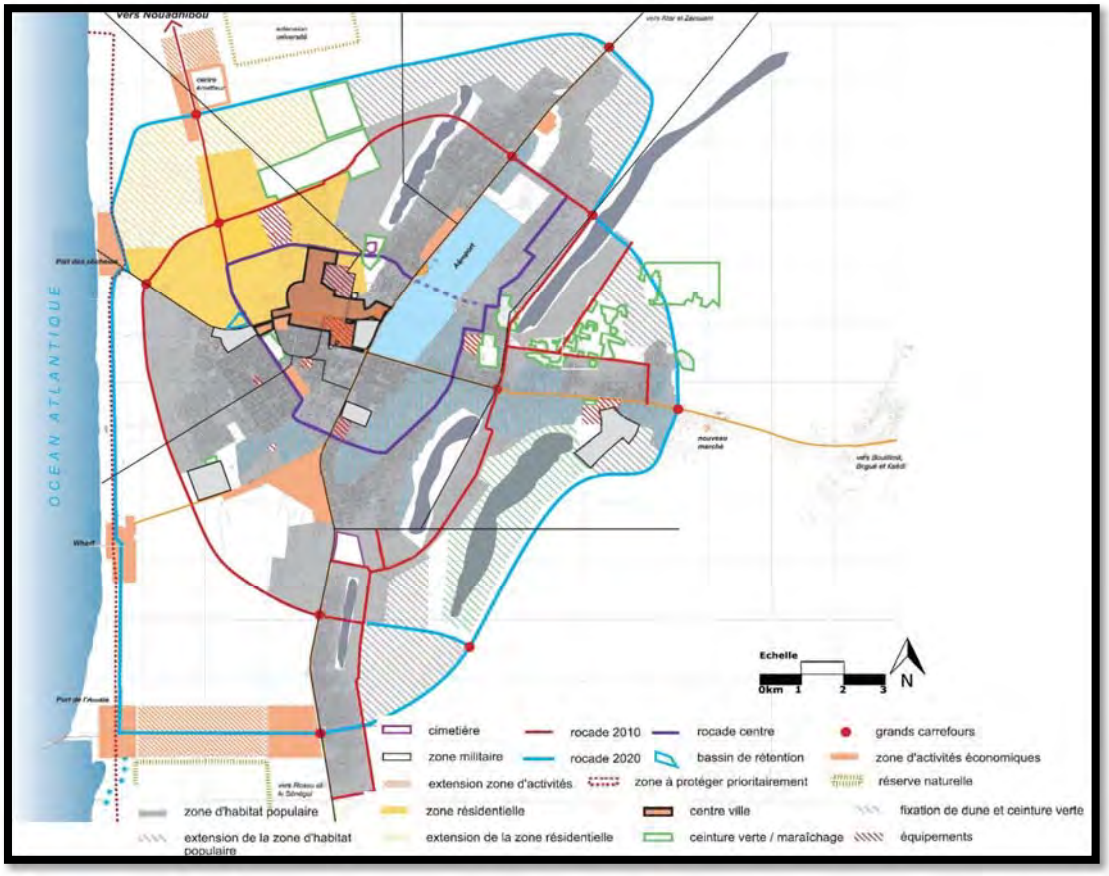


Figure 2.84: Proposed Drawing of SDAU for 2020

2.6 Opinions and Recommendations by Stakeholders

2.6.1 Recommendations from Cergy Workshop (2014)

In 2014, an urban planning workshop held in Nouakchott by "les Ateliers de Cergy" (or Cergy Workshop in English) and CUN benefited from the support of European Union, GIZ, AFD and the Embassy of France in Mauritania. It prompted more than 100 applications, from which 21 persons of different nationalities and specializations were selected to work full-time as teams from April 26 to May 9, 2014.

Cergy Workshop was at an intermediate step after the SDAU 2003 and for preparation of SDAU 2040. It was organized at a time when intense reflection on the city was needed, and in a really short time, the workshop could gather major actors of Nouakchott urban development around some key recommendation to follow for the next SDAU.

The following 12 recommendations, gathered around 3 themes, will be used as a theoretical basis for the planning of Nouakchott. They will be reviewed in detail by all the experts of the JST and especially in terms of feasibility and the results of this evaluation, in link with the results of the different surveys (social survey, traffic survey, GIS database etc.).

(1) Transform risks into opportunities
  1) In the short term, control water supply of the city
  2) In the long term, restore water place
  3) Green and fertilize the city
  4) Preserve the dunes

(2) Invent a sustainable urbanization and a planning Mauritania like
  1) Implement projects at the scale of the district
  2) Develop multi-centers
  3) Improve the mobility
  4) Develop adapted planning tools

5) Harmonize the various levels of governance

(3) Build together big projects for a capital that shines out

1) The former airport site as wonderful opportunity for eco-urbanization
2) Reinforce the identity of the capital
3) Emphasizing on the future of the coastal area

2.6.2 Recommendations by participants of the seminar

The Seminar of Consultation and Discussion on the Urban Development Master Plan (SDAU) of Nouakchott has been held on July 3 and 4, 2017. Not less than 138 participants, from the most influencing professionals of the urban sector, gathered during two days of presentations, exhibition, panel discussions and working sessions. The objective of the latter working sessions, divided into two thematic groups, was to formulate common recommendations to be studied by the team working on the elaboration of the SDAU.

The recommendations of "City Planning & Mobility" working group and "Society, living environment & sustainability" working group are shown respectively in Table 2.28 and 2.29 below.

Table 2.28: Recommendations of "City Planning & Mobility" Working Group

Sub-theme	Recommendation
Urban sprawl	Make efforts to change the mentalities of Mauritanians that "everybody wants his own plot";
	• Establish a commonly-shared and well-known physical boundary to city expansion;
	• Put an end to horizontal and linear urban expansion which hampers proper access to urban services;
	• Apply taxes to lands that are kept undeveloped deliberately (land speculation).
Housing	• Institute a law for shared ownership to develop the rental stock and thus urban densification of existing urban areas;
	• Create more diverse forms of financing of housing (home ownership accessibility);
	• Restructure remaining shantytowns;
	• Establish a cadaster system as soon as possible.
Mobility	• Put the emphasis on awareness raising regarding traffic rules, usage of road space, etc.;
	• Establish a brand new urban transportation plan for Nouakchott;
	• Develop incentives to accelerate the modal shift from private car to public transportation.
Infrastructure	• Creation of an "Agency for infrastructure management".
Cross-cutting issues	• Hold "urban management contests" between Wilayas to foster emulation and innovation throughout decision-makers;
	• Before planning to a future horizon, the SDAU shall propose how to improve existing situation of urban areas.

Source: JICA Study Team

Table 2.29: Recommendations of "Society, living environment & sustainability" Working Group

Sub-theme	Recommendation
Solid waste management	• Provide communes with the necessary means for waste management and clarify administrative boundaries;
	• Create more public or recreational open spaces in the perspective of fighting against wild dumping (the major cause of wild dumping is the existence of wastelands without any specific use);
	• Fill the missing link of waste collection in the solid waste management cycle. An option would be to rely on the fine-grained territorial mesh given by the mosques or to develop neighborhood communities ("association de quartier") for several urban services;
	• Give value to certain types of wastes that can be recycled;
	• Give specific treatment to toxic wastes (batteries etc.).
Wishes for new public spaces	• The major objectives of public places shall be recreation and relaxation, but also learning, exchanging ideas, or for scientific popularization, etc.;
	• Public, green and open spaces shall be organized so that all the citizens can have access to them: their entrance shall be free of charge, but at the same time they should be secured and well maintained;
	• Protect public lands from private or religious development (mosques for example which are often built on free lands);
	• Ensure the geographical distribution of public spaces: creation of small-scale parks throughout all the city and also in peripheral areas shall be studied;
	• Take advantage of coastal areas and ensure its accessibility as a public space at the scale of Nouakchott.
	• Mitigate public health risks generated by flooding;

Risks and vulnerability	• Enforce prohibition of sand extraction; • Construction of sanitation piping network in the whole city; • Carry out a constant monitoring of the evolution of the coastline to be able to prevent the risk of opening breach; • Struggle against silting and desertification by carrying out reforestation and greening of the city (including reinforcement of the green belt); • Establish and make respect zoning of flood-prone areas; • Take into account salinity in urban planning (zoning of urbanization areas outside salty soil areas and change of regulation regarding building materials); • Mitigate risks linked with electricity and electric network.
Other cross-cutting issues	• Make sure to enforce laws; • Strengthen citizenship which covers various kinds of issues; • Strengthen data and information sharing; • Rely on the important role of the mosques in the city; • Take into account the evolution of mentalities and urban attitudes; • Considerate what makes the modernity of the city: is it only metal and glass skyscrapers (modern appearance), or the fact of respecting rules (modern society).

Source: JICA Study Team

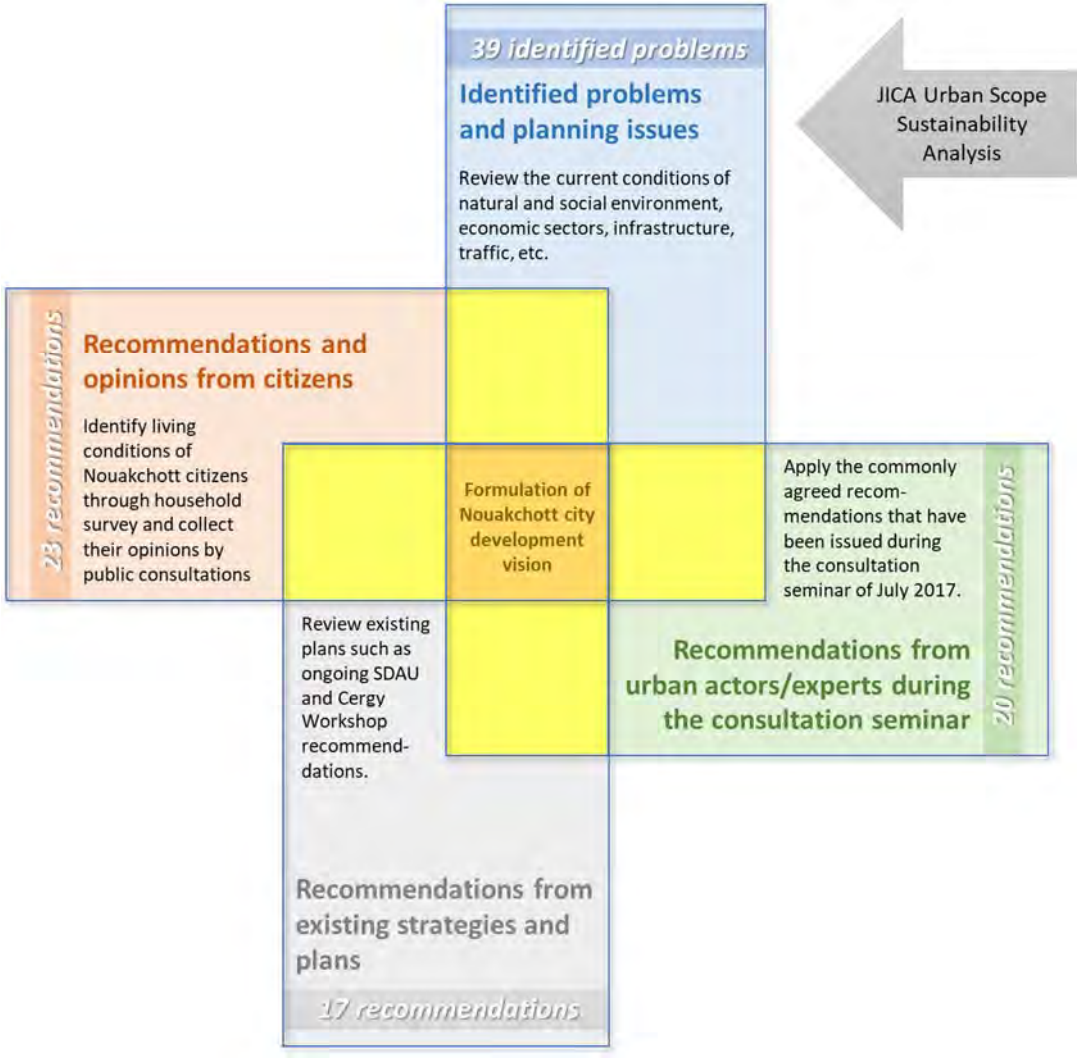
CHAPTER 3:
CONCEPTS FOR DEVELOPMENT OF NOUAKCHOTT

3.1 Identified Problems and Planning Issues to be Addressed

Development vision for Nouakchott City at horizon 2040 has been elaborated based on the analysis of 4 different components which all state about the existing situation of the Mauritanian capital.

In order to grasp the reality of the city and to propose a relevant vision for a coherent future urban development, the emphasis was put not only on expert knowledge and judgement (through review of existing strategies and plans and recommendations from the seminar), but also on the understanding of living conditions and opinions of the citizens of Nouakchott (in particular through household survey and public consultations).

The 4 analytic components and their source of information are detailed in the Figure 3.1 below.



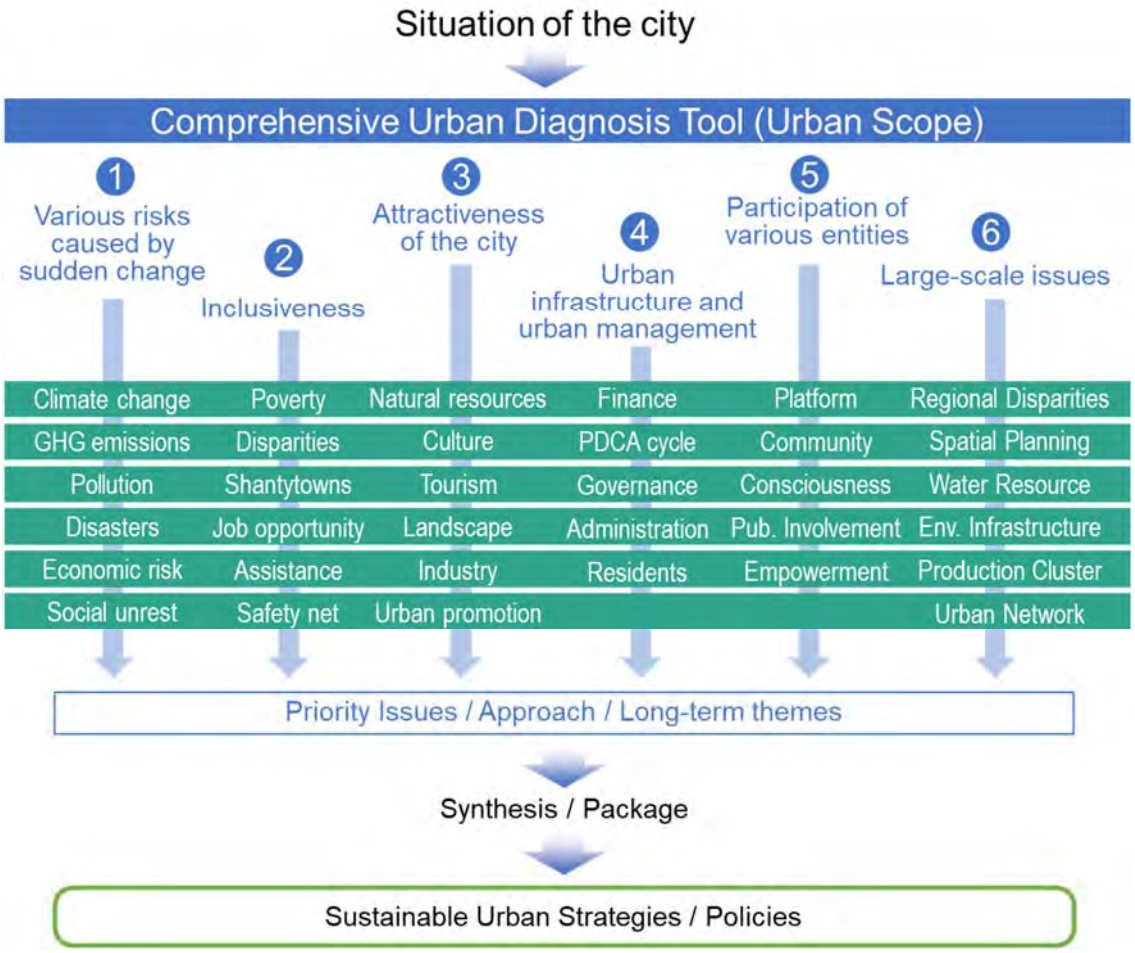
Source: JICA Study Team

Figure 3.1: The 4 Analytic Components Used to Formulate Nouakchott City Development Vision

3.1.1 Identification based on Sustainability Analysis (JICA Urban Scope)

(1) Introduction to the "Comprehensive Urban Diagnosis Tool (Urban Scope)"

The identification of problems and planning issues has been carried out based on the guidelines provided by the JICA Research on Sustainable Cities in Developing Countries ("JICA Research" hereafter). The comprehensive urban diagnosis tool, also called Urban Scope, contained in JICA Research, was followed to identify the most critical issues for sustainability of Nouakchott city.



Source: JICA

Figure 3.2: JICA Urban Scope comprehensive urban diagnostic tool

(2) Evaluation and selection of issues to be addressed

The components of the six themes of the JICA Urban Scope, shown in Figure 3.2 above, have been assessed based on their relevancy to the Study, namely to their relevancy to (1) the scope of the project: formulation of city planning (SDAU and PLU), and to (2) the situation of Nouakchott city as shown in Table 3.1 below. The issues with high relevancy on both aspects (shaded in the table) have been selected for integration as planning issues.

Table 3.1: Integration of Sustainability Issues based on JICA Urban Scope

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
1. Various risks caused by sudden change	Global environment (at the city level)	Sea level rise due to global warming	Sea level rise measurement	High	High	Yes (GE-08)	
		Frequent floods, drought, exhaustion of water resources due to climate change	Flooding damage frequency	High	High	Yes (GE-02 and 08)	JICA indicator
			Drought damage frequency	Low	High	No	No

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
	Global environment (at the global level)	Global warming	GHG emissions	High	High	Yes (EP-01)	
		Resource depletion	*No indicator*	High	High	Yes (SI-01)	
		Loss of biodiversity	*No indicator*	Low	Low	No	No
	Environ-mental pollution	Loss of natural environment	Area of green space per capita	High	High	Yes (UR-04)	JICA indicator
		Air pollution	SOx, NOx, PM 2.5 concentration	High	High	Yes (EP-01)	
		Water quality deterioration	Sewage treatment rate / BOD value of urban waters	High	High	Yes (EP-02)	Another indicator
		Waste increase, treatment method	Amount of waste per capita	Average	High	No	No
		Environmental improvement plan and operation status	*No indicator*	High	Ave-rage	No	No
	Natural disasters	Large-scale natural conditions	Disaster frequency	Average	Low	No	No
		Large-scale earthquakes, tsunamis, volcanic eruptions	Hazard map target area	High	Low	No	No
		Disaster hazard map	Flooding frequency	High	High	Yes (GE-02)	
		Disaster response manual	*No indicator*	Average	High	No	No
	Economic risk	Unbalanced industrial structure / Dependence on a single industry	Trade amount relative to GDP / Shipment value & number of employees by industry	Average	High	No	No
		Sharp declines in the domestic currency, collapse of the bubble economy, economic unease at the export destination	*No indicator*	Low	Low	No	No
		Inflation and outbreak of global economic crisis	*No indicator*	Low	Low	No	No
	Social unrest	Rapid population growth, expansion of regional disparity, urban sprawl, expansion of the gap between rich and poor	Population increase, natural increase, GINI coefficient	High	High	Yes (SE-01)	JICA indicator (GINI index)
			Percentage of shantytown population	High	High	Yes (UR-06)	JICA indicator
		Employment gap, rising unemployment rate, changes in community	Unemployment rate	Average	High	No	No
		Increase of social unrest due to regulation of freedom of speech	*No indicator*	Low	NA	No	No
		Expanding contradiction between traditional values and contemporary society	*No indicator*	Average	High	Yes at some extent (UR-04)	No

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
		Violent social change, deterioration of security, ethnic conflict, conflict due to various conflicts	Crime rate	High	High	Yes (SE-05)	JICA indicator: feeling of insecurity
	Others	Terrorism, diseases	*No indicator*	Average	Ave-rage	No	No
2. Inclusi-veness (poverty reduction/ dispari-ty correc-tion)	Situation of urban poverty	Number of poor, proportion of poor	Percentage of households below the poverty line	Average	High	Yes at some extent (SE-01)	No
		Gap between rich and poor	Gini coefficient	High	High	Yes (SE-01)	JICA indicator (GINI index)
		Distribution of shantytown area	Share of population in shantytown areas	High	High	Yes (UR-06)	JICA indicator
		Infrastructure development situation in poor areas	Urban service penetration rate in shantytowns	High	High	Yes (SI-04)	JICA indicator
	Basic human needs	Life safety	Mortality rate under 5 years old	Average	Ave-rage	No	No
			Average living area	High	High	Yes (UR-03)	JICA indicator
		Urban service penetration situation	Urban service penetration rate (water supply, sewerage, electricity)	High	High	Yes (SI-03)	JICA indicator
		Education / medical service dissemination situation	Educational penetration rate (by gender)	High	High	Yes (SF-03)	JICA indicator
			Number of hospitals / beds per 1,000 people	High	High	Yes (SF-03)	JICA indicator
	Social welfare system	Subsidies for low-income groups	*No indicator*	Low	High	No	No
		State of maintenance of social housing (for low-income people)	*No indicator*	High	Low	No	No
		Vocational training	*No indicator*	Low	Ave-rage	No	No
	Mobility	Public transport penetration situation	Public traffic share ratio / total distance	High	High	Yes (TM-03)	JICA indicator
		Traffic spending household burden	Percentage of traffic expenditure in total household expenditure	High	High	Yes (TM-03)	JICA indicator
		Subsidies to public transport management	*No indicator*	High	High	Yes (TM-03)	Other indicator
	Mutual assistance system	Traditional or historical mutual assistance system / religious system	*No indicator*	Low	High	Yes (SE-01)	No
		Presence of speech control	*No indicator*	Low	NA	No	No

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
	Socially vulnerable people	Presence of religious or ethnic conflict	*No indicator*	Low	NA	No	No
		Situation of political participation	*No indicator*	High	High	No	No
3. Attracti-veness of the city	Urban vitality	Visitors of the city	Number of tourists, business visits	Average	Low	No	No
		Situation of foreign investment	Number of foreign companies, FDI amount	High	Ave-rage	No	No
		Measures to attract foreign investment and status of operation	*No indicator*	High	Ave-rage	No	No
		Entrepreneurial environment	Production age population number / proportion	Average	Ave-rage	No	No
		Higher education institution	Number of higher education institutions and enrollment rate	High	Ave-rage	No	No
		Utilization of diverse human resources (women's social advancement)	Employment rate of women	Low	High	No	No
	History and culture	Historic heritage (temple, shrine, building etc.)	Number of historical heritage	High	Low	No	No
		Historical incident	*No indicator*	Low	Low	No	No
		Intangible cultural heritage (traditional festival, city festival event, art, etc.)	*No indicator*	Low	Low	No	No
		Historical culture preservation system	*No indicator*	High	Low	No	No
		History and culture related expenditure	*No indicator*	Low	Low	No	No
	Natural resources	Characteristic natural resources (green lands, lakes, trees, parks, etc.)	Area of green spaces and forests	High	Low	No	No
		Natural resources to be conserved (forest, green area, urban farmland etc.)	*No indicator*	High	High	Yes (UR-08)	Other indicators
		Nature conservation system	*No indicator*	High	Low	No	No
	Landscape	Characteristic urban landscape	*No indicator*	High	Low	No	No
		Traditional buildings	*No indicator*	High	Low	No	No
		Symbolic civil engineering structure	*No indicator*	High	Ave-rage	No	No
		Approach to landscape design	*No indicator*	High	Low	No	No
	Industry	Local industry, handicraft	Number of establishments by type of industry	Average	Ave-rage	No	No
		Modern industrial foundation, factory location	*No indicator*	High	High	Yes (SE-02)	No

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
		Measures to support SME	*No indicator*	Low	Ave-rage	No	No
4. Urban infrastructure and urban management that can respond to complexifying society and economy	Legal system related to urban planning and urban development	Urban planning system and scope (urban facilities, land use, etc.), operational situation	*No indicator*	High	High	Yes	No
		Development permission system and operational situation	*No indicator*	High	High	Yes	No
		Land acquisition system and operational situation	*No indicator*	High	High	Yes	No
		Land tenure system, real estate related system	*No indicator*	High	High	Yes	No
	Local government system	Progress of decentralization	*No indicator*	High	High	Yes	No
		Division of roles between the government and local governments	*No indicator*	High	High	Yes	No
		Division of roles for infrastructure development (planning, construction, financial resources, management and operation)	*No indicator*	High	High	Yes	No
	Urban finance	Independent revenue sources (local tax, bond issuance, ODA, etc.) and local allocation tax	Municipal resource revenue / expenditure per capita	High	High	Yes	No
			Percentage of local expenditure as a whole	High	High	Yes	No
			Voluntary financial share in expenditure	High	High	Yes	No
		Accounting system	Decision right of local tax	High	High	Yes	No
		Profitability of urban service business	*No indicator*	High	High	Yes	No
	Urban governance and administrative capacity	Administrative staff / personnel system	Number of staff of City Hall	High	Ave-rage	No	No
		Transparency of government, corruption / bribery case, cases of litigation	*No indicator*	High	Ave-rage	No	No
	Improvement of urban infrastructure	Basic city service penetration situation	Penetration of water supply, sewage, electricity	High	High	Yes (SI-04)	JICA indicator
		Improvement of ICT network	Internet penetration rate	Low	Ave-rage	No	No
		Urban mobility	Average commuting time, means sharing ratio, average number of trips, access time to international airport	High	High	Yes (TM-01)	JICA indicator

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
5. Participa-tion of various entities	Participation in local politics	Election system of the chief / local council members (direct election, indirect election, etc.)	Participation rate to elections	Low	Low	No	No
		Referendum, direct claim etc.	*No indicator*	High	Ave-rage	No	No
		Government expenditures on public relations	*No indicator*	Low	Low	No	No
	Framework of participation of residents	Residents' participation in urban planning process (briefing session, public comment)	*No indicator*	High	High	Yes in accompanying measures (Section 2.4.6 of Part III)	No
		Information disclosure framework	*No indicator*	Low	Low	No	No
	Resident participation at the community level	Traditional cooperation system	Number of registrated NGO	Average	Ave-rage	No	No
		Public awareness of residents	*No indicator*	Average	Ave-rage	No	No
		Community-level town development, infrastructure maintenance etc.	*No indicator*	High	High	Yes in accompanying measures (Section 2.4.6 of Part III)	No
5. Large-scale issues	Situation of national land use planning	Situation of urbanization progress, national land use planning	Urbanization rate, leading city ratio	High	Ave-rage	Yes	No
		Regional disparity (income, infrastructure development level, etc.)	Regional Gini coefficient	High	High	Yes (UR-01)	No
		Land use plan and operational status	*No indicator*	High	Ave-rage	No	No
		Regional planning system and operational status	*No indicator*	Average	Ave-rage	No	No
	Regional connectivity	Relationship between urbanized area and urban administrative area	*No indicator*	Average	High	No	No
		Relationship with surrounding cities (commuting, education, resources, transportation network)	Commuting area	High	High	Yes (UR-01)	No
	Natural condition	International rivers	*No indicator*	Low	Low	No	No
		International watershed management system and international agreement	*No indicator*	Low	Low	No	No
		Situation of regional resource availability	Regional resource availability	High	High	No	No
	Transboun-dary and regional	Transboundary human and logistic flows	*No indicator*	Average	Ave-rage	No	No

Components of JICA Urban Scope				Relevance to the Study		Integra-tion of issue	Selection of indicator
Theme	Sector	Issue to tackle	Indicator	City planning	Nouak-chott		
	transportation infrastructure	Situation of transboundary traffic infrastructure development	*No indicator*	Average	Ave-rage	No	No
		International agreement for transboundary traffic promotion	*No indicator*	Average	Ave-rage	No	No
	Regional industry	Industrial concentration in the surrounding area	*No indicator*	Low	Low	No	No
		Regional import and export, supply chain	Import / export value by major counterpart country	Low	Low	No	No
		Industrial potential	*No indicator*	Low	Low	No	No

Source: JICA and JICA Study Team

(3) Translation as criteria of SEA

As explained above, the problems with a high degree of relevance to urban planning and Nouakchott (shaded in the table) were selected for integration as a planning issue. As sustainable urban development issues adapted to the context of Nouakchott, they are selected to form the basis of the elaboration of the criteria of the Strategic Environmental Assessment (SEA), which will be used later to compare the development alternatives (see Section 3.3.4). Thus, the latter can be evaluated on the basis of the principles of sustainable development, in order to choose the most sustainable solution. There are 8 of them, the criteria for SEA are as follows.

1. Climate change (at the local level) - vulnerability to floods
2. Climate change (globally) - GHG emissions
3. Natural environment - green and wooded areas
4. Environmental pollution - deterioration of water quality
5. Inclusiveness - social disparities, precarious housing and solidarity
6. Inclusiveness - basic human needs
7. Inclusiveness - mobility
8. Urban Infrastructure - Improving Urban Infrastructure

(4) Selection of priority performance indicators for urban sustainability in Nouakchott

Regarding selection of indicators proposed by JICA Urban Scope, due to the lack of data in Mauritania, most of quantitative indicators could not be considered. Nevertheless, some other indicators, more relevant to the context, have been proposed (refer to the Monitoring Section).

3.1.2 Results of problems and planning issues identification

From the analyses in Chapter 2, the following problems were extracted. Urban development issues to be addressed in the SDAU for each problem are briefly described in Table 3.2 below.

A total of 39 problems, classified in 8 different themes, have been identified.

Table 3.2: Identified Problems, Planning Issues and Implication in City Planning

Category	Identified Problem	Planning Issues	Implication / Solutions in City Planning [reference to Strategic Orientation]
Global Environment and Vulne-rability to Disaster (GE)	GE-01: Hot desertic climate	• Hot weather makes walking / biking throughout the city difficult • Usage of public space by day time is limited • Making of the city (urban development and urban planning) shall consider specific climatic aspects (heat,	• Create a green network to allow walking / biking in cooler conditions [2.3] • Create more green spaces to cool down the general temperature of the city [2.1, 3, 4 & 5] • Consider shadow in designing public spaces [R]

	GE-02: Frequent flooding on large area	• From the viewpoint of the city, frequent flooding hinders smooth running of the city (transportation, social services, infrastructure) thus represents a major economic loss • From the viewpoint of the citizen, frequent flooding implies costly damage and resettlement, social conflicts and public health problems	• Control urban development in areas at risk of flooding by conditional construction [1.1.2] • Restructure and adapt buildings already located in flooding area [1.1.4] • Relocate social services (schools, hospitals etc.) located in flooding area • Pursue the efforts of large-scale drainage facilities construction
	GE-03: Stagnant water on low land areas	• Stagnant water ponds where gather all types of toxic effluents represent major risks to public health • Rehabilitation of stagnant water ponds shall consider both public accessibility and public health (mosquito hatching etc.)	• Promote change of land use of stagnant water ponds into local green areas [2.5.2] • Pursue the efforts of pumping and drainage facilities construction
	GE-04: Erosion of coastal dune and shoreline	• Breach in coastal dune aggravates the risk of flooding due to sea incursion • Urbanization of shoreline leads to modification of sediment distribution and threatens the integrity of human settlements inside the city	• Restrict new construction on the shoreline [2.2] • Promote shoreline as a major recreation area for the whole city while ensure protection of the dune [2.2] • Promote beach accessibility by soft modes of transportation (Rapid Transit to walk) [2.2] • Pursue the efforts of conservation of the coastal dune integrity
	GE-05: Silting threatening a part of the city	• Silting in the city area hinders smooth operation of urban services, and especially water supply and sanitation • Progression of dunes in the city implies important costs of sand removing in the streets by technical services	• Strengthening green belt efforts [2.1] • Greening the city to reduce wind velocity and sand drifts and increase soil moisture [2.1, 3, 4 & 5]
	GE-06: Salty soils (sebkhas)	• Building concrete is attacked by salt threatening the durability of the houses and public facilities • Majority of neighborhood built on sebkhas is already abandoned, causing public health problems (waste dump)	• Strongly prohibit construction in high flooding areas of sebkhas [1.1.1] • Restructuration of abandoned areas located on salty low lands of sebkhas [1.2.1]
	GE-07: Rise of underground water table	• Densification of urban area and provision of drinkable water and sanitation services in a concentrated area shall be performed carefully and with control	• Strongly prohibit construction in areas where underground water table is rising [1.1.1] • Plant trees in parks and green network to absorb rain water and shallow underground water to make the water table level decrease [2.3] • Pursue efforts of rain water drainage improvement
	GE-08: Climate change aggravating vulnerability	• Prepare the city to the worst scenario of climate change (sea level rise, global warming, increase of rain and wind intensity)	• Pursue efforts of adaptation of the city form to disaster risks
Environmental Pollution (EP)	EP-01: Natural and anthropic air pollution	• Nouakchott has natural air pollution from suspended particles due to sand and dust storms • Low GHG emission urbanization patterns and transportation models are prioritized	• Pursue pavement of roads, greening of the city and planting of green belt to increase resilience to sand and dust pollution • Articulate urban development and urban renewal with public

		• Further increase of car traffic amount by road infrastructure construction shall be controlled carefully	transport to create a compact and polarized city [1.2] • Promote walkability and bikeability to decrease car dependence by strategically intensifying urban fabric [1.1] and designing green network [2.3]
	EP-02: Water and soil contamination	• Water and soil contamination, alongside with increase of rain and stagnant water, creates a major public health risk to dense urban areas especially appearance of diarrhea in local commercial (market) areas • Densification of urban areas shall be performed carefully and based on strict sanitary standards	• Detail plans (PLU) shall organize land use through a perspective of public sanitary and especially shall operate a redistribution of commercial land use (markets) in low risk areas throughout the city • Pursue efforts of improvement of rain water drainage and sanitation environment
Socio-economic Situation (SE)	SE-01: Large urban poverty and income gap	• Poverty is important in terms of proportion of poor inhabitants and of seriousness of poverty • Social disparities created by income gap is an obstacle to the realization of harmony in the city • Traditional social safety nets and solidarity shall be preserved	• Promote and secure economic poles radiating at the metropolitan level [3.1] • Promote social mix and territorial balance by ensuring resettlement and affordable housing [1.4]
	SE-02: Mostly informal and weak economic sectors	• Solidification of all economic sectors, including industry, with increase of added-value through facilitation of economic activity in the urban environment • Structuration and formalization of economic sectors while keeping a tolerance for necessary informal sector in the urban environment	• Support economic growth through redefined sectoral poles and private investment [3.3] • Promote diversification of activities and jobs [3.5] • Detail plans (PLU) shall organize land use for promotion of formal economy sectors but shall also give a tolerance for more mixed and informal uses
	SE-03: Geographically unbalanced employment pools	• Concentration of jobs in city center generates a dual city with spatial discrimination • Urban environment shall favor job opportunity creation at the most fine-grained scale possible	• Promote the development of secondary mixed-use poles throughout the city in link with public transportation [1.3] • Optimize land use to introduce business activities and non-polluting small industries within residential urban fabric [3.4.1]
	SE-04: Degraded human health situation	• Urbanization patterns and transportation models, since they impact directly consumption habits and thus human health, shall be focused towards more regular physical activity	• Promote walkability and bikeability of the city to motivate physical activity by strategically intensifying urban fabric towards compact city [1.1] and by designing green and blue internal network [2.3]
	SE-05: Unstable security and feeling of unsafety	• Concentration of political power including foreign embassies in central district with important road accessibility makes the city vulnerable to terrorist attack • Feeling of unsafety shall be tackled through the establishment of socially and culturally inclusive environment	• Promote the rationalization of land uses towards more security, especially through the redistribution of political and administrative functions in dedicated metropolitan level cores (airport city administrative pole) [3.1] • Promote the multiplication of small scale public and green spaces [2.5] • Ensure a high and appropriate level of security in public and green spaces [2.7]

Urban Environment and Land Use (UR)	UR-01: An isolated position of Nouakchott in the regional context	• Nouakchott is an attractive economic magnet for rural population from hinterland. • Urban growth of Nouakchott outside its administrative area and re-balance with other cities in Mauritania shall be well considered	• Promote the setting of urban growth boundary in Nouakchott city • Ensure the balance of settlements at the regional scale • Establish Nouakchott as a hub at the regional scale
	UR-02: Uncontrolled and inequitable urban sprawl	• Urban sprawl is driven by the whole scope of economic realities through both survival occupation (*kebbe*) and land speculation (*gazra*). • Urban sprawl leads to the production of living environment deprived of services, jobs and infrastructures, and at risk of natural disaster • Discontinuous urban development leads to the extension of commuting times, partition of the city and to threatening of population unity	• Prohibit and control urbanization in risk areas especially flooding areas and outside ring road [1.1] • Articulate urban development with public transport to create a compact a polarized city [1.3] • Polarize urban extensions [1.5] • Pursue efforts for strong urban growth control
	UR-03: Low density of urban fabric	• Relatively large living area of individual houses is often pointed out as the main reason for low density of urban fabric • Nevertheless, there are other reasons for low density rather than living area: low occupancy rate of residential areas, only 30% of the urban area is built-up, lack of rational use of lands, disordered parking etc.	• Ensure limited land consumption by operating densification, regeneration and polarization of the urban area while ensuring the largest living area possible [1.2] • Promote various types of housing offer (rental/ shared ownership/ accessible home ownership, social housing/ high standing)
	UR-04: Influence of nomad culture and tradition	• Explaining some behaviors and for example driving habits, influence of nomad culture is still vivid in Nouakchott. • Values of nomads include freedom of movement and settlement on free and large spaces. • One symbol of Bedouin hospitality is the *khaima* (tent) which can be still be found throughout the city.	• Promote urbanization patterns and mobility policies that respect nomad culture and tradition • Preserve existing residential density and housing largeness • Introduce high level of public transportation service
	UR-05: Spontaneous and disordered land use	• Domestic breeding of goats and donkey is still practiced and leads to traffic obstruction, garbage eating, damaging green spaces. • Open spaces are used as garbage dumping sites. • Irrational land use and occupation of public roads shall be improved while not hindering economic and social activity.	• Detail plans (PLU) shall organize land use through a perspective of order and public sanitary • Design attractive and well managed green spaces in order to avoid garbage dumping in open spaces
	UR-06: Remaining shantytown area to address	• Shantytowns are generally erected in the most strategic places of the city: in the middle of dense areas, in proximity of working places (port, construction sites etc.), thus is represent an important potential for redevelopment, but at the same time relocation shall be carried out carefully to avoid moving the problem • Historical shantytowns evolved as proper urban entity and recent	• Promote in-situ consolidation and upgrade of ancient shantytowns [1.2.2] • Promote resettlement and relocation for newly formed slum pockets for strategic redevelopment towards common interest [1.2.4] • Explore innovate mechanisms to finance shantytown renovation by assistance of private sector

		slum pockets shall be considered separately • Traditionally shantytown settled on large areas, but some "slum pockets" can be still be find in interstitial spaces in rich neighborhoods	
	UR-07: Lack of green and public spaces	• Showing low density and lack of quality public spaces, Nouakchott is characterized by little invested interstitial spaces conducive to wild waste dumping • Creation of green and public spaces is an opportunity to struggle against various environmental problems, foster walkability and rationalize urban environment alongside intensification policies	• Foster the multiplication of small scale public and green spaces in the urban fabric by promoting change of land use of stagnant water ponds and former agriculture fields [2.5] • Support the establishment of nature in the city with major green poles [2.4]
	UR-08: Agricultural lands of uncertain future	• The important role of agricultural lands as a food source for the city shall be maintained in Nouakchott • Former agricultural lands shall be reallocated in priority to strategic urban development or conservation as open and recreational space	• Accompany the transition of urban agriculture from ancient Toujounine gardens to the establishment of the agricultural green belt in link with PK17 project [3.1]
Land Tenure Scheme (LT)	LT-01: Land speculation and illegal settlement	• Land speculation, only practiced by a handful of investors, is still vivid in Nouakchott, and leads to a continuous urban sprawl	• Pursue efforts for strong urban growth control • Establishment of a formal land market
	LT-02: Attachment to land property and lack of tenancy alternatives	• Attachment to land property and lack of tenancy alternatives reinforce the predominance of individual housing in the urban fabrics and urban sprawl	• Foster a law authorizing condominium ownership • Establish homeownership assistance program • Organize qualitative private rental offer targeting all social classes including middle classes • Promote social rental offer
	LT-03: Difficult securing of public lands	• Communes does not have any right on land. This situation hampers the process of decentralization and the responsibility of the commune in the planning and management of their own administrative space	• Simplify land request procedure from the commune to the State • Promote communication and coordination between State services and communes
Transport and Mobility (TM)	TM-01: Road traffic, congestion and road typology	• All the traffic passes through the city center, which suffers from serious traffic congestion • There are still many unpaved roads throughout the city	• Divert the unnecessary car trips in the city center by promoting bypass roads and ring roads • Pursue the paving of roads in all parts of the city
	TM-02: Low motorization rate	• A large proportion of the population is isolated in its neighborhood and cannot access to metropolitan services and jobs • Motorization rate increase shall be controlled towards the realization of NMT based city	• Propose affordable public transportation solutions • Promote the model of compact city in order to gather population and services and thus be less dependent of transportation
	TM-03: Limited public transportation system	• Almost not any public transportation, except for students, is established currently in Nouakchott, leading to a low transportation penetration rate	• Promote modal shift from private car to public transportation • Articulate urban development with public transport [1.3]
	TM-04: Disordered parking habits	• Parking space formalization and change of parking habits may constitute a cheap and soft way of resolving lack of public space and densification of urban fabric • Urbanization patterns shall be reoriented towards the use of the	• Limit parking space in central areas ("Heart of the city" zone) in order to clear space for public usage and encourage use of public transportation [1.2.3] • Reorganize parking lots in priority in the vicinity of Rapid

		city by all citizens and not only by car users	Transit nodes to encourage modal shift [1.3.5]
	TM-05: Difficult traffic management	• Risky driving behaviors such as over-taking and counter flowing are frequent in Nouakchott • There were many roadside frictions that disturb the smooth car flow in the streets	• Improve traffic safety and parking management • Formulate the urban space for NMT users
Urban Services and Infrastructures (SI)	SI-01: Water source to secure	• Water resources for the city of Nouakchott are secured until the horizon of the SDAU, but sustainable settlement on longer term seems compromised	• Promote the expansion of capacity of water source at the appropriate time based on the capacities of the groundwater source and surface water source
	SI-02: Lack of integrated urban water management	• Wastewater treatment and sewage capacity is not sufficient regarding the needs of urban population, thus population discharge in open pits • In parallel, the amount of potable water supplied has increased radically, aggravating wastewater discharge in the subsoil	• Promote integrated and balanced urban water management system
	SI-03: Infrastructure penetration coverage is weak and unequal	• Water supply distribution is geographically unequal (pipe network, donkey cart, etc.) in terms of water tariff and water quality • Sewerage network only covers a small proportion of the city	• Pursue the extension of all utilities networks to cover the city the most equally possible • Ensure the affordability of urban services and connection to urban infrastructures
	SI-04: Infrastructure deprived areas cumulates problems	• Infrastructure deprivation leads to the cumulation of important social unrest (more expensive water tariff etc.) and environmental degradation (water contamination by sewage discharge etc.)	• Zones of infrastructure deprivation, in particular shantytowns, shall be part of financially supported improvement and renovation programs
	SI-05: Infrastructure is not functioning properly	• Water supply distribution system suffers important leaks leading to overflow of drinking water in the network • Sanitation system suffers multiple malfunctions of the mechanical equipment, lack of maintenance of network structure, breakdown of water pumps to the presence of sand and debris coming from garbage dumped in the city	• Improve the functioning of urban infrastructure features while limiting various environmental problems (silting) and anthropic input (wild garbage dumping) which would affect their smooth operation
Social Services and Public Facilities (PS)	SF-01: Shortage of land for public facilities	• State reserved land planned for public facilities, being often replaced by another land use, shall be secured • Necessary large-scale land opportunities shall be secured as early as possible in the outskirts of the city	• Ensure the rationalization of land use and the securitization of public land reserves • Promote city entrance as Metropolitan Gateways to provide large-scale public facilities to the city [1.6]
	SF-02: Service quality does not match the needs of citizens	• Public facilities especially in the educational field suffer the competition from private institutions and cannot provide enough quality to citizens	• Promote quality schools, health centers and other cultural amenities in the Mauritanian capital city
	SF-03: Service capacity and penetration coverage is unequal	• There is a lack of health and education facilities in some dense residential neighborhoods, while other parts of the city are well equipped	• Ensure the respect of localization norms of public facilities and construct schools and health points where needed

Source: JICA Study Team

3.1.3 Cumulative problems and crossover issues

The problems and planning issues mentioned above were compile sector by sector in order to make the most comprehensive list possible of all the conditions and problems that Nouakchott city has to tackle. However, in reality, natural and anthropic issues are interlocked and combined and produce complex problems that has to be approached from a crossover perspective.

The Table 3.3 below shows some of the major combined and crossover issues to be dealt with in planning the city of Nouakchott.

Table 3.3: Identified Problems, Planning Issues and Implication in City Planning

Cumulative / Crossover issue	Factor 1	Factor 2	Factor 3	Factor 4
Low lands suffer from high afflux of water which provoke soil impermeability and remaining of stagnant water	GE-04: Erosion of coastal dune and shoreline (risk of sea incursion)	GE-08: Climate change aggravating vulnerability (risk of increase of rain intensity and frequency)	GE-07: Rise of underground water table (sea level rise linked to water table by capillarity)	SI-02: Lack of integrated urban water management (too much provided drinking water and no sewage results in discharge in soils)
Disease such as diarrhea is leading to death of children in poor and dense residential areas (contamination of fruits in the market)	SI-03: Infrastructure penetration coverage is weak and unequal (no collective sanitation leads to discharge in open pits)	GE-03: Stagnant water on low land areas (due to impermeability of soils)	EP-02: Water and soil contamination (stagnant water is contaminated by different sources: discharge, slaughterhouses etc.)	-
Citizens are not willing to walk through the city	SE-05: Unstable security and feeling of unsafety	UR-04: Lack of green and public spaces	GE-01: Hot desertic climate	-
Difficult access to jobs and isolation of poor population in the suburbs	SE-03: Geographically unbalanced employment pools (concentration of jobs in the center)	TM-02: Low motorization rate	TM-03: Limited public transportation system	-
Invasion of sands and debris sinking piping infrastructure and leading to misfunction	GE-05: Silting threatening a part of the city	TM-01: Road typology (lot of remaining sand roads)	UR-04: Spontaneous and disordered land use (open spaces used as dumping sites)	SI-05: Infrastructure is not functioning properly (insufficient maintenance)
Urban sprawl and resistance to densification is a rooted problem.	LT-01: Land speculation (land to make profit, most valuable asset or heritage)	LT-02: Attachment to land property and lack of tenancy alternatives (lack of condominium law)	UR-03: Influence of nomad culture and tradition (always finding a new virgin place)	-

Source: JICA Study Team

3.1.4 Recommended to consider at formulation of development concepts

Alongside the objective observation of the reality of problems occurring in Nouakchott, the planning process of SDAU is supported by 3 major types and sources of recommendations, namely (1) the recommendations from existing strategies and plans, (2) the recommendations and opinions from citizens based on household survey results and public consultation, and (3) the recommendations from urban actors and experts collected during the consultation seminar of July 2017. The total of 60 recommendations are shown in Table 3.4 below.

Table 3.4: List of existing development issues and opinions of the 4 analytic components

Analytic Component	Sub-Category	ID	Development Issue and Opinion
Recommenda-tions from existing upper	SDAU 2003 (SD)	SD-01	Densify formal neighborhoods
		SD-02	Stop the radial development of the city
		SD-03	Upgrade, reorganize and equip informal settlements

level strategies and plans		SD-04	Prohibit development on unsuitable areas and protect environment
		SD-05	Promote economic growth
	Cergy Workshop 2014 (CW)	CW-01	In the short term, control water supply of the city
		CW-02	In the long term, restore water place
		CW-03	Green and fertilize the city
		CW-04	Preserve the dunes
		CW-05	Implement projects at the scale of the district
		CW-06	Develop multi‐polar structure
		CW-07	Improve mobility
		CW-08	Develop adapted planning tools
		CW-09	Harmonize the various levels of governance
		CW-10	Redevelop former airport site as eco‐town
		CW-11	Reinforce the identity of the capital city
		CW-12	Emphasizing on the future of the coastal area
Recommenda-tions and opinions from citizens	Main results of household survey (HS)	HS-01	New settlements not only in suburbs but also within existing urban area
		HS-02	Traditional aversion to collective housing (apartment) tends to reduce
		HS-03	Wealthy households coexist with poorest households
		HS-04	Precarious settlements are still existing
		HS-05	Inequality regarding access to social services
		HS-06	Inequality regarding access to urban infrastructure
		HS-07	Inequality regarding mobility (low motorization rate and lack of public transportation)
		HS-08	Social peace, solidarity and religion as main pillars of Nouakchott society
	Opinions from Nouak-chott citizens through public consul-tation (PC)	PC-01	Struggle against pollution
		PC-02	New public spaces
		PC-03	A better society
		PC-04	Coherent and functional urbanism
		PC-05	Mitigate vulnerability to natural hazards
		PC-06	Operational sewerage network
		PC-07	Improve mobility
		PC-08	Improve housing
		PC-09	Improve public health
		PC-10	Access to water and electricity
		PC-11	A modern and attractive capital city
		PC-12	Consolidate spatial balance and diversity
		PC-13	Ensure the security of urban areas
		PC-14	Consider density at the human-scale
		PC-15	Get the city prepared for high public mobility
Recommen-dations from urban actors and experts during	Recom-mendation from “City Planning &	RS-01	Make change the attachment to land ownership
		RS-02	Establish a physical boundary to the city
		RS-03	Put an end to horizontal and linear urban expansion

consultation seminar (RS)	Mobility" Working Group	RS-04	Limit land speculation and tax lands kept undeveloped deliberately
		RS-05	Promote shared ownership (condo) to develop rental stock and densification
		RS-06	Create more diverse forms of financing of housing (home ownership accessibility)
		RS-07	Restructure remaining shantytowns
		RS-08	Raise awareness regarding mobility: traffic rules, usage of road space, etc.
		RS-09	Promote modal shift from private car to public transportation
		RS-10	Hold "urban management contests" between Wilayas to foster innovation
		RS-11	SDAU shall propose how to improve existing situation of urban areas
	Recom-mendation from "Society, living environ-ment & sustaina-bility" Working Group	RS-12	Create more public or recreational open spaces well distributed in the city
		RS-13	Promote the coastline as a large‐scale public space
		RS-14	Fill the missing link of waste collection in the solid waste management cycle
		RS-15	Mitigate public health risks generated by flooding
		RS-16	Struggle against silting by carrying out reforestation and greening
		RS-17	Establish and make respect zoning of flood‐prone areas
		RS-18	Take into account salinity in urban planning
		RS-19	Mitigate risks linked with electricity and electric network
		RS-20	Rely on the important role of the mosques in the city

Source: JICA Study Team

3.1.5 Grouping of problems and recommendations into priority planning themes

Identified problems and recommendations cannot be merged but they can be grouped into priority planning issues, as detailed in the Table 3.5 below.

Table 3.5: Grouping of Problems and Recommendations into Priority Planning Themes

	Priority Planning Theme	Identified Problem	Recommendations
1	Densification and limitation of urban sprawl	UR-02, UR-03	SD-01, SD-02, HS-01, HS-02, PC-14, RS-02, RS-03,
2	Shantytowns restructuration	UR-06	SD-03, HS-04, RS-07
3	Mobility improvement	TM-01~05	CW-07, HS-07, PC-07, PC-15, RS-08, RS-09
4	Green and public spaces	UR-07, UR-08	CW-03, PC-02, RS-12
5	Coastline promotion	GE-04	CW-12, RS-13
6	Mitigate environmental vulnerability	GE-01~08	SD-04, CW-01, CW-02, CW-04, PC-05, RS-16, RS-17, RS-18
7	Improve public health and depollute	EP-01, EP-02, SE-04	PC-01, PC-09, RS-15
8	Improve access to social and urban services	LT-03, SI-02~05, PS-01~03	HS-05, HS-06, PC-06, PC-10, RS-14
9	Unify the society	SE-03, SE-05	CW-06, HS-03, PC-03, PC-12, RS-20
10	Consider cultural and religious background	UR-04	HS-08, RS-20
11	Promote economic growth	SE-01, SE-02, UR-08	SD-05
12	Reinforce the identity of a capital city	UR-01	CW-11, PC-11
13	Improve urban planning governance	UR-05	CW-05, CW-08, CW-09, PC-04, RS-04, RS-10

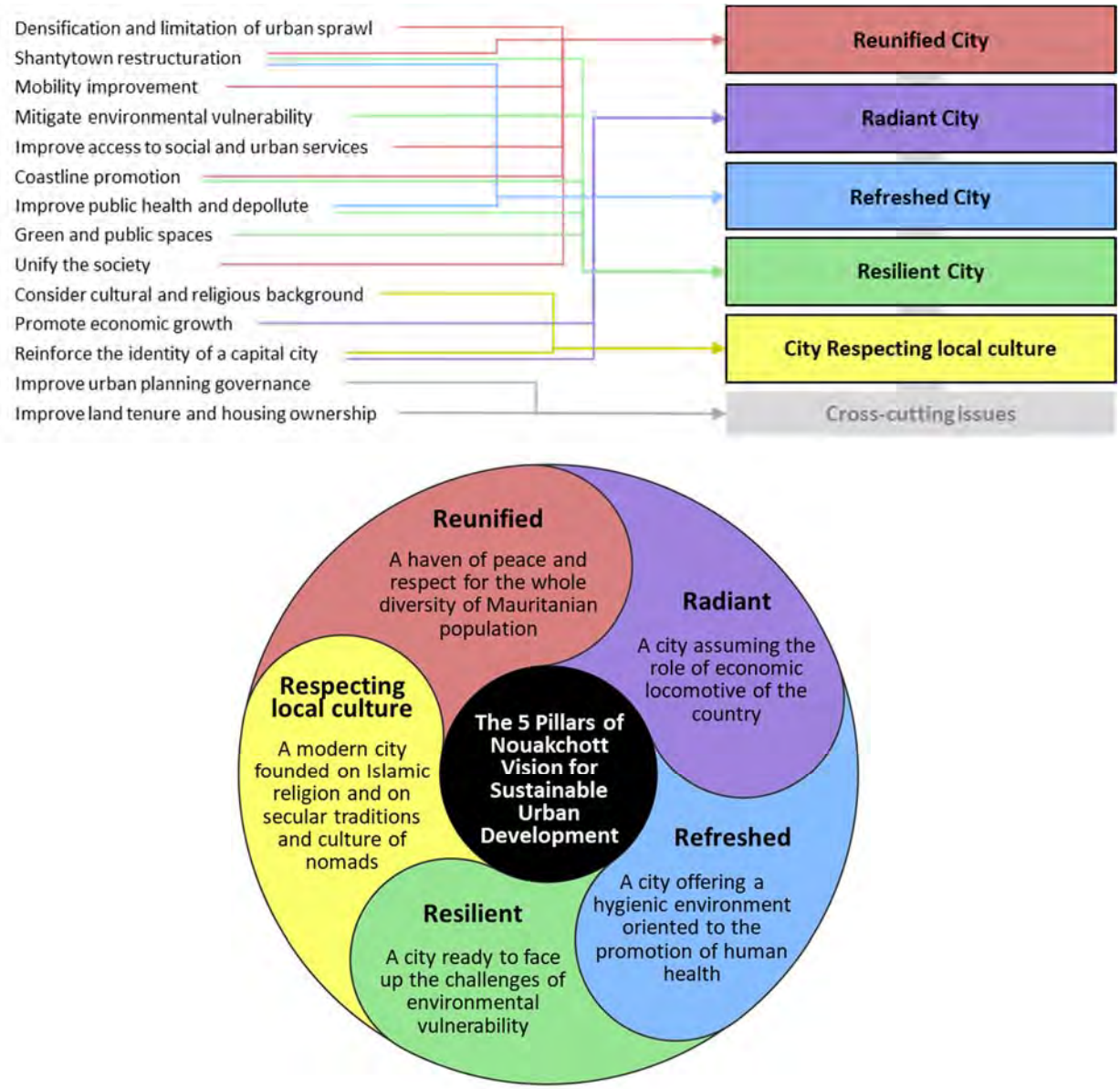
14	Improve land tenure and housing ownership	LT-01, LT-02	PC-08, RS-01, RS-05, RS-06

Source: JICA Study Team

3.2 Development Concepts

3.2.1 Basic policy for development of Nouakchott

It was discovered at the analysis of priority planning issues that it is not sufficient to cope with these issues by only focusing on the three ordinary pillars which seeks balance of economic, living, and natural environment. In Nouakchott, there is a need to focus on sanitary and health issues as well as consideration of Islamic religion and nomadic traditions and culture. Thus five pillars are introduced as basic policies for development of Nouakchott covering all the 14 priority issues as shown in Figure 3.3 below.



Source: JICA Study Team

Figure 3.3: Five-R Pillars for Development of Nouakchott City

All the propositions given in land use plan (Section 4.4) and sectoral development plans (Chapters 5 to 7) of the SDAU set foundation on thefive pillars (5 "R") as basic policy for development of Nouakchott. Elements of the "5-R" are described below.

Radiant: Nouakchott is an international gateway assuming the role of economic locomotive of the country;

Resilient:	Nouakchott is ready to face up the challenges of environmental vulnerability;
Reunified:	Nouakchott is a haven of peace and respect for the whole diversity of the Mauritanian population;
Refreshed:	Nouakchott offers a hygienic environment without diseases, where human health is promoted;
Respecting nomad culture:	Nouakchott is a modern city founded on Islamic religion and on secular traditions and culture of nomads.

3.2.2 Elaboration of basic concepts for Nouakchott Development

(1) Goals of Nouakchott in wider context

Although it is expressed in the public consultations and seminar discussions that people puts more importance on improvement of the existing conditions of the city, development of Nouakchott city needs to contribute achieving national policies as a capital city of Mauritania, Potential and expected role of Nouakchott in wider contexts are itemized below as a goal of the development of the city, based on the discussion in wider gio-economic context (Section 2.1) as well as upper policies of macro-economic development (Sub-section 2.3.6). These goals need to be achieved as an effect of solving the city's own problems through 5-R pillars..

1) Role of Nouakchott in West Africa and beyond

- ✧ Although Mauritania is one of the members states of the Arab Maghreb Association (AMU), the cooperation treaty's application is limited.
  - ➢ There is room to be active in the Association, although cultural and tourism exchanges are more promising than manufacturing and trade. Nouakchott needs to be established as a **major gateway of the country**.
- ✧ Trade with member states of the West African Economic Community (ECOWAS) is more active than that in AMU
  - ➢ There is a chance to promote not only resource trade but also agricultural products and handicrafts. Nouakchott needs to be function as a **market to provide foundation of agricultural and handicraft activities**.
- ✧ Mauritanians are active in commercial services all over Africa. Transmission of funding from them is and continue to be the source of consumption based economy in the capital.
  - ➢ There is a chance to transform Nouakchott as a **leading service and commerce center in the region**.

2) Role of Nouakchott in Mauritania

- ✧ Historically an emergency safety base for the population of the country
  - ➢ Maintaining the function of the **emergency safety base**, along with national efforts to strengthen economy and public services in other cities and rural areas.
- ✧ Continue to be political, administrative, economic center of Mauritania
  - ➢ Enhance the role of the **locomotive of national economic development**. As a consumption-led economy, contribution to promoting import substitution industry and suburban agriculture will be the key.
- ✧ International passenger gateway to the country
  - ➢ Holds important role in the national tourism development strategy, as a **face of Mauritania**.

(2) Elaboration of the Theme of Nouakchott development

The basic theme of Nouakchott development was elaborated through a series of discussion especially among the Task Force members and the JICA Study Team, which extended to various aspects of the city. These include history, nature, culture, economy, physical issues, social vulnerability, and responsibility to the global issues.

Several key words were identified during the discussion meetings as iconic highlights of the issues the city has to address. These key words are as follows:

Sand and Water:

Are the primary elements the city stands on. Both of them are subjects to overcome in the history of the city, but also the symbol of the city which formed the life style and culture of the citizens. These have potential to enhance locating tourists and thus should be treated as precious resource of the city, A new idea to integrate these elements are to connect by green network and urban primary corridor.

Service and Commerce:

Are the fundamental economic activities of the city and will continue to be the locomotive of the economic development of the city and the country as a whole. The success of the Mauritanian expatriates all over the continent is one of the legends, and the similar or even better performance will take place in the city.

Sea and Land (and Air):

Are the symbol of cultural foundation of the population of Nouakchott. The city is a platform of the people of various cultural background. The strategic location of Nouakchott has enabled interaction of people from the different culture, and will be enhanced with the strengthened air connection which extends to every parts of the world.

Above key words were further examined and crystalized to the basic concept of the urban development of Nouakchott:

Nouakchott: The Meeting Place of the Pearls

By its strategic location, Nouakchott will be the meeting place of the natural and human identities. Each element meeting in the city has own value and identity with brightness of a pearl. The city provides spaces and chances of meetings between, but not limited to, the following:

- ✧ Land, sea and air,
- ✧ Sand, water and green,
- ✧ Nomads and settled people,
- ✧ Mauritanian and foreign citizens,
- ✧ Producers and consumers (via traders)
- ✧ Provider and beneficiaries
- ✧ Historical and modern lifestyles,
- ✧ Local and global wisdoms

All of them represents the development issues of Nouakchott. The city is still in the early stage of development and integration in both physical and socioeconomic aspects. At the same time, the city is in a contemporary global community which shares sophisticated technology, as well as common risks in sustainability. Development of Nouakchott will seek solutions and prosperity of local and global citizens.

The meeting place of the pearls would have a shape of a traditional jewel of Mauritania, having a shape of envisaged shape of the compact city:

Figure 3.4: Sample Image of the Traditional Jewel of Mauritania

(3) Structure of Nouakchott Development Concepts

Relationship of vision, goal, and basic concept is illustrated in Figure 3.5. By the plans and projects formulated through the "5-R" development visions, the Meeting Place of the Pearls will be materialized, which will contribute to achiving expected roles in the national and regional

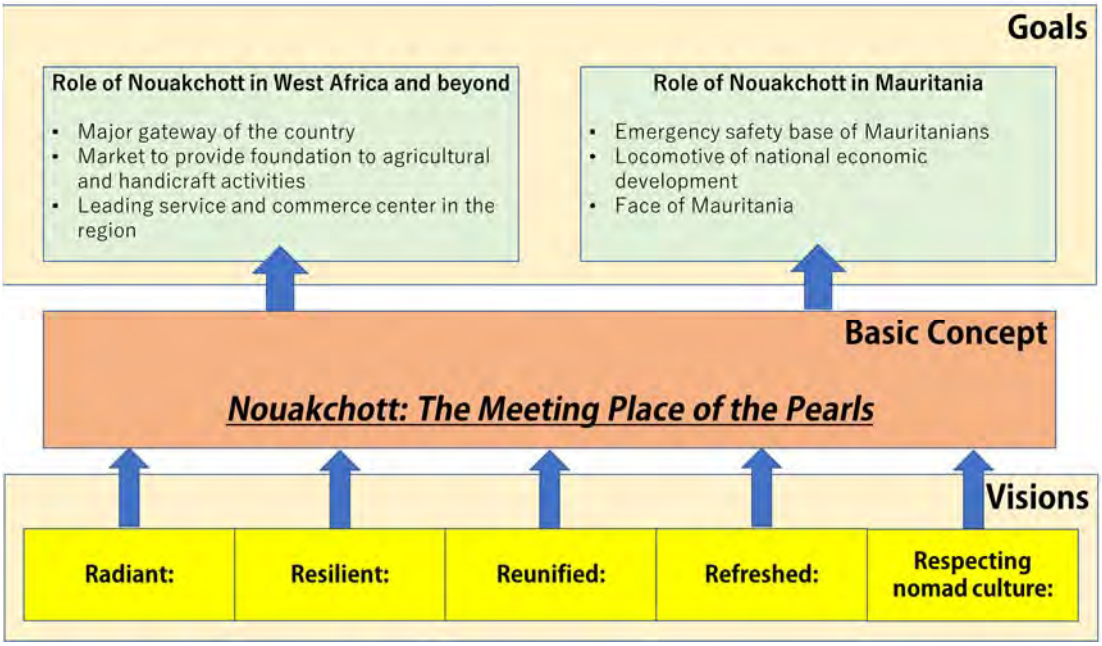


Figure 3.5: Structure of Nouakchott Development Concepts

3.3 Development Framework

3.3.1 Population framework

This section discusses the future population of Nouakchott in 2040 as a component of the socio-economic framework of the Master Plan.

The objective for setting up the future population is to guide for provision of (i) the appropriate level or volume of infrastructure including roads, traffic system, water supply, housing, industrial and commercial facilities, educational facilities, health facilities, and other utilities and (ii) the appropriate institutional arrangement in the targeted year.

