LEGEND

Residential
- High-density
- Medium-density UA(La Marsa)
- Low-density UB(La Marsa)
- Ariana Center by Detailed Land Use Plan
- Medina Type
- Mixed-use UC(La Marsa)

Commercial

Administrative

Recreational
- Sports/ Activities
- Parks
- Touristic

Institutional

Industrial

Agricultural

Green Area

Inundated zone

Reserved (cemetery)

Historic

Petroleum storage

Catchment Area

Mediterranean Sea

SEBKHET ARIANA

ONAS

N

Fig. 4 Future Land Use Plan in Ariana Community

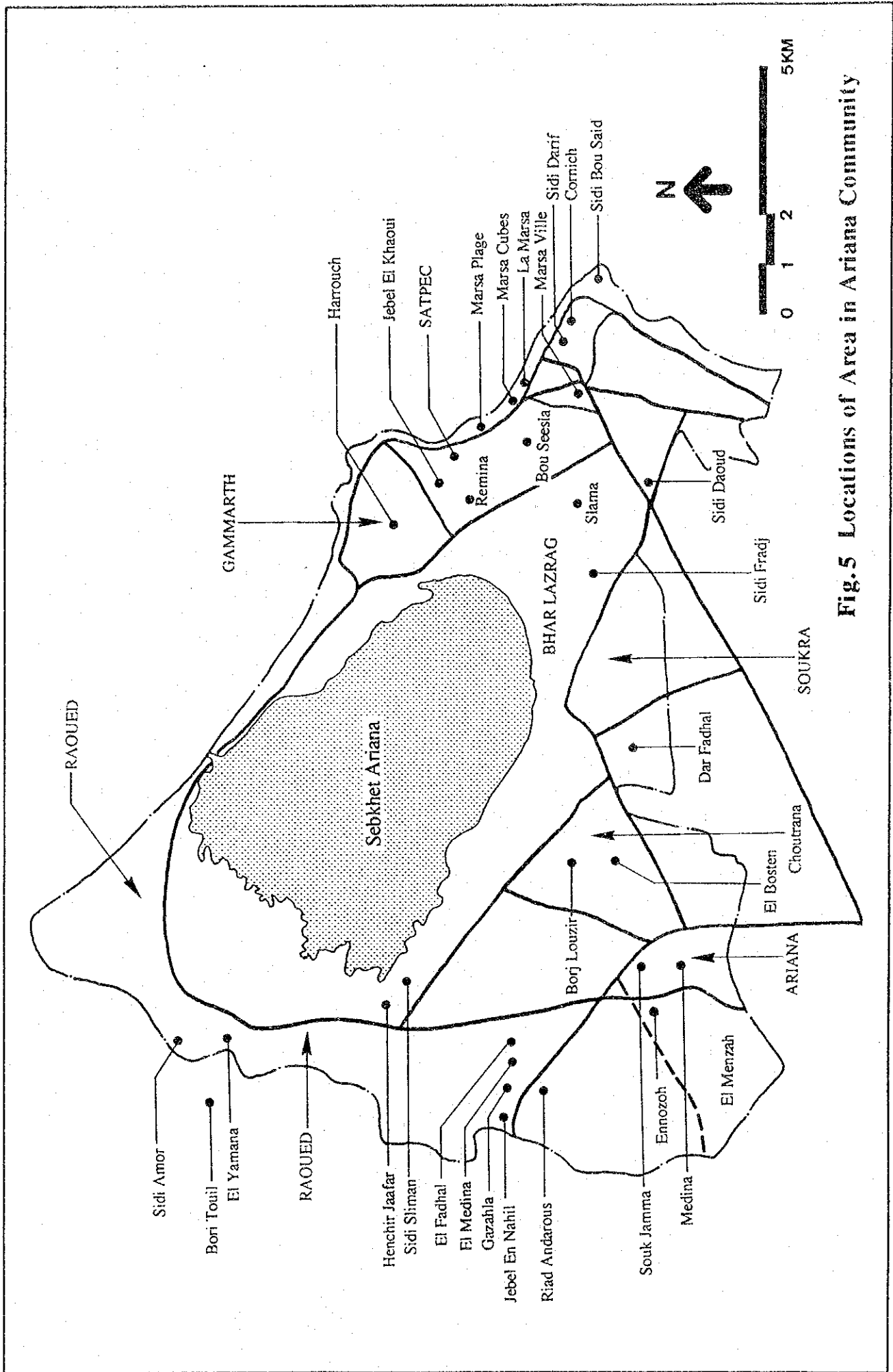0   500   1000   2500M

Fig.5 Locations of Area in Ariana Community
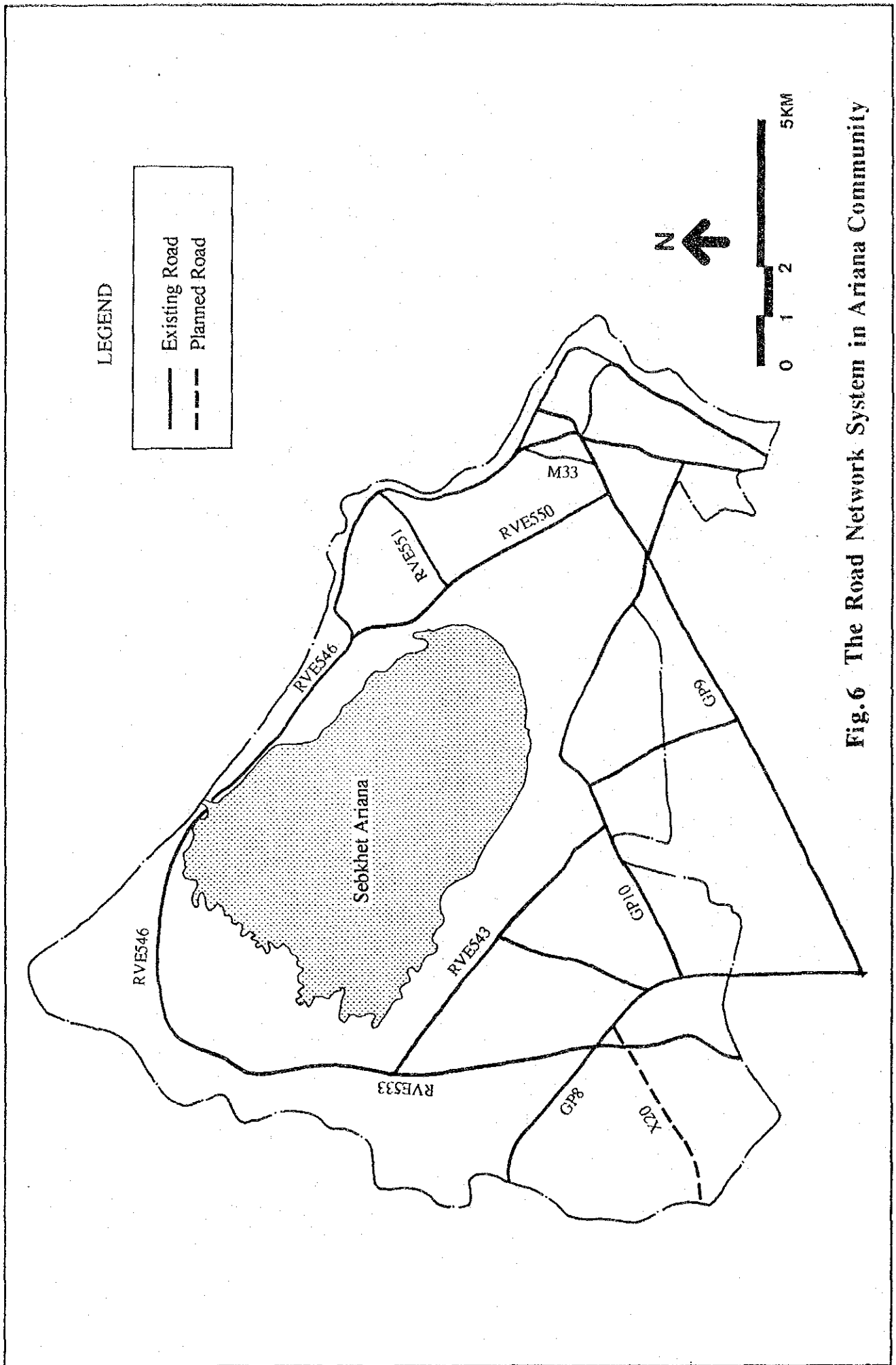
Fig.6 The Road Network System in Ariana Community

