



MINISTRY OF TRANSPORT &
COMMUNICATIONS
SULTANATE OF OMAN



JAPAN INTERNATIONAL
COOPERATION AGENCY

THE STUDY ON ROAD NETWORK DEVELOPMENT IN THE SULTANATE OF OMAN

FINAL REPORT

EXECUTIVE SUMMARY

MARCH 2005



KATAHIRA & ENGINEERS INTERNATIONAL

PREFACE

In response to a request from the Sultanate State of Oman, the Government of Japan decided to conduct the Study on Road Network Development and entrusted the project to Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Dr. Hani Abdel-Halim at Katahira & Engineers International from January 2004 to February 2005.

The team held discussions with the engineers at Directorate General of Roads, Ministry of Transport and Communications, as well as other officials concerned, and conducted field surveys, data analysis, Master Plan formulation and Feasibility Study. Upon returning to Japan, the team prepared this final report to summarize the result of the study.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Sultanate State of Oman for their close cooperation extended to the study.

March 2005

Kazuhisa MATSUOKA,
Vice President
Japan International Cooperation Agency

Mr. Kazuhisa MATSUOKA
Vice President
Japan International Cooperation Agency

March 2005

Letter of Transmittal

Dear Sir,

We are pleased to submit herewith the Final Report of "The Study on Road Network Development in the Sultanate of Oman". The report includes the advices and suggestions of the authorities concerned of the Government of Japan and your agency as well as the comments made by the Ministry of Transport & Communications and other authorities concerned in the Sultanate of Oman.

The report analyses the present and future conditions and demand of transport in the Sultanate. It comprehensively covers the road transport sector as well as the issues of institution, financing and environment.

The report presents the established road network development plan to the year 2030, and pre-feasibility study on high priority projects. The output of the Study concludes that the plan is technically, environmentally, economically and socially viable, and will contribute to the national and regional development in the Sultanate. In view of the urgency of developing the road network in the Sultanate, we recommend that the Government of the Sultanate of Oman implement the projects with high priority.

We wish to take this opportunity to express our sincere gratitude to your agency, the Ministry of Foreign Affairs and the Ministry of Land, Infrastructure and Transport. We also wish to express our deep gratitude to the Ministry of Transport & Communications, Directorate General of Roads as well as other Governmental Agencies concerned in the Sultanate of Oman for the close cooperation and kind assistance extended to us during the Study. We hope this report will contribute significantly to the development of the Sultanate of Oman.

Very truly yours,

Dr. Hani Abdel-Halim
Team Leader,
The Study on Road Network Development
in the Sultanate of Oman

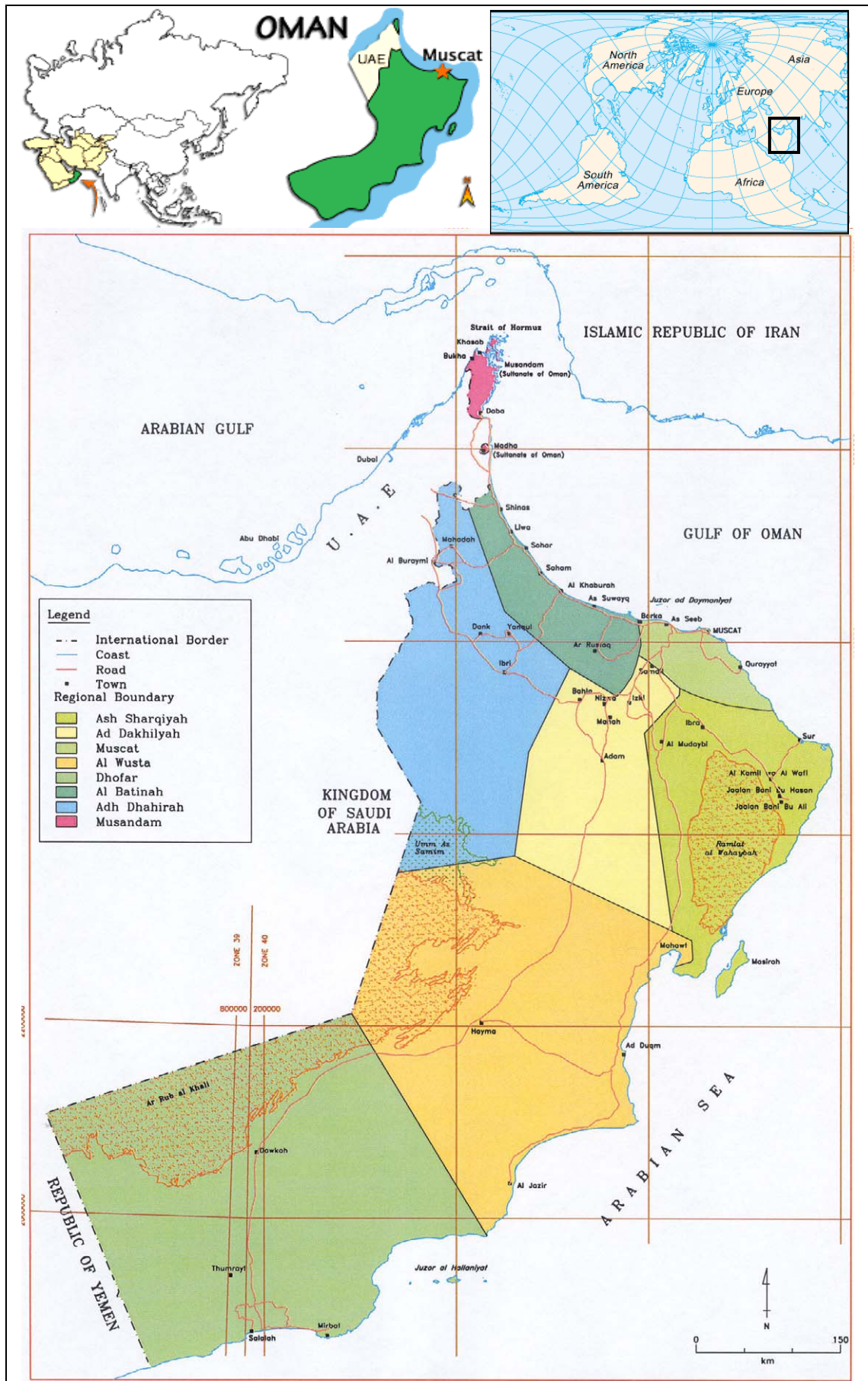


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Exchange Rate:

US\$1.00 = RO 0.385

RO 1.00 = JPY 278

(As of November 2004)

SUMMARY

ROAD DEVELOPMENT PLAN

- Although the road conditions have been greatly improved in recent years, the road network still has many problems such as missing links and weak connections as well as the interruption of traffic at *Wadis* during and after rainfall.
- Efforts are still needed to improve both primary and secondary road networks in order to provide a safe, efficient and reliable road network with better transport conditions that cope with future transport demand in the Sultanate.
- A well developed road network is required for the enhancement of the transport system in the country in order to support diversification of the economy and other development sectors and to transfer the country's economy from oil-oriented to non-oil-oriented.

Study Objectives

- To prepare the Master Plan (M/P) of development of primary and secondary road network improvement, which covers the period from 2006 to 2030, in the Sultanate of Oman,
- To carry out pre-feasibility study on high priority projects identified under the M/P; and
- To pursue technology transfer to Counterpart personnel in the course of the Study.

Network Development Policy

- Developing the road network on technical base will realize the national objectives of both Oman Vision 2020 and Sixth Five Year Development Plan, including:
 - Rationalizing government spending,
 - Promoting culture and heritage,
 - Providing employment opportunities,
 - Accelerating economic diversification,
 - Developing non-oil industries,
 - Developing natural gas based industries,
 - Promoting and upgrading tourism spots and attractions,
 - Encouraging investments from private sector and local and foreign investors,
 - Realizing regional development

Network Development Objectives

- To contribute to national and regional economic development; by providing access to important facilities, industrial estates and tourism activities.
- To support international and GCC settings; by enhancing the international transport facilities, especially those related to ESCWA road network, for more cooperation with other Gulf countries.
- To provide welfare and improve living standards; by providing access from remote communities to public services and job opportunity locations.
- To support national and economic integration; by

providing reliable and safe road network with better transport conditions especially to areas faraway from the capital region, such as the two governorates of Dhofar and Musandam.

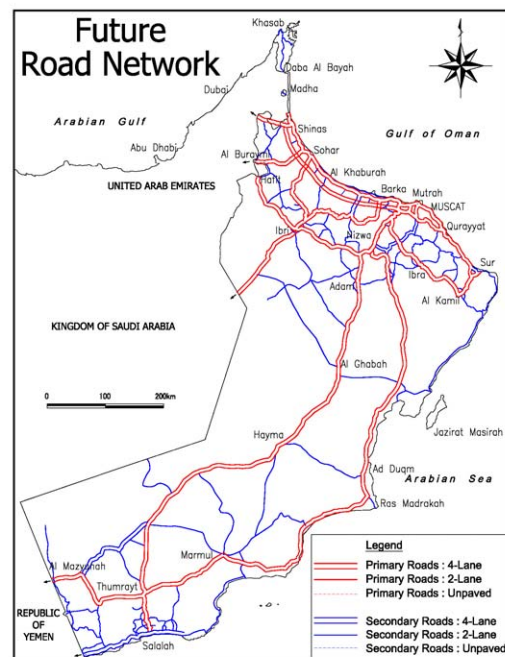
- To develop the network by considering measures to protect the heritage and natural environment of the Sultanate.

Network Development Strategies

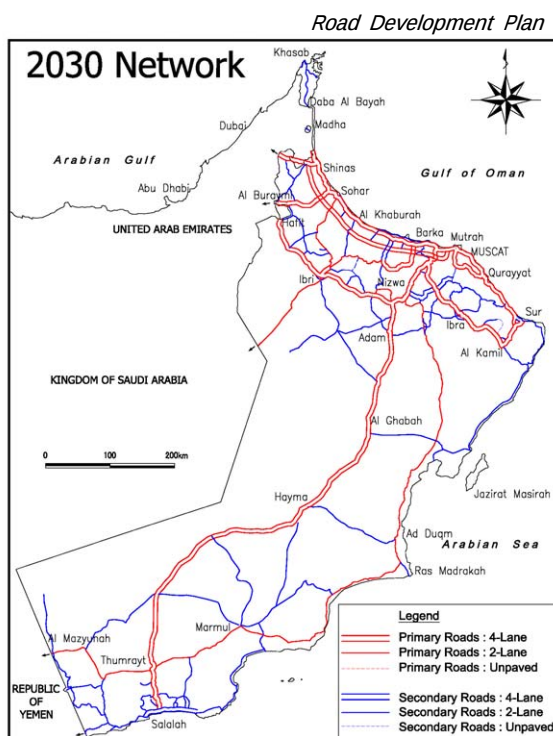
- Improving transport environment
- Improving international transport corridors that serve ESCWA
- Connecting major cities and development centres
- Increasing road safety on the network
- Providing strategic road alternatives
- Optimizing road density distribution
- Strengthening road network function
- Consideration of environmental aspects

Optimum Road Network

- This network is established, as a target for the future, to incorporate all the required improvement measures, with the main features of:
 - Primary roads are dualized to cater for high-speed, long-distance vehicle travel.
 - Connections across the mountain ranges are strengthened.
 - Detour routes for strategically important sections are secured.
 - All missing link sections are constructed.
 - Sections where traffic volumes are forecast to increase in the future are widened.
 - Specifically, New Batinah Expressway is constructed and NR No. 31 (Nizwa-Thumrayt-Salah Road) is dualized.



Master Plan Components and Cost



Major Components of Master Plan

Improvement Type	5-Year Plan					Total
	7 th	8 th	9 th	10 th	11 th	
Up-grading-km	-	270	-	-	-	270
Widening (4-L to 6-L)-km	-	-	-	-	54	54
Dualization (2-L to 4-L)-km	268	526	558	277	-	1,629
New Construction (4-L)-km	-	171	75	-	-	246
New Construction (2-L)-km	423	162	640	413	896	2,534
Bypass (4-L)-km	-	11	28	52	16	107
Grade Separation-Nos.	-	-	-	3	5	8
Pedestrian Crossing-Nos.	12	-	-	10	-	22

Road Investment (million RO)

Region	7 th	8 th	9 th	10 th	11 th	Total
Batinah	54.3	130.4	47.5	17.5	30.6	280.3
Musandam	62.1	-	-	-	-	62.1
Adh Dhahira	25.0	10.1	23.6	25.0	21.6	105.3
Ad Dakhiliyah	11.5	17.2	-	-	0.8	29.5
Ash Sharqiya	11.2	19.2	15.3	41.7	23.3	110.6
Al Wusta	1.8	15.3	17.6	-	13.1	47.8
Dhofar	21.2	48.8	64.7	49.1	50.0	233.9
Other Improvements	105.0	105.1	98.0	88.4	128.7	525.2
Total	292.1	346.2	266.7	221.7	268.0	1,394.7

Notes: 1. Budgets for other improvements are accumulated for all regions.
2. Investments in the table are those of primary and secondary networks only.

Environmental Evaluation

- The road network is developed to provide direct access between zones all over the Sultanate that will produce shorter trip-lengths and trip-hours. The shorter trips will result in less air pollution and positive environmental impact.
- Implementing the Master Plan projects as scheduled will improve the air quality by daily reduction of NO_x by 1.65 ton, HC by 1.69 ton and CO by 14.0 ton.

Plan Evaluation

- Traffic and economic parameters of average speed, congestion rate and savings in vehicle operating cost and travel time cost are used to assess the road network development efficiency.
- In addition to the indirect benefits of the plan regarding its impact on supporting national and regional development and improving living standards, all the applied parameters show that implementing the M/P projects will greatly improve the function and performance of the road network with daily savings of RO 644 million when compared with the "Do Nothing" case.

Traffic Parameters

Parameter	Case	2010	2020	2030
PCU-Km (million)	Do Nothing (A)	19.1	29.3	61.2
	Master Plan (B)	18.0	27.4	53.7
	B/A	0.94	0.93	0.88
PCU-Hr (million)	Do Nothing (A)	260.0	408.7	1,013.1
	Master Plan (B)	230.7	331.2	631.0
	B/A	0.87	0.80	0.61

Speed and Congestion

Parameter	Case	2010	2020	2030
Average Speed (km/hour)	Do Nothing (A)	73.4	71.7	60.5
	Master Plan (B)	78.1	82.7	85.0
	B/A	1.06	1.15	1.41
Average V/C Ratio	Do Nothing (A)	0.15	0.22	0.46
	Master Plan (B)	0.11	0.12	0.20
	B/A	0.73	0.55	0.43

Master Plan Savings (RO 1,000/day)

Year	Case	VOC Running	VOC Constant	Time Cost	Total
2010	W/O MP	627,736	282,429	192,645	1,102,810
	With MP	608,640	250,994	177,233	1,036,867
	Savings	19,096	31,435	15,412	65,943
2020	W/O MP	915,884	444,995	262,113	1,622,953
	With MP	867,441	360,337	222,814	1,450,592
	Savings	48,443	84,659	39,299	172,401
2030	W/O MP	1,709,549	1,109,426	435,552	3,254,528
	With MP	1,626,626	690,347	293,670	2,610,643
	Savings	82,924	419,079	141,882	643,885

Economic Indicators

Net Present Value (NPV)	RO 261 million
Benefit/Cost (B/C)	1.71
Economic Internal Rate of Return (EIRR)	12.3 %

Notes: A discount rate of 6.0% is applied

Main Conclusions

- The Road Network Development Master Plan is formulated in a comprehensive and systematic manner to cope with present and future transport requirements and to support economic diversification and welfare of the Sultanate.
- The Plan is justified to be economically, technically and environmentally feasible, and all projects can be implemented by applying normal construction methods and techniques.

PRE-FEASIBILITY STUDY PROJECTS

- The selected projects from the 7th Plan are four significant projects that meet the policy and concept of the Master Plan as well as the criteria required in Pre-F/S projects such as urgency, national integration and regional balance.
- In addition, three important projects in the 8th Plan that are delayed due to financial constraints, but need specific technical needs, are included.
- Al Hamra - Rustaq Road:** aims to strengthen the road network function in Northern Oman by providing connections across Al Hajar Al Gharbi Mountain Range. It is proposed that the "Without Bridge" plan be implemented first to meet the short-term traffic demand while the construction of the proposed bridge can be considered with the increase in traffic volume in the future.

	W/O Bridge Plan	W Bridge Plan
Cost:	RO 8,417 million	RO 11,495 million
NPV:	RO 34.1 million	RO 37.8 million
B/C:	4.95	4.24
EIRR:	27.3%	23.9%

- Madha - Dafta Road:** aims to provide basic road infrastructure within Wilayat Madha area without passing through UAE territory, to facilitate access to Dubai and other UAE areas, to improve the social welfare and strengthen the unity of the nation. It is technically and environmentally feasible but the direct economic benefits are low (based on the discounted rate of 6%).

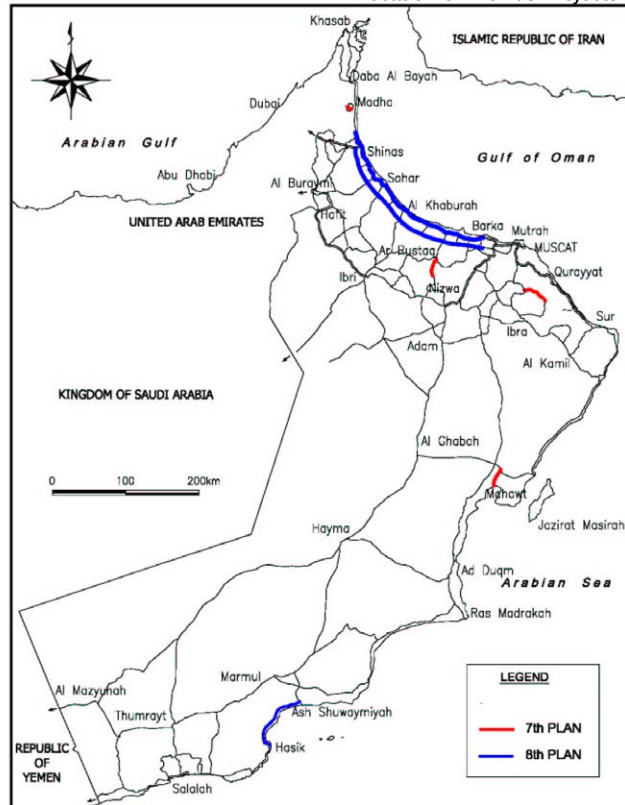
Cost:	RO 5.146 million
PV:	RO 465,600
B/C:	1.13
EIRR:	7.1 %

- Al Hij - Flim Road:** aims to provide proper access for people in this coastal area of Al Wusta Region. It supports development of tourism and provides access for local fishery to the markets in Muscat and UAE. It is technically and environmentally feasible but economic analysis results do not show high indicators.

Cost:	RO 1.767 million
NPV:	RO - 74,000
B/C:	0.95
EIRR:	5.5 %

- Mahla - Ismaiyah Road:** aims to strengthen the road network function in Northern Oman by providing connections across Al Hajar Ash

Location of Pre-F/S Projects



Sharqi Mountain Range and to support development of agriculture and tourism. The Project is technically, environmentally and economically feasible.

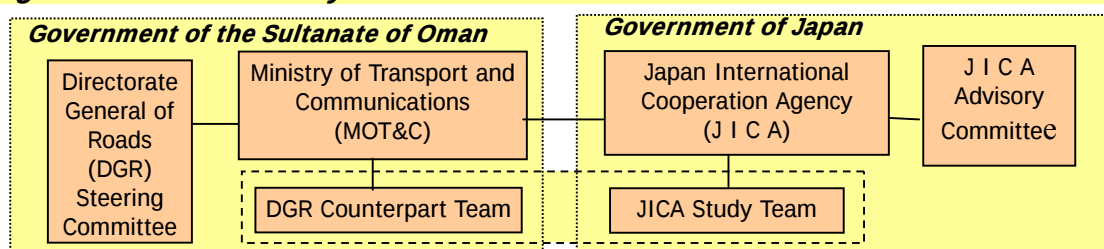
Cost:	RO 6.283 million
NPV:	RO 2.4 million
B/C:	1.45
EIRR:	9.1 %

- Hasik - Shuwaymiyah Road:** the most realistic alignment is along the coastline in the southern half, and then it goes inland to the north. In general it is found that the shorter the route, the higher the cost. As both sides of sea and mountains are environmentally critical, an EIA is required in coordination with MRMEWR.

