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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF EQUIPMENT AND HOUSING
THE REPUBLIC OF TUNISIA

THE STUDY
ON
FLOOD PROTECTION PROGRAM
FOR
GREATER TUNIS AND SOUSSE

FINAL REPORT

Volume III SUPPORTING REPORT

March 1994

Nippon Koei Co., Ltd., Tokyo

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1. UNIT HYDROGRAPH METHOD WITH RATIONAL FORMULA'S PEAK DISCHARGE

This method is an extension of the rational method for rainfalls lasting longer than the time of concentration on each sub-basin. This method was developed so that the concepts of the rational method could be used to develop hydrographs for storage design, rather than just flood peak discharges for channel design.

The shape of the unit hydrograph produced by this method is a trapezoid, constructed by setting the duration of the rising and recession limbs equal to the time of concentration t_c, and computing the peak discharge by the rational formula. Fig. 1.1 illustrates basic unit hydrographs for synthesis. The unit hydrograph rises linearly to the peak discharge at the time of concentration t_c, is constant until the rainfall ceases t_r, then recedes linearly to zero discharge at $t_c + t_r$.

The composite hydrograph is calculated from unit hydrograph of each sub-basin using the design hyetograph with time interval equal to the time of concentration at the calculation point in the basin. Table 1.1 shows sample results of runoff calculation by this method. Calculated runoff hydrographs from sub-basin and the composite hydrograph of those are graphically shown in Fig. 1.2.

Fig. 1.1 Basic Unit Hydrograph for Synthesis

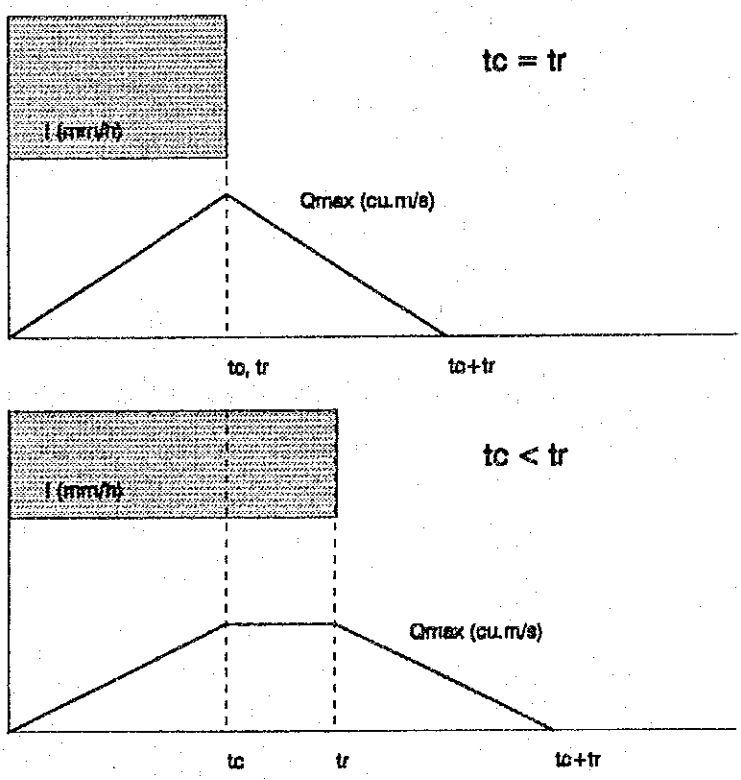

Table 1.1 Sample Results of Runoff Calculation by Unit Hydrograph Method with Rational Formula's Peak Discharge

Oued Ennkhilet Basin, Calculation Point No.5, tc = 14 (min) Calculation time pitch = 10 (min)