LEGEND

Existing Road
Planned Road

N

0 1 2 5KM
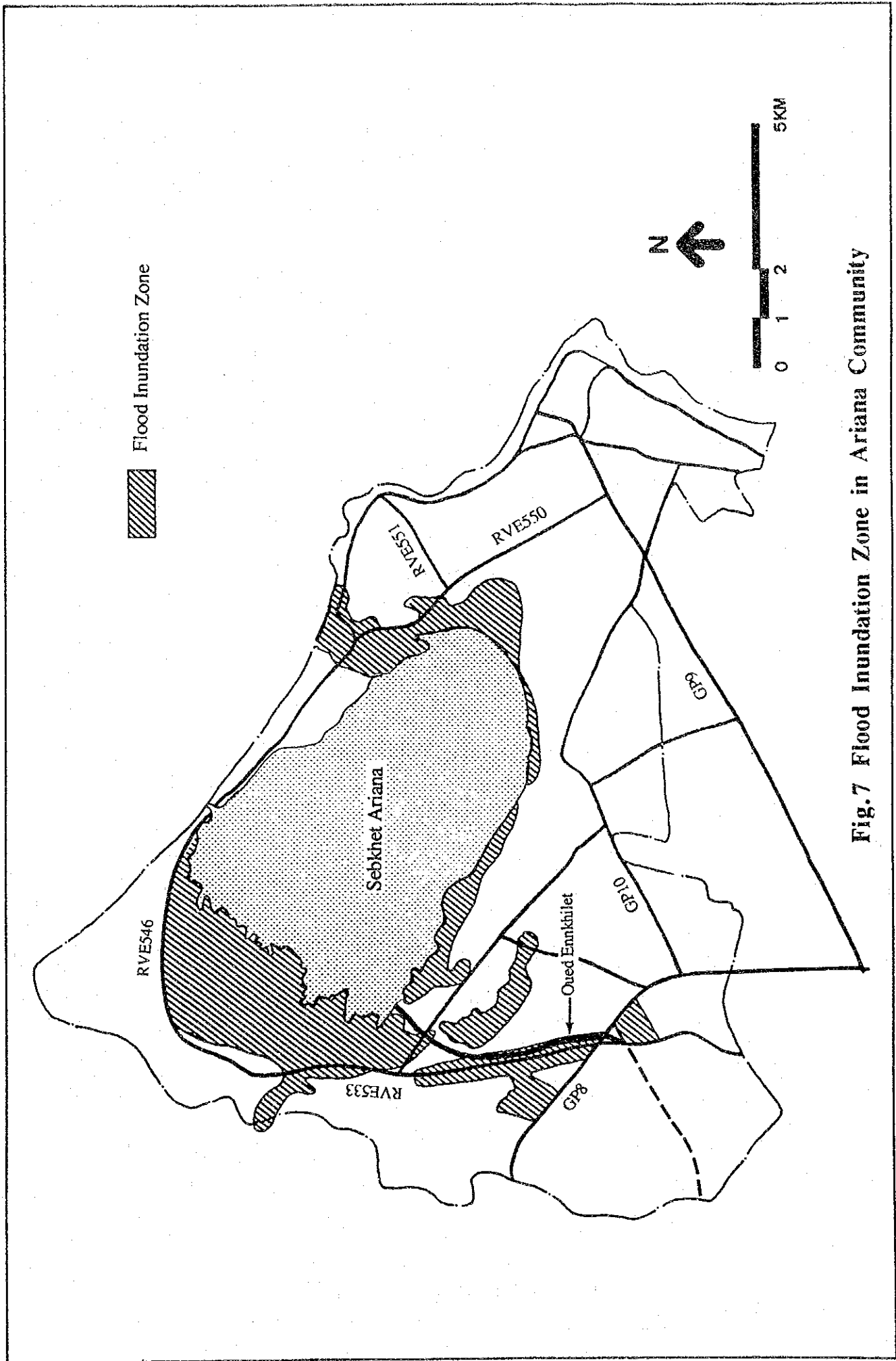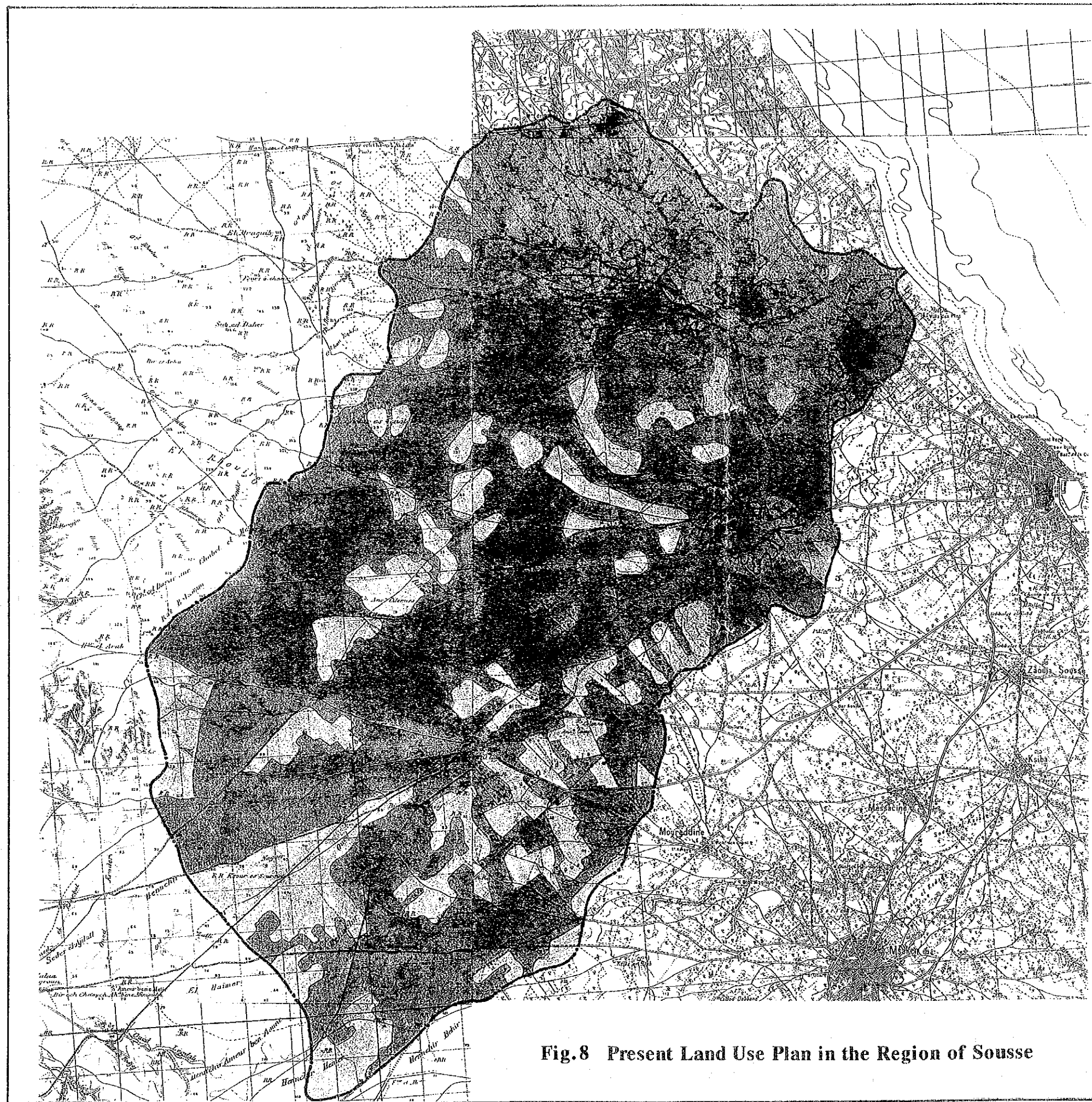
Sebkhet Ariana

RVES46
RVES46
RVES33
RVES51
RVES50
M33
RVES43
GP8
X20
GP10
GP9

Fig.7 Flood Inundation Zone in Ariana Community

Flood Inundation Zone

Sebknet Ariana

RVE551

RVE550

RVE546

RVE533

Oued Ennkhilet

GP9

GP10

GP8

N

0 1 2 5KM

LEGEND

- Urbanized Area
- Agricultural (olive trees)
- Agricultural
  Pomegranate, Orange trees / Open Space
- Catchment Area

N

0 1 2 5KM

Fig.8 Present Land Use Plan in the Region of Sousse
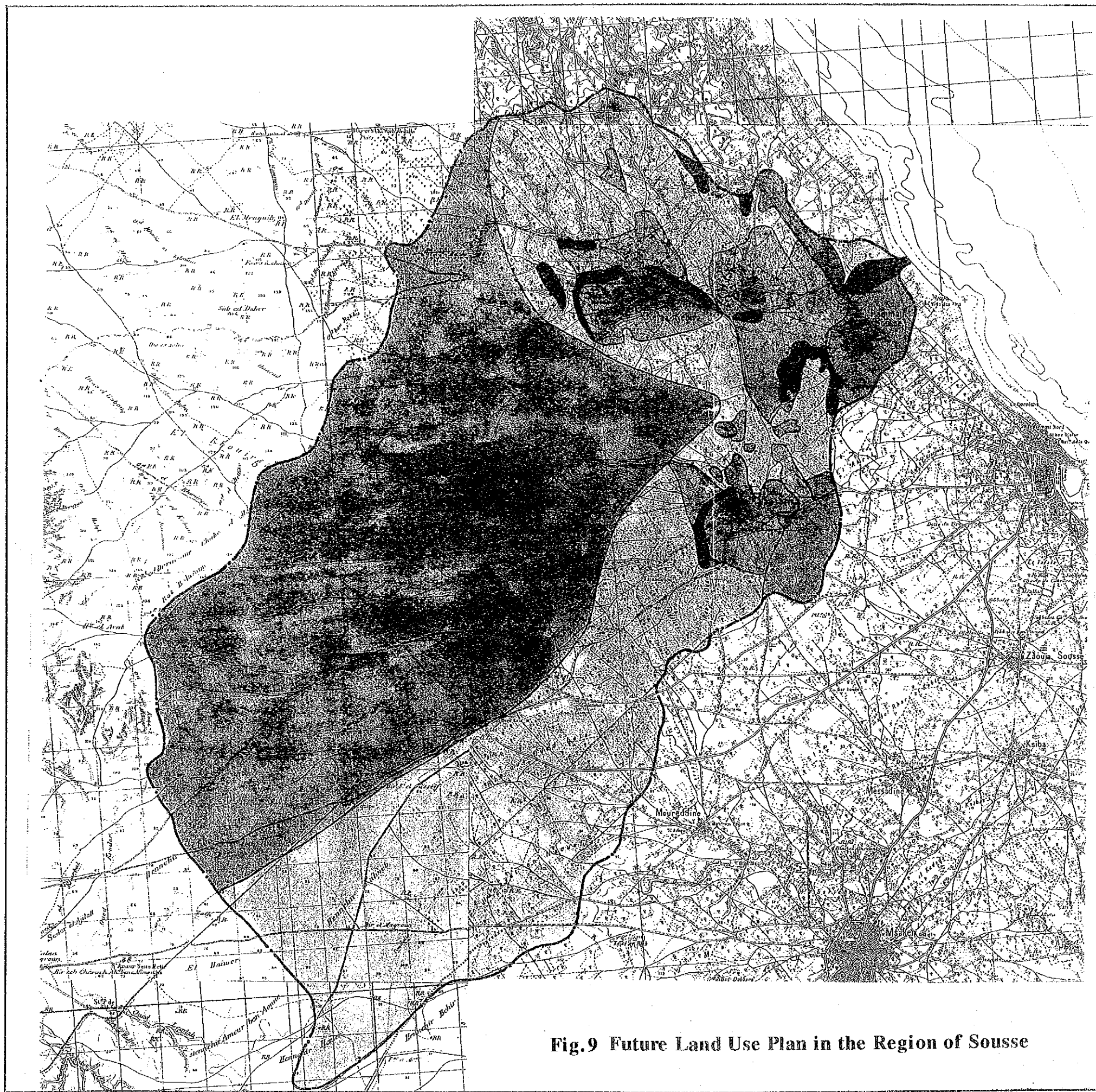
LEGEND

Urbanized Area

Industrial

Urban Green

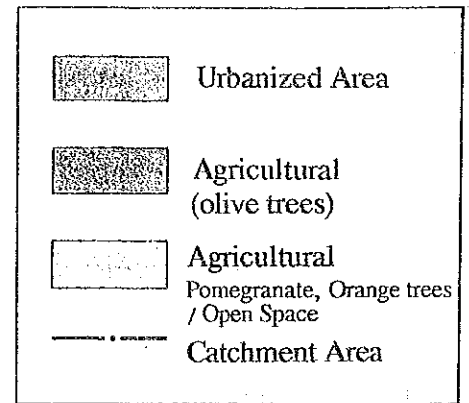Agricultural
(high-irrigated)

Agricultural
(mid-Irrigated, low-irrigated,
non-irrigated)