The future population of the Nouakchott City is considered under the planning process of the SDAU (Nouakchott City Urban Master Plan) utilizing the plausible methodologies for population projections, but it should be harmonized or adjusted by the overall national development policies or directions as the Capital City in a long-term perspective.

(1) The initial projections

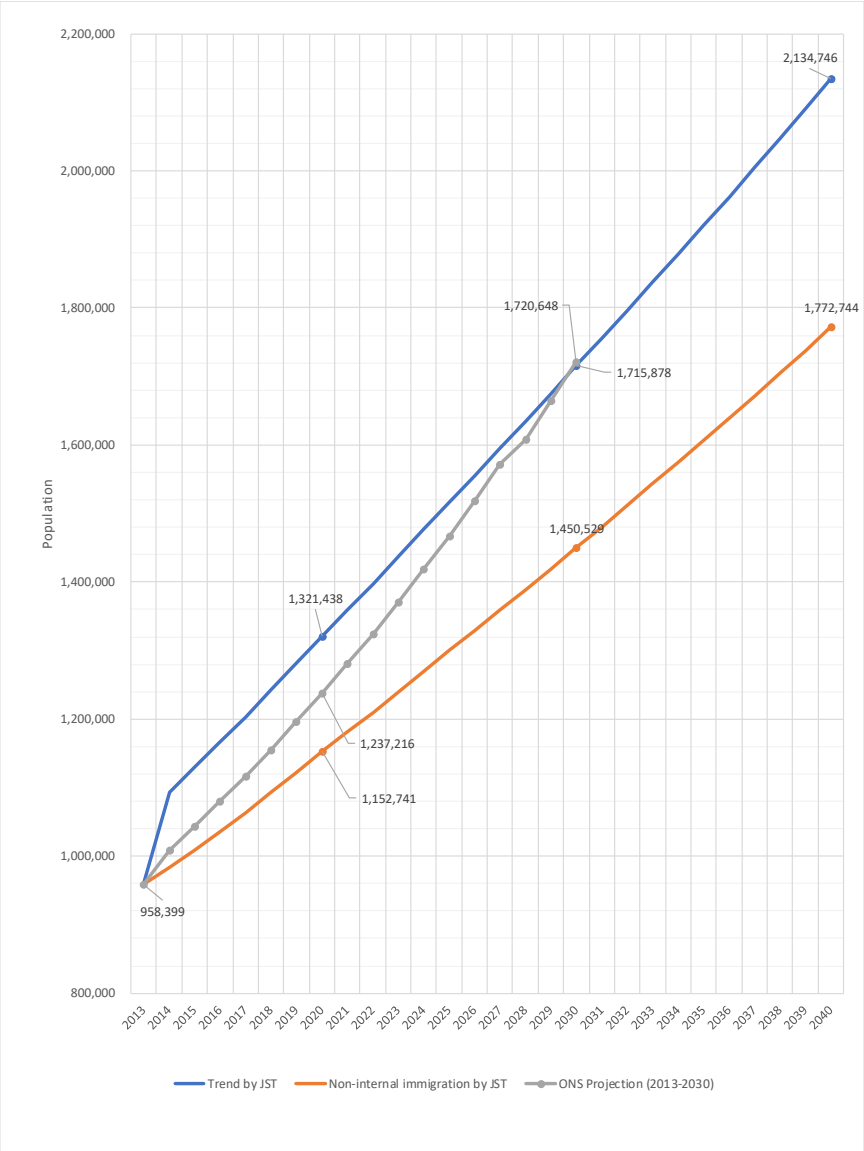
Initially, the following projections, as shown in Table 3.6 and Figure 3.6, were conducted or reviewed. The first and the second cases are conducted by JST. The third one is estimated by ONS until 2030. Based on the following reasons, it is concluded that the projected population of Nouakchott in 2030 by ONS is used as a given condition and the population in 2040 will be finalized by the above-mentioned concept and the appropriate projections for the extension to 2040, through several discussions with C/P and the related agencies as well as Technical Working Group.

a) The projections by ONS should be referred to as the official framework when the ministries and agencies formulate the plans and programs in Mauritania.
b) The methodology for the projected population of Nouakchott in 2030 by ONS seems to be plausible, taking the trend of the share of the past population by Wilaya (or the ratio method) in accordance with the population projection in the country as a whole, and
c) The projected population of Nouakchott between 2013 and 2030 by ONS is almost within the range of the JST's population projection during the same period, as shown in Figure 3.6.

Table 3.6: Summary of the Initial Projections

Case	Methodology	Data	Result
Case 1: Non-Internal Migration Population Projection (2013-2040)	Cohort method, which is based on the current population structure of a 5-year age group with the survival rate, will be applied. The internal migration to Nouakchott is not to be considered.	General Population and Housing Census (RGPH) 2013 United Nations World Population Prospects: the 2015 Revision (Medium Variant).	Population in 2040: 1.77 million **Population in 2030: 1.45 million** Average growth rate between 2013-2040: 2.3%
Case 2: Past Trend Projection with consideration for internal migration (2013-2040)	The past trend of internal migration to Nouakchott is taken into consideration. The projected number of the future population in this case will be a plausibly largest one.	General Population and Housing Census (RGPH) 2013 United Nations World Population Prospects: the 2015 Revision (Medium Variant), United Nations World Urbanization Prospects. 2014 Revision	Population in 2040: 2.13 million **Population in 2030: 1.72 million** Average growth rate between 2013-2040: 3.0%
Case 3: ONS projection **(2013-2030)**	ONS projection for Nouakchott is based on the population projection of whole country and its distribution by Wilaya in accordance with the share of the past trend.	General Population and Housing Census (RGPH) 2013 Other surveys	**Population in 2030: 1.72 million** Average growth rate between 2013-2030: 3.5%

Sources: JST and ONS



Sources: JST and ONS

Figure 3.6: Comparison of the results of population projections by JST and by ONS

(2) Elaborated projections (Extension of the population projections to 2040)

The several projections were conducted to estimate the population of Nouakchott in 2040 as shown in Table 3.7 and Figure 3.7.

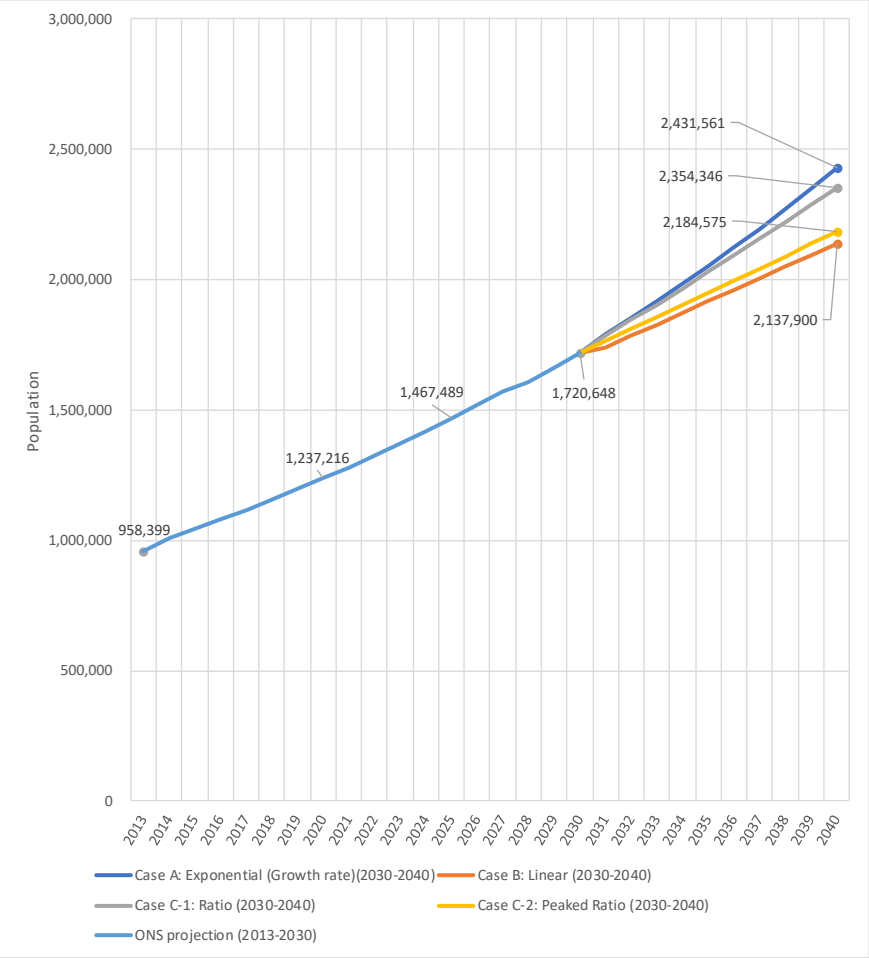
Case A is based on the regression of the Growth Rate (exponential) projection, while Case B is based on the Linear regression. Case C-1 is coming from the trend of the share of the Nouakchott population in the whole country. According to this calculation, the share of the Nouakchott population amounts to 35.9% in 2040. Case C-2 is also based on the trend of the share of the Nouakchott population in the whole country, but it is assumed that the share of the Nouakchott population in the whole country will be gradually peaked at 33.3% in 2040 from 32.6% in 2030.

Table 3.7: Summary of the Elaborated Projections

Case	Methodology	Results
Case A	Growth rate (exponential) projection based on the numbers between 2013 and 2030	Population in 2040: 2.43 million Average growth rate between 2013-2040: 3.5% The share of Population of Nouakchott in 2040 in the whole country: 37.1%
Case B	Linear Projection based on the numbers between 2013 and 2030	Population in 2040: 2.14 million Average growth rate between 2013-2040: 3.0%

		The share of Population of Nouakchott in 2040 in the whole country: 32.6%
Case C-1	Ratio analysis based on the trend of the share of the Nouakchott population in the whole country	Population in 2040: 2.35 million Average growth rate between 2013-2040: 3.4% The share of Population of Nouakchott in 2040 in the whole country: 35.9%
Case C-2	Ratio analysis based on assumption that the share of the Nouakchott population in the whole country will be gradually peaked in 2040*.	Population in 2040: 2.18 million Average growth rate between 2013-2040: 3.1% The share of Population of Nouakchott in 2040 in the whole country: 33.3% (The share of Population of Nouakchott in 2030 in the whole country: 32.6%)

Source: JST
Note*: The idea of this case is mainly coming from the statements about formulation of decentralization policies and the promotion of local development by Accelerated Growth and Shared Prosperity (SCAPP) 2016-2030 by the Ministry of Economy and Finance.



Source: JST

Figure 3.7: Comparison of the results of Case A through Case C-2

The shares of the population of the capital city in the whole country in the selected countries are summarized in Table 3.8. The population share of Nouakchott amounts to 28.0% in 2015 and 32.6% in 2030 with the higher concentration of population compared to those of the surrounding countries.

Table 3.8: Shares of the Capital City Population in the Whole Country in the Selected Countries

Country	Capital City	Population of the Capital City (thousand)		Share (%) of the whole country		Average annual growth rate (%) between 2015-2030
		2015	*2030*	*2015*	*2030*	
Mauritania	**Nouakchott**	**1,043.2**	**1,720.6**	**28.0**	**32.6**	**3.39**

Morocco	Rabat	1,966.8	2,574.5	5.7	6.7	1.81
Senegal	Dakar	3,520.2	6,045.7	23.3	27.5	3.67
Mali	Bamako	2,515.0	5,231.0	14.3	19.7	5.00
Guinea	Conakry	1,936.0	3,133.8	15.4	17.8	3.26
Burkina Faso	Ouagadougou	2,741.1	5,853.9	15.1	22.2	5.19
Côte d'Ivoire	Abidjan	4,859.8	7,772.6	21.4	25.1	3.18
Mongolia	Ulaanbaatar	1,377.3	1,849.6	46.5	54.7	1.99

Source: JST based on NSB data for Mauritania and the United Nations; World Population Prospects 2015 Revision and World Urbanization Prospects 2014 Revision for other countries

(3) Population projection of Nouakchott in 2040

Based on the analysis in the preceding sub-section, the population of Nouakchott in 2040 will be established at 2.20 million.

This rounding number (2.20 million) is based on the population projection by Case 2-2 (2.18 million in 2040), which is discussed and shown in Table 3.6 and Figure 3.7, but the proposed one is slightly bigger than this projection considering the lessons from the past SDAU which lost the public credit due to smaller population projection.

From the viewpoint of the capacity of infrastructure, water resources and water supply in particular, this population size is within an acceptable range.

Other year's populations are projected as shown in Table 3.9.

Table 3.9: Population of Nouakchott from 2013 to 2040

Year	Population	Source
2013	958,399	General Population and Housing Census (RGPH) 2013, ONS
2015	1,043,177	ONS projection
2017	1,116,739	ONS projection
2020	1,237,216	ONS projection
2025	1,467,489	ONS projection
2030	1,720,648	ONS projection
2040	**2,200,000**	JST

Sources: JST and ONS

3.3.2 Economic framework

This section discusses the future gross domestic product in Nouakchott as a component of the socio-economic framework of the Master Plan.

(1) Gross Domestic Product (GDP) in Mauritania

Table 3.10 shows the short-term real GDP projection by economic sector between 2014-2020 and the average annual growth rate in the same period in Mauritania. This projection is based on ONS. According to the table, the real GDP at 2004 constant prices amounts to about MRO 1,000 billion in 2020. The growth rate between 2015-2020 will be 3.2%.

Table 3.10: GDP projection between 2015 and 2020 in Mauritania

Unit: Million MRO at 2004 constant prices

Economic Sector	2014	2015	2016	2017	2018	2019	2020
Primary sector	**233,639**	**244,016**	**255,734**	**268,560**	**279,925**	**291,833**	**304,524**
1. Agriculture, fishing, logging	233,639	244,016	255,734	268,560	279,925	291,833	304,524
1.1Agriculture and Forestry	35,487	37,621	38,636	42,888	45,257	48,250	51,441
1.2 Livestock	171,887	180,307	189,283	195,613	202,155	208,916	215,903
1.3 Fishing	26,265	26,088	27,814	30,058	32,513	34,667	37,181
Secondary sector	**247,795**	**230,016**	**233,408**	**245,904**	**232,267**	**240,561**	**248,024**
2. Extractive activities	104,537	97,200	97,488	106,965	87,816	89,584	90,216
2.1 Extraction of petroleum products	25,680	23,721	21,152	23,044	0	0	0
2.2. Extractive industries other than petroleum products	78,857	73,479	76,336	83,920	87,816	89,584	90,216

2.2.1 Mining of metallic ores	75,217	69,237	71,929	79,075	82,746	84,412	85,008
Iron	48,343	42,178	49,056	55,237	58,159	61,787	61,787
Gold and Copper	26,874	27,059	22,873	23,839	24,587	22,625	23,221
2.2.2 Other Extractive Activities	3,640	4,242	4,407	4,845	5,070	5,172	5,208
3. Manufacturing	51,765	55,647	58,751	61,770	64,948	68,295	71,818
3.1 Manufacturing activities excluding Water-Electricity	50,385	54,142	57,120	59,976	62,974	66,123	69,429
3.2 Production and distribution of water and electricity	1,380	1,505	1,631	1,795	1,974	2,171	2,389
4. Building and public works	91,493	77,169	77,169	77,169	79,502	82,682	85,990
Tertiary sector	**292,207**	**305,582**	**314,146**	**322,372**	**331,527**	**344,122**	**357,933**
5. Transport and telecommunications	70,560	71,747	73,283	76,439	79,900	83,792	87,873
5.1 Transportation	19,883	20,587	19,565	20,034	20,675	21,606	22,578
5.2 Telecommunications	50,677	51,160	53,719	56,404	59,225	62,186	65,295
6. Trade	62,760	67,175	69,454	71,356	73,370	76,012	79,537
7. Other services	107,082	114,023	119,345	122,514	125,958	131,497	137,173
FISIM Correction	-20,375	-20,781	-21,493	-22,226	-23,018	-23,963	-24,978
Total market activities	701,461	706,197	729,731	762,548	768,402	799,732	832,152
8. Government	51,805	52,636	52,063	52,063	52,299	52,822	53,350
GDP at the factor costs	**753,266**	**758,834**	**781,795**	**814,611**	**820,701**	**852,553**	**885,503**
Net taxes on products	**89,358**	**94,719**	**97,930**	**101,020**	**104,917**	**109,715**	**114,949**
GDP at market prices	**842,624**	**853,553**	**879,725**	**915,631**	**925,618**	**962,268**	**1,000,452**

Source: ONS

As for the growth rate of the economic sector, as shown in Table 3.11, the primary sector is higher than the national average at 4.5%, followed by the tertiary sector at 3.2% and the secondary sector at 1.5 or 1.6%. In the primary sector, the growth rate of fishery sector shows the highest at 7.3%. The low growth rate of the secondary sector mainly comes from a reduction of the extraction of petroleum products since 2018. The manufacturing and utility sector shows the high growth rate at 5.2%.

Table 3.11: Projected GDP growth rate (%) by Economic Sector between 2015/2016 and 2020 in Mauritania

Unit: Percent (%)

Economic Sector	Annual Average Growth Rate between 2015 and 2020 based on the ONS projection	Annual Average Growth Rate between 2016 and 2020 based on the projection by SCAPP 2016-2030 (The basic trend scenario)
Primary sector	**4.53**	**4.5**
Agriculture and Forestry	6.46	6.5
Livestock	3.67	3.7
Fishing	7.34	7.3
Secondary sector	**1.52**	**1.6**
Extractive activities	-1.48	-
Manufacturing & utility	5.23	5.2
Building and public works	2.19	3.0
Tertiary sector	**3.21**	**3.2**
Transport and telecommunications	4.14	5.0
Trade	3.44	3.4
Other services	3.77	3.8
GDP at the factor costs	**3.14**	**3.2**
GDP at market prices	**3.23**	**3.2**

Source: JST based on ONS data and SCAPP 2016-2030

(2) Projection of Gross Regional Domestic Product (GRDP) of Nouakchott

1) Projection of the Current GRDP of Nouakchott

The data on the gross regional domestic product (GRDP) or gross domestic product in Nouakchott are not available. Consequently, the following steps of calculation are taken to estimate the current GRDP in Nouakchott.

(a) Estimating the share of the employed workers by the economic sector of Nouakchott in the whole country, based on the result of the Permanent Household Living Conditions Survey 2014 (EPCV 2014).

(b) Allocating the GDP in 2014 by the economic sector in the whole country to Nouakchott by using these shares of the employed workers of Nouakchott in the country, assuming the value-added amount or the labor productivity per worker in the same sector is the same all over the country.

The result of estimation is summarized in Table 3.12. According to this table, the GRDP at the factor costs of Nouakchott amounted to MRO 235 billion in 2014. This amount is about 31% of GDP of the whole country. This share is slightly higher than that of the population of Nouakchott in the country at 27% in 2013.

As for the economic sector, the share of the tertiary sector is the highest at 66.6%, followed by the secondary sector at 31.8% and the primary sector at 4.5%. The contribution of the informal sector to GRDP will be mainly reflected in trade/business sector and services sector.

Table 3.12: GRDP projection of Nouakchott by the Economic Sector in 2014

Unit: Million MRO at 2004 constant prices

Economic Sector	Amount	Share (%)
Primary Sector	10,507	4.5
Agriculture and Forestry	887	0.4
Livestock	1,031	0.4
Fishery	8,589	3.7
Secondary Sector	74,756	31.8
Mining and Quarrying	17,249	7.3
Manufacturing	19,629	8.3
Construction	37,878	16.1
Tertiary Sector	156,617	66.6
Transport	9,643	4.1
Communications	34,156	14.5
Trade/Business	23,598	10.0
Other services	58,499	22.0
Administration	30,720	13.1
FISIM correction	-6,724	-2.9
GDP at factor costs	235,156	100.0

Source: JST

2) Projection of the future GRDP in 2040

The future GRDP of Nouakchott is estimated based on the economic growth rates by sector which is shown in the ONS projection and SCAPP 2016-2030 in the whole country. Also, the economic growth rates in the sub-sectors of the Secondary Sector except mining and quarrying and Tertiary Sector of Nouakchott are assumed to be 1% point higher than those of the country considering the role of the capital region as the driver of economic growth of the country.

As shown in Table 3.13, the total GRDP at market prices amounts to MRO 715 billion at 2004 constant prices in 2040. In other words, the value of GRDP of Nouakchott rises from MRO 258 billion in 2017 to MRO 715 billion (a 2.78 fold increase) with the annual growth rate at 4.5%.

As for the composition of economic sector in 2040, Tertiary Sector shows the highest share at 67.0%, followed by the Secondary Sector at 27.4% and the Primary Sector at 5.6%.

Table 3.13: GRDP projection of Nouakchott by the Economic Sector in 2040

(1) Value of GRDP by Economic Sector

Unit: Million MRO at 2004 constant prices

Sector	***2017***	***2020***	***2030***	***2040***	*Annual growth rate between 2017-40*
Primary Sector	**12,075**	**14,740**	**23,640**	**38,011**	***5.1***

Agriculture & Forestry	1,072	1,286	2,095	3,412	*5.2*
Livestock	1,174	1,295	1,741	2,340	*3.0*
Fishery	9,829	12,158	19,804	32,259	*5.3*
Secondary Sector	**73,020**	**77,718**	**118,837**	**186,862**	***4.2***
Mining and Quarrying	17,649	14,886	16,443	18,163	*0.1*
Manufacturing	23,423	27,233	49,698	90,695	*6.1*
Construction	31,948	35,600	52,696	78,003	*4.0*
Tertiary Sector	**164,674**	**182,826**	**287,211**	**457,359**	***4.5***
Transport	9,717	10,950	17,837	29,055	*4.9*
Communications	38,017	44,009	78,813	141,143	*5.9*
Trade/Business	26,830	29,906	46,000	70,756	*4.3*
Other services& FISIM	59,237	66,325	105,996	169,395	*4.7*
Administration	30,874	31,637	38,565	47,010	*1.8*
GRDP at factor costs	**249,769**	**275,284**	**429,688**	**682,232**	***4.5***
GRDP at market prices	**257,649**	**288,418**	**450,313**	**714,979**	***4.5***

(2) Share of Composition of GRDP by Economic Sector

Unit: percent (%)

Sector	***2017***	***2020***	***2030***	***2040***
Primary Sector	**4.8**	**5.4**	**5.5**	**5.6**
Agriculture & Forestry	0.4	0.5	0.5	0.5
Livestock	0.5	0.5	0.4	0.3
Fishery	3.9	4.4	4.6	4.7
Secondary Sector	**29.2**	**28.2**	**27.7**	**27.4**
Mining and Quarrying	7.1	5.4	3.8	2.7
Manufacturing	9.4	9.9	11.6	13.3
Construction	12.8	12.9	12.3	11.4
Tertiary Sector	**65.9**	**66.4**	**66.8**	**67.0**
Transport	3.9	4.0	4.2	4.3
Communications	15.2	16.0	18.3	20.7
Trade/Business	10.7	10.9	10.7	10.4
Other services& FISIM	23.7	24.1	24.7	24.8
Administration	12.4	11.5	9.0	6.9
GRDP at factor costs	**100.0**	**100.0**	**100.0**	**100.0**

Source: JST

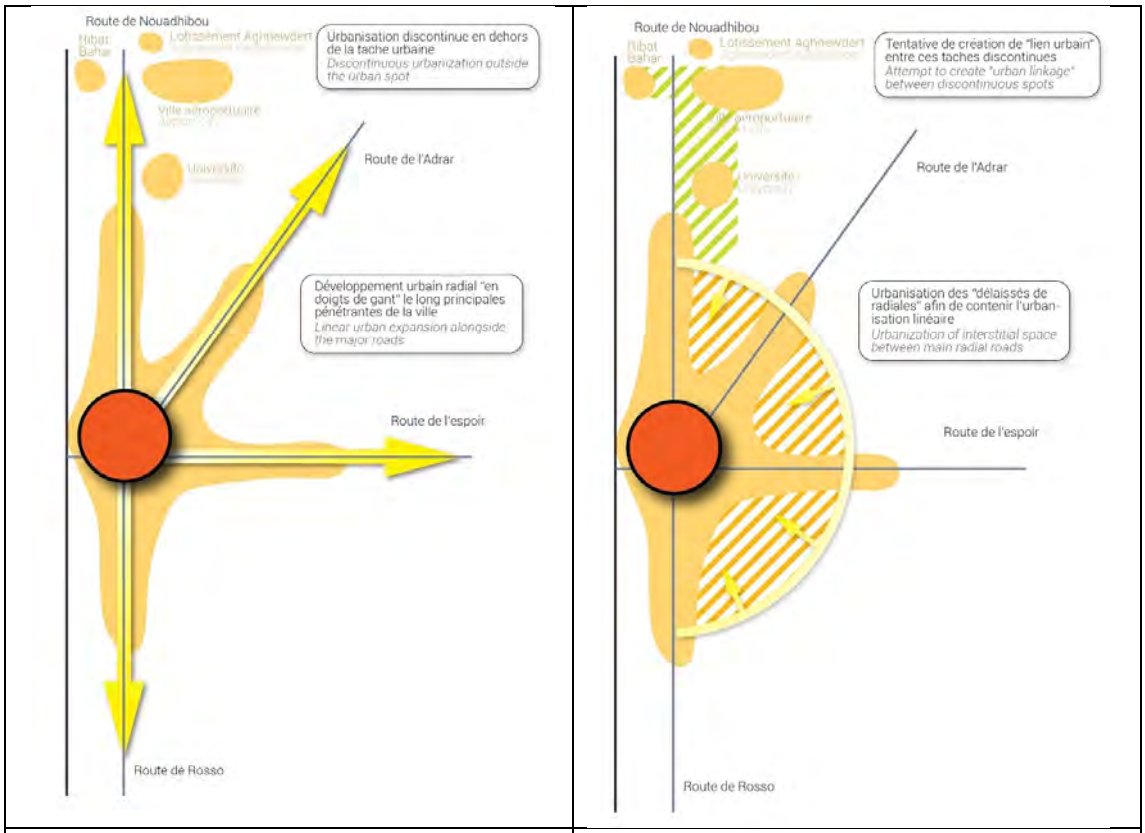
3.4 Future Urban Structure of Nouakchott City

3.4.1 Basic structural concepts for future urban development of Nouakchott

Based on the observation of the current development trends explained above, two basic structural approaches have been identified in order to achieve a more coherent urban development in the future.

- The first approach is the creation of "urban linkage" between discontinuous scattered urban spots that will appear in near future in the Northern side of the city. Those interstitial spaces will have the function to articulate all the spaces to each other and give a general coherence to the urban region. Needless to say that urban continuity shall be basis of a decent urban development and that scattering of subdivisions shall be stopped;
- The second approach, which was already promoted by SDAU 2003, is the urbanization in priority of interstitial space between main radials, and the abandon of linear development.

Figure 3.8 shows the two structural approaches (right) against on-going urbanization pattern (left).



Ongoing urbanization pattern	Two approaches to counter the ongoing urbanization pattern

Source: JICA Study Team

Figure 3.8: Basic structural approaches for future urban development of Nouakchott

3.4.2 Urban expansion scenario and development alternatives

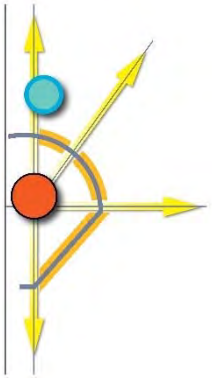
Based on the observation of the current development trends and on the basic structural concepts for urban development of Nouakchott explained above, different development alternatives for the 2040 horizon have been elaborated. The prospective phase in an urban planning project makes it possible to better anticipate the changes that a city may experience over the long term, and thus guide the development towards a horizon that is collectively desired.

Indeed, alongside the technical aspect of prospective planning, which is detailed in this section, the point of view of the residents, regarding the future urban development image of their city, is a crucial element to fulfill a sustainable prospective planning. That is why the development alternatives elaborated by the JICA Study Team have been discussed with inhabitants of each commune, in order to identify strengths and weakness of each proposition, from the viewpoint of citizens (transportation, social life, facilities, security etc.)

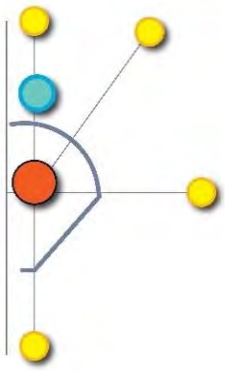
The three scenarios for the 2040 horizon can be summarized as below.

- The trend scenario, also known as “business as usual” or "0" scenario, is the first to be identified. It is the one that would occur if the current trend would continue to apply in the same way on the city, without intervention of the project or the public authorities in general. This scenario should shed light on the aspects to rely on or oppositely to fight against for the planning of the future shape of the city;
- Development alternative "A: bipolar development model supported by satellite cities" that promotes the concepts of relocation and specialization. This alternative represents the solution based on relocation often considered in cities like Nouakchott which have difficult natural settings. This alternative was mainly proposed by counterpart agency and is based on a current political vogue of urban sector decision makers;

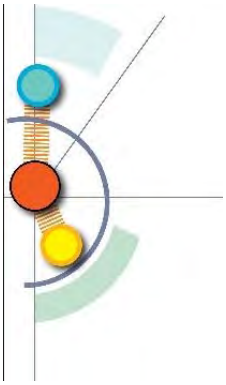
- Development alternative "B: tripolar scale model at the metropolitan scale" which promotes the concepts of densification and balance. This alternative is based on the two following technical findings: Firstly, the scientific results of urban expansion potential analysis (refer to Section 4.3) which concludes that the most suitable location for the expansion of the city is the continuity of Tarhil in South-East part of the city; Secondly, the basic structural concepts (see above Section) that urbanization shall be carried out in priority of interstitial space between main radials.



Business as usual scenario



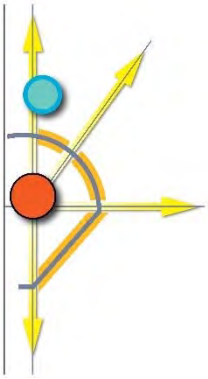
Development alternative A



Development alternative B

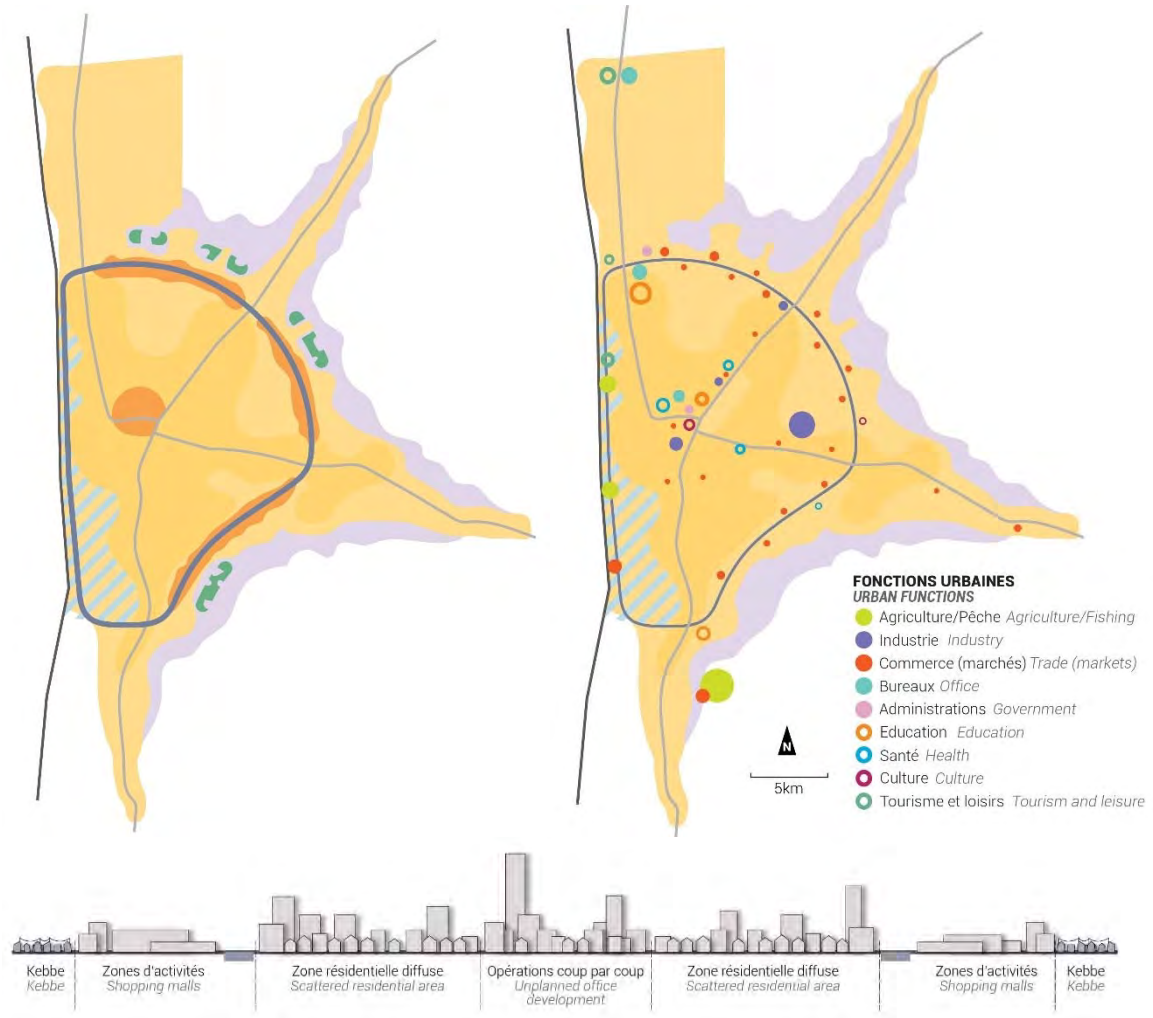
The three scenarios are briefly described below through the following 7 aspects: urbanization and density, main urban functions and economic activities, major impacts on the environment, mobility and transport, infrastructure and major structural equipment, urban planning leverages of public authorities and point of view from the users of the city. Environmental impacts of the different alternatives are studied and compared more precisely in point (4) below.

(1) Trend or "business as usual" scenario



Summary [Trend scenario]

The efforts of public authorities focus in the short term on the construction of the ring road on the one hand, and on the support to especially foreign private investments on the northern part of the city on the other hand. Other fields of urban development, such as densification of existing urban fabric or implementation of a social housing policy, simply fail to be achieve. In the medium term, land opportunities created by the construction of the ring road are acquired and small commercial franchises bloom along the ring road in a chaotic manner. In the long term, the traditional city-center is devitalized and becomes an office area. The entire agglomeration is structured around its peripheral activity areas, which become the new places of sociality of the Nouakchott inhabitants.



Source: JICA Study Team

Figure 3.9: Trend or "business as usual" scenario

Urbanization and density [Trend Scenario]

Urban sprawl spreads loosely along the four national roads going out of Nouakchott. The spread of the current level of low-density urbanization (around 25 population /ha) increases the dependence of peripheral areas in terms of employment, equipment and services and generates an influx of individual trips to city center which tends to lead to congestion.

The lack of urban control leads to the emergence of new slums beyond the ring road, encroaching the green belt, and extending along the newly established urban area along the roads.

New nodes of communication located at the crossing between ring road and national roads, become the strategic places of the development of the agglomeration, as well in commercial but also residential and services.

The urban fabric of the existing city built inside the ring road is not densified or renewed in a programmed manner. Destruction and construction of houses occur sporadically according to individual opportunities.

Main urban functions and economic activities [Trend Scenario]

At the level of the communication nodes described above, commercial investment opportunities are quickly spotted, and large parcels are coveted by retailers even before the completion of the ring road. However, due to lack of preparation and coherence of public authorities, the lands along the ring road are subdivided and allocated piecemeal to small local traders.

Thus, the opportunity to achieve real structuring urban cores at these nodes (crossing of ring road and national road) by the realization of commercial and services zones arranged in a concerted way (ZAC), fails. Instead, many small, disparate shops are emerging on both sides of the ring road and meet a quick success, resulting in an emulation of commercial activities and in attracting urbanization out of the physical limit created by the ring road.

In the long term, in addition to the increasing congestion of the city center, the attractiveness of peripherical commercial areas leads to a gradual devitalization of downtown small shops, which close their doors one after the other. Downtown is becoming more and more specialized as an office district.

The shopping mall becomes the new center for supplying goods, for business but also sociability at the scale of the whole agglomeration. The shopping mall represents for citizens a symbol of the accession to the consumer society and embodies their desire to participate in the global village on the move. Despite their offset geographical position towards city center and their certain genericity, since that they are identical throughout the world, these shopping centers become fully integrated into the daily life of the inhabitants and are the driving force of land valorization that generates urbanization outside the ring road.

Major impacts on the environment [Trend Scenario]

The major impacts of this scenario on the environment are as follows.

(-) Considerable and anarchic land consumption;
(-) Strong growth in terms of energy consumption and greenhouse gas emissions as a result of long distance between housing areas, jobs and services;
(-) Urban encroachment, scattering and disappearance of the green belt.

Mobility and transport [Trend Scenario]

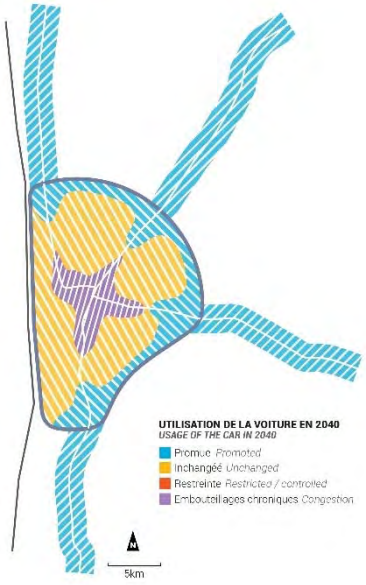
The private car, which helped formulation of the low dencity urbanization of Nouakchott, is enhanced by this scenario, which allows, through the intensive development of large areas along the ring road, to access any form of service by car (retail shops, public services, cultural services, etc.).

With the increase of the population in the city, the downtown area becomes more and more congested and difficult to access.

In addition, the continued low-density urbanization makes it impossible to organize any public transport system outside the ring road (too far) and inside (not profitable enough).

Thus, the use of the individual car is:

- Unchanged in the center (scattered urbanization);
- Promoted outside the ring road (urbanization permitted along the axes);
- Made difficult in the city center.



Infrastructure and major structuring equipment [Trend Scenario]

Due to lack of available land within the ring road and in view of the lack of intervention of the public authorities, all the major projects are implanted outside the ring road and are given to private initiative (especially foreign), in general with a recreational vocation more than cultural / social role. It is conceivable that commercial zones will be established on each of the four national roads leaving Nouakchott. Other amenities on the outskirts may include a movie theater, an outdoor zoo, or a water park.

Urban planning leverages of public authorities [Trend Scenario]

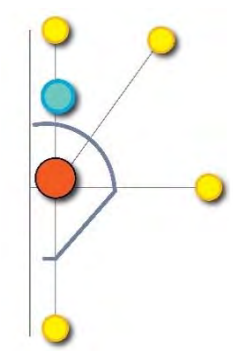
In this scenario, public authorities are not able to use the leverages of a virtuous urban development. The major aspects of urban planning leverages are as follows.

- Failure of implementing policy of densification of existing and future urban fabrics;
- Failure of implementing regulatory policy for commercial activities;
- Failure of implementing social housing policy.

Point of view of the users of the city [Trend Scenario]

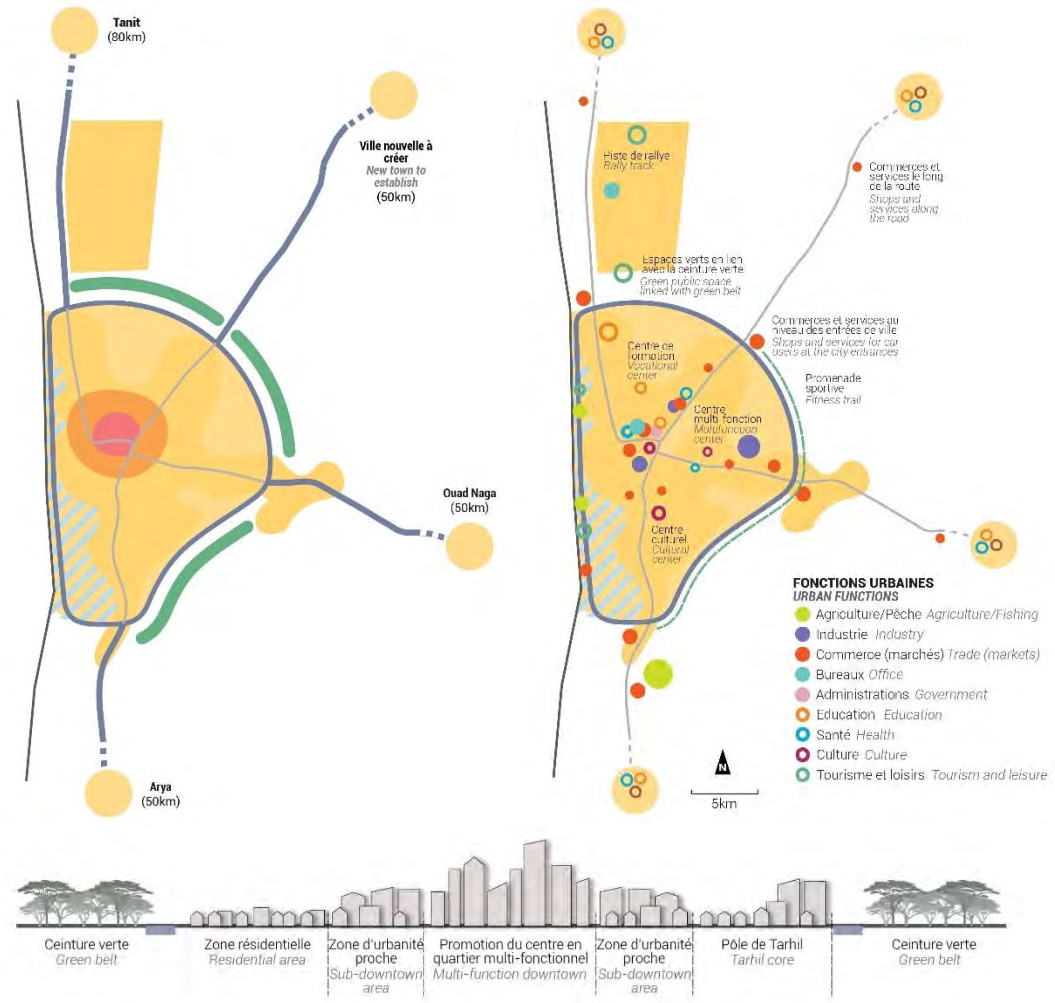
In this scenario, the people of Nouakchott mainly use the car to get to the nearest shopping mall quickly and safely in the evening or at the weekend. It is particularly the summer that throngs young and old to enjoy the air conditioning, and to eat a sorbet watching the majestic fountain or even go ice skating. By taking the ring road, other centers are accessible, such as the cine-city, the safari-zoo, or the aqua-park. As new mall or commercial city flourish every year in the outskirts of Nouakchott, people are happy to gather at their inaugurations. Shopping malls are the symbols of the young Mauritanian generation in fashion, consuming but still conscious and spiritual.

(2) Alternative A: Bipolar development model supported by satellite cities



Summary [Alternative A]

The authorities anticipate the urban growth created by new influxes of population and, based on the lessons of past mistakes of uncontrolled expansion of the urban area, will adopt a strong interventionist stance, particularly by densifying and modernizing the city center as a business district, by physically marking the limit of the city with a ring road and a green belt, and by offering to new comers of various social backgrounds to settle in newly developed satellite towns located between 50 and 80 km from Nouakchott. The future of the Mauritanian capital is concerning the regional scale and no longer local.



Source: JICA Study Team

Figure 3.10: Scenario A : Bipolar development model supported by satellite cities

Urbanization and density [Alternative A]

Two distinct movements are being implemented to counter uncontrolled urban expansion and to accommodate the influx of new populations: on the one hand (1) promotion / transformation of the historic city center as a modern and dense business district, and on the other hand (2) development of satellite towns outside Nouakchott: Tanit at 80 km north on the road to Nouadhibou, Ouad Naga at 50 km east on the road of hope to Boutilimit, and Arya at 50 km south on the road to Rosso. These three cities (currently villages), which will provide a more rural living environment close to the Bedouin way of life, will still have to provide basic infrastructure and services needed to accommodate the new populations. Finally, on the road leading to Atar, in the north-east, a new city will have to be created from scratch. These satellite cities will offer broad housing options from luxury housing to social housing, from homeownership to rental.

Main urban functions and economic activities [Alternative A]

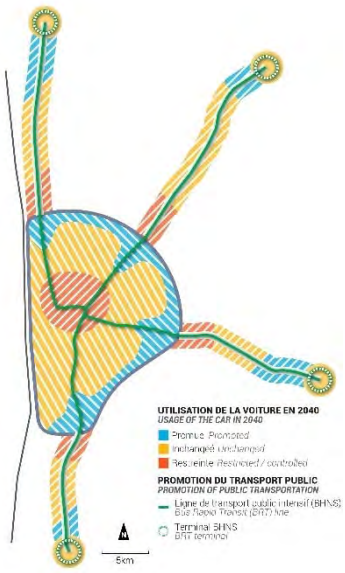
The physical separation and the maximization of the urban functions already started in 2017 is taking his maximum dimension in this scenario. The use of the space is rationalized to the extreme, at the regional level (residential function in satellite cities; employment function in Nouakchott), while proposing to the inhabitants a certain comfort of life (low density). The model of development is that of a mobile and fluid society that frees itself from physical distance.

Major impacts on the environment [Alternative A]

Major impacts of this scenario on the environment are as follows.

(-) Commuting towards Nouakchott of active populations residing in the satellite cities create phenomena of congestion, increase of the emissions of greenhouse gases and atmospheric pollution, stress for the users, etc.;
(-) The low areas of Sebkha along the coastline are terraced and urbanized to meet land needs;
(+) The dunes in the south of the agglomeration are preserved (not urbanized).

Mobility and transport [Alternative A]



The four national roads coming out of Nouakchott are first enlarged and promoted as highways, in order to be able to receive the commuting traffic between satellite cities (place of residence) and Nouakchott (place of employment).

Rapid bus services are being established between the four satellite cities and Nouakchott downtown newly remodeled business district. Issues related to modal change at the city entrance as well as parking in the city center need to be clarified.

In this scenario, the use of the individual car is:

- Restricted in the center, particularly because of the densification of downtown and its zone of influence (less space for parking, more congestion);
- Promoted outside the zone of influence of the center (access to the ring road to go to the 4 corners of the capital);
- Restricted outside the ring road (urbanization prohibited at the level of the green belt and along the national roads);
- Promoted in each satellite city vicinity.

Infrastructure and major structuring equipment [Alternative A]

Basic infrastructures (sanitation, drinking water, waste collection) as well as social services (education, health, etc.) will have to be established in all the different satellite cities. This will involve significant costs if we consider the efficiency of these systems at a certain minimum density.

In this scenario, since a large part of the population resides in the satellite cities and is present in Nouakchott only during the day to work there, the city will not be populated during nights of weekdays and during weekends. Consequently, all the facilities related to sports, cultural and leisure practices will not be viable (profitable for the private sector) and Nouakchott will lose its attractiveness in these fields.

However, the constant flows on the national roads towards satellite cities will generate the emergence of market towns (restaurants, various services) but also recreational places easily accessible by car.

Given this situation, the following major equipment is conceivable to be established.

- Shopping center in the northern part of Tevragh Zeina (at the interchange between ring road and Nouadhibou road);
- Recreational and villa areas linked to the green belt in the northern part of Tevragh Zeina, in connection with the airport city;
- Fitness and natural trail inside the green belt along the ring road;
- Rally track near the new airport to avoid rallies on the dune cordon;
- Landscape designed city entrances (services to motorists).

Urban planning leverages of public authorities [Alternative A]

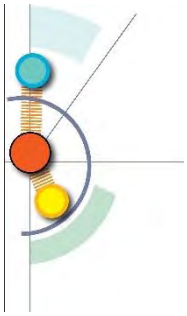
In this scenario, public authorities impose themselves by an interventionism and massive achievements, in particular by bringing to the standards of the satellite cities. The main aspects of public policy are as follows.

- No efforts to densify existing and future residential urban fabrics;
- Successful promotion of city center as a business district with vertical densification;
- Successful regulation of commercial activities;
- Successful implementation of social housing policy.

Point of view of the users of the city [Alternative A]

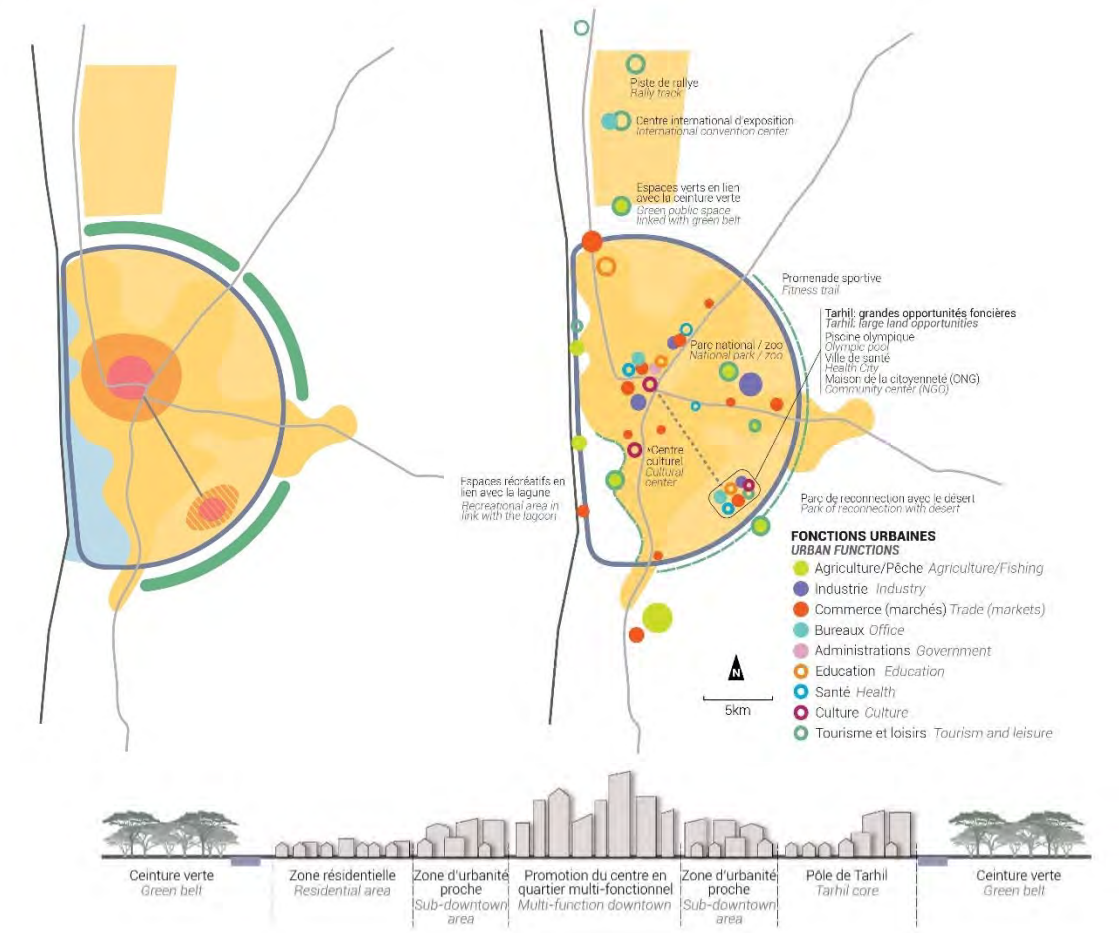
In this scenario, the people who commute to Nouakchott to work there come from very different horizons. Even if the time spent in the transportation is quite important and become an everyday burden for the inhabitants, they find the serenity on their return in their satellite city: a comfortable house, bigger in terms of habitable surface, a garden in which a *khaima* can be pitched or from which stars can be observed, a less polluted neighborhood, less mosquitoes and waste in the streets. At the same time, the inhabitants who stayed in Nouakchott must find that the city is much livable with a more limited population.

(3) Alternative B: tripolar model at the metropolitan scale



Summary [Alternative B]

The form of the ring road is modified in order to include vast public land reserves, in the south of the Tarhil district. Those area can welcome many activities, large structuring projects at the metropolitan scale but also ambitious social housing projects for modest families. The redevelopment of the Tarhil district and its connection of its population with the rest of the city is a necessary element to be able to rebalance the metropolitan area as a whole, which tends to specialize and spatialize its development towards international services in the north.



Source: JICA Study Team

Figure 3.11: Alternative B: tripolar scale model at the metropolitan scale

Urbanization and density [Alternative B]

The setting of the city within the ring road and the avoidance of Sebkha areas near the coast constraint the agglomeration to densify in a general way and especially in the perimeter around downtown. This scenario also envisages a new dense and multifunctional development in the south of the agglomeration.

Main urban functions and economic activities [Alternative B]

This tripolar development model focuses on the creation of a balance pole in the continuity of Tarhil district, in parallel with the redevelopment of the city center and support for urban development in the north of the agglomeration. The three poles work in complementarity with each other.

Tarhil's balance pole has a predominantly residential function, with a large portion of social housing built to stem the uncontrolled expansion of slums on the Boutilimit road to the east. Job creation activities are encouraged, especially in the fields of agri-food processing, particularly in connection with fisheries, livestock farming and agriculture (PK17).

Accessibility between these three poles, which are geographically close, will be ensured by large investments in public transportation. Tarhil district, through its new extreme connectivity with the central parts of the city, assumes a role of "hub" for the distribution of agricultural and agri-food products throughout the whole city.

Opening up the flooding areas in the south-west of the agglomeration to the water and making it a lagoon allow it to requalify the limits of the city and to reorganize a whole previously neglected urban fringe. Various economic and leisure activities can be implemented on these new lagoon spaces.

In summary, the basic planning principles of this scenario are:

- Polarization of development and creation of catchment areas endowed with jobs, housing, equipment and services essential for the accommodation of new populations;
- Rebalancing between residential and employment functions in the neighborhoods in favor of a new economic development model based on the loosening of activities;
- Establishment of a frank urban growth limit (ring road and green belt);
- Promotion of a multimodal travel system supporting urban development control.

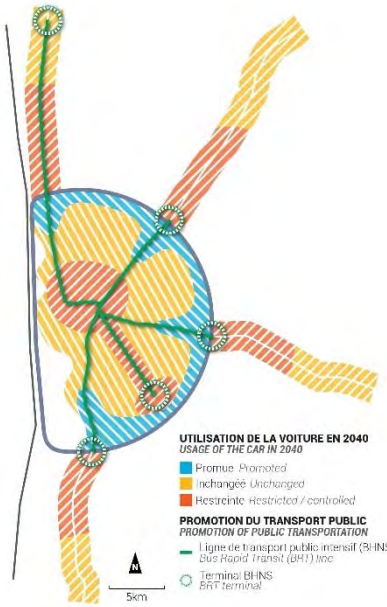
Major impacts on the environment [Alternative B]

Major impacts of this scenario on the environment are as follows.

(-) Dunes located in the south of the agglomeration are mobilized to prepare the extension of the urbanization of the Tarhil district;
(-) Development of the artificial lagoon may provoke negative effects on the hydrological and ecological equilibrium of the site.

Mobility and transport [Alternative B]

Rapid Transit dedicated lanes are laid out to the right of the four main roads, as well as on the Tarhil - Capital axis (to be defined) to be redeveloped. Intermodal terminals are established at the four city entrances. In the new Tarhil core, the Rapid Transit terminal is designed as a structuring and central infrastructure on the model of Japanese stations, integrating various businesses, shops and services.



The development of dedicated lanes for Rapid Transit on structuring main roads is accompanied by the creation of cycle paths that will, on the model of London *cycle superhighways*, drain the commuting flows of employees from the suburbs to the business district (about 50 minutes by bicycle to reach Capital from the new pole of Tarhil).

In this scenario, the use of the individual car is:

- Restricted in the center and Tarhil notably because of the densification of downtown and surrounding areas (less space for parking) and the promotion of other forms of transport (bus lanes and cycle lanes);
- Promoted outside the city center (access to the ring road to go to the 4 corners of the capital);
- Restricted outside the ring road (urbanization is prohibited beyond the green belt and along national roads).

Infrastructure and major structuring equipment [Alternative B]

The large public land reserves mobilized in the south of Tarhil allow the establishment of the following major public facilities. Those improvements could be made within the framework of a Concerted Development Area (ZAC, Zone d'Aménagement Concerté):

- Olympic swimming pool;
- Health city;
- Exhibition and meeting center for civil society (citizenship house).

At the metropolitan level, the following commercial, cultural and recreational facilities are conceivable:

- Shopping center in the northern part of Tevragh Zeina (at the interchange between ring road and Nouadhibou road);
- Recreational and villa areas linked to the green belt in the northern part of Tevragh Zeina, in connection with the airport city;

- Tourist, recreational and economic activities related to the newly developed lagoon to the southwest;
- National park / zoo at the place of Dar Naim farmlands;
- Fitness and natural trail inside the green belt along the ring road;
- Rally track near the new airport to avoid rallies on the dune cordon;
- Landscape designed city entrances.

Urban planning leverages of public authorities [Alternative B]

In this scenario, public authorities have been able to implement ambitious policies to radically reform the urban sector. The major aspects of public policy are as follows.

- Successful densification of existing and future urban fabrics;
- Successful regulation of commercial activities;
- Successful implementation of social housing policy.

Point of view of the users of the city [Alternative B]

In this scenario, the inhabitants of the different districts of Nouakchott are physically and socially close and united. Thanks to the Rapid Transit, the inhabitants of Tarhil can easily access downtown as well as airport site to work or shop. Equally, in the new urban downtown, some of the wealthiest population, whom have abandoned their car, can easily join Tarhil by Rapid Transit on weekends to enjoy the new facilities, the swimming pool, the health city, but also to relax and regenerate in contact with the desert and the new forest (green belt). In addition to the newly developed lagoon area along the coast, people of Nouakchott can truly live, work, relax and grow while staying in their city.

(4) Evaluation of the different alternatives through SEA

1) Evaluation objective and methodology

The process of prediction and comparison of the effects of the strategic alternatives is realized in order to pursue the best yet realistic alternative with well-balanced combination of advantage of each development alternative rather than to select the most preferable one from two alternatives emphasizing respectively economic, social or environmental objectives.

In terms of evaluation methodology, it shall be observed that this evaluation has been realized in the framework of the SEA, which basically corresponds to the comparison of effects on the environment and the discussion with Nouakchott citizens through public consultations. The methodology of evaluation is thus less comprehensive that what the Ministry of Land, Infrastructure and Transport (MLIT) of Japan has elaborated for the evaluation of city planning (handbook on evaluation of urban structure, 2014). However, the two following remarks regarding the nature of evaluation criteria and evaluation scope shall be observed.

Nature of evaluation criteria

The definition of environment contained in the SEA Objectives is broad and reflects both the effects on natural environment but also on human environment.

Nevertheless, in order to be as comprehensive as possible in this study which targets a multisector Masterplan, economic and social criteria have been added to strictly environmental criteria.

Evaluation scope: qualitative or quantitative dimension

Being carried out at a strategic level of the project, the evaluation of the development alternatives is done on the qualitative dimension only. Having been designed in a very simple way to foster a better understanding during public consultations, the maps of development alternatives do not contain geographical information that can be used for a quantitative analysis. At this stage of the project it is important to gather the opinions of the citizens in order to be able to draft the best land use plan possible, rather than focusing on quantitative details. That is why the emphasis was put on the definition of sharply contrasted development models that shows different development paradigms, on which opinions can be expressed.

Nevertheless, if the section above already mentions quantitative data (length of the road network to extend, cost of infrastructure works, etc.), a reminder will be shown in the evaluation table.

2) Prediction and comparison of the effects of the different development alternatives

The results of the assessment and comparison of the business as usual scenario and two development alternatives according to SEA objectives is shown in Table I-10 below.

Table I-10 Results of the Evaluation of Alternatives

Pillars of the planning vision		Trend scenario	Alternative A	Alternative B
1	Reunited	AT-	B -	A +
2	Radiant	B +	B +	B +
3	Reinvigorated	AT-	B +	B +
4	Resilient	AT-	B +	A +
5	Respecting the local culture	B-	A +	B +

Criterion's SEA		Trend scenario		Alternative A		Alternative B	
1	Climate change (at the local level) - vulnerability to floods	AT-	Uncontrolled urbanization in the flood zones of sebkhas leads to increased vulnerability.	B-	The further development of housing on areas prone to floods of sebkhas leads to increased vulnerability.	A +	The abandonment of housing development in the flood zones of sebkhas leads to the reduction of vulnerability.
2	Natural environment - green and wooded areas	AT-	Uncontrolled urbanization makes it impossible to increase green spaces.	A +	Green and open spaces can be developed in satellite towns; the low density in Nouakchott makes the city more open and airy.	A +	The creation of a new development center in a virgin zone makes it possible to freeze large areas for green and open spaces.
3	Climate change (globally) - GHG emissions	B-	The lack of an efficient public transport system leads to an increase in car use and therefore greenhouse gas emissions and air pollution.	AT-	Massive displacements to Nouakchott of satellite towns create congestion, increased greenhouse gas emissions and significant air pollution.	B +	The effort to implement an effective system of mass public transport leads to the stabilization and reduction of air pollution through traffic.
4	Environmental pollution - deterioration of water quality	AT-	Uncontrolled urbanization is leading to further degradation of water quality and public health in general. The worsening of the silting phenomenon leads to an increasingly deficient sanitation system.	B +	The disappearance of the silting problem thanks to the success of the green belt leads to an increase in the performance of the sanitation system.	B +	The disappearance of the silting problem thanks to the success of the green belt leads to an increase in the performance of the sanitation system.
				B-	However, further housing development in flood-prone areas of sebkhas could lead to degradation of the aquatic environment.	C-	However, the development of the artificial lagoon can have negative effects on the hydrological and ecological balance of the site.
5	Inclusiveness - disparity s social, insecurity housing and solidarity	AT-	Loss of activity e conomic of the existing city and many fraining slums around the city along the ring road.	B +	The mastery of urban growth in satellite cities allows the control of the formation of new slums. With the expansion of the distance between the place of residence and place ofwork, disparaité s accessat employment may be born.	A +	Controlling urban growthinside the ring roadallows the non-spread of slums. The construction of social housing and public transport provision willontribuer toc Atte nuence disparitiessocial.
6	Inclusiveness - hum ains basic needs	B-	The continuing urbanization under the same conditionsperpetuates the	C	Social services (education, health, etc.) should be e tnewly ablis in all satellite towns. This will	B +	Socialservices (education, health, etc.)will be located within the existing

			probè m e lack of land for public facilities.		involve significant costs. Not realistic.		city, especially for the people who need it most in the south of the city.
7	Inclusiveness - mobility	B-	Absence of an effective public transport system andreliance on the car traffic fre q uential.	B-	Longer distances between places of residence and places of employment created a i m with new mobility needs. Citizens' travel time in transport will impact the health of the ec onomic v ille.	B +	Even if the mobility of auto mobilists is likely to bereduced in the central areas,most of the population can enjoy a syste mpublic transportation and fast to reach the nearby pole between them.
8	Urban Infrastructure - Improving Urban Infrastructure	AT-	The construction of the infrastructure a posteriori by the public authorities tries to catch up with the galloping and anarchic urbanization.	C	Basic infrastructure (sanitation, drinking water, waste collection) will be e tnewly ablis in all satellite towns. This will involve significant costs. Not realistic.	B +	Urban infrastructure is concentratedin the compact city and can benefit from econo m ic scale.

Source: JICA Study Team
Note: A+/-: Remarkable positive/ serious negative effect is predicted
B+/-: Positive/ negative effect is predicted to some extent
C+/-: Limited positive/ negative/ neutral effect is predicted but further survey is required
D: Effect is very small or nil and further survey is not required

Even though it is not the purpose of the SEA to decide the alternative to be chosen for the future SDAU, but rather to provide information on the relative environmental performance in order to make the decision-making process more transparent, it seems obvious, from the results of the comparison of effects, that Alternative B is the most environmentally beneficial, sustainable development alternative for Nouakchott city.

3) Evaluation from the public consultation

As explained in Part III.2 of the Main Report, the second round of public consultation (January - February 2018) devoted to the evaluation of the scenarios explained above in terms of strengths and weaknesses. One workshop has been carried out in each commune to collect the opinions from the inhabitants.

Even though the purpose was not necessarily to make the members of the CCC chose one on the scenario, but more to discuss on the possible effects on everyday life of Nouakchott citizens and to make a brainstorming on how the alternatives can be improved, it is likely that the development alternative that has been preferred to become the basis of future SDAU was Alternative B.

3.4.3 Conception of future urban structure of Nouakchott City

(1) Major concepts of future urban structure

Based on the results of the evaluation of development alternatives through SEA and public consultation, Alternative B of tripolar model at the metropolitan scale is tentatively selected for the conception of future urban structure of Nouakchott city. Indeed, Nouakchott has grown as a unipolar city, with downtown concentrating all the urban functions. This area is thus congested and saturated. The development of the balance pole in Tarhil and the international pole in the surroundings of the airport will give more equilibrium to the city at the metropolitan scale.