- Batinah Highway:** Replacing Irish Crossings at wadi locations with multi-function culverts is justified economically, environmentally and technically. In addition, the provision of grade separation structures to eliminate at-grade junctions will upgrade the highway and improve its safety level.

- New Batinah Expressway:** is a major project detouring Batinah Highway that will promote economic diversification international transport and will play an important role in supporting Sohar Port. Government participation is required by applying a shadow toll system or in providing capital investment.

Organization of the Study



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Mr. UENO Ryuichi	Traffic Survey
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Mr. NAKAMURA Tomohiko	Construction Plan / Cost Estimate
Mr. KAJIMA Mikio	Environment and Social Impact
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Workshop



Steering Committee

INTRODUCTION

INTRODUCTION

General

Oman is located in the southeastern quarter of the Arabian Peninsula and covers a total land area of approximately 309,000 square kilometers. The land area is composed of varying topographic features; valleys and desert account for 82 percent of the land mass, mountain ranges for 15 percent, and the coastal plain for 3 percent.

Since the assumption of power of His Majesty Sultan Qaboos Bin Said in 1970, socioeconomic development has been greatly promoted in the Sultanate. As a part of his accomplishments, development of the transport sector has been very remarkable. At present, the Omani transportation system includes an expanding highway network, two modern deepwater ports, as well as other ports for oil and liquid natural gas, and two international airports facilitating international, intraregional, and domestic service. Currently, there are about 9,600 kilometers of paved roads and 27,100 kilometers of unpaved roads, of which 7,613 and 15,970 kilometers respectively are under the jurisdiction of the Ministry of Transport and Communications (as of December 2003); this in contrast to the situation in 1970, when there was only one paved highway with a length of 10 kilometers.

The Sultanate's modern transportation system links all significant populated areas within Oman and gives access to some international destinations. A four-lane highway runs west from Muscat along the Gulf of Oman to Dubai in the UAE. A second major paved highway in the interior connects locations from just east of Al Ayn in the UAE to Salalah on Oman's south coast. Good land connections link Oman only with the UAE, as roads that extend across the Saudi or Yemeni borders are still under improvement.

The transport planning and administration of primary and secondary road networks, as well as some local roads, with the exception of highways in Muscat Governorate, are administered by the Ministry of Transport and Communications through two Directorate Generals; of Roads in Muscat and of Communications in Dhofar.

Although pavement conditions have been improved, the road network still has many problems such as the interruption of traffic at *Wadis* during and after rainfall. Efforts are still needed for improving both primary and secondary road networks to provide all-weather roads with standard width and to efficiently increase the paved ratio of roads in the country. A well developed road network is required for the enhancement of the transport system in the country to cope with the diversification of industries

and development sectors to transfer the country's economy from oil-oriented to non-oil-oriented.

In response to a request from the Government of the Sultanate of Oman, the Government of Japan decided to conduct the Study on Road Network Development in the Sultanate of Oman. Accordingly, the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, is undertaking the Study. JICA organized and dispatched a Study Team to the Sultanate of Oman to commence the Study in January 2004.

Objectives of the Study

- To prepare the Master Plan (M/P) of development of primary and secondary road network improvement, which covers the period from 2006 to 2030, in the Sultanate of Oman,
- To carry out pre-feasibility study on high priority projects identified under the M/P; and
- To pursue technology transfer to Counterpart personnel in the course of the Study.

The Study Area

- The Study covers the whole Sultanate of Oman except the Governorate of Muscat.

Batinah Highway



Salalah – Yemen Border Road



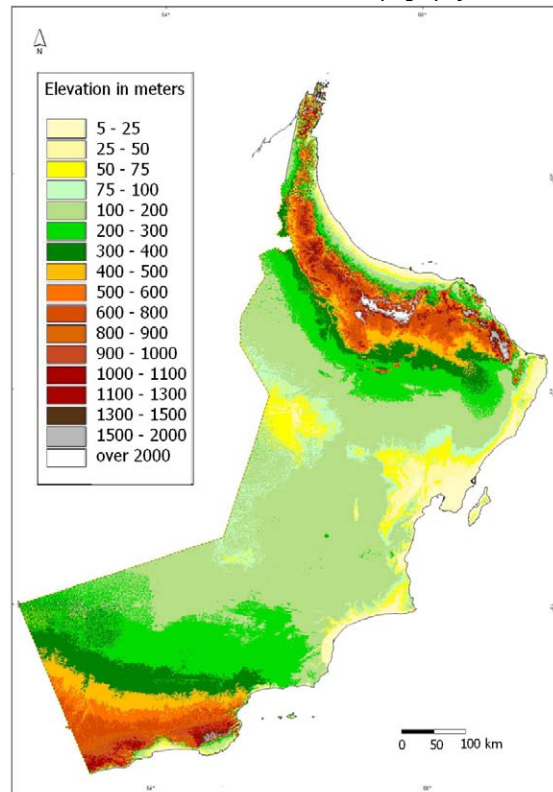
PART 1

PRESENT AND FUTURE ISSUES

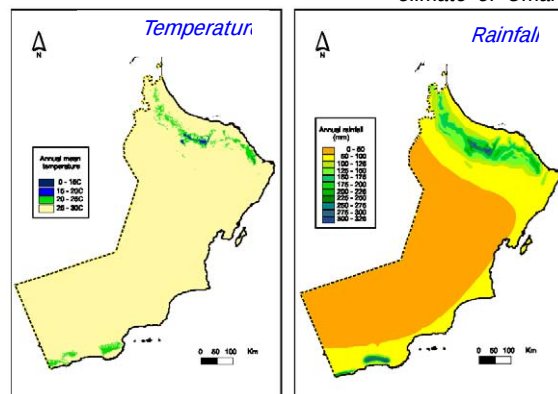
1. PHYSICAL PROFILE

- The Sultanate of Oman occupies the south-eastern corner of the Arabian Peninsula and has a total area of 309,000 km². It is bordered in the northwest by the United Arab Emirates, in the west by Saudi Arabia and in the south-west by Yemen. A detached area of Oman, separated from the rest of the country by the United Arab Emirates, lies at the tip of the Musandam Peninsula, on the southern shore of the Strait of Hormuz. The country has coastlines of almost 1,700 km, from the Strait of Hormuz in the north to the borders of Yemen in the south-west, overlooking three seas: the Arabian Gulf, the Gulf of Oman, and the Arabian Sea.
- Oman can be divided into the northern coastal plain with the most important part of the Batinah Plain, which is the principal agricultural area, and the southern Salalah Plain. There are also mountainous ranges occupy about 15% of the total area of the country.
- The mountain range that runs in the north close to the Batinah Plain is the Jabal Al Akhdar, with a peak at 3,000 meters. Other mountains are located in the Dhofar province, in the extreme southern part of the country, with peaks ranging from 1,000 to 2,000 meters. The internal regions lie between the coastal plain and the mountains in the north and south, consisting of several plains, with elevations not exceeding 500 meters.
- The climate of the Sultanate is characterized by mostly clear skies, light winds, warm dry winters and hot dry summers. It differs from one region to another. This arid climate is determined mainly by its location on the eastern side of the Arabian Peninsula.
- The climate is hot and humid during summer in the coastal areas, and hot and dry in the interior regions with the exception of some higher lands and the southern Dhofar region, where the climate remains moderate throughout the year. In the north and centre of Oman, rainfall occurs during the winter (November-April), while in the south and some internal parts of the country it is a result of summer storms (June-to September).

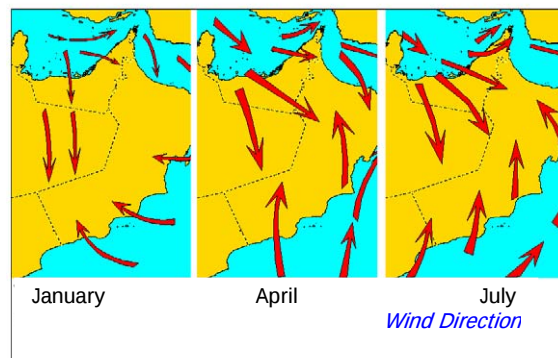
Topography of Oman



Climate of Oman



Wadi



PART 1: PRESENT AND FUTURE ISSUES

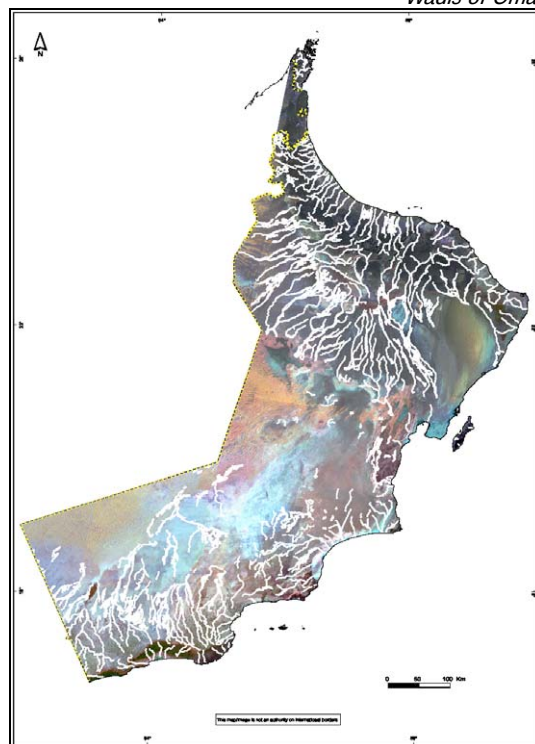
Wadis and Aflaj Systems

- The Sultanate of Oman is deprived of perennial **wadis** flowing to the sea, but a few wadis are perennial in part of their upper and middle reaches. Generally, surface water flow in Oman is rare; it lasts for a few hours or days following a storm and flooding.
- A wadi is a dry river bed that allows the flow of surface water. The topography of the Sultanate of Oman is carved and shaped by wadis that abound throughout the country. The location, shape, and nature of wadis are determined by the local geology and climate; conditions that change from one region of Oman to another.
- Drainage basins, which are delineated based on drainage divides, are also influenced by local geology and climate. All wadis eventually terminate either at the coastline, in inland depressions, or by vanishing into surface sand or alluvium. The erosive power of water over time scours and shapes the rocks; once the water has dissipated a spectacular view of the newly shaped surface is displayed. The amount of rainfall, surface rock characteristics, and topography dictate the patterns of drainage channels.
- Most wadi tributaries begin in the mountains and eventually join others to work their way to a lower elevation. These tributaries exhibit both dendritic and rectilinear patterns. As tributaries progress down-slope, the suspended sediments derived from chemical and mechanical weathering are deposited from the water as alluvium at the base of the mountains.
- Traditionally, most of Omani communities have evolved adjacent to **Aflaj systems**, which are channels originating from a mother well which intercepts the groundwater table or on the surface, for collecting groundwater or natural spring water, in order to be led away by tunnel for different uses, mainly for irrigation. The annual water requirement of the agricultural sector is 1,487 Mm³, which is used to irrigate 72,000 hectares throughout the Sultanate. The aflaj system provides 32% of the above requirement while 54% is obtained from wells.

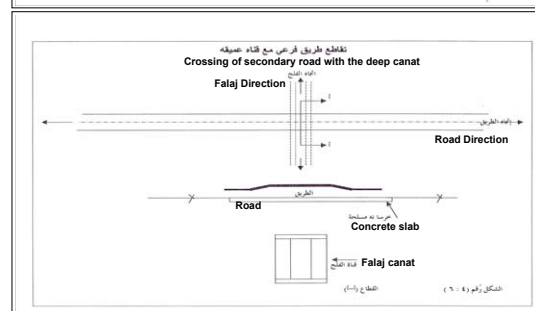
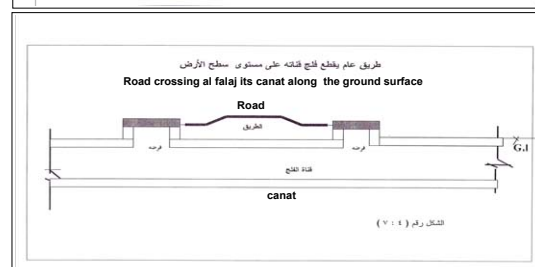
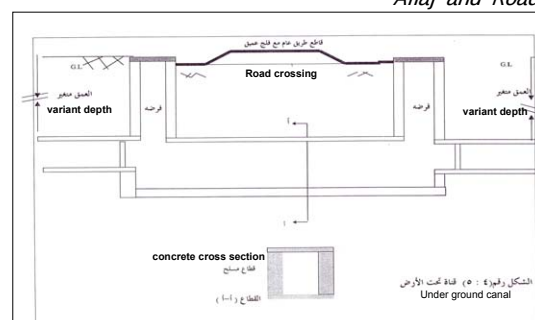
Aflaj System



Wadis of Oman



Aflaj and Roads



2. SOCIOECONOMIC FRAMEWORK

Present Conditions

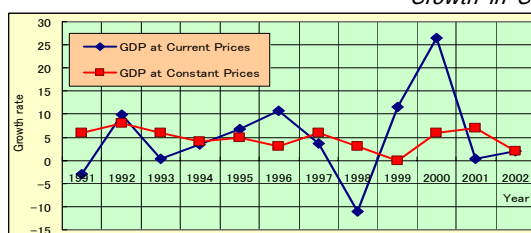
- The total population of Oman is 2,340,815 inhabitants (based on the final results of the census of 2003), with an increase of 322,741 from 1993 at an average growth rate of 1.45 %. About 23.9% of the total population, equivalent to 559,257, are expatriates and 76.1%, 1,781,558 are Omanis.
- More than half of the population of Oman is concentrated in the northern coastal governorate /regions of Muscat and Al Batinah, which occupy only 5% of the whole land area of the country.

Regional Population Density

	Area (km ²)	Population	Density
Oman	309,000	2,341,000	7.57
Muscat	3,900	632,070	162.07
Al Batinah	12,500	653,500	52.28
Musandam	1,800	28,370	15.76
A'Dhahirah	44,000	207,010	4.70
A'Dakhiliyah	31,900	267,140	8.37
A'Sharqiyah	36,400	313,760	8.62
Al Wusta	79,700	22,980	0.28
Dhofar	99,300	215,960	2.17

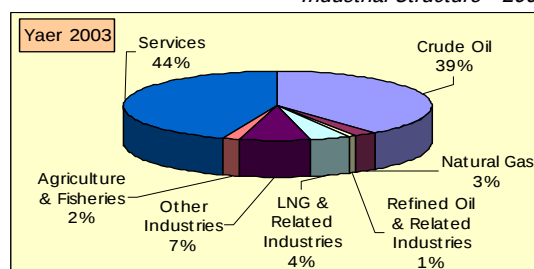
- Gross Domestic Product (GDP) of Oman is RO 8,302.4 million and GDP per Capita is RO 3,561, equivalent to US\$ 9,262 in 2003.
- Economic growth of Oman has been fluctuating in terms of current prices due to the fluctuation in oil prices. Despite such fluctuation, the Omani economy is considered to have been growing steadily as GDP at constant prices keeps its annual growth rates at around 4.5 %.

Growth in GDP



- In 2003, crude oil extraction accounted for 39% of the industrial structure of Oman, next to 45% for the service sector. All other sectors accounted for only 16%.

Industrial Structure - 2003



Future Framework

- Under this Study, three (3) possible scenarios are examined:

Scenario 1: Higher Omanization development

- to achieve Omanization as much as possible
- to promote higher productivity of each industrial sector, especially services and tourism industries
- to promote policies of 'Human Resource Development' and 'Omanization'

Scenario 2: New Oman Vision Development

- to attain the objectives of 'Oman Vision 2020'
- to promote higher productivity with the future target of more status employment

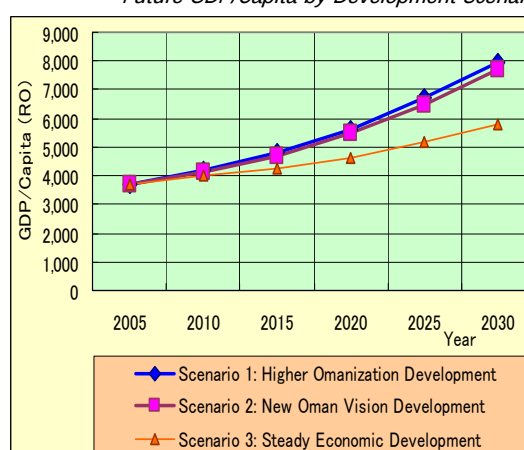
Scenario 3: Steady Economic Development

- to be rather a pessimistic future vision
- to keep future unemployment rate without declining under 20%

Among these scenarios, the Scenario 2 - New Oman Vision Development is adopted.

- The applied development scenario aims to economically attain the objectives and targets of Oman Vision 2020. In Oman, crude oil extraction is expected to drastically decrease in future. Daily average crude oil production was 819.5 thousand barrels in 2003. Oman Vision 2020 assumes a production level of 426 thousand barrels per day. To compensate, the Vision expects a high growth of natural gas extraction of 11.1% on annual average. And the Omani Government is making efforts to develop LNG and related industries.

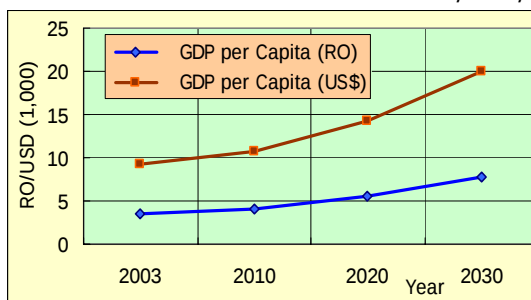
Future GDP/Capita by Development Scenario



- Adopting this scenario, the GDP will grow from RO 8,300 million in 2003 to RO 23,370 million (2.8 times the present scale) in 2030, at an annual average rate of 3.9%. GDP per Capita will rise from RO 3,560 (US\$ 9,260) in 2003, to RO 4,130 (US\$ 10,750) in 2010, RO 5,480 (US\$ 14,250) in 2020, and to RO 7,720 (US\$ 20,080) in 2030.

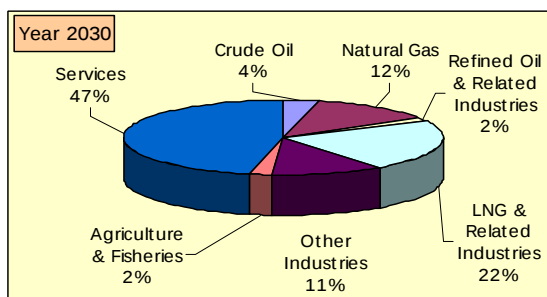
PART 1: PRESENT AND FUTURE ISSUES

Future GDP per Capita



- In 2030, the crude oil sector's share will decline to 4% and natural gas extraction will grow to occupy 12%. LNG and related industries will have a large share of 22%. Other industries will also expand their share from 7% in 2003 to 11% in 2030. The service sector will occupy the largest share of 47%, a little larger than the share in 2003. These indicators show that diversification of the Omani economy will gradually develop in the future.

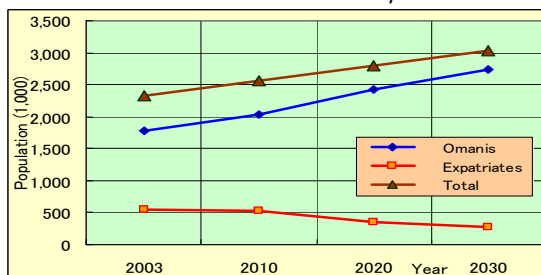
Industrial Structure in 2030



Population and Labour Force Forecast

- In future, despite a rapid decline of fertility rate, Omani population will increase gradually from 1,782 thousand in 2003, to 2,033 thousand in 2010, 2,433 thousand in 2020, and 2,746 thousand in 2030.
- Labour force participation rate of Omanis will rise and the number of employed Omanis will increase in future, due to the effect of human resources development. As a result, labour force demand for expatriates will decline and expatriate population will decrease from 552 thousand in 2003, to 526 thousand in 2010, 354 thousand in 2020, and 282 thousand in 2030.