Catchment Area

N

0   1   2   5KM
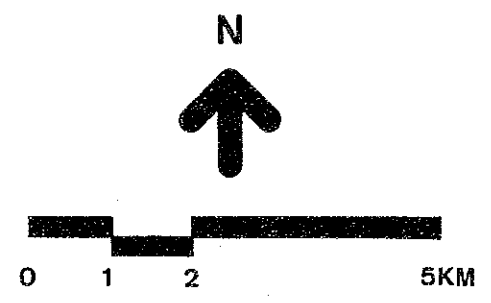
Fig. 9 Future Land Use Plan in the Region of Sousse
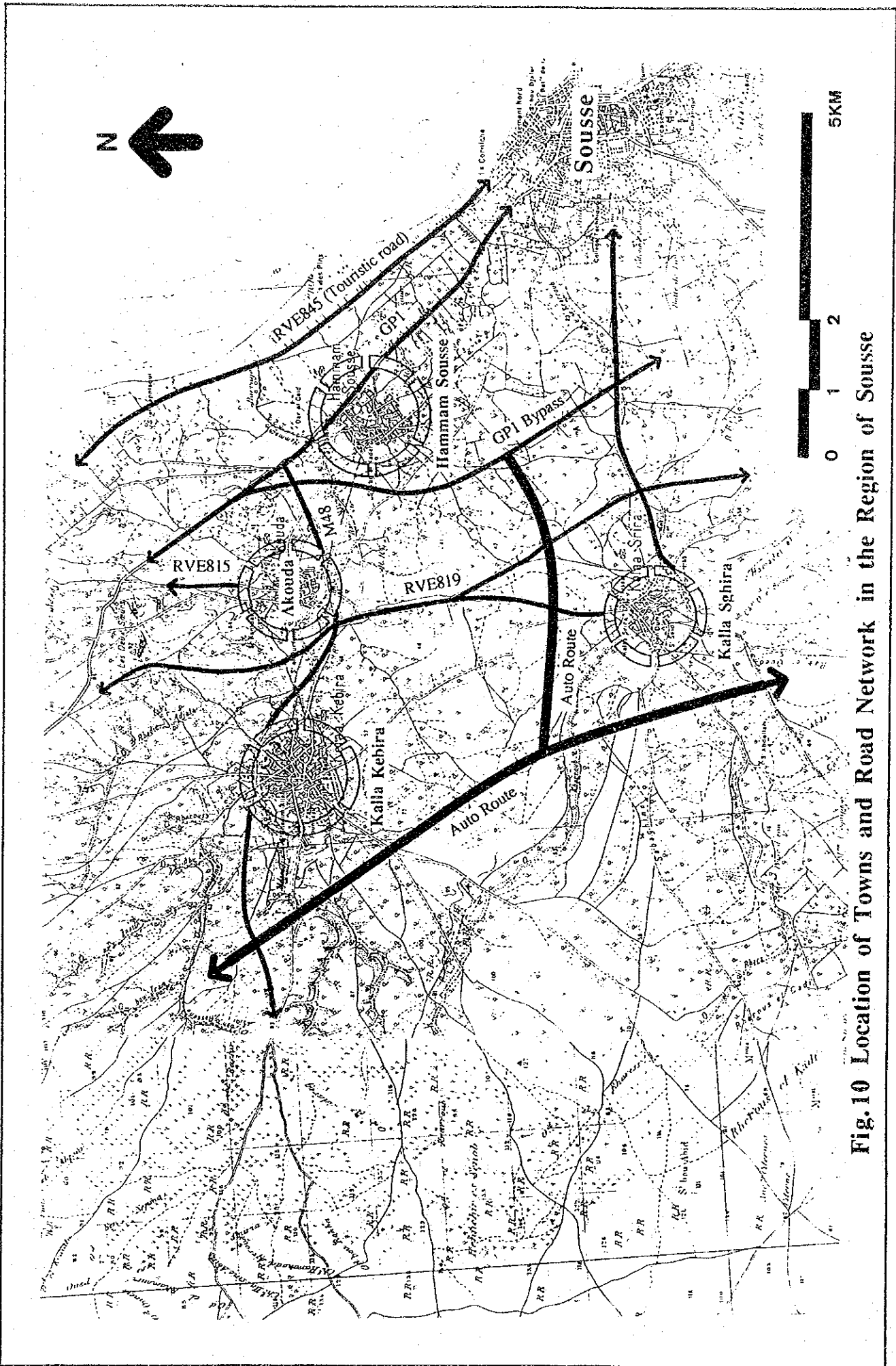
Fig. 10 Location of Towns and Road Network in the Region of Sousse
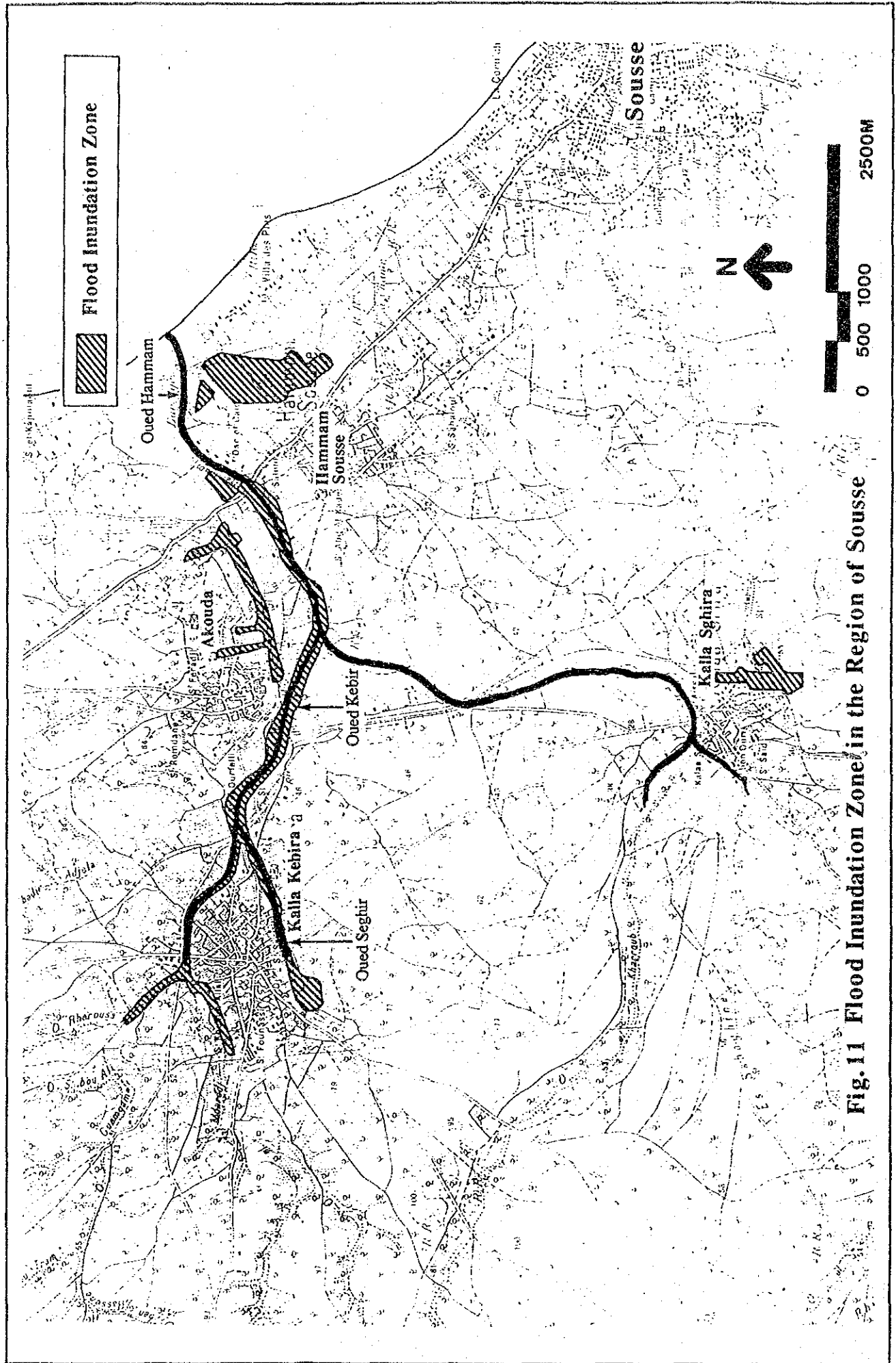
Fig. 11 Flood Inundation Zone in the Region of Sousse

LEGEND

	Residential(Existing Urbanized Area)
	Urbanized Area (Long term)
	Industrial
	Agricultural
	Agricultural protection
	Green Area
	Touristic
	Golf course
	Town boundary

B-95 Highway (Industrial)

GP1

M48

GP1 Bypass

Mediterranean Sea

Old Central Town

N

0   500   1000   2500 M
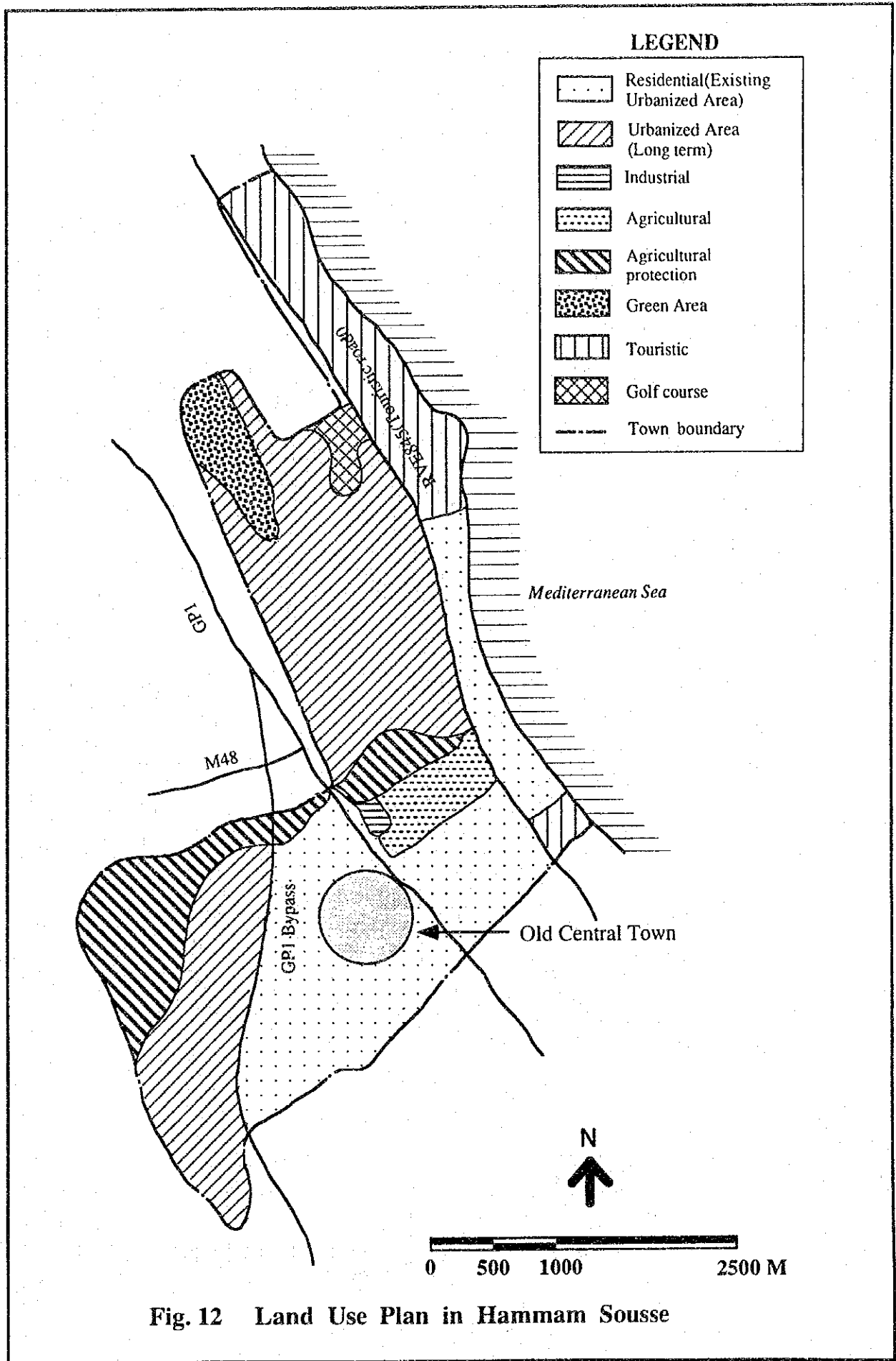
Fig. 12   Land Use Plan in Hammam Sousse

LEGEND

Residential(Existing Urbanized Area)

Urbanized Area (Long term)

Industrial

Agricultural

Agricultural protection

Green Area

Golf course

Town boundary

Mediterranean Sea

RVE 815

M48

Old Central Town

GPI Bypass

GPI

RVE 819

N

0   500   1000   2500 M
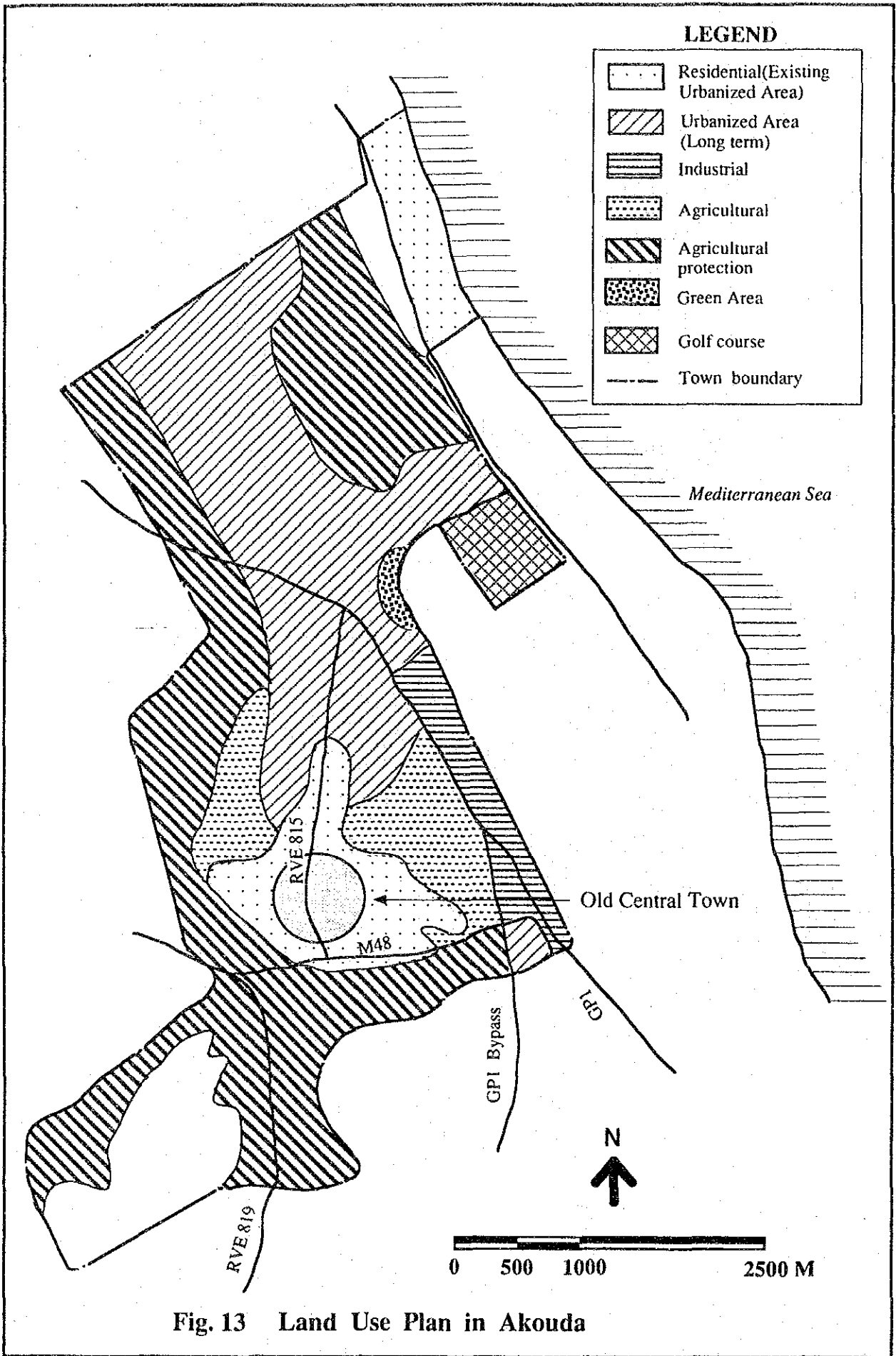
Fig. 13   Land Use Plan in Akouda