However, in addition of the three major cores that will compose the Nouakchott of the year 2040, some supplementary secondary poles of development shall be developed towards a multipolar structure. The goals of this structure are the following.

- Give more strength to the general city structure by dispatching urban functions;
- Achieve compact city concepts by getting services and shops closer to the inhabitants;
- Improve existing urban area, as it was requested by Seminar recommendations.

(2) Identification of secondary development poles for the realization of multipolarity

In order to identify secondary development poles in the existing city to realize the future multipolar structure of Nouakchott, several types of suitability analysis have been carried out based on the following criteria.

- Proximity from Tarhil balance pole.
- Density of commercial activity, mixed land use, and residential land use with boutiques, which are all evidences of high urban attractivity, as shown in Figure 3.12 below. This criterion could be computed through the analysis of GIS land use data gathered on field;
- Accessibility and connectivity by existing arterial road network;
- Availability of unoccupied land parcels within existing city, which could be utilize in a land redevelopment operation, as shown in Figure 3.13 below. This criterion also could be computed through the analysis of GIS land use data gathered on field.
- Presence of shanty towns which can be the target of restructuration projects.

The result of the analysis of candidate secondary development poles for the realization of multipolarity based on proximity analysis of above criteria is shown in Figure 3.14, and the identification of possible free land to promote or restructure as secondary pole is shown in Figure 3.15 below.

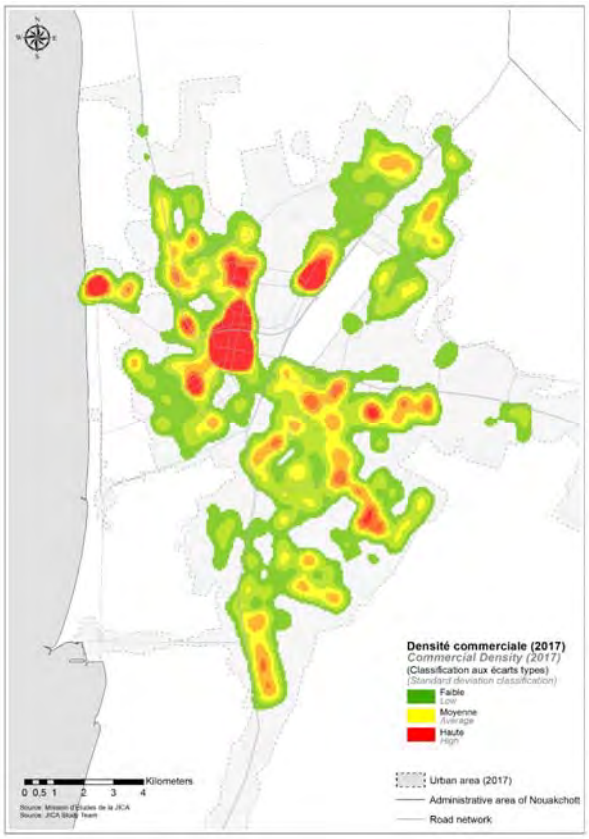


Figure 3.12: Commercial density

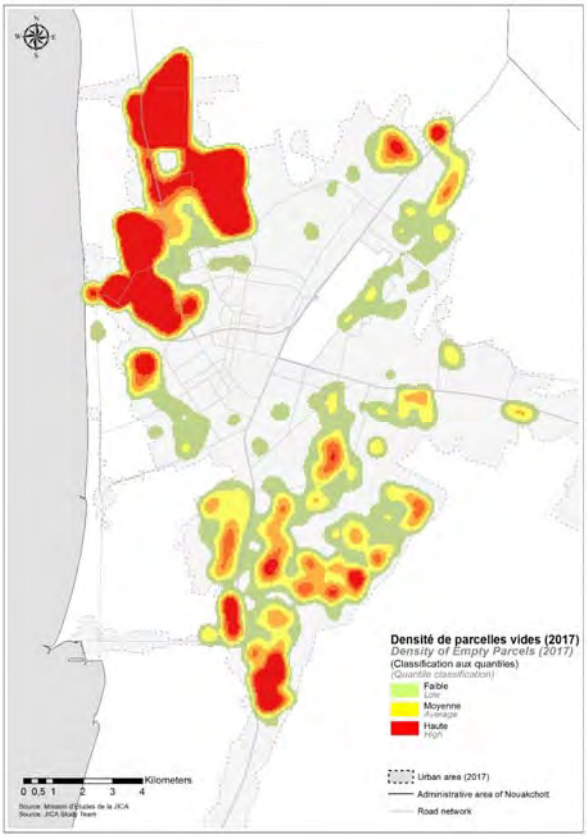


Figure 3.13: Density of empty parcels

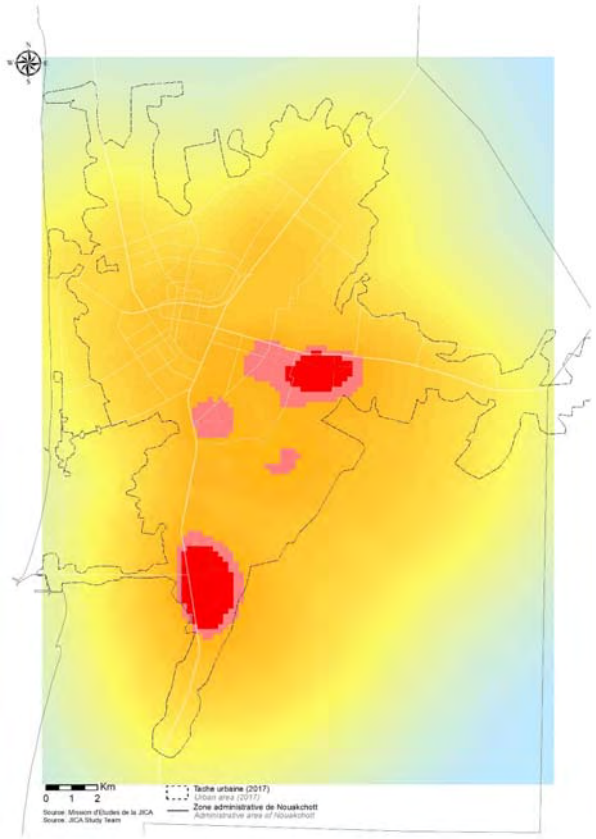


Figure 3.14: Proximity analysis

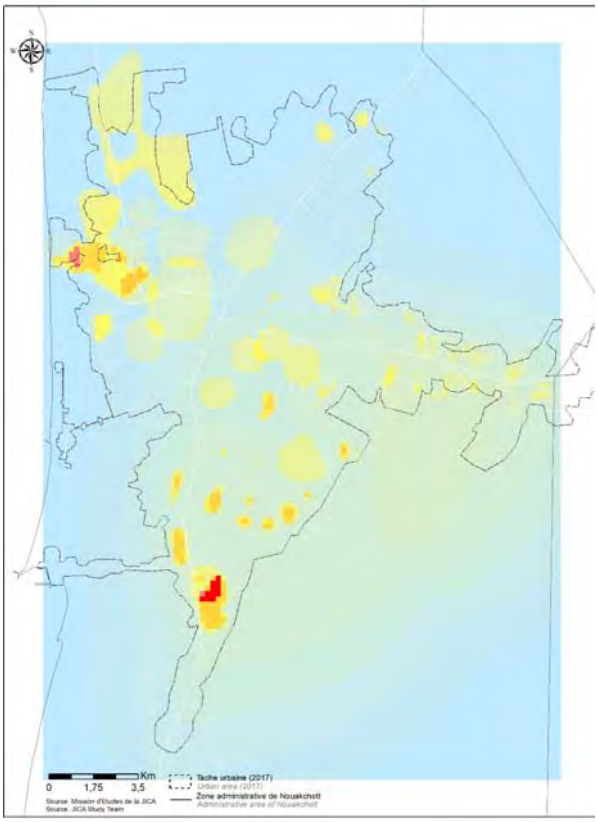
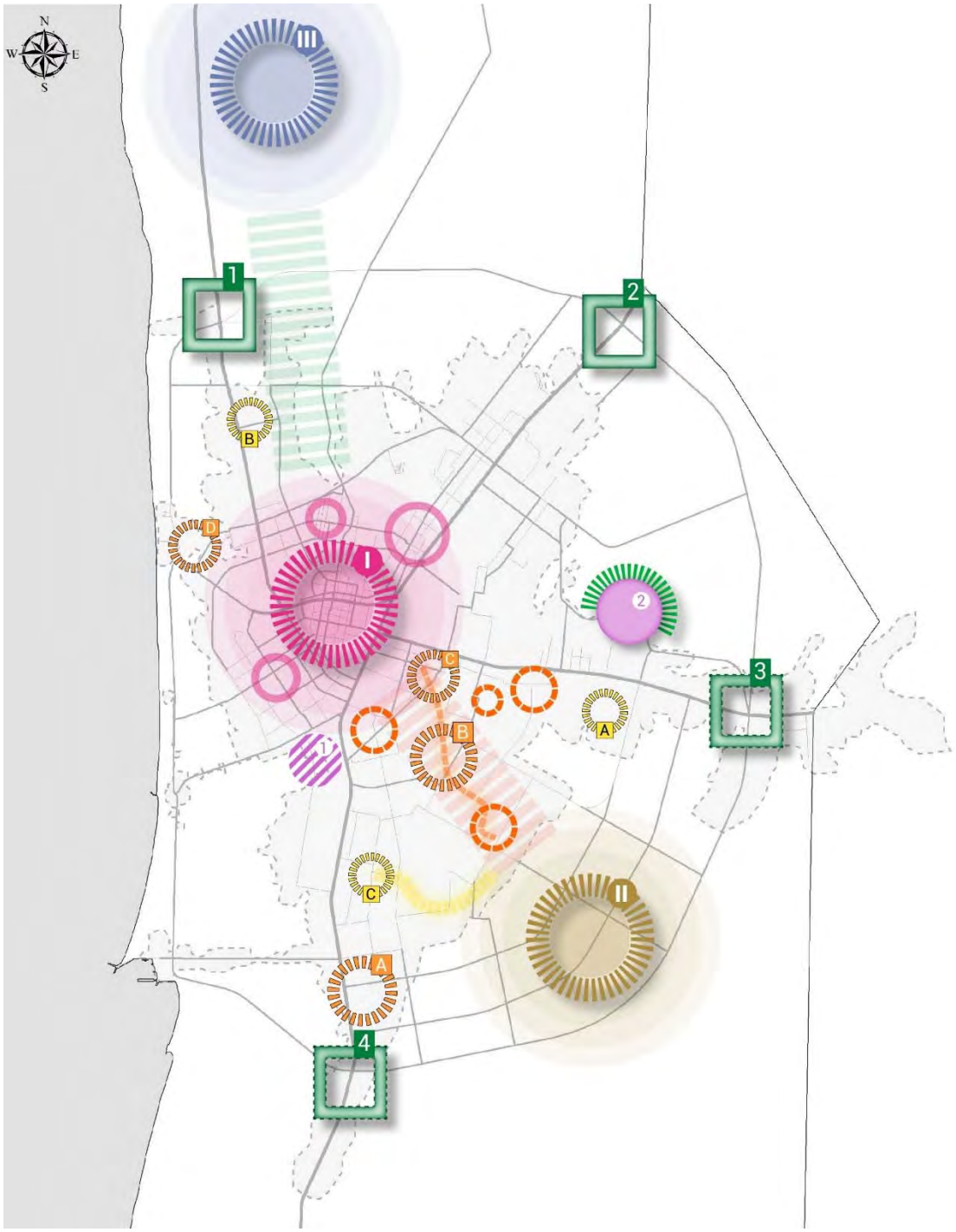


Figure 3.15: Opportunities of land development (empty parcels and slums)

(3) Future urban structure of Nouakchott City

Based on the existing urban structure, selected development alternative and on identified secondary poles, the multipolar future urban structure of Nouakchott city is established tentatively as shown in Figure 3.16 below.



Source: JICA Study Team

Figure 3.16: Proposed Tentative Future Urban Structure of Nouakchott (2040)

Each feature of proposed future urban structure is described in Table 3.15 below.

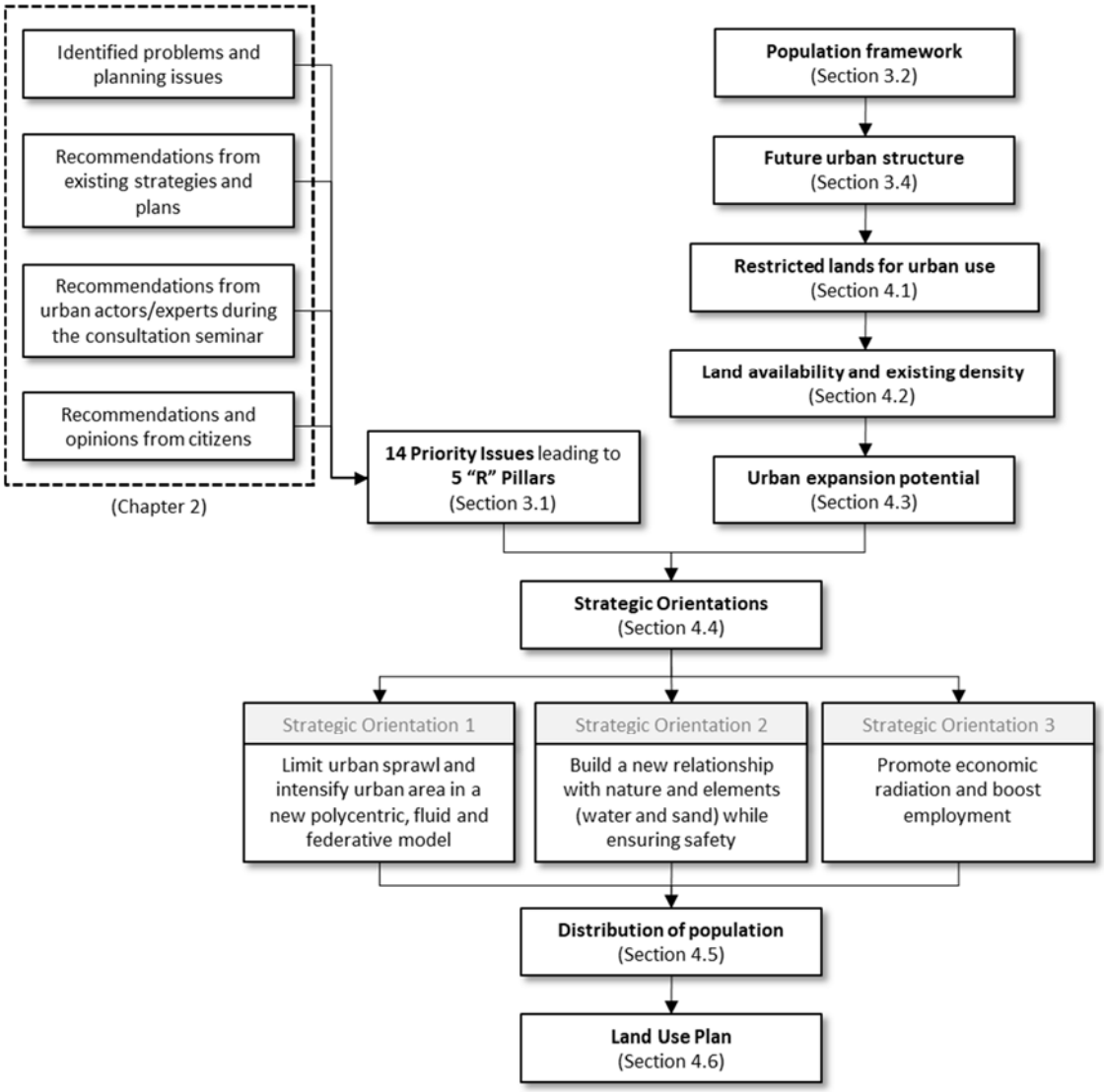
Table 3.15: Description of Future Urban Structure components

	Icon	Designation	Future function / role in the urban structure	Proposed strategy / leverage for development
Main cores		Downtown Metropolitan Core	Office and trade	-
		New Tarhil Balance Core	Large scale public facilities, small-scale industries related to agriculture and fishery, mixed housing including social housing	Important intervention from both government and private sector is necessary (ZAC)
		International Airport Development Core (IADC)	Tourism, high standard residential, transportation, convention	Large private investments and monumental public actions
Potential secondary poles		High potential secondary pole	Both commercial activity and land opportunities are coexisting. Pole B is likely to become a key pole for articulating Tarhil and Downtown	Government shall acquire and freeze land to be developed as soon as possible, especially Pole A which is on the way of Rapid Transit route
		Newly created secondary pole	Land opportunities are available (Pole "A" is slum area), but no particular commercial activity is existing. Economic activity shall be developed from scratches	Development needs great interventionism of ADU and support from medium scale private sector
		Urban redevelopment secondary pole	Structuring commercial activity is existing, but no land opportunity. Promotion to secondary pole shall necessarily be achieved through urban renewal / land readjustment	Urban renewal schemes such as land readjustment shall be mobilized. Most likely difficult to be implemented
Industrial poles		Industrial zone to be relocated	Together with the restructuration of flood-prone areas, El Mina industrial zone will be relocated in the exterior of the city on long term (destination to be defined)	-
		Industrial and ecological development pole	Continuation of the expansion of Resistance industrial zone in link with green belt and newly developed green spaces	-
Metropolitan gateways		Metropolitan gateways with high land opportunity	Metropolitan gateways have an important role of interconnection between public transportation and private car. They can welcome new public service that necessitate high level of traffic (hospitals, universities, sport facilities) but also new economic sectors	Important intervention from both government and private sector is necessary (ZAC)
		Metropolitan gateways with low land opportunity		Urban renewal schemes such as land readjustment shall be mobilized. Most likely difficult to be implemented
Main linkages between cores		Downtown – IADC linkage	Downtown – International Airport Development Core linkage is ensured by two national roads	-
		Downtown – New Tarhil linkage	Direct Downtown – New Tarhil linkage poses problems of feasibility. Several technical solutions shall be proposed, including widening of community road.	For direct linkage, expropriation might have to be utilized. Most likely difficult to be implemented
Potential corridors		Commercial corridor to be developed	Structuring secondary commercial activity is existing alongside community road, but land opportunity is rare	-
		Land opportunity corridor	Numerous land opportunities are still available along this community road	-

Source: JICA Study Team

CHAPTER 4:
LAND USE PLANNING FOR SDAU 2040

Based on the development issues and on the population framework for Nouakchott City at the horizon 2040, the land use plan is formulated as presented in the following sub-sections. The planning of land use requires the integration of numerous factors such as natural environment, social conditions and so on. Figure 4.1 below shows the work flow for the planning of land use conducted in the SDAU.



Source: JICA study team

Figure 4.1: Work Flow of Land Use Planning

4.1 Restricted Lands for Urban Use

Related to description of environmental conditions, Nouakchott city faces numerous natural hazards. The conditions for the construction of residential areas and infrastructures are not easy. Thus, it is necessary to study well the degree of vulnerability of each zone and to not propose to establish housing and facilities where specific difficulties make the construction of infrastructures almost impossible, and where future populations would be exposed to dangerous living conditions.

As a strategic city planning document, SDAU has the responsibility to set-up "non aedificanti" (construction prohibited) areas. It will help to formulate the boundary of urban growth, and it will be a

guideline for the establishment of bidding zoning and regulations to be formulated in the future PLU of each commune.

The major environmental components to be taken into consideration in the establishment of non aedificanti areas are the following.

(1) Flood-prone areas

Salty depressions or s*ebkhas* located between the actual city and the sea are the riskiest zones in terms of flooding. Exposed partly to disaster risks in case of failure of barrier beach, flood-prone in case of heavy rains and rising of the groundwater, they are also quite impossible to fit with sanitation facilities and even water supply is problematic. It would be unacceptable to let the city develop more in such an unfavorable zone. However, despite the recommendation of SDAU 2003, housing and industrial development have been established in flood-prone areas, between the actual city and the sea.

Regarding the source of data to use for the setting-up of relevant zoning, the abundant existing literature and data have been reviewed. Within the numerous and sometimes heterogeneous sources of information, one specific scientific study[1] based on the interpretation of multitemporal satellite images and on a good knowledge of climate dynamics, was evaluated as the most deeply analyzed and appropriated for the SDAU. This study has the advantage of being based on several sources of geographic information such as flood-prone zones, erosion zones and zones of salty soils of *sebkhas*. The study identified two levels of risk of flooding: the highest in the coastal salty depression; and an average risk in low lands in the interior of the city.

(2) Coastal dune

The protection of the coastal dune, also called "barrier beach" has been stressed by numerous studies and projects as a necessary condition for the future integrity of the city of Nouakchott. Even though there is an existing regulation on building permit issuing on the coastal area, the preservation of this area shall be firmly promoted by the current SDAU.

The source of information that was used for establishing the coastal dune and beach zoning is the land cover that was produced from the interpretation of the satellite image purchased by the JICA Study Team, since it consists in the most recent and most accurate date available.

In addition, the proposition of the buffer zone from the coastal dune to the hinterland shall be studied at both political and technical levels.

(3) Industrial hazard areas

As it was reported during the public consultation workshops, the booming expansion of the newly establish industrial zone of the Resistance in Dar Naim is a source of anxiety for local residents. This zone is already containing, and obviously will continue to welcome in the future, heavy industries such as metal foundry, and thus has a risk of air pollution and explosion for inhabitants who would like to settle in is vicinity.

It has been decided, according to international land use planning standards, to establish a 500-meters construction prohibited buffer around the industrial zone.

(4) Green belt

The green belt has a significant role in struggling against sand encroachment in the city. However, it has also a major symbolic role in preventing urban development to spread outside in an anarchic way. This symbolic role shall be enforced legally by the current SDAU, which has a bidding force towards administrations. Consequently, the currently achieved green belt, as well as the projects of future plantations are promoted as non aedificanti areas.

[1] Ould Sidi Cheikh, M.A, Ozer, P., Ozer, A. (2007). Flood risks in the city of Nouakchott (Mauritania). *International journal of tropical geology, geography and ecology* (31), 19 – 42.

In terms of data source, land cover map produced by JICA Study Team has been used to delineate existing green belt, and OMRG plans have been used for the future expansion of this green wall.

Figure 4.2 below shows construction prohibited areas identified for land use planning in Nouakchott at the horizon 2040.

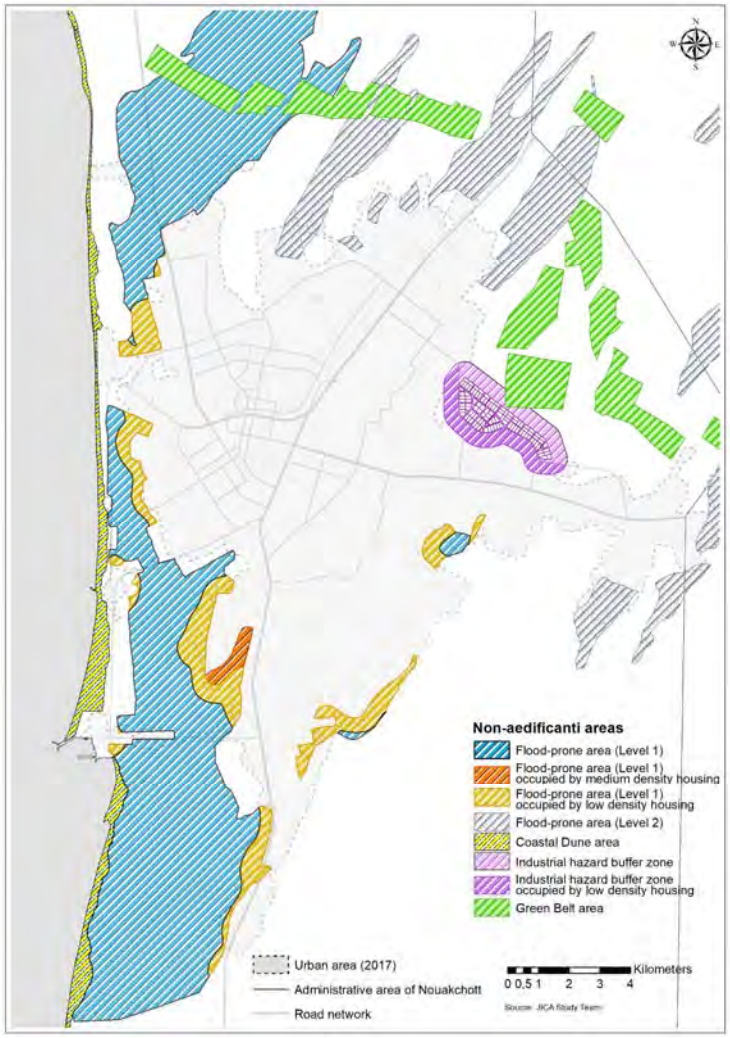


Figure 4.2: Construction Prohibited Areas

Preliminary land development policies in construction prohibited areas are described in Table 4.1 below.

Table 4.1: Land development policies in Construction Prohibited Areas

Area designation	Sub-Area designation	Housing development policy	Economic and public facilities development policy	Open space development policy
Flood-prone areas	Flood-prone area (Level 1)	All type of construction prohibited (no new building permit issued)		Open and green space development
	Flood-prone area (Level 1) occupied by medium density housing	Relocation on mid-term (2030)	Relocation of industries and public facilities	Development of green space on long term (2040)
	Flood-prone area (Level 1) occupied by low density housing	Dedensification (no new building permit issued)	Relocation of public facilities	Gradual green space development when a land is freed
	Flood-prone area (Level 2)	Construction possible at certain conditions	No new public facilities	
Coastal dune area	-	All type of construction is prohibited (no building permit issued)		

Industrial hazard buffer zone	Industrial hazard buffer zone	All type of construction prohibited (no new building permit issued)		Open and green space development
	Industrial hazard buffer zone occupied by low density housing	Dedensification (no new building permit issued)	Relocation and/or no new public facilities	Gradual green space development when a land is freed
Green belt area	-	All type of construction is prohibited (no building permit issued)		

Source: JICA Study Team

4.2 General Land Availability and Existing Density Analysis

Taking into account existing built-up density, unoccupied parcels inside the existing urban area, and previously established construction prohibited areas, a general land availability analysis has been carried out for each commune.

Gross density of existing built-up areas has been calculated based on a remote sensing operation of the satellite image acquired by JICA Study Team. Building polygons have been interpreted roughly and then computed through a kernel interpolation analysis.

The results of existing built-up density analysis have allowed to establish four different gross density categories. The calculation of average density for the area of each category gives an overall result in terms of population that is extremely close to the macro figure of Nouakchott population in 2017 (1,116,638). Thus, it can be concluded that the four identified gross density categories can be used for the housing planning of Nouakchott city.

Verification calculation based on GIS figures for establishment of existing built-up gross density categories is shown in Table 4.2 below.

Table 4.2: Verification calculation for establishment of existing built-up gross density categories

Category designation	Density scope (population/ha)	Average density (population/ha)	Area (ha)	Population
Very low density	0 to 50	25	10,443	261,081
Low density	50 to 100	75	6,223	466,691
Average density	100 to 150	125	3,120	389,998
High density	150 and more	150	467	70,094
Total calculated population				1,187,863

Source: JICA Study Team

In addition, on the basis of parcel data that has been surveyed all over Nouakchott on asphalted roads, and with a 10% sample rate in residential areas, a general categorization of 50 zones has been done in terms of occupancy of parcels and residential density categorization. The latter density has been extracted thanks to the land use information contained in the sampled parcels (especially the share of mixed-use parcels).

The results of gross built-up density analysis and general occupancy is shown in following Figures 4.3 and 4.4, respectively. The comparison of the two maps allows to make qualitative extrapolation in terms of potential urban expansion by commune. As it can be seen on the maps, some communes such as Sebkha or El Mina are extremely handicapped in their future urban expansion, while Riyad has a enormous amount of available land for urban development.

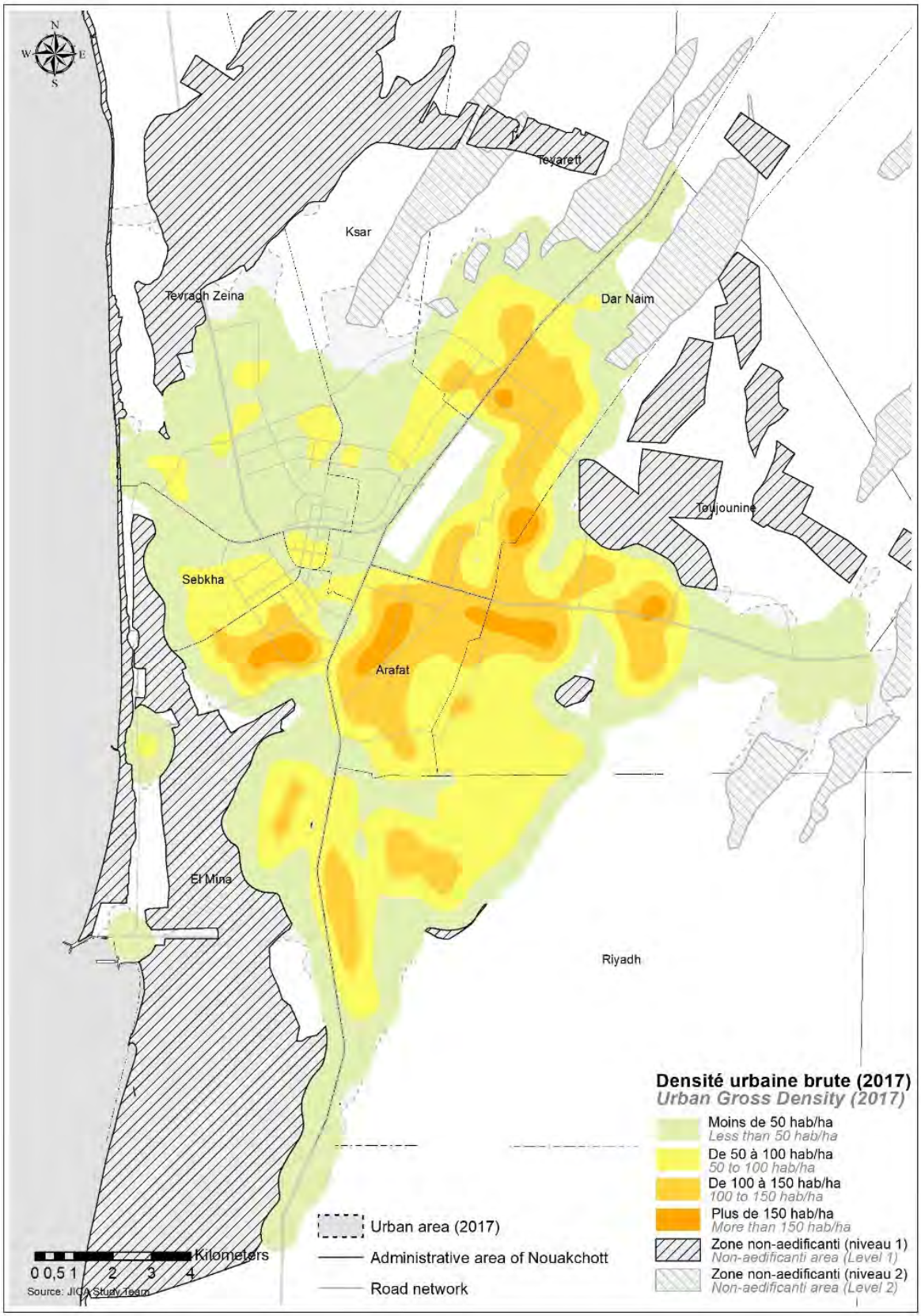


Figure 4.3: Gross built-up density

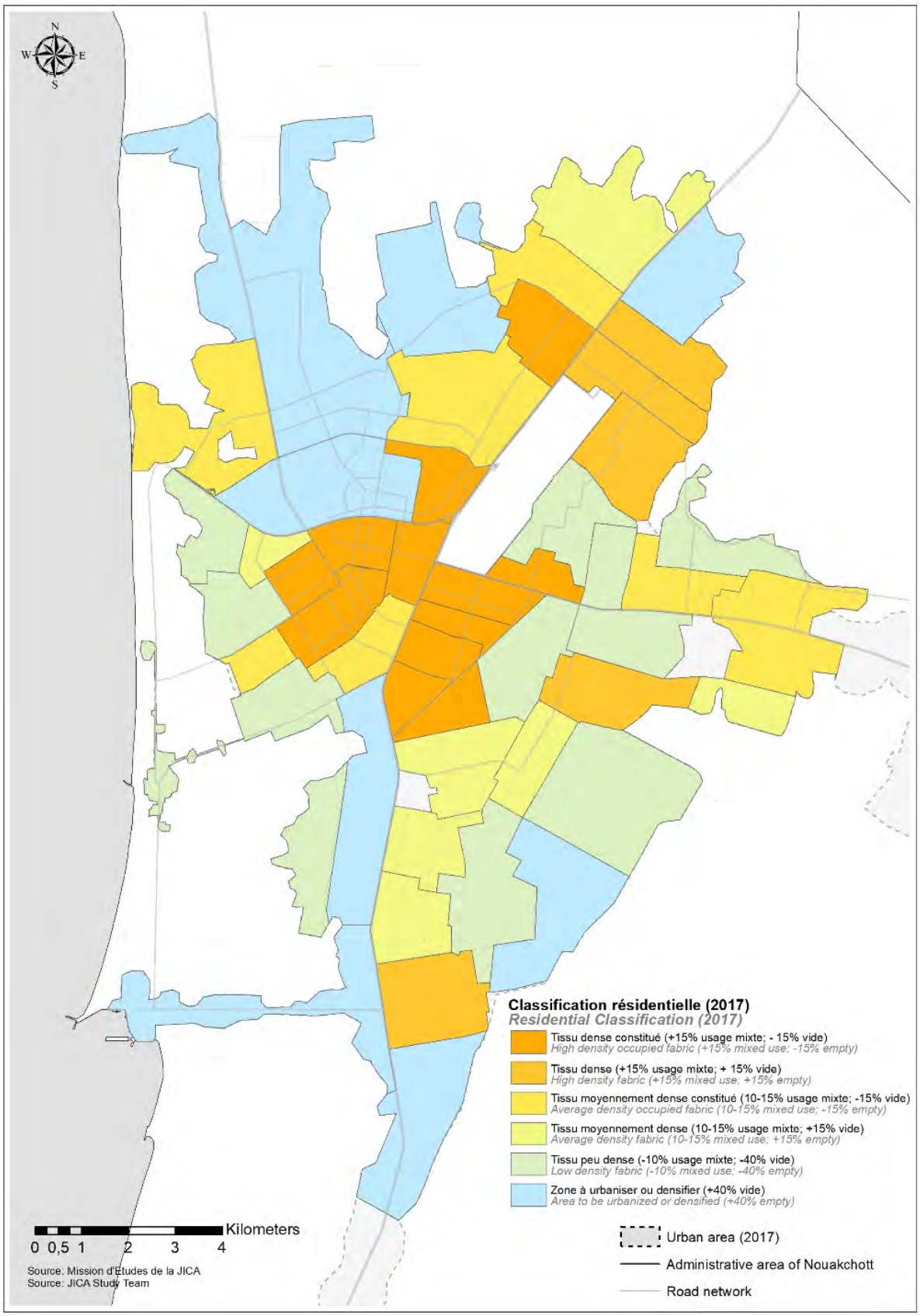


Figure 4.4: Residential categorization and occupancy

4.3 Analysis of Urban Expansion Potential

In the perspective of selection of the preferential extension zones of the city of Nouakchott, an analysis of the potential of urban expansion of the surroundings of the city was carried out, on the basis of purely geographical criteria. As Nouakchott is a vulnerable city with many environmental issues, the capacity of its soils to accommodate new urbanization needs to be rationalized.

4.3.1 Methodology

The criteria taken into account in the analysis are of natural and human nature and are either attractive or repulsive for urbanization. In terms of methodology, a 500-meter grid was first generated throughout the project area. According to the weighted linear combination (WLC) aggregation method, each square of the mesh receives an urban expansion potential score calculated on the basis, on the one hand, of the attractive or repulsive character of the criterion, but also of its weighting. This, established on a scale of 1 to 10, was decided through working groups with the Mauritanian side in July 2017.

Table 4.3 below shows the different criteria used in the analysis of the urbanization potential of the city of Nouakchott.

Table 4.3: Criterion used for urban expansion potential analysis of Nouakchott city

Criterion	Effect on the score	Spatial influence	Weight (on a 1 to 10 scale)
Airport zone	Repulsive (-)	Overlap	10.0 (urbanization forbidden)
Flood-prone and inland flooding areas	Repulsive (-)	Overlap	9.0 (extremely repulsive)
ROW of high-voltage line	Repulsive (-)	Overlap	9.0 (extremely repulsive)
Green belt	Repulsive (-)	Overlap	9.0 (extremely repulsive)
Coastal dune	Repulsive (-)	Overlap	9.0 (extremely repulsive)
Airport security zone (5,000 m)	Repulsive (-)	Overlap	7.0 (relatively repulsive)
Industrial zones surrounding area (500 m)	Repulsive (-)	Proximity	7.0 (relatively repulsive)
High sand dunes (15 m high or more)	Repulsive (-)	Overlap	4.0 (relatively repulsive)
Cemetery	Repulsive (-)	Proximity	2.5 (slightly repulsive)
Low sand dunes (less than 15 m high)	Repulsive (-)	Overlap	2.0 (slightly repulsive)
Area of bus service	Attractive (+)	Proximity	2.0 (slightly attractive)
Waste dumping site proximity	Repulsive (-)	Proximity	2.0 (slightly repulsive)
Senegal river proximity	Attractive (+)	Proximity	1.5 (slightly attractive)
Slaughterhouses proximity	Repulsive (-)	Proximity	1.0 (slightly repulsive)

Source: JICA Study Team

It should be emphasized that this analysis is not intended to put at the same level different environmental issues that have different implications, nor to prioritize these same issues instead of others. Indeed, even if the green belt protection and the coastal dune protection have the same weighting, it is obvious that the integrity of the coastal dune is more important in a perspective of sustainability of the city on the long term. The purpose of this exercise is rather to give visibility to the theme on environmental vulnerability, which is often abstract, and to give a general idea of the direction of future urban expansion.

4.3.2 Results

Figure 4.5 below presents the results of the urban expansion potential analysis, represented by the score of the aggregation of the criteria explained above through a gradient from red (low urbanization potential) to green (high urbanization potential).

The urbanization of the space between major roads is now essential in the future expansion of the Mauritanian capital, in order to thwart the linear historical extension along the penetrant roads. Putting aside the coastline as a space on which urbanization is not advisable, the following three directions have been identified for the comparison of the potential of urban development.

(1) Northern direction between Nouadhibou road and Adrar road;
(2) Eastern direction between Adrar road and Hope road;
(3) Eastern direction between Hope road and Rosso road.

It seems clear from the results of the analysis of the potential for urban expansion that the preferential direction for urbanization is the Southern direction between Hope road and Rosso road, in the urban continuity of the neighborhood called Tarhil, located at the extreme south of the city of Nouakchott. This conclusion is true at the same time on the short term, but also on the medium and long terms, since the urbanization will be blocked notably in the North by the presence of the airport.

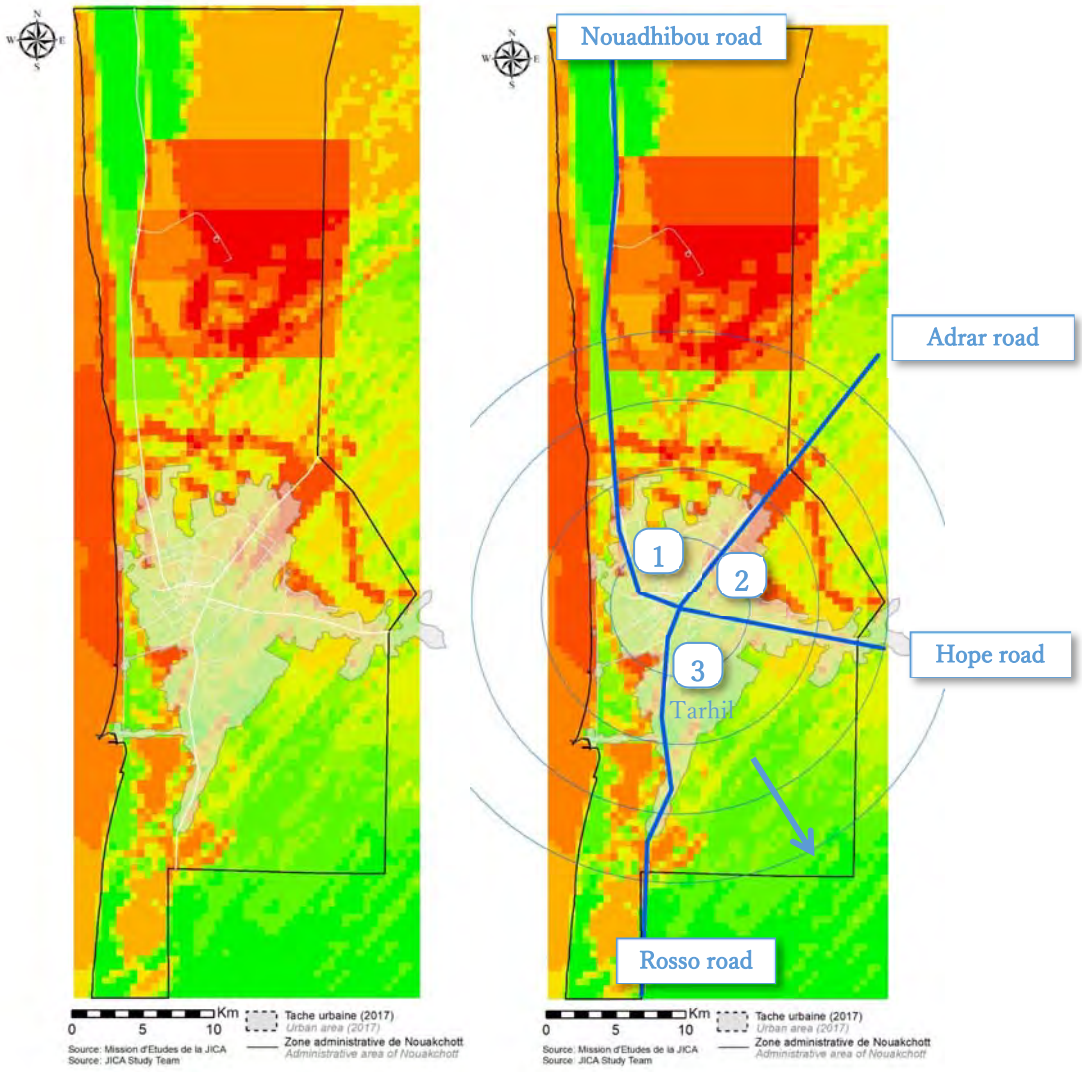
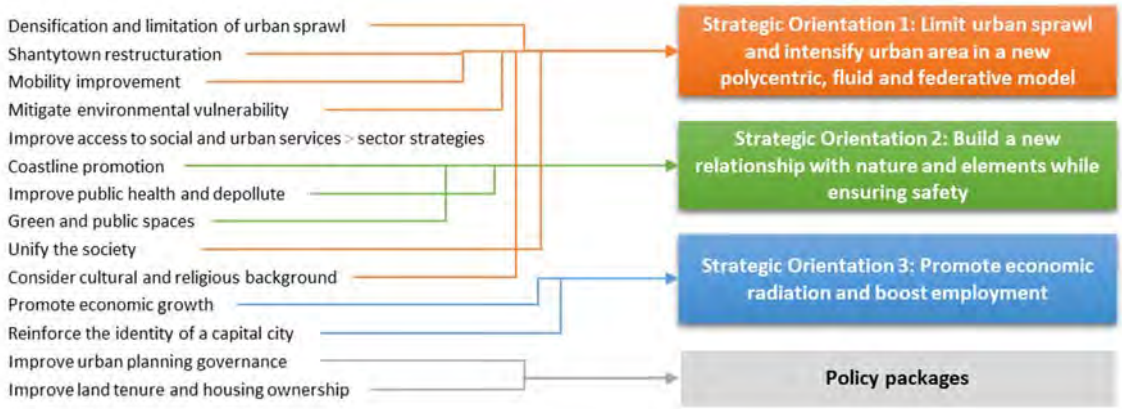


Figure 4.5 Urban expansion potential of Nouakchott city

4.4 Strategic Orientations

As explained in the scope of SDAU in introduction of Part I of this report, strategic orientations and planning concepts has been elaborated in order to make the link between the Priority Planning Issues and the land use plan, as shown in Figure 4.6 below.



Source: JICA Study Team

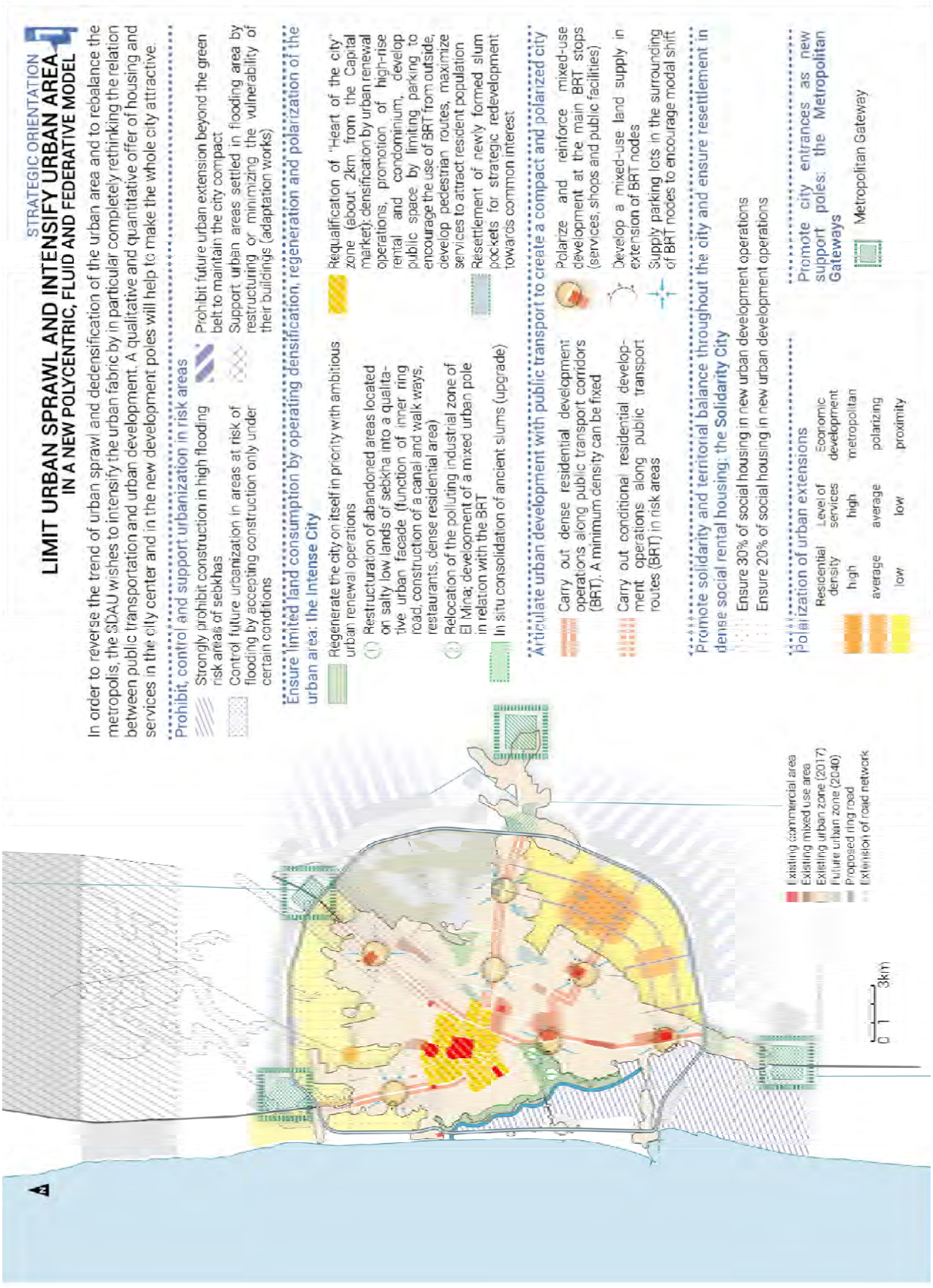
Figure 4.6: Formulation of Strategic Orientations to tackle Priority Planning Issues

The three proposed strategic orientations are explained below through summary maps and detail explanation on specific aspects that needs to be clarified regarding implementation. The propositions shall be discussed with all stakeholders before being detailed in more concrete action plans.

4.4.1 Limit urban sprawl and intensify urban area in a new polycentric, fluid and federative model

In order to reverse the trend of linear urban sprawl and dedensification of the urban area and to operate the re-equilibrium of the metropolis that was identified as the most suitable development alternative, the SDAU intends to densify and intensify the urban fabric. This will be possible by putting in relation newly introduced public transportation and urban development, especially through the realization of secondary poles. A qualitative and quantitative offer of housing and services in the city center and in the new development poles will help to make the whole city attractive. The proposed intensification model is aiming at polarizing the densification effort on some strategic urban nodes (primary and secondary poles), while generally preserving Nouakchott's low density and quality of life in already existing residential areas.

The following sub-section details specific planning concepts of strategic orientation 1, while Figure 4.7 below summarizes it and show its spatial implications.



Source: JICA study team

Figure 4.7: Summary of Strategic Orientation 1

(1) Prohibit, control and support urbanization in risk areas

In order to guarantee a healthy future urbanization of the city, it is necessary to take into account the risk of flooding in the planning. Since it is not conceivable to prohibit all form of urbanization in flood-prone areas, some degree of risk has been established, as explained above. If some areas shall be deprived of any new construction, some other less vulnerable areas can accept construction at some conditions.

1) Strongly prohibit construction in high flooding risk areas of sebkhas

Salty depressions or s*ebkhas* located between the actual city and the sea are the riskiest zones in terms of flooding. Exposed partly to disaster risks in case of failure of barrier beach, flood-prone in case of heavy rains and rising of the groundwater, they are also quite impossible to fit with sanitation facilities and even water supply is problematic. It would be unacceptable to let the city develop more in such an unfavorable zone.

This zone is designated as construction prohibited area. In SDAU land use plan, no development will be proposed.

On a larger scale and following the recommendations of the Mauritanian Coastal Master Plan (PDALM), the coastal line running from the north of the new airport to the south of the port of l'Amitié will have to constitute the perimeter of Nouakchott Coastal Planning Directive (DAL) having the value of Coastal Risk Prevention Plan (PPRL).

2) Control future urbanization in areas at risk of flooding

Especially in the northern part of the city, even though there is a risk of flooding, construction shall not be strictly forbidden. Since this area is likely to welcome important private urban development operations in the near future, completely forbidding construction would curb economic growth of Nouakchott.

In those zones, the conditions for according building permits can be specified to focus on the adaptation of building methods (earthwork, stilt) and material to the risk of flooding. In addition, a dedicated Flooding Risk Prevention Plan on the model of French PPRI (plan de prévention du risque inondation) might be established as upper-level document to apply to city planning (SDAU, PLU). This plan, that would be based on serious field survey and scientific studies, would especially designate the risks zones to be reflected in the PLU, and would recommend specific measures for building permit issuing.

Nouakchott Coastal Planning Directive (DAL) having the value of Coastal Risk Prevention Plan (PPRL) and the Flooding Risk Prevention Plan (PPRI) proposed above should be developed simultaneously and coordinated in order to refine the spatial orientations of the SDAU for their effective translation into the different PLUs to be formulated. Thus, these two plans, whose regulatory outline will have to be clarified, will have to be formulated and implemented in priority.

In SDAU land use plan, newly proposed urban extension and road network in this area, especially of Airport City, is designed to avoid the flooding risk areas, even though some high-standard residential development might be settled in them.

(2) Ensure limited land consumption by operating densification, regeneration and polarization of the urban area: The Intense City

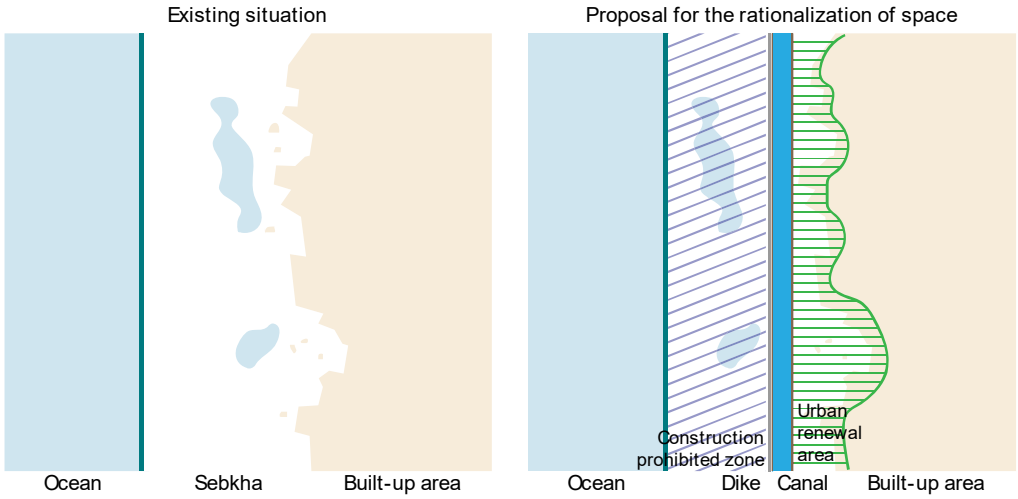
Having consumed large amounts of lands in an unplanned manner during the past decades, Nouakchott urban development shall from now limit its land consumption. Before considering continuing urban extension on the virgin lands in the outskirts of the city, opportunities for urban regeneration in the existing city shall be pursued in priority.

1) Regenerate the city on itself in priority with ambitious urban renewal operations

Two sites have been identified as potential areas for urban renewal. The two sites, which are adjacent, have large areas, which make their regeneration challenging but also crucial for the future of the city on long term.

① Restructuration of abandoned areas on low lands of Sebkha into a qualitative urban façade

As explained above, the zone of sebkhas will be classified as construction prohibited area. In parallel, with the creation of a dike and a canal as a symbolic and physical buffer (see strategic orientation 2), there is an opportunity to requalify the urban part of this land strip, as shown in the illustration below.



Protected by the dike and fully oriented towards the canal, a new neighborhood targeting both residents and visitors would be created: high-standard housing development, mixed areas with restaurants and welcoming places, walkways along the canal, etc.

In addition, the shape and position of this land strip makes it relatively strategic to bear the function of linkage between North part and South part of the city, and between populated shoreline of Sebkha commune to Rosso road at the Southern entrance of the city. If its role in the green and blue framework supporting walking and biking activity is a priority, as discussed in Section 4.4.2 below, its function of inner ring road or shortcut for automobiles shall be studied furthermore.

② Redevelopment of El Mina industrial zone into a mixed urban pole linked with the Rapid Transit

El Mina industrial zone, located at an extremely strategic position close to central district and having vast plots of lands own by industrial estates, has an important potential for redevelopment. It is proposed that, at horizon 2040, the industries will be delocalized in other industrial zones located in more appropriate areas. El Mina zone will thus be totally deindustrialized. Redevelopment of the zone, which stands on the Rosso road, will be focused on the articulation with newly introduced Rapid Transit system.

2) Requalification of “Heart of the city” zone

The traditional city center which is historically concentrating all major urban functions of Nouakchott, is currently changing at a rapid pace. In downtown area, large land plots own by government are sold to private sector to make commercial and business-oriented development, and a real central business district is about to be formed.

It is proposed to plan the surrounding of this central business district (about 2km from the Capital market) as a specific residential zone, entitled “Heart of the city” zone, which would maximize living environment for urban citizens. As investigated in household survey results, this area shows already some characteristics of a new type of urban area comparable to compact city: people settle there to be near their jobs (access by taxi, no need to own a car), to benefit from high quality urban services and commercial areas. The proposition of requalification is the concretization of this trend.

The basic concepts of this zone are to (1) rise the quality of urban environment and services and to (2) enhance the linkage with the central business district situated in close distance. The implementation of

those two basic concepts will participate in giving an added-value to this area, by the creation of a competitive "urban-oriented" neighborhood mostly based on rental apartment housing as an alternative to individual homeownership in the suburbs, and thus will attract resident population. Targeting mostly working individual and small-scale households, the zone will provide a more efficient living environment with the promotion of high-rise rental and condominium through redevelopment operations. Public and green space will be increased and enhanced mostly by limiting parking area, which will also encourage the use of Rapid Transit from outside. Pedestrian and biking routes will be designed from each sector of the zone to be able to reach the central business district easily and quickly.

3) On site consolidation and upgrade of ancient slums

The first slums of Nouakchott that has remain untouched by ADU redevelopment operations have been historically consolidated spontaneously and have evolved into real dense and mixed neighborhoods. Those areas shall be studied precisely and propositions in terms of upgrading urban and social services and improving housing condition shall be done. The on-site requalification of shantytowns shall be the occasion of finding land for public or green spaces.

4) Resettlement of newly formed slum pockets for strategic redevelopment

Regarding slums pockets formed recently, even though the international trend for slum restructuration is on-site redevelopment, clearance of the area and resettlement of their population shall be proposed in some areas. The two major objectives for this policy are (1) to accommodate population in better housing conditions, for example in social housing projects to be developed throughout the city, and (2) to benefit from strategically located lands (in particular alongside Rapid Transit corridors) for strategical redevelopment towards common interest. The resettlement of slum pockets shall be the occasion of finding land for public or green spaces.

(3) Articulate urban development with public transport to create a compact and polarized city

The introduction of an efficient public transportation in the city is crucial for the future development of the unvisaged 5-R urban development. The most suitable type of Rapid Transit system for Nouakchott is identified to be the BRT (Bus Rapid Transit) system as analysed in Chater 5 of this report. Throughout 5 different BRT routes linking central district to the different part of the city shall become the backbone for the future scheme of urban development. The dependency to car use will progressively decrease with the formation of public transportation oriented compact city based on the following planning concepts.

1) Carry out dense residential development operations along public transport corridors

Along the public transportation (BRT) corridors, a densification of residential land use shall be promoted in order to make the operation of public transportation profitable. In terms of implementation measures, minimum densities can be fixed in the PLU.

To achieve the pursued densification of residential function alongside BRT corridors, "axis contract" can be introduced. Based on the French model of "contrat d'axe" which can be seen as an evolution of TOD policies. The expression refers to a mutual commitment between two types of partners: on the one hand, a transport organizing authority, which commits itself to the commissioning of a new or renewed transportation network and on the other hand, the served communes, which undertake the responsibility to densify the urbanization along the corridor and to arrange access to the stations.

Another tool that can be used in Nouakchott for implementation of this policy would be a convention signed between all partners of development (public and private) along a specific public transportation corridor to regulate land prices. Indeed, in all TOD operations, there is a trend of high increase of land value and of gentrification of redeveloped residential area along public transportation corridors. In order to anticipate this increase and to make it possible for the majority of households to settle close to public transportation corridors, the convention between the public authority, social landlords and private developers can fix the proportion of social housing and housing with a ceiling selling price. For example, the city of Bordeaux in France, through the operation of "50,000 dwellings along the axis of public transportation" ("50 000 logements autour des axes de transport collectifs"), has signed a convention with 9 social landlords and 16 private developers to respect 1/3 of rental social housing, 1/3 of

homeownership at a ceiling selling price of 2,500 euros/m^2 and 1/3 of homeownership at free selling price.

2) Carry out conditional residential development operations along public transport in risk areas

In areas of flooding risk, residential development operations along public transport routes can be operated, but at certain conditions discussed previously. In SDAU land use plan, residential densities are kept low along BRT corridor of Adrar road because of the potential flooding risk.

3) Polarize and reinforce mixed-use development in secondary poles / BRT nodes

The surrounding of BRT stops shall be planned in a way to enhance mixed use development (services, shops and public facilities) and to form a multi-polar structure in the city. Those places shall become attractive and convenient spaces for the satisfaction of the needs of public transportation users, but also for local residents, on the model of Japanese stations.

4) Supply parking lots in the surrounding of BRT nodes to encourage modal shift

Finally, parking lots shall be supplied in the surrounding of BRT nodes to encourage residents to leave their car to use the public transportation.

(4) Promote solidarity and territorial balance: The Solidarity City

As it was analyzed from the household survey, solidarity is one of the main pillar of Nouakchott society, and social mix is already well established in current urban area. SDAU intends to support solidarity and territorial balance throughout the city by operating resettlement of slum population in dense social rental housing, and by ensuring 20% to 30% (tentative) of social housing in new urban development operations.

(5) Promote city entrances as new supporting poles: Metropolitan Gateways

The proposition of development of special planned areas entitled Metropolitan Gateways is based on the following reasons.

- There is in Nouakchott a shortage of available public land in general, and especially of vast plots of land, which hinder the development of large-scale public facilities. Thus, in order to avoid large-scale expropriation inside the existing city, it is necessary to find land opportunities outside the existing urban area;
- Currently the modal change between inter-city buses and inner-city taxis and minibus is done in an informal way at each entrance of the city, and especially on the road to Boutilimit in the eastern direction in the area called Tenweich. Taxis and buses are parked alongside the road and drink and food stalls are established to satisfy the needs of the travelers. There is an opportunity to formalize this existing informal attractivity to enhance its efficiency.
- With the construction of ring road, general accessibility in the city will be improved and the areas at the intersection of national roads and ring road will become strategic positions at the interface between the inside and the outside of Nouakchott City urban area. Since those areas are not yet privatized, there is an opportunity for the public authorities to develop them harmoniously;
- There is a necessity, as proposed in the conclusion by Cergy Workshop, to develop each entrance of the city symbolically as a pleasant and welcoming space.

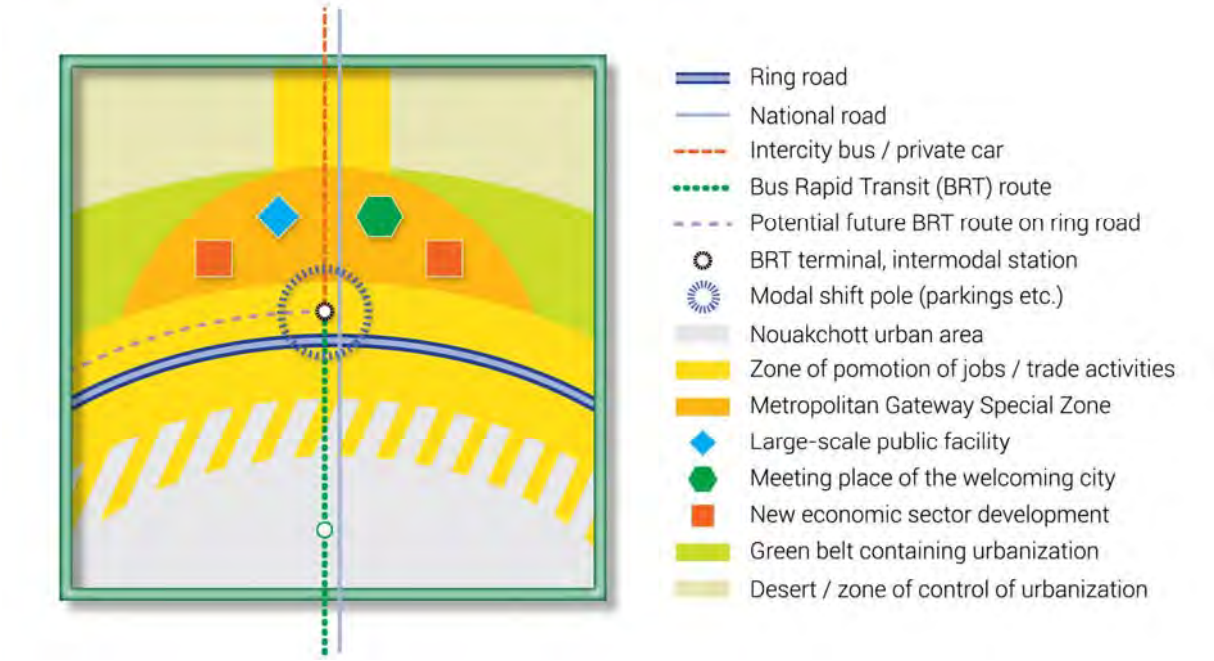
Based on the above four reasons, Metropolitan Gateways are proposed to endorse the following roles.

- Role of welcoming new large-scale public facilities, especially the ones that necessitate vast land plot and high level of traffic (hospitals, universities, sport facilities, fire stations);
- Role of modal shift and interconnection between inner-city public transportation, especially BRT, and inter-city transportation, such as private car or inter-region taxis or coaches. Thus, BRT terminal, inter-city bus terminal, taxi parking and parking for modal shift of private cars shall be developed;
- Role of public space to welcome travelers in optimal conditions. In addition to necessary services to travelers such as toilets, shadow, or drinkable water sources, those spaces can be designed and landscaped to become the symbol of entrance in Nouakchott;
- Role of welcoming medium and small scale private companies of generally two types: on one hand personal services companies which can benefit from the presence of travelers (shops,

restaurants, etc.), and on the other hand the companies which can grow on the high-transit potential of the position between the ring road and national roads (logistics hubs);

- Role of welcoming commercial activity zones or shopping malls which could benefit from the strategic position of Metropolitan Gateways, under specific conditions.