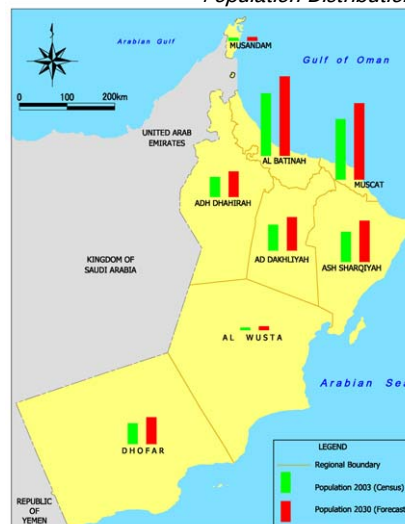
Population Forecast



Population Distribution

- In the future distribution of population, the share of Muscat and Batinah is expected to decline gradually due to constraints of land use and government development policy for regional balance.

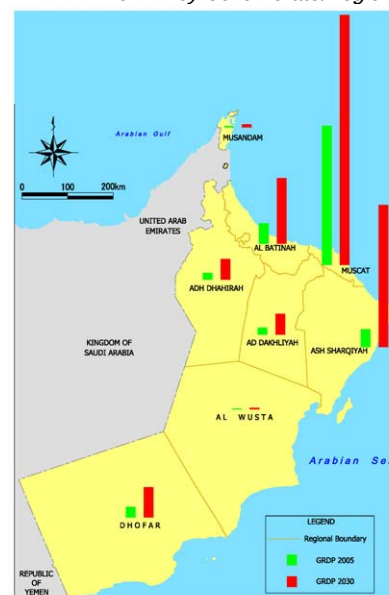
Population Distribution



Gross Regional Domestic Product (GRDP)

- Based on population distribution plans, large-scale industrial development projects, tourism development projects, etc., GRDP is estimated to grow strongly, especially in eastern regions.

GRDP by Governorate/Region



- The GRDP share of Muscat and Batinah is expected to decline gradually as a result of government development policy for regional balance, while the share of Ash Sharqiyah will increase due to large-scale development.

3. ROAD NETWORK

Transport System of Oman

- The transport system characteristics in Oman can be described as "Three Concentrations". Concentrations are: to vehicular transport, to Muscat and to private mode of transport.
- The transport infrastructure is composed of roads, ports and air transport. Railway does not exist at present. In addition, pipelines are widely used for oil and gas.
- The major airport is Seeb International Airport and the country has five other airports located at Salalah, Masirah, Khasab, Diba and Sur.
- The Sultanate is served by five major commercial ports, which are Khasab, Shinas, Sohar, Sultan Qaboos and Salalah, in addition to two ports for handling specific items in Muscat and Sur. A new port at Duqm is under planning.

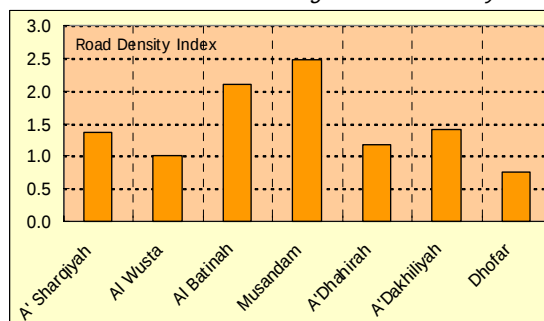
Road Length in Oman - 2003

Class		Length (km)
National Roads	Paved	7,613
	Unpaved	15,970
	Total	23,589
Municipal Roads		12,000
Total		36,000

Existing Road Network

- The length of paved roads is 7,613 km at present, compared with a mere ten (10) km in 1970.
- The total length of the national roads is about 23,589 km.
- High densities of national road are seen in Al Batinah and Musandam while low densities are seen in Dhofar and Al Wusta. It should be noticed that there is a considerable length of PDO roads in Al Wusta.

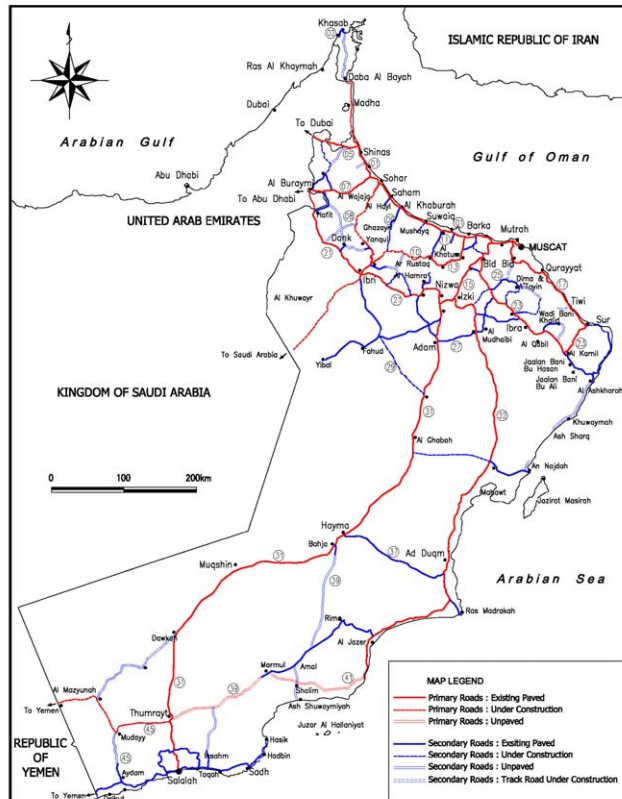
Regional Road Density Index



$$[Index = Length (km) / \{Population ('000) \times Area (km^2)\}^{1/2}]$$

- All major cities with populations of 5,000 or more, major ports, airports, industrial estates and trade zones are covered by the existing road network of primary and secondary roads.

Functional Classification of Road Network



- Missing links are recognized at two areas along the coastline, which are: from Ashkharah to Shanna in A'Sharqiyah Region and from Hasik to Shuwaymiyah in Dhofar Governorate. Other missing links exist also across the northern mountain range.

Hierarchy and Functional Classification

- Primary Roads are the backbone of the road network in Oman, which are used for high speed long-distance trips, connecting main towns, regions and neighbouring countries. Design speed is 120 km/hr and ROW is 80-120 m.
- Secondary Roads provide access from Primary Roads, connect towns and villages. Design speed is 100 km/hr and ROW is 50-80 m.
- Local Roads provide access from Secondary Road to villages. Design Speed is 80 km/hr and ROW is 30 m.
- Access Roads provide access to hamlets and farms. Design speed is 60 km/hr. ROW is 30 m.

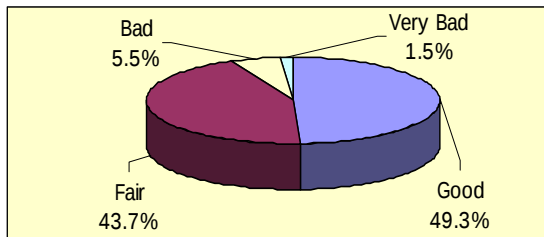
Road Network Condition

- A comprehensive inventory survey was carried out to establish a database and to assess the existing road network. The scope of the survey includes nationwide primary and secondary roads excluding Muscat Governorate.

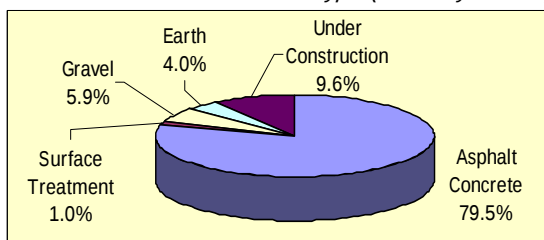
PART 1: PRESENT AND FUTURE ISSUES

- The recorded items of the road inventory survey are terrain, roadside land use, carriageway type, surface condition, median division, shoulder/sidewalk type, embankment/cut, drainage type, substandard alignment, wadi, safety barrier, drainage structure and side slope protection.
- Collected database includes bridges data with bridge name, road name, region, station, bridge type, span length, total length, carriageway width, sidewalk width, super-structure type (deck & beams) substructure (abutment, pier and foundation type), appurtenance (guardrail, shoe, expansion joint, drainage & skew angle), number of lanes and approach (inbound & outbound).
- The surface conditions are within reasonable margin since the ratio of bad and very bad is less than 10%. However, about 44% is fair condition and in future the maintenance of these roads is a very important task in order to maintain the road infrastructure in a satisfactory condition.
- Substandard shoulder widths are recognized in many locations. The ratios of widths less than 1.0 m and 2.0 m for secondary and primary roads are 13% and 25%, respectively.
- The survey on lengths of existing Irish Crossing show that 5% of the total surveyed road length is provided by this type of water crossing.

Road Surface Condition (Inventory Results)



Road Surface Type (Inventory Results)



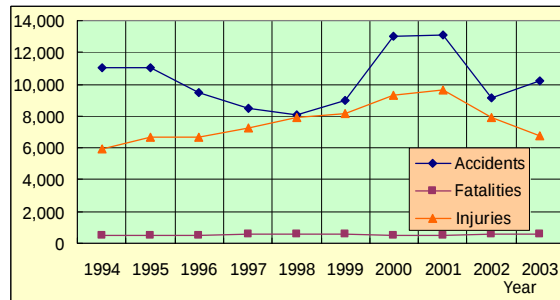
Road Administration

- Public roads are classified into National Roads and Municipal Roads. Further, there are roads maintained by PDO.
- National roads are administrated by MOT&C through two directorate generals; DGR and DGC. DGC is responsible for Dhofar Governorate while DGR is responsible for all other regions except Muscat Governorate.
- Budget for roads accounts 0.4 to 1.95% of the national budget which is considered small compared with international standards.

Traffic Accidents

- Neglect, speed and bad driving manner are the major causes of traffic accidents
- Major types of accidents are collision with other cars, fixed objects, and animals, respectively.
- The highest share of fatalities belong to Al Wusta (19.4%) and Ad Dakhliyah (10.1%) Regions, while the lowest shares are those of Muscat (2.6%) and Musandam (3.4%) Governorates.

Number of Traffic Accidents in Oman



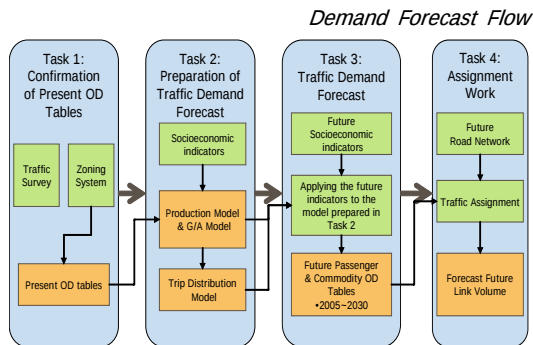
Road Network Problems

- Network Problems
 - Weak connection across the mountain ranges due to topographical restrictions
 - Many sections of the primary road network are not suitable or equipped for high-speed, long-distance trips
 - Vulnerability to flash flood at wadis
 - Lack of an alternative route for many roads including Batinah Highway
 - Missing links that decrease network function
 - Insufficient capacity at some road sections
 - Low pavement ratio of lower-class roads
- Road Link Problems
 - Poor pavement conditions (unpaved or deteriorated pavement) on some sections
 - Insufficient shoulder width along some sections
 - Substandard alignment (steep grades and small radius of horizontal curvatures) at some sections
 - Defective bridges and culverts
 - Low capacity roundabouts on heavy traffic roads
 - Traffic accident black spots, especially at the at-grade junctions of Batinah Highway and on 2-lane highways.
- Road Maintenance Problems
 - Shortage of competent personnel and human capacity building programs
 - Institutional insufficiency and weakness in regional offices,
 - Lack of advanced maintenance management systems
 - With the increase in road network length and traffic volumes in the future, maintenance tasks and problems, as well other existing problems, will be more severe if appropriate measures are not applied.

4. FUTURE TRANSPORT DEMAND

Demand Forecast Methodology

- Preparation of present OD tables,
- Development of traffic demand forecast model,
- Forecast of future traffic demand; and
- Assignment of traffic volumes on road network.



Present OD Tables

- Tables are prepared by applying the maximum entropy method to 2004 road traffic counts.
- The obtained results are assigned to the present road network; with a total difference less than 5% between the absolute value of the assigned results and observed results.
- In order to adjust seasonal difference of commodity flow, yearly average commodity flow on a regional basis is obtained from published statistics.
- The year 2005 is used as the basic year. The obtained 2004 OD tables are converted to the 2005 OD tables using DGR traffic count data (counted year by year until 2002)

Trip Generation / Attraction

- Production model is prepared in wilayat base 76 zoning system, utilizing the regional number of secondary and tertiary workers and Private car ownership.
- Generation/Attraction (GA) models of both passengers and commodity are prepared separately.
- GA model of passengers is formulated applying multi regression analysis method to the 2005 person trip OD and socio-economic indices of wilayat in 2005.

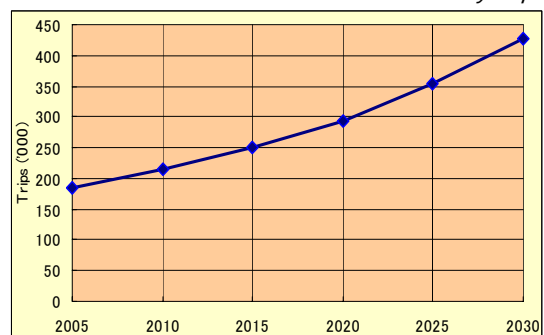
Socioeconomic Indicators

	2005	2030	Growth
Total Traffic (ADT)	103,810	263,855	3.8%
GDP (million RO)	8,888.3	23,371.0	3.9%
Population	2,421,750	3,027,835	0.8%
Car Ownership	305,736	577,759	2.6%

- GA model of commodities is prepared based on agricultural products, mineral products and industrial products.

- The GA models are developed first on a regional basis due to wilayat data limitations.
- Models are expanded in the wilayat base using the number of primary industry workers and number of secondary industry workers of wilayat.
- Distribution model is considered in the present pattern method.
- Modal split model is deduced from 2005 OD table by transport mode.
- Traffic demand forecast and future OD tables for passengers, commodity and vehicles are done for each five-year plan from 2005 until 2030.

Growth in Future Daily Trips



Desire Line

- The highlight growth in generation and attraction trips belongs to the Governorate of Muscat. It will keep its role as the core of the Sultanate of Oman in the future too, as indicated by the Desire Line Charts.
- Other cities with remarkable increased trips are Sohar, in which a large industrial area is located, and Sur sited beside on LNG plant. They are followed by zones in Al Batinah Region and Salalah.

Traffic Assignment

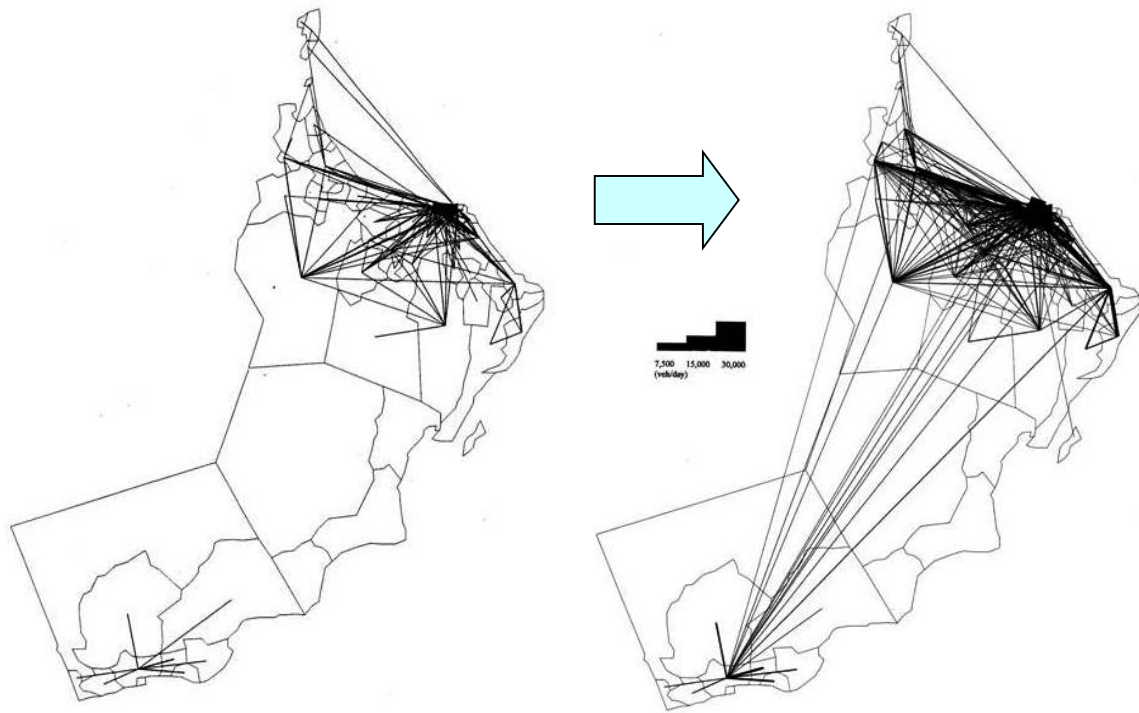
- Estimated traffic volumes for the years 2010, 2020 and 2030 are assigned on the present road network.
- In 2030, eight roads show overcapacity. All of the congested sections are located in the northern areas and are mostly links of Sur - Muscat - Al Khaburah Road (extension to Sohar).

Overcapacity Road Sections

Route No	Road	Section
Route 1	Batinah Highway	Muscat – Al Khaburah
Route 7	Wadi Hattah Road	As Sihaylah – Az Zurub
Route 15	Rusayl – Nizwa	Rusayl – Bidbid
Route 17		Muscat – Qurayyat
Route 21	Nizwa - Hafit	Nizwa – Bahla
Route 23	Bidbid – Sur	All Sections
Route 31	Nizwa – Thumrayt	Nizwa – Adam
Route 33		Izki – Al Mukhtara

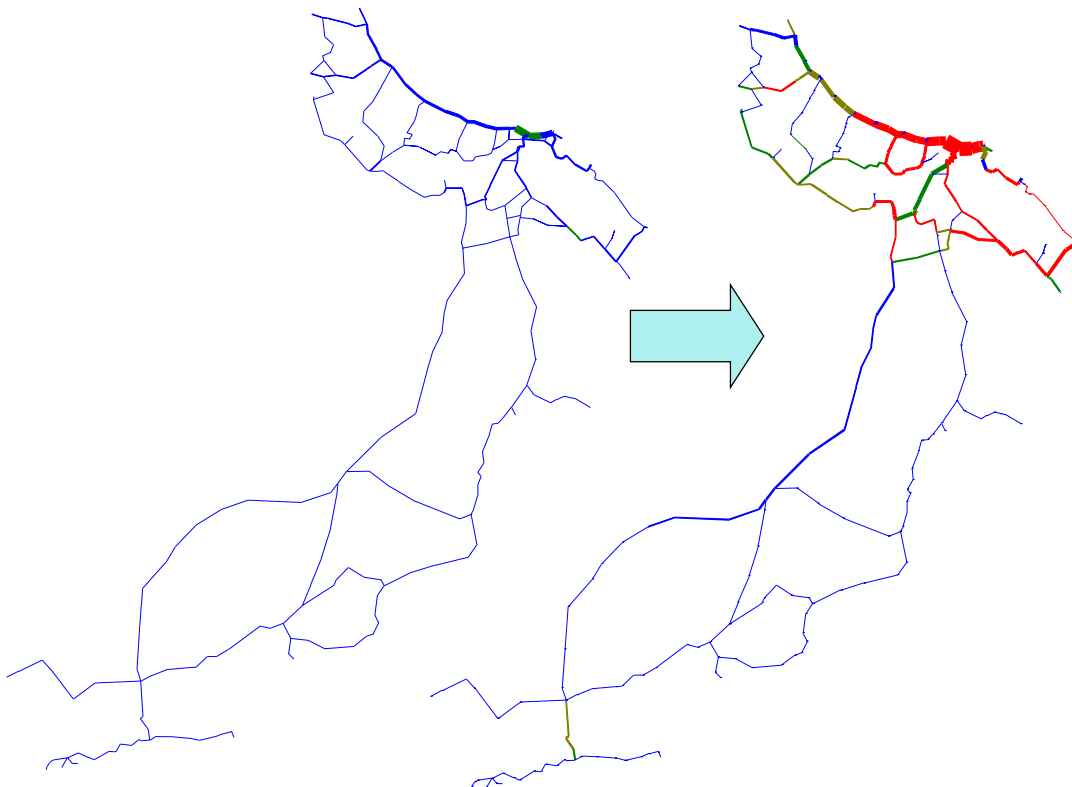
2005

2030



Traffic Flow
 VCR<0.60
 VCR<0.80
 VCR<1.00
 1.00<VCR

Assigned Traffic Volumes



PART 2

ROAD NETWORK DEVELOPMENT PLAN

5. NETWORK DEVELOPMENT POLICY

Future Development in Oman

- Oman Vision 2020, which gives the most important long-term development policy in the Sultanate, adopted the "Achievement of Economic Balance and Sustainable Growth" as the basic target, with the main strategies of:
 - Human Resources Development
 - Economic Diversification
 - Private Sector development
- The Sixth Five Year Development Plan is the second phase within the framework of Oman Vision 2020.
- Developing the road network on technical base will realize the national objectives of both Oman Vision 2020 and Sixth Five Year Development Plan, including:
 - Rationalizing government spending,
 - Promoting culture and heritage,
 - Providing employment opportunities,
 - Accelerating economic diversification,
 - Developing non-oil industries,
 - Developing natural gas based industries,
 - Promoting and upgrading tourism spots and attractions,
 - Encouraging investments from private sector and local and foreign investors,
 - Realizing regional development.