Time	Runoff from Sub-basin			Total	Time	Runoff from Sub-basin			Total	Time	Runoff from Sub-basin			Total	Time	Runoff from Sub-basin			Total
(hr)	B-01	B-02	B-03		(hr)	B-01	B-02	B-03		(hr)	B-01	B-02	B-03		(hr)	B-01	B-02	B-03	
00:00	0.007	0.000	0.011	0.018	06:00	4.121	6.848	1.689	12.656	12:00	0.026	0.045	0.011	0.082	18:00	0.016	0.025	0.006	0.046
00:10	0.027	0.045	0.011	0.083	06:10	1.546	3.252	0.211	5.009	12:10	0.026	0.044	0.011	0.081	18:10	0.014	0.025	0.006	0.045
00:20	0.027	0.045	0.011	0.084	06:20	0.401	0.768	0.103	1.272	12:20	0.025	0.043	0.011	0.079	18:20	0.014	0.025	0.006	0.045
00:30	0.028	0.047	0.011	0.087	06:30	0.238	0.413	0.086	0.737	12:30	0.025	0.042	0.011	0.078	18:30	0.014	0.024	0.006	0.044
00:40	0.029	0.048	0.013	0.089	06:40	0.181	0.309	0.070	0.560	12:40	0.025	0.041	0.009	0.076	18:40	0.014	0.024	0.006	0.044
00:50	0.030	0.050	0.013	0.092	06:50	0.148	0.256	0.053	0.459	12:50	0.024	0.040	0.009	0.074	18:50	0.014	0.024	0.006	0.044
01:00	0.031	0.050	0.013	0.094	07:00	0.125	0.219	0.044	0.388	13:00	0.024	0.039	0.009	0.072	19:00	0.014	0.023	0.006	0.043
01:10	0.031	0.052	0.013	0.096	07:10	0.109	0.180	0.044	0.333	13:10	0.023	0.039	0.009	0.071	19:10	0.014	0.023	0.006	0.043
01:20	0.032	0.054	0.013	0.099	07:20	0.097	0.164	0.039	0.299	13:20	0.023	0.038	0.009	0.070	19:20	0.014	0.023	0.006	0.043
01:30	0.033	0.055	0.015	0.103	07:30	0.087	0.150	0.033	0.270	13:30	0.023	0.037	0.009	0.069	19:30	0.013	0.022	0.006	0.041
01:40	0.035	0.057	0.015	0.106	07:40	0.080	0.134	0.031	0.245	13:40	0.021	0.036	0.009	0.067	19:40	0.013	0.022	0.006	0.041
01:50	0.036	0.059	0.015	0.109	07:50	0.073	0.122	0.029	0.224	13:50	0.021	0.036	0.009	0.066	19:50	0.013	0.022	0.006	0.041
02:00	0.037	0.061	0.015	0.113	08:00	0.068	0.115	0.028	0.210	14:00	0.021	0.035	0.009	0.065	20:00	0.013	0.022	0.006	0.041
02:10	0.038	0.063	0.017	0.118	08:10	0.063	0.108	0.024	0.195	14:10	0.020	0.035	0.009	0.064	20:10	0.013	0.021	0.006	0.040
02:20	0.039	0.064	0.017	0.120	08:20	0.060	0.099	0.024	0.183	14:20	0.020	0.034	0.009	0.063	20:20	0.013	0.021	0.006	0.040
02:30	0.041	0.069	0.017	0.126	08:30	0.056	0.094	0.022	0.172	14:30	0.020	0.034	0.007	0.062	20:30	0.013	0.021	0.006	0.040
02:40	0.043	0.070	0.018	0.132	08:40	0.054	0.090	0.020	0.164	14:40	0.020	0.033	0.007	0.061	20:40	0.013	0.021	0.006	0.040