C. ESTIMATION OF FLOOD DAMAGES

I. Master Plan Stage

II. Feasibility Study Stage

C. ESTIMATION OF FLOOD DAMAGES

I. MASTER PLAN STAGE

C. ESTIMATION OF FLOOD DAMAGES

TABLE OF CONTENTS

ESTIMATION OF FLOOD DAMAGES

I. MASTER PLAN STAGE

1. Flood Damage

1.1 Methodology

Flooding data on the extent of flooding and its duration in present land use and in future land use conditions is used as a basis for evaluating flood damage. Since at this stage it is impossible to define exact land use for every flooding period, damage assessment has been made for the 100-year return period, and damage for the intervening years has been made on a pro-rata basis according to areas flooded.

The estimation of flood damage is based at this stage on a number of assumptions concerning present and future land use and data on the socio-economic conditions of specific areas. Since the purpose is to prioritise the different oueds and to draw up a Master Plan, a common basis of comparison is made. Detailed evaluations based on site surveys will be carried in the next phase of the Study.

Flood damage is based on the following aspects:

*Damage to housing and residential property
In view of the various factors which affect property values within the same area, including speculation, construction costs are used as a proxy. In general three types of housing are available. 3% of construction costs are proposed to account for flood damage. The following factors are used:

Table 1 Estimated Flood Damage Costs by Building Type

Category	Construction Cost (DT/m2)	Flood Damage (DT/m2)
Popular Housing	200	6.0
Medium Standard	350	10.5
High Standard	500	15.0

Housing Density in the various flooded areas is based on Urban Plans and data used by ONAS.

*Loss of Income by residents

Assuming that duration of flooding will prevent residents from going to work, loss of income will be involved. It is assumed that there are 2 workers in each household affected. Projections of wages have been made till the year 2020 based on expected growth of GDP (6% p.a. till the year 2000, 5.5% between 2000 and 2010 and 5% between 2010 and 2020). On this basis the estimates for skilled labour are DT67 per day and for unskilled labour DT22 per day in 2020.

*Loss of Income - Industrial employees

Loss is calculated on the same basis as for residents

*Damage to Factories

3% of construction costs (DT500/m2) is taken as a proxy for rehabilitation of factories.

*Damage to Agricultural areas

Since at this stage it is impossible to estimate actual crops damaged, it is proposed to take as a proxy the value of agricultural land for lost income. This varies according to fertility and location, but an average figure is DT15,000 per hectare and this figure is used.

*Road Damage

It is assumed that in both cases (Flooding under present land use conditions and flooding under future land use conditions) roads flooded will need rehabilitation. These are assumed at DT120,000 per km for primary roads and DT80,000/km for secondary roads.

*Traffic Delays

These are a major element in damages caused through delays and the consequent loss of income. The value of time is taken at 25% of earnings. It is assumed that passengers in private cars and taxis will be in the skilled labour bracket and all others will be unskilled. Rates for 2020 are used for the base case, and these are estimated at DT2.1/hour for skilled and DT0.7/hr for unskilled labour. Traffic flows and occupancy rates are based on traffic surveys. Where no data is available, assumptions have been made based on surveys in the vicinity.

Traffic projections are based on GDP growth rates till the year 2000. Lower rates are used beyond that to account for saturation levels : these are 4% p.a. for 2000 to 2010, and 2% p.a. for 2010 and 2020.

*Increased vehicle Operating costs

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. For the purposes of the evaluation it is assumed that increased VOCs will be experienced for a period of 30 days during which the road will be rehabilitated. The costs of increased vehicle operation are based on assumptions from the World Bank HDM model, assuming different degrees of roughness of surfaces in a "with" and "without" situation.

The difference in costs is estimated as follows:

Table 2 Difference in Operation Costs in the Flooded and Non-flooded Cases

	(DT per 1,000 vehicle/km)		
Vehicle Type	Non-flooded Case	Flooded Case	Difference
Private Car / Taxi	114.51	143.3	28.79
Bus	459.57	511.17	51.60
Light/Medium Goods	247.59	333.70	86.11
Heavy Goods	663.81	900.54	236.73

These rates are applied to the existing and expected traffic flows. It is assumed that damage will be the same in cases of present and future land use conditions.

Damage assessments for the various oueds is presented below.

2. Oued Ennkhilet and Sebkhet Ariana

2.1 Introduction

The estimated flooded area on the basis of 100-year return period is 396 hectares on future land use conditions and 326 hectares on present land use conditions. Although some of the area is agricultural at present, the growth of spontaneous housing has meant effectively that all the flooded area in the future is likely to be used for residential purposes and the evaluation is carried out in this basis. The base data for housing and population as used by ONAS is shown in Table 3.

Table 3 Existing and Projected Population in the Catchment Area of Ariana Nord

	1990	1992	1996	2001	2006	2011
Total Area (Ha)	6348.6	6348.6	6348.6	6348.6	6348.6	6348.6
Urban area	1281	1281	1843	2003	2324	2501
Population	108 804	123 311	157 604	201 635	242 711	286 163
Persons/House	5.2	5.2	5.2	5.7	5.3	5.0
Houses	21 087	23 896	30 455	35 512	45 473	57 273
Density (Houses/Ha)	16	19	17	18	20	23

Population growth rates for this area are expected to gradually reduce from 6.45% p.a. in 1990 to 3.3% between 2006 and 2011. As saturation is reached the rate can be expected to reduce even further and a rate of 2.5% is used for the years 2011 to 2020. On this basis population in 2020 is expected to be in the region of 358,000. Density of population is estimated to be 140 persons per hectare in 2020. Assuming flooded areas of 326 ha. and 396 ha. the total resident population likely to be affected by flooding will be around 45,600 and 55,000 respectively.

2.2 Estimation of Damages

(1) Loss of Income to residents

The total number of households affected on the basis of 5 persons will be 9,000 and 11,000 respectively. It is further assumed that there will be two workers per household, i.e. 18,000 and 22,000. An analysis of the housing data expected for 2011 indicates that 75% of the housing will be popular housing, 17 % medium standard, and 8% high standard. These housing ratios are used as proxies for calculating lost income insofar as 75 % of the population will consist of unskilled and the rest of skilled workers. Daily wages are assumed to be DT67 for skilled workers and DT22 for unskilled workers in 2020.

With a duration of flooding estimated at 20 hours and 35 hours in 2020 under future land conditions it is assumed that two full working days will be lost. Total income losses for residents are estimated to be in present land use conditions DT600,000 for skilled and DT595,000 for unskilled labour; in future land use conditions these figures are DT737,000 for skilled workers, and DT726,000 for unskilled workers. Total losses from income for residents are therefore estimated to be DT1.2 million and DT1.5 million.

(2) Damage to Buildings

The flooded area is expected to be heavily urbanised., and it is assumed that 80% of the flooded area will consist of built up areas. The total constructed areas are therefore expected to be 260 ha in present land use conditions and 317 ha in future land use conditions. These are broken down according category of type of housing as described above. Based on 3% of construction costs damage in future land use conditions is shown in Table 4.

Table 4   Estimates of Damages to Housing in Flooded Areas in 2020 under Future
           Land Use Condition

Category	Hectares Flooded	Typical Costs (DT per m2)	Estimated Damages (DT1,000)
Popular Housing	237	200	14,220
Medium Standard	54	350	5,670
High Standard	26	500	3,900
Total	317		23,790

Under present land use conditions, damage to housing is estimated at DT19.5 million.

(3) Transport And Traffic Losses

(a) Traffic Flow Data

No detailed traffic counts are available for the sections of road expected to be flooded. However, The Transport Study for Greater Tunis carried out in 1988 indicated that traffic on the GP8 in Ariana was estimated to be around 25,000 vehicles per day. In applying the GDP growth rates and the relevant growth rates for traffic flows, it is estimated that traffic will reach 46,800 by 2000, 69,000 by 2010 and 84,500 by the year 2020.
The structure of traffic for the GP 8 is estimated as follows:

Private Cars and Taxis   : 51%
Light vehicles   : 24%
Heavy Vehicles   : 22%
Buses   : 2%
Others (2 wheels)   : 1%

In applying the following occupancy rates the flow of passengers is estimated on the North-South axis to be as follows for the year 2020 (Table 5) :

Table 5 Oued Ennkhilet - Estimate of Daily Passenger Flow on the GP8

Category	Vehicles	Occupancy Rate	Total Passengers
Passengers and Taxis	43,100	3.8	163,780
Buses	1,700	45	76,500
Light vehicles	20,300	2.0	40,600
Heavy vehicles	18,600	2.0	37,200
2 wheels	800	1.5	1,200
Total	84,500		319,280

(b) Estimated Loss of Income due to traffic delays

It is assumed that traffic will be halted for 20.5 hours under present land use conditions and 35 hours under future land use conditions and delays will be encountered on this route. The value of time is estimated at 25% of the hourly wages of skilled and unskilled labour. At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labour and DT0.16 per hour for unskilled labour in present conditions. These are assumed to increase in line with expected GDP growth and to be DT2.1/hour and DT0.7/hour respectively in the year 2020. Passengers in private cars are costed at skilled labour rates and the rest at unskilled. On this basis the loss of income in the year 2020 is estimated at DT12,000,000 skilled labour and DT3,810,000 for unskilled, a total of DT15.8 million. for traffic delayed on the GP8 data is not available on traffic on the RVE533 and 50% of the traffic flow of the GP8 is taken. Total value of time lost on the major roads is therefore estimated to be DT23.7 million in future land use conditions and DT13.9 million in present land use conditions. In addition there will be losses to local traffic. These movements are likely to be relatively small, since most of the potentially flooded are is adjacent to the road. The overall estimates are therefore increased by a factor of 5% to account for these. Total income loss is therefore estimated to be DT14.6 million and DT25.0 million respectively.

(c) Increased Vehicle Operating Costs

It is estimated that approximately 0.5 km of the GP8 will be flooded, and approximately 4 km of the RVE533E. The following additional costs are incurred for traffic on a daily basis in the year 2020 (Table 6).

Table 6 Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases - GP8 - Future Land Use Situation in 2020

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs per Day
Private Car/Taxi	28.79	43,100	5,600
Bus	51.60	1,700	400
Light/Medium Goods	86.11	20,300	7,900
Heavy goods	236.73	18,600	19,800
Total			33,700

Assuming that 30 days will be required to repair the roads affected, total increased VOCs will be DT1.0 million.