Development Potential Areas in Oman

- The concentration of population and economic activities in the northern areas along the northern coast and south of the mountainous ranges is a continuation of the historical and present socio-economic distribution patterns.

- The national plan is promoting comparable levels of development in the different regions of the country, and the economy diversification to new sub-sectors. The economic establishment of new development centres and activities through regional development is a major target of the government's vision toward the future.
- As such efforts by the government are expected to continue for the short-, medium- and long-term planning periods, development of the road network should proceed towards future development requirements.

Network Development Objectives

- To contribute to national and regional economic development; by providing access to important facilities, industrial estates and tourism activities.
- To support international and GCC settings; by enhancing the international transport facilities, especially those related to ESCWA road network, for more cooperation with other Gulf countries.
- To provide welfare and improve living standards; by providing access from small and remote communities to public services, markets and job opportunity locations.
- To support national and economic integration; by providing reliable and safe road network with better transport conditions especially to areas faraway from the capital region, such as the two governorates of Dhofar and Musandam.
- To develop the network based on environmental considerations; by taking into consideration measures to protect the rich natural environment of the Sultanate.

Network Problems and Countermeasures

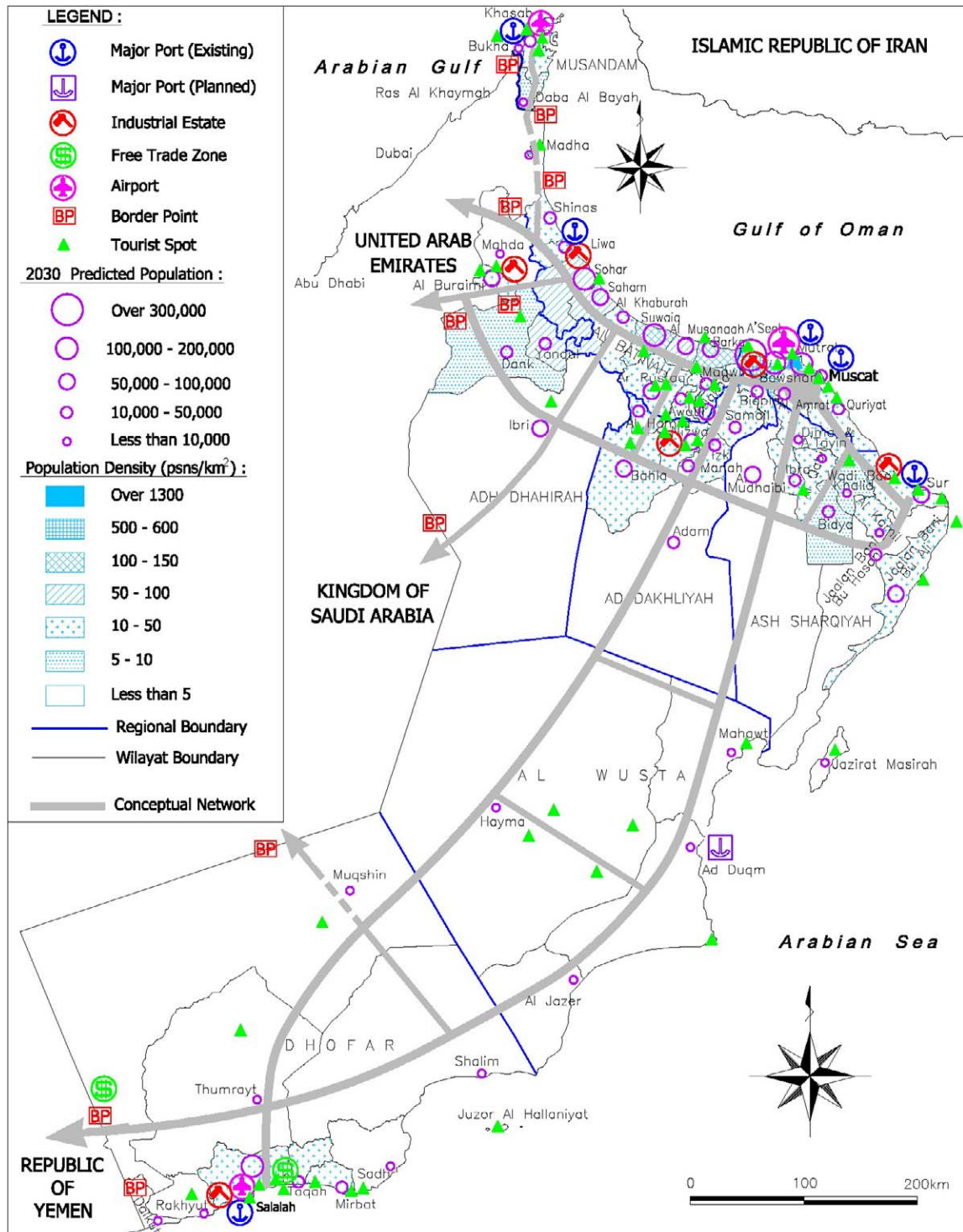
No.	Problems	Countermeasures
Road Network Problems		
i	Weak connection across the mountain ranges	- Construction of roads across mountain ranges
ii	Primary road network not suitable for high-speed, long-distance trips	- Dualization - Providing grade separation at major intersections - Construction of bypasses
iii	Vulnerability to flash flood	- Construction of detour routes - Convert Irish crossing into culverts (Batinah Highway)
iv	Lack of an alternative route to Batinah Highway	- Construction of New Batinah Expressway
v	Missing links	- Construction of missing link roads
vi	Insufficient capacity at some sections	- Widening of congested sections - Provision of alternate route
vii	Low pavement ratio of lower-class roads	- Paving local and access roads
Road Link Problems		
viii	Poor pavement conditions on some sections	- Paving unpaved roads - Rehabilitation of deteriorated pavement
ix	Insufficient shoulder width along some sections	- Widening of shoulders
x	Substandard alignment at some sections	- Improvement works for substandard sections
xi	Defective bridges and culverts	- Repair defects
xii	Low capacity roundabouts on heavy traffic roads	- Provide grade-separation structures
xiii	Traffic accident black spots	- Physical improvement - Enforcement - Road-user education

PART 2: ROAD NETWORK DEVELOPMENT PLAN

Network Development Strategies

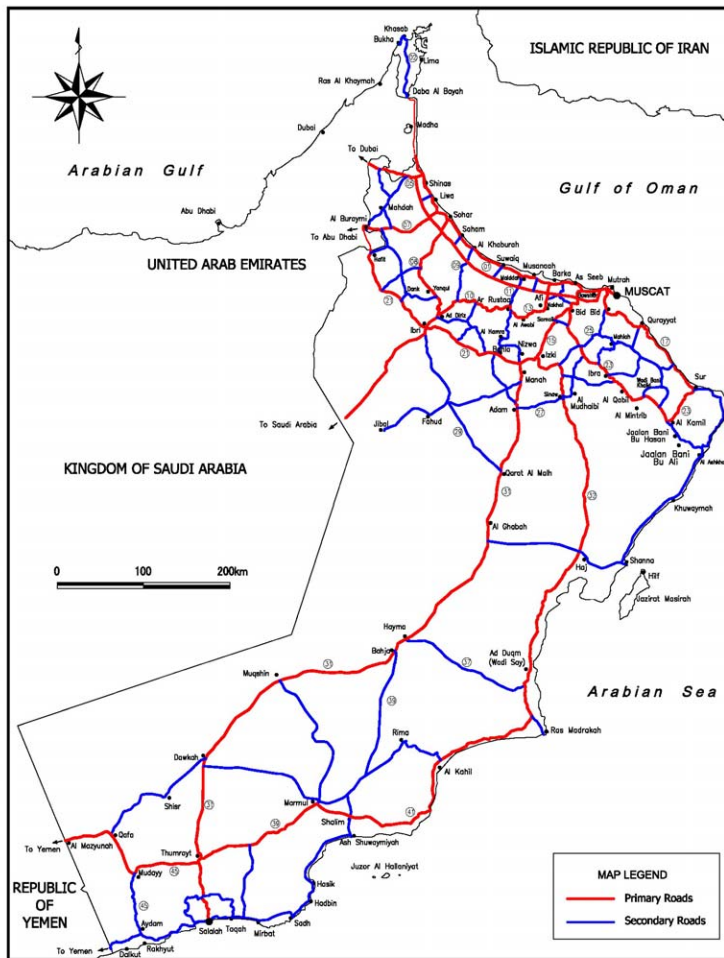
- Improving transport environment
- Improving international transport corridors by integrating them with ESCWA network
- Connecting major cities and development centres
- Improving road safety on the network
- Providing strategic road alternatives
- Optimizing road density distribution
- Strengthening road network function
- Consideration of environmental aspects

Future Development Potential in Oman and Basic Conceptual Network



6. ALTERNATIVE NETWORK AND EVALUATION

Basic Future Road Network



Basic Road Network

- To establish alternatives of the future road network, a basic network with the basic requirements is formulated.
- In this basic road network, all the measures to achieve the objectives of the future road network planning, such as strengthening of connections across mountain ranges, provision of detour routes and elimination of missing links are incorporated.
- Considering great difference in the characteristics of regions, alternatives are prepared separately for:
 - Northern Part
 - Central and Southern Part

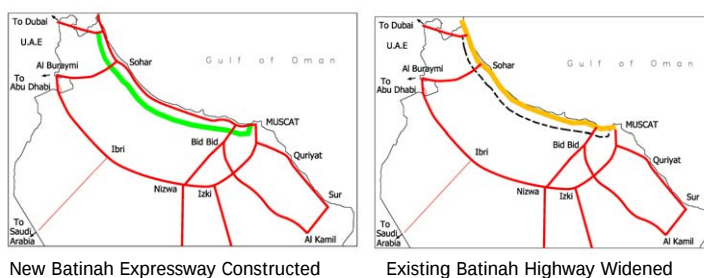
Alternatives for Northern Part

- The following two alternatives are established:
 - Construction of New Batinah Expressway (NBE)
 - Without NBE and widening of existing Batinah Highway

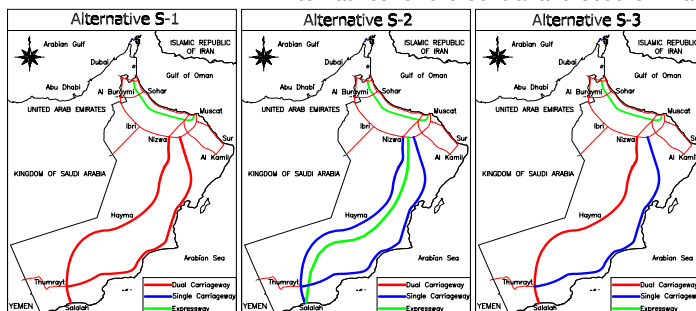
Alternatives for Central and Southern Part

- For this part, three alternatives are considered:
 - Alternative S-1: Both of the Central and Coastal Routes of North-South Corridor are dualized
 - Alternative S-2: A new 4-Lane dualized expressway is constructed between the two Central and Coastal Routes and both routes are maintained as 2-Lane single carriageway road.
 - Alternative S-3: Only the Central Route is dualized as 4-Lane and the Coastal Route is maintained as 2-Lane single carriageway road.
- After preliminary screening, the Alternative S-2 option of constructing a new expressway is discarded due to technical difficulties, negative environmental impact as well as the higher cost of construction.

Alternatives for Northern Part

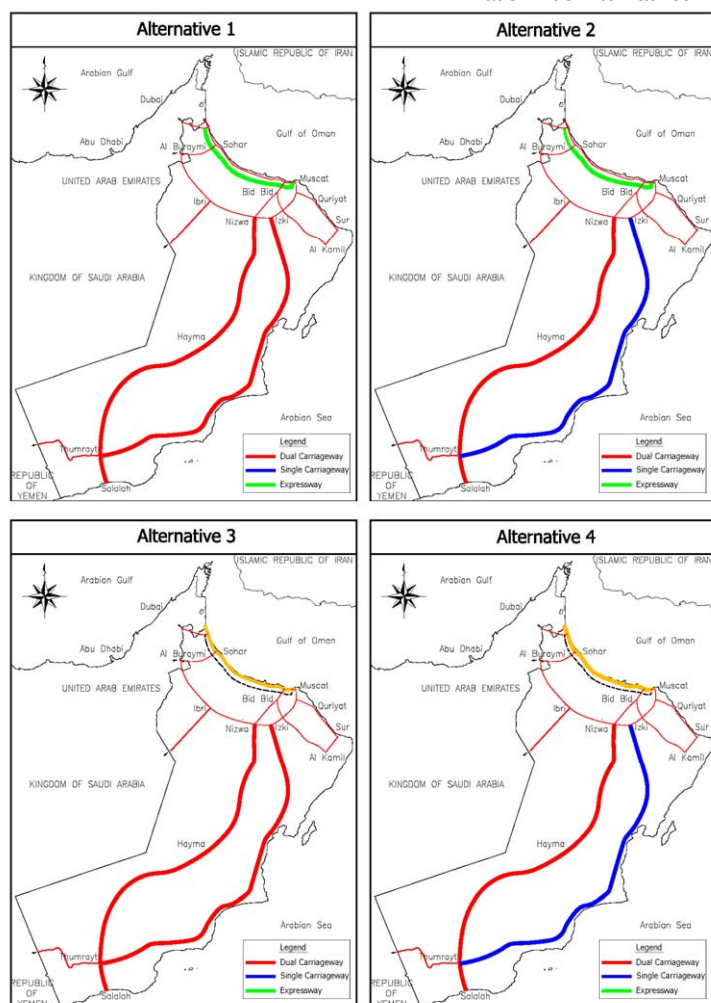


Alternatives for the Central and Southern Part



Part 2: Road Network Development Plan

Nationwide Alternatives



Alternatives for Nationwide Network

- Consequently, four alternatives are established for the nationwide network.

Comparative Evaluation

- Alternatives 3 and 4 are not recommended as no detour route is provided for Batinah Highway, and severe traffic confusion is anticipated if Batinah Highway is closed. In addition, NBE will promote economic diversification by developing new areas.
- Alternative 2 gets the higher score between the remaining two alternatives.

Selected Road Network

- Alternative 2 fulfils its assumed functions and requirements, and thus is adopted as the Optimum Road Network.
- The difference of scores between Alternatives 1 and 2 is relatively small. Therefore, Alternative 1 is recommended as a "Substitute Plan" to be considered in later years depending on changes in the assumed conditions and financial resources.

Comparative Evaluation of Alternatives

				Alternative - 1		Alternative - 2		Alternative - 3		Alternative - 4					
Cost (RO Million)				1,271.9		△	1,141.8		○	1,180.4		○	1,070.4		◎
Traffic Efficiency (Year 2030)	Congestion (V/C)			0.169		◎	0.199		◎	0.174		◎	0.204		◎
	Ave. Travel Speed (km/hr)			83.9			83.0			83.2			82.1		
	LOS by length (km) in Northern Part	A-C	7,581 (95%)	7,599 (95%)			7,497 (97%)			7,427 (97%)					
		D	413 (5%)	380 (5%)			224 (3%)			268 (3%)					
		E-F	0 (0%)	0 (0%)			0 (0%)			0 (0%)					
Economic Efficiency	Savings in VOC (RO 1,000)			271,129		○	269,315		◎	262,741		◎	256,529		◎
	Single Year B/C			1.96			2.04			2.03			2.08		
	Single Year NPV (RO 1,000)			133.160			137,330			133,500			133,410		
Reliability/Flexibility of Network				Requirements satisfied		◎	Requirements satisfied		◎	Severe confusion of traffic is anticipated if Batinah Highway is closed		X	Severe confusion of traffic is anticipated if Batinah Highway is closed		X
Development Effects				Requirements satisfied		◎	Requirements satisfied		◎	Requirements satisfied		◎	Requirements satisfied		◎
Environmental Consideration				Exhaust gas reduced		◎	Exhaust gas reduced		◎	Exhaust gas reduced		◎	Exhaust gas reduced		◎
Score				◎4, ○1, △1			◎5, ○1			◎4, ○1, X 1			◎6, ○0, X 1		
Evaluation				Future Substitute			Optimum Plan			Not Recommended			Not Recommended		

7. ROAD NETWORK DEVELOPMENT PROJECTS

Basic Measures

- Based on the identified problems for the whole road network and on the link base, measures are designed to mainly include:
 - Construction of roads across the mountain ranges of Al Hajar Al Gharbi, Al Hajar Al Sharqi and Dhofar Chains.
 - Establishing a network of main primary roads suitable for high-speed, long-distance trips to be integrated with ESCWA Network.
 - Reinforcement of the road network at built-up areas and against flash floods by converting Irish crossings to culverts especially those of Batinah Highway.
 - Construction of New Batinah Expressway as an alternate route for Batinah Highway.
 - Construction of missing link road sections
 - Paving local and access roads.

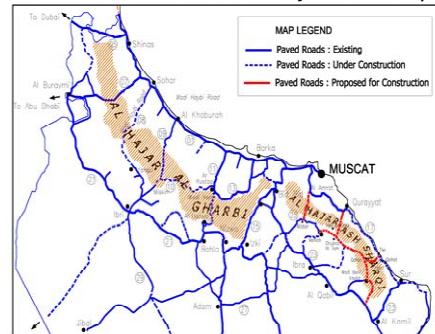
Optimum Road Network

- This network is established to incorporate all the required improvement measures, with the main features of:
 - Main primary roads are dualized to cater for high-speed, long-distance vehicle travel.
 - Connections across the mountain ranges are strengthened.
 - Detour routes for strategically important sections are secured.
 - All missing link sections are constructed.
 - Sections where traffic volumes are forecast to increase in the future are widened.
 - Specifically, New Batinah Expressway is constructed and NR No. 31 (Nizwa-Thumrayt- Salalah Road) is dualized.