In order to fulfil the various roles described above, Metropolitan Gateways shall be planned and developed as multi-functional spaces, as shown in the conceptual scheme below (Figure 4.8).



Source: JICA study team

Figure 4.8: Conceptual scheme of Metropolitan Gateway

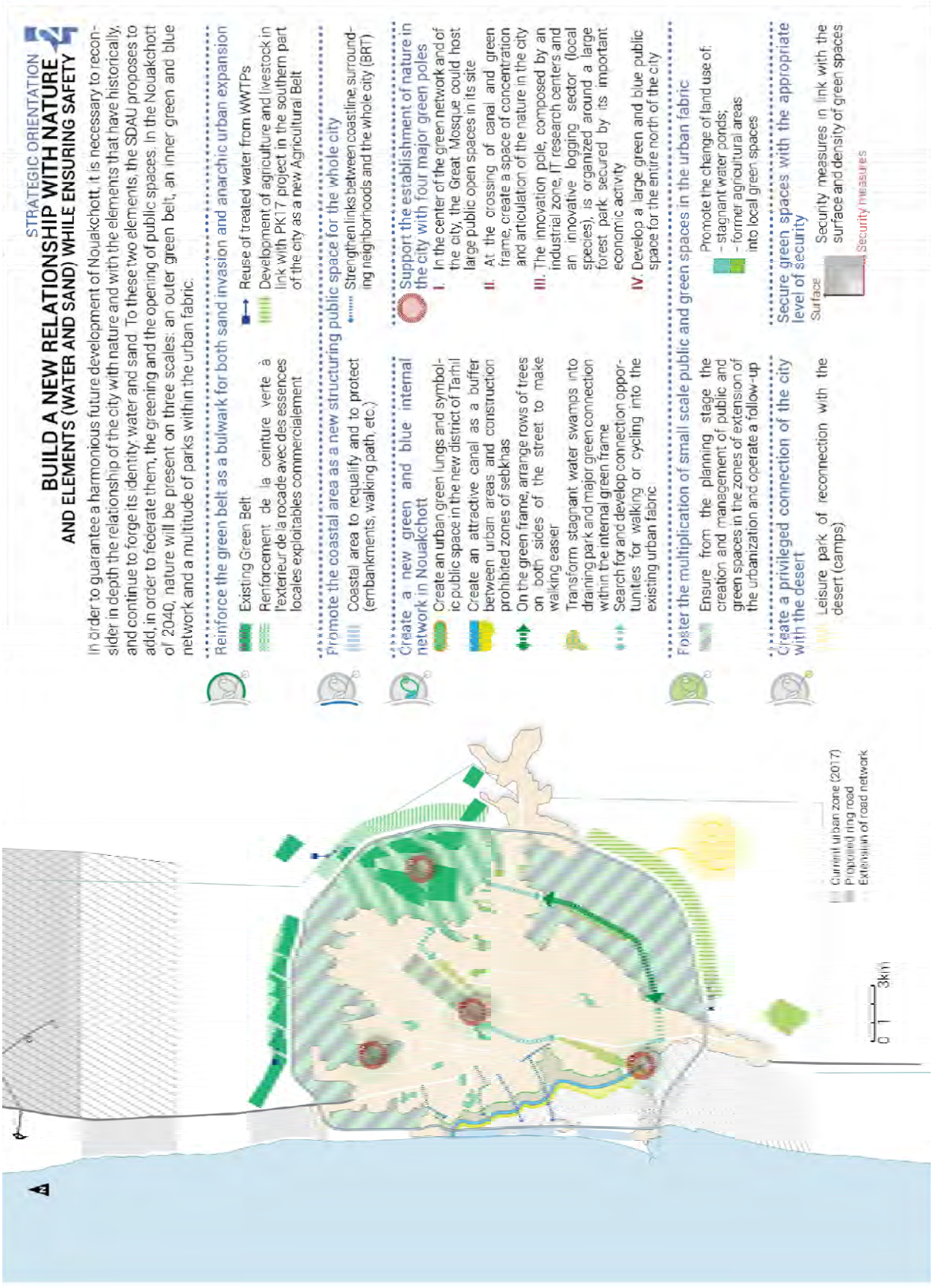
In terms of implementation, it is advisable that MHUAT takes the lead of the planning operations through the establishment of a Concerted Development Area (ZAC: Zone d'Aménagement Concerté). Ideally, the four Metropolitan Gateways can be part of the same convention in order to multiply finance options and to increase the fluidity of negotiations, as proved previous example of financing of the construction of the new international airport.

In terms of planning of public facilities, each of the four Metropolitan Gateways shall be planned based on both specific needs of the locality and also the need for a supra facility at the metropolitan scale.

4.4.2 Build a new relationship with nature and elements while ensuring safety

Nouakchott is settled on a vulnerable natural environment. In order to guarantee a harmonious future development of Nouakchott, it is necessary to reconsider in depth the relationship of the city with natural environment and phenomenon like presence of stagnant water and silting. The SDAU proposes to create a city which would benefit and not suffer from its environment. Also, since the need for more green space has been demanded by citizens through household survey and public consultations and has been recommended by professionals during the seminar, greening and the opening of public spaces is a key strategy for the future of the city. In the Nouakchott of 2040, nature will be present on three scales: an outer green belt, an inner green and blue network and a multitude of parks within the urban fabric.

The following sub-section details the main planning concepts of strategic orientation 2, while Figure 4.9 below summarizes it and show its spatial implications.



Source: JICA study team

Figure 4.9: Summary of Strategic Orientation 2

(1) Reinforce the Green Belt as a bulwark of sand invasion and anarchic urban expansion

After the completion of ring road, efforts for expanding the experience of green belt shall be pursued to realize the planting of an outer green belt. The objectives of the outer green belt are similar to the one of existing green belt, that is to say to protect the city from silting and to limit the urban sprawl. Nevertheless, the proposed outer green belt adds another objective of economic profitability, as detailed in strategic orientation 3 below.

In the Southern part of the city, agriculture development will be led, in association with PK17 project, to form an outer frontier to urbanization and to boost economical opportunities for southern areas. As detailed in wastewater development plan of this report, WWTP to be built will have irrigated areas in their vicinity, that can support the constitution of this agricultural belt.

(2) Promote the coastline as a new structuring public space for the whole city

As it was strongly recommended by Cergy Workshop and requested during the public consultation meetings, there is a necessity, in a city like Nouakchott which lacks public spaces, that the coastal area shall be planned as a major public space for the city. Beach is already a magnet for Nouakchott citizens who are willing to breath far from the congestion of the capital city.

The two major actions proposed in SDAU are physical protection and requalification of the shoreline itself on one hand and strengthening of its accessibility to citizens on the other hand.

Apart from the necessary engineering works (embankments etc.) to increase the resiliency of the shoreline, facilities to improve the hospitality of the coastal area as a public space shall be introduced in the backside area of the beach: benches, walking path, sports facilities, children playgrounds, etc.

Linkage between the most populated surrounding neighborhood and the coastline have been identified during public participation workshops. Those routes shall be developed to welcome the greatest possible transportation mean, including walk and biking. Similarly, giving the fact that coastal area has the potential to become a public space at the scale of the whole metropolitan area, easy access shall be possible from BRT stops, especially from the one that will be developed at the place of El Mina industrial area.

(3) Create a new green and blue internal network in Nouakchott

Fostering both soft mobility (walking and biking) and multiplication of green spaces, SDAU proposes the establishment of a green and blue internal network within the existing city. The constitution of the green and blue network will be possible on the long term, by implementing progressively the planning concepts detailed below. Once finished, the internal network will facilitate local mobility of population, especially by linking Southern and Eastern peripheries together and to the most central areas of the city.

1) Create an urban green lung and symbolic public space in the new district of Tarhil

The new extension to the south of the city in the continuity of Tarhil area will be done in an area of sand dunes of average size. One of the valley between the dunes, which has a little risk of flooding, shall be developed as the major green area of the neighborhood.

2) Create the attractive “buffer canal” of Sebkha – El Mina

As discussed previously, salty depressions or sebkhas located between the actual city and the sea are the riskiest zones in terms of flooding, and it would be unacceptable to let the city develop more in such an unfavorable zone. This area represents a relatively important surface in the southwest part of Nouakchott. In order to prevent further urbanization on sebkhas, to rationalize land use and to prepare the city to climate change, several solutions have been studied.

The proposition issued by Cergy Workshop to open to the sea the coastal low lands of sebkhas in order to turn the whole area into a lagoon has also been analyzed in technical terms. The conclusion is that this proposition would have a disturbing impact on the equilibrium of underground water table, which are shallow, and the penetration of rainwater, would become even more difficult. In addition, industrial effluents and wastewater discharges might contaminate the water from the lagoon and thus create public health problems.

The best solution to prevent urbanization, to federate the whole sebkhas area with a positive impact on water outflow would be the creation of a dike and a canal that would link all the small lagoon spots. It would prevent sea incursion and allow the population to enjoy a cool, open and unpolluted resting place. Also, the proposed canal could be used for pedagogical and educational purposes to the environment (school visits, ecotourism etc.). However, precautions shall be taken towards implementation of the canal, especially regarding the changes in hydraulic dynamics, general evolution of sanitary situation with possible appearance of mosquitoes and on-spot security (plan the construction of fences to avoid children from falling in the canal).

3) Arrange rows of trees on both sides of the street to make walking easier

Giving the hot and arid weather of Mauritania, the creation of shadow in the city is a major challenge for the future well-being of the citizens. Similarly to the habit of having trees and *khaima* tent to cool down the private courtyard, trees can be planted on roadsides to refresh the public space and thus foster walkability. With a relatively dense tree continuity alongside the roads of the internal green network, the temperature can drop of 1 or 2 degrees, depending on the type of tree used. Further studies shall be carried out to determine the best essence to use, even though local Acacia already existing in the city, or fruit trees like mango or lemon trees may be the most appropriated.

4) Transform stagnant water swamps into draining park and green connections

Stagnant water swamps that are scattered throughout the city are not suitable places for urbanization. Most of them have been abandoned by residents. The opportunity shall be taken to change the vocation of the land from residential to green area, especially because some of the swamps have a linear shape due to the form of the valley, and thus can become major green connection within the internal green frame. It is the case for the long North-South swamp that follows road of Rosso. This area, almost completely abandoned, could become a 5-kilometer-long park welcoming walking courses and recreational activities.

(4) Support the establishment of nature with four major green poles

The building of a new relationship with nature in Nouakchott shall be accompanied by the creation of major green poles of high symbolic importance.

I. In the center of the green network and of the city, the Great Mosque to be constructed in the site of the former airport, could host large public open space;
II. At the crossing of the canal of Sebkha – El Mina and of the green framework, create a space of concentration and articulation of the nature in the city;
III. The innovation pole, composed by an industrial zone, IT research centers and an innovative logging sector (local species) is organized around a large forest park secured by its important economic activity;
IV. Develop a large green space around the wetland in Tevragh Zeina benefitting to the whole Northern part of the city.

(5) Foster the multiplication of small scale public and green spaces in the urban fabric

As the household survey results reflects, the most important criteria for a green space according to the citizens of Nouakchott, is the proximity (62% of surveyed persons, ranked 1st criteria to the question "what are the 3 most important criteria for your ideal park or green space?"). Thus, public and green spaces shall be designed in Nouakchott so they are equally distributed in the residential areas, at the smallest distance possible from houses. Since it is difficult to find land reserves in the existing urban fabric, new extensions and urban renewal operations shall be used to multiply the number of parks. In terms of implementation, the use of incentives and bonuses scheme for private investors and shop owners who establish publicly accessible green or public space (POPS: Privately Own Public Space) can be planned in future PLU.

(6) Manage green spaces with the appropriate level of security

It has been pointed out in the public consultations that citizens are in need of more green spaces, but that security shall be first ensured in those areas. Indeed, even though there is not any scientific proof that neighborhood parks are necessarily crime generators, not considering this risk would lead to miss out a

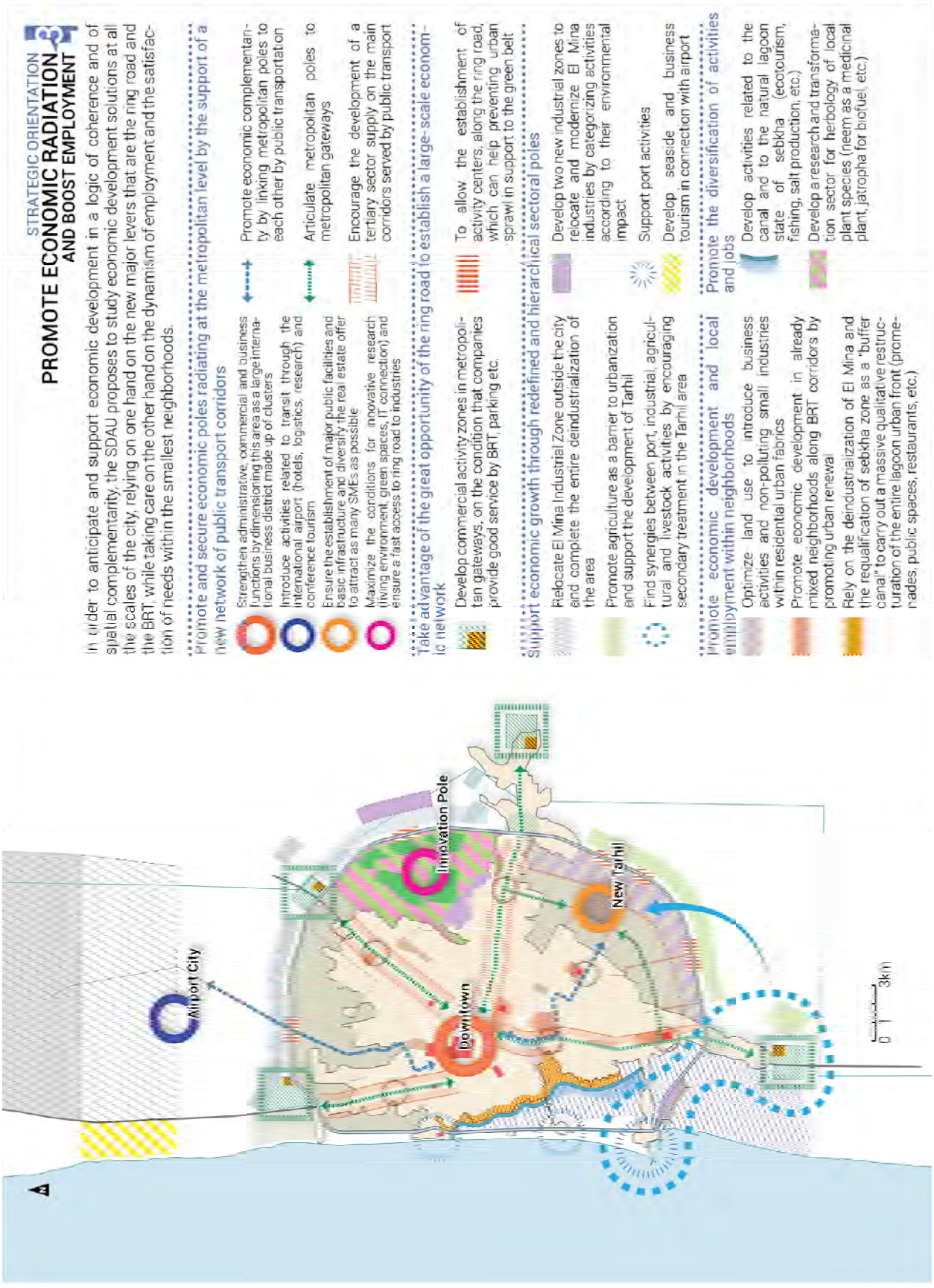
crucial issue for the acceptation of public spaces as positive spaces in Nouakchott. Thus, it is necessary to analyze what would be the elements likely to make public a criminogenic green space in Nouakchott, and to propose avoidance features a priori, and not securing excessively spaces posteriori.

green and open spaces, especially when they are (1) far from dwellings, (2) deeply planted so people can hide, and (3) have a vast area, are criminogenic. Green area planning shall thus be done tackling the three mentioned factors in order to ensure security: they shall be close to the dwellings, of small area, and not planted with too many trees. The model of pocket parks seems to be adapted in Nouakchott, especially due to the fact that small plot of land are remaining scattered into residential areas.

4.4.3 Promote economic radiation and boost employment

As explained by current SDAU, urbanization masterplan has a role of enabling the organization and development of new economic activities towards job generation in the city. In order to anticipate and support economic development in a logic of coherence and of spatial complementarity, the SDAU proposes to study economic development solutions at all the scales of the city, relying on one hand on the new major levers that are the ring road and the BRT, while taking care on the other hand on the dynamism of employment and the satisfaction of needs within the smallest neighborhoods.

The following sub-section details the planning concepts of strategic orientation 3, while Figure 4.10 below summarizes it and show its spatial implications.



Source: JICA study team

Figure 4.10: Summary of Strategic Orientation 3

(1) Promote and secure economic poles at the metropolitan scale

As established by the proposed urban structure for horizon 2040, Nouakchott will be composed of three major economic poles. General complementarity and promotion of each economic poles radiating at the metropolitan level is supported by the new network of public transportation which links them to each other's.

1) Downtown

In traditional central economic pole, administrative, commercial and business functions shall be strengthened by dimensioning this area as a large international business district. It is likely that the small-scale shops established in the few markets of downtown might know a modernization through redevelopment operations. Still, as it was recommended by MHUAT, the economic planning of downtown area shall be articulate around the concept of specialization into clusters that have spontaneously emerged (electric town, handicraft street etc.).

2) Airport city

Based on the demand of activities for future economic growth, new development in the vicinity of Nouakchott international airport is proposed in the combination of the 3 following distinct but complementary sub-cores.

- Commercial sub-core: situated on Nouadhibou road, this area bears the function of providing urban services to the neighboring touristic zone. Convention and hotel functions are also developed (average population: 70,000);
- Administrative sub-core: connected by a newly constructed road, this city welcomes the relocated central administrations (average population: 60,000);
- Business park sub-core: situated in close vicinity to the airport, this area receives logistics, airport-related and research functions (average population: 15,000).

3) New Tarhil

In newly developed economic pole in the Southern part of the city, ensure the establishment of major public facilities and basic infrastructure and diversify the real estate offer in order to attract as many SMEs as possible.

(2) Create a large-scale economic network based on ring road

The construction of the ring road will carry big opportunities to establish a large-scale economic network at the level of the metropolis and to drive economic development.

1) Develop commercial activity zones in metropolitan gateways

In Metropolitan Gateways areas depicted above, commercial activities can be implanted but in respect with specific conditions. Indeed, in order to maximize the integration to public transportation and to establish Metropolitan Gateways as modal shift cores, the condition for the companies to establish might include the provision of welcoming BRT stops, parking, etc.

2) Allow the establishment of activity centers along the ring road

The potential that represents the ring road shall be exploited at its maximum with the allowance of the establishment of commercial activity centers at some strategic points along the ring road. Establishment of private activities on both sides of the ring road, if correctly controlled, can help preventing urban sprawl in support to the green belt.

(3) Promote economic development and local employment within neighborhoods

In the newly developed urban fabrics of the southern part of the city, land use regulation shall be drafted in order to allow business activities and non-polluting small industries within residential areas. This will lead to the creation of numerous jobs within the neighborhood and will attract SME willing to develop their activity in their living environment.

4.5 Analysis of Housing Needs and Population Distribution by 2040

The population forecasted at the macro level for Nouakchott in 2040 is approximately double of the current population. The newcomers shall be accommodated in the city in the best conditions possible. Thus, responsible agencies, i.e.) MHUAT, and Direction of Domain, MEF, shall have a clear policy to distribute the future population throughout the neighborhoods of Nouakchott city. The analysis of both night and commuting population distribution by 2040 proposed below constitute the framework of future land use plan of the capital of Mauritania.

4.5.1 Distribution of night population (inhabitants)

Population of Nouakchott is estimated at 2,200,000 persons at the horizon 2040. The distribution of all the inhabitants in the various parts of the city for 2017 and 2040 was studied based on different assumptions, detailed below.

(1) Baseline data for calculation of 2017 population

Baseline population has been computed through a two-steps operation: firstly, a bottom-up approach with the data from the field, and secondly a posterior adaptation to macro figures.

Firstly, the average baseline population (2017) has been estimated for each traffic zone on the basis of the results of GIS land use survey. Indeed, this survey have been carried out through all the parcels of PLU area, on all the parcels of an area superior to 1,000 m2, all the parcels along asphalted roads, and a sample of 10% of all other areas, which means residential areas. Assumptions in terms of household size and population for each land use category has been formulated based on literature and results of social survey.

Finally, the figures obtained for each traffic zones were compared to macro population data of each commune. The margin of error found was from 1% to 30%. Then, in order to cope with the macro population data, the latter have been extrapolated to each traffic zone based on the share of population of each traffic zone calculated with GIS land use data.

Since land use survey also has spotted unoccupied parcels in comparison with observation of satellite image, a residential occupancy rate could be set-up for each traffic zone.

(2) Modelling distribution of 2040 population

Based on future urban structure and development orientations of Nouakchott, calculation of population in 2040 has been achieved through the following three growth assumptions: increase of occupancy, densification and urban expansion.

1) Increase of parcel occupancy

Firstly, it has been assumed that the parcels left empty in 2017 will be urbanized in close future. Thus, occupancy rate has been increase based on common criteria for whole Nouakchott as follows.

- Occupancy rate less than 40% in 2017 increase to 70% in 2040;
- Occupancy rate from 41% to 60% in 2017 increase to 80% in 2040;
- Occupancy rate from 61% to 70% in 2017 increase to 90% in 2040;
- Occupancy rate from 71% to 90% in 2017 increase to 95% in 2040;
- Occupancy rate more than 91% in 2017 increase to 99% in 2040.

The percentage of increase was then multiplied by the population of the same traffic zone to give the increased population by occupancy.

2) Densification of existing urban area

In terms of densification, two assumptions were identified: individual initiative of vertical densification, and real estate private operations.

Regarding densification, two assumptions were identified: individual initiative of vertical densification, and real estate private operations. Regarding individual initiative, it is the transcription of a phenomenon currently ongoing in Nouakchott, which is that owners are adding an additional floor to their dwelling.

Based on our interviews, it has been assumed that 50% of the owners who proceed to the addition of a floor to their house is doing it to rent it to another household, and thus get benefits from his land asset. The other 50% add a floor to their house to accommodate their own family, so this was not count in the calculation of population distribution. The proportion of residential houses to be modified to welcome a new floor as been taken from the results of the household survey (the question "do you want to add a floor to your house in the future?" was asked to the heads of households). Aside of private initiative, it has been assumed that attractive neighborhoods, such as the one close to downtown area, will receive real estate private operations of densification. This figure, which concerned only 3 traffic zones of Tevragh Zeina, was assumed arbitrarily.

3) Urban expansion in undeveloped areas

Finally, new urban expansion has been calculated based on the potential lands to be urbanized until 2040. This includes former airport development in Dar Naim, subdivision development in the North of Tevragh Zeina, or the lands to be newly developed in the urban continuity of the existing city. For urban expansion, assumed gross density of new development has been multiplied by the area which have the potential for receiving residential development (outside construction prohibited areas).

4) Results of modelled 2040 population distribution

In order to clarify the methodology of modelling the distribution of 2040 population, the steps explained above are illustrated through the detail example of traffic zone number 1030 in Tevragh Zeina, in Table 4.4 below.

Table 4.4: Details of Modeling Distribution of 2040 Night Population

Category	Traffic Zone 1030
A. BASELINE DATA FOR CALCULATION	
Population estimated from land use GIS data (2017)	9,697
Margin of error compared to macro population figure of the commune	6%
Population corrected by comparison of macro population figure (2017)	9,144
B. INCREASE OF LAND OCCUPANCY	
Occupancy rate of residential parcels from GIS data (2017)	58%
Assumed future occupancy rate (2040)	80%
Increase of occupancy rate between 2017 and 2040	22%
Population increase through land occupancy increase between 2017 and 2040	2,012
C. DENSIFICATION	
Number of occupied residential parcels from GIS data (2017)	3,500
Percentage of households willing to add a floor from household survey results	12%
Number of parcels to be added a floor	429
Percentage of floor additions for renting purpose	50%
Number of parcels to be added a floor for renting purpose	215
Average household size for collective housing from household survey	4,4
Population increase through individual initiative of vertical densification	946
Population increase by real estate private operation	1,000
Population increase through densification	1,946
TOTAL POPULATION 2040 (A+B+C)	**13,102**

Source: JICA Study Team

At the scale of Nouakchott city, the accommodation of the inhabitants in 2040 is carried out in all communes according to the joint processes of increase of parcel occupancy, densification of the existing urban fabrics, and expansion in undeveloped areas, as shown in following Table 4.5.

Table 4.5: Details of modeling distribution of 2040 night population

Commune	Baseline population (2017)	Population increase (2040)						Total Population (2040)
		Parcel occupancy increase		Densification of existing urban area		Urban expansion		
Tevragh Zeina	56,793	8,158	4%	10,924	5%	187,525	91%	263,400
Ksar	54,908	12,203	8%	50,949	34%	85,135	57%	203,196
Teyarett	93,743	12,565	9%	25,612	19%	97,230	72%	229,150
Dar Naim	167,381	27,292	25%	38,556	35%	44,369	40%	277,598
Sebkha	83,913	5,806	28%	3,427	16%	11,675	56%	104,821

Arafat	202,517	8,866	22%	11,872	29%	19,839	49%	243,094
Toujounine	167,893	17,042	10%	27,551	17%	120,967	73%	333,454
El Mina	153,706	11,632	36%	20,756	64%	0	0%	186,094
Riyadh	135,884	31,669	14%	22,114	10%	169,527	76%	359,193
TOTAL	**1,116,738**	**135,234**		**211,760**		**736,268**		**2,200,000**

Source: JICA Study Team

(3) Conversion of population into dwelling units

In order to verify through GIS spatial tool the hypothetic calculation of population distribution forecast described above, household size in 2030 and 2040 has been calculated and applied to population figures in order to give gross number of dwelling units.

1) Calculation of average household size by commune

Estimation by ONS of Mauritanian Total Fertility Rate (TFR), which is a standard demographic indicator used internationally to estimate the average number of children that a woman would have over her childbearing years (i.e. age 15-49), testify of a relatively important reduction of number of children by household in the near future (- 0.8 children by household between 2017 to 2040 equivalent to a drop of 20% of current figure).

Based on ongoing demographic transition and on changes in society such as increase of uniparental families due to the increase of divorces, it has been estimated that the number of household members excluding the children will slightly drop from 1,3 in 2017 to 1,2 in 2040. Combined with TFR, those figures give average household size of 5.5 in 2017, 4.9 in 2030 and 4.6 in 2040.

The estimated drop of average household size in Mauritania has been compared to each commune by using the average household size in 2017 resulting from the household survey carried out by JICA Study Team.

Table 4.6 below shows the calculation of average household size by commune for horizon 2040.

Table 4.6: Calculation of Average Household Size by Commune (2040)

Year	TFR*[1]	Average Household Size	Drop in Household Size		Tevragh Zeina	Ksar	Teyarett	Dar Naim	Sebkha	Arafat	Toujouni ne	El Mina	Riyadh
2017*[2]	4.2	5.5			4.7	5.9	5.9	6.7	7.8	6.0	6.6	5.1	4.6
2030	3.7	4.9	- 0,6	- 11%	4.2	5.2	5.2	6.0	6.9	5.4	5.8	4.5	4.1
2040	3.4	4.6	- 0,3	- 6%	3.9	4.9	4.9	5.6	6.5	5.1	5.5	4.3	3.8

Source: JICA Study Team based on ONS data
Note: (*1) Based on ONS calculation of Total Fertility Rate (TFR)
(*2) Based on household survey carried out by JICA Study Team

2) Refining of household size per dwelling unit by traffic zone

Based on the average household size by commune identified as described above, the evolution of the household size per dwelling units has been refined in each traffic zone in order to give a more realistic idea of the housing patterns that will be used in Nouakchott in 2040. Different evolutions of household size per dwelling units are detailed below.

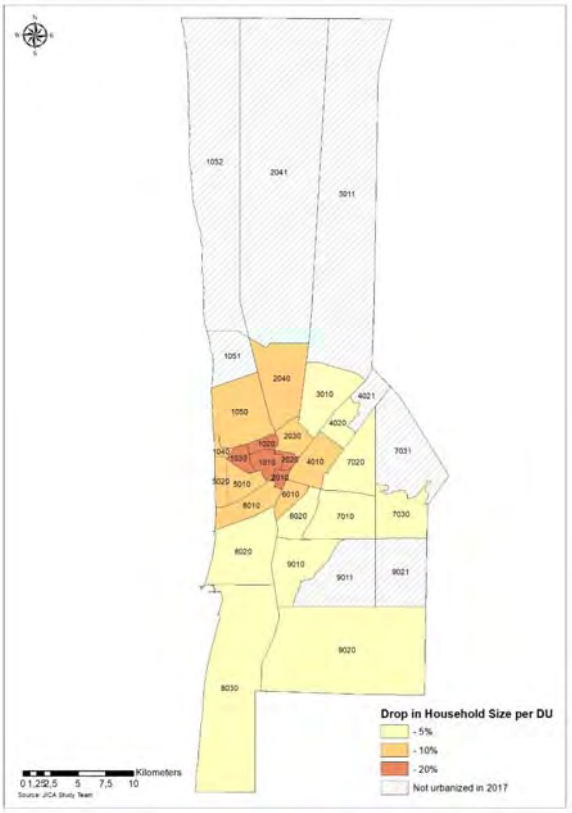
Firstly, it is assumed that the biggest drop in household size per dwelling unit will occur in the central part of the city. Following the planning principle of the Intensive City, and especially the requalification of "Heart of the city" zone, the downtown area will be planned in a specific manner by densification by urban renewal operations, promotion of high-rise rental building and condominium. This will lead to the formation of a new housing offer mostly based on rental but also homeownership apartment targeting households in their early residential course and families with limited number of children. To reflect this evolution in housing pattern, the household size of traffic zones included in the "Heart of the city" zone has been reduced by 20%.

Secondly, it has been assumed that the surrounding areas of the mentioned central zone will also evolve in a way that more apartments will be created and that the average household size will be reduced

relatively compared to the current situation. To reflect this evolution in housing pattern, the household size of traffic zones in the surrounding of the "Heart of the city" zone has been reduced by 10%.

Finally, it has been assumed that the housing pattern in the other parts of the built-up areas in Nouakchott will not evolve drastically. Nevertheless, it is likely that due to scattered densification operations mainly based on private initiative (adding a floor to the house or partition of land plot), the general household size per dwelling unit the existing areas will reduce by 5%.

Table 4.7 and Figure 4.11 below show the evolution of household size per dwelling unit by traffic zone.



Source: JICA Study Team

Figure 4.11: Drop of household size per dwelling unit by traffic zone

Table 4.7: Evolution of household size per dwelling unit by traffic zone

Commune	Traffic Zone	Household Size	Drop of Household per DU	Household Size per DU
Tevragh Zeina	1010	4.7	-20%	3.8
	1020		-20%	
	1030		-20%	
	1040		-10%	4.2
	1050		-10%	
Ksar	2010	5.9	-20%	4.7
	2020		-10%	5.3
	2030		-10%	
	2040		-10%	
Teyarett	3010	5.9	-5%	5.6
Dar Naim	4010	6.7	-10%	6.0
	4020		-5%	6.3
Sebkha	5010	7.8	-10%	7.0
	5020		-10%	
Arafat	6010	6.0	-10%	5.4
	6020		-5%	5.7
Toujounine	7010	6.6	-5%	6.2
	7020		-5%	
	7030		-5%	
El Mina	8010	5.1	-10%	4.6
	8020		-5%	4.8
	8030		-5%	
Riyadh	9010	4.6	-5%	4.4
	9020		-5%	

Source: JICA Study Team

Regarding the household size per dwelling unit to settle in zones newly opened to urbanization, mostly situated in the continuity of urban area and inside the ring road, it is assumed that housing pattern will be focused on homeownership of individual houses mostly, targeting newcomers to Nouakchott. To reflect this trend, the household size per dwelling unit used in those traffic zones will not have any reduction.

4.5.2 Distribution of commuting population (employees and students)

The number of employees in Nouakchott is estimated at 272,719 persons in 2017 and at 689,832 persons in 2040. For the estimation of the distribution of commuting population, a two-step methodology has been applied. Firstly, at the scale of the commune, the results of Person-Trip (PT) survey have been utilized to identify the attractive communes in terms of employment and education. Secondly, the numbers have been refined at the scale of the traffic zone by using a GIS-based graphical computation method based on land use survey results for verification of concrete urban reality.

1) Calculation of average commuting population at the commune level using PT survey results

The results of the Person-Trip survey, carried out during the household survey, have been utilized to identify the attractive communes in terms of employment and education. The results in terms of destination for "work" and "school" purposes have been extrapolated to the total working population in 2017 to obtain the number of employees per traffic zone, as shown in Table 4.8 below.

Table 4.8: Calculation of Average Commuting Population at the Commune Level using PT Survey Results

Commune	Number of destination recorded in PT survey	Share of destination (%)	Average commuting population
Tevragh Zeina	310	44.0%	120,090
Ksar	106	15.1%	41,063
Teyarett	28	4.0%	10,847
Dar Naim	49	7.0%	18,982
Sebkha	40	5.7%	15,495
Arafat	42	6.0%	16,270
Toujounine	26	3.7%	10,072
El Mina	77	10.9%	29,829
Riyadh	26	3.7%	10,072
TOTAL	**704**	**100%**	**272,720**

Source: JICA Study Team

2) Refining of commuting population by traffic zone using GIS land use survey results

In order to have a more precise idea of the distribution of commuting population inside each commune, the average commuting population described above has been refined using a graphical approach thanks to GIS tool supported by the land use survey results.

Firstly, the spatial unit to be used in the graphical interface, the commuting population / ha (or number of employee / ha), has been calculated based on the results of land use survey of the PLU target commune of Tevragh Zeina, which all the parcels have been visited, as shown in Table 4.9 below.

Table 4.9: Calculation of Number of Employees (per/ha)

Commune	Land use categories	Total area of parcels (ha)	Percentage of land use	Number of employees	Employee/ha
Tevragh Zeina	Commercial Land Use	171	41%	46,243	271
	Mixed Land Use	100	21%	21,528	215
	Public / Government Land Use	273	34%	50,445	185
	Industrial Land Use	16	4%	1,872	120
	TOTAL	**559**	**100%**	**120,090**	**-**

Source: JICA Study Team

Based on the number of employees / ha unit calculated above and on the kernel analysis of concentration of activity land use types (commercial, mixed-use, government, industrial) coming from the result of land use survey on the whole Nouakchott City, major land uses have been computed graphically based on the methodology described in Figure 4.12 below. Each square of the GIS grid represents 4 ha. Thus, one square identified as commercial land use contains 271 x 4 = 1,085 employees.

During graphical computation, tradeoffs were operated so that the total of commuting population fit as much as possible the results of macro calculation of average commuting population by commune.

Land use of surveyed parcels (red: commercial; brown: mixed use) | Kernel analysis of concentration (red: commercial; brown: mixed use) | Input of unit in GIS grid (red: commercial; grey: mixed use)

Source: JICA Study Team

Figure 4.12: Overview of methodology of GIS-based graphical computation of land use

4.5.3 Results of distribution of night and commuting population

Based on the assumptions and calculations detailed above, the results of distribution of night and commuting population by traffic zone for baseline 2017 and horizons 2030 and 2040 are shown in Table 4.10, Figure 4.13 and Figure 4.14.

Table 4.10: Distribution of Night and Commuting Population per Traffic Zone in 2017, 2030 and 2040

Commune	Traffic Zone	Dwelling Unit (DU)			Household per DU			Night Population			Day Population		
		(2017)	(2030)	(2040)	(2017)	(2030)	(2040)	(2017)	(2030)	(2040)	(2017)	(2030)	(2040)
Tevragh Zeina	**1010**	2,964	4,279	8,423	4.7	4.3	3.8	13,931	18,163	32,009	48,498	66,698	70,781
	1020	1,300	1,955	4,341	4.7	4.3	3.8	6,108	8,297	16,495	17,590	19,043	23,088
	1030	2,825	3,852	7,169	4.7	4.3	3.8	13,277	16,350	27,244	8,539	10,770	12,379
	1040	732	920	1,067	4.7	4.5	4.2	3,439	4,088	4,483	14,319	15,502	15,364
	1050	3,602	14,144	30,989	4.7	4.5	4.2	16,931	62,857	130,154	9,084	16,399	20,840
	1051		1,938	7,919	4.7	4.6	3.9	-	8,905	30,885	-	8,381	8,306
	1052	661	3,778	4,811	4.7	4.6	4.6	3,108	17,357	22,129	-	12,080	35,783
	TOTAL	**12,084**	**30,866**	**64,719**				**56,793**	**136,019**	**263,400**	**97,850**	**148,873**	**186,541**
Ksar	**2010**	1,153	1,478	2,126	5.9	5.3	4.7	6,805	7,826	9,991	3,066	4,319	5,586
	2020	1,889	3,606	5,146	5.9	5.3	4.7	11,146	19,086	24,188	2,048	3,077	4,803
	2030	5,907	7,475	9,152	5.9	5.6	5.3	34,851	41,802	48,503	34,711	37,579	39,801
	2040	357	9,019	10,666	5.9	5.6	5.3	2,106	50,437	56,528	-	6,060	9,009
	2041		3,787	13,910	5.9	4.6	4.6	-	17,395	63,986	-	3,394	17,125
	TOTAL	**9,306**	**25,365**	**41,000**				**54,908**	**136,546**	**203,196**	**39,824**	**54,429**	**76,324**
Teyarett	**3010**	15,506	25,561	33,444	5.9	5.8	5.6	91,484	146,782	187,285	10,769	19,819	29,990
	3011	383	386	9,101	5.9	5.3	4.6	2,259	2,627	41,865	-	-	23,949
	TOTAL	**15,889**	**25,947**	**42,545**				**93,743**	**149,409**	**229,151**	**10,769**	**19,819**	**53,939**
Dar Naim	**4010**	13,679	20,296	25,416	6.7	6.4	6.0	91,651	128,710	152,494	9,791	17,930	20,615
	4020	10,863	13,027	13,134	6.7	6.5	6.3	72,779	80,564	82,746	8,073	11,320	13,479
	4021	440	4,444	7,564	6.7	6.2	5.6	2,951	27,292	42,358	-	1,720	5,783
	TOTAL	**24,982**	**37,767**	**46,114**				**167,381**	**236,566**	**277,598**	**17,864**	**30,970**	**39,877**
Sebkha	**5010**	10,647	14,760	14,775	7.8	7.4	7.0	83,044	109,079	103,427	13,901	15,050	16,621
	5020	111	99	214	7.8	7.2	6.5	869	1,408	1,394	-	-	-
	TOTAL	**10,758**	**14,859**	**14,989**				**83,913**	**110,487**	**104,821**	**13,901**	**15,050**	**16,621**
Arafat	**6010**	12,594	13,676	16,553	6.0	5.7	5.4	75,567	77,849	89,387	8,946	22,725	31,561
	6020	21,158	22,358	26,966	6.0	5.9	5.7	126,949	130,620	153,707	19,688	23,895	37,141
	TOTAL	**33,752**	**36,034**	**43,519**				**202,516**	**208,469**	**243,094**	**28,634**	**46,620**	**68,702**
Toujounine	**7010**	12,789	21,972	25,926	6.6	6.4	6.2	84,410	140,433	160,740	13,370	19,635	25,545
	7020	10,573	14,251	14,650	6.6	6.4	6.2	69,782	91,084	90,832	2,212	18,006	31,974
	7030	2,062	9,191	12,295	6.6	6.4	6.2	13,610	58,746	76,231	-	3,734	7,804
	7031	14	49	1,027	6.6	6.1	5.5	91	297	5,651	-	2,874	13,476
	TOTAL	**25,438**	**45,463**	**53,898**				**167,893**	**290,560**	**333,454**	**15,582**	**44,249**	**78,799**
El mina	**8010**	18,044	18,448	20,869	5.1	4.9	4.6	92,025	94,328	95,996	16,682	18,620	21,408
	8020	9,904	11,918	15,380	5.1	5.0	4.8	50,510	58,917	73,826	6,365	12,051	26,720
	8030	2,190	3,006	3,390	5.1	5.0	4.8	11,171	14,862	16,272	-	2,580	3,448
	TOTAL	**30,138**	**33,372**	**39,639**				**153,706**	**168,106**	**186,094**	**23,047**	**33,251**	**51,576**
Riyadh	**9010**	27,507	35,754	37,093	4.6	4.5	4.4	126,531	160,682	163,208	25,249	32,055	37,696
	9011	1,055	24,797	41,385	4.6	4.2	3.8	4,853	104,010	157,264	-	50,816	62,974
	9020	978	1,873	5,028	4.6	4.5	4.4	4,500	8,416	22,123	-	-	5,251
	9021		2,998	4,368	4.6	3.8	3.8	-	11,377	16,598	-	7,018	11,534
	TOTAL	**29,540**	**65,422**	**87,874**				**135,884**	**284,485**	**359,193**	**25,249**	**89,889**	**117,455**
TOTAL		**191,887**	**315,095**	**434,297**				**1,116,738**	**1,720,648**	**2,200,000**	**272,720**	**483,150**	**689,832**

Source: JICA Study Team

Figure 4.13: Estimation of distribution of night population by traffic zone in 2017 and 2040

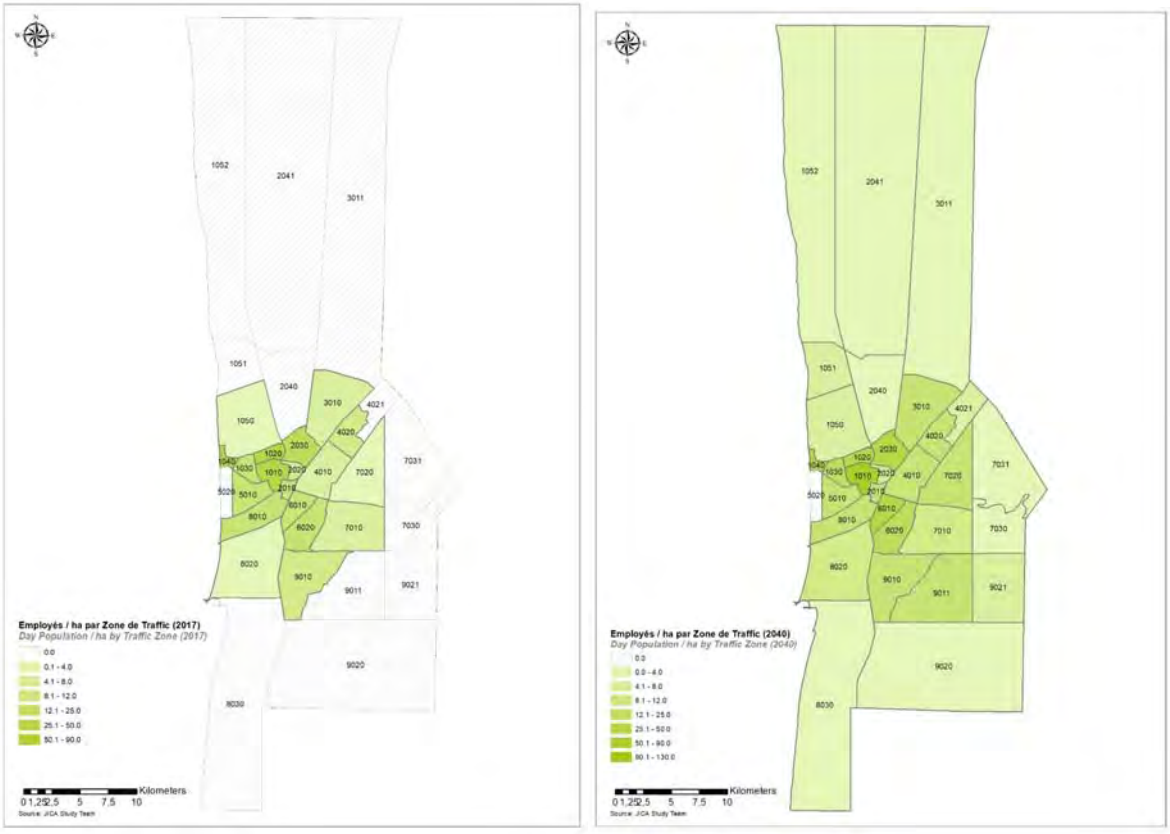


Figure 4.14: Estimation of distribution of commuting population by traffic zone in 2017 and 2040

4.6 General Land Use Plan

4.6.1 Scope and drawing style of General Land Use Plan

The land use plan is formulated based on the future urban structure, on analysis of urban expansion potential and on distribution of population by traffic zone explained above. The future road network and land use plan are proposed in broad terms. Thus it should be noted that the character of the map is indicative, and that should not be used for measuring by individual plot holders.

The drawing style chosen for the land use plan is based on a 200 m x 200 m grid. Each square of the grid receives a land use category. This method of land use design can be qualified as "General" Land Use Plan. The reason for selecting this method of representation are the following.

- Land use category on each square of the grid is computed into the GIS software with a value in terms of dwelling units and number of employees (commuting population). While painting the land use, the software recalculates dynamically the total number of dwelling units and number of employees for each traffic zone, each commune, and for the whole city of Nouakchott. Thus, it can be said that the land use plan is consistent with the population framework decided earlier;
- The representation is simplified in order to facilitate the understanding of land use changes between 2017 and 2040 at the masterplan level, this it participates to a better decision-making process at this stage of the project.

Based on the explanation above, the drawing style of the General Land Use Plan can be considered as a spatial simulation of socio-economic framework, in order to give a realistic foundation to the land use plan.

4.6.2 Land use categories

The major role of the land use plan in a SDAU, as defined in Mauritanian Urban Planning Code, is the definition of preferred zones of urban extension, and the indication of land usages in terms of housing, trade, equipment and green spaces. Moreover, even though it is not specified in the law, the major role of the land use plan of the SDAU is the designation of future densities.

Land use categories for General Land Use Plan are specified in Table 4.11 below.

Table 4.11: Land Use categories and allocation of densities in SDAU General Land Use Plan

	Land Use Category		Number of Dwelling Units / ha	Average Population / ha	Number of Employees / ha
Settlement allocation		Very low density residential	0-4	25	-
		Low density residential	5-10	50	-
		Medium density residential	11-20	100	-
		High density residential	21-30	150	-
		Very high density residential	31-40	200	-
Commercial		Commercial	-	-	1,085
		Average density mixed use	11-20	100	860
		High density mixed use	21-30	150	1,000
Industrial		Industrial	-	-	479
Public services		Public services and government	-	-	739
Green spaces		Recreation and green spaces	-	-	-

Source: JICA Study Team

4.6.3 Land Use plan

Existing land use (2017) and proposed future general land use plan for horizons 2030 and 2040 are shown in Figures 4.15, 4.16 and 4.17 respectively.

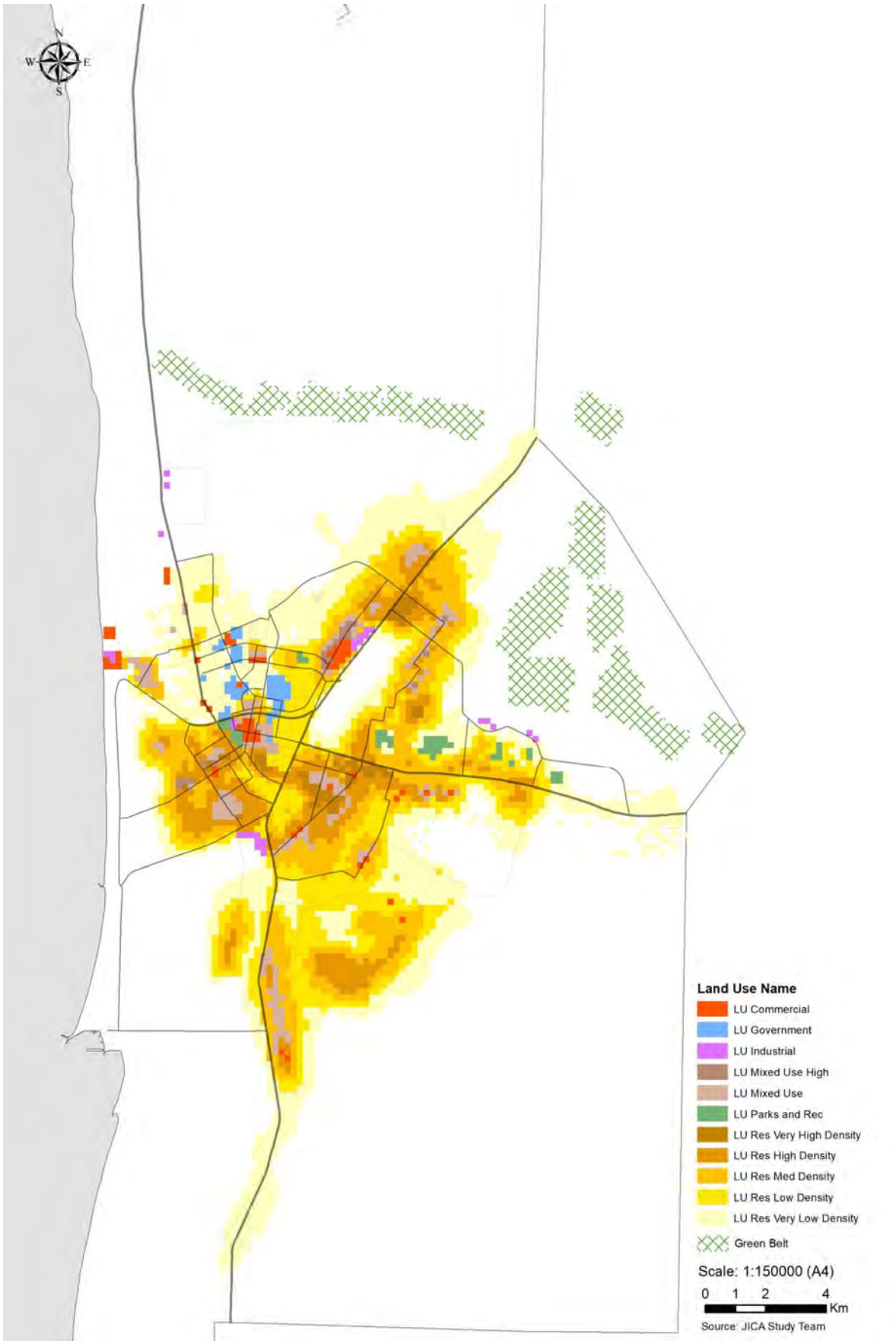


Figure 4.15: Existing Land Use (2017)

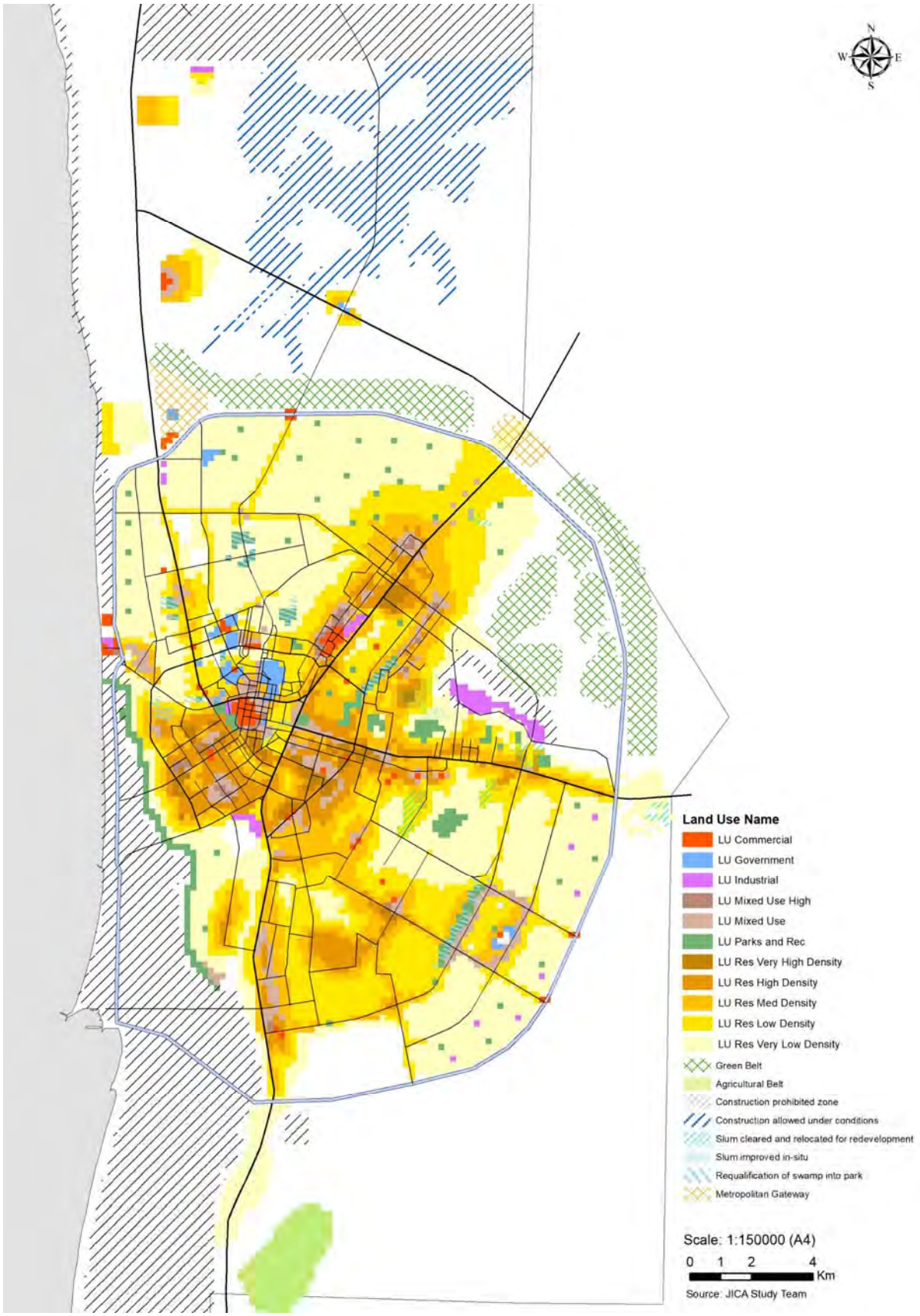


Figure 4.16: Proposed Future General Land Use Plan (2030)

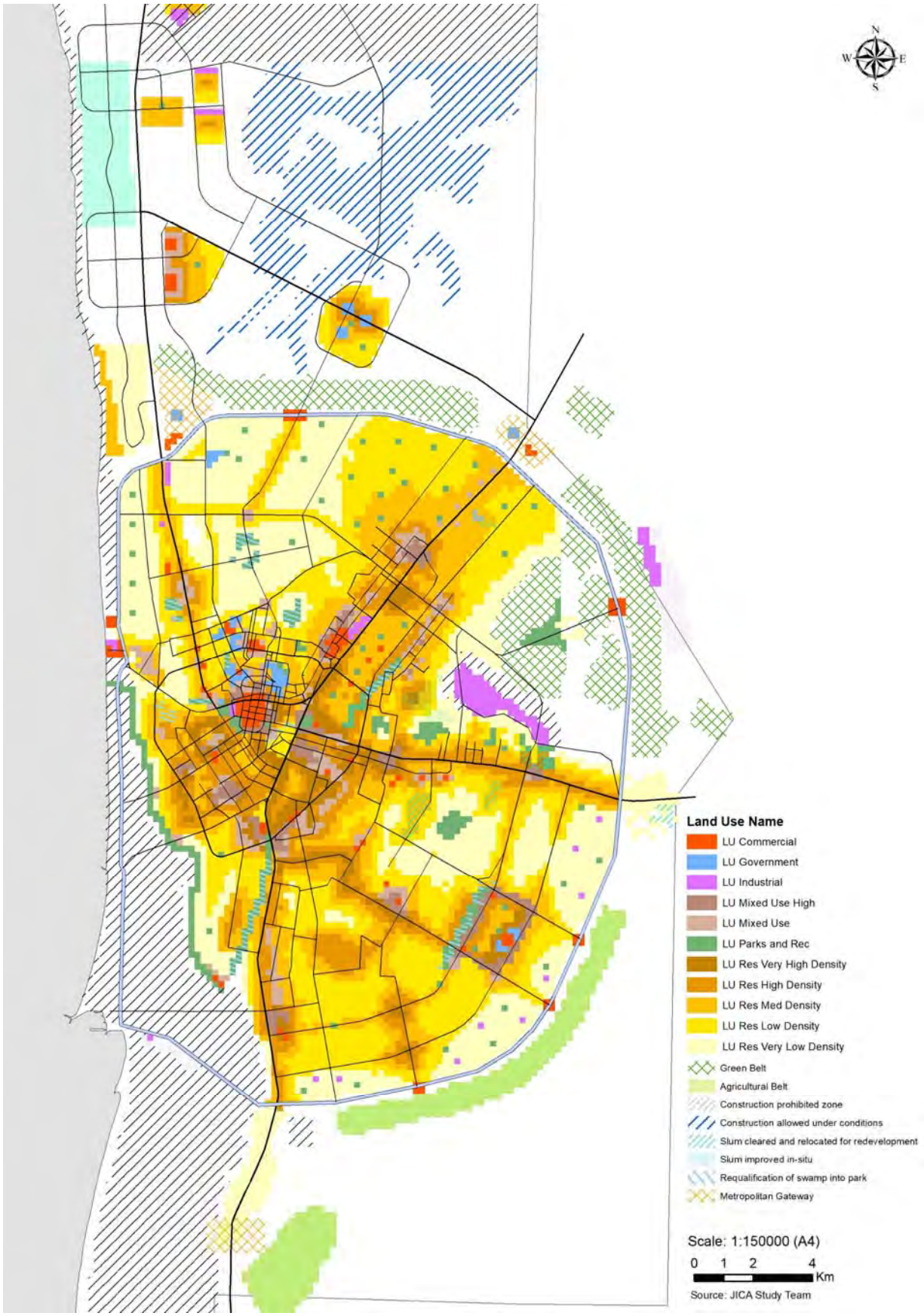


Figure 4.17: Proposed Future General Land Use Plan (2040)

4.6.4 Analysis of Land Use composition

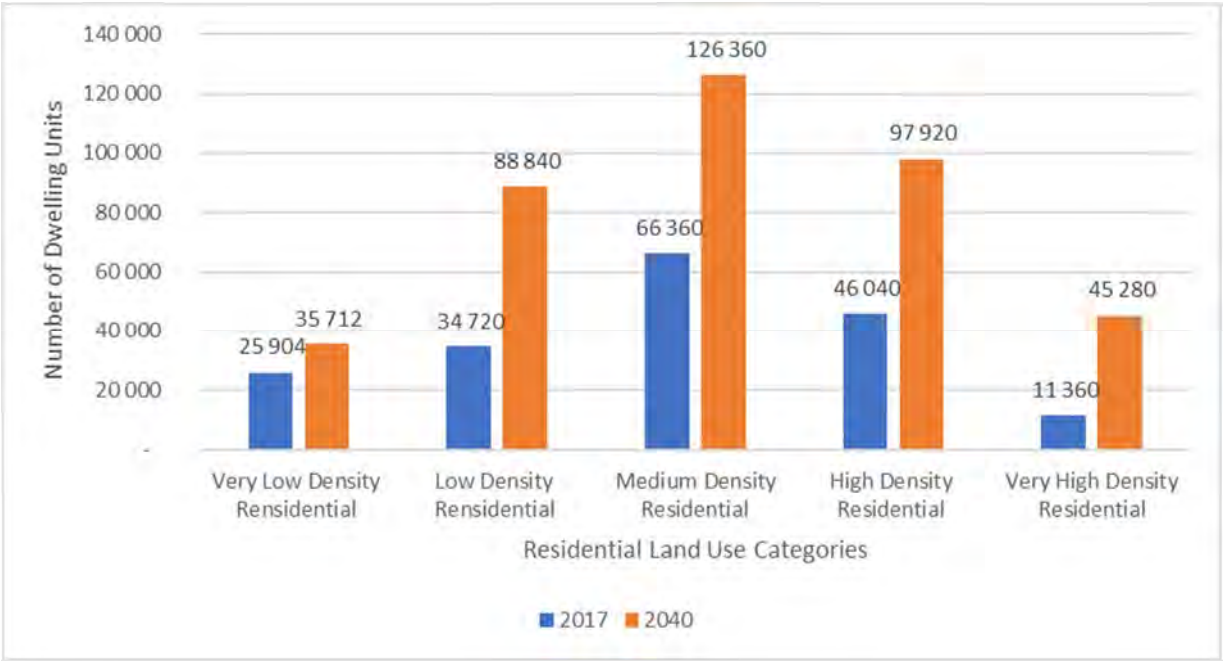
(1) Summary of Land Use composition

Table 4.12 below shows the composition of existing and proposed land use at horizon 2040, while Figure 4.18 focus on the distribution of dwelling units by residential land use categories.

Table 4.12: Composition of Existing and Proposed Land Use

Land Use Category	Dwelling Units		Area (ha)		17-40 Growth	Share (%)		17-40 Trend
	2017	2040	2017	2040		2017	2040	
Very low density residential	24 722	35 430	6 476	8 928	+38%	35.3%	21.0%	-14.3%
Low density residential	33 135	88 139	3 472	8 884	+156%	18.9%	20.9%	2.0%
Medium density residential	63 331	125 363	3 318	6 318	+90%	18.1%	14.9%	-3.2%
High density residential	43 939	97 147	1 535	3 264	+113%	8.4%	7.7%	-0.7%
Very high density residential	10 842	44 923	284	1 132	+299%	1.5%	2.7%	1.1%
Commercial	-	-	952	2 342	+146%	5.2%	5.5%	0.3%
Average density mixed use	13 514	21 033	1135	1 699	+50%	6.2%	4.0%	-2.2%
High density mixed use	2 404	22 262	135	1 202	+790%	0.7%	2.8%	2.1%
Industrial	-	-	108	496	+359%	0.6%	1.2%	0.6%
Public services, government	-	-	204	256	+25%	1.1%	0.6%	-0.5%
Recreation and green spaces	-	-	730	7 989	+994%	4.0%	18.8%	14.8%
TOTAL	191 887	414 297	18 349	42 510		100.0%	100.0%	

Source: JICA Study Team



Source: JICA Study Team

Figure 4.18: Distribution of Dwelling Units by Residential Land Use Category

(2) Detailed Analysis of Land Use composition

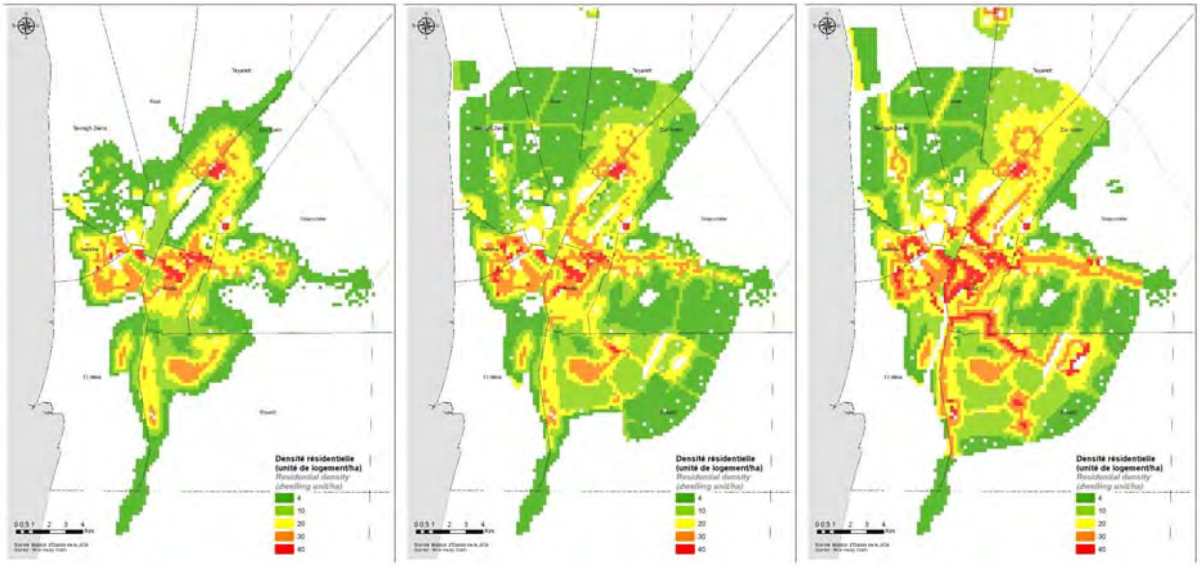
The following points can be analyzed from land use composition data.