(d) Damage to Roads

It is estimated that up to 4 km of the RVE 533E will be affected by the flooding, and 0.5 of the GP8. Assuming road maintenance and rehabilitation costs of DT120,000 per kilometres the estimated flood damage could be DT540,000. Local roads will also be affected. In applying a ratio of 1 km per 10 hectares of local roads, the total number of roads affected will be 39.6 km. Assuming a rehabilitation cost of DT80,000/km the total damage to local roads could be around DT3.2 million. Total road damage is therefore estimated to be DT3.7 million.

(4) Total estimated Flood damages

The estimate of total damages are shown in Table 7. These estimates ignore other items such as losses to industries and shops located in the area. In order to cover for these an additional amount has been added.

Table 7 Oued Ennkhilet - Summary of Estimated Flood Damages - Present and Future Situation

	Present		Future
*Persons affected	45,600		55,000
		(DT 1,000)	
*Damage to Property	19,500		23,790
*Loss of Income (Residents)	1,200		1,500
*Road Damage	3,700		3,700
*Traffic Delays (Income losses)	14,600		25,000
*Increased Vehicle Operating Costs	1,000		1,000
Total	40,000		55,000

3. Oued Greb

3.1 Introduction

The estimated flooded Area for the Oueds Greb and Roriche in the year 2020 is 159.2 ha under future flooding conditions, and 111.8 ha under present land use conditions. Three zones will be flooded and their major impacts will be as follows:Zone A : Disruption of traffic on the GP9 and on some secondary roads :Zone B : (Oued Greb) : Flooding of residential areas (80 ha.) and traffic disruption on major axis Zone C : (Oued Roriche) : Disruption of traffic on major axis. The base data for housing and population as used by ONAS is shown in Table 8.

Table 8 Population Estimates for the Catchment Area of the Oueds Greb and Roriche

	1990	1992	1996	2001	2006	2011
Total Area(Ha)	1887	1887	1887	1887	1887	1887
Urban Area(Ha)	1077	1127	1327	1326	1326	1326
Population	66 196	72 620	85 591	104 751	121 379	136 000
Persons/house	3.1	3.2	3.4	4.0	4.2	4.6
Number of houses	21 682	22 593	25 354	26 454	28 954	29 812
Density (Houses/Ha)	20	20	20	20	22	22

3.2 Estimation of Damages

(1) Loss of Income to residents

The impact of flooding on residents will only be felt in Zone B where it is estimated that on a 100-year return period, 57 ha based on present land use conditions, and on future land use conditions some 80 ha of residential areas will be flooded. Assuming a rate of growth of 2.3% p.a. between 2011 and 2020 population in the area will be 167,000, with a density of 126 persons per hectare in the urban areas. The population affected will be 7,100 on present land use conditions and 10,000 on future land use conditions. On the basis of 5 persons per family there will be 1,400 and 2,000 households respectively.

The population of this area is expected to be in the upper income bracket and daily wages are assumed to be DT67 for skilled worker for the year 2020. It is assumed that there will be two earners per household i.e. 2,800 and 4,000 employees.

With a duration of flooding estimated at 8.5 hours under present land use and 13 hours in 2020 under future land conditions it is assumed that one full working day will be lost. Total income losses for residents are estimated to be DT188,000 and DT268,000.

(2) Damage to Buildings

An analysis of the housing data by ONAS in the area expected for 2011 indicates that 56% of the housing will be of high standard, 27 % medium standard, and 17% apartments. The flooded area is expected to be heavily urbanised., and it is assumed that 80% of the flooded area will consist of built up areas. The total constructed areas are therefore expected to be 46 ha in the present land use conditions and 64 ha in future conditions. These are broken down according category of type of housing as described above. It Is assumed that damages will be 3% of Construction Costs. Damage estimates are shown in Table 9.

Table 9   Estimates of Damages to Housing in Flooded Areas in 2020 under Present and Future land Use Conditions

Category	Hectares Flooded Present	Future	Typical Costs (DT Per m2)	Estimated Damages Present (DT1,000)	Future
Apartments	8	11	500	1,200	1,650
Medium Standard	13	18	350	1,365	1,890
High Standard	25	35	500	3,750	5,250
Total	46	64	6,315		8,790

(3) Transport And Traffic Losses

(a) Traffic Flow Data

Three major roads will be affected. The evaluation is based in the disruption to traffic on the three main roads. A small allocation is made for the roads flooded in the residential areas.

In view of the lack of sufficient data on traffic counts, it is assumed that the estimates for the main traffic flow will be scaled down for the other two main roads by a factor of 0.5.

No detailed traffic counts are available for the sections of road expected to be flooded. However, The Transport Study for Greater Tunis carried out in 1988 indicated that traffic on the major north- south route in Greb was in the region of 32,300 in 1988.

In assuming the growth rates of GDP till 2000 and the relevant growth rates for traffic flows, it is estimated that traffic will reach 60,000 by 2000, 90,000 by 2010 and 110,000 vehicles per day by the year 2020. Traffic flows for the other two main roads cut off are based on a factor of 0.5. It is assumed that the same structure will be maintained. The structure of traffic for the GP 8 is estimated as follows:

Private Cars andTaxis	: 51%
Light Vehicles	: 24%
Heavy Vehicles	: 22%
Buses	: 2%
Others (2 wheels)	: 1%

In applying the following occupancy rates the flow of passengers is estimated on the North-South axis to be as follows for the year 2020 (Table 10) :

Table 10 Oued Greb - Estimate of Daily Passenger Flow on the GP8

Category	Vehicles	Occupancy Rate	Total Passengers
Passengers and Taxis	56,100	3.8	213,180
Buses	2,200	45	99,000
Light Vehicles	26,400	2.0	52,800
Heavy Vehicles	24,200	2.0	48,400
2 wheels	1,100	1.5	1,650
Total	110,000		415,030

(b) Estimated Loss of Income due to traffic delays

It is assumed that traffic will be halted for 8.5 hours in the present land use situation and 12.5 hours in the future land use situation. Delays will be encountered in Zones B and C.

Passengers in private cars are costed at skilled labour rates and the rest at unskilled. Losses on the other two main roads are taken at 50% of this value for each road. In addition there will be losses to local traffic. These movements are likely to be relatively small, since only a relatively small residential area will be flooded. The overall estimates are therefore increased by a factor of 5% to account for these. Estimated losses are as follows :

	(DT 1,000)	
	Present Land Use	Future Land Use
Skilled Labour	3,805	5,596
Unskilled Labour	1,201	2,523
Total	5,006	8,119
Total Plus 5%	5,256	8,525

(c) Increased Vehicle Operating Costs

The flooding is expected to cut the major roads rather than damage large sections of it. Adding together the various points which will be affected, it is assumed that damage will occur to approximately 1 km of major roads. The following additional costs are incurred for traffic passing through all the three major roads in the year 2020 (Table 11).

Table 11 Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases on Major Roads Affected by the Oueds Greb and Roriche - Present and Future Land Situation in 2020

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	112,200	3,230
Bus	51.60	4,400	227
Light/Medium Goods	86.11	52,800	4,600
Heavy Goods	236.73	48,400	11,200
Total			17,257

Based on different flooding periods in the present and future land use conditions daily costs are estimated at DT13,400 and DT18,200 respectively. Assuming 30 days for road repairs, losses will be DT402,000 and DT546,000 respectively.

d) Damage to Roads

About 1 km of major roads and 6.4 km of secondary roads(applying a ratio of 1 km per 10 hectares), will be affected by the flooding. Assuming road maintenance and rehabilitation costs of DT120,000 per kilometres for major roads and DT80,000/km for secondary roads the estimated flood damage could be DT632,000.

4) Total estimated Flood Damages

The estimate of total damages are shown in Table 12. These estimates ignore other items such as losses to industries and shops located in the area. In order to cover for these an additional amount has been added. Total losses due to floods on a 100-year return basis are therefore estimated to be DT11.7 million.

Table 12   Oued - Summary of Estimated Flood Damages - Present and Future
            Situation

	Present		Future
*Persons affected			10,000
		(DT 1,000)	
*Damage to Property	6,315		8,790
*Loss of Income (Residents)	188		268
*Road Damage	632		632
*Traffic delays (Income losses)	5,256		8,525
*Increased Vehicle Operating Costs	402		546
Total	12,793		18,761

4.   Oued Gariana and Sebkhet Sijoumi

4.1   Introduction

The Oued is located along the following districts: Cite Universitaire, Seniet Ben Abdallah, El Boudria, Kasr Essaid; Major population areas are in Mannouba, (Cite Wihda), Sidi Amor, Eddenden, Ezzouhour II, III, IV, and V, and El Hraira.

Under present land use conditions it is expected that in a 100-year return period 226.6 ha will be flooded. Under future conditions, this will increase to 412.1 ha. Flooded areas can be divided into six zones. It is difficult to estimate the population likely to be affected

, and estimates are based on the data provided by ONAS for the "Bardo-Gariana" catchment areas as shown in Table 13 below:

Table 13 Existing and Projected Population in the Catchment Area of Bardo-Gariana

	1990	1992	1996	2001	2006	2011
Total Area (Ha)	10703.8	10703.8	10703.8	10703.8	10703.8	10703.8
Urban area	3951	3951	4143	4597	4871	4871
Population	485301	522 549	596 106	675 065	760 786	857 969
Persons/House	5.4	5.2	5.1	5.0	5.0	5.0
Houses	89 992	101 072	116 803	134 802	152 157	171 590
Density (Houses/Ha)	23	26	28	29	31	35

4.2 Estimation of Damages

(1) Damage to Residential Areas

According to the ONAS statistics for the catchment area of Bardo-Gueriana the total population of the area in 2011 is estimated to be 858,000. Assuming a growth rate of 2.33% the population will reach 940,000 in the year 2020. Urban area is estimated at 4,871 ha representing a density of nearly 200 persons per ha.

In applying this factor to the expected flooded areas on a 100-year return basis, the total resident population affected will be 45,300 under present land use conditions and 82,400 under future conditions.

Residential areas liable to be flooded are identified from the cartography according to the five separate areas. The evaluation also takes into account the nature of housing in the area. Data provided in the ONAS Study (Master Plan for Greater Tunis, January 1993) has been analysed. This indicates that for the Bardo - Gariana area, the general breakdown by type of housing is as follows. Relevant construction costs for different types are shown in Table 14.

Table 14   Forecast of Housing Type in 2011 in the Bardo-Gariana Areas and
              Typical Construction Cost

Type of Housing	Hectares	(%)	Typical Costs (DT per m2)
Popular Housing	4,017	82%	200
Medium Standard	300	6%	350
High Standard	554	12%	500

This breakdown is assumed to apply to all the potentially floodable residential areas and will be valid for the year 2020. With regard to damages, it is assumed that maintenance

and repair costs will amount to 3% of construction costs. i.e. DT6/m2 for popular housing, DT 105/m2 for medium standard, and DT15/m2 for high class housing. The residential areas affected by flooding vary in the different flood prone areas. Analysis of mapping shows the following densities to be appropriate for the different areas (Table 15):

Table 15 Estimated Residential Areas Prone to Flooding under Present and Future
Land Use Conditions in 2020

Area	Urban Area (%)	Flooded Area (Hectares)		Built Up Area (Hectares)	
		(i)	(ii)	(i)	(ii)
A	80	54.5	87.6	44	70
B	50	42.1	84.5	21	42
C	20	37.5	93.9	8	19
D	80	31.5	53.4	25	43
E	30	28.1	49.3	8	15
F	10	32.9	43.4	3	4
Total		226.6	412.1	109	193

*Note : (i) Under Present Land Use Conditions
(ii) Under Future land Use Conditions

In applying the breakdown and construction costs by type of housing , and assuming damage at 3% of construction costs, housing damage is estimated at DT8.0 million under present land use conditions and DT14.2 million under future conditions.

(2) Loss of Income to Residents

Households affected are estimated at 9,060 under present land use conditions and 16 480 in future conditions. It is assumed that there are two earners per household, and that these are likely to be skilled labour. In the present land use conditions it is assumed that one days income will be lost (8 hours of flooding), and in the future two days are lost (16 hours of flooding). On this basis, total income losses are DT1.2 million andDT 2.2 million respectively.