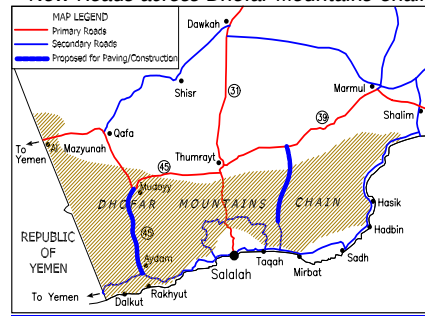
Road Network Development Projects

- Upgrading:** This project is to replace Irish crossings with (multi-function) culverts. The road development plan includes the upgrading of Batinah highway to a full-weather highway. Grade-separation structures are also provided at the black-spot locations of at-grade junctions/intersections.
- Widening:** These works are to increase the number of lanes of the same carriageway from 2-lane to 3-lane per direction. Widening from 2-lane (undivided) to 4-lane (divided) is classified as "Dualization" as described later.
- Dualization:** This work is to construct new carriageway parallel to an existing one. Here, the single carriageway 2-lane road will be converted into divided or dualized 4 or more-lane road. This includes the construction of a median between the two carriageways
- New Construction:** This is conversion of an unpaved road to a paved road. It may include improvement of alignment, cross section, drainage and other facilities. Also, it includes the construction of new paved roads where there is no existing road.
- Bypass Construction:** This is to construct a bypass of an urbanized road section at cities and towns.
- Grade Separation:** This is to provide grade-separated structures at congested roundabouts and intersections by constructing a viaduct (flyover) or underpass.
- Other Improvements (Mainly Measures for "Road Link Problems):** Road rehabilitation and maintenance,

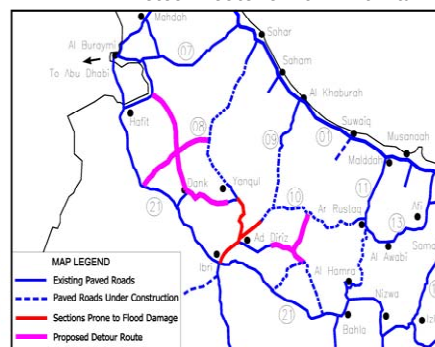
New Roads across Al Hajar Ash Sharqi



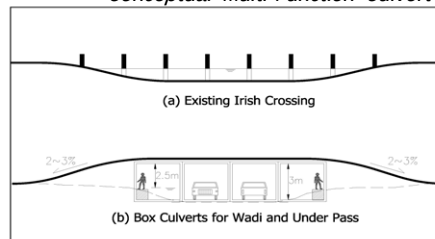
New Roads across Dhofar Mountains Chain



Detour Route for Ibri – Ad Dariz

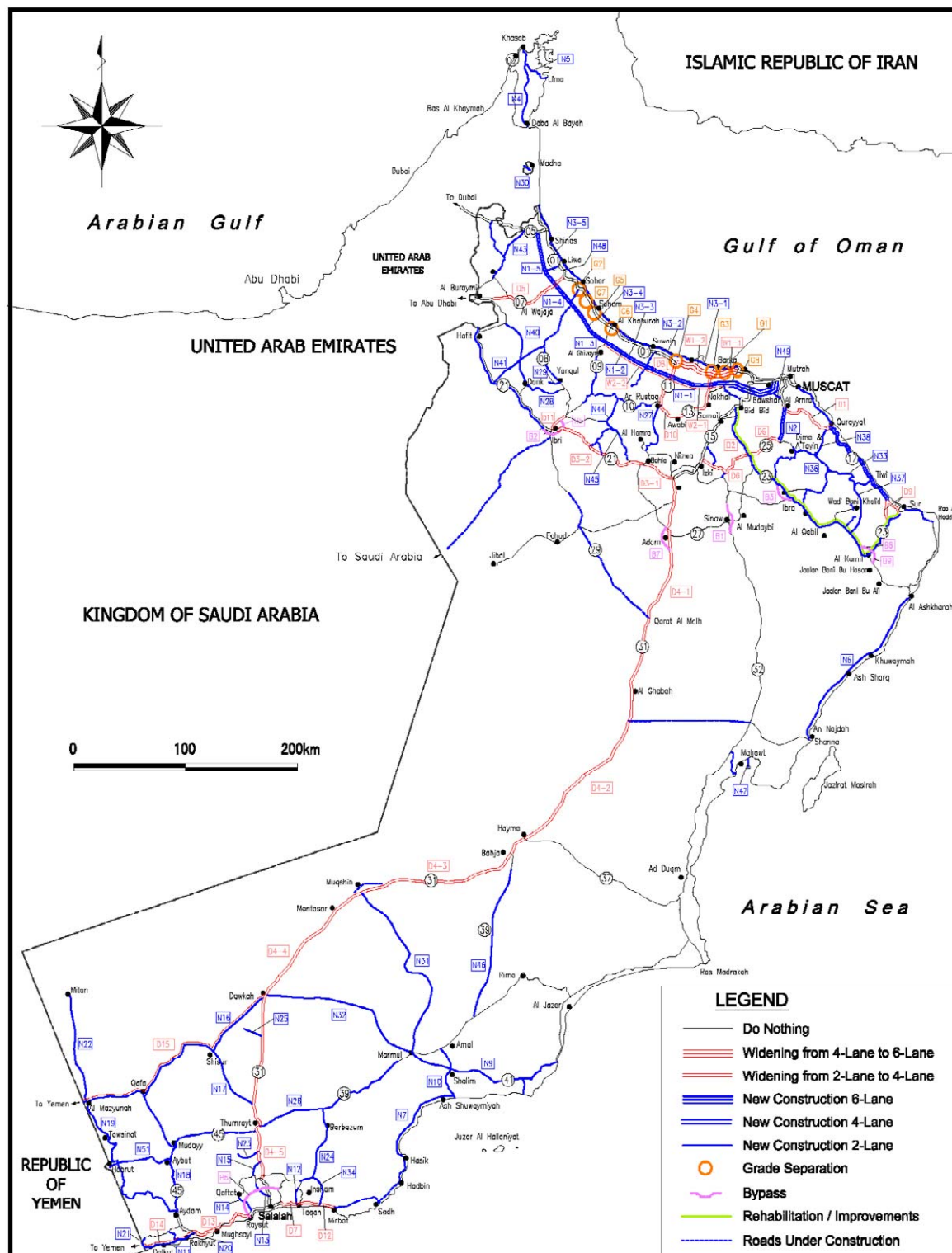


Conceptual Multi-Function Culvert



construction of pedestrian crossings, rehabilitation of defective bridges, improvement (widening) of shoulders and physical improvement of black spots are the major improvements included under this type.

Optimum Road Network



8. Initial Environmental Examination

Legislation

- The “Law on the Conservation of Environmental and Preservation of Pollution”, which is the basic environmental law of Oman, was initially instituted as RD 10/1982, and revised as RD 114/2001.
- The law establishes rules for the protection of Omani environment, nature conservation, and historical and cultural heritages. It contains pollution standards, environmental permit process for projects, environmental impact assessment study, ecosystems monitoring and control, standards for hazardous waste, marine environment, exploitation of natural resources, etc.
- The “National Biodiversity Strategy Action Plan” as the national strategy was declared in 2001.
- The “Guidelines for Obtaining Environmental Permit” require to carry out an “Environmental Impact Assessment (EIA)” for road construction projects, mostly involving national road.

Initial Environmental Examination (IEE)

- The objectives of the “Initial Environmental Examination (IEE)” at the Master Plan stage are to investigate the present condition of the proposed road area, to identify and anticipate adverse impacts due to implementation of the proposed road projects and to propose necessary mitigating measures, if necessary.
- The IEE study covered a total number of 91 road projects with a total length of 5,694 km by using the developed “Environmental Checklist” based on the guidelines in both Oman and Japan.
- The environmental items consist of air pollution, effluent, noise and vibration, land subsidence, topography and geology, soil and soil erosion, hydrology and groundwater, ecosystem, flora and fauna, landscape, regional development on the natural environment, hazards, other impacts on natural environment, wastes, cultural heritage, regional development and other impacts on the social environment.

ENVIRONMENT OF CRITICAL PROJECTS

Project Roads in Mountainous Terrain

- Project N27 is located in the central part of the Jabaj Al Hajar Al Gharbi Mountains (Oman Mountains) at Al Jabal Al Akhdar (Jabal Shams) Mountains. The road crosses the eastern ridge of Jabal Shams, being the highest peak, 3,009m, in Oman. The vegetation can be classified as an open xenomorphic *Euphorbia* community type. Wildlife known to the area includes the Arabian Leopard, Gazelle, Arabian Tahr, Red Fox, etc. The IUCN red list of threatened animals (IUCN 1990) describes the mountain gazelle as vulnerable. Adverse impacts of alteration of topography due



Landscape of N27 Project northeast of Jabal Shams

to large-scale excavation and embankment are anticipated.

Project Roads along Wadi

- Project N36 passes along Wadi Tayin and Wadi Kabbah. Kabbah village is located in the middle part of the wadi, marked by narrow wadi channel with wadi vegetation and dates palm farmland. Adverse impacts of noise, vegetation, etc. due to increased traffic are anticipated.



N27 narrow Wadi Kabbah channel

Project Roads at Flat Area

- D4-3 is located from Hayma to Muntasaar in the Al Wusta Region. The project area is mostly flat desert terrain with rare or sparse vegetation. Slight impacts of alteration of topography are anticipated. The area is continuously affected by sand dunes encroaching from the northwest.

Project Roads along Coastline

- Project N7 is located between Hasik and Shuwaymiyah along the coastline, where the area is proclaimed as the protection area of the “Jabel Samhan Natural Reserve”. There is no existing road, hence significant adverse impacts on ecosystem, flora and fauna, landscape, topography, etc. due to alteration of topography are anticipated in the area.

Project Roads Accessing to Coast

- Project N47 is located between Al Hij and Flim adjoining coast. Flim is the access point to Mahawt Island. Mangroves are locally found around the lagoon and sabkha at Flim and Mahawt Island.

PART 2: ROAD NETWORK DEVELOPMENT PLAN



*Coastline and Wadi Mouth of Wadi Sunayk
between Hasik and Shuwaymiyah*



*Alteration of topography and deforestation
(Dry season)*



Sabkha and Mangroves at Flim

Mahawt Island is surrounded by rich fishing areas. Hence, adverse impacts on ecosystem, flora and fauna, etc. due to road construction and increased visitors to the area are anticipated.

Project Roads Passing Woodlands of Salalah

Projects N11, N12, N13, N14 and N20 are located in Salalah area. These roads pass through limestone cliffs and steep slopes, which are covered by rich vegetation with numerous valuable fauna, including Arabian Leopard, Nubian Ibex, Arabian Gazelle, Striped Hyenas, Caracal, etc., that forms typical woodland of subtropical monsoon terrain. Adverse impacts on ecosystem, flora, fauna, landscape, etc. due to alteration of topography, deforestation of woodland, usage of road, etc. are anticipated.

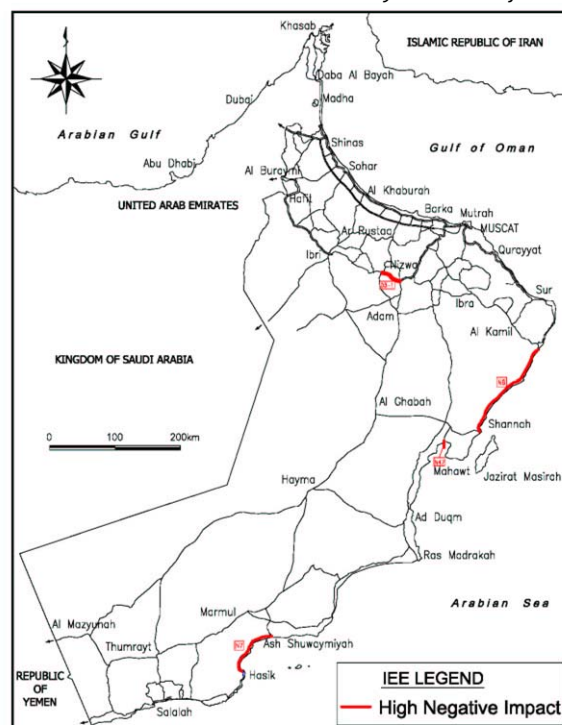


*Green woodland at Salalah in October
(Wet season)*

Results of IEE

- The impact rating for the comprehensive evaluation to each project road is classified into five classes, including 3 (significant), 2~3, 2 (moderate), 1~2, and 1 (slight) classes.
- Project roads on N7 and N47 are designated as Class 3 by the comprehensive evaluation. A comprehensive EIA as well as examination of alternatives should be required.
- Project roads on D3 and N6 are designated as Class 2~3. A comprehensive EIA should be required.
- A total of 34 projects are designated as Class 2. A comprehensive EIA is recommended.
- A total of 27 projects are designated as Class 1~2. Partial EIA after scoping of the project is required.
- A total of 28 projects are designated as Class 1. EIA is not required.

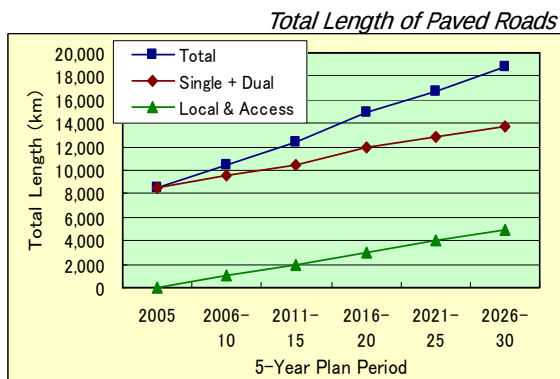
Location of Environmentally Critical Projects



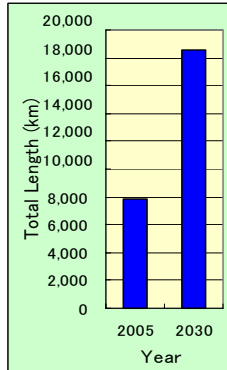
9. MAINTENANCE PLAN

Future Maintenance Demand

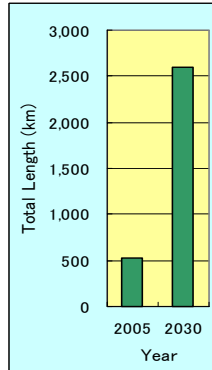
- The total length of paved primary and secondary roads will increase to 11,000 km in year 2030 from around 8,000 km in 2005.
- The total length of paved roads including local and access roads will increase from 7,800 km to 18,600 km in 2030.
- The total length of dual carriageway roads will increase to 2,800 km in 2030 compared with 531 km in 2005.



*Total Length Including
Local & Access Roads*

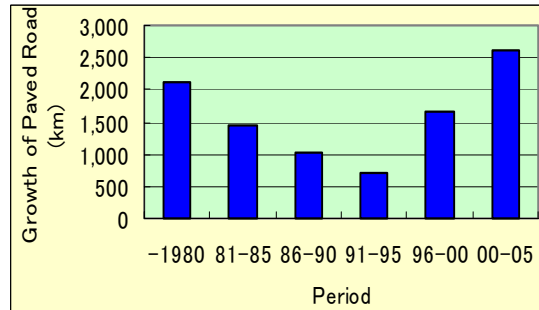


*Length of Dual
Carriageway Roads*



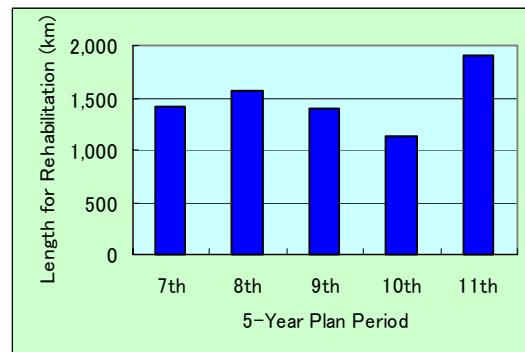
- In the past, the total length of pavement constructed in each 5-Year Plan Period was between about 700 km to 2,600 km.
- From the result of the Road Inventory Survey and the record of construction, life period of pavement in the Sultanate is estimated as 25 years even though it is assumed to be 15 years in the design process.
- Long life of pavement in Oman is attributed to the following three factors:
 - Favourable sub-grade condition
 - Light traffic
 - Scarce rain
- The pavements constructed before 1980 are 25 years old and will need rehabilitation in the 7th 5-Year Plan Period.

*Length of Pavement
Constructed in Past 5-Year Period*



- However, judging from the fact that pavements of considerable sections older than 25 years are still in good condition, 25 % of the rehabilitation of pavement constructed before 1980 is assumed to be carried forward to the 8th 5-Year Plan Period.
- Similar adjustment is made for the pavements to be rehabilitated in the 8th 5-Year Plan Period.
- Conversely, life period of pavements of some sections to be rehabilitated in the 11th and 12th 5-Year Periods are assumed to become shorter than 25 years due to increase in traffic volume.
- After the above adjustment, the length to be rehabilitated in each 5-Year Plan Period becomes as shown in the figure below:

Length of Pavement Rehabilitation



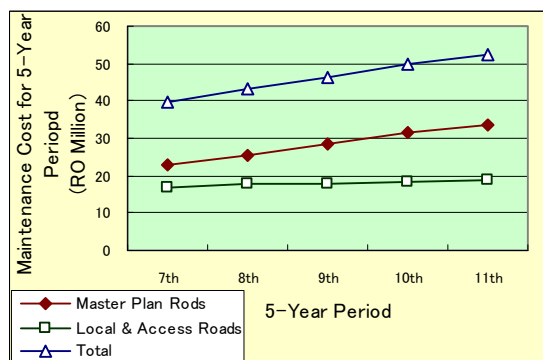
Maintenance Cost

Routine Maintenance:

- As the length of paved roads increases, the cost of routine maintenance is also estimated to increase in the future.
- Nationwide average unit cost of routine maintenance is calculated from the current contracts of maintenance and used in estimation of the cost of routine maintenance in each 5-Year Plan Period.
- The cost of periodic maintenance for each 5-Year Plan Period is estimated to increase as shown in the figure below.

Part 2: Road Network Development Plan

Cost of Routine Maintenance

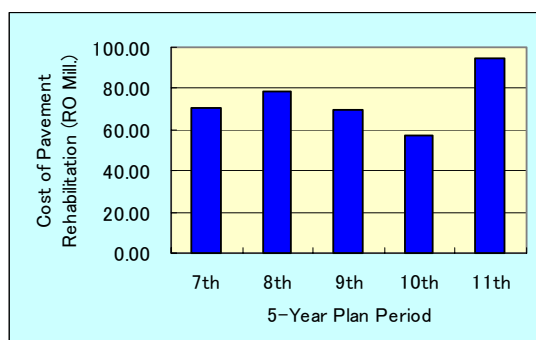


- Cost of routine maintenance for 5-Year Plan Period for the Master Plan Projects increases from about RO 23 million in the 7th Plan Period to about RO 34 million in the 11th Plan Period.

Cost Of Periodic Maintenance:

- Cost of periodic maintenance is estimated based on the length of pavement rehabilitation as described above.

Cost of Periodic Maintenance



- Cost of periodic maintenance for each 5-Year Plan Period is in the range of RO 57 million to 78 million except that in the 11th 5-Year Plan Period which is about RO 95 million.

Identification of Sections to be Rehabilitated

- Pavement in Oman can be used for a few years even after considerable cracks start develop. This is due to favourable sub-grade condition.
- Therefore, sections to be rehabilitated in the next year should be identified based on visual inspection of the actual condition of cracks.

Traffic Management and Road User Services

- Traffic management is necessary for efficient road usage.
- The basic road network in Oman is being completed. Therefore, attention should be paid to better traffic management.

- The major item of traffic management to be undertaken by the road administrator (DGR and DGC) is road user services.
- DGR and DGC should start studying the possibility of providing services of road/traffic information through radio broadcasting and/or traffic information boards.

Road Information Board



[Message: Be aware of strong Wind]

- Medical services to road users should be secured at appropriate intervals.
- When such services described above will become available, road use will be more convenient for drivers and movement of people and goods will be encouraged.
- DGR and DGC should start studying ITS (Intelligent Transport System). ITS is expected to bring about a remarkable advancement in both road user services and road management by applying IT (information technology).

Organization Plan

- To supervise maintenance and construction, more engineers should be stationed in Regional Road Departments and the function of Regional Road Departments should be strengthened.
- To study engineering problems unique to Oman, as well as to improve design and maintenance, a Department of Engineering should be established.
- The planning function of DGR/DGC should be strengthened in view of the fact that actual services of design, construction supervision and maintenance are contracted out to consultants and contractors.
- To cope with the newly introduced system, a Toll Road Section and an ITS Section should be established within DGR/DGC.
- The current number of engineers/surveyors in DGR and DGC is insufficient. The total number of engineers/surveyors in DGR and DGC should be increased such that by 2030, the numbers will have risen to 150 and 45, respectively.
- To realize these goals, DGR and DGC should recruit 6 engineers/surveyors and 2 engineers/surveyors every year, respectively, and give them appropriate and comprehensive training with planned career paths.

10. MASTER PLAN EVALUATION

Evaluation Process

- Evaluation of the Master Plan projects is done in three stages during the planning process with each stage serving a different purpose. The first stage is to select the optimum alternative by comparison between different approaches for developing the network. The second stage is the investment scheduling procedure to determine relative priority among projects.
- The last stage is to evaluate the economic feasibility of the plan in accordance with the proposed implementation schedule. The economic evaluation is carried out by conducting comparative analysis between benefits and costs for the two cases of with "Master Plan" and "Do Nothing".