02:50	0.044	0.073	0.018	0.135	08:50	0.050	0.085	0.020	0.155	14:50	0.019	0.032	0.007	0.059	20:50	0.013	0.021	0.006	0.039
03:00	0.047	0.077	0.020	0.144	09:00	0.048	0.080	0.020	0.148	15:00	0.019	0.032	0.007	0.059	21:00	0.012	0.021	0.006	0.038
03:10	0.049	0.081	0.020	0.150	09:10	0.047	0.077	0.018	0.142	15:10	0.019	0.031	0.007	0.058	21:10	0.012	0.021	0.006	0.038
03:20	0.051	0.084	0.022	0.158	09:20	0.044	0.074	0.017	0.135	15:20	0.019	0.031	0.007	0.057	21:20	0.012	0.021	0.006	0.038
03:30	0.054	0.088	0.024	0.165	09:30	0.042	0.070	0.017	0.129	15:30	0.018	0.031	0.007	0.056	21:30	0.012	0.020	0.006	0.037
03:40	0.057	0.095	0.024	0.176	09:40	0.041	0.068	0.017	0.125	15:40	0.018	0.030	0.007	0.055	21:40	0.012	0.020	0.006	0.037
03:50	0.061	0.100	0.026	0.187	09:50	0.039	0.068	0.015	0.120	15:50	0.018	0.030	0.007	0.055	21:50	0.012	0.020	0.006	0.037
04:00	0.064	0.106	0.028	0.198	10:00	0.038	0.063	0.015	0.116	16:00	0.018	0.029	0.007	0.054	22:00	0.012	0.020	0.006	0.037
04:10	0.069	0.113	0.029	0.212	10:10	0.037	0.061	0.015	0.113	16:10	0.017	0.029	0.007	0.053	22:10	0.012	0.020	0.006	0.037
04:20	0.075	0.124	0.031	0.230	10:20	0.036	0.059	0.015	0.109	16:20	0.017	0.028	0.007	0.052	22:20	0.012	0.019	0.006	0.036
04:30	0.082	0.133	0.035	0.250	10:30	0.035	0.058	0.013	0.105	16:30	0.017	0.028	0.007	0.052	22:30	0.012	0.019	0.006	0.036
04:40	0.090	0.143	0.040	0.273	10:40	0.033	0.055	0.013	0.102	16:40	0.017	0.027	0.007	0.051	22:40	0.012	0.019	0.006	0.036
04:50	0.099	0.165	0.040	0.305	10:50	0.032	0.054	0.013	0.099	16:50	0.017	0.027	0.007	0.051	22:50	0.011	0.019	0.006	0.035
05:00	0.113	0.184	0.050	0.347	11:00	0.031	0.052	0.013	0.096	17:00	0.017	0.027	0.007	0.051	23:00	0.011	0.019	0.006	0.035
05:10	0.131	0.207	0.061	0.399	11:10	0.030	0.050	0.013	0.093	17:10	0.016	0.026	0.007	0.049	23:10	0.011	0.018	0.004	0.033
05:20	0.156	0.246	0.072	0.474	11:20	0.030	0.050	0.013	0.092	17:20	0.016	0.026	0.006	0.047	23:20	0.011	0.018	0.004	0.033
05:30	0.186	0.317	0.083	0.585	11:30	0.029	0.048	0.011	0.088	17:30	0.016	0.026	0.006	0.047	23:30	0.011	0.018	0.004	0.033
05:40	0.276	0.421	0.136	0.832	11:40	0.029	0.047	0.011	0.087	17:40	0.016	0.026	0.006	0.047	23:40	0.011	0.018	0.004	0.033
05:50	1.413	0.550	1.689	3.652	11:50	0.027	0.045	0.011	0.084	17:50	0.016	0.026	0.006	0.047	23:50	0.011	0.018	0.004	0.033