(3) Transport and Traffic Losses

(a) Traffic Flow Data

No detailed data is available on traffic on specific roads within the flooded areas. However traffic counts carried out for the Master Transport Plan prepared in March 1989, reflecting 1988 figures show that North - South traffic in the Bardo Gariana area was estimated at 33,000, while East- West traffic was around 21,000. In order to arrive

at possible estimated for the base year - 1995, these figures are escalated by the growth of GDP (3.7% in 1989, 7.6% in 1990, 3,.5% in 1991, 8.1% in 1992, and 6.0% p.a. till 1995). On this basis, traffic will be 46,000 vehicles per day in a north-south direction, and 29,000 in an east-west direction in 1995. Applying the rates of growth expected in GDP in the future, - 6% p.a. until 2000; in view of rapidly approaching saturation levels in the city, it is proposed to use lower growth rates in the future, 4% p.a. between 2000 and 2010 and 2% between 2010 ands 2020. On the above basis traffic forecasts for the two major arteries are shown in Table 16.

Table 16 Oued Gariana - Traffic Forecasts for the Major Artieries

| Year | Flows (Vehicle per day) | |
	North-South	East-West
1988	33,000	21,000
1995	46,000	29,000
2000	61,600	38,800
2010	91,100	57,400
2020	111,000	70,000

Most of the traffic on these roads will be through traffic, and a factor of 25% is taken as local traffic flows. The structure of traffic as estimated for the northern area is as follows:

Private Cars and Taxis	:	73%
Buses	:	2%
2 wheels	:	10%
Light and Heavy Trucks:		15%

In applying the following occupancy rates the flow of passengers is estimated on the North-South axis to be as follows for the year 2020 (Table 17) :

Table 17 Oued Gariana - Estimate of Daily Passenger Flow on the North - South Axis

Category	Vehicles	Occupancy Rate	Total Passen Tgers
Passengers and Taxis	81,030	3.8	308,000
Buses	2,220	45	100,000
Light and Heavy Vehicles	16,650	2.0	33,000
2 wheels	11,100	1.5	17,000
Total	111,000		458,000

The relevant figures for East-West traffic are as follows (Table 18) :

Table 18 Oued Gariana - Estimate of Daily Passenger Flow on the East - West Axis

Category	Vehicles	Occupancy Rate	Total Passengers
Passengers and Taxis	51,100	3.8	194,000
Buses	1,400	45	63,000
Light and Heavy Vehicles	7,000	2.0	14,000
2 wheels	10,500	1.5	16,000
Total	70,000		287,000

(b) Estimated Loss of Income due to traffic delays.

North- South traffic will be affected by flooding in Zones A, B D and E, where the duration of flooding varies from 8 to 16.5 hours in present land use conditions, and 11 to 28 hours under future conditions.. It is assumed that traffic will be halted for the maximum time and 12 hours and 24 hours of delays respectively will be encountered on this route. The value of time is estimated at 25% of the hourly wages of skilled and unskilled labour. At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labour and DT0.16 per hour for unskilled labour in present conditions. These are assumed to increase in line with expected GDP growth and to be DT2.1/hour and DT0.7/hour respectively in the year 2020. Passengers in private cars are costed at skilled labour rates and the rest at unskilled. Loss of income is estimated at DT14.2 million under present land use conditions, and DT28.4 million under future conditions. In taking account of local traffic these figures are increased by 25 % and total income losses are therefore DT17.7 million and DT35.5 million respectively.

(c) Increased Vehicle Operating Costs

It is estimated that approximately 3 km of road on the North-South axis will be flooded. It is assumed that the split between heavy and light lorries is 50% -50%. In applying the difference in vehicle operating costs to expected traffic over 3 km, the following additional costs are incurred for traffic in the year 2020 (Table 19).

Table 19   Additional Vehicle Operating Costs in the Flooded and Non-flooded
              Cases - Future Situation, North - South Traffic

Vehicle Type	Difference (DT per 1,000 vehivle/km)	Daily Traffic	Costs (DT per day)
Private Car / Taxi	28.79	81,030	6,999
Bus	51.60	2,220	345
Light/Medium Goods	86.11	8,325	2,151
Heavy Goods	236.73	8,325	5,910
Total			15,385

On the East West Axis approximately 4 km of roads will be affected by flooding. The following Table shows the increased vehicle operating costs expected (Table 20) :

Table 20 Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases - Future situation, East - West Traffic

Vehicle Type	Difference (DT per 1,000 vehivle/km)	Daily Traffic	Costs (DT per day)
Private Car / Taxi	28.79	51,100	5,884
Bus	51.60	1,500	1,204
Heavy goods	236.73	3,500	3,312
Total			10,692

Total increases in VOCs are estimated to be DT26,077 per day. This factor is increased by 25% to account for local traffic to arrive at an estimate of DT32,600. Assuming a period of 30 days to effect road repairs, total traffic losses from vehicle operating costs are therefore estimated at DT978,000.

(d) Damage to Roads

It is estimated that up to 7 km of major roads could be affected by flooding. Assuming road maintenance and rehabilitation costs of DT120,000 per kilometres the estimated flood damage could be DT840,000. Local roads will also be affected. In applying a ratio of 1 km per 10 hectares of local roads, the total number of roads affected will be 8 km. Assuming a rehabilitation cost of DT80,000/km the total damage to local roads could be around DT640,000. Total road damage is therefore estimated to be DT1,480,000, say DT1.5 million.

(4) Total Estimated Flood Damage

The estimate of total damages are shown in Table 21.

Table 21 Oued Gariana - Summary of Estimated Flood Damages - Present and Future Situation

	Present	Future
*Persons affected	45,300	82,400
	(DT 1,000)	
*Damage to Property	8,000	14,000
*Loss of Income (Residents)	1,200	2,200
*Road Damage	1,500	1,500
*Traffic delays (Income losses)	17,700	35,500
*Increased Vehicle Operating Costs	978	978
Total	29,378	54,178

5. Oued Maliyan

5.1 Introduction

On a 100-year flooding basis the area covered is estimated at 7,300 ha and the damage will be widespread and considerable. Vast tracts of agricultural land will be damaged, and the populations of some major conglomerations, in particular parts of Rades and the coastal areas will, be affected. Damage will also be caused to local industries. For the purposes of the evaluation it is assumed that the impact on flooding of present and future land use conditions will be similar.

In view of the large area under evaluation, assumptions are made concerning damage caused. Statistical data is not available for the area as a whole, since it covers both the heavily urbanised area of Rades, conglomerations in rural areas and large agricultural areas. In order to arrive at approximate estimates of population affected , density criteria are used from data provided for some of the main areas in the flooded area and its vicinity, and coefficients taken to estimate statistical data for other areas.

The base data for housing and population used by ONAS for its projections is given in the following Tables for Rades and Mornag, both of which will be affected by the flooding, and for Fouchana which borders on the edge of the flooded areas and will provide indicators as to the likely socio-economic structure of the flooded areas in Oued Maliyan.

Table 22 Existing and Projected Population in the Catchment Areas of Oued Maliyan

(A) RADES

	1990	1992	1996	2001	2006	2011
Total Area (Ha)	1603.5	1603.5	1603.5	1603.5	1603.5	1603.5
Urban area	388.5	388.5	388.5	388.5	388.5	388.5
Population	36 082	38 279	43 083	49 262	54 389	60 050
Persons/House	4.6	4.5	4.5	4.7	4.7	4.7
Houses	7780	8443	9663	10 426	10 426	10426
Density (Houses/Ha)	20	22	25	26	26	26

(B) MORNAG

	1990	1992	1996	2001	2006	2011
Total Area (Ha)	4 457	4 457	4 457	4 457	4 457	4 457
Urban area	120	120	120	120	120	120
Population	16 122	16 938	18 697	21 153	23 933	27 078
Persons/House	5.4	5.4	5.3	5.2	5.1	5.0
Houses	2 960	3 137	3 527	4 068	4 693	5 416
Density (Houses/Ha)	25	26	29	34	39	45

(C) FOUCHANA/MOHAMEDDIA

	1990	1992	1996	2001	2006	2011
Total Area (Ha)	3353	3353	3353	3353	3353	3353
Urban area	460	460	460	460	460	460
Population	33 044	37 832	48 670	65 131	87 160	116 640
Persons/House	5.4	5.4	5.3	5.2	5.1	5.0
Houses	6 119	7 006	9 183	12 525	17 090	23 328
Density (Houses/Ha)	5.4	5.4	5.3	5.2	5.1	5.0

The coastal area at Rades is expected to reach saturation point and a low growth rate is predicted for the later years - 2.0%. Mornag has a rate of growth of 2,5% between 2006 and 2011, while Fouchana which is proposed in the Urban Master plan as a major growth Centre in the future has an expected rate of growth of 6% p.a. In applying these trends, the populations of Rades and Mornag are estimated to be 71,800 and 33,800 respectively in the year 2020

In order to estimate the population affected by flooding in the total area, an analysis of the mapping shows that approximately 25% of the population of Rades, and the total population of Mornag urban area will be subject to flooding. This represents a figure of 52,000. In addition the rural population of Mornag should be taken into account. According to the 1984 Census the population of Mornag Rural was estimated at 18,943. It is assumed that this population has grown at a lower rate as a result of migration and assuming a low growth rate of 2% p.a. total rural population in the area will be 38,500 in the year 2020. In taking account of other smaller villages and scattered farms in the potentially flooded area, a total population of 90,000 is assumed as being affected by the flooding.

According to the Regional Master Plan for Tunis the population affected along the corridor of the MC34 which runs through the flooded area past Mornag is as follows:

Year	Population
1988	:110,844
1996	:134,697
2001	:140,101

At these e rates of growth (2.1%) population in this corridor will be 210,000 in the year 2020. It is therefore estimated that approximately 43 % of the total population estimated for this corridor will be affected by flooding.

5.2 Estimation of Damages

(1) Loss of Income to Residents

With a population of 90,000 persons affected by flooding and taking into consideration the densities for the different areas used by ONAS, the number of households affected would be 4,000 in Rades and 6,760 in Mornag. Assuming higher number of persons per household in rural areas, a further 5,000 households are expected to be affected by flooding, total households affected would be around 15,000.

It is assumed that there will be two workers in each household. With 35 hours of flooding, it is assumed that residents will lose 3 days of income. Assuming that population in the urban areas of Rades and Mornag are skilled labour (with rates of DT67 per day in the year 2020), and rural population is unskilled (DT22 per day) total loss of income is estimated to be DT4.4 million for urban population, and DT0.6 million in the rural areas - a total of DT5.0 Million.

(2) Damage to Buildings

As a guideline it is assumed that urban areas together with areas of spontaneous housing account for 10% of the flooded areas - approximately 730 ha. With a built up ratio of 80% total surface affected will be around 600 hectares or 6 million m2.

In assuming the breakdown by category of housing in the Governorate of Ben Arous as representing the structure of housing affected, and applying the estimated average construction costs by category (3% of Construction costs are used as a proxy for flood damage), the estimated flood damage to buildings is shown in Table 23.

Table 23 Estimated Damage to Residential Buildings

Category	%	m2 (1,000)	Unit Cost (per m2)	Estimated Damage (DT1,000)
Houses	38	2,280	350	23,940
Villas	44	2,640	350	27,720
Apartments	12	720	250	4,950
Rudimentary and Spontaneous	6	360	150	1,620
Total	100	6,000		58,230

(3) Traffic and Transport Costs

(a) Traffic Flow Data

It is expected that the floods will have a major impact on the main roads. The roads affected will be the GP-1, MC 33E the MC 34 and the MC 39, in addition to several secondary and minor roads.

With regard to traffic flows detailed data is not available except for the main arteries. The latest traffic counts are available in the Regional Transport Master Plan for the District of Tunis.(Ministry of Interior, 1989). The traffic count on the GP1 at the Southern exit to Tunis indicated flows in the region of 40,000 vehicles per day. the structure of traffic was estimated to be 33% for private cars and taxis, 3% for buses, 39% for heavy vehicles and 25% for light vehicles.

The rate of occupation for private cars and taxis ranged from 2.1 to 3.8, and for camionettes and lorries between 1.2 and 2. The higher figures are used for the evaluation. For buses data was not readily available and an occupancy factor of 45 is used. It is also assumed that passengers in private cars and taxis will be in the skilled labour bracket, while those in buses, and heavy and light vehicles unskilled.