1) Residential land use: intensification and polarization

The intensification and polarization of the city, as recommended by strategic orientation 1, lead to the densification on certain points of the urban fabric of Nouakchott City, especially the secondary poles. Most of the already dense residential categories has been doubled. The polarization process, especially around public transportation nodes, can be noticed by the booming (+299%) of Very High Density Residential (40 DU/ha) category. Only the Very Low Density Residential (4 DU/ha) which was until

2017 the most common land use type (37.7%) is dropping of 15.2 points in 2040. This low residential land use representing an urban fabric of detached individual housing, is still the most common in 2040 but is closely followed by the Low Density Residential (10 DU/ha) category (22.5% and 22.4% respectively) which becomes the standard in newly built urban extensions.

The strategic orientation of creating an intense city based on public transportation but at the same respecting the local culture of great living areas and freedom of movement can be seen in the densities proposed by the land use plans. Indeed, the double process of intensification of secondary poles and BRT corridors and the maintenance of low residential urban fabrics can be testified by the density maps of Figure 4.19 below.



Note: 4DU/ha, 10DU/ha, 20DU/ha, 30DU/ha, 40DU/ha (DU: Dwelling Units)
Source: JICA Study Team

Figure 4.19: Densities of 2017, 2030 and 2040 Land Use

2) Recreational and green spaces

The implementation of the actions recommended in strategic orientation 2 such as the creation of numerous types and number of parks leads to multiple almost 10 times (994%) the area of green areas in Nouakchott City. The green space area per capita indicator would then grow from 6.5 m^2 per inhabitant in 2017 to 36.3m^2 in 2040, making the city comply with World Health Organization (WHO) suggestion that every city should have a minimum of 9 m^2 of green space per person, and would even become comparable to cities such as London (27 m^2) or Amsterdam (36%).

CHAPTER 5:
TRANSPORT INFRASTRUCTURE DEVELOPMENT PLAN

5.1 Existing Transport Conditions

5.1.1 Overview of transport sector

(1) Overall transport conditions and needs

The Mauritania government started reforming the road transport sector since 2005. This reform includes improvement of road network and transportation infrastructure such as airport and port among others. Through this reform, Mauritania's transport infrastructures are getting better little by little. However, the same progress is not observed in other fields of transportation such as traffic management system and human resources development.

Under these circumstances, the Mauritanian Government formulated the Strategy of the Transport Sector (2011-2025) and is engaged in improving current transport conditions. Its plans to strengthen not only the infrastructure side (hard component) such as expansion of the road network but also the management side (soft component) such as human resource development and institutional development that is useful to road management. However, the above plan is not proceeding on schedule due to issues such as lack of budget, staff and knowledge.

(2) Transport administration

The Ministry of Equipment and Transport (MET) is responsible for planning, design, implementation and maintenance of transport infrastructure including roads, ports and airports. MUHAT is responsible for planning, design, implementation and maintenance of transport infrastructure in urban planning area except for the road under the jurisdiction of MET.

All the current road projects in Nouakchott are 100% financed by the Mauritanian government which started in 2005. MET is responsible for making transport policies and also administering public transport services for trucks, buses, ferry-boats and others operated under the government management.

(3) Transport policies and strategy

The Mauritanian government aims a sustainable development of the Mauritania socio-economy through private sector-led market-oriented economy. It recognizes poor state of road network and public facilities (ports, airport, etc.) as major bottlenecks which prevents the growth of private industry and trade. Moreover, the improvement of transport infrastructure is expected to support the improvement of trade and commercial relationships with neighboring countries, taking advantage of Mauritania's strategic location.

Under these policies, the Government has developed a Medium-term Investment Program (2011-2015) to launch the process of implementing the strategy. Under this program, construction of new airport, expansion of Nouakchott port and improvement of road network were pursued. In addition, a program to rehabilitate approximately 496 km of national roads (Kiffa-Tintane, Nouakchott-Rosso, Boutilimit-Aleg) was also executed.

The Government intends to continue addressing issues confronting the transport sector which hinders economic and social development of the country.

Based on this thorough assessment of the condition of transport sector, the Government has adopted the Sector Strategy (2011-2025) based on the following five main points, all of which are cross-cutting in nature and affect almost all sub-sectors.

Strategy 1: Strengthen institutional and operational capacities to improve the overall efficiency of the sector
Strategy 2: Preserve and modernize existing infrastructure and equipment
Strategy 3: Ensure the harmonious development of infrastructures and equipment

Strategy 4: Developing links with neighboring countries to foster sub-regional and regional exchanges
Strategy 5: Ensuring the quality of services in the sector

In addition, the government is also advancing reform of the institution (laws and regulations) governing transport safety. Since 2014, the government applied a policy forbidding the entry in the country of cars used for more than 8 years, 4-wheel vehicles used for more than 10 years and trucks used for more than 12 years. Likewise, new traffic rules were put into effect from May 1, 2017. The main contents of the new traffic rules are as follows:

- Enforce penalties such as fines for traffic violators.
- Oblige vehicle owner to properly maintain and manage their vehicles.

However, implementation of the new traffic rules is facing resistance from the motorists.

5.1.2 Existing transport conditions in Nouakchott City

(1) Road characteristics

1) Road characteristics

a) Road network in Nouakchott City

The road network extends in a radial form from the Nouakchott City center to the north, northeast, east and south directions. It consists of national, provincial and rural roads. The national and provincial roads are at least two-lane paved roads. Most of the rural roads are not paved except for the main roads of each community.

b) City road system

Road classification

The roads in Nouakchott City are classified into the following four categories.

- Artery roads
  The four national roads radiating from the city center form the main frame of the city road system. The carriageways are at least two lanes and paved with asphalt concrete.
- Secondary roads
  Secondary roads supplement the four main arteries to inter-connect the districts in the city. Most of the artery roads have common names of their own. The carriageways are two lanes and paved with asphalt concrete.
- Community roads
  Community roads have two lanes and are mostly paved with asphalt concrete.
- Other roads
  Other roads are forming town blocks in areas not designated for use by urban planning. Most of them are narrow unpaved roads.

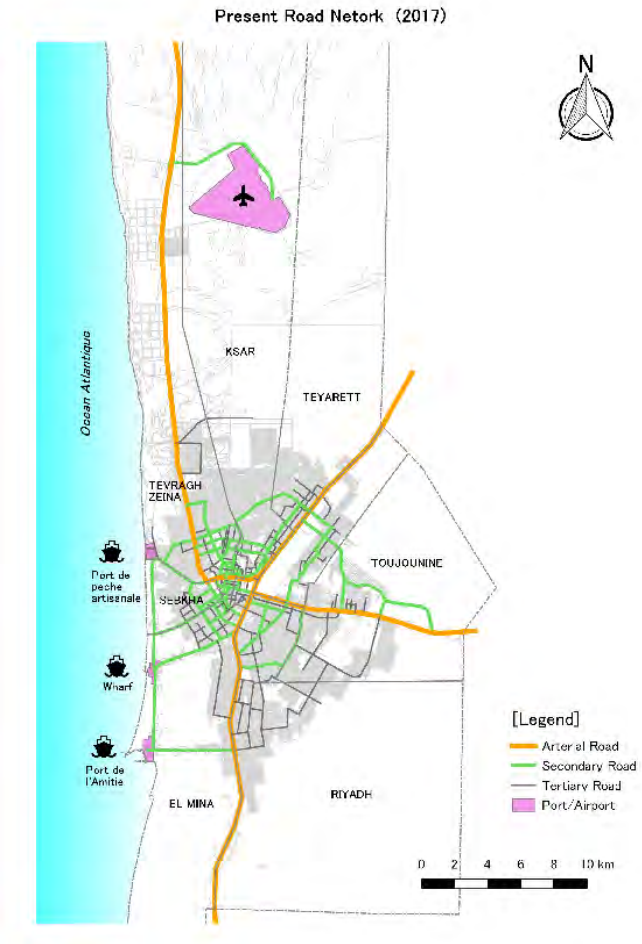
Road conditions

Asphalt concrete is commonly used for road pavement. However, due to insufficient maintenance, the road surface conditions have deteriorated with damaged pavement. Since 1995, Etablissement National DE L'Entraetien Routier (ENER) was established as an agency for the execution of road maintenance work by the government. The agency tried to create a database (road data bank (BDR)) that gathers information about Road Inventory Data such as road length and number of lanes. However, due to a lack of financial and human resources, it is not well-structured in terms of programming.

Recently, the artery and secondary roads have been rehabilitated and paved with asphalt concrete resulting to good surface condition. However, many sections of the community roads have their surface deterioration due to insufficient maintenance. Other roads are mostly unpaved.

Intersections

There are two types of intersections in Nouakchott City: traditional stop sign (signal-controlled) and roundabout. At least seventy-two (72) intersections are signal-controlled.



Source: JST

Figure 5.1: Road Network of Nouakchott City

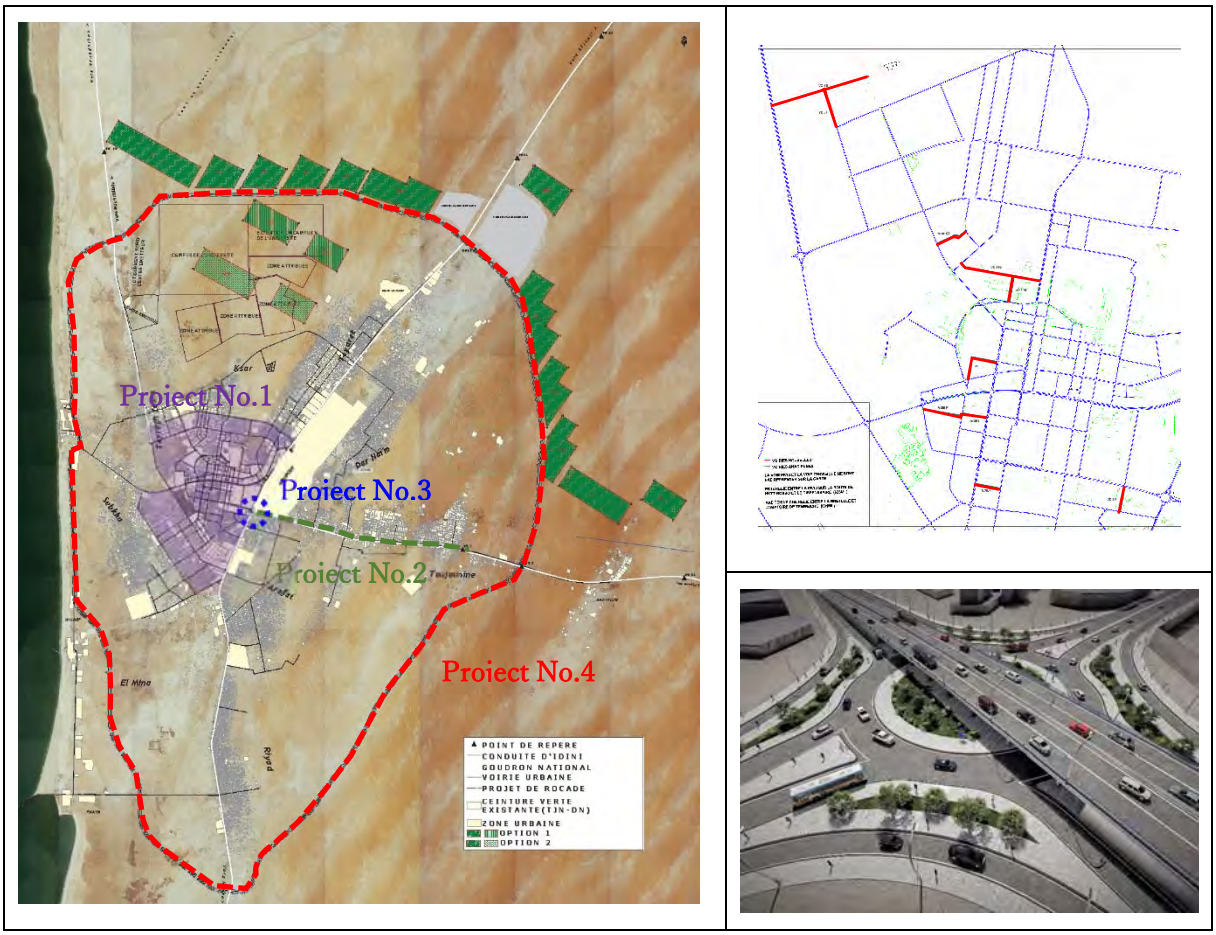
2) Planned and on-going projects

The Urban Transportation Master Plan of Nouakchott City was formulated in 2006. City roads are implemented based on this master plan. Many roads and transportation projects have been studied and planned individually and were supported by international aid organizations. On-going projects studied by MET are summarized in Table 5.1. Intersection improvement is planned for Madrid intersection which is the most congested point of the road network in Nouakchott City. The design has been completed and MET is currently preparing the technical scope of work. Alignment of the planned Nouakchott City ring road needs to be reviewed in relation to the planned new city development (PLU).

Table 5.1: Ongoing Road Projects in Nouakchott City

Project No.	Project Name	Implementing Agency	Stage
1	Construction voirie à Nouakchott	MET	Ongoing
2	Réalisation de pavage en pierre de roche de l'axe Carrefour de Madrid-Tenweich	MET	Ongoing
3	Etude Echangeur Madrid	MET	Planning
4	Circular Road Plan	MET	Planning

Source: MET



Source: DCIG/MET/DGIT/JST

Figure 5.2: Ongoing Road Project in Nouakchott City (Left: Project site map, Right (Upper): Project Site map of Project No.1, Right (Lower): Completion image of Madrid Intersection)

3) Traffic accidents in Nouakchott City

The number of traffic accident in Nouakchott City in 2016 is 3,540. This is down by about 38% from 2012. The decrease in number of traffic accident is due to improvement of road surface condition and installation of street lighting which was highlighted in the Midterm Investment Plan (2011-2015).

Table 5.2: Number of traffic accident in Nouakchott city

Year	Number of minor collision	Number of injury accidents	Number of fatal accidents	Total
2012	4,300	1,249	71	5,620
2016	2,920	602	18	3,540

Source: Commissaire de police

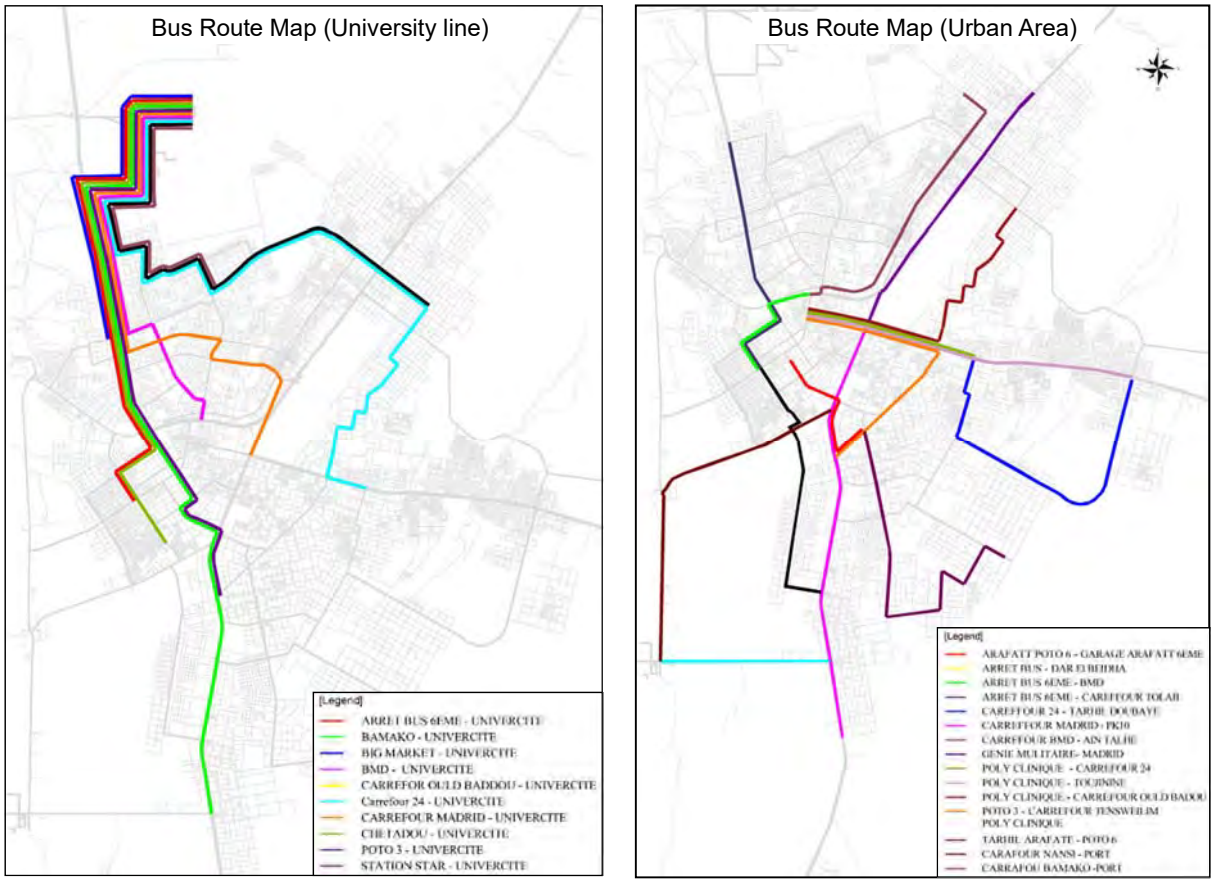
(2) Conditions of public transport for the Nouakchott City

1) Current public transport system in Nouakchott City

There are three types of public transportation modes (bus, mini-bus and taxi) in Nouakchott City. Due to the limited bus routes, the main public transport in Nouakchott City is taxi. Public transportation is under the jurisdiction of MET. MET is planning the strategy of public transportation including its supervising organizations that operates and manages the public transport. Société De Transport Public (STP) and L'Autorité d'organisation et de Régulation des Tranports Routiers (ARTOR), both under MET, are managing and operating the public transportation.

2) Bus

STP operates and manages bus services in Nouakchott City. It operates 15 routes in urban areas and 10 routes for Nouakchott University (See Figure 5.3). STP had bus routes from/to the airport but these routes were stopped due to low demand. Intercity bus services are operated by private bus company. STP is considering the possibility of Nouadhibou-Nouakchott and Atar-Nouakchott bus services. (See Figure 5.5)



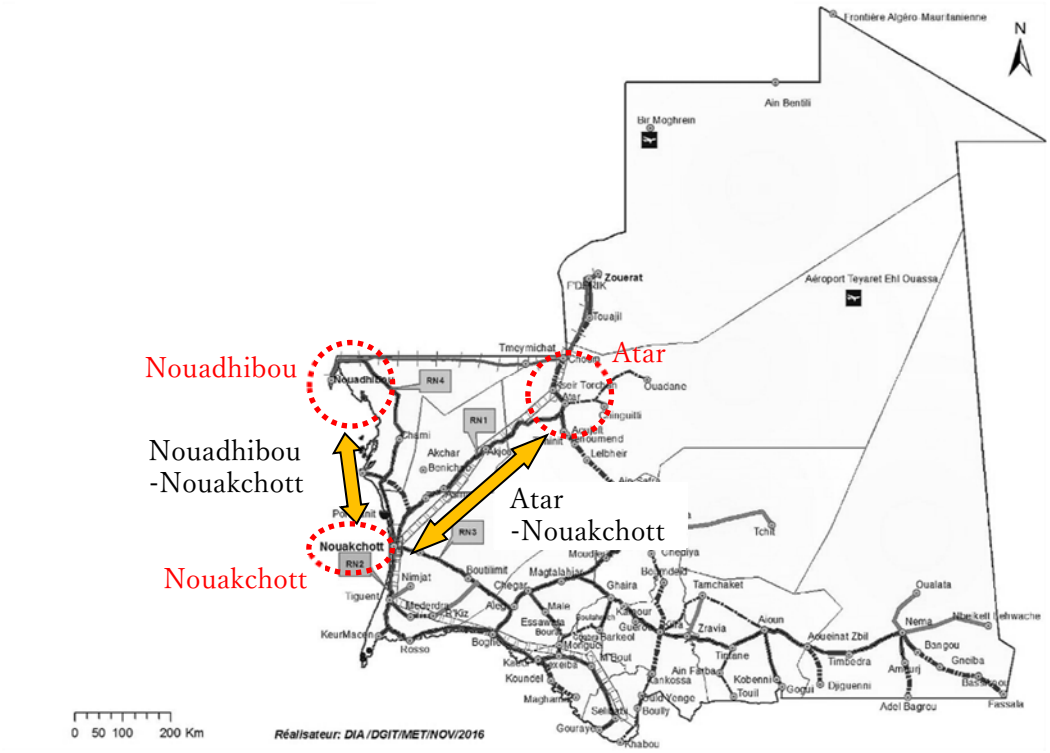
Source: JST

Figure 5.3: Bus route map (University Line and Urban Area)

Currently, 115 buses are in operation in Nouakchott City (40 Chinese buses (new), 75 American buses (used)) (See Figure 5.4). Due to limited maintenance budget, STP cannot efficiently operate the buses.

Source: JST

Figure 5.4: Bus (Left: Chinese new buses, Right: American used buses)

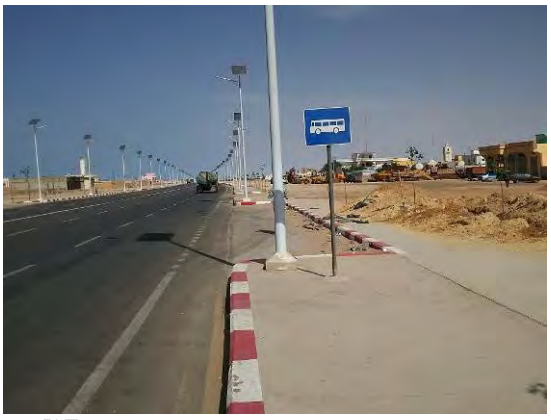


Source: JST

Figure 5.5: Future Bus Network Plan in Intercity

Bus fares are 50 MRO for city routes and 20 MRO for university routes. Bus cards for students will be operational from 2017(Fares for the student's cards; 1,200/1 month, 2,300/2 months, 3,300/3 months, 4,300/4 months, 5,300/5 months, 6,000/6 months, 7,000/7 months, 8,000/8 months, 9,000/9 months (MRO)). Since the operational budget exceeds the income, STP tried to carry out fare hike but it was not approved by MET.

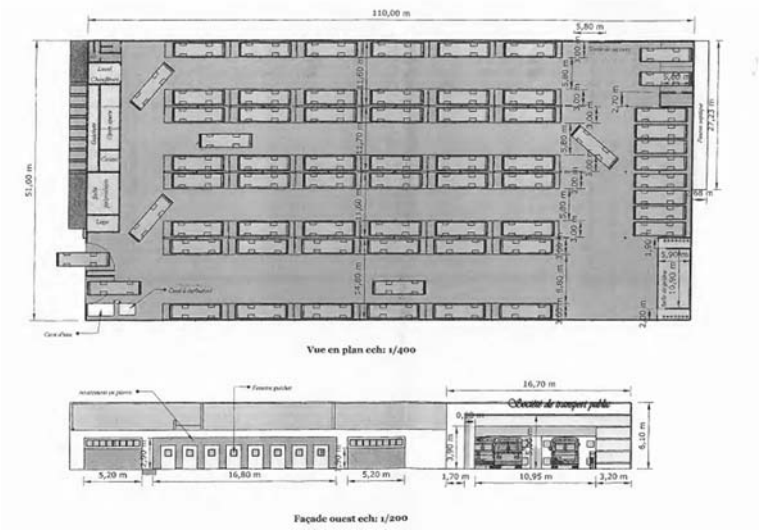
STP has installed bus stop facilities which aimed to improve its services and bring comfort to its users. At some bus stops, bus shelters and bus bays are already in place (See Figure 5.6). However, there are still some critical facilities/information missing needed by its users such as lack of bus routes information including time table and route maps.



Source: JST

Figure 5.6: Bus stop Facilities (Left: Bus bay, Right: Bus shelter)

Likewise, to improve the management of buses, construction of a garage is also planned in the Arafat commune. (See Figure 5.7).



Source: STP

Figure 5.7: Bus Garage Layout Plan

3) Mini-bus and taxi

a) General

In 2013, ARTOR was established to operate and manage the mini-bus and taxi services in Nouakchott City. Before that, these transport services were regulated by the CUN. Nowadays, there is still an overlap between the powers of these two institutions.

The authorities issued an "annual permit of transport" for taxis and buses. The price of the permit is calculated based on the number of passengers that taxi or bus should have and is covered by insurance. However, since the authorities are executive organs, the permit is issued by MET through a technical committee. This committee is composed of several members, one of them is a permanent representative of the authorities.

b) Mini-bus

The mini-buses are operated by private companies. One box car is mainly used for mini-buses. A system whose operation is dictated by the economic profitability of the service, insured by private and managed by the directives of the transport federations. From above, mini-bus operational companies could decide the route and price themselves. Therefore, for the end user, mini-buses have unreliable services - absence of plan, schedules, information on the destination and the places served, etc.

As of 2013, 402 mini-buses of 55 companies are operating in Nouakchott city. (See Table 5.3)

Table 5.3: Number of Mini-Bus Companies And Buses

Lines	Number of Companies	Number of Mini-bus
El Emal Road	20	150
El Chourouk Road	15	40 Bus + 67 Hilux
Nouadhibou Road	14	120
Rosso Road	6	25
Total	**55**	**402**

Source: STP

c) Taxi

Taxis can be distinguished in the following two categories:

- Official taxi
- Informal taxi

The official taxi is, in principle, green, with a yellow band. Informal taxis have no specific characteristics, the difference from passenger car is unrecognizable. In fact, it can be any vehicle whose owner spontaneously offers his services in order to supplement his income. This system is widespread in Nouakchott, which is indicative of several dysfunctions in terms of both the overall transport supply and the institutional level. The route of each taxi has been decided and it is going back and forth as the same route as bus. There are 54 points for taxis origin and destination points in Nouakchott city.

The taxi fare is around 100 MRO per ride. In case of transfer to another taxi, it is necessary to pay 100 MRO again. Also, in order to move to a place out of the route, it is necessary to pay additional fare.

As of 2013, 3,639 taxies of 10 companies are operating in Nouakchott city. For the taxi registration number for each commune, El mina has the largest at 34.5%, followed by TVZ at 22.2%. (See Table 5.4)

Table 5.4: Number of Registrated Taxies

(Unit: Vehicles)

Commune	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Company H	Company I	Company J	Total
Araffat	0	0	0	20	60	0	0	0	0	0	80
Dar naim	0	30	0	0	57	0	204	0	0	56	347
El mina	0	0	0	724	0	95	439	0	0	0	1,258
Ksar	0	0	0	27	135	0	0	0	0	60	222
Sebkha	0	0	0	274	35	0	0	0	33	0	342
TVZ	0	50	164	109	0	0	201	155	130	0	809
Teyarett	0	0	0	0	0	0	31	0	0	0	31
Toujounine	70	30	150	60	240	0	0	0	0	0	550
Total	**70**	**110**	**314**	**1,214**	**527**	**95**	**875**	**155**	**163**	**116**	**3,639**

Source: ARTOR

Source: JST

Figure 5.8: Public transportation (Left: Mini-Bus, Right: Taxi)

(3) Public urban transport study in Nouakchott City

Assistance mission of recovery urban transport in Nouakchott was conducted by world bank fund. The objective of this study was the identification of a priority action plan for setting up the institutional framework and the conditions for better functioning of the Urban Public Transport Society. It follows the diagnosis report which focuses primarily on the environment of the Society of Public Transport Nouakchott (STP) and the analysis of performance requirements for the STP. Draft Final Report was prepared in 2017, September. In the report, recommendations were described below.

Recommendation 1: To combine the organization functions in urban transport, by creating a single structure responsible for the organization of public transport in the CUN. Its main responsibilities will be (i) defining the transport offer, (ii) determining the form in which the public transport service will be carried out, and (iii) signing contracts with the responsible operators for the operation of urban public transport lines.

Recommendation 2: To adopt a legal form for the STP that allows the involvement, alongside the government, of partners of the sub-sector to contribute to the financing of the development of the STP and the urban public transport.

Recommendation 3: To ensure that tariff resources contribute more significantly to the financial balance of the STP:

- raise rates in line with changing costs; and
- re-examine the impact of social and flat rates, evaluate them and get a fair compensation for the loss of income they generated for the STP.

Recommendations 4: To involve the STP in bus procurement procedures at a high level.

Its choice must be based on technical standards specific for this activity.

The STP should be involved in the vehicle procurement procedure and participate in drawing up the specifications defining their technical characteristics.

The purchase contract will include supplier commitment clauses for the delivery of spare parts for a specified period.

Recommendation 5: To provide in the organization of the STP, the creation of a structure dedicated to the training of the staff. Human resource is one of the main levers of the performance of a company. However, urban public transport is a specific activity whose knowledge or expertise is not acquired in dedicated academic training schools. Only the company can identify its training needs and create the framework and conditions for implementing the policy it has defined in the area. A Training Plan that will analyze the training needs of executives and different trades and categories of personnel.

Recommendation 6: To improve by equipping it in bus stops and in bus shelters to allow its visibility and offer good conditions of waiting for users. A transport network must be visible and identifiable. The bus stop and bus shelters that constitute the street furniture of a public transport network contribute to this. They are constituent elements of the transport offer and the quality of the service offered by the operator. The bus stop is a fundamental element of the transportation offer, because it is the first point of contact between the user and the transport company, but also the essential mean for access to the transportation service.

Recommendation 7: To provide the department of operation and workshop material and human resources to properly carry out their missions.

Recommendation 8: The STP must otherwise operate the urban public transport lines by designing an adapted transport offer. The rational exploitation of an urban transport line is based on a few major principles:

- The knowledge of the demand, in particular to the actual demand expressed at the different stopping points;
- The knowledge of the conditions of execution of the transport, in particular to the journey time, which integrates the traffic conditions on the route served;
- The availability of buses and staff.

There is no implementation schedule of the recommendations, STP does not have any budget for the project and there is no donor support for each recommendation

(4) Issues of urban transportation

The Urban Transport Master Plan was formulated in 2006, but it is not used for policy making due to low level of awareness of stakeholders. Likewise, congestion due to traffic concentration and disorderly road development are happening in some places because there is no road development plan based on traffic conditions.

Nouakchott city has three types of public transport facilities (bus, mini-bus and taxi). However, public transportation is not functioning well due to lack of operational management capacity.

5.1.3 Logistic infrastructure

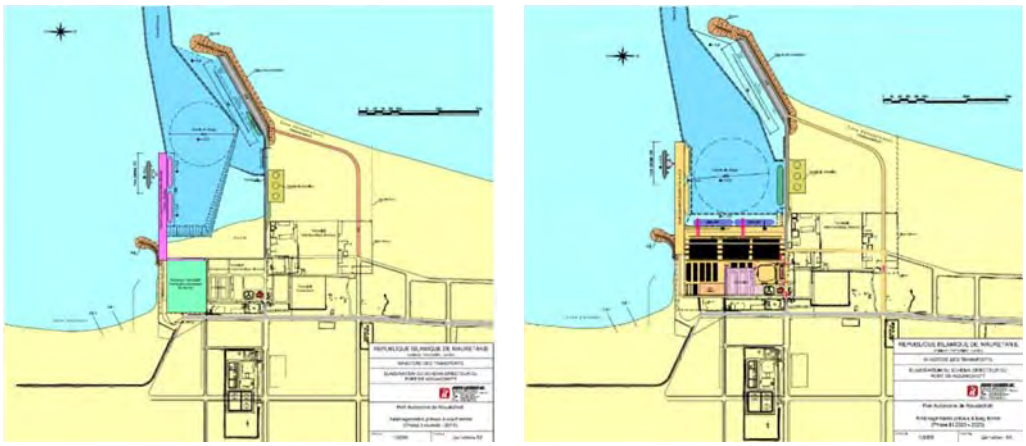
(1) Logistic infrastructure in Nouakchott City

There are two large logistics facilities in Nouakchott City: port and airport. Both facilities are managed and operated by Le Port Autonome de Nouakchott dit Port de l'Amitie (PANPA) and L'Agence Natinale de l'Aviation Civile (ANAC) under the jurisdiction of MET. The share of handled cargo volume is 99% in port and 1% in airport.

(2) Nouakchott Port

1) Outline

The Nouakchott Port is located at about 12 km southwest from the city center. Nouakchott Port was opened in 1966. Construction of the deep-sea port to increase the handling volume was started with the support of China in 1979 and was completed in 1986. To further improve the handling cargo volume, the Mauritania Government is underway to expand the Nouakchott Port under the support of the Chinese government and will be completed in 2025. With this expansion plan, cargo handling capacity will increase to 9,000,000 tons. (See Figure 5.9 and Table 5.5)



Sauce: PANPA

Figure 5.9: Plan view of Nouakchott Port (Left: Phase 1, Right: Phase 3)

Table 5.5: Future Plan of Nouakchott Port

ITEM	Unit	Phase 1	Phase 2	Phase 3
Period		～2014	2015～2019	2020～2025
Number of Quay		5	7	8
Length of Quay	m	958	1,538	1,818
Space of Terminal	ha	33.4	42.6	46.7
Container handling equipment		REACH STACKER	REACH STACKER	REACH STACKER
Container handling and storage capacity	TEU	145,000 162,000	289,000 289,000	468,000 476,000
Cargo handling capacity	ton	4,200,000	5,800,000	9,000,000
Cargo storage capacity	ton	470,000	720,000	890,000

Sauce: PANPA

There are 5,860 people working at Nouakchott Port. Bus service between the city and the port is not available. Most employees use taxis for communing since charter buses and trucks services are not reliable. The average round - trip taxi fare from home to the port is as high as about 1,000 MRO, which is a heavy burden on employees.

Aside from the above issue related to port, narrow access road is also a concern. Although the road has two lanes, it is difficult to accommodate two large trucks moving from opposite directions. PAN has made a request to MHUAT to address the issue above but this has not been granted yet.

2) Cargo handling volume

Since the domestic industries are not growing, the basic supplies depend on imports. Imported goods account for 88% (weight basis) of cargo handled. Main handled cargoes are rice, corn, sugar, tea and milk, and construction materials, such as steel and cement.

There have been no major changes in the volume of cargo handled in the last 5 years as shown in Table 5.6.

- Imported cargo volume: 3 million tons / year to 3.5 million tons / year
- Export cargo volume: 0.3 million tons / year to 0.45 million tons / year

In this survey, an interview survey was conducted on the loading of freight vehicles incoming and outgoing the port. More than 90% of freight vehicles going into or out of Nouakchott port are origin and destination points in Nouakchott city.

Table 5.6: Breakdown of cargo handled at Nouakchott Port

(Unit: 1,000 ton)

Item	Year 2011	Year 2012	Year 2013	Year 2014	Year 2015
Import	**2,506**	**3,173**	**3,008**	**3,578**	**3,387**
Rice	120	181	141	156	113
Corn	292	486	381	447	586
Sugar	224	259	244	314	316
Tea	9	11	13	12	8
Milk	69	80	85	89	90
Iron	69	122	101	93	126
Cement	542	644	659	892	705
Edible oi	94	129	112	118	110
Other	1,087	1,263	1,271	1,458	1,332
Export	**348**	**373**	**387**	**377**	**450**

Source: ONS (Annuaire Statistique 2015)

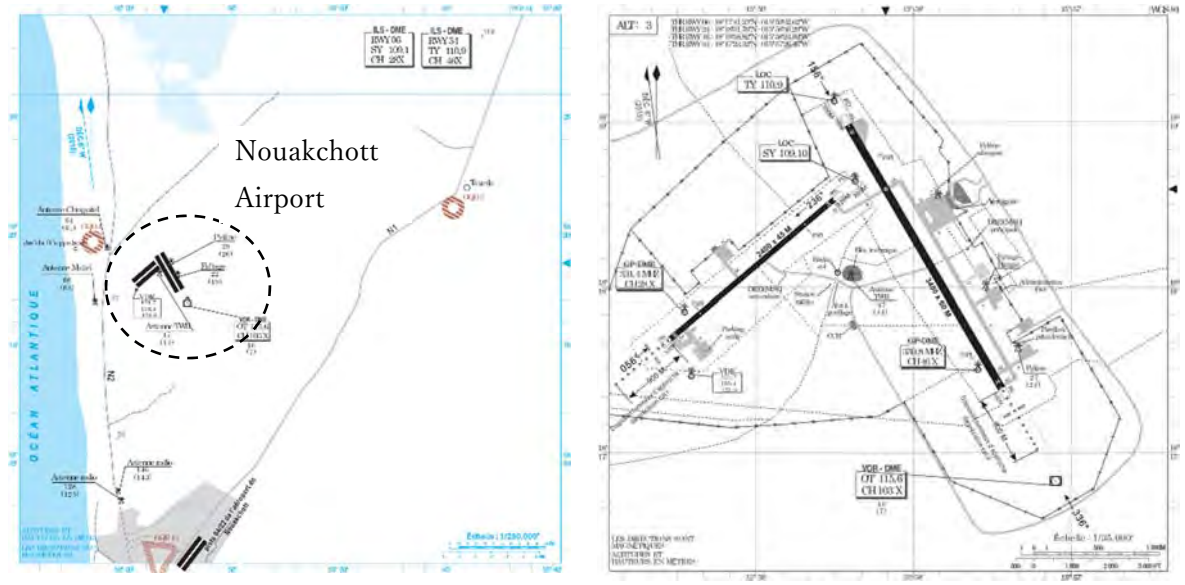
(3) Airport

1) Outline

The Nouakchott Airport is located at about 25 km north from the city center. This airport was newly constructed in 2016 to address issues such as deterioration of airport facilities, safety of people living in the neighborhood of the airport among others. (See Figure 5.10)

2) Cargo handle volume

The airport has 10 routes in six countries such as France and Senegal. The number of passengers of Nouakchott Airport increases by 1.5% from 98,976 in 2007 to 347,576 in 2014. Moreover, the cargo volume handled at Nouakchott Airport also increases by 3.15% from 2,853 ton in 2007 to 4,338 ton in2014. (See Table 5.7)



Source: ANAC

Figure 5.10: Plan View of Nouakchott Airport (Left: Location, Right: Airport facilities)

Table 5.7: Volume of Traffic and Cargo Handled by Nouakchott International Airport

Year	Number of departures / arrivals (times)	Number of passengers (Person)	Handled cargo (tons)
2007	1,938	98,976	2,853
2008	1,924	102,288	2,856
2009	2,675	131,559	3,371
2010	2,689	114,069	3,461
2011	3,295	118,252	2,764
2012	3,962	295,600	3,366
2013	4,402	271,290	3,401
2014	6,371	347,576	4,338

Source: ONS (Annuaire Statistique 2015)

(4) Issues of logistic infrastructure

The issues of the Logistic Infrastructure are as follows.

- Absence of logistics facility plan considering demand and supply
- Lack of road network with neighboring countries
- Imbalance of import and export due to undeveloped of domestic industry

5.2 Road Traffic Characteristics

5.2.1 Outline of Traffic Survey

(1) Survey method

1) Survey outline

Traffic survey was conducted to understand the current traffic situation in Nouakchott City of Mauritania and to gain the necessary data for future traffic volume estimation. The survey was conducted from February to April 2017.

2) Survey items

The survey items are classified into five categories: simple person movement survey, cordon line survey, truck OD survey, traffic count survey and travel speed survey. Survey items are given in Table 5.8. The person trip survey is conducted as a part of social survey.

Table 5.8: Traffic Survey Items

Number	Category	Survey Items
(1)	Simple Person movement survey	Survey method: Household(HH) interview survey No. of Sampling 1000 HH Interview Items: HH information, Personal information, Trip information and Transport Issues Survey day: March to April 2017
(2)	Cordon line survey-Roadside interview survey and traffic count	Survey Points: 4 (Nouakchott City border) Survey time: 7: 00～19: 00 (12 hours) Target: vehicles passing through boundary of Nouakchott City Survey Items: 1) Vehicle type 2) Origin and Destination 3) Trip purpose 4) Number of Passengers 5) Loading capacity / weight and volume 6) Loading items *5) & 6) are for trucks only *Traffic volume survey was also conducted in the same day Survey day: Weekday (Tue - Thu)
(3)	Truck OD survey	Survey Points: 1 (Nouakchott Port entrance) Survey time: 7: 00～19: 00 (12 hours) Target: Trucks entering and leaving Nouakchott Port Survey Items: 1) Vehicle type 2) Origin and Destination 3) Loading capacity / weight and volume 4) Loading items Survey day: 15th of February
(4)	Traffic count survey	Survey Points: 30 (12 hours: 28 points、24 hours: 2 points) Survey time: 7: 00～19: 00 (12 hours), 7: 00～7: 00 the following day (24hours) Target: All vehicles passing through the survey point Survey day: Weekday (Tue - Thu)
(5)	Travel speed survey	Number of Route: 6 Survey time: (Morning) from 7: 00 a.m. (Daytime) from 13: 00 p.m. (Evening) from 17: 00 p.m. Survey day: Weekday (Tue - Thu)

Source: JST

5.2.2 Results of simple person movement survey

(1) Survey outline

A simple person movement (PM) survey is one of the traffic surveys, aiming to grasp the daily movements of residents in the study area. Based on the survey results, the present traffic flow characteristics in the area were analyzed. The survey was carried out by surveyors who visit selected houses determined randomly in advance and conducted interviews with the residents to record the daily movements of the family members.

The PM survey was conducted using tablet-type device. The use of relatively simple questionnaire items was determined in consideration of the current situations in the Study Area.

The surveyors visited the houses from March to April 2017 to interview and record the movements of their family members on the visited day (When the survey day was a holiday, Thursday 's trip was asked).

(2) Survey items

The survey items are classified into three categories: characteristics of household, family members, and trips. Survey items are given in Table 5.9.

Table 5.9: PM Survey Items

Category	Survey items
Household Information	Number of family members Car ownership Vehicle type Earning
Personnel Information	Sex and age
Trip Information	Origin Destination 7 Trip purposes (For work, For school, For business, For shopping, Private, Pick-up or send-off, Others) 10 Transport modes (Walk, Bike, Mini-bus, Large bus, Taxi, Car, Truck, wow, cart, chart)

(3) Sampling

The population in the Nouakchott city in 2013 is estimated as 958.4 thousand. Assuming that the average family of a household consists of 5 persons, the total number of households is 200,000. The survey was conducted on 1,000 households, representing 0.5% of the total households.

The Nouakchott city consists of 9 communes and each commune consists of many communities called quartiers. Therefore, the number of households was determined in accordance with the population of each commune. Furthermore, in order to consider the population distribution in the commune, the population of each quartier was calculated on GIS and the number of households in each quartier was determined by the population of each district.

(4) Data processing

In order to prepare the present OD tables, the data were processed in the following order.

1) Coding and data input

Collected questionnaires were arranged in order, coding for origin and destination was carried out, and the data were input into a computer.

2) Error check on the PM survey results (range check and logical check)

Range check and logical check were carried out on each question, and errors were corrected except for the uncorrectable errors that were treated as ineffective samples.

3) Analysis on effective PM survey results

a) Outline

Effective sample data were summed up and characteristics of person trips were analyzed. Table 5.10 shows the outline of the effective samples. The average family members are 5.8 persons.

Table 5.10: Outline of the Effective Samples

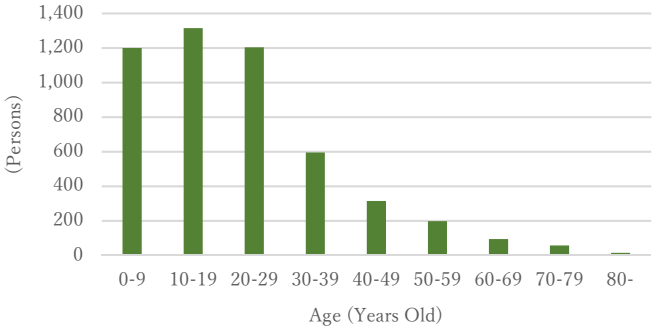
Surveyed households	1,000
Responded households	1,000
Number of households owning cars	230
Ratio of car ownership	23.0%
Total number of family members	5,844
Average number of family members	5.8

Source: JST

b) Information of family members

Age

Among the age profile, "young age such as 0-9 age, 10-19 age and 20-29 age has the largest share of 24.0%, 26.3% and 24.1%, respectively.

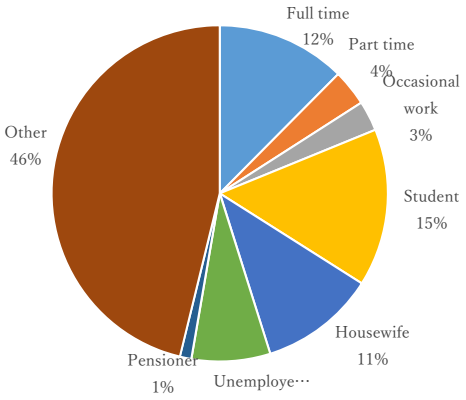


Age	persons	Rate (%)
0-9	1,200	24.0%
10-19	1,315	26.3%
20-29	1,204	24.1%
30-39	595	11.9%
40-49	315	6.3%
50-59	198	4.0%
60-69	94	2.0%
70-79	57	1.1%
80-	15	0.3%
Total	4,993	100.0%

Figure 5.11: Age profile of family members

Employee statement

Among the Employment status, "Student" has the largest share of 15.2%, followed by "Full-time" at 12.4%. However, about half of the respondent were unanswered.

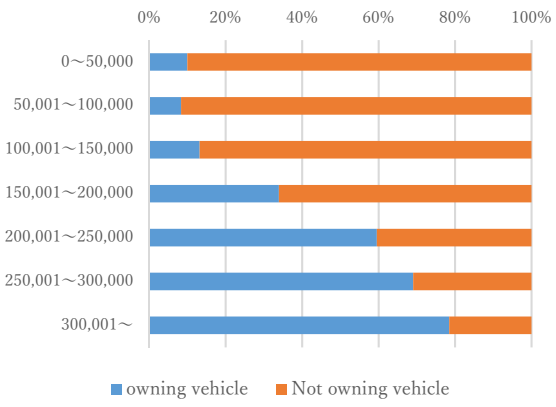


Employment status	Number	Rate (%)
Full time	621	12.4%
Part time	174	3.5%
Occasional work	145	2.9%
Student	757	15.2%
Housewife	557	11.2%
Unemployed	378	7.6%
Pensioner	55	1.1%
Other	2,306	46.2%
Total	4,993	100.0%

Figure 5.12: Employment Status of Family Members

c) Monthly Family income and car ownership rate

Car ownership ratio is related to monthly family income. If the monthly income of a household is higher, the car ownership rate will also be higher. Especially, the tendency of car ownership rate rapidly increases from 150,00 MRO (See Figure 5.13).



Monthly Income	owning car	Rate (%)	Not owning car	Rate (%)	Total
0～50,000	16	10%	144	90%	160
50,001～100,000	30	8%	330	92%	360
100,001～150,000	26	13%	171	87%	197
150,001～200,000	39	34%	76	66%	115
200,001～250,000	28	60%	19	40%	47
250,001～300,000	29	69%	13	31%	42
300,001～	62	78%	17	22%	79
Total	230	—	770	—	1,000

Figure 5.13: Monthly income and car ownership rate

d) Summary of samples on households owning and not owning car

The rates of going out and the number of trips is similar for households with and without car.

Table 5.11: Summary of Samples on Households Owning and Not Owning Car (1)

Car Owner-ship	Households	family mem-bers	Number of persons going out	Number of trips	Ratio of going-out	Unit rate of Trips
Not owned	770	4,392	2,707	5,554	61.6%	2.05
Owned	230	1,452	908	1,948	62.5%	2.15
Total	1,000	5,844	3,615	7,502	61.9%	2.08

The rate of going out on foot for the households without car is 62%, higher than that of households with car (Table 5.12). The trips using private and public transport share 35% and 3% of the total number of trips by households owning cars, respectively larger than the shares for households not owning cars.

Table 5.12: Summary of Samples on Households Owning and Not Owning Car (2)

	Households owning car				Households not owning car			
	Walk	Public transport	Private transport	Total	Walk	Public transport	Private transport	Total
3-mode total	780	356	788	1,924	3,390	1,902	170	5,462
	41%	19%	41%	100%	62%	35%	3%	100%
Total w/o walk mode	—	356	788	1,144	—	1,902	170	2,072
	—	31%	69%	100%	—	92%	8%	100%

(5) Survey results

1) Outline

a) Total trips

The total number of trips in a day related to the Nouakchott city is 6,998 trips, of which 4,036 trips are on foot within the City (See Table 5.13). Trips by vehicles moving are 2,962 trips.

Among the traffic connecting inside and outside the Nouakchott city, the largest is in the direction towards Mali with only 6 trips, followed by the direction towards Rosso with only 2 trips. There were no trips in other routes (Toward Nouadihbu and Atar).

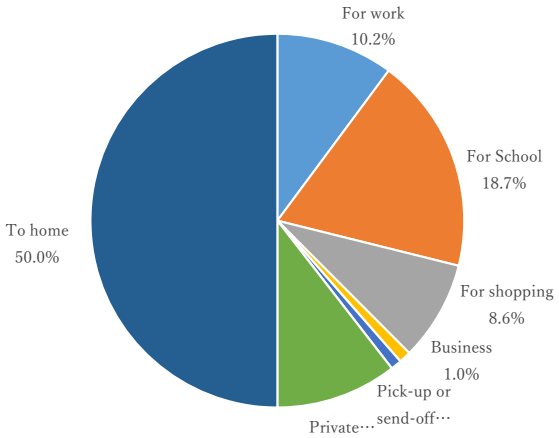
Table 5.13: Number of Trips Related to Nouakchott City

(Unit: trips/day)

		Nouakchott City	Airport	Port	Toward Nouadihbu	Toward Atar	Toward Mali	Toward Rosso	Total
Nouakchott City	Walk	4,036	—	—	—	—	—	—	4,036
	Public Transport	2,114	12	24			0	2	2,152
	Private Transport	778	10	16			6	0	810
	Public + Private	2,892	22	40			6	2	2,962
								Non-vehicle	4,036
								Vehicle	2,962
								Total	6,998

b) Trip purposes

The purposes of the trips by the inhabitants of the Nouakchott are 10.2% for commuting, 18.7% for schools, 1.0% for business, 0.9% for pick up or send off, 8.6% for shopping, and 10.5% for private purposes (See Figure 5.14). Trips with purpose of school account for the majority of the total trips.

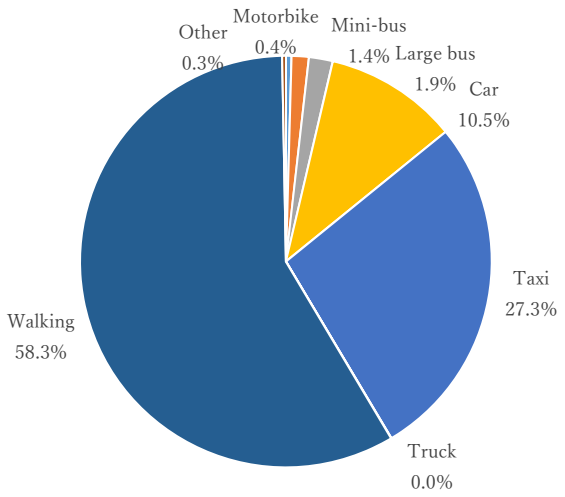


Purpose	Trips	Share
For work	704	10.2%
For school	1297	18.7%
For shopping	599	8.6%
Business	72	1.0%
Pick-up or send-off	65	0.9%
Private	727	10.5%
To home	3,464	50.0%
Total	6,928	100.0%

Figure 5.14: Trip Composition by Purpose

c) Main transport mode

Among the transport modes, “Walking” has the largest share of 58%, followed by Taxi at 27% and Private car at 11% (See Figure 5.15). Public transportation including mini-bus, buses and taxis shares 30%, implying that public transport is the important mode for the inhabitants for Nouakchott City.



Mode	Trips	Share
Motorbike	30	0.4%
Mini-bus	94	1.4%
Large bus	130	1.9%
Car	726	10.5%
Taxi	1,890	27.3%
Truck	2	0.0%
Walking	4,036	58.3%
Other	20	0.3%
Total	6,928	100.0%

Figure 5.15 Trip Composition by Main Transport Mode

2) Trip distribution

a) Distribution by all purposes

There is a large amount of trips between the Nouakchott City Center, Tevragh Zeina, Ksar,Sebkha and El Mina and the other zones (Figure 5.16). There is also a large amount of trips between Zone Toujounine and 901Riadh.

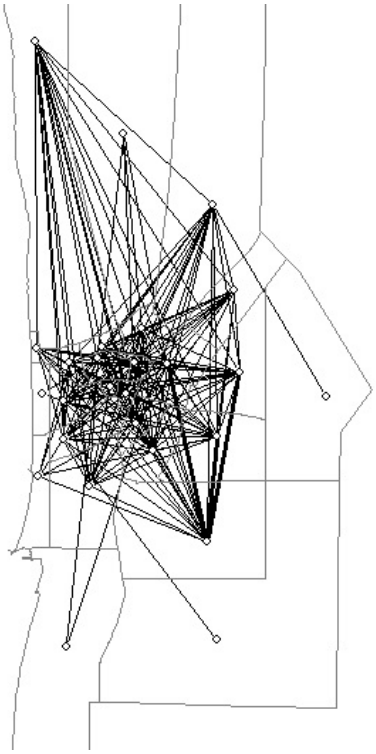


Figure 5.16: Desired Line (All purposes)

b) Distribution by each purpose

As for the trip distribution by each purpose, there is a large amount of trips between the city center and the other zones (Figure 5.17 through Figure 5.18**)**.

For commuting and business purposes, the Center part of Nouakchott city, where business core is located, has concentration of trips from surrounding communes.

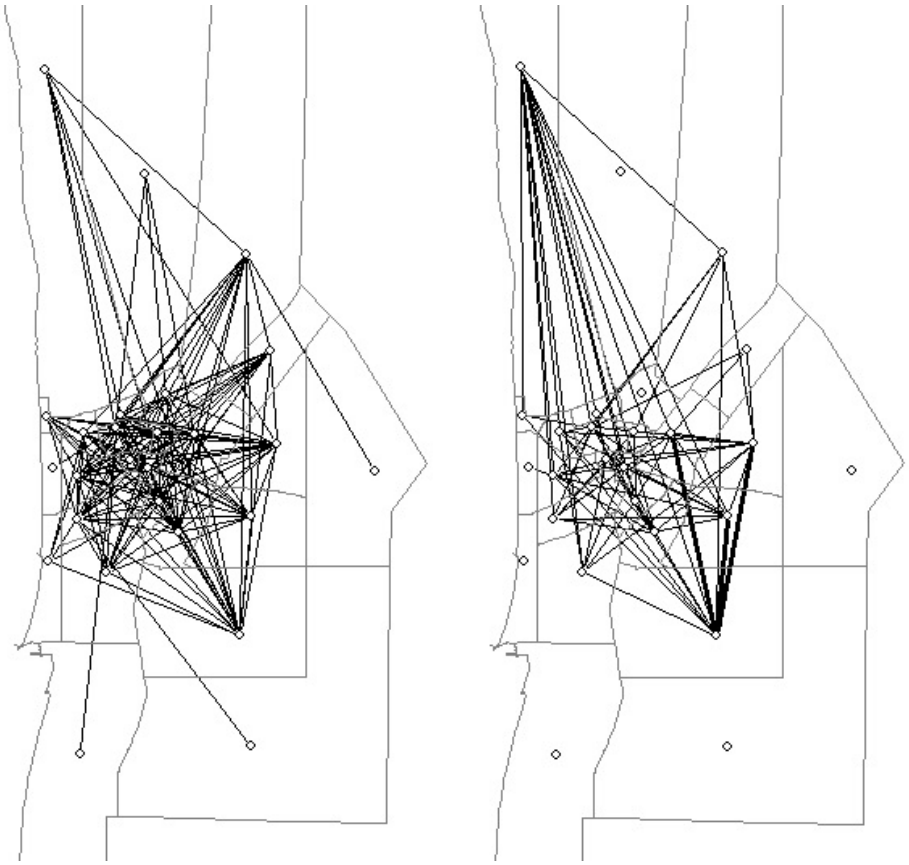


Figure 5.17: Desired Line (Left: Work, Right: School)

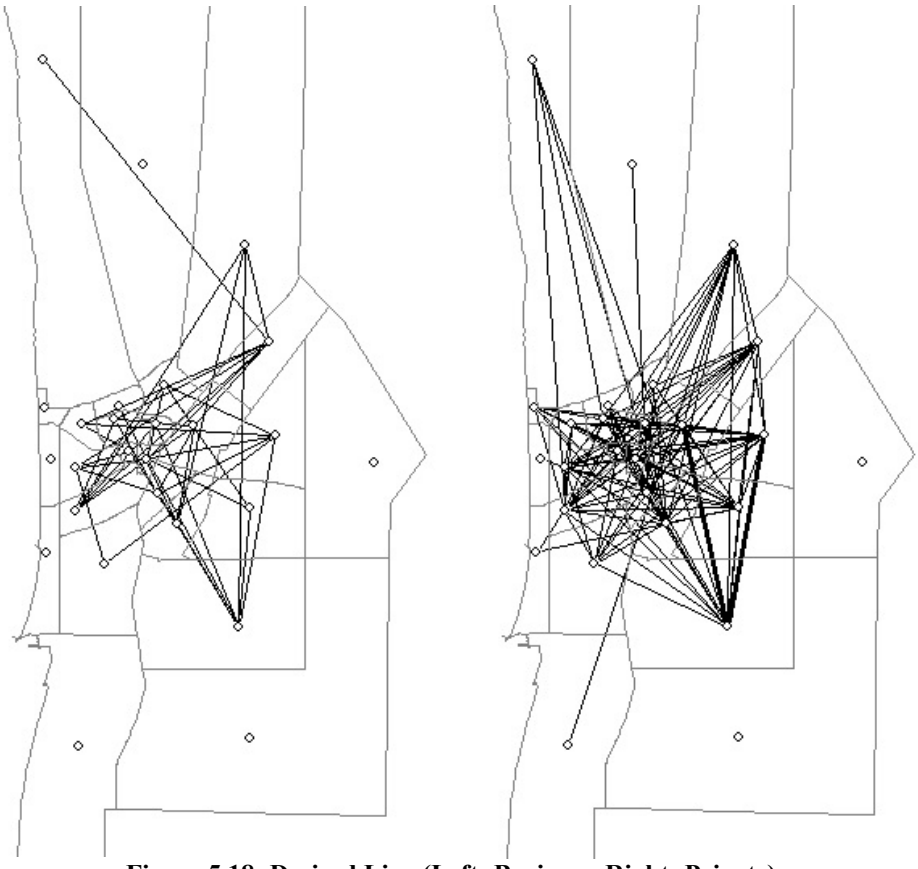
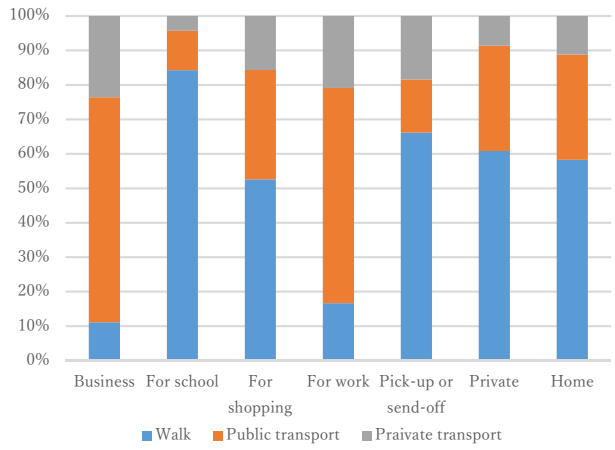


Figure 5.18: Desired Line (Left: Business, Right: Private)

3) Modal split by purpose

The share of public transportation for the commuting and Business purposes is about 60%, which is the highest, followed by private transport mode such as passenger cars, motor bikes, etc. (Figure 5.19). Trips-on-foot shares 84% for the way to schools, followed by the trips with public transport sharing 11%. For shopping, Pick-up or send-off and Private trips, the share of trips on foot was highest compared to other purposes.



Purpose	Walk	Public transport	Private transport	Total
Business	8	47	17	72
	11.1%	65.3%	23.6%	-
For school	1093	148	56	1,297
	84.3%	11.4%	4.3%	-
For shopping	315	190	94	599
	52.6%	31.7%	15.7%	-
For work	117	440	147	704
	16.6%	62.5%	20.9%	-
Pick-up or send-off	43	10	12	65
	66.2%	15.4%	18.5%	-
Private	442	222	63	727
	60.8%	30.5%	8.7%	-
Home	2,018	1,057	389	3,464
	58.3%	30.5%	11.2%	-
Total	4,036	2,114	778	6,928
	58.3%	30.5%	11.2%	

Figure 5.19: Modal Split by Purpose

4) Distribution by mode

It is apparent that the desired lines for the public transport, which is the main transportation mode, are concentrated on the trips connecting the Nouakchott city center from the surrounding communes (Figure 5.20). And also, the desired lines for private transport mode shows a tendency which is almost the same as that of the public transportation.

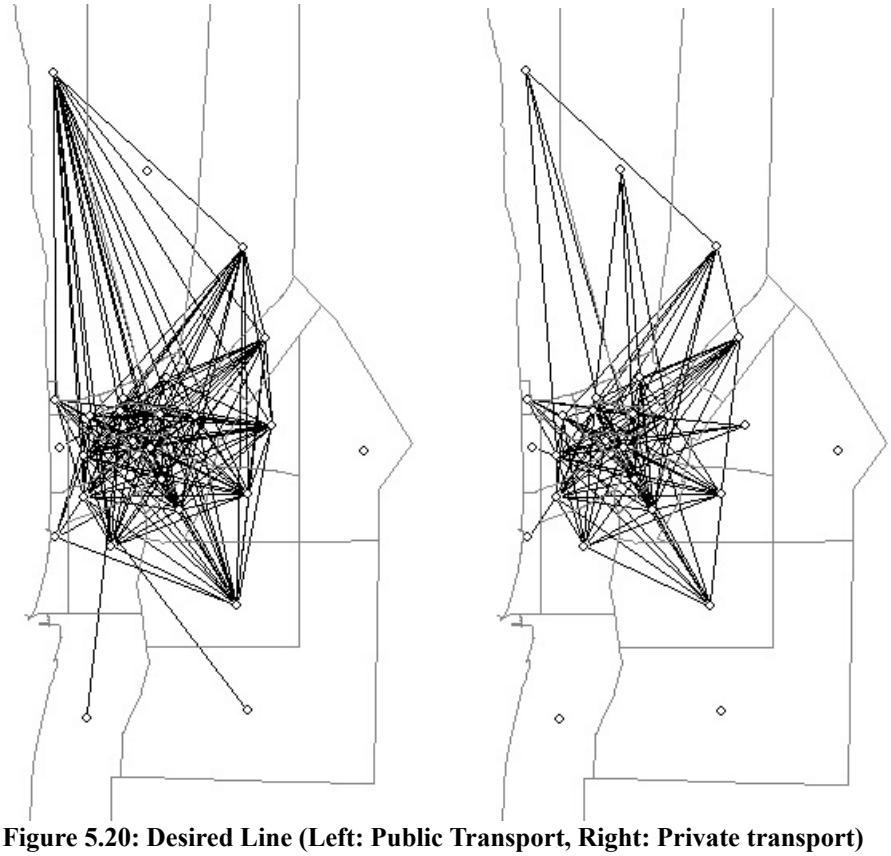


Figure 5.20: Desired Line (Left: Public Transport, Right: Private transport)

5.2.3 Results of cordon line survey

(1) Survey outline

Cordon line survey was conducted in Nouakchott city border to understand Origin-Destination (OD) traffic from outside of Nouakchott city.

Cordon line survey in the Nouakchott city was conducted with a questionnaire in a sheet of A4 size to minimize the items to ask. The use of relatively simple questionnaire sheets was determined in consideration of the current traffic situations in the city. Not less than 40% from the traffic shall be stopped at random, and then drivers shall be interviewed. To understand the volume of vehicles at the survey point, traffic count survey was also conducted in the same points.