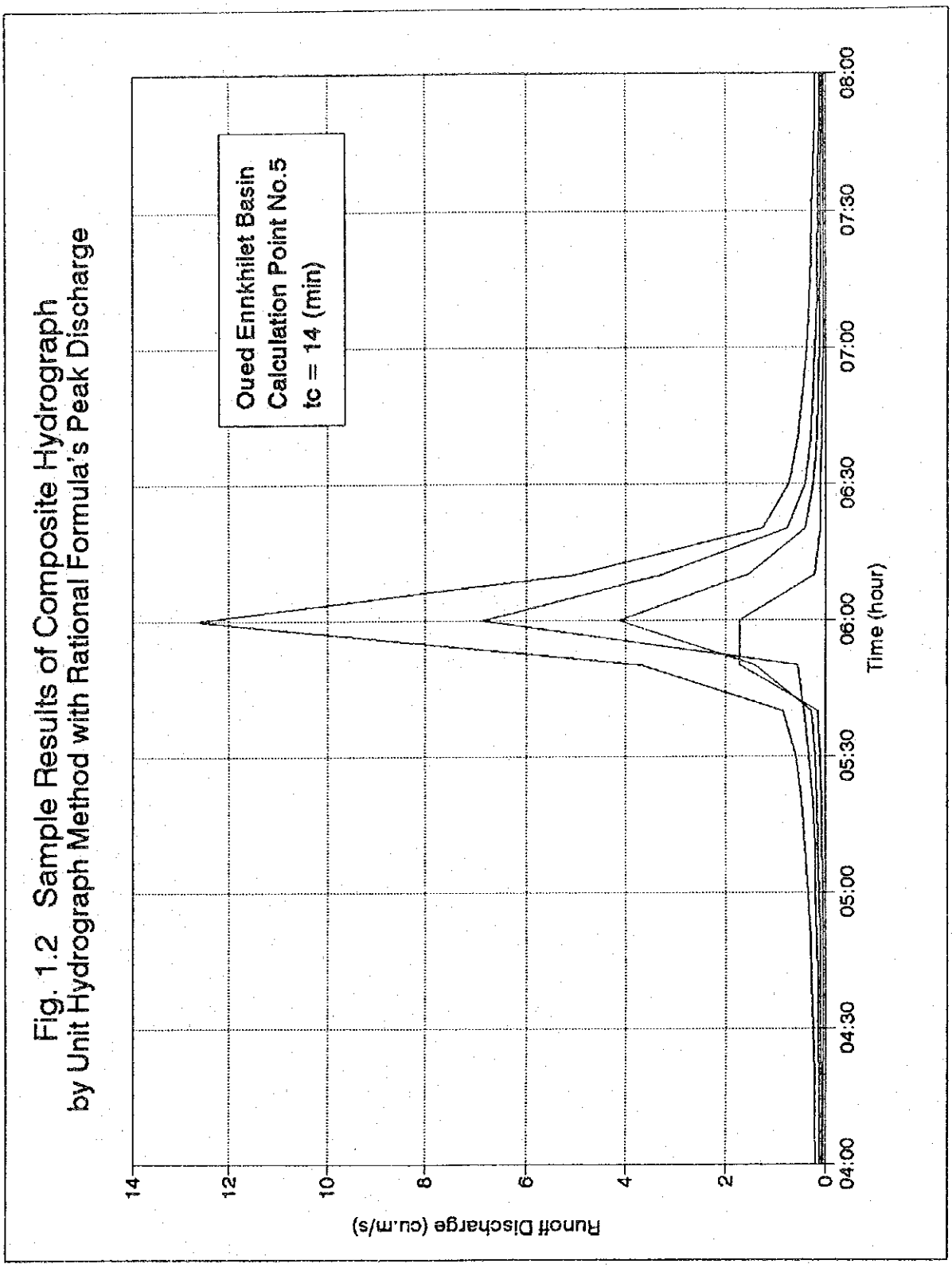

Fig. 1.2 Sample Results of Composite Hydrograph
by Unit Hydrograph Method with Rational Formula's Peak Discharge

2. STORAGE FUNCTION METHOD

In the runoff analysis of Oued Maliyan, the storage function method is applied, since the method enables the estimation of runoff hydrographs from rainfall data in consideration of effect of flooding.

2.1 Runoff from Sub-basin

A runoff from a sub-basin is estimated as follows :

Equation for runoff from a sub-basin

$$S_l = K\, q_l^{\,P} \quad (\textit{equation of storage}) \qquad \cdots\cdots\cdots\cdots \quad (2.1)$$

$$r - q_l = \frac{dS_l}{dt} \quad (\textit{equation of continuity}) \qquad \cdots\cdots\cdots\cdots \quad (2.2)$$

Where, S_l : storage in a sub-basin (mm)
r : effective rainfall (mm/hr)
q_l : runoff from a sub-basin (mm/hr)
K, p : storage coefficient

Constants values of K and P in the equation are estimated employing the following empirical formula;

$$K = 43.4 \cdot C \cdot S^{-\frac{1}{3}} \cdot L^{\frac{1}{3}} \qquad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2.3)$$

$$P = \frac{1}{3} \qquad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (2.4)$$

Where, C : reserve constant (= 0.120)
S : average basin slope
L : river length (km)