Based on the above assumptions the numbers of passengers affected are shown in Tables 24 and 25.

Table 24   Estimates of Number of Passengers per Day on the GP1 at Present

Category	Vehicles No.	Occupancy Rate	Total Pass
Private Cars and Taxis	13,200	3.8	50,160
Buses	1,200	45	54,000
Light Vehicles	10,000	2.0	20,000
Heavy vehicles	15,600	2.0	31,200
Total	40,000		155,360

Traffic is expected to grow in line with GDP forecasts. In maintaining the present structure the following estimates are made for traffic in the year 2020:

Table 25   Estimates of Number of Passengers per Day on the GP1 in 2020

Category	Vehicles No.	Occupancy Rate	Total Pass
Private Cars and Taxis	55,200	3.8	210,000
Buses	5,000	45	225,000
Light Vehicles	42,000	2.0	84,000
Heavy vehicles	65,000	2.0	130,000
Total	167,000		649,000

(b)Estimated Loss of Income due to Traffic Delays

(i) GP1

It is assumed that the roads will be cut off for the duration of the flooding. It is probable that this could be a longer period due to clearing up operations, but for the purposes of the evaluation it is assumes that the roads will be cut off for 35 hours in both present and future land use conditions. The value of time is estimated at 25% of the hourly wages of skilled and unskilled labour. At current rates the appropriate value is estimated to be DT0.5 per hour for skilled labour and DT0.16 per hour for unskilled labour in present conditions. These are assumed to increase in line with expected GDP growth and to be DT2.1/hour and DT0.7/hour respectively. In assuming delays of 35 hours and taking into account increases in salaries in line with GDP, total losses in 2020 are estimated to be : DT29,900,000 for skilled labour, and 20,780,000 for unskilled labour - a total of DT58.6 million.

(ii) MC 33E, MC 34 and MC39

No traffic counts are available for this road. However, the Master Transport Plan for Greater Tunis indicates that traffic movements within the sectors and between the corridors are approximately half the movements of those on the major arteries. 50% of the values of the traffic of GP1 are therefore taken as the values to cover losses on these roads , i.e. DT29.3 million.

(iii) Losses of Incomes on other roads

These are taken at 25% of the losses on the MC roads i.e. DT7.3 million.

(iv) Total Income Losses

Total income losses from traffic delays on all the roads in the flood prone areas are estimated to be DT95.2 million.

(c) Increased Vehicle Operating Costs

(i) GP1

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation (35 hours), a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. In applying the cost differences as proposed in the methodology between flooded and non-flooded roads ., and assuming that 1.5 km of the GP1 will be flooded, the following Table show the costs by category .

Table 26   Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases
- Present and Future situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	13,200	570
Bus	51.60	1,200	93
Light/Medium Goods	86.11	10,000	1,292
Heavy goods	236.73	15,600	5,540
Total			7,495

Assuming increased VOCs for a period of 30 days for road repairs, additional costs for traffic could amount to DT225,000.

(ii) MC33E, MC 34, MC 39

It is estimated that up to 50 km of these roads could be subjected to flooding. Assuming half the traffic level of GP1 on these roads, the increased VOCs will be DT3.7 million over a period of 30 days.

(iii) Other traffic

The increased VOCs are estimated at 10% of the costs incurred on the MC roads i.e. DT370,000.

(iv) Total Increases in VOCs in the flooded areas are estimated at DT4,300,000.

(d) Road Damage

The rehabilitation costs applied to the roads affected are shown in Table 27.

Table 27 Estimated Road Damage Caused by Flooding

Road	Km	Unit Cost	Total Costs
*GP1	1.5	120,000	180,000
*MC Roads	50	80,000	4,000,000
*Other Roads			4,220,000

*Note Assumed to be 10% of costs of MC roads

(5) Damage in Agricultural Areas

Some loss of income for population in rural areas has already been estimated (DT 0.6 million). in view of the large variation in Agricultural production from one year to another and in different areas of the flooded zone, it is impossible to calculate the probable loss of crops. As a proxy it is proposed to use the value of land as reflected in the selling price - on average it is estimated by the Department of Agriculture in Ben

Arous that the price of land is DT15,000 per hectare.(although this varies enormously due to speculative purchases). Damage is taken at 20% of this value.

In order to arrive at approximate agricultural areas, it is proposed to take the analysis of land use carried out in the Regional Master Plan for the North East. This indicates that approximately 50% of land use was for cultivable lands, and a further 10% pasture land. On this basis, 4,380 hectares will be under agricultural use. The value of this land is estimated at DT65.7 million. Damages are estimated at DT13.1 million.

(6) Damage to Industries

Rades is a major Industrial Centre. According to a survey carried out by the Industrial Promotion Agency in 1993, there are 43 factories employing 2,319 persons in Rades. Mornag has 23 enterprises employing 472 persons. No data is available on the production or turnover of these factories. The total investment value of these factories is estimated at DT14.4 million for factories in Rades and DT570,000 for factories in Mornag.

While all the factories located in Mornag will be affected, it is assumed that only those in the vicinity of Oued Maliyan will be affected - say 10. The investment values of these factories is estimated at around DT4 million. As a proxy it is proposed to use 3% of these costs for flood damage, and total damage is estimated at DT120,000. 20% is added on to account for damage to equipment. Total damages to factories are estimated at DT 140,000.

In addition assuming that the factories are affected for 3 days by the floods, loss of income by employees is estimated at DT561,000, assuming that labour affected will be skilled.

(7) Total Estimated Flood Damages

The estimate of total damages are shown in Table 28.

Table 28 Oued Maliyan - Summary of Estimated Flood Damages in 2020

*Persons affected	90,000
	(DT1,000)
*Damage to Property (Residents)	58,230
*Loss of Income (Residents)	5,000
*Damage (local roads)	4,220
*Traffic delays (Income losses)	95,200
*Increased Vehicle Operating Costs	4,300
*Agricultural Areas	13,100
*Damage to Industries	120
*Loss of income(Industries)	561
Total	180,731

6. Oued Mayzette

6.1 Introduction

On the basis of a hundred year return period, flooding will occur in three areas, as indicated on the attached map. The areas flooded according to different return periods are indicated in the Tables 29 and 30. The evaluation of damages is carried out on the basis of 100-year return period under present and future land use conditions.

Table 29   Maygette - Flood Inundation Area (Ha)

	Land Use Conditions							
	Present				Future			
Return Period	Zones				Zones			
	A	B	C	Total	A	B	C	Total
1.05	0.0	0.2	10.0	10.2	16.4	2.2	13.0	31.6
10	19.2	6.3	20.0	45.5	51.2	10.2	27.0	88.4
25	31.4	10.3	24.0	65.7	73.9	15.5	31.0	120.4
50	43.3	14.2	27.0	84.4	96.0	20.6	36.0	152.5
100	58.0	19.0	31.0	107.9	123.3	26.9	41.0	191.1

Table 30   Maygette - Flood Inundation Duration (Hr)

	Land Use Conditions					
	Present			Future		
Return Period	Zones			Zones		
	A	B	C	A	B	C
1.05	0	1.5	3.5	7.6	2.2	4.5
10	8.2	3.2	7.1	15.0	4.1	11.6
25	10.9	4.1	9.4	19.8	5.4	14.4
50	13.3	5.1	11.6	24.5	6.3	18.7
100	16.6	6.2	14.4	31.0	7.0	24.0

Three areas will suffer from flooding:

*ZONE A

This is a residential area consisting mainly of detached housing and four story housing.
According to the Master Plan the area will expand between GP1 and MC33. The flooded
area also cuts across the two main roads. Damage in this area will be as follows:

       *Damage to housing
       *Damage to internal, secondary and major road arteries
       *Loss of income to residents due to immobility caused by floods
       *Loss of income to drivers and passengers due to traffic delays
       *increased vehicle operating costs

*ZONE B

This area is agricultural with a few scattered farmhouses. According to the Urban Plan
the area will continue to be agricultural. Damages will be to existing and potential crops.

*ZONE C

The area which borders the oued consists of agriculture, swamp and grassland.
Damages will be to existing and potential crops.

6.2 Estimation of Damages

Damage Assessment is based on the 100-year return period for present and future land
use conditions.

A) ZONE A

(1) Damage in Residential Areas

The present flooded area under a 100-year return period is estimated at 58 ha, and in
future land use conditions at 123.3 ha. The population density in the area is estimated to
be 72 persons per ha; on the basis of 15 houses per hectares (used by ONAS studies for
the "South Coast area", which includes Mayzette) and 5.8 persons per house (as per the
Urban Plan for Ben Arous) the population in the area affected (58 ha) will be 5,046.
However, it is likely that there will be a large number of four storey houses with
apartments and these will increase in the future due to housing shortages; assuming that
one third of houses are of this type then the total population affected will be in the region
of 10,000 persons, or an average density of around 173 per ha. ONAS estimates a
population growth rate of 2.33% p.a. for this area, and on this basis, the total population
living in the area of 58 ha will, in the year 2020, be in the region of nearly 18,600
persons, representing an average density of 320 persons per ha.

Taking into account the expansion of the residential area in the future, it is probable that the full 123.3 ha which will be flooded in the future land use condition will be residential; assuming the same density the total population affected is estimated to be 39,500 in the year 2020.

No data exists on the level of damage caused to housing in previous floods. Estimates are therefore based on a number of assumptions. Damage will mainly be to the foundations; assuming a density of 15 houses per ha in 1993 and 17 in 2020, the number of houses affected will be 870 in present land use conditions and 2096 in future land use conditions. Since data is not readily available on the size of the houses it is assumed that constructed areas will cover 50% of the flooded area, or 290,000 m2 in present land use conditions and 616,000 m2 in the future.

It is assumed that depth of flooding will be between 0.5 and 1 metre. In Tunisia, property values vary enormously due to land speculation and other factors, and it is proposed to take 3% of construction values as a proxy. Theses vary between DT250/m2 and DT400/m2 (Department of Housing). In using a figure of DT350/m2, flood damage is estimated at around DT10.5 per m2. Damage to residential property is therefore estimated at DT3,045,000 in present land use conditions, and DT6,468,000 in future conditions for a 100-year return period.

(2) Loss of Income to residents

It is assumed that for the period of flooding, the residents of the area will be prevented from travelling to work. On the assumption that there will be two workers per household, it is probable that 3,500 persons will lose their income in the present situation and 13,600 in future conditions. Losses are estimates at DT469,000 (Present flooding of 16 hours will effectively means two days work will be lost.). In future, assuming salary growth rates in line with GDP, (6.0% p.a. till the year 2000, 5.5 % between 2000 and 2010 and 5% between 2010 and 2020), daily wages will reach DT67. Under future flooding conditions, flooding period of 31 hours will effectively mean three days of work lost. Total losses for future conditions are therefore estimated to be DT2,733,600.

(3) Transport and Traffic Losses

a) Traffic Flow Data
It is assumed that the roads will be cut off for the duration of the flooding. It is probable that this could be a longer period due to clearing up operations, but for the purposes of the evaluation it is assumes that the roads will be cut off for 16 hours in present

conditions and 31 hours in future conditions. With regard to traffic flows detailed data is not available except for the main arteries. The latest traffic counts are available in the Regional Transport Master Plan for the District of Tunis (Ministry of Interior, 1989). The traffic count on the GP1 at the Southern exit to Tunis indicated flows in the region of 40,000 vehicles per day. The structure of traffic was estimated to be 33% for private cars and taxis, 3% for buses, 39% for heavy vehicles and 25% for light vehicles. The rate of occupation for private cars and taxis ranged from 2.1 to 3.8, and for camionettes and lorries between 1.2 and 2. The higher figures are used for the evaluation. For buses data was not readily available and an occupancy factor of 45 is used. It is also assumed that passengers in private cars and taxis will be in the skilled labour bracket, while those in buses, and heavy and light vehicles unskilled.Based on the above assumptions the numbers of passengers affected are shown in Table 31.