Table 5.14: Cordon Line Survey Items

Survey Items	Contents
Survey Points	4（See Figure 5.21）
Survey time	12hours（7: 00～19: 00）
Survey Items	1) Vehicle type 2) Origin and Destination 3) Trip purpose 4) Number of Passengers 5) Loading capacity / weight and volume 6) Loading items
Survey day	Weekday (Tue - Thu)

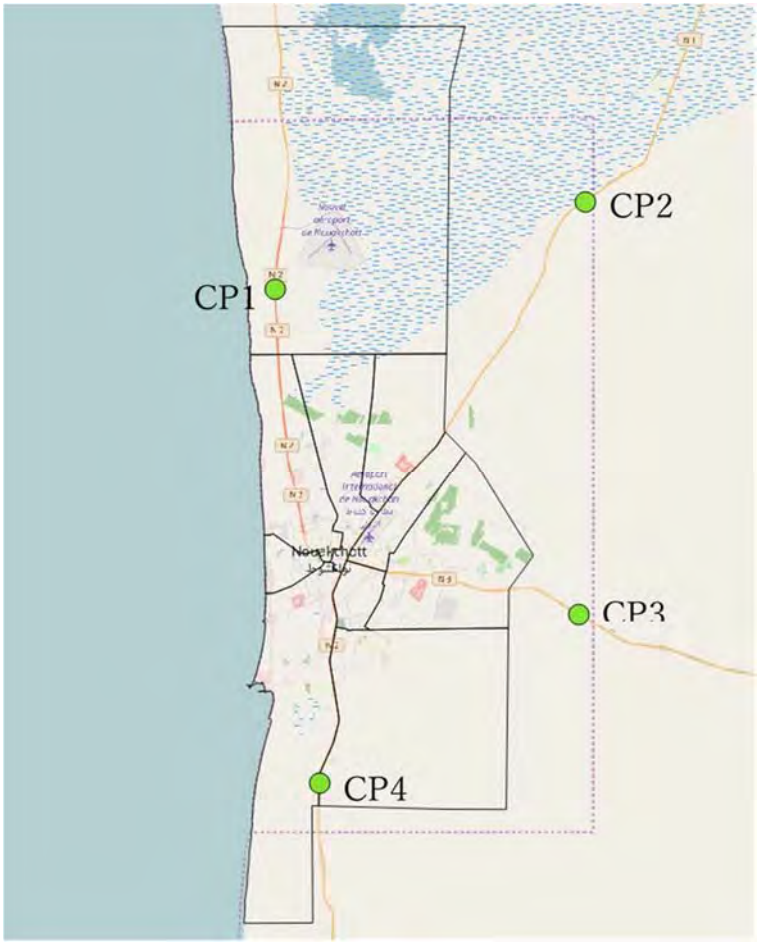


Figure 5.21: Cordon Line Survey Points

Table 5.15: Summary of samples on Cordon line survey

	Number of vehicles (Vehicles / 12h)	Number of Sample (Vehicles)	Ratio (%)
CP1	1,925	1,095	56.8%
CP2	883	328	37.1%
CP3	1,749	738	42.2%
CP4	1,326	874	65.9%

(2) Survey result

1) Total trips in Nouakchott city border

The total traffic volume for 12 hours coming into and going out of the Nouakchott City is 5,833 vehicles. The largest traffic volume (1,925 vehicles) was observed on the National Route 2 (N2: toward Nouadhibou), followed by 1,749 vehicles recorded at National Route 3 (N3: toward to Mari). For vehicle type, passenger cars have the highest share (68%), followed by trucks (including Trailer) with a share of 20%. (See Table 5.16 and Figure 5.22). The peak hour of inbound traffic was observed at around 18: 00 pm, while the peak hour of outbound traffic was at around 12: 00 pm. There is not much difference in the traffic pattern between the inbound and the outbound traffic. (See Table 5.16)

Table 5.16: Traffic Volume by Vehicle Type in Nouakchott City Border

(Unit: Vehicles / 12h)

Survey Station	Direction	Motor Cycle	Mini Bus	Large Bus	Car / Taxi	Light Truck	Heavy Truck	Trailer	Others	Total
CP1	Inbound	4	154	4	698	130	26	28	1	1,045
N2: toward to Nouadhibou	Outbound	7	79	9	613	117	29	21	5	880
	Total	**11**	**233**	**13**	**1,311**	**247**	**55**	**49**	**6**	**1,925**
CP2	Inbound	0	43	0	239	161	10	23	5	481
N1: toward to Atar	Outbound	0	23	2	147	187	23	17	3	402
	Total	**0**	**66**	**2**	**386**	**348**	**33**	**40**	**8**	**883**
CP3	Inbound	1	102	5	789	41	23	60	7	1,028
N3: toward to Mari	Outbound	1	73	0	541	51	19	31	5	721
	Total	**2**	**175**	**5**	**1,330**	**92**	**42**	**91**	**12**	**1,749**
CP4	Inbound	3	62	1	485	33	21	40	3	648
N1: toward to Rosso	Outbound	2	66	4	508	29	24	43	2	678
	Total	**5**	**128**	**5**	**993**	**62**	**45**	**83**	**5**	**1,326**
Total	Inbound	8	361	10	2,211	365	80	151	16	3,202
	Outbound	10	241	15	1,809	384	95	112	15	2,681
	Total	**18**	**602**	**25**	**4,020**	**749**	**175**	**263**	**31**	**5,883**
	Share	*0.30%*	*10.20%*	*0.40%*	*68.30%*	*12.70%*	*3.00%*	*4.50%*	*0.50%*	*100.00%*

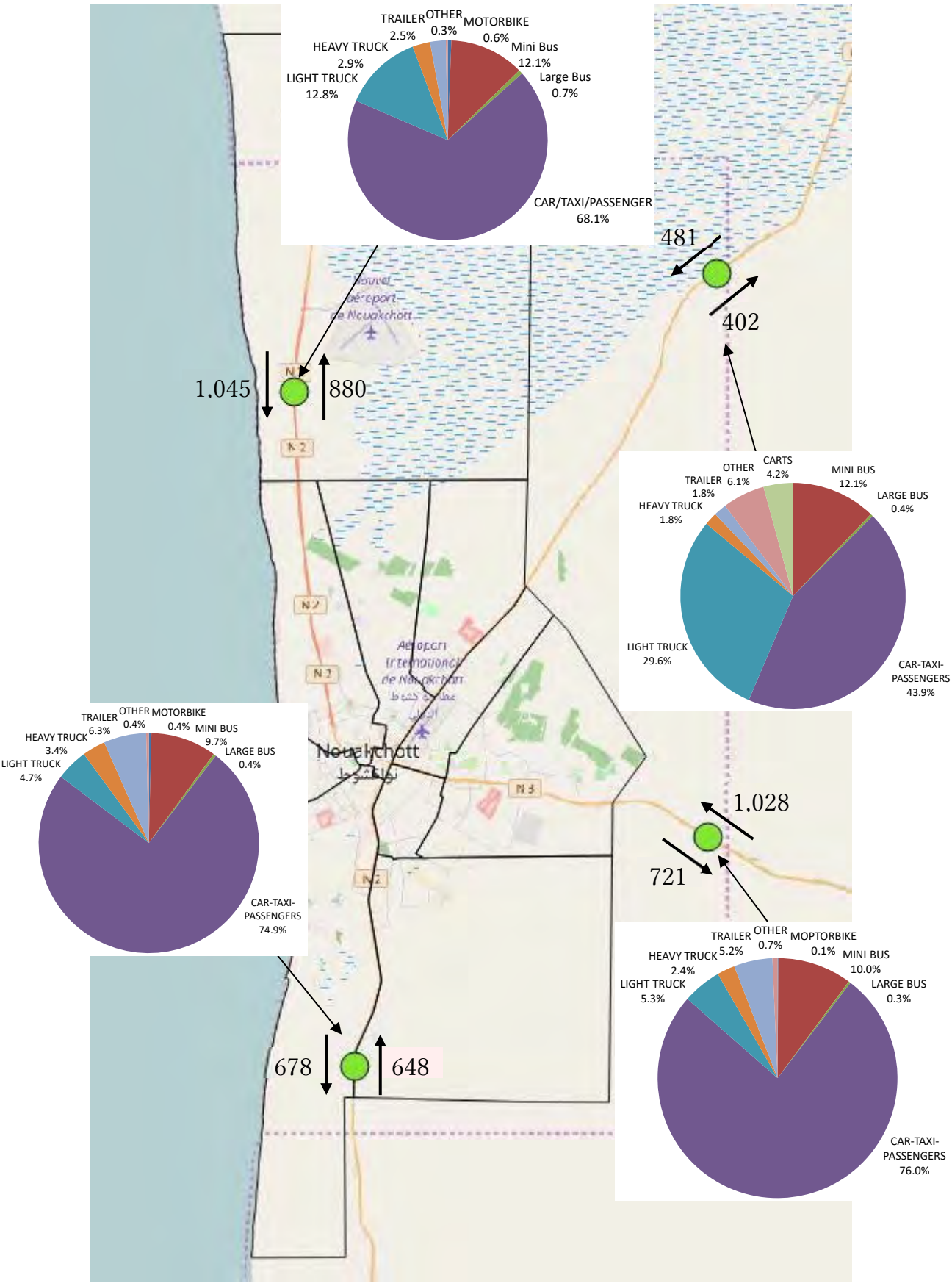
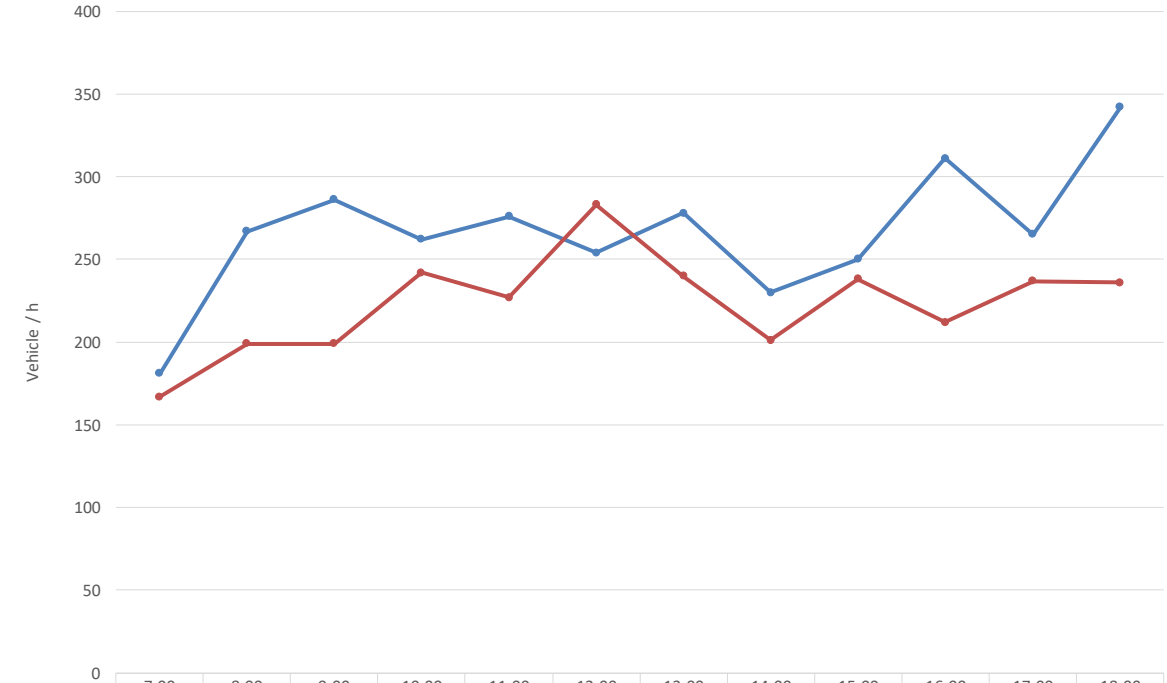


Figure 5.22: Traffic Characteristics at the Cordon Line

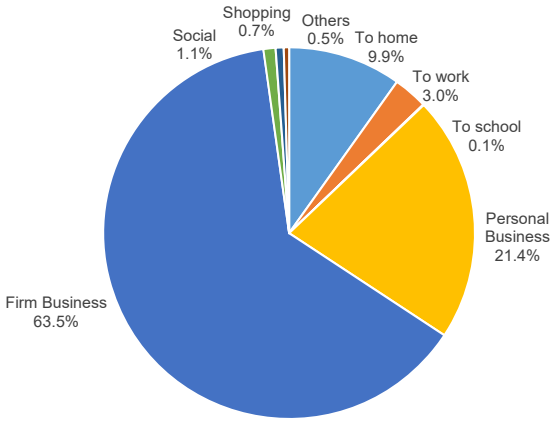


	7:00 ~8:00	8:00 ~9:00	9:00 ~10:00	10:00 ~11:00	11:00 ~12:00	12:00 ~13:00	13:00 ~14:00	14:00 ~15:00	15:00 ~16:00	16:00 ~17:00	17:00 ~18:00	18:00 ~19:00
inbound	181	267	286	262	276	254	278	230	250	311	265	342
outbound	167	199	199	242	227	283	240	201	238	212	237	236

Figure 5.23: Hourly Traffic Fluctuation Measured by Vehicle Type in Nouakchott City Border

2) Trip purposes

Personal and Firm business account for the majority of the total trips. (See Figure 5.24).

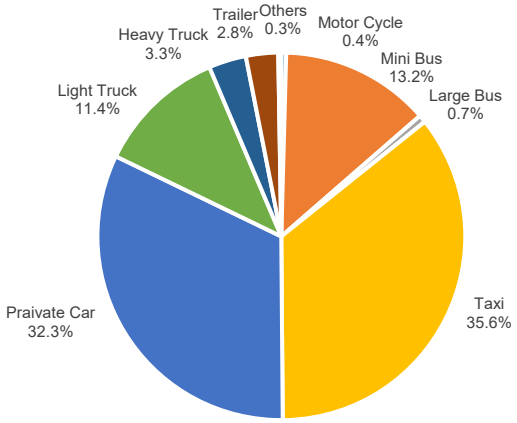


Purpose	Trips	Share
Home	298	9.9%
Work	90	3.0%
School	2	0.1%
Personal Business	646	21.4%
Firm Business	1921	63.5%
Social	32	1.1%
Shopping	21	0.7%
Others	14	0.5%
Total	3,024	100.0%

Figure 5.24: Trip Composition by Purpose

3) Main transport mode

Among the transport modes, “Taxi” has the largest share of 36%, followed by Private car at 32% and mini bus at 13% (See Figure 5.25). Public transportation including buses and taxis shares 50%, implying that public transport is the most important mode for the people living near Nouakchott City.



Mode	Trips	Share
Motor Cycle	13	0.4%
Mini Bus	400	13.2%
Large Bus	20	0.7%
Taxi	1081	35.7%
Private Car	980	32.4%
Light Track	347	11.5%
Heavy Track	100	3.3%
Trailer	86	2.8%
Others	8	0.3%
Total	3,035	100.0%

Figure 5.25: Trip Composition by Main Transport Mode

4) Origin and destination in Nouakchott city border

Most origins and destinations of vehicles passing through the border were in Nouakchott City. The number of through traffic (vehicles passing through Nouakchott City) are only 38 Vehicles for 12h.

Table 5.17: Origin and Destination in Nouakchott City border

(Unit: Vehicles / 12h)

	Nouakchott city	CP1 toward Nouadhibou	CP2 toward Atar	CP3 toward Mari	CP4 toward Rosso
Nouakchott city	—	227	116	277	395
CP1: toward Nouadhibou	450	—	2	2	15
CP2: toward Atar	202	16	—	0	0
CP3: toward MAri	422	1	0	—	0
CP4: toward Rosso	447	2	0	0	—

Total through traffic is 38 veh

5.2.4 Results of traffic count survey

(1) Survey outline

Traffic count survey was conducted to confirm the validity of the result of traffic allocation of present origin-destination matrix prepared from social survey results.

Table 5.18: Traffic Count Survey Items

Survey Items	Contents
Survey Points	30 (12 hours: 28、24hours: 2)
Survey time	7: 00～19: 00 (12 hours), 7: 00～(tomorrow)7: 00 (24hours)
Target	All vehicles passing through the survey point
Survey day	Weekday (Tue - Thu)

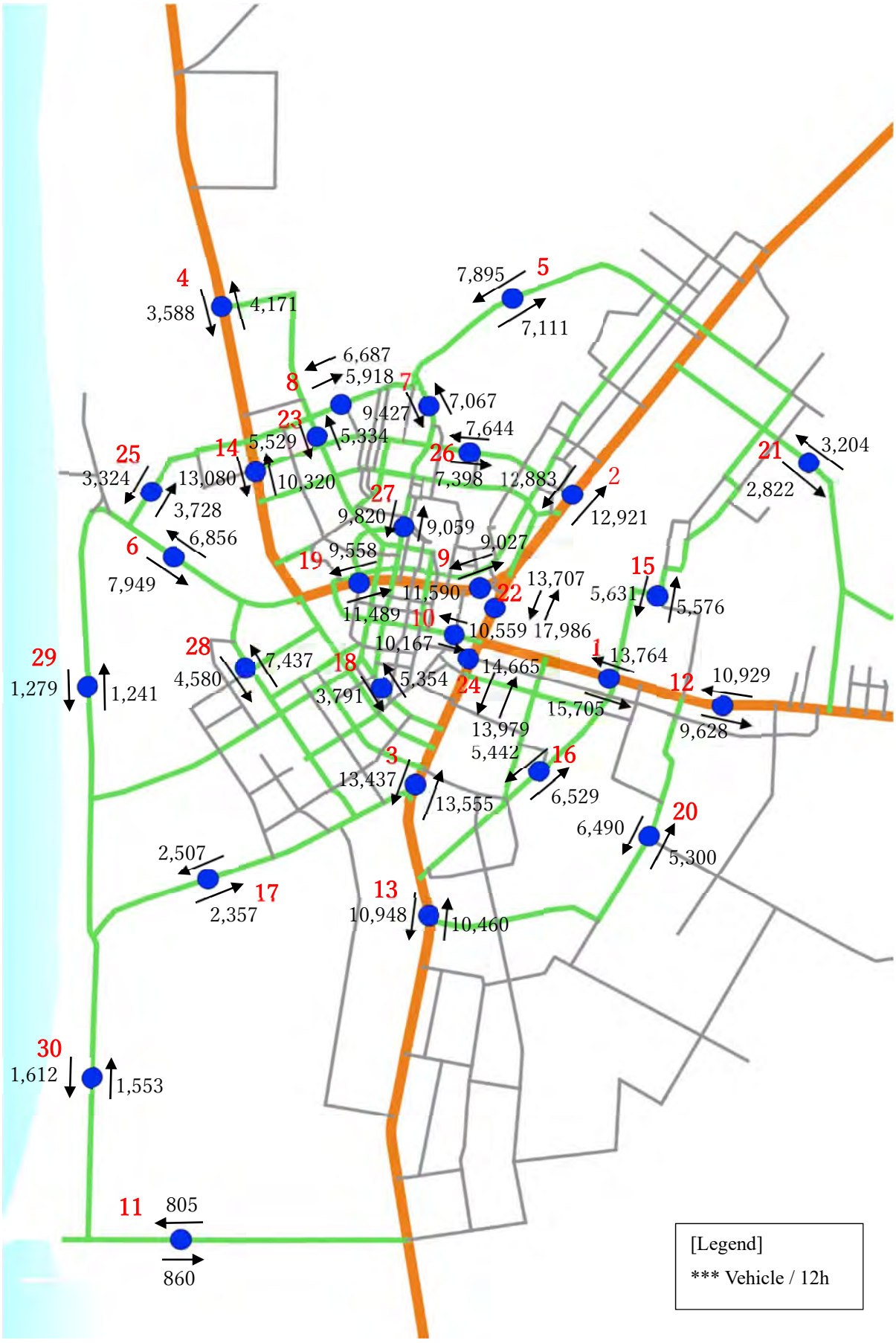


Figure 5.26: Traffic Count Survey Points

(2) Survey result

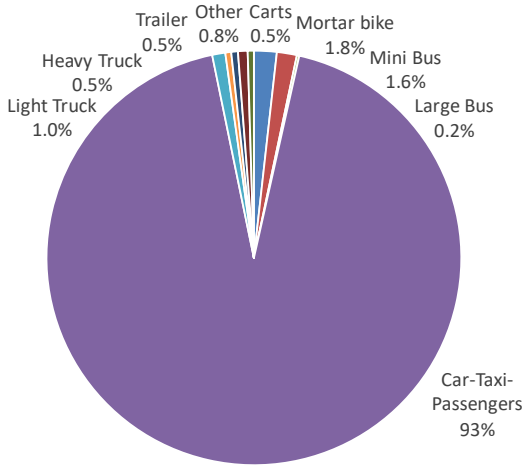
Road traffic is concentrated in the city center at about 20,000 to 30,000, and there is a tendency that the traffic volume decreases as the distance from the city center increases.

As for the traffic volume by each vehicle type, Car / Taxi / Passenger Car have the highest share of 93%, followed by motorcycles. (See Figure 5.27)

Table 5.19: 12 Hour Traffic Volume

(Unit: Vehicles / 12h)

Station No.	Motor cycle 1	Mini Bus 2	Large Bus 3	CAR/TAXI /PASSENGER 4	Light Truck 5	Heavy Truck 6	Trailer 7	Other 8	Carts 9	Total
1	286	905	49	27,817	91	43	46	138	94	29,469
2	451	334	12	24,382	255	206	95	63	6	25,804
3	306	418	95	25,085	330	211	340	158	49	26,992
4	152	258	167	6,410	461	149	117	38	0	7,752
5	342	104	29	13,912	288	149	136	26	20	15,006
6	665	79	1	13,764	112	29	28	113	14	14,805
7	294	70	2	15,785	152	36	6	144	5	16,494
8	220	107	16	11,954	198	41	17	46	6	12,605
9	400	263	14	19,587	118	47	56	126	6	20,617
10	284	841	47	19,228	41	8	26	140	111	20,726
11	35	26	4	1,265	82	124	104	16	0	1,665
12	225	887	40	18,802	203	61	79	80	180	20,557
13	34	70	9	2,234	32	13	4	17	0	2,413
14	536	402	85	21,569	452	68	75	213	0	23,400
15	206	233	26	10,418	85	51	31	3	154	11,207
16	135	147	2	11,290	116	12	22	247	0	11,971
17	18	7	0	267	11	21	20	12	0	356
18	370	111	22	7,888	124	30	73	92	435	9,145
19	484	200	28	19,679	68	61	32	490	5	21,047
20	158	166	6	10,910	128	26	3	55	338	11,790
21	122	133	6	5,269	135	58	115	32	156	6,026
22	256	196	80	30,642	189	183	78	61	8	31,693
23	237	50	3	10,432	52	25	16	57	1	10,873
24	250	306	65	27,359	185	110	200	131	38	28,644
25	134	80	2	6,516	130	70	71	39	10	7,052
26	192	97	39	14,477	137	14	9	69	8	15,042
27	390	91	2	17,980	28	25	4	354	5	18,879
28	496	127	12	10,529	50	18	9	316	460	12,017
29	53	42	3	2,186	71	55	85	24	1	2,520
30	58	83	5	2,403	171	93	349	3	0	3,165



Vehicle type	Share
1.Mortar bike	1.8%
2.Mini Bus	1.6%
3.Large Bus	0.2%
4.Car-Taxi-Passengers	93.2%
5.Light Truck	1.0%
6.Heavy Truck	0.5%
7.Trailer	0.5%
8.Other	0.8%
9.Carts	0.5%

Figure 5.27: Trip Composition

5.2.5 Results of truck OD survey

(1) Survey outline

In order to understand the Origin-Destination (OD) of truck traffic, truck OD survey was conducted at the entrance of Nouakchott Port.

The Truck OD survey was conducted with a questionnaire in a sheet of A4 size to minimize the items to ask. The use of relatively simple questionnaire sheets was determined in consideration of the current traffic situations near Nouakchott port. The interview was conducted for all target vehicles.

Table 5.20: Truck OD Survey Items

Survey Items	Contents
Survey Points	1 (Nouakchott Port entrance)
Survey time	12hours（7: 00～19: 00）
Survey Items	1) Vehicle type 2) Origin and Destination 3) Loading capacity / weight and volume 4) Loading items
Survey day	15th of February

(2) Survey result

1) Total Trips in Nouakchott Port

The total traffic volume of freight vehicles coming into and going out of the Nouakchott Port is 592 vehicles (12-hrs). As for the traffic volume by each vehicle type, trailer have the highest share (91% for inbound and 87% for outbound) and followed by heavy trucks (5% for inbound and 8% for outbound). (See Figure 5.28).

The peak of inbound traffic was observed at around 17: 00 pm, while the peak of outbound traffic was at around 12: 00 pm. There is not much difference in the traffic pattern between inbound and outbound traffic. (See Table 5.21)

Table 5.21: Traffic Volume by Vehicle Type

(Unit: Vehicles)

Hour	Light Truck		Heavy Truck		Trailer		Total	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
9: 00～10: 00	1	8	10	7	11	15	22	30
10: 00～11: 00	1		3		14	7	18	7
11: 00～12: 00	1	2	1	2	22	20	24	24
12: 00～13: 00	1				30	44	31	44
13: 00～14: 00	2	2		2	28	24	30	28
14: 00～15: 00	1	1			23	27	24	28
15: 00～16: 00	3	2		7	31	21	34	30
16: 00～17: 00					28	38	28	38
17: 00～18: 00	1	2		6	43	20	44	28
18: 00～19: 00	2				34	44	36	44
Total	**13**	**17**	**14**	**24**	**264**	**260**	**291**	**301**

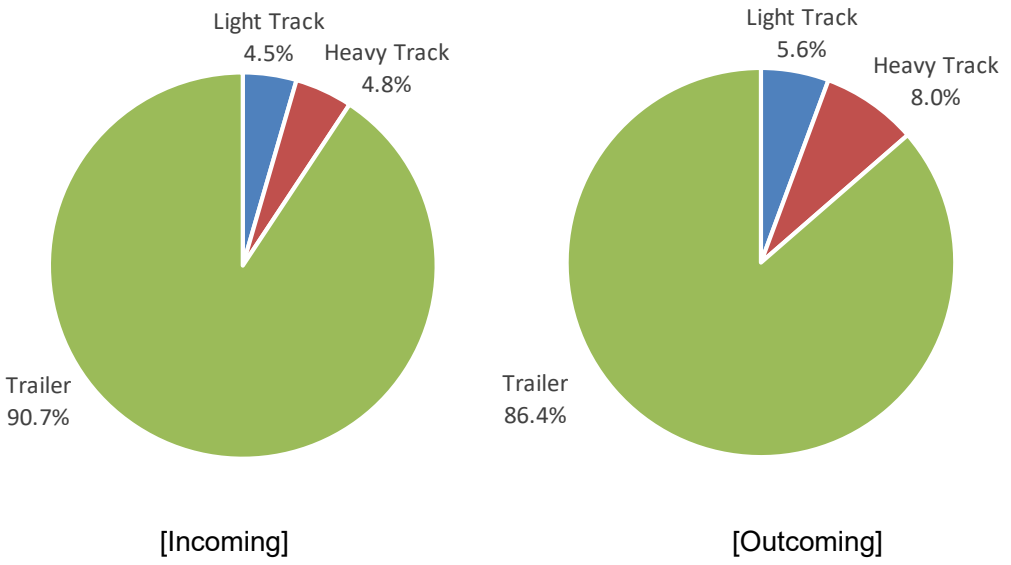
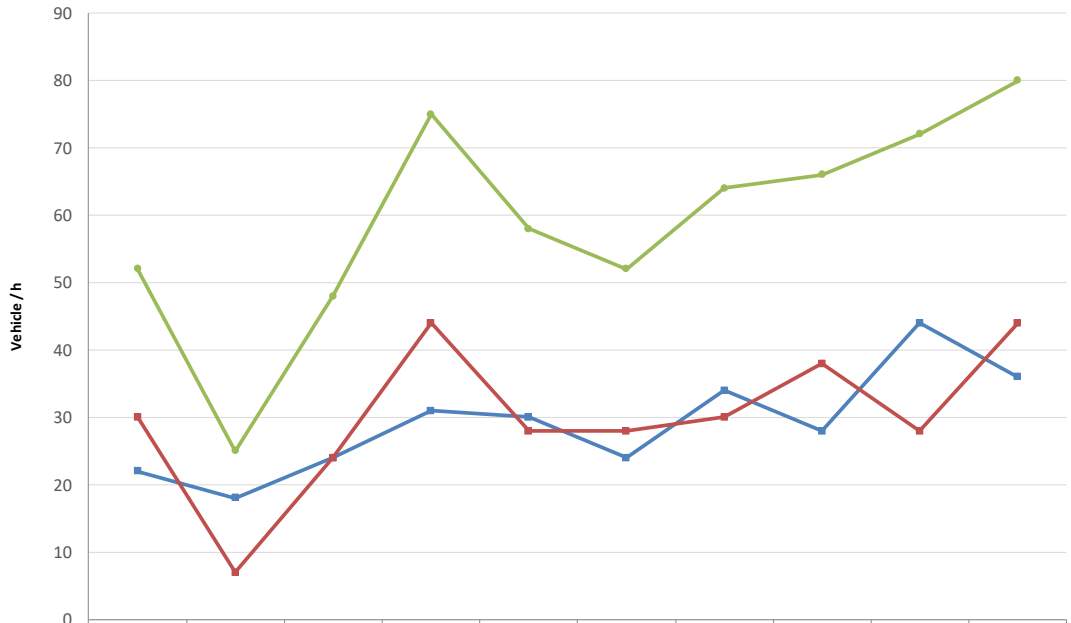


Figure 5.28: Trip Composition by Transport Mode



	9:00～10:00	10:00～11:00	11:00～12:00	12:00～13:00	13:00～14:00	14:00～15:00	15:00～16:00	16:00～17:00	17:00～18:00	18:00～19:00
Incoming	22	18	24	31	30	24	34	28	44	36
Outgoing	30	7	24	44	28	28	30	38	28	44
Total	52	25	48	75	58	52	64	66	72	80

Figure 5.29: Hourly Traffic Fluctuation by Vehicle Type in Nouakchott Port

2) Origin and destination of freight vehicles

More than 90% of freight vehicles going into and out of Nouakchott Port have their origin and destination points in Nouakchott City. Among the commute, “El mina” has the largest share of 66%, followed by “Tevragh Zeina” with 16%. (See Table 5.22).

Table 5.22: Origin or Destination of Freight Vehicles in Nouakchott Port

(Unit: Vehicles / 12h)

Commune	Incoming		Outgoing		Total	
	Number	Share	Number	Share	Number	Share
Tevragh Zeina	68	23.3%	27	9.0%	95	16.0%
Ksar	17	5.8%	5	1.7%	22	3.6%
Teyaret	3	1.0%	0	0.0%	3	0.5%
Dar Naim	1	0.3%	0	0.0%	1	0.2%
Sebkha	0	0.0%	3	1.0%	3	0.5%
Arafat	1	0.3%	5	1.7%	6	1.0%
Toujounine	1	0.3%	0	0.0%	1	0.2%
El mina	146	50.1%	249	82.5%	395	66.6%
Riadh	0	0.0%	1	0.3%	1	0.2%
Nouakchott port	29	10.0%	1	0.3%	30	5.1%
From/to Akjoujt	25	8.6%	11	3.6%	36	6.1%

3) Commodity type

More than 90% of inbound freight vehicles at Nouakchott Port are empty. However, 54% of the outbound freight vehicles at Nouakchott Port are loaded with agricultural products. (See Table 5.23).

Table 5.23: Commodity Type at Each Way

(Unit: Vehicles / 12h)

Code number	Commodity Type	Inbound		Outbound	
		Number	Share	Number	Share
0	Empty	268	92.1%	43	14.2%
1	Agricultural Produce	0	0.0%	163	54.0%
2	Livestock	1	0.3%	0	0.0%
3	Manufactured Goods	0	0.0%	14	4.6%
4	Construction Materials	0	0.0%	5	1.7%
5	Petroleum/Chemical Products	0	0.0%	1	0.3%
6	Industrial Equipment	22	7.6%	0	0.0%
7	Other(Specified)	0	0.0%	76	25.2%
Total		291	100.0%	302	100.0%

5.2.6 Results of travel speed survey

(1) Survey outline

Travel speed survey was conducted to understand traffic congestion situation of Nouakchott City. It was carried out at three peak hours (morning, afternoon, evening) on weekdays for each route. The details of the travel speed survey are shown in the table below.

The travel speed survey was conducted by floating car method that travels each route according to the traffic flow and records speed and position at one (1) second intervals using GPS device.

Table 5.24: Travel Speed Survey Items

Route Number	Survey Date	Survey time
Route 1	2017/2/22 (Wed)	Morning: 7: 00~ 8: 00 Day Time: 14: 00 ~ 15: 00 Evening: 17: 00～18: 00
Route 2	2017/2/23 (Thu)	
Route 3	2017/3/1 (Wed)	
Route 4	2017/3/2 (Thu)	
Route 5	2017/3/7 (Tue)	

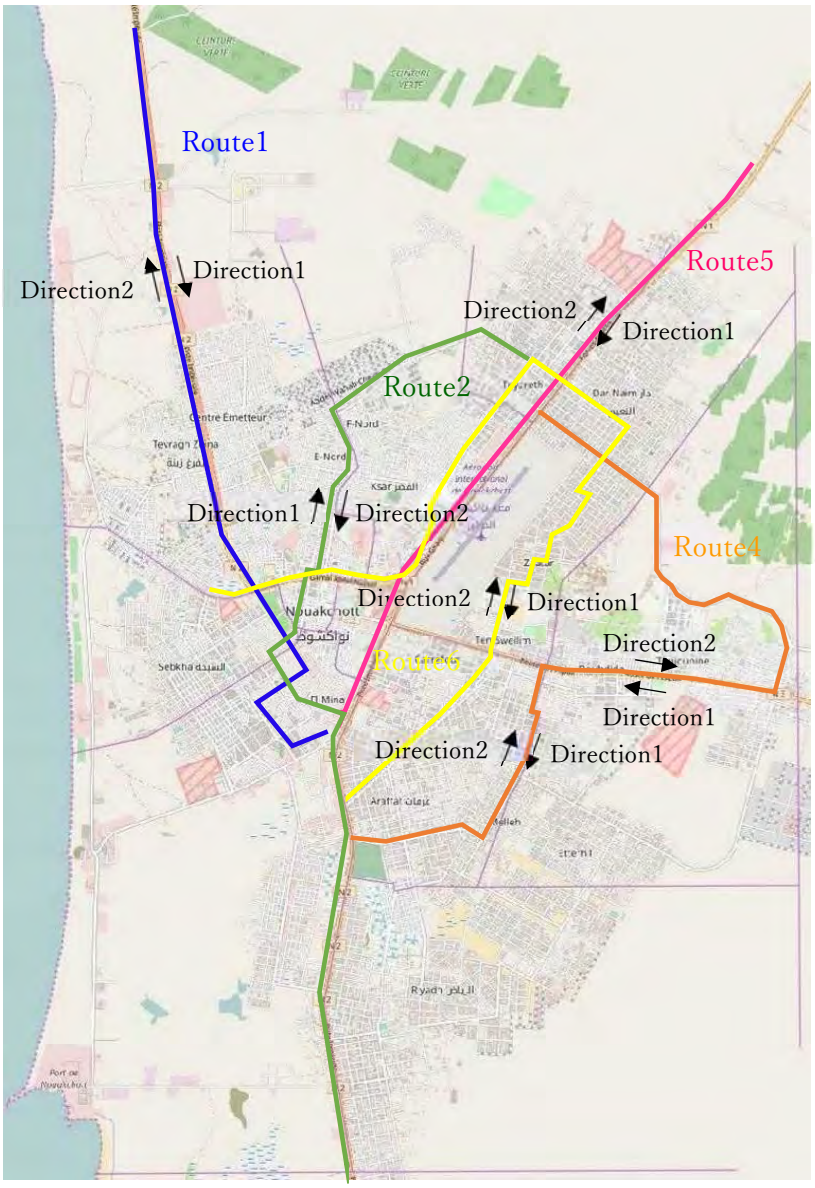


Figure 5.30: Travel Speed Survey Routes

(2) Survey result

Traffic flowed relatively smooth in all time except for city central area and Madrid intersection. The average travel speed was over 20 km/h. In the evening time, the average speed was lower than 20 km/h only for Route4 (Outbound).

Table 5.25: Average Travel Speed at Each Route

Route	Direction	Survey time	Distance	Average Speed
Route1	Direction1 (Inbound)	Morning	10.7km	34.6km/h
		Afternoon		24.3km/h
		Evening		29.2km/h
	Direction2 (Outbound)	Morning	10.7km	36.8km/h
		Afternoon		26.6km/h
		Evening		31.5km/h
Route2	Direction1 (Inbound)	Morning	13.6km	34.8 km/h
		Afternoon		26.5 km/h
		Evening		29.0 km/h
	Direction2 (Outbound)	Morning	13.5km	29.2 km/h
		Afternoon		28.6 km/h
		Evening		28.8 km/h
Route3	Direction1 (Inbound)	Morning	16.4km	32.8 km/h
		Afternoon		29.3 km/h
		Evening		31.0 km/h
	Direction2 (Outbound)	Morning	16.4km	33.0 km/h
		Afternoon		34.8 km/h
		Evening		33.9 km/h
Route4	Direction1 (Inbound)	Morning	22.3km	30.0 km/h
		Afternoon		26.1 km/h
		Evening		23.0 km/h
	Direction2 (Outbound)	Morning	22.3km	26.9 km/h
		Afternoon		22.2 km/h
		Evening		16.8 km/h
Route5	Direction1 (Inbound)	Morning	20.7km	33.0 km/h
		Afternoon		22.3 km/h
		Evening		20.0 km/h
	Direction2 (Outbound)	Morning	20.7km	30.4 km/h
		Afternoon		28.7 km/h
		Evening		22.6 km/h

The average travel speed of each route was more than 20 km/h except for Route4 outbound direction of evening peak time. Traffic was flowing relatively smooth.

On the other hand, travel speed in the city center was less than 20 km/h in all time zones. This reduction of speed attributed to traffic concentration, decrease in the number of lanes due to on street parking and stopping for getting on and off taxi and minibus passengers.

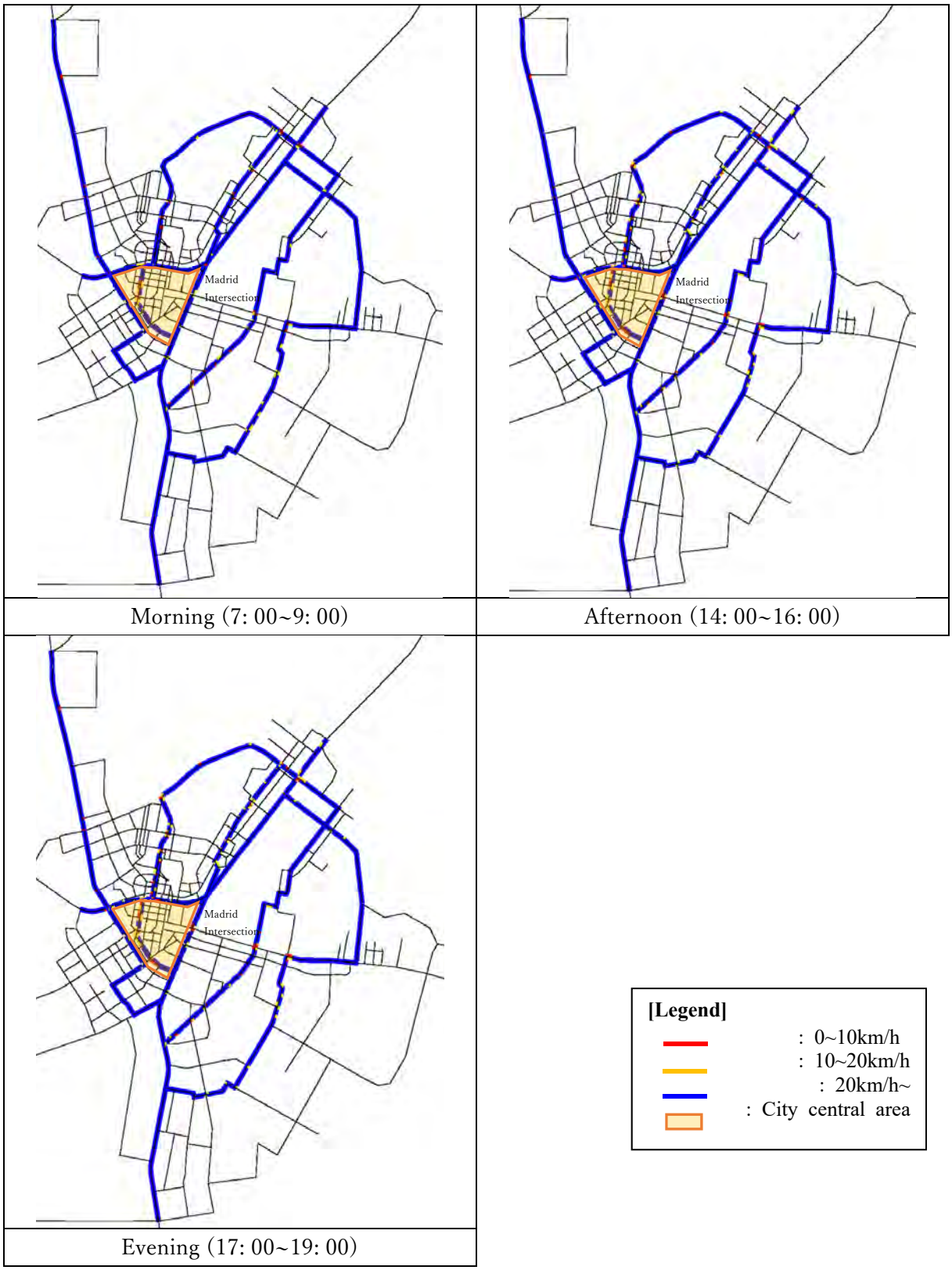


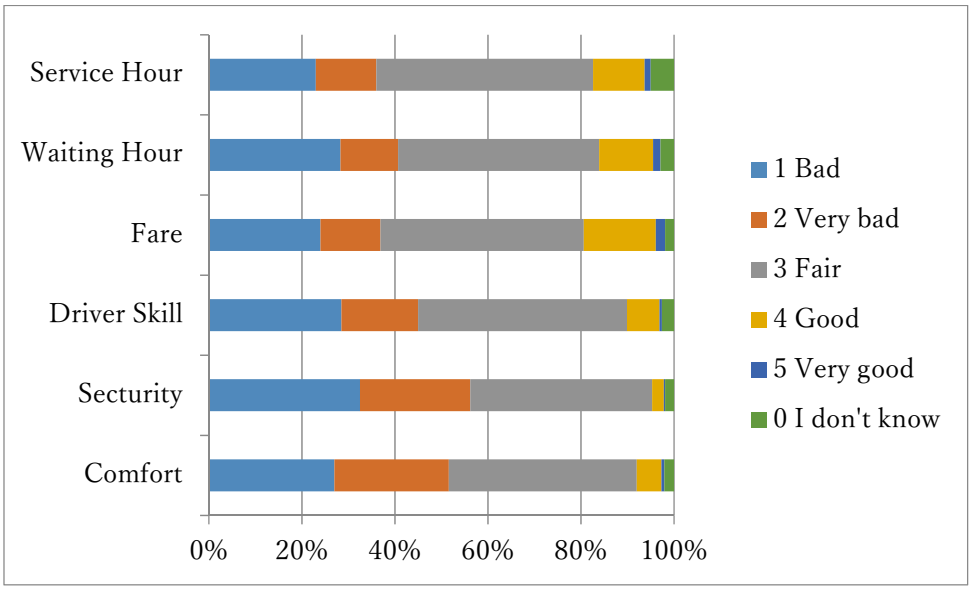
Figure 5.31: Travel Speed Map

5.2.7 Results of transport interview survey

In order to identify the present transport concerns, household heads were interviewed. This survey was conducted as a part of Simple Person Movement Survey. The number of sample was 1,000. The summary of interview result is shown below.

(1) Assessment of present taxi service

Most respondents are not satisfied with the present taxi service. Especially, respondents are not satisfied in terms of "security" and "comfort".

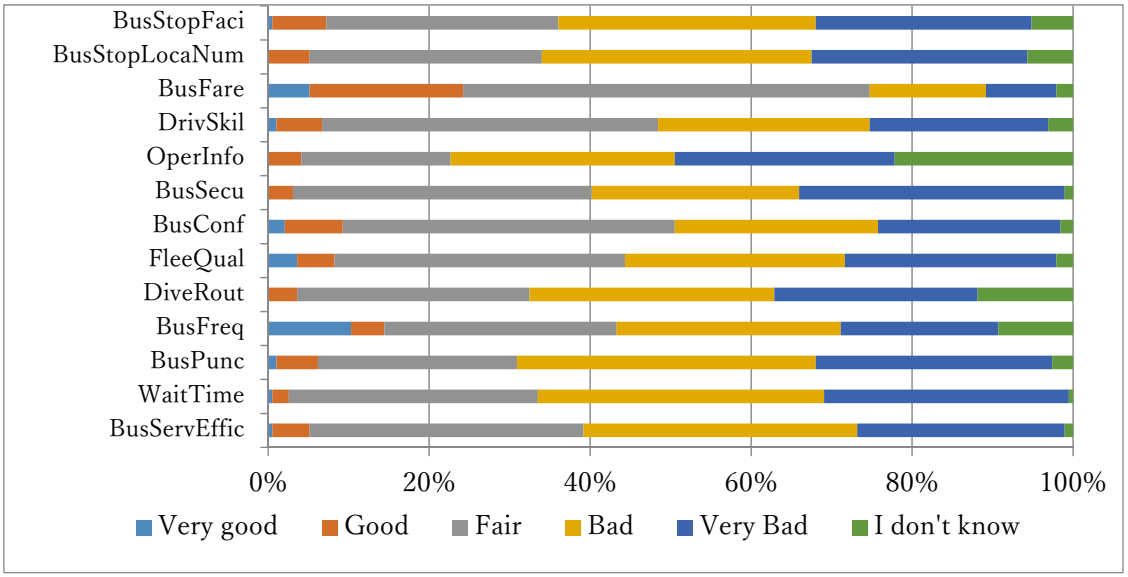


Source: JST (N=1000)

Figure 5.32: Assessment of Present Taxi Service

(2) Assessment of present bus service

With regards to the present bus service, the respondents were not satisfied with almost all items except bus fare as shown in Figure 5.33.

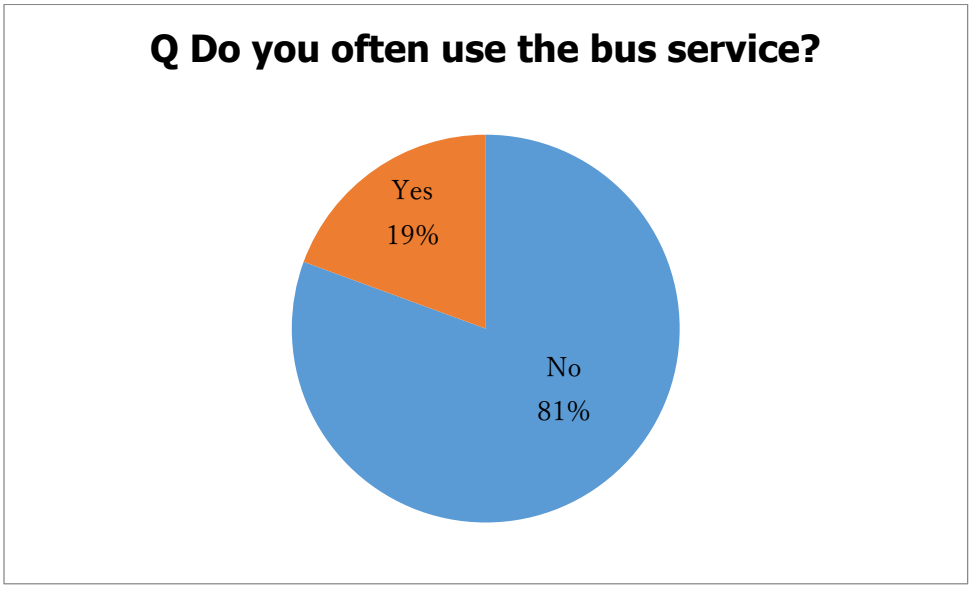


Source: JST (N=1000)

Figure 5.33: Assessment of Present Bus Service

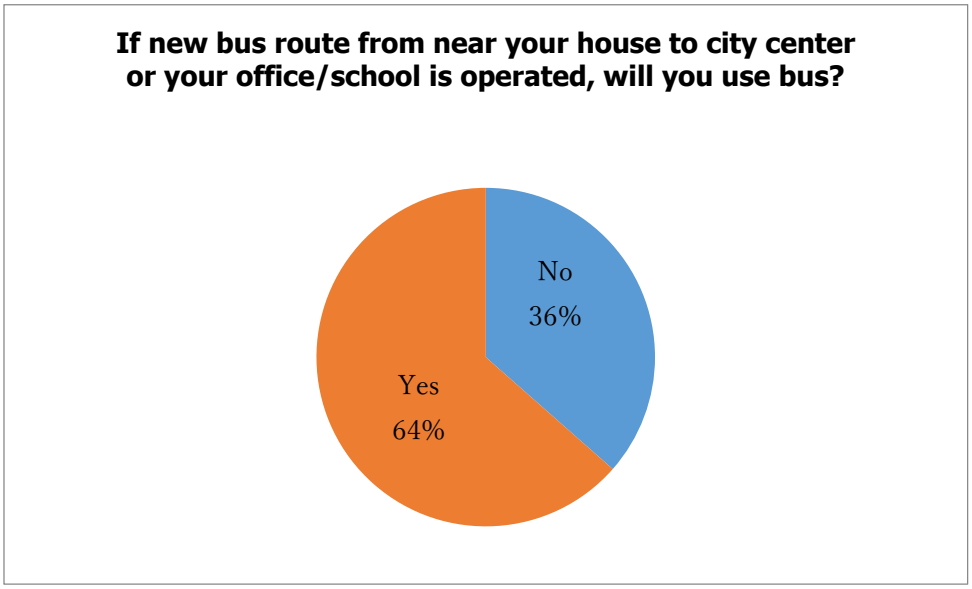
(3) New bus service

Only 19% of the respondents use the bus often as shown in Figure 5.34. If in the future, a new bus route is operated, 64% of the respondents answered to use the bus as shown in Figure 5.35. A total of 118 owners out of 216 private car owners responded to shift use to bus while the remaining 108 owners responded not to use the new bus system. It shows that even the private car owners also to expect the introduction of new good public transport system in Nouakchott.



Source: JST (N=1000)

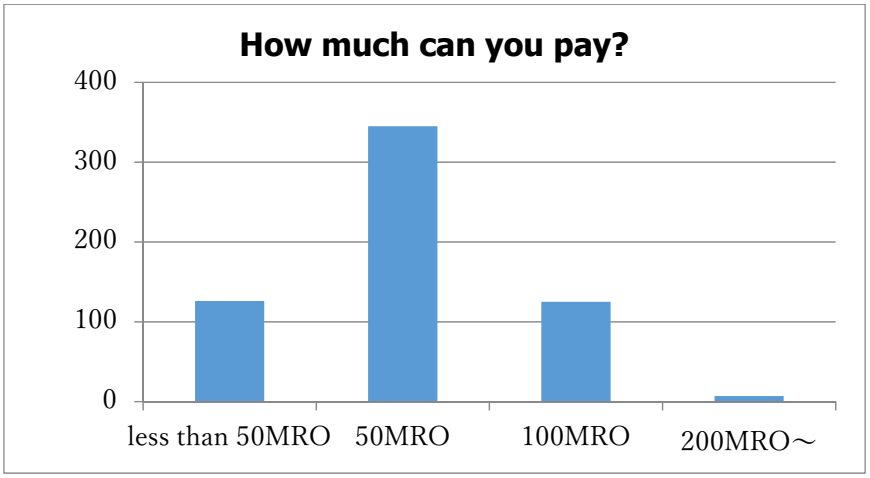
Figure 5.34: Share of Present Bus Service Usage



Source: JST (N=1000)

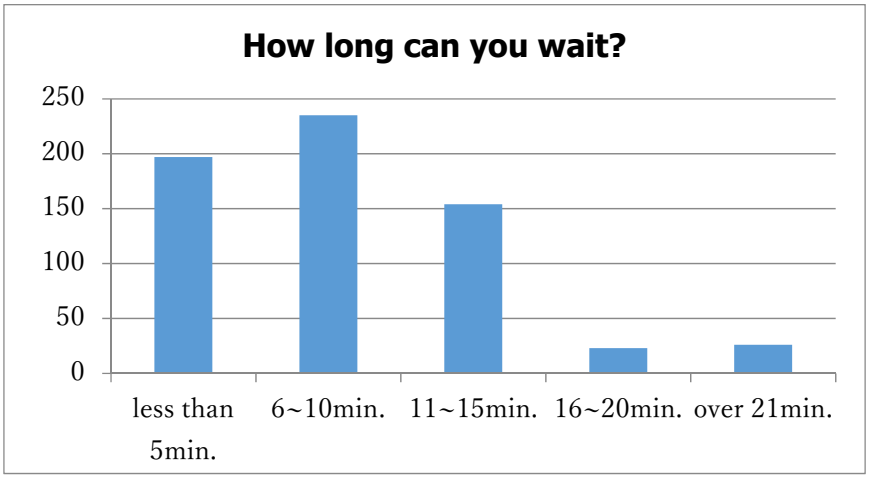
Figure 5.35: Willingness to use Bus Service

Most of the respondents are willing to pay 50MRO for a bus service with the expected waiting time of 6-10 min. Respondents are expecting for low fare, comfortable and safe bus service as shown in Figure 5.38.



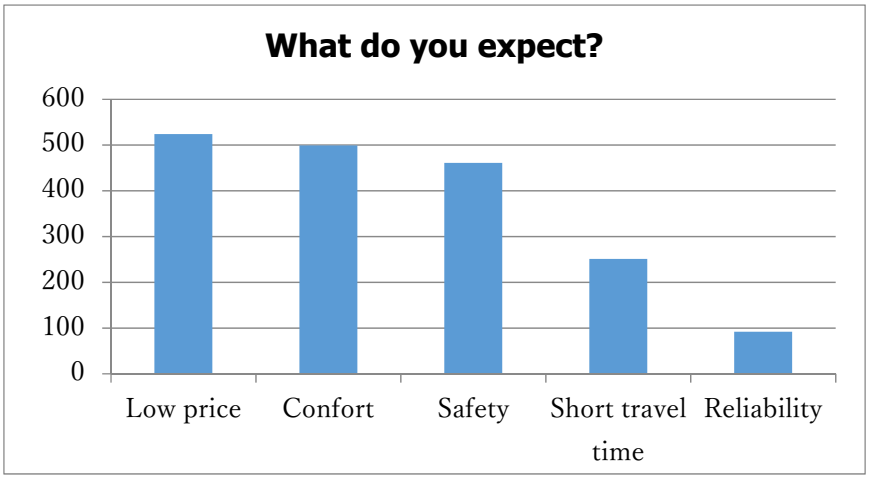
Source: JST (N=635)

Figure 5.36: Expected Bus Fare



Source: JST (N=635)

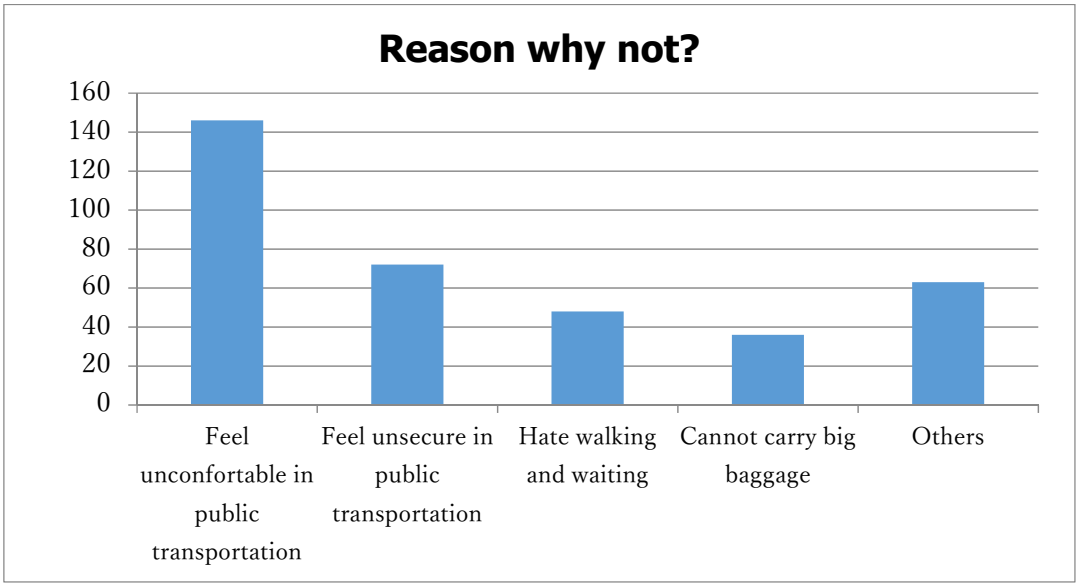
Figure 5.37 Waiting Time at Bus Stops



Source: JST (N=635)

Figure 5.38: Expected Bus Service

Comfort is the main reason why most of the respondents do not want to use the Bus Service shown in Figure 5.39.

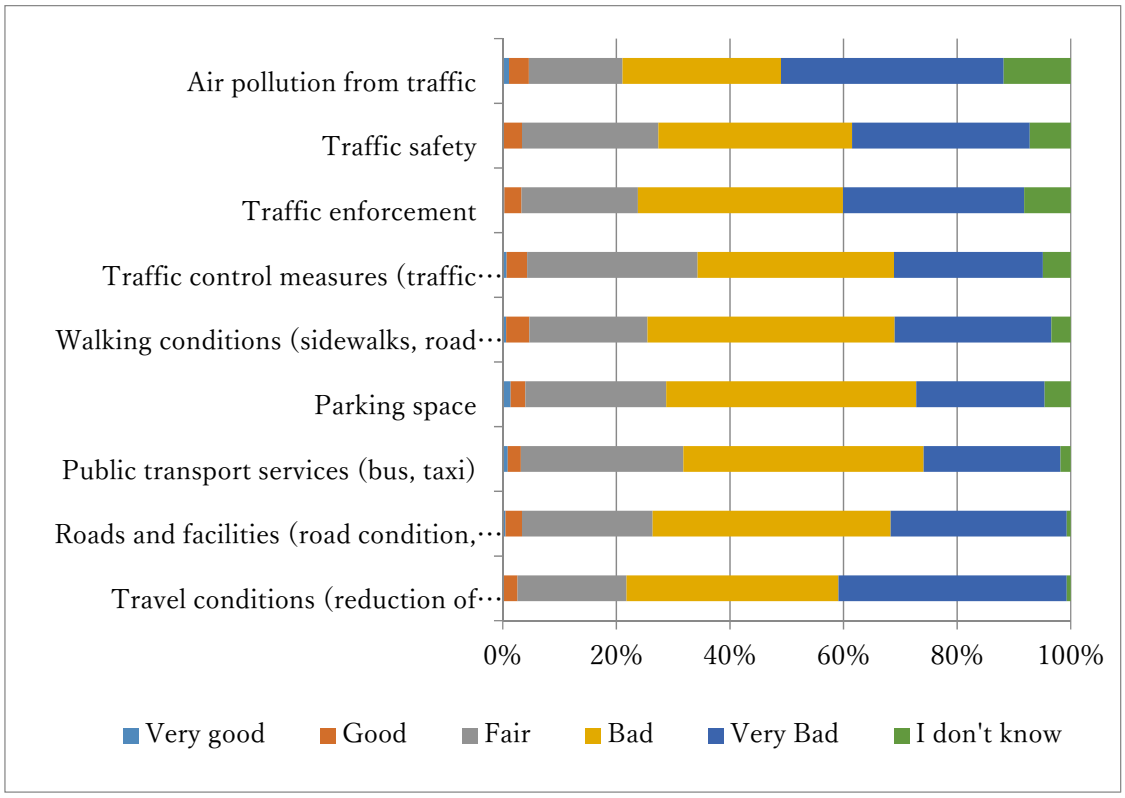


Source: JST (N=355)

Figure 5.39: Not Willingness to use Bus Service

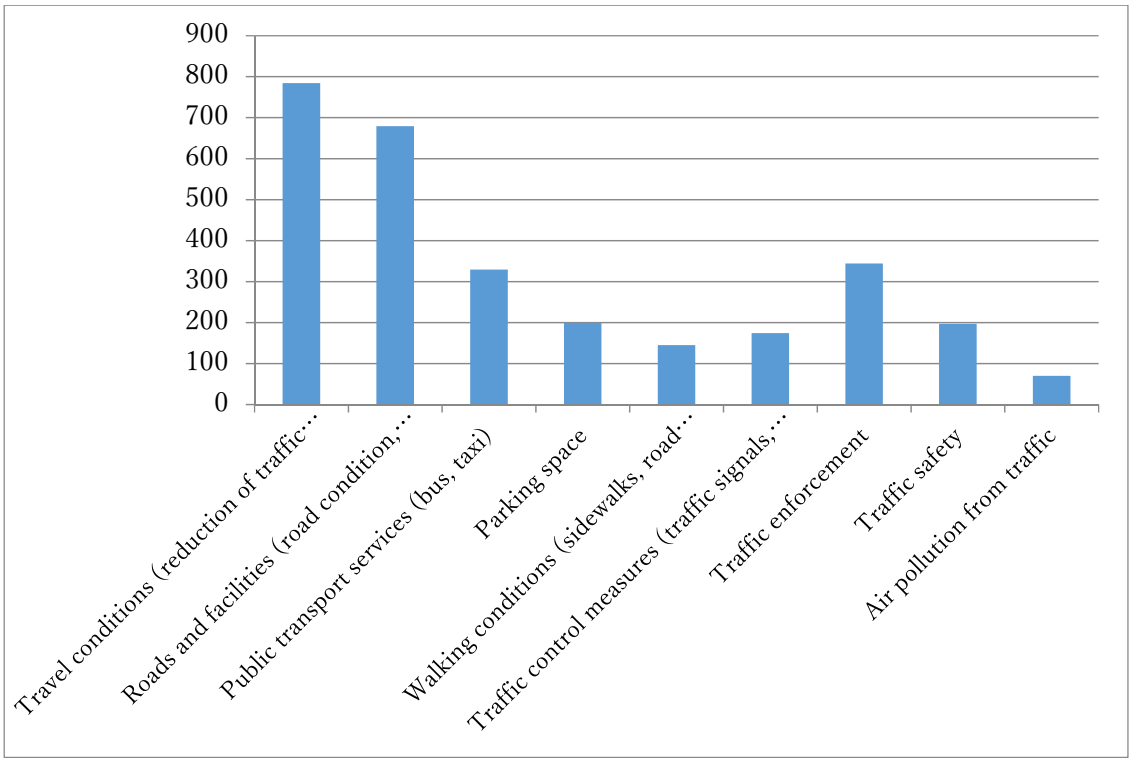
(4) Transport issues

All items of transport are evaluated from "bad to very bad" as shown in Figure 5.40. Respondents think that the most challenging is the "Travel conditions (reduction of traffic congestion)," "Roads and facilities (road condition, street lighting, etc.)," " Traffic enforcement" and "Public transport services (bus, taxi)" as shown in Figure 5.41.



Source: JST (N=1000)

Figure 5.40: Assessment of Present Transport System



Source: JST (N=1000, multi answer)

Figure 5.41: Challenging Theme in Nouakchott

5.2.8 Summary of traffic survey

(1) Simple person movement survey

- Car ownership ratio is related to family income. A present average car ownership ratio is 23%(230 vehicle per 1000household).
- The share of main transport mode is as follows: Walking: 58%, Taxi: 27%, Private Car: 11%, Mini Bus and Large Bus: 3%. Taxi mode is the main public transport in Nouakchott.

(2) Cordon line survey

- The total traffic volume coming into and going out of the Nouakchott City is 5,833 vehicles per 12 hours. Most origins and destinations of vehicles passing through the border were in Nouakchott City. On the other hand, the number of vehicles passing through Nouakchott City is only 38 Vehicles / 12h.
- Trips with purpose of Personal and Firm business for most of the total trips.

(3) Truck OD survey

- The total traffic volume of Freight vehicles coming into and going out of the Nouakchott Port is 592 vehicles per 12 hours. As for the traffic volume by each vehicle type, Trailer have the highest rate of 91% (inbound) and 87% (outbound), followed by heavy trucks with a share of 5% (inbound) and 8% (outbound).
- More than 90% of freight vehicles going into and out of Nouakchott Port have their origin and destination points in Nouakchott City.
- More than 90% of inbound freight vehicles at Nouakchott Port do not load anything (empty trucks). However, 54% of the outbound freight vehicles at Nouakchott Port are loaded with Agricultural Products.

(4) Traffic count survey

- Generally, there was a tendency for road users to increase in the morning commuting time (7: 00 - 9: 00) and the afternoon returning time zone (17: 00 - 19: 00).

- Road traffic is concentrated in the city center (about 20,000 to 30,000) and there is a tendency that the traffic volume decreases as distance from the center increases.
- As for the traffic volume by each vehicle type, “Car / Taxi / Passenger Car” have the highest share of 93%, followed by motorcycles.

(5) Travel speed survey

- The average travel speed of each route was more than 20 km/h except for Route3 and Route5 outbound direction of evening peak time. Traffic was flowing relatively smooth.
- On the other hand, travel speed in the city center was less than 20 km/h in all time zones. This reduction of speed attributed to traffic concentration, decrease in the number of lanes due to on street parking and stopping for getting on.

(6) Transport interview survey

- Most respondent is not satisfied with the present taxi service. Especially, respondents are not satisfied in terms of “security” and “comfort.”
- With regards to the present bus service, the respondents were not satisfied with almost all items except bus fare. Only 19% of the respondents use the bus often. If a new bus route is operated in the future, 64% of the respondents answered to use the bus.
- With regards to present transport system, respondents think that the most challenging is the "Travel conditions (reduction of traffic congestion)," "Roads and facilities (road condition, street lighting, etc.)," " Traffic enforcement" and "Public transport services (bus, taxi)".