Flood runoff from sub-basin is adjusted taking lag time into consideration. The lag time is estimated by empirical formula expressed below;

$$\begin{aligned} T_l &= 0.047L - 0.56 \quad (L > 11.9\ km) \\ T_l &= 0.0 \qquad\qquad\quad (L < 11.9\ km) \end{aligned} \qquad \cdots\cdots\cdots\cdots \quad (2.5)$$

Where, T_l : lag time in basin (hr)
L : river length (km)

The factors such as a primary runoff percentage f_1 and saturation rainfall R_{sa}, are used for estimates of effective rainfall. The following assumption are used in the calculation.

i) The runoff consists of a direct runoff and a base flow.

ii) The drainage area of sub-basin is divided into the infiltration and primary runoff areas.

iii) In the infiltration area, the rainfall is infiltrated up to a saturation point, after that all rainfall becomes a direct runoff. The rainfall from the beginning to saturation point is called the saturation rainfall (R_{sa}).

iv) In the primary runoff area, all rainfall changes to a direct runoff, and a ratio of the primary runoff area to a drainage area is called the primary runoff percentage (f_1).

The runoff from the primary runoff area, q_1 is calculated by the following equation which is derived from Eqs. (1) and (2).

$$q_1(t) = 2\left[r_{(t)} - \frac{K}{\Delta t}\left\{q_1^p(t) - q_1^p(t-\Delta t)\right\}\right] - q_1(t-\Delta t) \quad \cdots\cdots \quad (2.6)$$

Where Δt is time interval in calculation. In the calculation, trial and error is used.

The runoff from the infiltration area, q_{sal}, is calculated by the following equation.

$$q_{sal} = 0, \quad (\Sigma r < R_{sa}) \quad \cdots\cdots\cdots\cdots \quad (2.7)$$

$$q_{sal} = q_1, \quad (\Sigma r > R_{sa}) \quad \cdots\cdots\cdots\cdots \quad (2.8)$$

Where Σ r is a cumulative rainfall from the beginning.

The total discharge from a sub-basin is calculated by use of the following equation.

$$\bar{Q} = \frac{1}{3.6} f_1 A q_1 + \frac{1}{3.6}(1-f_1) A q_{sal} + Q_1 \quad \cdots\cdots\cdots \quad (2.9)$$

$$Q(t) = \bar{Q}(t - T_1) \quad \cdots\cdots\cdots\cdots \quad (2.10)$$

Where,
- $\underline{Q}$: runoff from a sub-basin (m^3/s)
- Q : hypothetical runoff (m^3/s)
- q_1 : runoff from a primary area (mm/hr)
- q_{sal} : runoff from an infiltration area (mm/hr)
- f_1 : primary runoff percentage
- A : drainage area of sub-basin (km^2)
- Q_1 : base flow (m^3/s)
- T_1 : lag-time (hr)

2.2 Channel Flow

The storage function of channel flow is estimated as follows :

Equation for the channel flow :

$$S_l = K\,Q_l^p - T_l\,Q_l \quad (\textit{equation of storage}) \cdots\cdots\cdots (2.11)$$

$$I - Q_l = \frac{dS_l}{dt} \quad (\textit{equation of continuity}) \cdots\cdots\cdots (2.12)$$

$$Q(t) = Q_l(t - T_l) \quad (\textit{equation of retarded runoff}) \cdots\cdots\cdots (2.13)$$

Where, S_l : storage in channel (m^3/s)
Q_l : Discharge at the middle point in the channel (m^3/s)
I : inflow at the channel entrance (m^3/s)
K, p : storage coefficient
T_l : lag-time (hr)
Q : outflow at the channel exit (m^3/s)

Constants values of K and P are estimated by the result of flow calculation the river cross section and river length.

The lag time in river channel is estimated by the empirical formula expressed below;

$$T_l = 7.36 \times 10^{-4} \cdot L \cdot s^{-0.5} \cdots\cdots\cdots\cdots (2.14)$$

Where, T_l : lag time in river channel (hr)
L : river length (km)
s : average river bed slope

The procedure of calculation is the same as that of runoff from a sub-basin.