Traffic Parameters

- The traffic system performance of the Master Plan is assessed based on savings in traffic parameters and transport cost between the two cases of "Do Nothing" and "Master Plan". The M/P will provide savings in PCU-kilometer (or travel distance) of 7.58 million per day and in PCU-hour (or travel time) of 382 thousand per day in 2030.
- PCU-km would be reduced by 5.4%, 6.5% and 12.5% in the years 2010, 2020 and 2030, respectively.
- PCU-hr would be greatly reduced by 11.1%, 19.0% and 37.7% in the years 2010, 2020 and 2030, respectively.

Traffic Parameters

Parameter	Case	2010	2020	2030
PCU-Km (million)	Do Nothing (A)	19.1	29.3	61.2
	Master Plan (B)	18.0	27.4	53.7
	B/A	0.94	0.93	0.88
PCU-Hr (million)	Do Nothing (A)	260.0	408.7	1,013.1
	Master Plan (B)	230.7	331.2	631.0
	B/A	0.87	0.80	0.61

Network Efficiency

- Other traffic efficiency measures are the average travel speed and average traffic congestion ratio (v/c ratio) on the whole network. The results show large improvement in the efficiency of the network either in the increased average speed or the decreased V/C ratio.

Speed and Congestion

Parameter	Case	2010	2020	2030
Average Speed (km/hour)	Do Nothing (A)	73.4	71.7	60.5
	Master Plan (B)	78.1	82.7	85.0
	B/A	1.04	1.24	1.38
Average V/C Ratio	Do Nothing (A)	0.15	0.22	0.46
	Master Plan (B)	0.11	0.12	0.20
	B/A	0.73	0.55	0.43

Level of Service by Length (%)

LOS	2010		2020		2030	
	Do Nothing	Master Plan	Do Nothing	Master Plan	Do Nothing	Master Plan
A- B- C	96.3	100.0	91.7	99.7	75.8	94.4
D	3.4	0.0	3.2	0.3	6.3	4.1
E	0.3	0.0	2.9	0.0	6.1	1.5
F	0.0	0.0	0.0	0.0	11.8	0.0

Master Plan Savings (RO 1,000/day)

Year	Case	VOC Running	VOC Constant	Time Cost	Total
2010	W/O MP	627,736	282,429	192,645	1,102,810
	With MP	608,640	250,994	177,233	1,036,867
	Savings	19,096	31,435	15,412	65,943
2020	W/O MP	915,884	444,995	262,113	1,622,953
	With MP	867,441	360,337	222,814	1,450,592
	Savings	48,443	84,659	39,299	172,401
2030	W/O MP	1,709,549	1,109,426	435,552	3,254,528
	With MP	1,626,626	690,347	293,670	2,610,643
	Savings	82,924	419,079	141,882	643,885

Economic Evaluation

- The Master Plan will provide an annual savings in traffic cost of RO million 66 in 2010, 132 in 2020 and 644 by the target year 2030.
- Vehicle operating cost including travel time cost would be reduced by 6.0%, 8.2% and 19.8% in the years 2010, 2020 and 2030, respectively.
- Based on a discount rate of 6%, the sensitivity analysis results show that the Master Plan is economically feasible under higher costs or lower benefits.

Economic Indicators

Net Present Value (NPV)	RO 261 million
Benefit/Cost (B/C)	1.71
Internal Rate of Return (EIRR)	12.3 %

Notes: 1) Project life is assumed to be 30 years
2) A discount rate of 6.0% is applied

Sensitivity Analysis

Cost	Benefit	NPV (RO m)	B/C	EIRR%
+20%	± 0	190	1.42	9.8
Base Case		261	1.71	12.3
± 0	-20%	138	1.37	9.3
+20%	-20%	66	1.14	7.3

Indirect Benefits

- Impact on National and Regional Economy: In the medium and long term, dynamic socioeconomic changes are expected to occur on both the national and regional level as a result of the road network development. Travel time reduction, transport cost reduction, accessibility improvement and safe, convenient and reliable means of transport would directly and indirectly provide positive impact, especially on the sectors of agriculture, fishery, manufacturing, commercial, and tourism.

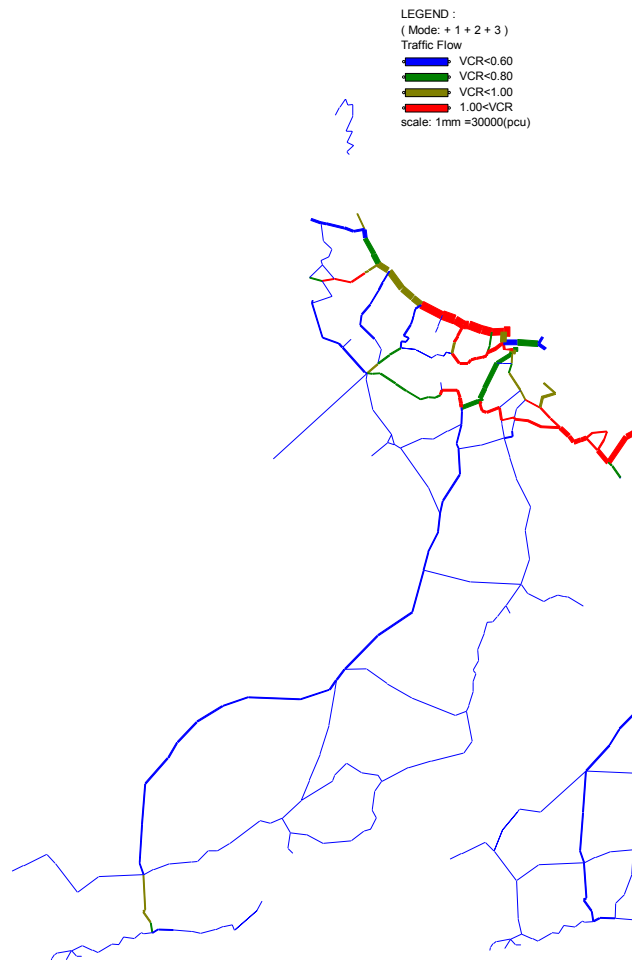
PART 2: ROAD NETWORK DEVELOPMENT PLAN

- **Impact on Commodity Prices:** The transport cost (in VOC per vehicle-km) of trucks would be reduced in Oman. Reduction of transport cost would favourably reduce affect commodity prices.
- **Improving Standard of Living:** The Master Plan is expected to contribute to improving the standard living of people by improvements in road accessibility from remote areas to schools, work places and other basic facilities.

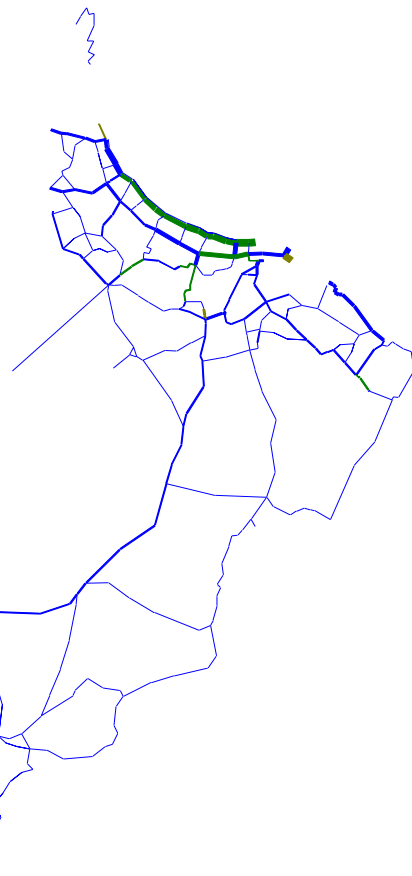
Environmental Evaluation

- The road network is developed to provide direct access between zones all over the Sultanate that will produce shorter trip-lengths and trip-hours. The shorter trips will result in less air pollution and positive environmental impact.
- Implementing the Master Plan projects as scheduled will improve the air quality by daily reduction of NOx by 1.65 ton, HC by 1.69 ton and CO by 14.0 ton.

Without "Master Plan" Case - 2030



With "Master Plan" Case - 2030



11. IMPLEMENTATION PLAN

Project Prioritization

- The established Road Network Master Plan covers five future 5-Year Development Plans from 2006 to 2030 (7th~11th Plans).
- Under this process, the applied prioritization criteria are developed based on the objectives and strategy of road network development as well as financial framework with fund resources and availability.

Road Investment (million RO)

Plan	Years	GDP	Road Investment
7 th	2006-10	49,395	292.1
8 th	2011-15	58,957	346.2
9 th	2016-20	70,904	266.7
10 th	2020-25	86,952	221.7
11 th	2026-30	107,554	268.0

Development Objectives and Phasing

Objective	2006-10	2011-20	2021-30
International Network	⊙	○	○
Economic Diversification	⊙	⊙	○
Living Standards	○	⊙	⊙
Regional Balance	○	⊙	⊙
National Integration	⊙	⊙	○

⊙ Major Policy ○ Supporting Policy

- The prioritization criteria are developed for roads that generate inter-zonal traffic, roads that generate intra-zonal traffic, and for access and local roads in order to facilitate DGR selection of road improvement projects in future.
- In addition to the objectives of road network development, other prioritization factors include economic efficiency of the project, increase in traffic efficiency and urgency of the project.
- Projects in the Master Plan are divided on a regional basis for future implementation through DGR Regional Offices after organizational strengthening as planned.

Implementation Schedule

- Higher investments are required in the first two plans in order to optimize benefits and to utilize higher oil revenues expected in the short- and medium terms.
- For large-scale projects in the 8th plan, foreign investments can be used as loans that can be repaid by budgetary surplus in the years to follow.

Road Investment (million RO)

Region	7 th	8 th	9 th	10 th	11 th	Total
Batinah	54.3	130.4	47.5	17.5	30.6	280.3
Musandam	62.1	-	-	-	-	62.1
Adh Dhahira	25.0	10.1	23.6	25.0	21.6	105.3
Ad Dakhliyah	11.5	17.2	-	-	0.8	29.5
Ash Sharqiya	11.2	19.2	15.3	41.7	23.3	110.6
Al Wusta	1.8	15.3	17.6	-	13.1	47.8
Dhofar	21.2	48.8	64.7	49.1	50.0	233.9
Other Improvements	105.0	105.1	98.0	88.4	128.7	525.2
Total	292.1	346.2	266.7	221.7	268.0	1,394.7

Notes: 1. Budgets for other improvements are accumulated for all regions.
2. Investments in the table are those of primary and secondary networks only.

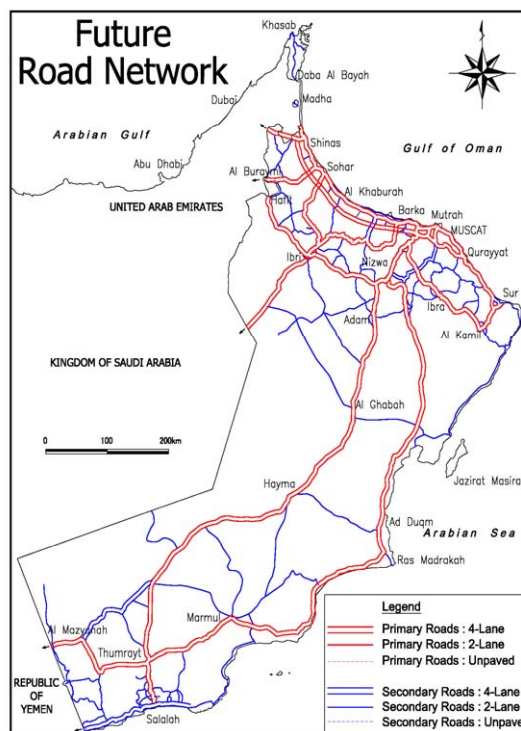
Formulation of Implementation Plan



Major Components of Master Plan

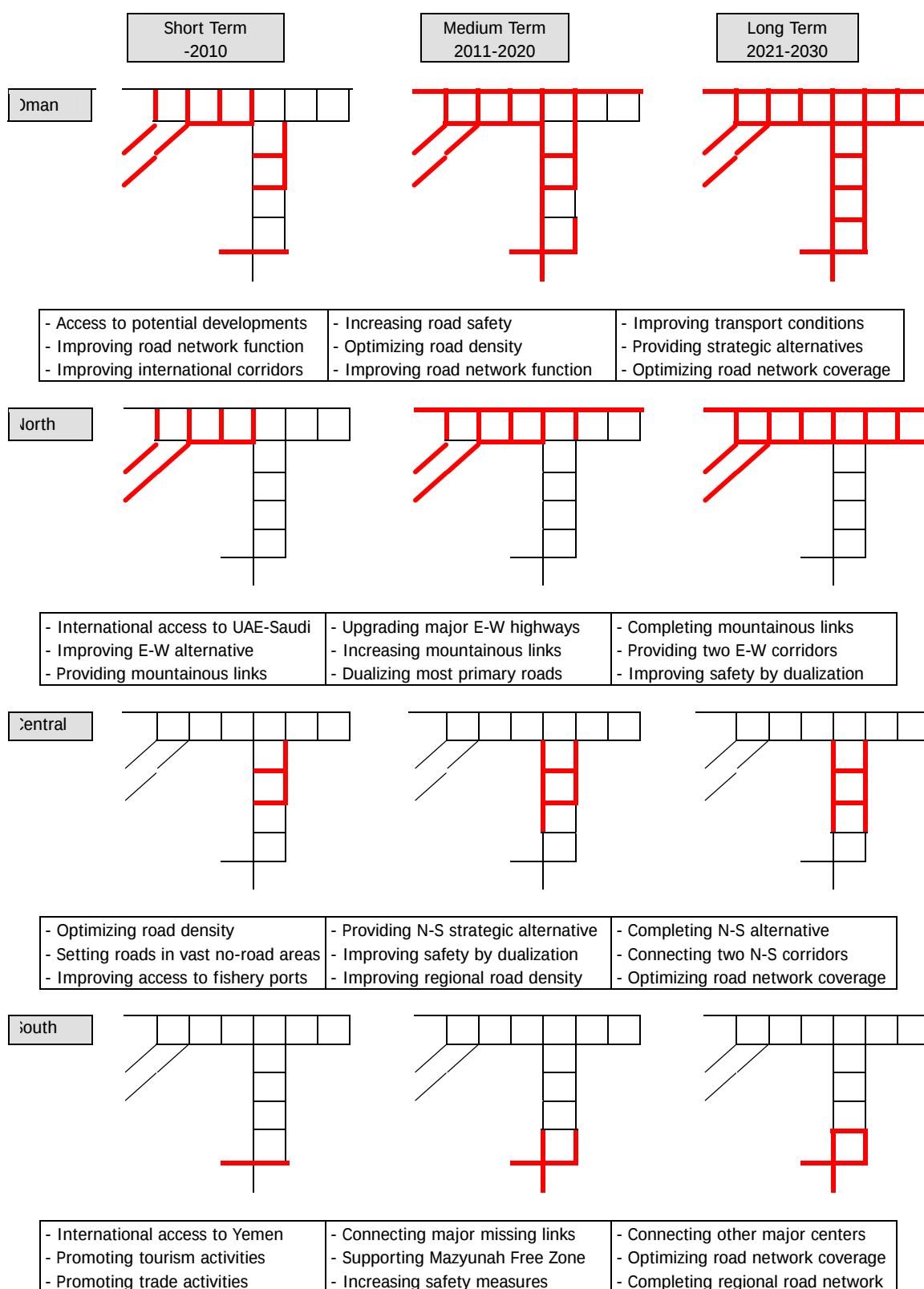
Improvement Type	7 th	8 th	9 th	10 th	11 th	Total
Upgrading-km	-	270	-	-	-	270
Widening (4-L to 6-L)-km	-	-	-	-	54	54
Dualization (2-L to 4-L)-km	268	526	558	277	-	1,629
New Const. (4-L)-km	-	171	75	-	-	246
New Const. (2-L)-km	423	162	640	413	896	2,534
Bypass (4-L)-km	-	11	28	52	16	107
Grade Separation-Nos.	-	-	-	3	5	8
Pedestrian Cross.-Nos.	12	-	-	10	-	22

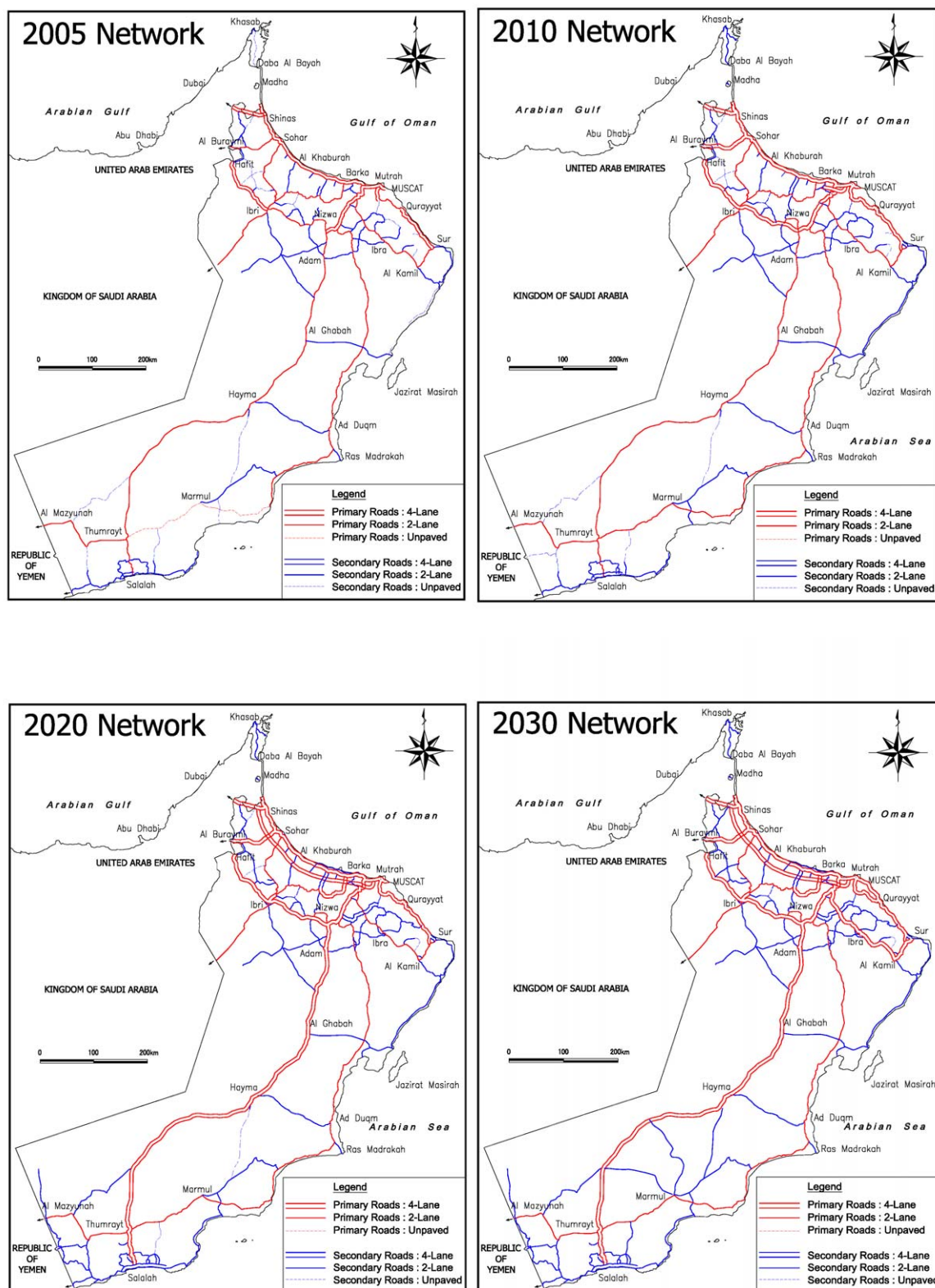
- The annual implementation program for each road project is scheduled in accordance to the prioritization criteria and budget allocation, in which the optimum benefits from project implementation sequence can be achieved.