5.3 Transport Problems/Issues, Development Strategy

5.3.1 Summary of transport issues

Based on the results of the recent traffic condition survey, the traffic issues of Nouakchott City are identified as follows:

- Urban major facilities are concentrated in the city center, and so with the traffic flow.
- Road network that must pass through the city center is formed. (All national roads are connected to the city center and ring roads are not maintained)
- Most of the residents currently using public transportation are not satisfied with the current transport service.
- Many residents are willing to use public transportation. However, they are unable to use it because of insufficient service provided.

5.3.2 Overall development strategy

The development strategy of transport infrastructure shall consider the present transport problems/issues and it should be harmonized to support the future urban development strategy. Mainly, the following transport strategy were identified:

- The transport infrastructure development including the major arterial road is essential for future urban structure;
- With public transport infrastructure development, easy access to the city even without a private car will be realized. The reduction in the number of car utilization will realize an environmental-friendly urban city;
- To develop a Non-Motorized Transport（NMT）infrastructure in order to create an easy and walkable urban structure ; According to Simple Person Movement Survey, Trips-on-foot has the largest share of 58% (See Figure 5.15). About 70% of the trip purpose related to students such as way to school, home and pick -up and send-off were Trips-on-foot (See Figure 5.19);
- As traffic in Nouakchott was often seen with dangerous driving; safety and high secured city will be created by the introduction of traffic safety countermeasures through hard and software;
- To support the proposed future urban structure, transport network will be formulated. One is the modified ring road alignment to adjust the urban core layout. The other one is to promote the redevelopment of the Tarhi district which is located in the eastern area; and Table 5.26 shows the

transport problems/issues, development strategy/policy and countermeasures through urban structure, road, traffic management and public transport.

Table 5.26: Transport Problems/Issues, Development Strategy/Policy and Countermeasures in Nouakchott

Category	Present and Future expected issues	Strategy and Policy	Countermeasures
Urban Structure	• The present urban structure is centralized at city center. • Future expansion of urban development in the northern area and eastern area (Tarhi district). • Northern area around new airport will be developed by private sector.	• To support proper urban development with road and public transport infrastructure project. • To strengthen the connection of city center and new development district, especially northern and eastern area.	• New arterial road construction for expansion area, such as Ring road and/bypass. • New public transport route and facilities (bus terminals and bus stops) to connect the expansion areas and city center.
Road	• All existing national roads connect from/to city center. All traffic passes through the city center. • At present, there is a serious traffic congestion at the city center. In the future, serious traffic congestion will expand to the suburb area if no countermeasures will be given. In 2040, traffic volume will be twice as the present traffic volume. • Not so much road density in the city center, still many unpaved roads in the city.	• To divert unnecessary car trips in the city center by constructing a bypass road. • To achieve a better than the present level of service. • To construct new paved roads.	• Ring road /Bypass development for removing the unnecessary car trips in the city center. • Widening of existing roads to accommodate the future traffic demand. • Pavement of unpaved roads. • New roads will be proposed, especially new development district (ex.Tarhi district).
Traffic Management	• Risky driving behaviors such as over-taking and counter flowing are adamant in Nouakchott. • There were so many roadside frictions that disturb the smooth car flow in the streets. • In Mauritania, there are many unlicensed people driving a car and does not follow the traffic behaviors such as traffic movement at intersections, overtaking and lane changing etc.	• To improve traffic safety. • To utilize more efficient vehicle system. • Parking Management • Formulate the urban space for NMT users.	• Installation of median and road markings. • Geometric improvement at intersection, road markings and installation of left turn pocket, etc. for proper traffic flow. • Clarification of permit or prohibited parking space. Enforcement of illegal parking which affect the smooth traffic flow. • Countermeasures for promotion of public transport use. Introduction of NMT facilities such as bicycle/walking space, pedestrian crossing, overpass and underpass, etc. • Introduction of Intelligent Transport System (ITS) for more efficient vehicle use. • Issues of driver's license, the strengthening of unlicensed drivers' enforcement. • Installation of vehicle system.
Public Transport System	• Taxi is the major public transport mode in Nouakchott (2017 survey NMT 58%, Private car 11.5%, Taxi 27.3%, Bus 3.2%, person base). • With the increase of car ownership rate in the future, increase of private car trips will be a major concern.	• Modal shift from private trips to public transport trips. • To increase high-capacity public transport user instead of taxi utilization.	• Introduction of new bus route and good bus facilities, such as bus terminal and bus stops. • Introduction of high capacity bus fleet. • In the future, introduction of new high capacity public transport system. • To remove unauthorized taxi by proper traffic enforcement.

5.4 Transport Demand Forecast

5.4.1 Approach

(1) The "Four Steps" approach

In order to identify future transport planning, traffic demand forecast was conducted. It applied the use of travel demand and forecasting models. In this case, the models have utilized socio-economic data to estimate travel demand coupled with a simulation of the transport system to represent transportation supply. Together, the socioeconomic data, the simulated network, and mathematical travel models simulate the ability of the transport system to serve the estimated demand. Basically, the following four steps were applied:

- Trip Generation - the prediction of trips produced and attracted to each zone;
- Trip Distribution - the prediction of origin-destination flows, the linking of trip ends predicted by trip generation;
- Modal Split - the estimation of percentages of trip flows made by each transport; and
- Traffic Assignment - the allocation of trips to routes in the transportation network.
- The four stages represent a sequential decision structure.
-

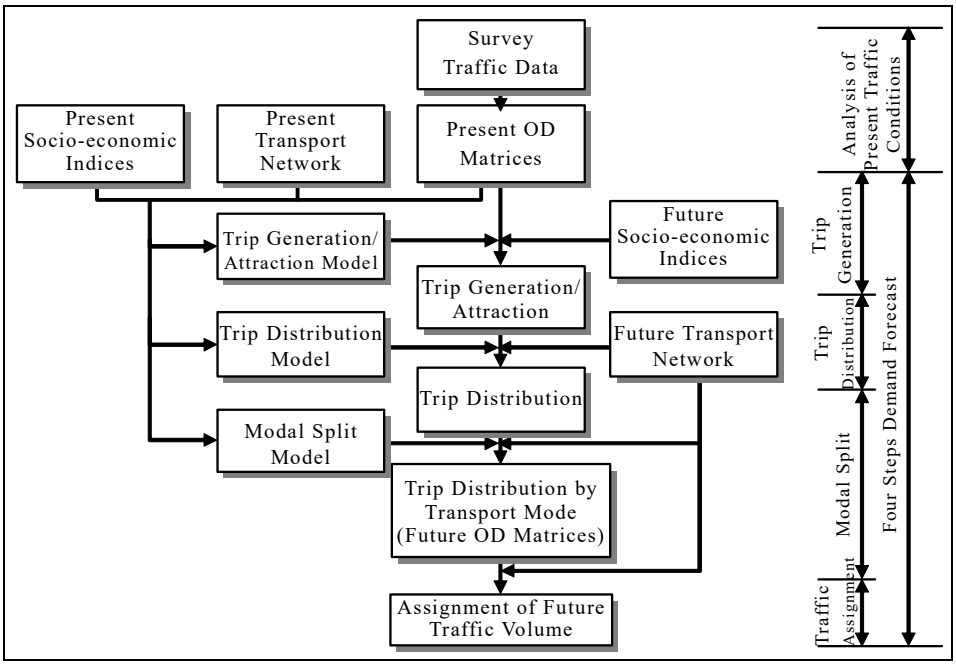


Figure 5.42: Flow of Transport Demand Forecast

(2) Zone system in Study Area

The model predicts trips over the transport network based on the attributes of traffic analysis zones developed. Zonal attributes used in trip generation include population and employment. A key component of the model development process was the development of the zone system to cover the Study Area. The study is defined from zone numbers, 1 to 32 in traffic survey zoning system, and outside the study area is defined from zones, 33 and 38 shown in Figure 5.43 and Table 5.27.

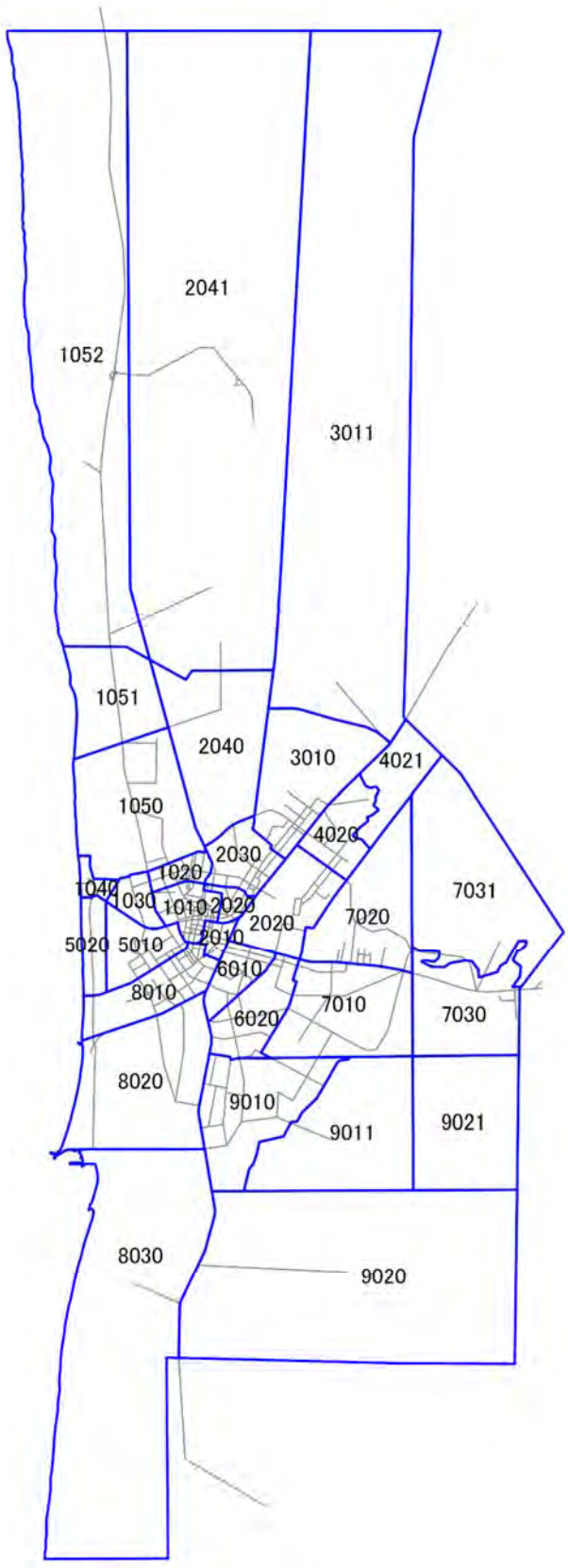


Figure 5.43: Traffic Zoning Map

Table 5.27: Traffic Zoning List

No.	Small Zone	Name	Remarks	Large Zone	Name
1	1010	Tevragh Zeina (1)		1000	Tevragh Zeina
2	1020	Tevragh Zeina (2)			
3	1030	Tevragh Zeina (3)			
4	1040	Tevragh Zeina (4)			
5	1050	Tevragh Zeina (5)			
6	1051	Tevragh Zeina (6)	New		
7	1052	Tevragh Zeina (7)	New		
8	2010	Ksar (1)		2000	Ksar
9	2020	Ksar (2)			
10	2030	Ksar (3)			
11	2040	Ksar (4)			
12	2041	Ksar (5)	New		
13	3010	Teyarett (1)		3000	Teyarett
14	3011	Teyarett (2)	New		
15	4010	Dar Naim (1)		4000	Dar Naim
16	4020	Dar Naim (2)			
17	4021	Dar Naim (3)	New		
18	5010	Sebkha (1)		5000	Sebkha
19	5020	Sebkha (2)			
20	6010	Arafat (1)		6000	Arafat
21	6020	Arafat (2)			
22	7010	Toujounine (1)		7000	Toujounine
23	7020	Toujounine (2)			
24	7030	Toujounine (3)			
25	7031	Toujounine (4)	New		
26	8010	El mina (1)		8000	El mina
27	8020	El mina (2)			
28	8030	El mina (3)			
29	9010	Riyadh (1)		9000	Riyadh
30	9011	Riyadh (2)	New		
31	9020	Riyadh (3)			
32	9021	Riyadh (4)	New		
33	10001	Nouakchott Airport		10000	Facilitiies
34	10002	Nouakchott Port			
35	20001	From/to Nouadhibou		20000	Outside Nouakchott City
36	30001	From/to Akjoujt		30000	
37	40001	From/to Aleg		40000	
38	50001	From/to Rosso		50000	

(3) External zone transportation demand

Traffic that enters or leaves the modeling area around its perimeter is not specifically included in four steps approach as outlined above. The modeling area contains 4 locations where the road network connects with the “outside modeling area.” It is at these locations where internal/external interactions must be accounted for at these locations.

Traffic count data from the cordon line survey at the external stations provides the total volume of traffic that constitutes the internal/external interaction, although some portion of the traffic volume at these locations merely passes through the modeling area without an internal origin or destination.

(4) Modeling and forecasting tools

In all steps of travel model calibrations and demand forecast, JICA STRADA system is employed. JICA STRADA is a software tool for planning, managing, and analyzing of transport systems. The software provides a set of tools for travel demand modeling as well as capabilities for presentation graphics and transport models. JICA STRADA system applied for simulation of travel time and cost. Modeling and forecasting in trip generation, trip distribution and traffic assignment is computed by JICA STRADA system.

(5) Travel mode classifications

Travel Mode consists of four categories as shown in Table 5.28.

Table 5.28: Travel Mode Category in Demand Forecasting

Travel Mode Category in Person Trip Survey		Travel Mode Category in Demand Forecasting	
1	Walking	1	WALK
2	Bicycle		
3	Taxi	2	TAXI
4	Mini Bus	3	Bus
5	Large Bus		
6	Motor Cycle	4	Private Car
7	Car		
8	Others		

5.4.2 Forecasting trip production

(1) Future framework

Based on future socioeconomic prediction, total framework is summarized in Table 5.29.

Table 5.29: Future Framework

	Year 2017	Year 2040	2040/2017	AAGR
GRDP (Nuakchott) (thousand MRO)	257	714	2.8 times	4.5%
Population (thousand)	1,100	2,200	2.0 times	3.0%
Employee (thousand)	272	690	2.5 times	4.1%
Car ownership per 1000 persons	40	84	2.1 times	3.0%
No. of private car *estimated by social interview survey	43,600	185,900	4.3 times	6.5%

Note: AAGR; Annual Average Growth Rate

(2) Future total trip generation

Based on the total future framework, the total trips generated in the Study Area is forecasted to expand to 4,288 thousand trips per day in 2040 from 2,144 thousand trips in 2017. (See Table 5.30)

Table 5.30: Future Total Trip Generation

Year	Thousand Trips per day
2017	2,144
2040	4,288

5.4.3 Forecasting trip generation and attraction

(1) Modeling trip generation and attraction

The objective of trip generation and attraction model is to forecast the number of trips that will start and arrive in each traffic zone within the study area. The linear regression models by trip purpose are adopted in the study. The model parameters are calibrated shown in Table 5.31.

$$Gi = ai*X1i + bi*X2i + C$$
$$Aj = aj*X1j + bj*X2j + C$$

Where, Gi: Trip Generation in zone i
Aj: Trip attraction in zone j
X1i, X2j: Attributes in zone i, j
ai, aj, bi, bj: Coefficient
C: Constant

Table 5.31: TRIP Generation and Attraction Model Parameters

Model Type	Population	Employee	Constant	Correlation Coefficient
Trip Generation	0.624	0.127	6087.1	0.947
Trip Attraction	0.612	0.140	6555.0	0.947

(2) Verification of trip generation and attraction models

Figure 5.44 shows the verification results between observed and estimated trips.

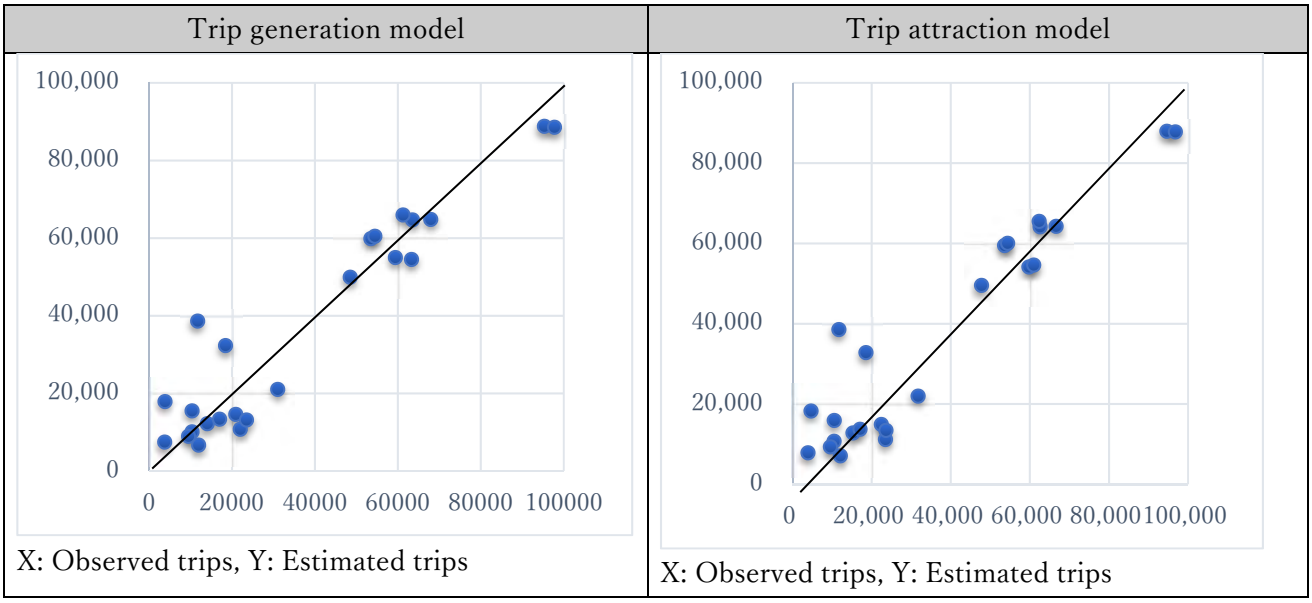


Figure 5.44: Verification of Trip Generation and Attraction Model

(3) Future trip generations and attractions

Figure 5.45 shows the future trip generations by zone in 2017 and 2040.

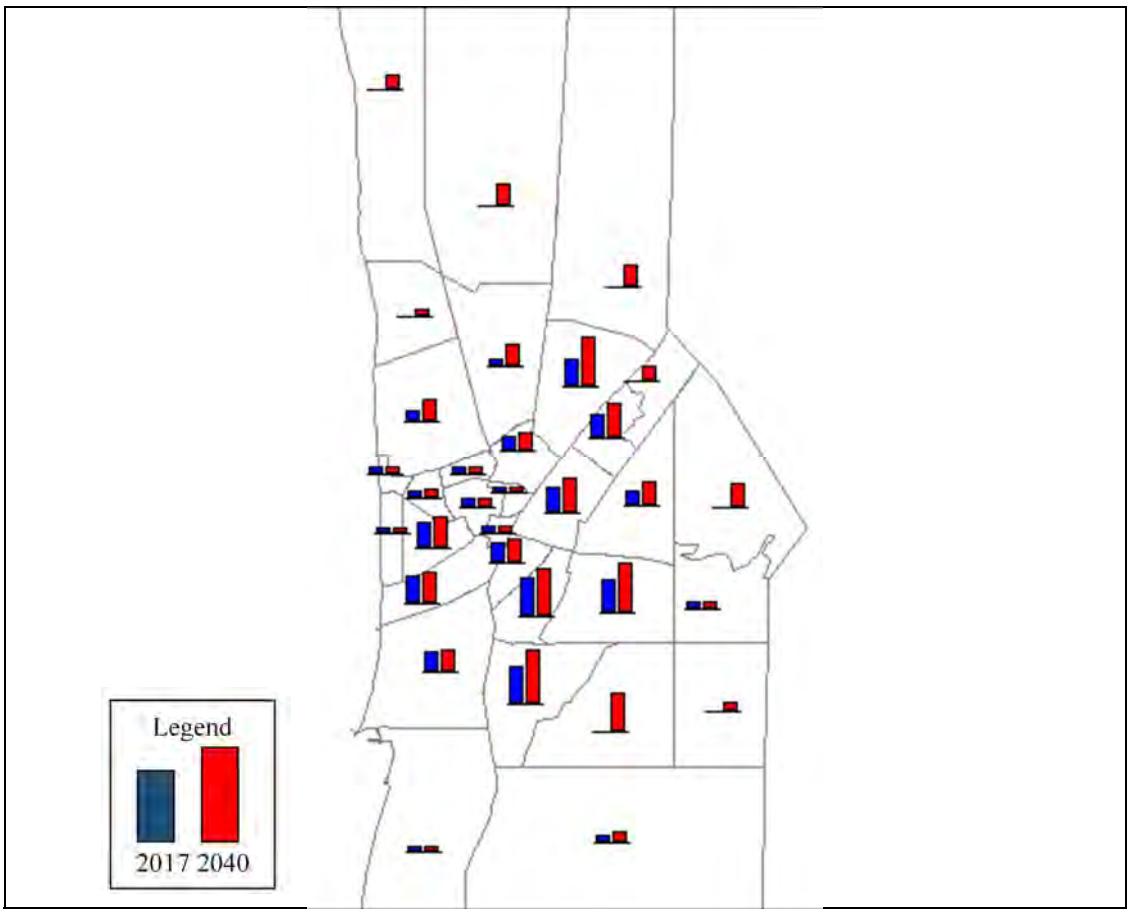


Figure 5.45: Trip Generation in 2017 and 2040

5.4.4 Forecasting trip distribution

Trip distribution is the second major step in the travel demand modeling process. Trip production (the first major step) provided methodology for estimating trip generations and attractions within each zone. Trip distribution is the process that links the generations to attractions for each zone pair.

(1) Building trip distribution model

In this study, the gravity model for inter-zonal trips are applied for trip distribution forecast, shown in following equations.

Inter zonal trip $Xij = K * Oi^{\alpha} * Dj^{\beta} / Tij^{\gamma}$

Where; Xij: inter zonal trip distribution from zone i to j
Oi: trip generation in zone i
Dj: trip attraction in zone j
Tij: travel distance from zone i to j (time)
K, α, β, γ: model parameters

To balance a sum of trip distribution in certain zone, the doubly-constrained method is applied after estimation of each distribution by the gravity model. This type of model is also known as Fratar Balancing. The forecast matrix should then be such that the sum of each trips generated per zone is within a given convergence criterion of the corresponding forecast generation for that zone, and the sum

of each trips attracted per zone is within a given convergence criterion of the corresponding forecast attraction.

Calibration results of the gravity models before applying the doubly-constrained method are shown in Table 5.32.

Table 5.32: Inter Zone Trip Distribution Model Parameters

α	0.9777
β	0.9392
γ	-0.2285
K	2.9685E-006
Correlation Coefficient	0.72

(2) Future trip distribution

Based on the trip distribution in 2017 and 2040, the charts by desired line, which clarify the trip distribution and interaction among zone pairs, are presented in Figure 5.46.

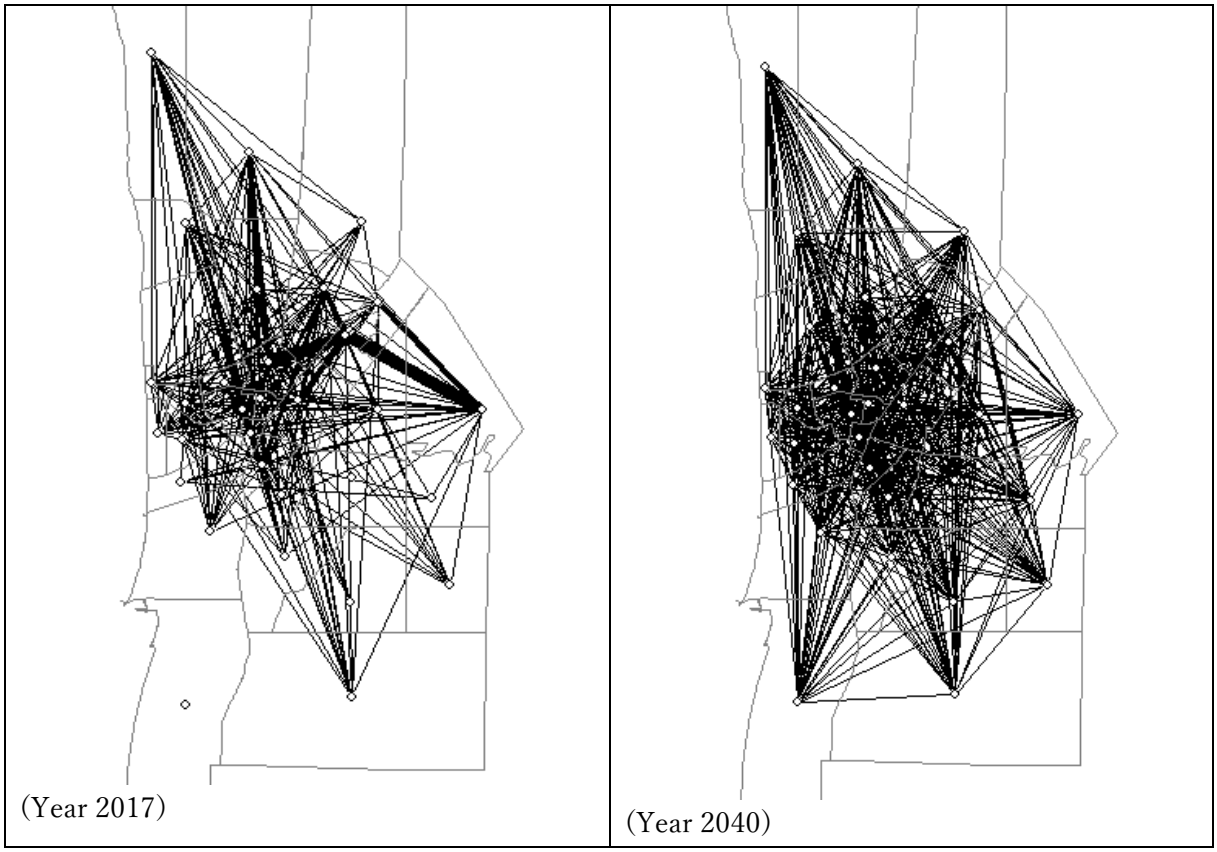
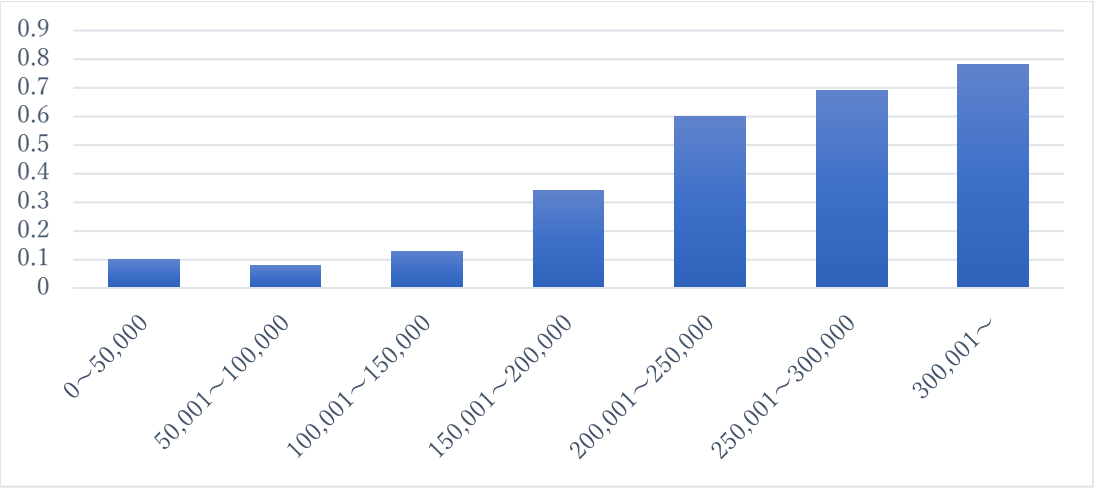


Figure 5.46: Desire Line of Total Trips in 2017 and 2040

(3) Forecasting modal split

Modal split was assumed based on the future car ownership and the mode share of other similar cities. If there are no special transport measures, private car share will increase as the same trend of car ownership. Shown in Figure 5.47, car ownership related in the income rank based on interview survey, if monthly income will increase in the same rate as GRDP, car ownership rate will increase. Estimate growth rate of GDP in Mauritania is 4%, future monthly income was assumed same as GDP growth, Car ownership in 2040 will be 49% per house hold from 23% in 2017.



X: monthly income(MRO), Y: car ownership rate
Source: JST

Figure 5.47: Family Monthly Income and Car Ownership Rate (2017 survey result)

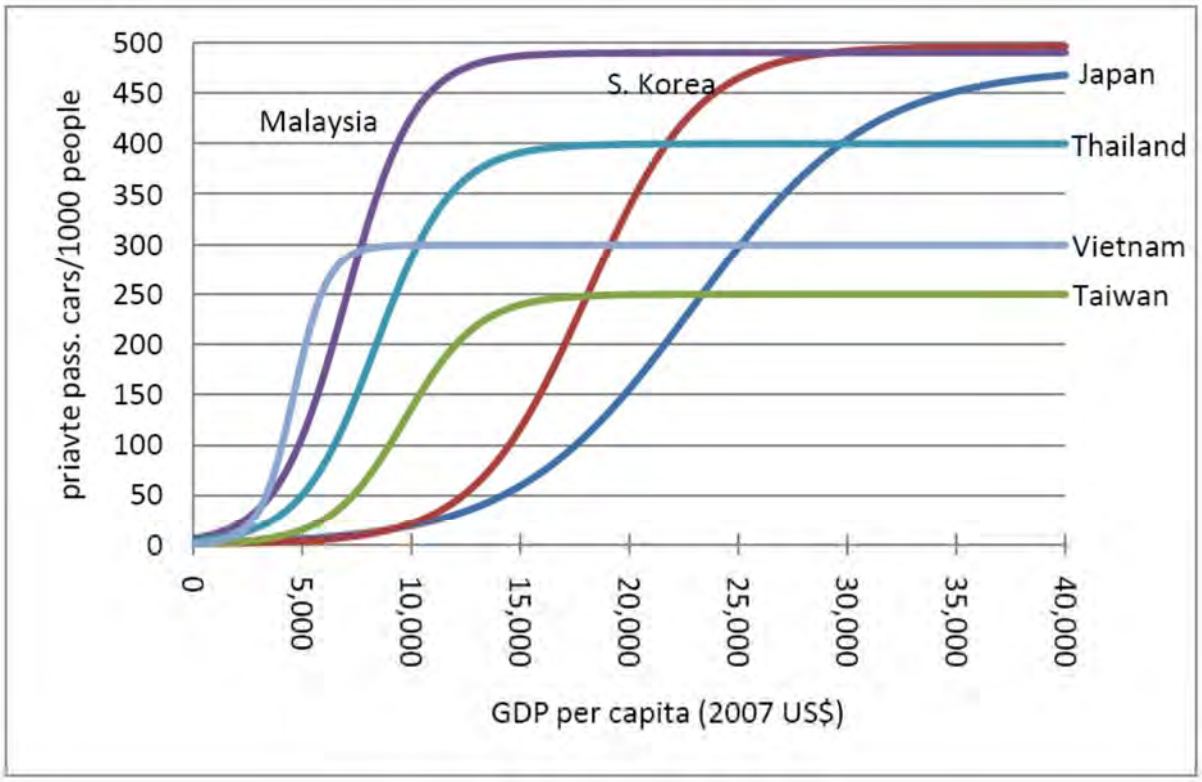
(4) Car ownership rate of other countries

Recently, the economic development of East and Southeast Asian countries remarkably grow up, and simultaneously the increase in car is the remarkable situation. Based on the article of "Dynamic Interactions between Private Passenger Car and Motorcycle Ownership in Asia: A Cross-country Analysis," estimated car ownership models were formulated from the historical relation between car ownership and GDP per capita. Shown in Figure 4.48, basically S-curve line will be created and the curve shape depends on the countries characteristics, etc., and at least less than 5,000 US dollars, all countries were very sharp curve shape.

Currently, the GDP capita in Mauritania is 1,120 USD in 2016(World Bank) and it will reach as high as 2800USD in 2040.

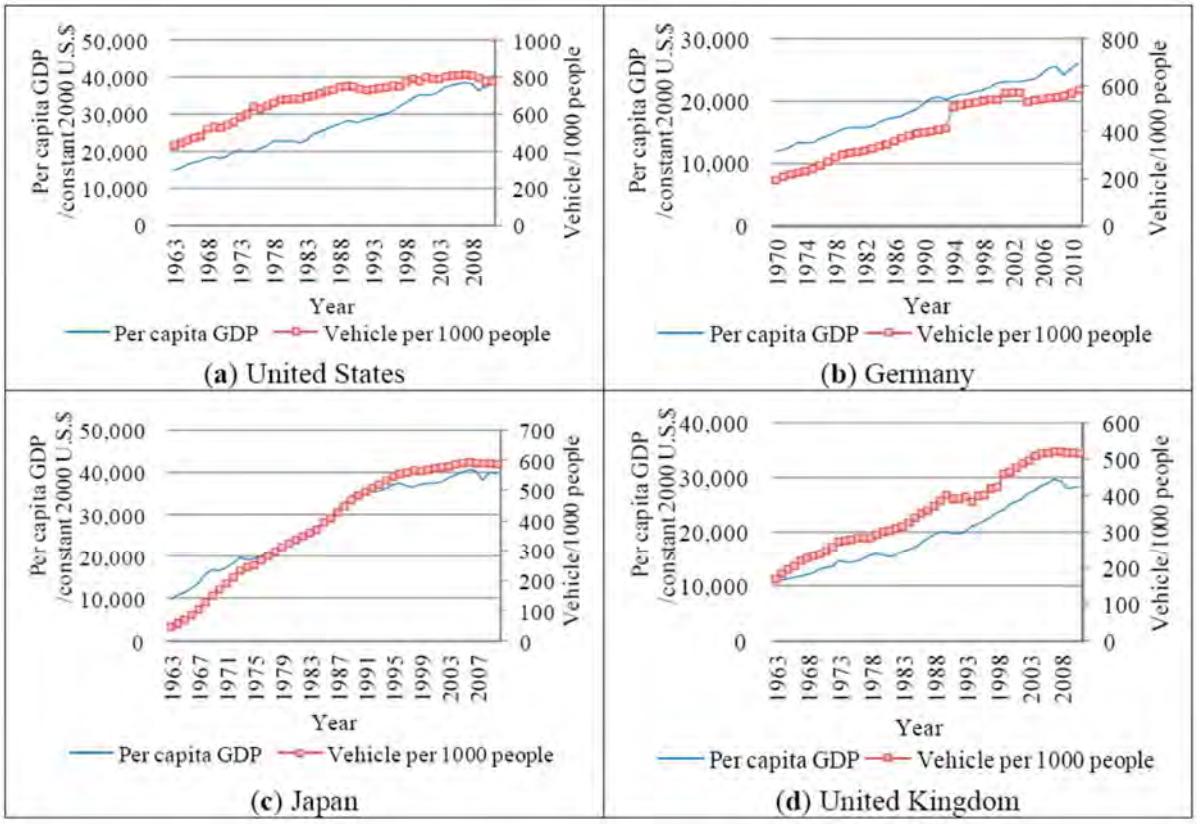
Based on this figure, 2,800 USD is less than 80 passenger cars/ 1000 (converted household 48% 1 household is 5.8 person) from Figure 5.48, it will be about the same figure as estimated. It can be said that in the future, car ownership rate will increase based on this figure.

And if the transport system will not change drastically, the number of private car will keep increasing with the growth of GDP (at least 5000 USD per capital) after year 2040. Although there was regional difference in Africa and Asia, it is assumed that the tendency of the growth rate of the car by the economic development was at the same level. This information is as a reference of future car ownership in the Mauritania.



Source: Dynamic Interactions between Private Passenger Car and Motorcycle Ownership in Asia: A Cross-country Analysis

Figure 5.48: Long term trends of car ownership



Source: Vehicle Ownership Analysis Based on GDP per Capita in China 1963-2050

Figure 5.49 Annual vehicle ownership and economic development

(5) Future modal share

Based on the data above, the assumption of private car trips will increase as follows.

No. of private trips: 247 thousand (2017) → 864 thousand (2040) 3.5 times

Table 5.33: Future Modal Share

Unit: 1,000-person trips/day

Year	Walk/Bicycle	Public Transport	Private Car/ Motor Cycle	Total
2017	1,244 (58%)	654 (30%)	247 (12%)	2,145 (100%)
2040	2,364 (55%)	1,032 (24%)	864 (20%)	4,260 (100%)
Growth Rate (=Y2040/Y2017)	1.90	1.58	3.50	2.00

As reference, modal share of other cities in Africa is shown in Figure 5.50 and Figure 5.51.

1) Lusaka

Lusaka is the capital of Zambia. The population in Lusaka is 1.7 million (Year 2014) and GDP per Capital is 1,304 USD (Year 2015). Lusaka is a little bigger population city in Nouakchott.

In 2007, traffic demand forecasted was conducted in the study on comprehensive urban development plan for the City of Lusaka in the Republic of Zambia funded by JICA. Private Car trips will drastically increase in the future as the Nouakchott assumption.

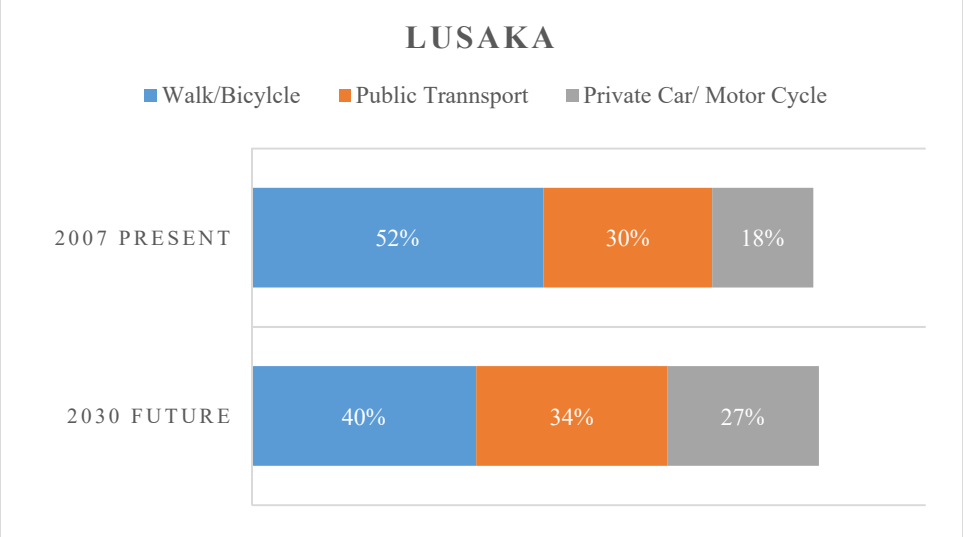


Figure 5.50: Future Estimated Modal Share in Lusaka (as reference)

2) Dar es Salaam

Dar es Salaam is the most populated city in Tanzania. The population in Dar es Salaam is 4.3 million (Year 2012) and GDP per Capital is 87 USD (Year 2015). Though Dar es Salaam is a much bigger population city than Nouakchott, public transport share in present is as high as Nouakchott's.

In 2017, traffic demand forecast was conducted in the study on comprehensive urban development plan for the project for revision of Dar es Salaam urban transport master plan funded by JICA. In the report, public transport incentive plan was proposed and reduced the private car trips.

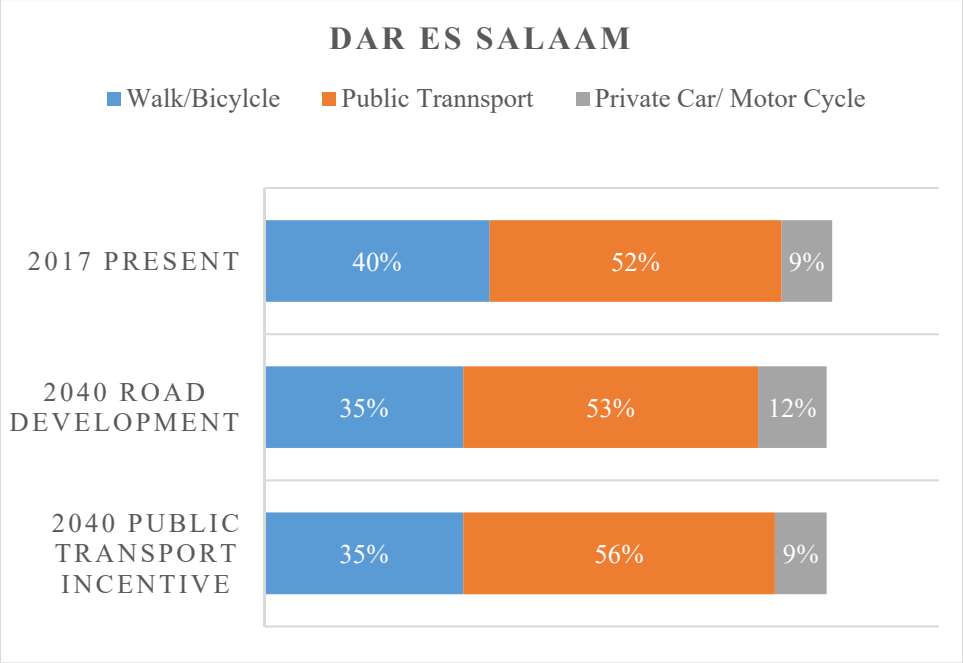


Figure 5.51: Future Estimated Modal Share in Dar es Slaam (as reference)

5.4.5 Port traffic and cordon data

Based on the future economic indicators, the estimate growth of truck traffic and outside of Nouakchott traffic is shown in Table 5.34.

Table 5.34: Port Traffic and Traffic of boundary of Noakchott

	Year 2017 Present	Year 2040 Estimated
Port Traffic (Truck/day)	553	1548
Nouakchott City from/to outside (vehicle/day)	5,498	15,394

5.4.6 Traffic assignment

The traffic assignment process allocates vehicle traffic to individual roadway links. This step serves as input of matrix of flows (vehicles) that indicate the volume of traffic between origin and destination pairs.

(1) Vehicle assignment model

a) Assignment method

Various assignment techniques are used ranging from manual methods to complex iterative procedures by computer programs. In this study, the method used is the capacity restraint assignment which is the most straightforward used in network models, and the most efficient particularly where the number of zones in the trip matrix is large. This assignment technique is based on the speed – flow relationship, and the flow chart of the applied methodology is shown in Figure 5.52.

In this assignment technique, and by calculating the required travel time for each link according to its travel speed and road conditions, the program determines the fastest routes between each origin and destination by evaluating the consuming time on links and assigns the trips between the given origin and destination to these routes starting at the destination and working back to the origins. As congestion increases until a certain level, alternative routes are introduced to handle the unassigned traffic. Zone-to-zone routing, which is the fastest path from each zone to any other, is built and all trips are assigned to these optimum routes.

Since the link-travel time varies with the traffic volume of vehicles using that link, which can be explained as a degree of link congestion, the OD tables are divided to apply an iteration procedure on five stages. At each iteration, and depending upon the current link loadings, the flows are divided between all the shortest routes generated and a new travel time is computed for the average assigned link flow at each pass. The iteration continues to re-estimate the speed on those links considering the assigned traffic on links, and to produce alternative routes so that more accurate allocation can be achieved. The accumulated assigned traffic volume from each OD pair on the links composes the total assigned traffic volumes per direction for the network.

JICA STRADA is used to estimate traffic volumes.

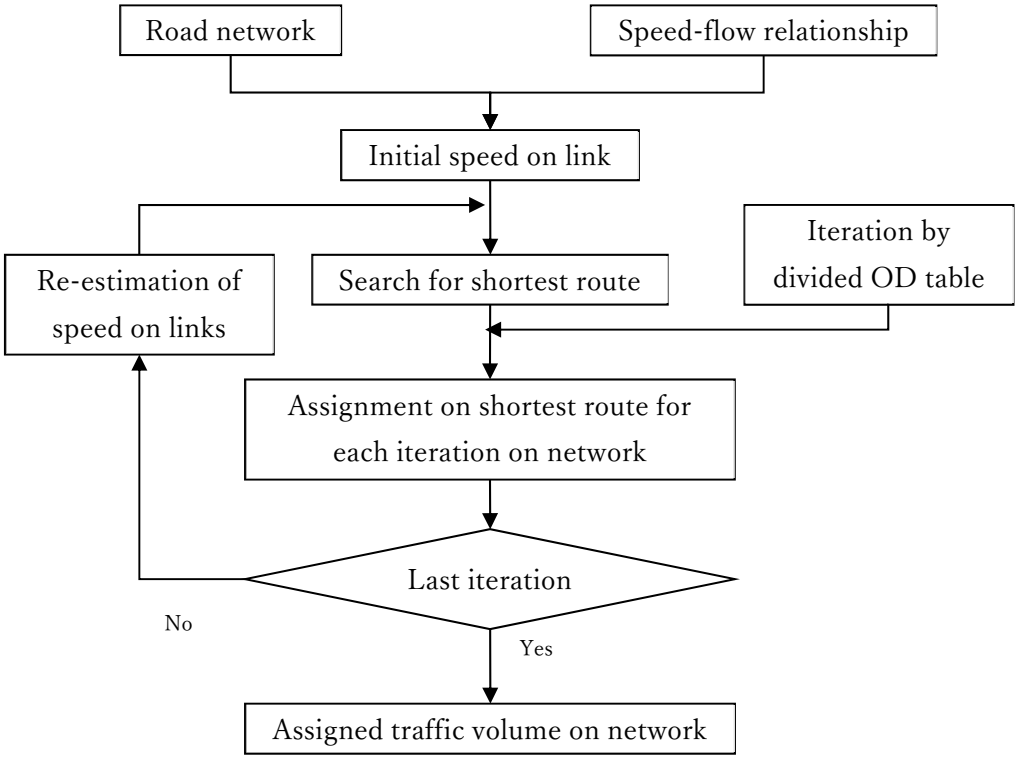


Figure 5.52: Traffic Assignment Procedure

b) Auto occupancy rate and passenger car unit

Trips generated during the trip generation step (and consequently through the trip distribution step) are in person trips, as discussed above. Auto occupancy rates and passenger car units (PCU) are utilized to convert from person trips to vehicle trips prior to assigning the traffic to the roadway network. Auto occupancy rates are obtained from on-site survey in.

Table 5.35: Occupancy Rate and Passenger Car Unit

Mode	Auto Occupancy Rate	Passenger Car Unit
Private- Car	2.0	1.00
Public-Taxi	2.5	1.00
Public Bus (mini bus, bus)	12.0	2.00
Truck		2.50

c) Speed-flow relationship

The speed - flow relationship used in the traffic assignment procedure is shown in Figure 5.53. When the traffic volumes are over the maximum capacity 0.3*Qmax, it is assumed that the vehicle speed drastically reduces. The basic free flow and capacity is shown in.

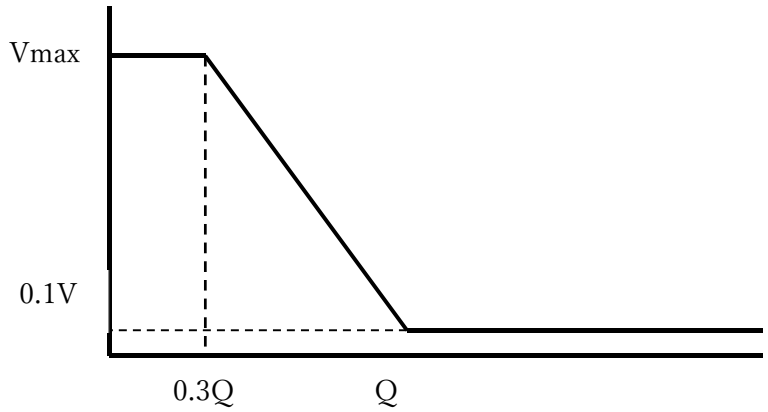


Figure 5.53: Speed –Flow Relationship

Table 5.36: Free Flow Speed and Capacity by Road Type

Road Class	Location	Lane	Free Speed (km/hr.)	Capacity (PCU/day)
Arterial roads	Urban Area	2	40	12,000
		4	40	48,000
		6	40	72,000
	Rural Area	2	60	12,000
		4	60	48,000
		6	60	72,000
Secondary roads	Urban Area	2	40	9,000
		4	40	36,000
	Rural Area	2	60	12,000
		4	60	48,000
Tertiary road	Urban/Rural	2	30	8,500

d) Traffic assignment validation

In general, trips between individual pairs of zones are uncertainly estimated by aggregation of the trips matrices cells and the allocated through assignment techniques to routes cover large number of zones pairs. Therefore, it is necessary to examine the result of the assignment so as to ensure that trips are assigned in a realistic pattern well matching to the actual situation.

A comparison between the observed and individual traffic count at 20 observed stations shown in Figure 5.54. This comparison between observed traffic count and assigned traffic flow at individual sites is done via the Mean Absolute Difference (MAD) [2]Ratio. For daily traffic counts, the value of the MAD

[2] MAD Ratio is defined by the following formula: MAD Ratio $= \sum \left| \frac{count - assignment}{assignment} \right| / n$

where n is the number of observations.

ratio is 0.31 which is considered to reflect a fair calibration. By indicator the assignment has relatively replicated year 2017.

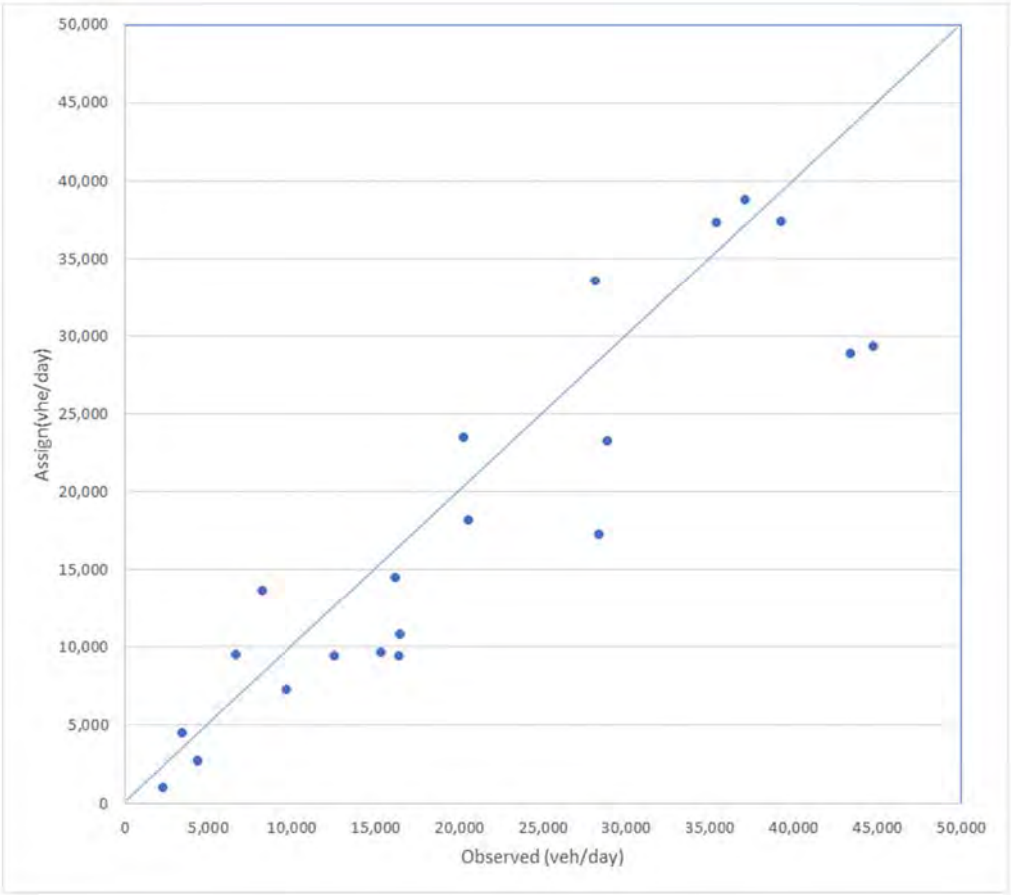


Figure 5.54: Comparison between Observed and Assigned Traffic at Individual Sites

(2) Transit (public mode) assignment model

The all-or-nothing assignment method prepared in JICA STRADA system is chosen for Public Mode Assignment Model.

5.4.7 Assessment of transport network plan

(1) Case setting and modal share assumption

As the mode was relatively replicated in present situation, future traffic demand forecast was conducted for the following case.

Table 5.37: Simulation Case for Demand Forecast

	Case Name	Forecast Year	Road Network	Public Transport
1	Current Conditions	2017	Current Network	Current Service
2	Do-nothing Case	2040	Current Network	Current Service
3	Alternative Case	2040	Proposed Network (see section 5.5)	Current Service
4	Master Plan Case	2040	Proposed Network (see section 5.5)	Proposed Service BRT introduction and Bus service expansion Parking Control at City Center (see section 5.6)

Based on the simulation above, the additional OD matrix was prepared for Master Plan Case (case-4). This case is Public Incentive Plan such as installation of BRT and bus service expansion to increase public transport users (Case 3 does not take the implementation of measures to promote the use of public transport such as BRT introduction, Bus service expansion and the Parking Control at City Center into consideration).

Table 5.38 shows the Future modal share of each case. Public Transport Incentive assumed 15% of private car user transferred to public transport user.

Table 5.38: Future Modal Share

Unit: 1000-person trips/day

Year	Walk/Cycle	Public Transport	Private Car/ Motor Cycle	Total	Remarks
2017	1,244 (58%)	654 (30%)	247 (12%)	2,145 (100%)	For Case-1
2040 Road Development	2,364 (55%)	1,032 (24%)	864 (20%)	4,260 (100%)	For Case-2 and Case-3
2040 Public Transport Incentive	2,364 (55%)	1,164 (27%)	735 (17%)	4,260 (100%)	For Case-4

Public Transport was divided to taxi and bus as shown in Table 5.39. Share of taxi and bus for road development case is applied to the current share and for public incentive case is taxi: bus is 3: 7 in order to promote bus users by public transport improvement (BRT installation, expansion of bus network, bus operation frequency, bus related improvement facilities at the same time parking control at the city center etc.).

Table 5.39: Future Modal Share (only Motorized Trip)

Unit: 1000-person trips/day

Year	Taxi	Bus	Private Car/ Motor Cycle	Total	Remarks
2017	589 (65%)	65 (7%)	247 (27%)	901 (100%)	For Case-1
2040 Road Development	929 (49%)	103 (24%)	864 (20%)	1,896 (100%)	For Case-2 and Case-3
2040 Public Transport Incentive	348 (55%)	813 (43%)	735 (39%)	1,896 (100%)	For Case-4

Table 5.40 shows the vehicle base divided by the average occupancy. Average bus occupancy for public incentive will increase due to the introduction of large bus fleet.

Table 5.40: Future Modal Share (Vehicle Base)

Unit: 1000 vehicle trips/day

Year	Taxi	Bus	Private Car/ Motor Cycle	Total	Remarks
2017	235.4 (65%)	5.5 (1%)	123.5 (34%)	364.4 (100%)	For Case-1
2040 Road Development	371.5 (46%)	8.6 (1%)	432.3 (53%)	812.3 (100%)	For Case-2 and Case-3
2040 Public Transport Incentive	139.4 (26%)	33.9 (6%)	367.4 (68%)	540.7 (100%)	For Case-4

(2) Result

For the objective of the transport poly and countermeasure studies, it was assumed that no improvement would be applied to transportation supply, which is called “Do-Nothing” case analysis. Then, verification of the effect of two alternative plans described in 5.4.7 are conducted by comparing with Case-2.

The car assignment results of existing case in 2017 (Case-1), Do-Nothing case in 2040 (Case-2), Alternative case (Case-3) and Master Plan case (Case-4) were summarized as follows. (See Table 5.41)

Table 5.41: Car Assignment Results in Do-Noting Case

	Case-1	Case-2	Case-3	Case-4
	Year 2017 Current Condition	Year 2040 Do Nothing	Year 2040 Alternative Case	Year 2040 Master Plan Case
Total Vehicle Trips (Vehicle)	395,909	683,952	683,952	485,891
Vehicle -km	3,240,971	8,752,499	8,945,995	6,351,764
Vehicle -Hour	103,215	469,374	260,106	165,071
Volume / Capacity	0.27	1.28	0.61	0.44
Average Speed (km/h)	31.4	18.6	34.4	38.5

(3) Traffic indicator

Annual traffic indicators of vehicle trips are evaluated from the viewpoints of changes in Total Vehicle Trips, vehicle-hr, vehicle-km and average speed. The vehicle trips are forecasted to increase from 395,909 trips in 2017 to 683,952 in 2040 with a growth of about 2.0 times. In addition, the indicators of vehicle-hr and vehicle-km are also increasing, especially the vehicle-km that increases from 3,240,971 vehicle-hr in 2017 to 8,752,499 in 2040 with a growth of about 2.7 times.

As a result, the average travel speed is decreased from 31.4 km/hr in 2017 to 18.6 km/hr in 2040, which means that the level of service on the road network will face a severe situation from the economic and environmental points of view.

On the other hand, when applying alternative plan, the average travel speed is dramatically improved to 34.4 km/h in Case-3 and 38.5 km/h in Case-4 as compared with Case-2.

(4) Traffic congestion

Results of analyzing the volume to capacity ratio V/C to investigate the road congestion in 2017 show desirable ratio 0.27.

Results of the year 2040 show unacceptable level of traffic congestion with an average value of 1.28.

On the other hand, when the alternative plan is applied, the volume to capacity ratio V/C is also dramatically improved to 0.61 in Case-3 and 0.44 in Case-4 as compared with Case-2.

(5) Summary

- If any countermeasures against traffic congestion are not implemented in the transport sector, when road traffic volumes drastically increase, the level of service will become worse.
- Systematic road development can prevent deterioration of the road environment such as decrease of travel speed and congestion.
- Measures to increase public transport users such as BRT introduction, Bus service expansion and Parking Control at City Center will reduce traffic volume and the effect of improving the road environment will further increase.
  (Compared with Case-3 to Case-4, the degree of congestion has improved mainly in the national roads)
- From the above, our team recommends Case-4 and formulates new road development plan, public transport development plan and traffic management plan based on Case-4.

Figure 5.55: Traffic Assignment Result In Existing Case(2017)

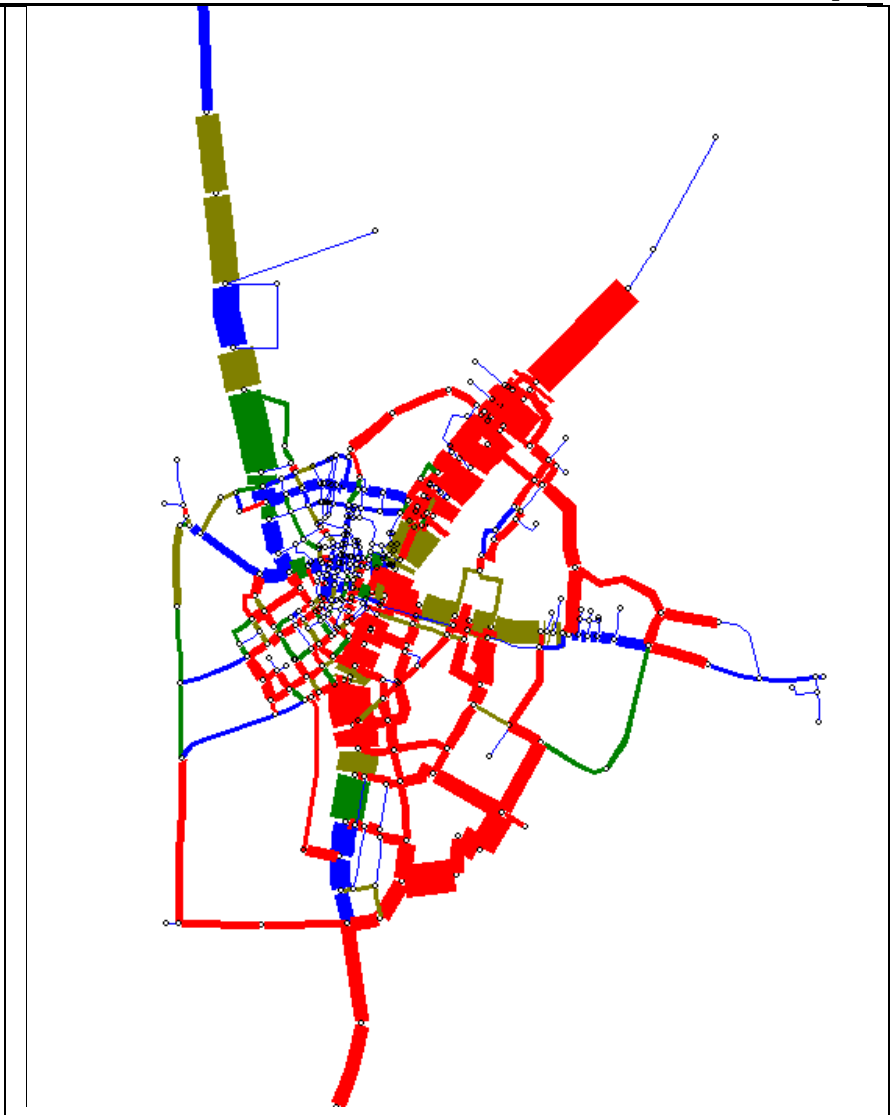


Figure 5.56: Traffic Assignment Result in Do-Nothing Case 2040

Figure 5.57: Traffic Assignment Result in MP Case-1

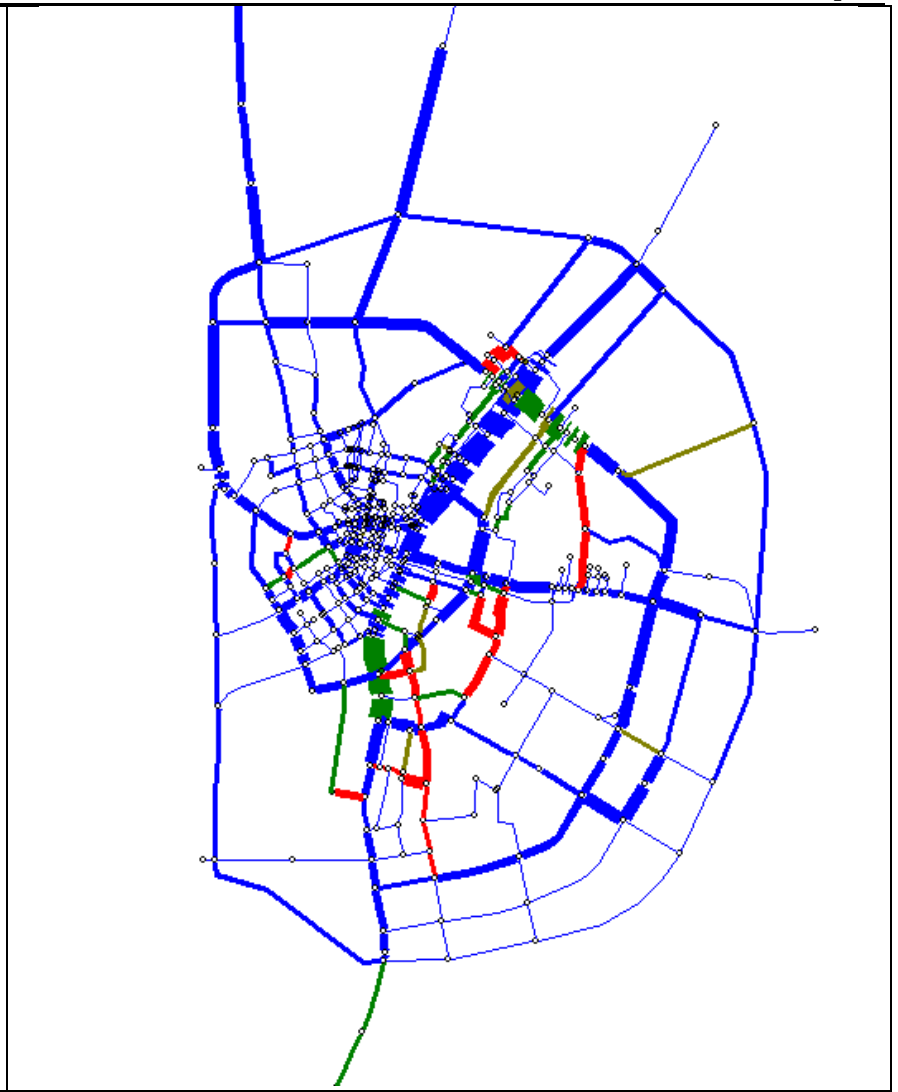


Figure 5.58: Traffic Assignment Result in MP Case-2

5.5 Road Network Development Plan

5.5.1 Road classification

Some road design standards do not exist in Mauritania. Therefore, problems such as road width (lane width, shoulder, sidewalk, etc.) varies in each route and roads have no sidewalks where pedestrian traffic is large.