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B. LAND USE PLAN

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B. LAND USE PLAN

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LAND USE PLAN

1. Introduction

It deals with a feasibility study focusing on present and future land use plan in the study area of Ariana Community including Sebkhet Ariana area within the Governorate of Ariana and La Marsa Community in the Governorate of Tunis. In addition, the study covers the Regional Sousse that incorporates Hammam Sousse, Akouda, Kalaa Kebira and Kalaa Sghira within the Governorate of Sousse.

Since Old Media has been a center of Greater Tunis, Ariana area has expanded and urbanized during recent two decades. Also, the towns in regional Sousse have been encouraged by the geological situation near the Metropolitan Sousse. Through those rapid expansions of urbanization in Ariana area and regional Sousse, some problems have been indicated due to uncontrolled expansion in urban fabric.

Under the present land use plan, several phenomena are observed in these areas such as predominance of spontaneous settlements (illegal settlements) and expansion of urbanization in the agricultural zone and flood inundated zone. Many habitants have suffered damages from flood inundation by constructing their houses inside inundated zones and agricultural zones in a form of illegal way.

In this aspect, the delimitation of the all study areas was determined by a catchment area basis against flood inundation. The study area is located partially in two governorates, Ariana Community and La Marsa Community with different zoning regulations. In this regard, the presentation of the land use plan was separated Ariana Community from La Marsa Community, respectively. In addition, the land use plan in regional Sousse was approached by regional concept, considering rapid-changing urbanization in the context of conurbation in Regional Sousse as illustrated in Fig.8 and Fig.9.

This land use plan herewith aims to clarify present land use and provide guidelines for future urban development in the projected site as illustrated in Fig.3 and Fig.4 as a countermeasure of flood inundation and urban sprawl through effective and strategic land use development plan with a target year of 2000 in a short term and 2020 in a long term.

2. Regional Tunis

2.1.Ariana Community

2.1.1 General

The Governorate of Ariana comprises 8 administrative delegations : Ariana, North Ariana, Sidi Thabet, Ettadhamen, Monouba, Mornaguia, Tebourba and Kalaat El Andalous. The study area is situated within two delegations that involve Ariana and Ariana North (hereinafter referred to Ariana Community).

Inasmuch as controlling the management, Ariana Community was divided into 6 areas: Three of them are in the Delegation of Ariana that consist of Soukra, Borj Louzir and Raoued. The other three are in the Delegation of Ariana North that are composed of Superior Ariana, El Menzah and Ariana Medina as shown Figure 1. In terms of all the location of the areas, it is indicated in Figure 5.

2.1.2 The Site

The perimeter of Ariana Community is depicted as follows that shows in Figure 1.

-Sebkhet Ariana and the Mediterranean Sea up to Garaat Bouhanech in the North.
-La Marsa Community in the northeast and southeast.
-Borj Touil and the Mountain Djebel Nahli in the northwest.
-Road GP10, Tunis Airport and Roman historic sites in the South

The whole site of the study area occupies a total area of 117.5km2. The delimitation of study area was determined based on the criteria of catchment area against flood inundation. Nevertheless, the area is approximately overlapping with the administrative sectors of the Ariana Delegation and the Ariana North Delegation. Considering the urbanization that is more subject to the administrative delimitation, the study of land use plan was conducted in terms of regional context that is not absolutely confined to the catchment area standard.

2.1.3 The Urbanization

Ariana Community had been a small agglomeration, composed of Ariana Center and El Menzah until 1975. The Community doubled in 1980 and has extended 5 times in area at

present as illustrated in Figure 2 from the source of "The Regional Development Plan" by the District of Tunis.

In 1980, the Ariana area extended by the creation of Superior Ariana and zone of Cite Ettaamir toward the Southwest. The El Menzah has expanded to high-density and mixed residential patterns such as isolated, collective and semi-collective. In the other side of the GP9, Bourj Louzir extended as well. At the same time, North Ariana has witnessed a new phenomenon of unplanned urbanization by creating spontaneous housing.