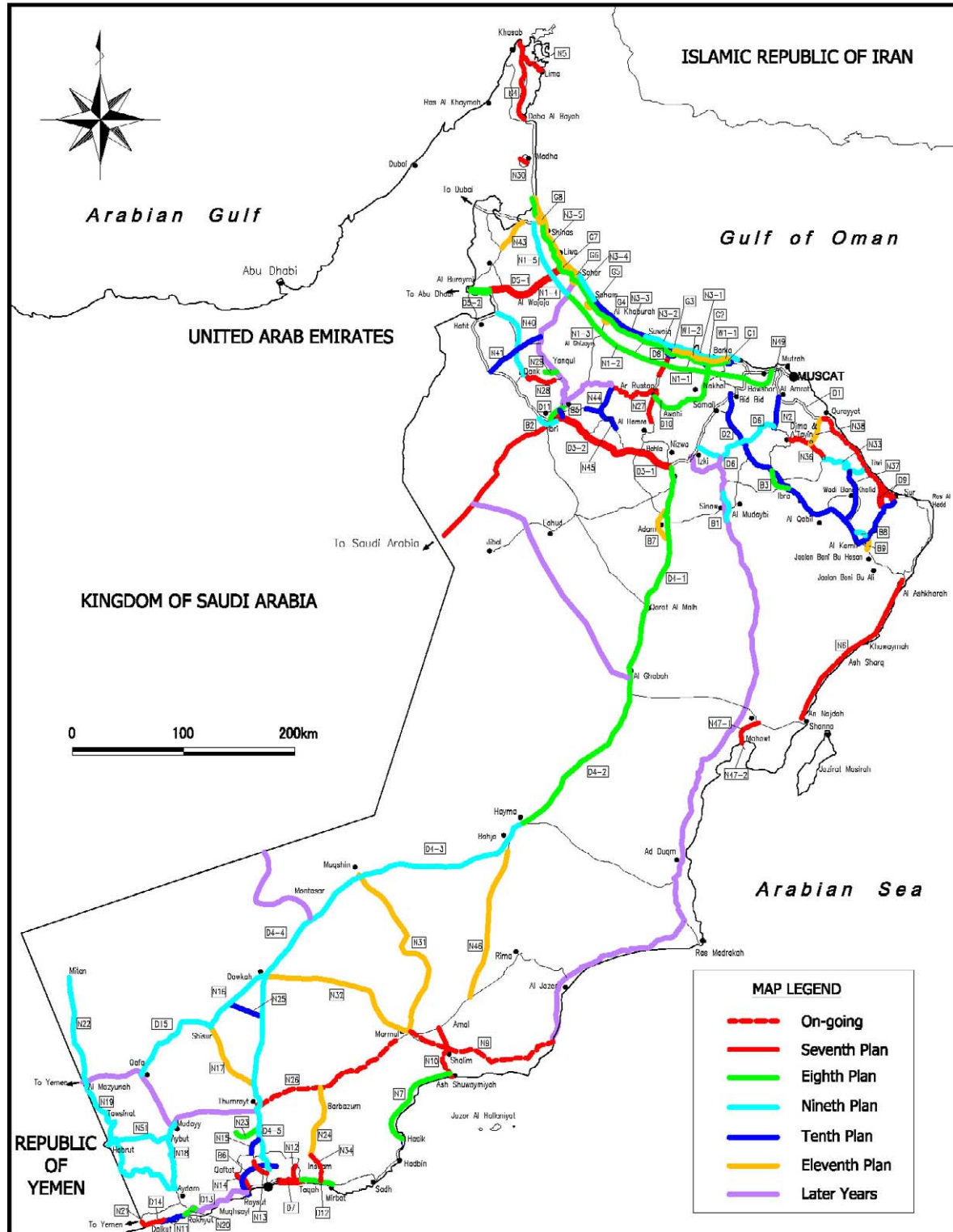


PART 2: ROAD NETWORK DEVELOPMENT PLAN

Conceptual Development Program of Road Network







[illegible]

PART 3

PRE-FEASIBILITY STUDY

PART 3: PRE-FEASIBILITY STUDY

12. SELECTED PRE-FS PROJECTS

Selection Procedure

- In the selection of high priority projects for the Pre-F/S, basically significant road projects in line with the policy and concept of the Nationwide Master Plan are selected, providing that such projects require further studies before future implementation. In the mean time, the following criteria are considered:
 - **Urgency:** Projects that are in urgent need for implementation, and are intended to solve urgent transport problems and will greatly improve the network function.
 - **Integration:** Projects that promote and provide integration with other socioeconomic development projects.
 - **Regional Balance:** Projects that are distributed in different regions to eliminate disparities by promoting regional development as well as to strengthen the capability of DGR regional offices.
 - **Technical Issues:** Projects that require technical depth in important issues such as environmental assessment, hydrological analysis at Wadi locations and privatization schemes through the systems of build-operate-transfer (BOT) and public - private - participation (PPP).

Selected Projects

- Four projects in the 7th 5-Year Development Plan that are in line with the policy and concept of the Master Plan and meet the selection criteria required for Pre-F/S are included. However, due to the limited number of projects selected from the 7th Plan, three projects in the 8th Plan, which are important and require specific technical needs but are delayed due to financial constraints, are included based on an agreement with DGR.

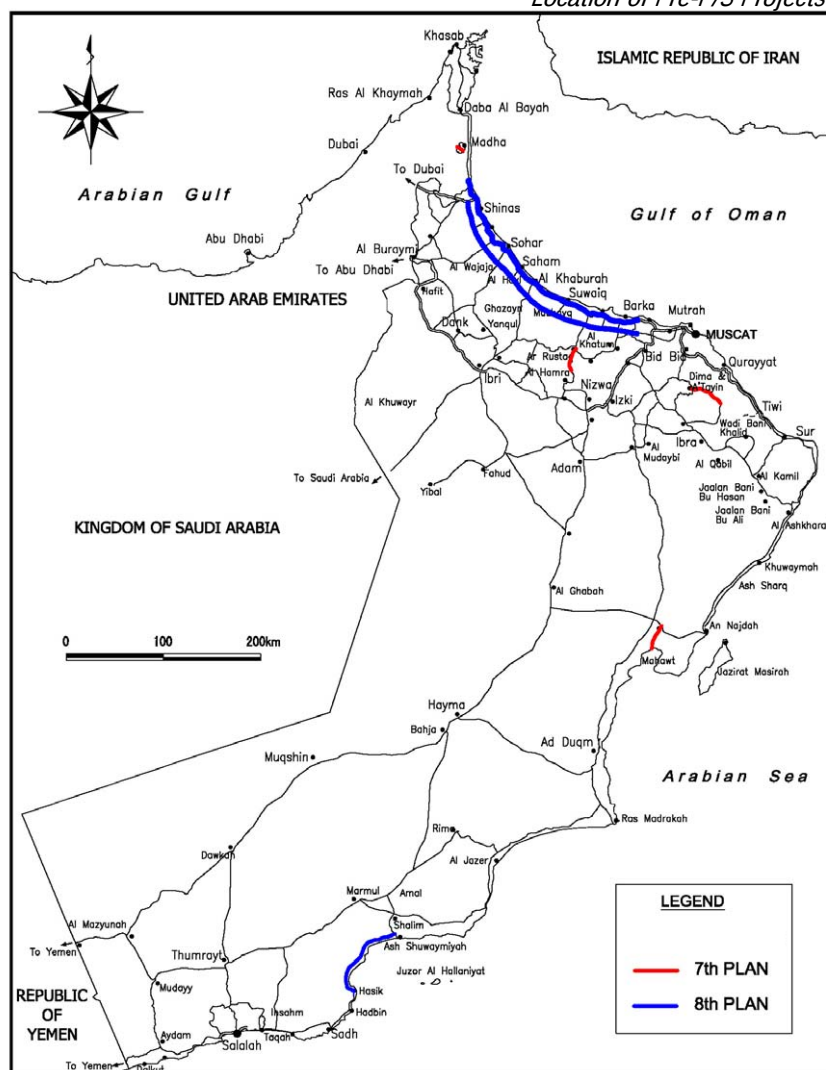
Study Procedure

- Projects under the 7th Plan are subject to field survey, preliminary design, cost estimate, environmental investigation and economic analysis.
- Projects under the 8th Plan are subject to extensive studies on a different specific topic for each project.

Selected Projects

Plan	Project	Length Km	Study
7 th	Hamra – Rustaq	29	Technical Pre-F/S
	Madha – Dafta	15	
	Al Hij – Flim	19	
	Mahlah – Ismaiyah	45	
8 th	Hasik – Shuwaymiyah	80	Environment
	Batinah Highway	270	Hydrology
	New Batinah Ex'way	246	Management

Location of Pre-F/S Projects

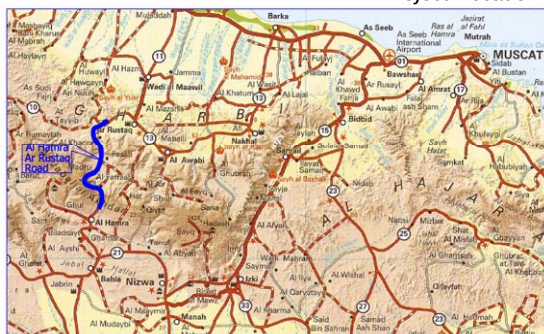


13. AI HAMRA - RUSTAQ ROAD

Objectives of Project

- To strengthen the connection across Al Hajar Al Gharbi Mountain Range
- To strengthen the linkage between the two routes of East-West Corridor (Batinah Highway: NR 01 and NR 21: Nizwa-Ibri Road)
- To provide detour route for NR 15 between As Seeb and Nizwa when necessary
- To improve the standard living of people along the Project Road
- To support the development of tourism

Project Location



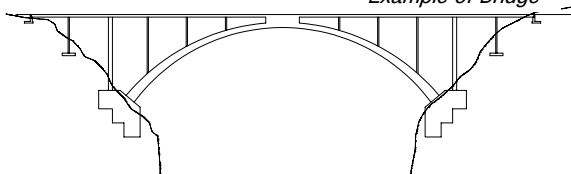
Outline of Project

- Project No.: N27
- Project Type: Construction of 2-lane paved road (Improvement of existing road)
- Length = 28.3 km (Phase 4)
- Estimated Traffic Volume: 11,058 pcu/day (2030)

Preliminary Design

- The topography of the area that the Project Road traverses is very rugged.
- It is assumed that the planned alignment basically follows the existing road because substantial alteration of alignment requires construction of large-scale elements such as tunnel and long bridge, and, thus, results in an extremely high construction cost.
- However, improvement of alignment by constructing a bridge (about 120 m long) is proposed at the critical road section between Chainage 3+700 and 6+100 to avoid the high cut-and-fill section of the existing road. Constructing a bridge will shorten the length of the road by about 2 km.
- The figure below shows an example of likely form of bridge.

Example of Bridge



Environmental Impact

- Traffic volume of the Project Road is estimated to substantially increase by 2030. Accordingly, adverse impacts such as air pollution, noise, and increase in traffic accidents are anticipated.
- On the other hand the Project Road is expected to improve the living environment of the local residents by providing access to schools and other public services.
- The Project Road is also anticipated to exert impacts on the natural environment including topography, eco-system, flora and fauna.
- Consequently, it is recommended to carry out an Environmental Impact Assessment (EIA).

Project Cost

Project Financial Cost (RO 1,000)

	Without Bridge Plan	With Bridge Plan
Detailed Design	236	322
Construction	7,866	10,743
Construction Supervision	315	430
Total	8,417	11,495

Project Evaluation

- Economic analysis shows high values of indicators for both plans (with and without Bridge) and both plans are judged to be economically feasible.
- The "without Bridge" plan shows higher values of economic indicators than those of "with Bridge" plan due to smaller initial construction cost.

Economic Indicators

	Without Bridge Plan	With Bridge Plan
NPV	RO 34.1 million	RO 37.8 million
BCR	4.95	4.24
EIRR	27.3%	23.9%

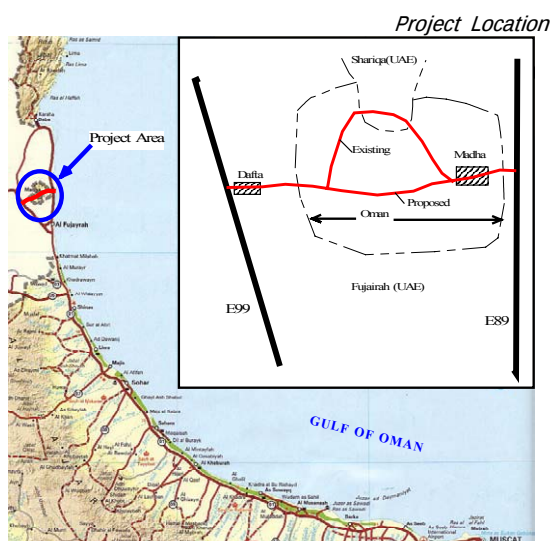
- Based on the results of the preliminary design and economic analysis, the Project Road is judged to be technically and economically feasible.
- Construction of the Project Road is expected to strengthen the function of the road network in northern areas as well as to contribute to the improvement of standard living of the roadside residents.
- It is proposed that the "Without Bridge Plan" be implemented as the first stage to meet the traffic and other requirements and construction of the proposed bridge be considered when traffic volume on the Project Road increases in the future.

PART 3: PRE-FEASIBILITY STUDY

14. MADHA - DAFTA ROAD

Objectives of Project

- To provide basic road infrastructure within Wilayat Madha area without passing through UAE territory,
- To provide a transport link between E 89 road and E 99 road in UAE, and thus improve the access to Dubai,
- To improve the standard of living of the residents along the Project Road,
- Strengthen the unity of the nation.



Outline of Project

- Project No.: N30
- Project Type: Construction of 2-lane paved road
- Length: 15 km
- Estimated Traffic Volume: 382 pcu/day (2030)

Preliminary Design

- The existing road follows the alignment of wadis shifting from one to the other, and passes through UAE territory in Wilayat of Madha.
- The alignment is proposed to be shifted to the south and pass along another wadi to avoid traversing the UAE territory.
- The proposed alignment basically follows old paths used by camel and people on foot.
- The proposed alignment is shorter than the existing alignment by about 4 km.
- Since the substantial part of the proposed alignment traverses wadi, longitudinal grade of the Project Road is relatively moderate except near Chainage 10.9 km where there is a mountain ridge which makes another boundary of UAE territory and Oman territory.
- On the other hand, width of the wadi is often narrow and the road needs to be constructed adjacent to either the left or right banks to minimize reduction of waterway area for

discharge of flood water. In addition the embankment slope has to be protected by rip-rap in many sections.

Environmental Impacts

- Small alteration of topography caused by excavation of cut slopes is anticipated.
- The Project Road is also anticipated to exert small impacts on eco-system, flora and fauna due to excavation and embankment.
- No relocation of houses is anticipated since there are currently no people living along the proposed alignment.
- Consequently, it is recommended to carry out an environmental impact assessment (EIA).

Project Cost

Project Financial Cost (RO 1,000)

Detailed Design	144
Construction	4,810
Construction Supervision	192
Total	5,146

Project Evaluation

- The economic analysis shows positive but low economic benefit as represented by the economic indicators, based on the discount rate of 6%.

Economic Indicators

NPV	RO 465,600
B/C	1.13
EIRR	7.1 %

- The Project Road is technically feasible but economic benefit is low.
- The Project Road is expected to greatly contribute to the improvement of social welfare of the residents in Wilayat Madha.
- The Project Road is to provide the basic road infrastructure for people of Wilayat Madha area without passing through UAE territory.
- It is also important for the unity of the nation.

Old Foot Path along Wadi



15. AL HIJ - FLIM ROAD

Objectives of Project

- To provide a proper access road for people who are living in Flim and Mahawat Island to Wilayat center of Al Hij,
- To support development of tourism of Mahawt Island and surrounding areas,
- Improve the access of the local fishery to the markets in the north (Sinaw, Muscat, UAE, etc.) via NR 32, and
- To improve infrastructure facility in Al Wusta Region.

Location of Project Road



Outline of Project

- Project No.: N47
- Project Type: Construction of 2-lane paved road (Improvement of unpaved road)
- Length: 19.3 km
- Estimated Traffic Volume: 208 pcu/day (2030)

Preliminary Design

- The proposed alignment basically follows the exiting unpaved road.
- The existing road traverses a flat area and there will be no difficulties in design/ construction of road or substantial increase in construction cost if minor alteration becomes necessary.
- Near the end point (village of Flim), the elevation of the ground is very low and submergence by seawater is frequently experienced, particularly during spring tide. Therefore, the elevation of road surface is planned to be raised by 1.0 - 1.5 meters.

Environmental Impact

- There are some mangroves around Flim and in Mahawt Island. However, the Project Road does not pass through these mangrove areas. Therefore no significant impact is anticipated.
- The sea around Mahawt Island is very shallow. Also there are some lagoons near Flim. Various kinds of birds are seen in these shallow waters

and mangroves. Although the construction of the Project road itself is not anticipated to give significant impacts to these birds, the influence of the increase numbers of tourists needs further study.

- Consequently, it is recommended to carry out the partial environmental impact assessment (EIA)
- It is also recommended that an EIA be carried out if tourism is to be developed.

Project Cost

Project Financial Cost (RO1,000)

Detailed Design	50
Construction	1,651
Construction Supervision	66
Total	1,767

Project Evaluation

- The economic analysis shows negative value of Net Present Value (NPV) and B/C ratio less than 1.0. Therefore, the Project is not justified from an economic viewpoint alone.

Economic Indicators

NPV	RO - 74,000
BCR	0.95
EIRR (%)	5.5 %

- The Project Road can be constructed without significant engineering problems.
- Construction of the Project Road is expected to contribute to the improvement of standard of living of the local residents who are living in this less developed area in Oman.
- The Project Road is expected to contribute to fishery industry development and to promote tourism development.
- Therefore, the Project is recommended from the view point of alleviation of regional disparity and improvement of social welfare.

Shallow Seawater around Mahawt Island

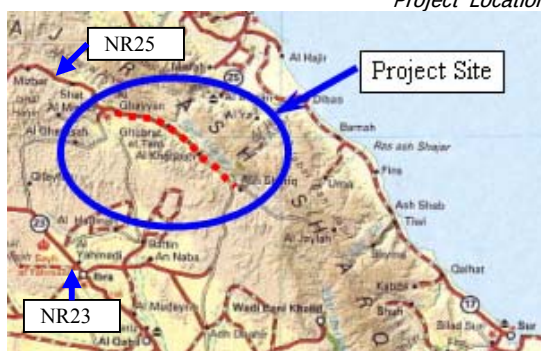


16. MAHLA - ISMAIYAH ROAD

Objectives of Project

- To complete the road linkage between Sabkhat and Ibra through the central valley of Al Hajar Ash Sharqi Mountain Range,
- To provide a proper access road for people who are living in the Project impact area,
- To provide a detour route for NR 23 when necessary,
- To provide the axis to which the roads across the mountain range are connected,
- To support development of agriculture and tourism.

Project Location



Outline of Project

- Project No.: N36
- Project Type: Construction of 2-lane paved road (Improvement of existing road)
- Length: 37.9 km
- Estimated Traffic Volume: 1,084 pcu/day (2030)

Preliminary Design

- The proposed alignment basically follows the existing road which runs along Wadi Tayin and Wadi Khabbah.
- While in the section along Wadi Khabbah which faces cliffs or steep mountains on both sides, the road alignment remains within the Wadi. The remaining section is planned to be shifted to the left or right side of the Wadi.
- Except for those sections going out of the wadi, the longitudinal grade of the planned alignment is generally moderate.
- Consequently, there is no serious engineering problem anticipated.

Environmental Impacts

- Traffic volume of the Project Road is estimated to increase by 2030. Accordingly, adverse impacts such as air pollution, noise, and increase in traffic accidents are anticipated.
- On the other hand the Project Road is expected to improve the living environment of the local

residents by providing access to schools and other public services.

- The Project Road is also anticipated to exert impacts on the natural environment including topography, eco-system, flora and fauna.
- Consequently, it is recommended to carry out a partial Environmental Impact Assessment (EIA).

Project Cost

Project Financial Cost (RO 1,000)

Detailed Design	175
Construction	5,873
Construction Supervision	235
Total	6,283

Project Evaluation

- The economic analysis shows positive but low value of Net Present Value (NPV), B/C ratio of 1.45 and EIRR of 9.1 %, based on discount rate of 6%.