In order to solve the problems above and to plan road development properly, the road is classified into three categories (arterial road, secondary road and tertiary road) from the viewpoint of traffic function and access function.

The relationship between road and area classification is shown in Table 5.42.

Table 5.42: Road Functional Classification and Right-of-Way (ROW)

Classification	Area specification	Design speed (km/h)	Lanes (n)*	ROW (m)
Arterial Road	Urban	40	4-6	24.5 – 38.0
	Rural	60	2	16.0
Secondary Road	Urban	40	2-4	16.0 – 33.5
	Rural	60	2	16.0
Tertiary Road	Urban	30	2	10.0
	Rural	30	2	10.0

Note: * No. of lanes depends the future traffic demand.
Source: JST

5.5.2 Design criteria

(1) Carriageway

In Nouakchott City, lane and shoulder width are normally installed at 3.5m and 1.5 m. Therefore, lane and shoulder width were basically set according to the current practice.

The shoulder width of Secondary Road in the urban area has considered the installation of on-street parking space where there is high parking demand.

Table 5.43: Width of Median, Lane and Shoulder

Classification	Area specification	Median（min） (m)	Lane width (m/lane)	Shoulder (min) (m)
Arterial Road	Urban	1.5	3.5	1.5
	Rural	-	3.5	1.5
Secondary Road	Urban	1.5	3.5	1.5 – 6.0**
	Rural	-	3.5	1.5
Tertiary Road	Urban	-	3.5	1.5
	Rural	-	3.5	1.5

Note: * in case of high parking demand area, shoulder will be secured for on-street parking space.
Source: JST

(2) Provision for the Non-Motorized Transport（NMT）

1) Basic conditions for NMT facilities

Since pedestrian and bicycle uses very different styles and speeds than automobiles, it is basically desirable to provide exclusive spaces for the NMT. However, it is not economical to provide such space on all roads. Therefore, it is important to decide on the provision for the NMT based on the traffic volumes, the traffic speed differences, the roadside conditions and other factors.

2) Bicycle and Pedestrian traffic volume

Based on the traffic survey result, the current bicycle traffic volume is less than 1% of the total traffic volume. Therefore, it is not economical to install bicycle-exclusive facilities such as cycle lanes and bicycle lanes at the present time. In the future, cycle lane will be installed with the progress of new urban development and the increase of cyclist demand.

The current pedestrian traffic volume was more than 60% of the total traffic volume as a result of simple person trip survey. Therefore, the necessity for the installation of pedestrian facility is very high.

3) Width of NMT facilities

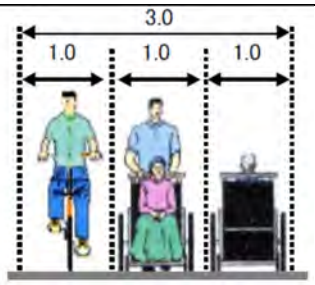
Based on the above consideration, the following strategy is suggested for sidewalk / cycle lane according to road classifications. Tertiary roads are generally used only by local residents and traffic volumes are quite limited. The vehicles speed in these roads are constrained. Accordingly, community roads should be shared with pedestrian and, by principle, there should be no provision of sidewalk.

The minimum widths for sidewalk / cycle lane are determined by road classification as shown in Table 5.44. Minimum width shall be set upon taking Mauritania's customary value (3.0m) and Japanese standards.

Table 5.44: Recommended Standards of Sidewalk Development

Road Class	Traffic Volume	Traffic Volume (Pedestrian)	Width of Sidewalk/cycle lane (min) (m)	Note
Arterial Road	Heavy	Heavy	3.0	Physically to separate pedestrians from cars
Secondary Road	Heavy	Heavy	3.0	〃
Tertiary Road	Little	Heavy	3.0 (2.0)*	〃
	Little	Little	-	Does not separate pedestrians from cars

* In cases where site width is restricted, the width of sidewalk could be reduced up to 2.0m.



Usual sidewalk

Source: Ministry of Land Infrastructure, Transport and Tourism, Japan

Figure 5.59: Usual Sidewalk Width

With the urban development of city center or new cities, some roads may be developed with the symbol road or transit mall as the same as public transport system.

Osaka Sakai Symbol Road(Wide sidewalk)

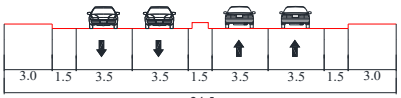
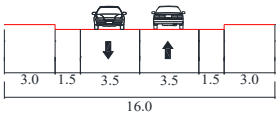
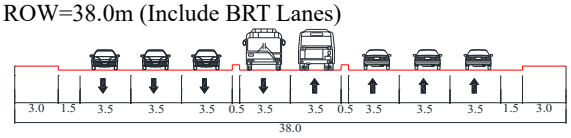
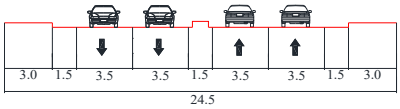
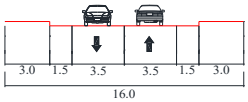
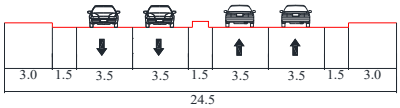
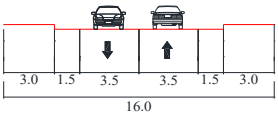
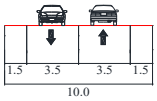
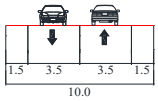
Gunma Mebashi Transit Mall

Figure 5.60: Image of Symbol Road and Transit Mall

(3) Typical cross section

A typical cross section of roads in each design class has been prepared based on the design criteria presented above and shown in Table 5.45.

Table 5.45: Typical Cross Section of Roads in Each Design Class

Road Category	Typical Cross Section	
	Rural	**Urban**
Arterial Road	[4 Lanes] ROW=24.5m  [2 Lanes] ROW=16.0m  	[6 Lanes] ROW=38.0m (Include BRT Lanes)  Row=31.5m  [4 Lanes] ROW=31.0m (Include BRT Lanes)  ROW=24.5m 
Secondary Road	[2 Lanes] ROW=16.0m  	[4 Lanes] ROW=33.5m (Include angle (45°) parking)  ROW=27.5m (Include Parallel parking)  ROW=24.5m  [2 Lanes] ROW=16.0m 
Tertiary Road	[2 Lanes] ROW=10.0m  	[2 Lanes] ROW=10.0m 

5.5.3 Road network development plan/projects

(1) Road network

Current Road Density by Traffic Zone is shown in Figure 5.61. The target road density has already been secured in the existing urban areas and residential areas. On the other hand, road density is not sufficiently secured in the northern and southern regions where future development is expected. Regarding the above areas, it is necessary to promote road improvement so that necessary road density can be secured depending on the city planning.

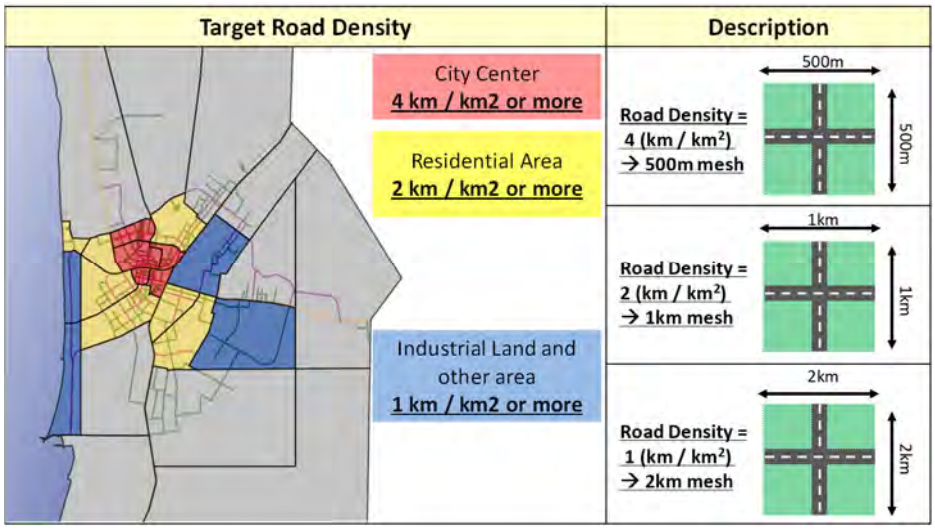


Figure 5.61 Road Density by Traffic Zone in Nouakchott City

(2) Road network development plan

1) Outline

The Road Network Development Plan in Nouakchott City is shown in Figure 5.71. The outline of the road network development plan is shown in below.

[Outline]

- The airport connecting road and three ring road in the 0 - 5km, the 5 - 10 km and the 10 - 15 km area respectively will be installed as the Arterial roads.
- In the urban area, the current road widening will be carried out as necessary.
- New road network will be constructed in the Airport city and Tarhil district, which will be formed as a new city.
- Detailed conditions such as the number of lanes on each road are determined based on the urban structural plan and the results of the future traffic volume estimation.

2) Road length and density

The road length and density in 2017 and 2040 are compared in Table 5.46.

In all road classes, the road length will be increased more than the present situation (Especially, Arterial road will be 2.7 times from the current situation). The future road density of Nouakchott city will be increased 1.8 times from the present condition.

Table 5.46: Summary of Road Length and Density by Classification

Road classification	Present (2017)			Future (2040)		
	Urban area (km^2)	Road length (km)	Road density (km/km^2)	Urban area (km^2)	Road length (km)	Road density (km/km^2)
Arterial	1,132	105.3	0.09	1,132	279.1	0.25
Secondary		141.3	0.12		218.1	0.19
Tertiary Road		164.6	0.15		210.1	0.19
Core Road Total		411.2	0.36		707.3	0.63

3) Detail plan of each road

Each Road Development Plan is described in below.

a) Arterial road (Airport Link Road / Inner, Middle and Outer Ring Road / Airport city Road)

Justification

The function of the ring roads is to divert the traffic connecting destinations outside Nouakchott instead of passing through the Nouakchott city so that the congestion in the urban area can be mitigated. They also help to disperse the traffic coming into the city center by providing some radial roads from the center to suburbs.

- The Airport Link Road is planned to serve the traffic between the city center to Nouakchott airport, and to function as a main artery of the airport and the new city (airport city).
- The Nouakchott city inner ring road is planned to circle the city center within 5km distance, and to function to disperse traffic coming into the center.
- The Nouakchott city Middle ring road is planned 5-10km from the city center, and to function as a main artery of the new city (Tarhil and Airport city).
- The Nouakchott City Outer ring road is planned at 10-15 km from the city center, and to function as a main artery of a large vehicle heading from the outside of Nouakchott to the airport / port.
- The Airport city Road is planned to serve the traffic between the National Road 1 (Northeast direction) to National Road 2 (North direction), and to function as a main connection road of the new city (airport city) and National road 1 and 2.
-

Development plan

Design conditions of all roads are shown in below (See Table 5.47).

Table 5.47: Outline of Airport Link Road and Three Ring Roads

Road	Area*	Design speed (km/h)	Road width (m)	Lanes (n)
Airport Link Road	Urban	40	24.5	4
	Rural	60	24.5	4
Inner Ring Road	Urban	40	24.5	4
Middle Ring Road	Rural	60	24.5	4
Outer Ring Road	Rural	60	24.5	4
Airport city Road	Rural	60	16.0	2

* Urban area: The inside of Middle Ring Road, Rural area: The outside of Middle Ring Road

Typical cross section

Typical cross-sections of the roads constituting the arterial road are provided in Figure 5.62.

Figure 5.62: Typical cross section of Arterial Road

b) National road widening

Justification

New urban development will accelerate naturally in rural areas between Middle and Outer ring roads and near airport. This will increase the traffic between these areas and the city center and

the traffic of the national roads which are the main roads to access the city center will be increased dramatically. To cope with the increased traffic, the existing national roads should be expanded.

And also, the introduction of BRT is under consideration in the national road. To install the BRT lane, the existing national roads should also be expanded.

Development plan

Design conditions of all roads are shown in below (See Table 5.48).

Table 5.48: Outline of National Road

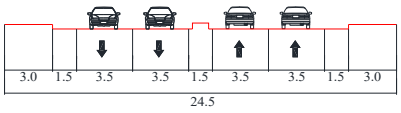
Road	Area*	Design speed (km/h)	Road width (m)	Lanes (n)
National Road 1 (North East Direction)	Urban	40	38.0	6
	Rural	60	16.0	2
National Road 2 (North Direction)	Urban	40	31.0	4
	Rural	60	24.5	4
National Road 2 (South Direction)	Urban	40	31.0-38.0	4-6
	Rural	60	16.0	2
National Road 3 (East Direction)	Urban	40	31.0	4
	Rural	60	16.0	2

* Urban area: The inside of Outer Ring Road, Rural area: The outside of Outer Ring Road

Typical cross section

Typical cross-sections of the National roads are provided in Figure 5.63 and Figure 5.64.

[4 Lanes] ROW=24.5m



[2 Lanes] ROW=16.0m

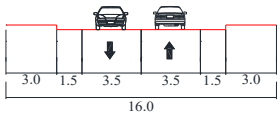


Figure 5.63: Typical cross section of National Road (Rural Area)

[6 Lanes]
ROW=38.0m (Include BRT Lanes)

[4 Lanes]
ROW=31.0m (Include BRT Lanes)

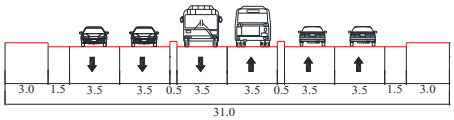


Figure 5.64: Typical cross section of National Road (Urban Area)

c) New city roads development (Airport City / Tarhil district)

Justification

In Nouakchott city, two new city developments is planned in the urban structural plan (Airport city and Tarhil district). Roads are fundamental infrastructure for forming the axes of urban development to support daily life as well as industrial activities. Therefore, it is important to develop the roads accordingly with plans to lead the urban development effectively. Especially the development of artery roads, which will not only form the framework of the city but also be utilized as the space to accommodate urban utilities need to be realized in the earliest stage.

Development plan

Design conditions of the New city roads are shown in below (See Table 5.49).

Table 5.49: Outline of New city Road

Road	Road Class	Area*	Design speed (km/h)	Road width (m)	Lanes (n)
Airport City	Secondary	Rural	60	16.0	2
	Tertiary		30	10.0	2
Tarhil district	Secondary	Urban	40	16.0-33.5**	2-4
		Rural	60	16.0-24.5	2-4
	Tertiary	Urban	30	10.0	2
		Rural	30	10.0	2

* Urban area: the inside of Middle Ring Road, Rural area: the outside of Middle Ring Road
** The presence or absence of install an on-street parking space shall be determined the situation of Land use along the target roads.

Typical cross section

Typical cross-sections of the New city roads are provided in Figure 5.65 to Figure 5.67.

Figure 5.65: Typical cross section of New city Road (Secondary: Rural Area)

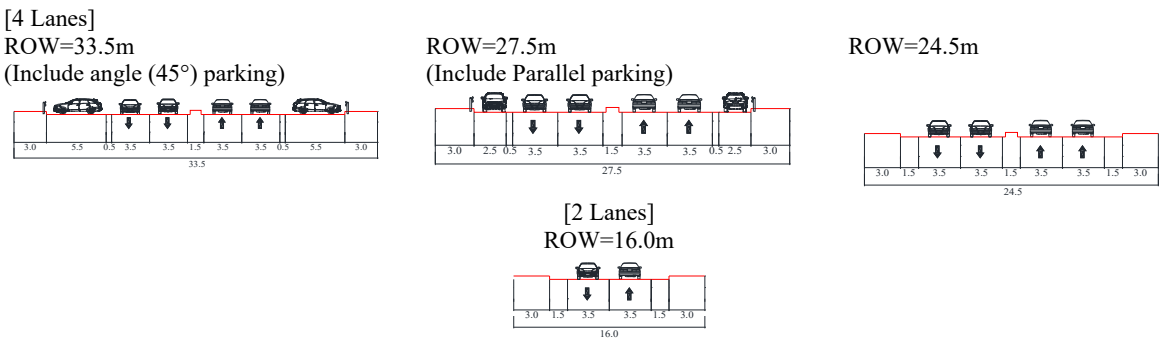


Figure 5.66: Typical cross section of New city Road (Secondary: Urban Area)

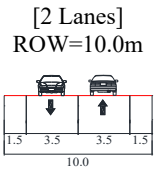


Figure 5.67: Typical cross section of New city Road (Tertiary: Urban / Rural Area)

d) City center roads development

Justification

There are shortages of secondary roads as trunk roads in expanding areas in the North and the South-East of the existing urban area. Secondary roads should be provided to serve new residential areas in each district.

And also, accessibility to the access road from the city center to the Outer Ring Road is low. Therefore, access road improvement is indispensable.

Development plan

Design conditions of all roads are shown in below (See Table 5.50).

Table 5.50 Outline of National Road

Road	Road Class	Area*	Design speed (km/h)	Road width (m)	Lanes (n)
City center	Secondary	Urban	40	16.0-33.5**	2-4
		Rural	60	16.0-24.5	2-4
	Tertiary	Urban	30	10.0	2
		Rural	30	10.0	2

* Urban area: the inside of Middle Ring Road, Rural area: the outside of Middle Ring Road
** The presence or absence of install an on-street parking space shall be determined the situation of Land use along the target roads.

Typical cross section

Typical cross-sections of the City Center Roads are provided in Figure 5.68 to Figure 5.70.

[4 Lanes] ROW=24.5m

[2 Lanes] ROW=16.0m

Figure 5.68: Typical cross section of City center Road (Secondary: Rural Area)

[4 Lanes]
ROW=33.5m
(Include angle (45°) parking)

ROW=27.5m
(Include Parallel parking)

ROW=24.5m

[2 Lanes]
ROW=16.0m

Figure 5.69: Typical cross section of City center Road (Secondary: Urban Area)

[2 Lanes]
ROW=10.0m

Figure 5.70: Typical cross section of City center Road (Tertiary: Urban / Rural Area)

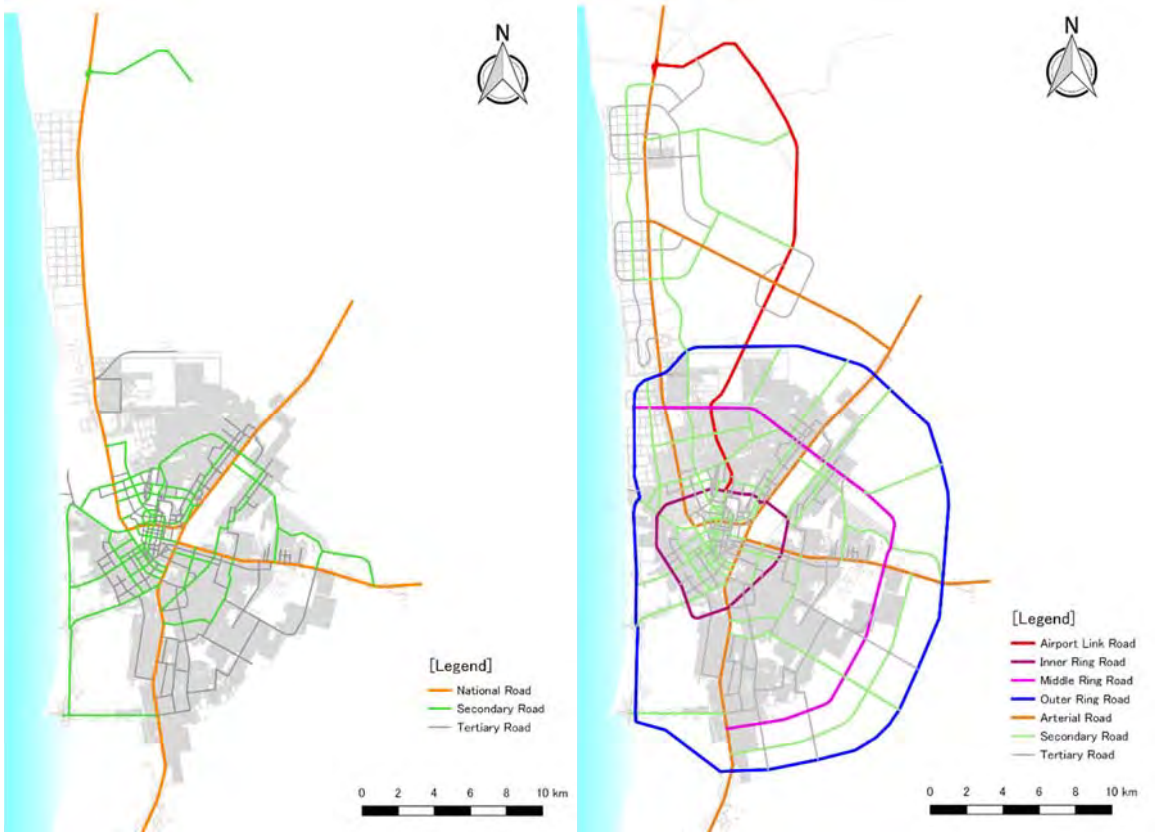


Figure 5.71: Road Network Plan in Nouakchott City (Left: Present(2017), Right: Future (2040))

Figure 5.72: Road Network with Number of Lanes

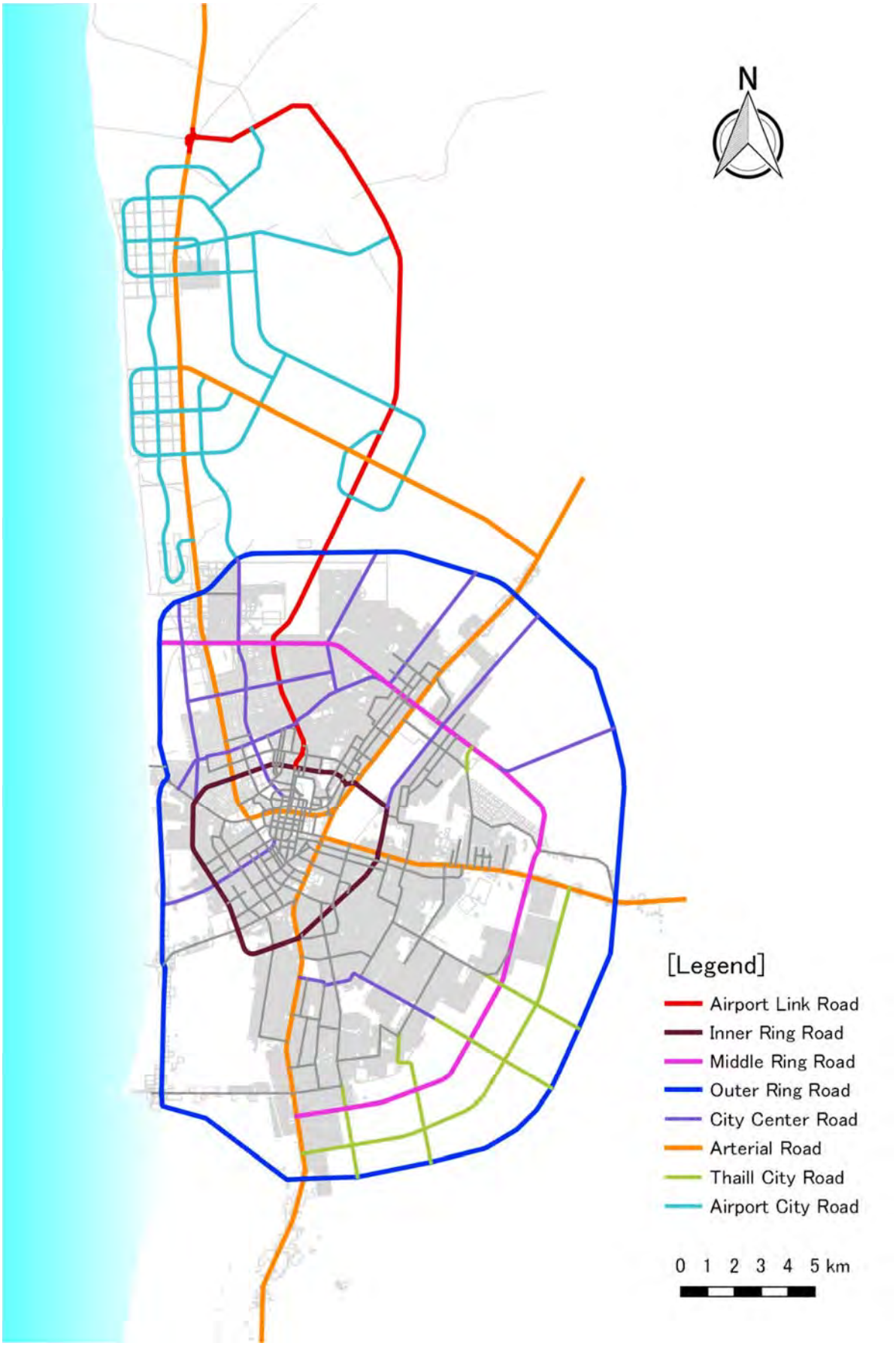


Figure 5.73: Road Network for each project

Phase1: 2019~2025	Phase2: 2026~2030
Phase3: 2031~2035	Phase4: 2036~2040

Figure 5.74: Road Network Construction Diagram for each phase

5.6 Traffic Management System Development Plan

Traffic Management Plan will be implemented as short-term projects (or some medium-term projects) to solve the present traffic problems and issues. Especially, the reduction of traffic accident shall be fully considered since many dangerous driving situations are seen everywhere in Nouakchott City.

The proposed projects of traffic management are shown below.

(1) Installation of median and road markings

To reduce the traffic accident/road crashes with counter flowing vehicles, it is recommended to install a median for more than four lanes road. Also, install a road marking to have a smooth flow and to improve a traffic safety shall be emplaced.

Wide median
Source: Tokyo, National Road (Route 246)

Narrow median
Source: Tokyo, Kuramaebashi Street

Figure 5.75: Image of Median for Urban Road

In case of the road section which has a much different traffic volume of inbound and outbound during morning and evening peak hour, reversible lane can be applied depending on the peak volume. Though reversible lane measure was implemented in Japan before, it is currently not implemented due to the risk of head-on collisions.

(2) Intersection improvement

To ensure the traffic safety at intersections, it is essential to smoothen the traffic flow. Proposed countermeasures for consideration are geometric improvement, left turn lane (or pocket) installation and road marking, installation of traffic island and traffic signal.

Roundabout is also applicable as an intersection handling method. Provided Intersection inflow traffic is less than 15,000 to 20,000 (vehicle / day・all direction), the roundabout could be installed at an intersection.

<Improvement measures>
Installation of traffic signal light
Improvement of geometrical design
Installation of left turn lane with left turn signal arrow
Indication of turning arrow
Installation of lane marking and stop line
Installation of zebra crossing
Installation of traffic island, street light, guard rail and etc.

Source: https: //tinewsdaily.com(improving the safety of the intersection at Illinois, USA)

Figure 5.76: Image of Improved Intersection

(3) Parking management system

Serious traffic congestions occurred in some streets in the city center occurred due to lane closures by on-street parking or roadside friction illustrated in Figure 5.77. Proposed countermeasures are the clarification of permitted or prohibited parking space and enforcement of illegal parking which affect the smooth traffic flow. Parking sign and marking (parking prohibited) shall be installed in urban streets. Of course, it may be necessary to off-street parking space for high density area.

If there are no restrictions in the city center, parking space itself may induce traffic to that area. Therefore, the parking management system would be conducted. It is important to consider "selection and concentration" for adjusting traffic inflow to the urban area.

When the new public transport system is introduced, parking space will be needed near the station or terminal for mode transfer and Park and Ride (P&R).

Control of parking fee is also one of the management measures for parking vehicle demand. Traffic concentration in city center area will be one of the serious issues in the future, and it is effective to charge parking fee for decreasing traffic concentration when public transport system is introduced.

However, it is necessary to strengthen crackdown and punishment of illegal parking with the parking fee management.

Figure 5.77: On Street Parking Situation in City Center Area

<Example-prohibited parking>
At red color area, parking is strictly prohibited in Tokyo.

<Example-permit parking space>
Parking meter system is installed on both roadside.

Figure 5.78: Example of Parking Control at Roadside

(4) Promoting modal shift

To utilize more efficient transport infrastructure space, modal shift measures from private car trips to public transport trips shall be implemented. The measures are not only the development of public transport infrastructure, but also the countermeasures of software for public transport improved convenience.

To promote the Non-Motorize Transport (NMT), the development of NMT space (walk way, bicycle way) and some alternatives as car free day, transit mall, etc. shall be implemented.

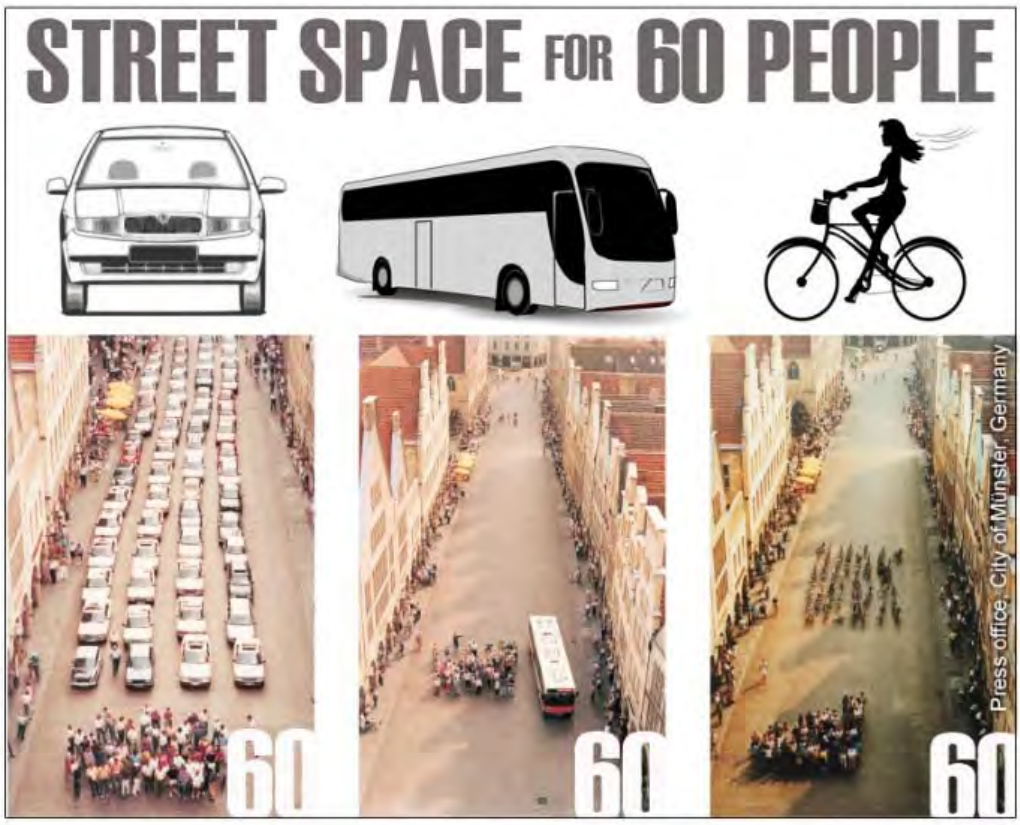


Figure 5.79: Image of Street Space for 60 people

Each implementation schedule including this project is shown below

Action 1	Encouraging of modal shift to the public transport By Publication, Seminar, Mass Media, Education etc.	Short Medium Term (2019 – 2030)
Action 2	Improvement of bus operation and improvement facilities of, priority lane, terminal and bus stops	Short Medium Term (2019 – 2030)
Action 3	Development of BRT/ BRT road, Automated Fare Collection System for BRT, Bus and Taxi	Long Term (2031 – 2040)

	Example- Bus exclusive or priority lane <public transport promotion measures>
	Bus terminal for intermodal connectivity <public transport promotion measures>

	< Automated Fare Collection System > Prepaid e-money card for moving around and shopping. Suica is the most famous prepaid e-money card in Japan. There will be no more need to buy a ticket from a vending machine and just touch e-money card to the ticket gate and the fare is automatically deducted from e-money card.

Figure 5.80: Image of Public Transport Promotion

(5) Introduction of ITS (Intelligent Transport System)

To use more efficient transport facilities, introduction of ITS will be considered.

ITS consist of many components, but in Nouakchott City, the proposed ITS systems are: a) traffic control center with traffic signals, b) traffic information system, and c) security monitoring system. And it is also included in the emergency vehicle operation system.

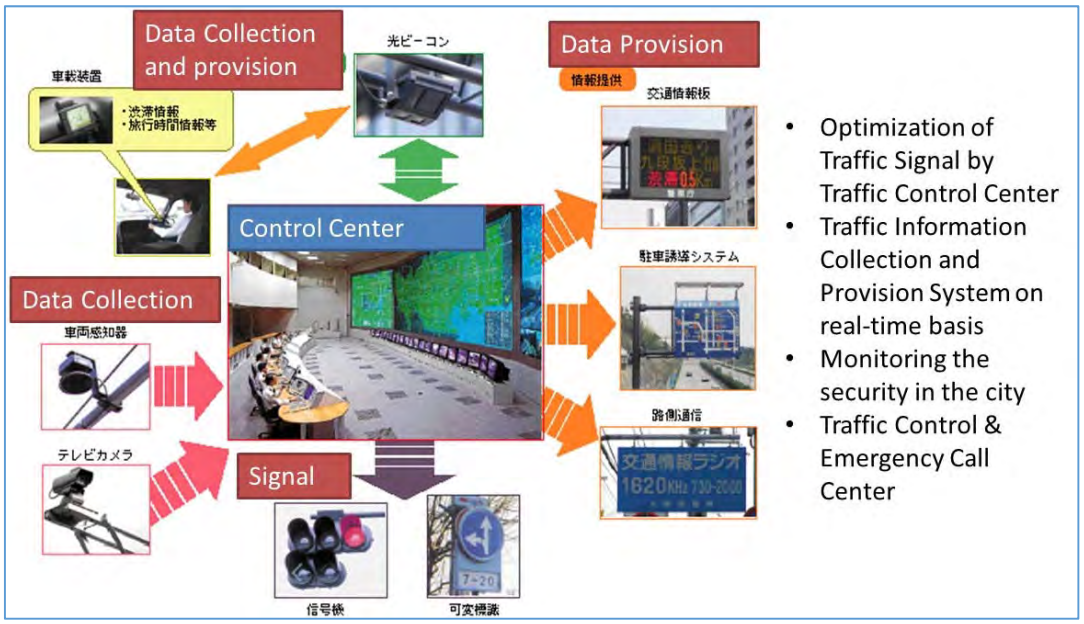


Figure 5.81: Image of Traffic Control Center with Traffic Information Center

Action 1	Signalized Traffic Signal and Area Control and Emergency Call Center Year 2018: No. of Signalized Intersection 70(present, 2018 see Figure 5.82) Short Term: 100 Medium Term: 150	Short Medium Term (2019 – 2030)
Action 2	Dynamic Signal Optimization System Public Transport Priority System Information Collection & Provision System (Travel Time, Congestion information, Event, etc.) (see Figure 5.83)	Short Medium Term (2019 – 2030)

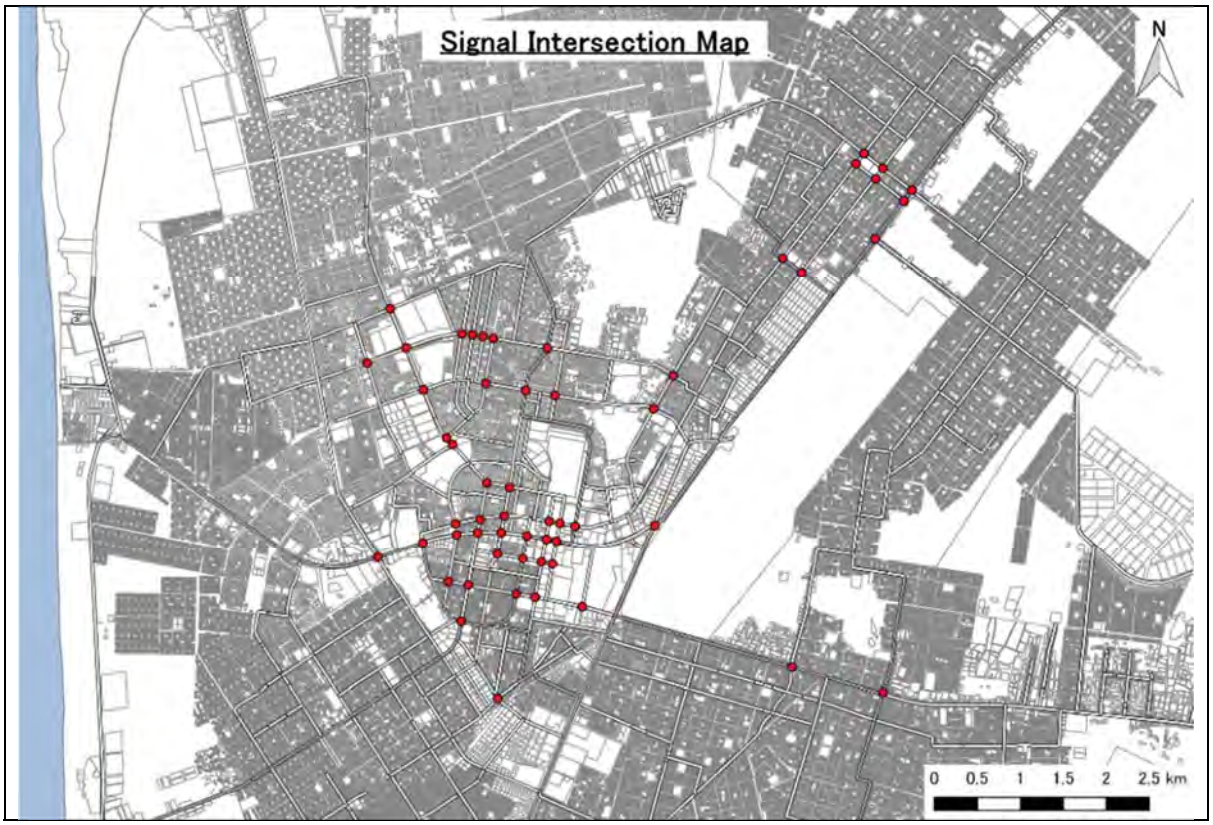


Figure 5.82: Location Map of Present Signalized Intersection

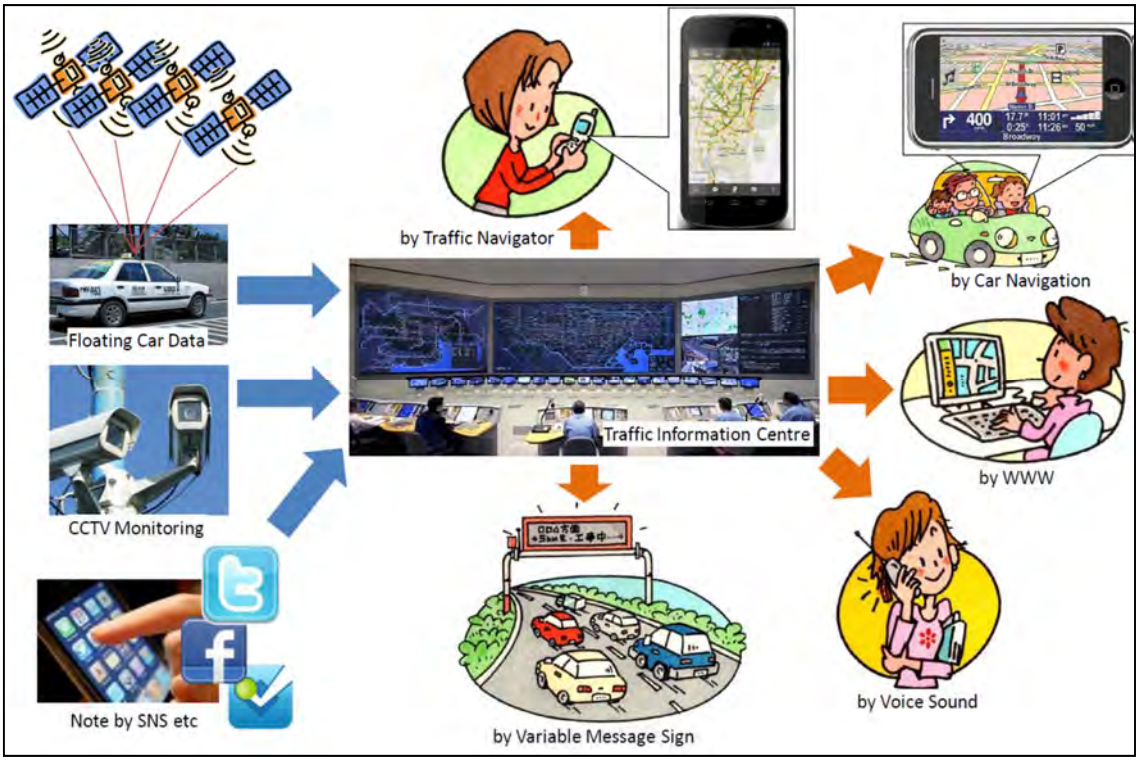


Figure 5.83: Image of Traffic Information Center System

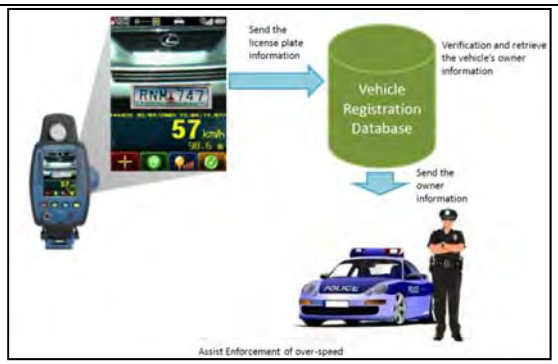
(6) Introduction of vehicle inspection system

At present, huge number of old cars (over 20 years) were seen in Nouakchott City, which have negative impact on air quality. Therefore, the government should implement a new regulation prohibiting the importation of old vehicles.

Introduction of vehicle inspection system is highly recommended and only the vehicles that passed the automobile exhaust gas regulations can be used in Nouakchott City. And the enforcement for inspection of cars should be strengthened.

All vehicles should be registered and old vehicles should be inspected every year (in case of Japan, vehicle inspection of private car is as follows: Initial expiration is 3 years, then next expiration is 2 years.).

Inspection vehicle stickers can be placed on the front window for traffic police can easily detect the inspected vehicle or not.



If government can have vehicle registration database, traffic police on the roadside can easily detect by utilizing information technology (IT).

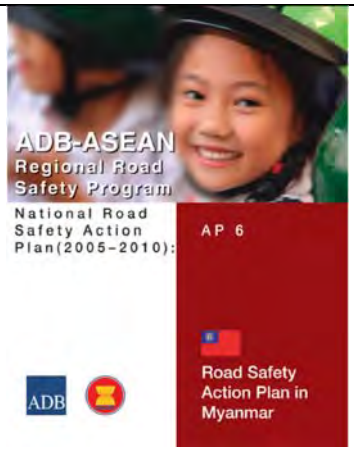
Figure 5.84: Image of Vehicle Inspection System

(7) Traffic safety

Main purposes are to decrease traffic accidents/road crashes and to improve traffic behaviors.

- Issuance of driver license, the strength of unlicensed drivers' enforcement.
- Traffic Safety Campaign, especially for children.

Image of Traffic Safety Campaign



Road Safety Action Plan

Figure 5.85: Image of Traffic Safety Tool

5.7 Public Transport Development Plan

5.7.1 Strategic public transport system development plan

Proposed future urban structure of Nouakchott is a tripolar model at metropolitan scale and a kind of compact city development within outer ring roads. In order to support this future urban structure formulation, public transport system is recommended to move easy access main cores and various poles etc. Introduction of public transport system will also contribute to create an environmental friendly city such as reduction of the number of private car use.

The Transport Interview Survey Results are summarized as the following: (The details of the Transport Interview Survey Results are as shown in 5.2.7):

- Respondents are not satisfied with the present taxi service. Approximately 40% rated “very bad” and “bad”. (N=1000)
- Respondents are also not satisfied with the present bus service. More than 60% respondents rated almost all items except bus fares as “very bad” and “bad”. (N=1000)
- If a new bus route is operated in the future, 64% of the respondents answered to utilize the bus service.

Therefore, people are not satisfied with the present pubic transport system and if a good public transport system (Setting appropriate bus routes based on user’s trend and offering safe and comfortable bus services) will be introduced, respondents will use it.

- It is recommended that the good public transport system will be introduced in Nouakchott City.
- In the initial stage, it will be installed with Bus service with bus priority lane. When public transport demand increases in the future, high capacity public transport system such as Light Rail Transit (LRT) or Bus Rapid Transit (BRT) will be introduced along the high demand roads.
- Though the capacity of LRT is higher than that of BRT, project cost is also high as shown in Table 5.51. As the traffic demand forecast result has shown, BRT will fit on Nouakchott City in, target year, 2040.

Table 5.51: Summary of Moroccan LRT Project

Project: Morocco Rabat-Salé tramway (LRT)
Project Cost: EURO 303 million (15 million EURO per km)
Opening year: 2010
Daily transport 180,000 passenger a day
Two lines total length 20km and 31 stations

<Route Map> <Typical Cross Section: LRT is running at center>

Table 5.52: Sample Comparison of Public Transport Type

	Light Rail Transit (Train)	Bus Rapid Transit (BRT)	Conventional Bus
Major feature	- Operated mainly on exclusive rails - Sometimes mixed with other traffic	- Utilize exclusive lanes - Occasionally share certain sections of the roads with other vehicles	- Mixed with other motorized Traffic
Interval	0.8-1.5 km	0.4-1.0 km	0.2-0.4 km
Photo			
Capacity (PHPDT*)	-20,000	-10,000	-6,000
Average Speed	20-30 km/h	20 km/h	15-35 km/h
Vehicles	- Electric motor cars - Articulated cars - Low-floor cars	Conventional bus, articulated bus, low-floor bus, diesel bus and hybrid bus	
Investment (US$ million/km)	30-50	6-13	-

Note: PHPDT: Peak Hour Peak Direction Traffic
Source: JST revised based on the "The Research on Practical Approach for Urban Transport Planning (JICA)"

5.7.2 Public network plan

Initially, conventional bus service will be expanded in the area. The current main bus routes are from/to university for student and some urban bus route. In order to increase bus user, the following bus service will be introduced. Based on the future demand forecast, proposed public transport network is illustrated in Figure 5.86.

In order to achieve this bus network, it is necessary to change unpaved roads to paved roads and to achieve sustained expansion of the bus network, routes of the proposed network are prioritized according to the following policy.

[Bus route introduction policy]
Priority1**:** To set up the routes on the main road such as national road and Middle Ring Road where concentration of city functions and high passenger demands are expected; By the introduction of these routes, the axis of the public transportation network (national highway (east west, north-south axis), Middle Ring Road (annular axis)) will be formed.
Priority2: To set up the routes on the main road in the district such as secondary and Tertiary road; By the introduction of these routes, the public transportation axis with priority 1 is supplemented, and the bus service could be provided over a wide area within the urban area.
Priority3: To set up the routes according to the development situation of the new city

	Contents	Term
Action Plan 1	Capacity Development of STP -Bus Operation and Maintenance Currently, only bus parking/waiting space exists, there are no workshop for bus maintenance. As there are no enough spare parts for bus repair, and no technical staff for repair, there are many unrepaired buses. STP expected to support technical assistance for bus O&M, especially maintenance.	Short Term (2019 – 2022)
Action Plan 2	Expansion of Bus Service - Bus network (See Figure 5.86) - Road improvement for candidate bus route - Improvement of bus service (frequency, bus fleet quality, bus priority lane, bus stop, bus information) See section 5.7.5	Short, Medium, Long Term (2019 – 2030)
Action Plan 3	Terminal Construction See section 5.7.4	Short Medium Term (2019 – 2030)
Action Plan 4	BRT Construction See section 5.7.3	Long Term (2031 – 2040)

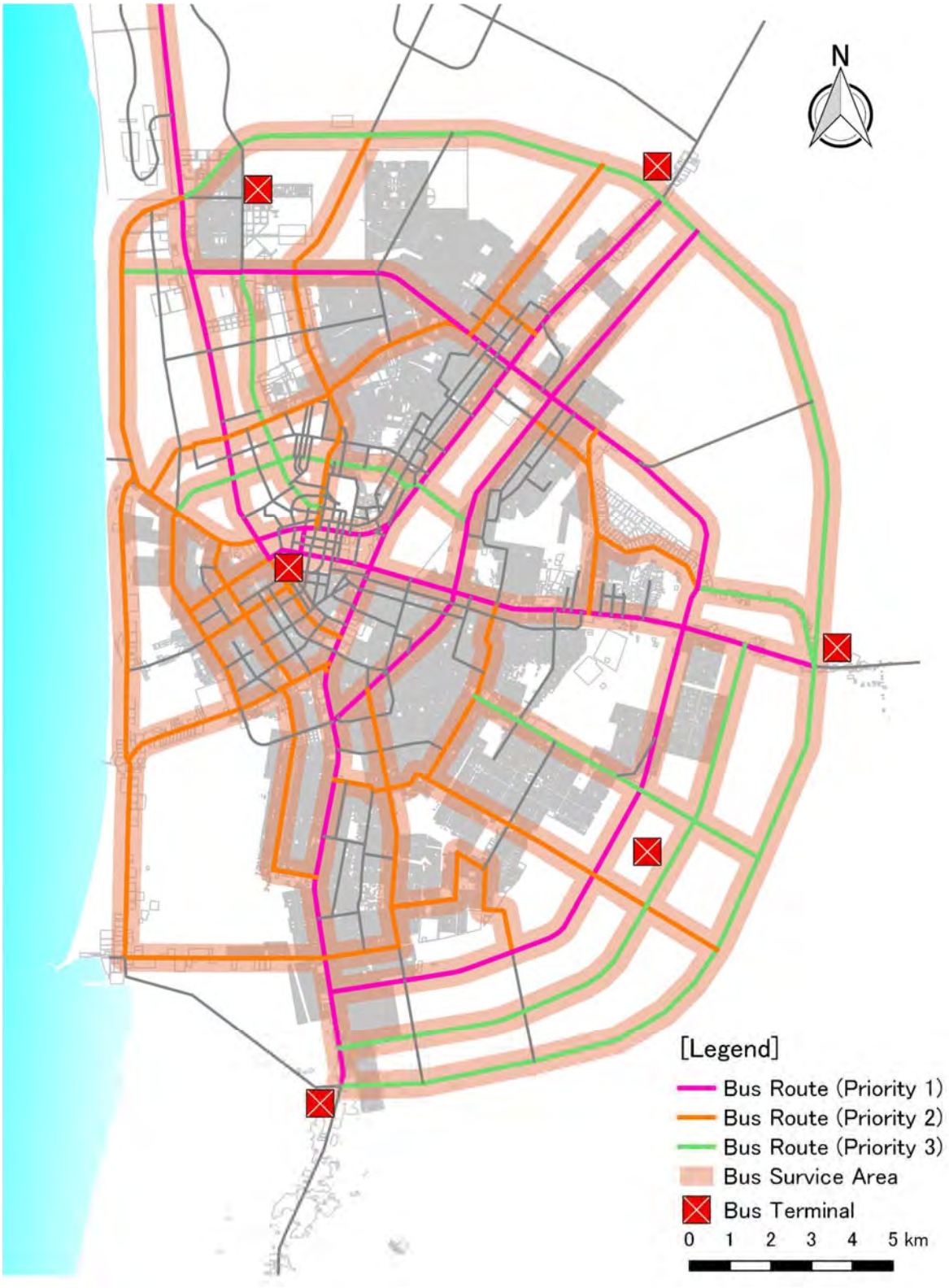


Figure 5.86: Proposed Public Transport Network

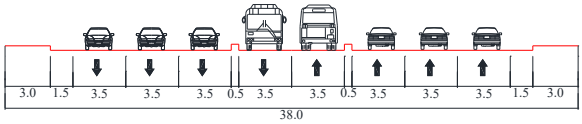
5.7.3 BRT network plan

Traffic dynamics in Nouakchott city has been clarified that main traffic flow is from the suburbs to the city center as a result of the social survey. From the above results, almost all bus routes will probably be the routes connecting between city center and suburbs. The operation distance of each route and the number of routes will be supposed to increase as the expanding urban area in near future. This will complicate bus routes and increase traffic congestions in the city central area.

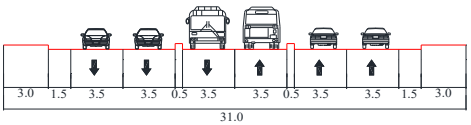
In order to solve those problems, it will be desirable to establish region-wide trunk routes connecting major points in the region together with feeder bus routes in the surrounding area. Combination of the region-wide trunk routes and feeder routes will enable to transport mass passengers on the region-wide trunk routes and passengers in the surrounding area.

And also, it is possible to suppress the inflow of the bus to the city center and the traffic congestion in the city central area will be decreased. Therefore, we proposed to introduce the high capacity public transport system such as Light Rail Transit (LRT) or Bus Rapid Transit (BRT) as the region-wide trunk services complementing the feeder bus transport system.

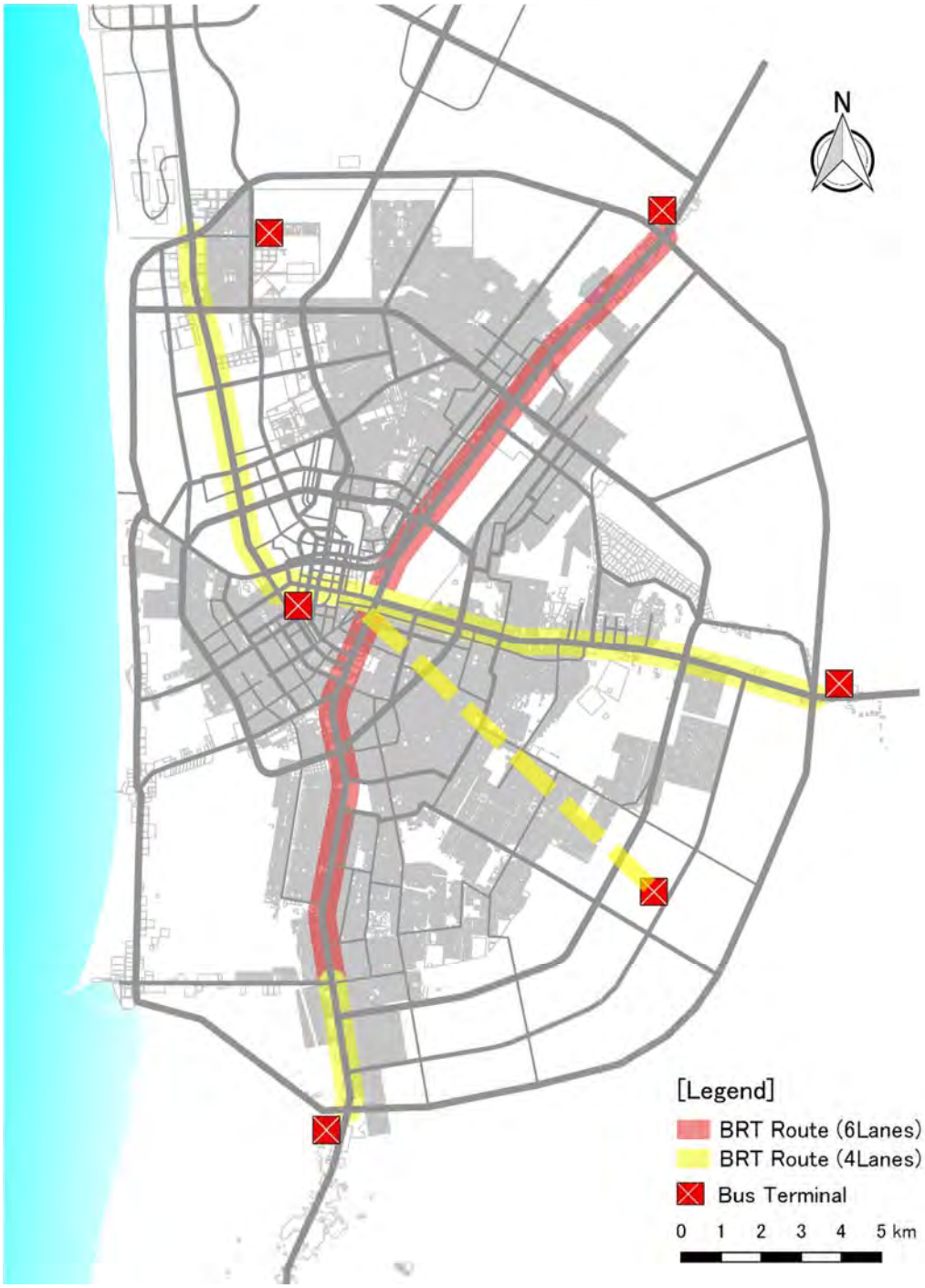
Though the capacity of LRT is higher than that of BRT, project cost is also high as shown in Table 5.51. As the traffic demand forecast result has shown, BRT will suitable for Nouakchott City in, target year, 2040. The proposed BRT network and typical cross sections are shown in Figure 5.87.



6 lanes＋BRT, 38.0m



4 lanes＋BRT, 31.0m



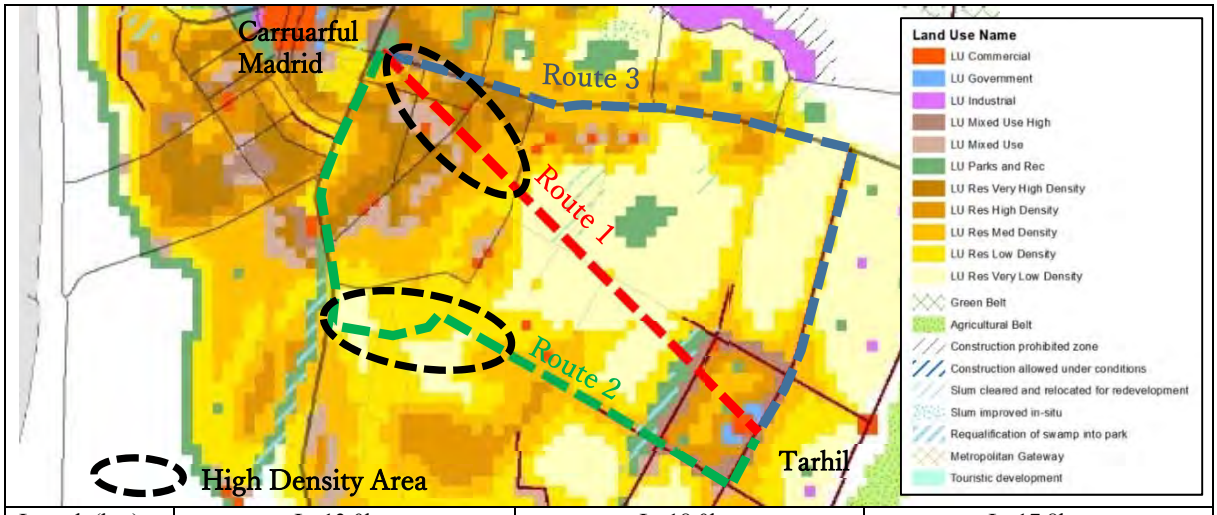
Source: JST

Figure 5.87: BRT Network/Terminal Layout and BRT Typical Cross Section

Table 5.53 shows the comparison of BRT route for Tarhil. Route-3 is recommended among 3 alternative routes. The outlines of the 3 routes are as follows:

Route1: The route to minimize transport distance between city center and Tarhil district, by newly construct the road connecting straightly from Carruarful madrid intersection" to Tarhi District.
Route2: The route to reduce social impact by utilizing existing road network which is National Road 2 (South Direction) and main road in the district.
Route3: The route to reduce social impact by utilizing existing road network which is National Road 3 (West Direction) with the road developed during new urban development.

Table 5.53: Comparison Table of BRT route from/to Tarhil



Length (km)	L=13.0km		L=18.0km		L=17.8km	
Project Cost (Million USD)	●	123.5 (Million USD) (9.5 M USD/km×13.0km)	▲	171.0 (Million USD) (9.5 M USD/km×18.0km)	▲	169.1 (Million USD) (9.5 M USD/km×17.8km)
Passenger Demand	◎	Passenger demand is very high because it will pass through the high density populated area.	◎	Passenger demand is very high because it will pass through the high density populated area.	●	Passenger demand is moderate although the route pass through the middle/low density populated area.
Social Impact	▲	Social impact is very high because house relocation for installation of new road is necessary in many areas. [Extension of Density populated area] L = 7,750m (High Density populated area) L = 3,500m (Middle Density populated area)	●	Social impact is high because house relocation for existing road widening is necessary in some area. [Extension of Density populated area] L = 2,100m (High Density populated area) L = 3,800m (Middle Density populated area)	◎	Social impact is small because it will mainly pass through middle/low density populated area. [Extension of Density populated area] L = 0m (High Density populated area) L = 3,000m (Middle Density populated area)
Evaluation result	▲	Most economical route in terms of construction cost, as construction length is shortest. Demand of BRT is expected to be high considering the route goes through densely populated areas. However, social impact is highest as it goes through densely populated areas. Therefore, project feasibility is low.	▲	Demand of BRT can be expected as this route goes through density populated area. However, construction length and cost are longest/highest and high social impact is expected as widening of road is necessary at density populated area. Therefore, project feasibility is low.	●	Less economical route than route 1, but less social impact as this route mainly pass through low density populated area. Therefore, project feasibility is highest.

Note: ◎ very good, ● good , ▲ fair

5.7.4 Terminal plan

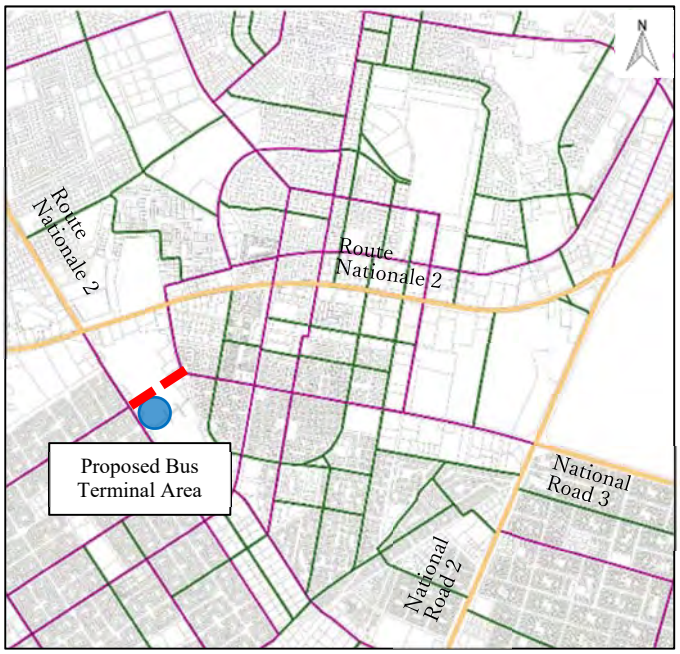
As shown in Table 5.54, the Terminals are proposed at the city center and at the suburb area. Currently, the proposed terminal locations are shown in Figure 5.87. The outline of the bus terminal plan for each area is as follows:

[City Center Terminal]
City Center Terminal is proposed at the nodal point of the BRT route (See Figure 5.88). This terminal is relatively easy to construct because the planned construction site is located at the park managed by the government. This location is confirmed to MET and MHUAT. It should be built as early as possible because it is the core facility of public transport services in Nouakchott city.

[Suburb Area Terminals]
Suburb Area Terminals are proposed at the intersection of Outer ring road and National Road based on the land use plan (See 4.4.1(5)) (Except for University Terminal). These terminals are relatively easy to construct because the three planned construction sites are located in the suburbs and there are almost no buildings at present. These locations are confirmed to MET and MHUAT. These terminals shall be built according to the deployment situation of public transportation services.

Table 5.54: Candidate Public Bus Terminal

Terminal	Term
1. City Center Terminal	Short (See Figure 5.87, Figure 5.88)
2. University Terminal (National Road 2)	Existing (See Figure 5.87)
3. Metro Gateway (National Road 1)	Medium, Long (See Figure 5.87)
4. Metro Gateway (National Road 3)	Medium, Long (See Figure 5.87)
5. New Tarhil	Medium, Long (See Figure 5.87)
6. Metro Gateway (National Road 2)	Medium, Long (See Figure 5.87)



Proposed Bus Terminal Area

Source: JST

Figure 5.88: Proposed Bus Terminal Located at City Center

5.7.5 Other public transport project

The proposed Public Transport Projects have been formulated based on the interview survey results for the business operator (STP) and respondents of social survey. Proposed Public Transport Projects except for Public transport network plan, BRT network plan and BRT network plan are as shown below.

(1) New bus stop

Though some bus stops were installed along some major roads, they are quite few. With the construction of bus stop, sun shade, and benches; bus information provision such as time table and route map should be installed.

(2) Introduction of bus fleet

As described in the previous sections, the procured bus in 2016 were 40 new bus made in China and 75 used bus made in USA. In order to expand the bus operation in the future, new bus fleet should be introduced.

(3) Introduction of Public Traffic Information Provision System.

In order to enhance the bus service, information provision such as timetable and route map at bus terminals and bus stops should be provided. In the future, present travel time and event (road accident) should be incorporated.