Table 31 Estimates of Number of Passengers per Day on the GP1 at Present

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	13,200	3.8	50,160
Buses	1,200	45	54,000
Light Vehicles	10,000	2.0	20,000
Heavy vehicles	15,600	2.0	31,200
Total	40,000		155,360

Traffic is expected to grow in line with GDP forecasts. In maintaining the present structure the following estimates are made for traffic in the year 2020:

Table 32 Estimates of Number of passengers per Day on the GP1 under Future Conditions

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	55,200	3.8	210,000
Buses	5,000	45	225,000
Light Vehicles	42,000	2.0	84,000
Heavy vehicles	65,000	2.0	130,000
Total	167,000		649,000

b) Loss of Income due to Delays

Under present land use conditions, there is expected to be delay of 16 hours, and in future 31 hours (representing 2 days salaries). Income losses will be as follows:

(DT 1,000)

	Present Land Use	Future Land Use
Skilled Labour	7,056,000	13,671,000
Unskilled Labour	4,916,800	9,526,000
Total	11,972,800	23,197,000

In addition there will be income losses on the MC33E. No traffic counts are available for this road. However, the Master Transport Plan for Greater Tunis indicates that traffic movements within the sectors and between the corridors are approximately half the movements of those on the major arteries. 50% of the values of the traffic of GP1 are therefore taken as the values for the MC33E, i.e. DT5.986 million and DT11.6 million respectively for the present and future situation.

c) Increased Vehicle Operating Costs

*GP1

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation (16 hours in present situation and 31 hours in the future situation), a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface. This additional cost should be included in the damage assessment. The rates for different vehicle operating costs are applied to the existing and expected traffic flows on the GP1, of which 750 metres is expected to be flooded. In the present situation traffic is expected to be affected for two days and in the future for three days. The following Table show the costs by category in the present and future situations.

Table 33   Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases
                - Present Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	13,200	380
Bus	51.60	1,200	62
Light/Medium Goods	86.11	10,000	861
Heavy goods	236.73	15,600	3,693
Total			4,996

Assuming a period of 30 days, increased VOCs are estimated at DT150,000.

*MC33E

Assuming half the traffic level on the MC33E, the damages caused will be DT75,000.

d) Road Damage

According to the cartography, there are approximately 5,000 metres of "internal roads" within the residential district at present. Reconstruction costs of these roads are estimated at DT80,000 per km. Total rehabilitation costs could therefore amount to DT400,000. Taking into account future residential areas roads of up to 10 km could be affected by flooding, with possible rehabilitation costs of DT1 Million. In addition there will be damages to 750 metres of major roads for which rehabilitation costs are estimated at DT120,000 per km. Total costs will there fore be DT90,000.

(4) Oued Mayzette - Total estimated Flood Damage

The following Tables summarise the damages estimated for 2020 under present and future land use conditions.

*ZONE A

Table 34   Oued Mayzette - Summary of Estimated Flood Damages - Zone A - Present
and Future Land Use Situation in 2020

	Present Situation	Future Situation
*Persons affected	18,600	39,500
		(DT1,000)
*Damage to Property	3,045	6,468
*Loss of Income (Residents)	469	2,734
*Damage (local roads)	600	1,100
*Traffic delays (Income losses)	17,958	23,197
*Increased Vehicle Operating Costs	225	225
Total	22,297	33,724

*ZONE B

This area is expected to remain agricultural. Under present conditions, the flooded area is estimated to be 19 ha, and in future this will increase to 26.9 ha. Since no data is available on the typical cropping patterns in the region, the land values are taken as a proxy. These range from DT15,000 to DT75,000 in Ben Arous; assuming an average value of DT45,000, the loss could amount to DT855,000 and DT1.2 million. Since the area is non residential and no major roads are affected, there is no value imputed to damages to residents or traffic.

* ZONE C

It is assumed that one third of the area is potential agricultural land. In present conditions, the value of this land (10.2 ha) is estimated at DT460,000, and in the future (13.5 ha), the value is DT609,000.

* Summary Of Damages - Oued Mayzette

Table 35 summarises the damages likely to be caused by flooding in the Oued Mayzette under present and future conditions.

Table 35 Summary of Damages - Oued Mayzette

	(DT1,000)	
	Present Conditions	Future Conditions
ZONE A	22,297	33,723
ZONE B	855	1 200
ZONE C	460	609
Total	23,612	35,533

7. Oued Bou Khamsa

7.1 Introduction

The flooded areas are estimated to be 88 hectares under existing land use conditions and 176 hectares under future land use conditions in the 100-year return period. The land utilisation is broken down as follows:

Category	Future land Use
	(Hectares)
Residential	78
Cite El Habib (Residential / Tourism)	26
Industrial/commercial	72
Total	176

In addition to damage caused to housing and inconvenience to residents, two major roads will be flooded (GP1 and MC33E), and several kilometres of secondary and minor roads. Damage will be caused to industrial and commercial enterprises in terms of flood damage to buildings and loss of income to workers.

7.2 Estimation of Damages

(1) Damage to Residential Areas

The main residential area that will be affected by the floods is estimated to be 52 ha. In addition, the Cite El Habib area which has a Hotel and commercial enterprises, also contains some residential areas. In the future a further area will be developed for residential purposes. Population estimates are based on the following assumptions:

*For the main residential areas, a density of 15 houses per hectare is assumed, of which one third will be 4 storey houses, i.e. 30 households per ha. The average family size is assumed to be 4.8 persons, representing a population of 144 per ha. For the area of 52 ha, the total population estimated is around 7,500.

* With regard to the Cite El Habib, it is assumed that 50% of the area will be occupied by housing, i.e. 13 ha. On the same assumptions as above, the residential population will be in the region of 2,000.

*The total residential population affected under present land use developments is therefore estimated to be 9,500.

*Future population growth is based on a factor of 2.33% p.a. as used by ONAS. On this basis the population in the year 2020 will reach 17,700, a density of 272 persons per ha.

* Future population will also be increased by the development of an additional area south of GP1 of 28 ha. Applying a density factor of 272 persons per ha an additional population of nearly 7,600 persons will be affected by the flooding. Thus, a total of 17,100 persons, or around 3,500 households will be in the flooded areas. Assuming that 50% of the residential area consists of built up area, the buildings affected will cover an area of 325,000 m2. In applying a construction cost of DT350/m2, and a flood damage factor of 0.130% of property values (based on the Consultant's experience elsewhere), i.e. DT0.46/m2, the total flood damage to property is estimated to be DT150,000. In future the development of a further 28 hectares will result in the construction of 140,000 m2 of built up area resulting in additional damage of DT64,400, - a total of DT 214,400.

(2) Loss of Income to Residents and Employees

a) Residents
The duration of flooding (12.2 hours at present and 24 hours in the future) effectively means a loss of income of one day at present, and 2 days in the future. Since the area consists mainly of detached housing, it is assumed that the residents will be skilled labour, and the appropriate rates are applied (DT16 per day at present and DT67 per day in the future). The total number of households affected is approximately 2,000, and income losses will be DT32,000 under present conditions. In the future conditions it can

be expected that 3,500 persons will lose two days income, amounting to a total of DT469,000.

b) Employees in the Industrial Sector

In view of the lack of data on specific Industries and commercial enterprises located in the flooded areas, assumptions are made on typical Industrial data in order to arrive at an order of magnitude of employees in the area. As a planning guideline in Tunisia, a norm of 80 employees per hectare is taken for the industrial sector. This rate is applied to the major industrial area between GP1 and MC33E, a total of 48 ha, representing 3,840 employees. It is assumed that 2,000 of these are skilled and the balance unskilled labour. Income losses are therefore estimated as follows:

	Present	Future
Skilled Labour	32,000	64,000
Unskilled Labour (DT5/day)	9,200	18,400
Total	41,200	82,400

(3) Transport and Traffic Losses

(a) Traffic Flow Data

With regard to traffic flows detailed data is not available except for the main arteries. The latest traffic counts are available in the Regional Transport Master Plan for the District of Tunis (Ministry of Interior, 1989). The 40,000 vehicles per day. the structure of traffic was estimated to be 33% for private cars and taxis, 3% for buses, 39% for heavy vehicles and 25% for light vehicles. The rate of occupation for private cars and taxis ranged from 2.1 to 3.8, and for camionettes and lorries between 1.2 and 2. The higher figures are used for the evaluation. For buses data was not readily available and an occupancy factor of 45 is used. It is also assumed that passengers in private cars and taxis will be in the skilled labour bracket, while those in buses, and heavy and light vehicles unskilled. Based on the above assumptions the numbers of passengers affected are shown in Tables 36 and 37.

Table 36 Estimates of Number of Passengers per Day on the GP1 at Present

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	13,200	3.8	50,160
Buses	1,200	45	54,000
Light Vehicles	10,000	2.0	20,000
Heavy Vehicles	15,600	2.0	31,200
Total	40,000		155,360

Traffic is expected to grow in line with GDP forecasts. In maintaining the present structure the following estimates are made for traffic in the year 2020:

Table 37 Estimates of Number of Passengers per Day on the GP1 under Future Conditions

Category	Vehicles (Number)	Occupancy Rate	Total Pass
Private Cars and Taxis	55,200	3.8	210,000
Buses	5,000	45	225,000
Light Vehicles	42,000	2.0	84,000
Heavy Vehicles	65,000	2.0	130,000
Total	167,000		649,000

b) Estimated Loss of Income due to Traffic delays

In applying the rates for the value of time of skilled labour to private cars and taxi passengers and unskilled labour to the others, and assuming delays of 12.2 hours, the total benefits of the project are estimated to be DT306,000 for delays to passengers in cars and taxis, and DT205,000 for others- a total ofDT 511,000. 50 % of the value is taken for loss of income on the MC33E, i.e. DT255,000.

In assuming delays of 12 hours and taking into account increases in salaries in line with GDP, (DT2.1 per hour for skilled labour, and DT0.7 for unskilled labour in the year 2020), total losses are estimated to be : DT3.5 million for skilled labour, and DT2.5 million for unskilled labour - a total of DT6.0 million. Where the MC33E is concerned, 50% of the values of the traffic on the GP1 are assumed, i.e. DT3.0 million.

c) Increased Vehicle Operating Costs

While it is assumed that the level of flooding will be sufficient to halt traffic completely during the period of inundation (12.2 hours in present situation and 24 hours in the future situation), a further impact will be felt in the increased operating costs experienced by vehicles both as a result of more difficult operating conditions and following the degradation in the road surface.

The differences in Vehicle operating costs are applied to the existing and expected traffic flows on the GP1, of which 2.2 kilometre is expected to be flooded. In the present situation traffic is expected to be affected for 0.51days (12.2 hours on 24 at present), and one day (24 hours) in the future. The following Tables show the costs by category in the present and future situations.

Table 38   Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases -
Presnt Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	13,200	380
Bus	51.60	1,200	62
Light/Medium Goods	86.11	10,000	861
Heavy goods	236.73	15,600	3,693
Total			4,996

Assuming a 30 day period for road repairs, increased VOCs will be DT150,000 on the GP1. These costs are increased by 50% to account for traffic on the MC33E. Total costs are estimated at DT225,000.

Table 39   Additional Vehicle Operating Costs in the Flooded and Non-flooded Cases
- Future Situation

Vehicle Type	Difference (DT per 1,000 vehicle/km)	Daily Traffic	Costs Per Day (DT)
Private Car / Taxi	28.79	55,200	1,589
Bus	51.60	5,000	258
Light/Medium Goods	86.11	42,000	3,617
Heavy Goods	236.73	65,000	15,387
Total			20,851

Total costs under this category for increased VOCs under the future land use situation are estimated at DT938,250.

d) Damage to Roads

Assuming 1 km of minor roads per 10 hectares, the total number of roads affected by the flood will be 8.8 km in the present flood condition and 17.6 km in the future. It is assumed that flood damage will require an additional rehabilitation programme. Rehabilitation costs for secondary roads are estimated to be approximately two-thirds of the rehabilitation costs for main roads which are estimated at DT120,000/km. On the above basis the additional expenditure on road maintenance and reconstruction directly attributable to the flood is estimated to be :

*DT704,000 in the present situation.
*DT1,408,000 in the future situation.

The two major roads that will be flooded are the GP1 and the MC33E. 2.2 km of the former and 2 km of the latter will be flooded. Assuming an additional maintenance programme will be required, a cost of DT504,000 (4.2 Km x DT120,000) will be required for repairs to GP1, and for the MC33E.