Economic Indicators

NPV	RO 2.4 million
B/C	1.45
EIRR	9.1 %

- The Project Road can be constructed without serious engineering problems.
- The Project is to contribute to the development of agriculture and tourism in the central valley of Al Hajar Ash Sharqi where rich clear water is seen.
- The Project Road is also expected to play an important role in strengthening the function of the road network.
- Further, the Project Road is an extension of the already paved section of NR 25, and a section which is currently being paved.
- In view of the above, it is recommended that the Project is given a high priority for implementation.

Clean Water in Wadi Khabbah



17. HASIK - SHUWAYMIYAH ROAD: ENVIRONMENTAL STUDY

Objective of Project

- Strengthening of the road network function
 - Completion of circuit route
 - Provision of detour route for the Coastal Route of North-South Corridor
- Support for social activities of the area
- Promotion of tourism along the coastal area



Project Location

- Alternative 3: Same as Alternative 1 and 2 up to Chainage 20+680 and traverses the wadi further inland (about 20 km inland).
- Alternative 1 is further divided into two sub-alternatives according to road structure as follows:
 - Alternative 1-1: Pass along the shoreline or excavate roadway on the steep slope of the coast.
 - Alternative 1-2: Traverse the cliff tops by constructing many tunnels and long-span, high-pier bridges.

Engineering Evaluation

- Approximate length and cost for each alternative are as given in the table below.

Length and Cost				
	Alt. 1-1	Alt. 1-2	Alt. 2	Alt. 3
Length (km)	55.9	70.6	113.2	144.6
Cost (RO mill.)	71.8	74.6	39.0	36.6

Outline of Project

- Project No.: N7
- Project Type: Construction of 2-lane paved road
- Length: Approximately 120 km (Alternative 2)
- Estimated Traffic Volume: 300 pcu/day (2030)

Preliminary Design

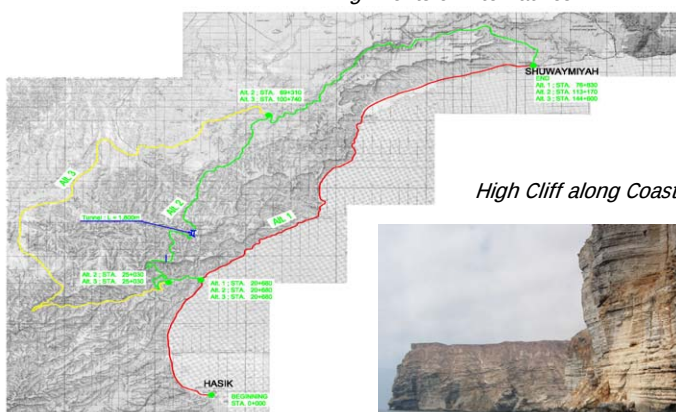
- There is no existing road due to the extremely rugged terrain, especially along the coastal line which is the shortest route.
- Three alternative routes are considered. (See the map at the bottom of the page.)
 - Alternative 1: Along the coastal line for the entire road.
 - Alternative 2: Along the coast line up to the Chainage 20+680 and traverses the wadi located 5 to 15 km from the coast. Excavation of a 1.8 km-long tunnel is necessary.

- While Alternative 1-1 and Alternative 1-2 connects Hasik and Shuwaymiyah with minimum length, construction costs of these alternatives are very high. These alternatives also require construction of long-span, high-pier bridges and/or extremely high cut slopes.
- Accordingly, Alternative 2 is recommended as the realistic plan from the engineering viewpoint.

Environmental Impact

- The area that the planned alignments of all alternatives traverse is designated as a natural reserve area.
- The wildlife in the area includes Arabian Leopard, Arabian Gazelle and Wild Cats.
- While adverse impact on the marine biology is anticipated if alignment of Alternative 1-1 or 1-2 is adopted, adverse impact on wild animals is anticipated if the alignment of Alternative 2 or 3 is adopted.

Alignments of Alternatives



High Cliff along Coast

- In case of Alternative 1-1, substantial alteration of topography and adverse visual impact will occur due to excavation works at areas of high-cut slopes.
- Close consultation with the Ministry of Regional Municipalities, Environment and Water Resources (MRMEWR) is recommended on the usage of explosives in rock excavation.
- Close consultation with MRMEWR on road structure and mitigation measures is required before the alignment is finally decided.

PART 3: PRE-FEASIBILITY STUDY

18. WADI STUDY ON BATINAH HIGHWAY

Objective of Project

- Alleviation/elimination of delay and confusion of traffic due to flash floods at existing Irish crossings.
- Provision of safe crossing facilities for pedestrians and vehicles.

Project Location



Outline of Project

- Project Type: Upgrading (Improvement of existing road)
- Length: 270 km (31 locations)
- Estimated Traffic Volume: 80,000 pcu/day (2030; Bait Al Barka R/A - Barka R/A)

Hydrological Analysis

- There are 31 Irish crossings on Batinah Highway between Bait Al Barka R/A and UAE Border (Khatmat Milahah).
- Based on past rainfall data, average number of rainy days occurring at any for the wadis located along Batinah Highway is 16 days per year.
- According to other studies, the probability that same rainfall recorded at more than one wadis covering 25 % of the entire wadis is 0.6. Therefore, the actual average number of rainy days is estimated as;
 $16 \times 0.75 \times 0.6 = 7.2$ days.
- From stochastic analysis of the past data, and calculation of relation between flood volume and depth at main Irish crossings, it is assumed that the probability of occurrence of flood with volume exceeding the depth of 40cm is 0.75
- Accordingly, the number of day of occurrence of such rainfall is estimated as;
 $7.2 \times 0.75 = 5.4$ days.
- Consequently, the number of days of closure of road is estimated to be 6 days per year.

- Based on past experience, it is assumed that flood duration at maximum is 18 hours in usual cases.

Preliminary Design of Culverts

- Three types of culverts are considered:
 - Type 1: W 3.0 m x H 1.5 m (For water only)
 - Type 2: W 3.0 m x H 2.5 m (water + pedestrian crossing)
 - Type 3: W 4.5 m x H 4.0 m (water + vehicle underpass)
- Considering the small difference of costs between Type 1 and 2, it is recommended to provide Type 2 culverts at all locations of the existing Irish crossings.
- Based on the result of site surveys, water-pedestrian-vehicle type is planned at 8 locations and water-pedestrian type (Multi-Function culvert) is planned at the remaining 23 locations.
- Furthermore it is proposed to construct underpasses (box culverts) which allow passage of large vehicles at an interval of about 10 km (17 locations) to eliminate crossings of such vehicles and other types of vehicles on Batinah Highway from the viewpoint of traffic safety.

Cost Estimates

- The cost for converting 31 locations, with a total length of 3.75 km, of Irish crossing into culverts is estimated at RO 14.67 million.
- The cost for constructing 17 underpasses for large vehicles is estimated at RO 14.45 million.

Economic Analysis

- The economic analysis shows that both projects yield high economic returns.

Economic Indicators for Conversion of Irish Crossings

NPV	RO 17.9 million
BCR	2.83
EIRR	18.7 %

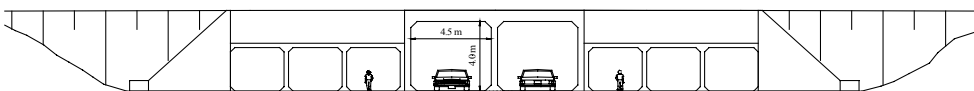
Economic Indicators for Construction of Underpasses

NPV	RO 12.2 million
BCR	2.27
EIRR	15.2%

Project Evaluation

- Considering the high economic returns and "unquantifiable benefits", such as reduction of traffic accidents, it is recommended that these projects are implemented.

Conceptual Illustration of Multi-Function Culverts

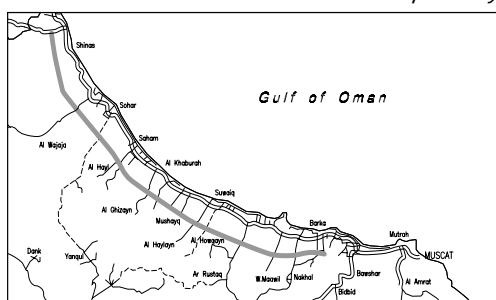


19. MANAGEMENT STUDY ON NEW BATINAH EXPRESSWAY

The Expressway

- New Batinah Expressway (NBE) is planned to be constructed on the southern side of the existing Batinah Highway (EBH) with a design speed of 120 km/hr. The expressway length is 246.3 km.
- The expressway will provide a safer strategic alternative to Batinah Highway, handle future transport demand and create new development centres to decentralize socioeconomic activities from Batinah coastal areas.

New Batinah Expressway



Study Objective

- This study is to examine the financial feasibility of the Expressway project under privatization.

Project Financial Cost (RO 1,000)

Item	Quantity	Cost
Pavement and Earthwork	246.3 km	56,615
Interchanges	11	40,000
Overpasses	19	7,600
Fencing	500 km	5,000
Toll Facilities		4,000
Engineering		6,793
Contingency	10%	12,001
Total		132,009

Toll System Policy

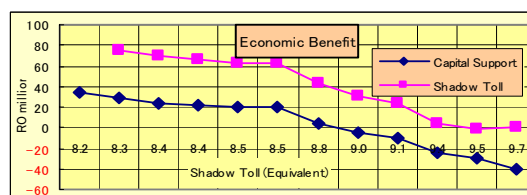
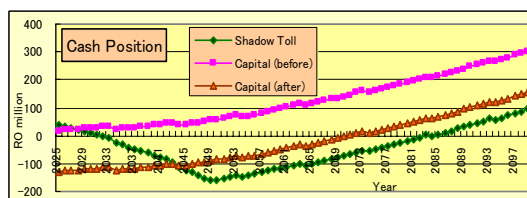
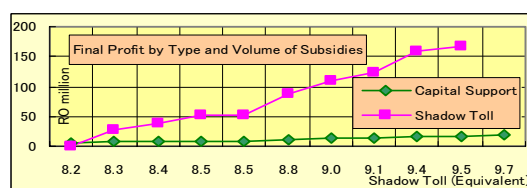
- Private sector investment is encouraged to participate in road sector projects, and applying the BOT (Build-Operate-Transfer) system to implement this project is recommended by the Government. Previous studies were carried out on BOT feasibilities of NBE, Qurayyat-Sur Road (QSR) and Bowshar-Al Amarat Road only discussed and introduced the toll system in general.
- In this study, results of toll interview survey and modelling study of traffic assignment on toll road are examined. Next, the shadow cost concept is applied to develop a feasible approach to attract private sector participation.
- Applying the toll alternatives on QSR business model conditions does not provide any feasible option. Easing QSR conditions to the level of Severn Toll Bridge (UK) conditions is considered as one of the best conditions for toll road BOT, but any toll case still does not show feasibility. It is concluded that some types of governmental support are necessary to put privatization into practice.

Toll Alternatives

Toll Alternatives	Toll Rate (Baisas/km)	Annual Revenue (RO 1,000)
Previous FS Proposal (Representative)	12..2	1,267
Interview Survey Result (Max. Revenue)	20..3	1,876
Traffic Assignment Result (Max. Revenue)	24..4	1,024
Shadow Cost (Equal to Economic benefit)	0.0	0

Privatization Schemes

- A possible privatization scheme is Government participation to apply shadow cost concept or to participate in investment (capital participation). The minimum participation rate is 70% share with 6% interest rate p.a. for private financing.
- Shadow cost application and investment participation are compared from: a) Company viability (Profit when closed); b) Attractiveness to the Concessionaire (Cash balance of every year); and c) Attractiveness to the Government (Economic benefit).
- In this comparative analysis, cash balance is compared with shadow costs of RO 9.4 millions and capital participation of RO 145.0 millions, annual burden is RO 8.811 millions assuming 6% interest rate and 75 years loan period. The results show the superiority of the shadow toll system in the limit of positive economic benefit.
- Also, the creation of new business opportunity for the concessionaire gives additional points to the shadow toll system, which satisfy requirements from Government on positive economic benefit and from concessionaire on positive profitability.
- The quotient of RO 9.4 millions divided by annual traffic through NBE free of charge, 1,198.6 millions vehicle-km is 7.9 Baisas/km/ vehicle. This is less costing than the proposed tolls.



CONCLUSIONS AND RECOMMENDATIONS

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CONCLUSIONS

Plan Justification

- The Road Network Development Master Plan is formulated in a comprehensive and systematic manner to cope with present and future transport requirements and to support economic diversification and welfare of the Sultanate.

- The Plan is justified to be technically, environmentally and economically feasible with the following economic indicators (based on a discounted rate of 6 %):

EIRR (%):	12.3
NPV:	RO 261 million
B/C:	1.71

- Projects under the Master Plan are technically feasible and can be implemented by applying normal construction methods and techniques. Due to the severe topographical features in mountainous areas, a few tunnelling sections are planned in order to improve the geometric design at locations with sharp curves and steep slopes
- In addition to the indirect benefits of the Master Plan, such as promoting regional development and improving living standards, the evaluation results of the Master Plan show high efficiency parameters, such as the increase in the average travel speed of all vehicles on the network by about 40%, and decrease in the average volume/capacity ratio by 40%. Further, the total trip length (in pcu-km) will decrease by about 12% and total travel time (in pcu-hour) by 38%.

Network Development Plan

- The primary road network is developed to provide strategic and reliable alternative corridors in the two major transport directions of "East-West" on both sides of the northern Al Hajar Mountain ranges, and "North-South" across central and coastal areas of the Sultanate, in addition to international links to neighbouring countries.
- The secondary road network is developed to provide strong connections and access between the primary roads and to all major present and future socio-economic development and activity centres, as well as enhancing the function of the primary road network.
- The implementation program of the Master Plan projects provides a timeframe on an annual basis for the five 5-Year Development Plans from 2006 to 2030. In addition, more projects are proposed for later years that can be introduced as far as financial resources are secured.

- The Master Plan is developed, generally, to realize its objectives on phases in which networks for national integration and international connections will be completed in the short-term, economic diversification will continue to the medium-term, while enhancement of living standards and reduction of regional imbalance will continue to the long-term.

Pre-F/S Projects

- *Pre-F/S Projects under 7th Plan:*

- The four roads are basically significant projects in line with the policy, objectives and concept of the nationwide Master Plan.
- The projects will provide important links as basic transport facilities in the road network to strengthen its function, will improve the living standards of people and will promote regional and rural development.
- The four projects are justified technically, socially and environmentally for the early implementation.

- *Pre-F/S projects under 8th Plan:*

- Hasik – Shuwaymiyah Road: The most realistic alignment is along the coastline in the southern half, and then it goes inland to the north. EIA is required as both sides of sea and mountains are environmentally critical areas.
- Batinah Highway: Replacing Irish Crossings at wadi locations along the highway with multi-function culverts is justified economically, environmentally and technically. In addition, the elimination of at-grade junctions through the provision of underpasses for vehicles will upgrade the highway function and improve its safety level.
- New Batinah Expressway: This is a major project in the M/P detouring of Batinah Highway that will promote economic diversification, international transport and will play a very important role in supporting the function of Sohar Port. To apply private financing schemes, considerable Government participation is required by applying a shadow toll system concept or in capital investment. The shadow toll system will satisfy requirements from the Government on positive economic benefit and from the concessionaire on positive profitability. However, the project requires a more comprehensive study on environmental, technical and economic aspects to facilitate its successful implementation.

RECOMMENDATIONS

Plan Authorization

- The Master Plan authorization is vital for systematic implementation of the planned projects under the authorized ministries, authorities and agencies, so that all efforts can be integrated toward the same targets at the optimum timing.
- Projects in the Master Plan should be included in the Five Year Development Plans to secure required funds and to assure the development of the road network based on the established schedule for the smooth implementation and maximum efficiency.

Plan Implementation

- The Master Plan implementation program is formulated based on a comprehensive prioritization multi-criteria integrated with the available financial resources and budgetary limitations. However, future follow-up and updating of the program are required in which projects of later years may be introduced during the plan period with securing required additional financial resources.
- To implement projects as scheduled, feasibility studies should be conducted few years before the project schedule in order to secure required fund and to avoid delay. Major projects, such as New Batinah Expressway and other large-scale projects, will require a comprehensive study that includes route selection, environmental impact assessment as well as technical, economical and financial analysis, with fund planning.
- To keep the growth of the road network with the target of 80% pavement ratio by the year 2030, DGR should annually improve access and local roads with minimum length of about 200 kilometres, with an annual cost of about RO 10.0 million in addition to the road projects under the Master Plan. The Figure presents the growth of the network from 1970 to the later years after the planned period.
- In case of implementing projects ahead of schedule, due to supplemental financial resources for example, it is recommended to update the Master Plan by introducing projects from later plans to replace implemented projects in order to realize the targeted Future Road Network.

Road Network Classification

- The established road network functional classification should be applied and used in all future network development activities in order to keep a well-organized network with international standards that can meet all future transport planning and utilization requirements.

Administration and Legislation

- The existing legislation system and regulations related to road transport are generally well established. However, there are some details that should be included, such as a clear definition for the power and responsibilities of DGR and DGC.
- To introduce new concepts in road financing, management, and operation (including toll collection and roadside land development schemes), it is required to establish the legislation system that can attract private sector investments and provide high level of service for road users.
- The administration systems of DGR and DGC are based on the small-size organization principle. As there are many other agencies involved in the operation and administration activities related to road transport and network development, the establishment of a coordination body is required.
- DGR database system should include all basic information such as annual and project budgets as well as status of projects which should be also disseminated among staff members.
- Since practical works of design, construction supervision and maintenance are contracted out, DGR and DGC should strengthen the functions of planning and policy making.

Organization and Institution

- The Master Plan includes a large number of road and structure projects which require large investments and implementation capability. An effective organization for systematical implementation approach is the vital key for successful realization of the plan.
- Taking into account the DGR small-organization principle, the required organization should be strengthened by establishing new Engineering Department with experts for bridges and structures, transport economy, road environment and other related fields.
- A well-established database section is required to provide all departments and decision-makers with all necessary information. It should be considered to utilize expertise of foreign experts in the process of implementing the Master Plan.
- To enhance administration for the developed road network, function and capacities of DGR Regional Offices should be strengthened for regional-base road network development.
- The present number of engineers in both DGR and

DGC is not sufficient. The number of engineers should be increased by recruiting a constant number of engineers (6 engineers) every year.

Maintenance and Management

- The road network development with the construction of new roads and pavement of track roads will increase the tasks and activities of road Maintenance Department under DGR in the near future. This Department should be ready for the increasing tasks and work volumes by the early establishing of a road maintenance management system.
- Human capacity building programs for maintenance engineers and technicians, as well as for other fields, is a major task that should be strongly established to develop required experience through on-the-job training and other systemized training programs.
- Routine maintenance and rehabilitation of pavement are essential to maintain the sound function of the road network. Sufficient fund should be secured.

Fund Preparation Measures

- The cost estimation and required budget in the Study are those to implement projects under the Master Plan, which deals with the primary and secondary road networks. Required budgets are generally ranging between 220 to 270 million for each 5-Year Development Plan.
- Pavement, maintenance and improving works for lower classes of roads will require an additional budget that is roughly estimated as about RO 20 million annually.

Environmental Consideration

- The Master Plan projects aim to minimize any negative impact on both natural and social

environmental conditions, and coordination with the MRMEWR is important throughout different stages of project implementation.

- Alignments with negative impact potential are modified to avoid environmentally protected areas. However, Environmental Impact Assessment (EIA) will be required for some projects and it should be prepared in advance during the design stage of each projects.
- When implementing road projects in areas where land acquisition is required, acquisition and resettlement schemes should be prepared in early stages together with the allocation of required fund.

Coordination with other related Projects and Agencies

- Implementing the Master Plan projects should be carried out as scheduled and in coordination with other related infrastructure and socioeconomic development plans and major projects to provide optimum integration and maximum benefits.
- Muscat Governorate is the major trip generation/ attraction zone in the country that strongly interacts with the nationwide network especially with roads in the northern areas. An urban transport development plan for the transport network under Muscat Municipality is urgently required for the integration with the nationwide road network development plan and to deal with capacity increasing of Sultan Qaboos Port, expansion of As Seeb Airport and development plans of other socioeconomic sectors.
- Good understanding and supporting by policy makers and budgeting agencies are indispensable for successful implementation of the Maser Plan. DGR and DGC should exert full effort to obtain understanding of those people and agencies.

Growth of Road Network in Oman