From 1980 to 1985, the Community evolved according to the land use plan approved in 1981 by the Governorate of Ariana in defining non-urbanized zones in the Community. Nevertheless, all the urban sprawl phenomenon had continued toward the North of Ariana except El Menzah 7 and some plots (Riadh El Aldalous) in the West of GP8 in the form of anarchic way as an example Gazahla is the case. To solve this phenomenon, the authority signed a decree in March 1985. The decree involved the protection of agricultural lands in the Governorate of Ariana by classifying as prohibited zones and preservation zones. North Ariana area and Raoued area were classified by urbanized zones that are subject to the authorization of the Ministry of Agriculture from 1981.

The urbanized area in the Ariana Community has reached 5 times larger from 1985 to 1989. The half of the urban expansion was occurred in the area that are not planned by the land use development plan in 1981. In this period, the evolution of urbanization was vitalized in Ariana North by appearing towns such as Mansoura, Ennkhilet, Ezzhani and other towns that were created without any authorization. Other authorized housing development was accomplished in Borj Louzir and El Bosten along the GP9. However, the urban regulation that advocates division of land into large plots was not respected. In La Gazahla, the constructions are booming and have another status than that of unplanned authorized housing. The same status is applied to a new city of Nasr in the North of El Menzah. These towns were created according to the P.I.F (Perimeter d'Intervention Foncier). The authorized and approved town by the land use plan (1981) is only El Menzah 8.

As the urbanization to the South has been saturated, the urban extension of Ariana Community has taken place only to the North. Nevertheless, some problems arise along with this expansion. The major obstacle is the surrounding area by the Sebkhet Ariana that is flood inundation zone. The other one is the Mountain Nahili and Jibel Amor in the West.

2.1.4 Present Land Use

A work of present land use map for the Ariana Community was carried out on the basis of the topographic maps by the MOEH (Ministry of Equipment and Housing) and site reconnaissance as shown in Fig.3 and Table 1. Nevertheless, the present land use mapping was done in much reliance on the site survey due to insufficient data and on-going development within the Community.

The Sebkhet Ariana and its surrounding areas

The Sebkhet Ariana is located in the upper part of the study site that covers an area of approximately 36.5km2. This lake has very few communications with the sea, maintaining not deep water level. This lack of communication with the sea creates poor water evacuation capability to the Mediterranean Sea, causing flood inundation around the Sebkhet Ariana during the rainy season. When the Sebkhet is saturated, the water can be discharged to the sea crossing over the roads in Gammarth. To remove these constraints, improvement of outlet facility is required to allow smooth discharge of water to the sea.

Urban Center Area

The zone of Ariana Center and all the agglomerations of El Menzah and Superior Ariana constitute most important urbanized area with high density in the Great Tunis area. These extensions take the formation of urbanization throughout the Ariana Community. The urbanized areas have evolved with the form of various residential types such as collective, individual and isolated patterns. In addition, these areas are equipped with commercial centers and road infrastructure facilities.

The Zone of Choutrana

The Choutrana area occupies approximately 17.6km2, of which 3.0km2 is reliable to inundation and the rest of 14.6km2 is not. Of these 14.6km2, 2.9km2 is occupied by the authorized housing of La Gazahla and Borj Louzir. The rest of the area (11.7km2) is distributed for agricultural use (7.6km2) and spontaneous housing (4.0km2).

The Zone of Soukra plain

This zone extends from the GP8 and along the RVE533 until reaching the Sebkhet Ariana in the North and Gammarth in the East. The majority of this zone is composed of

agricultural fields covering 9.0km2 (80%) in Soukra area in terms of study area. Moreover, a big occupation of spontaneous settlements accounting for 6.0km2 in a total area of Soukra is one of the most serious problems in this Community. Furthermore, this zone surrounded by the Sebkhet Ariana is considered as a flood inundation zone due to the insufficient drainage network facilities and poor discharge capacity of the Sebkhet Ariana water to the sea.

The Zone of Raoued

In this zone, 10.1km2 (33%) of the area accounts for agricultural fields and 9.0km2 (30%) of the area is open space in the total area of 30.2km2. The zone is already occupied by the spontaneous housing in the plain of agricultural zone along the RVE 546. With having much open space in this zone, urban expansion will be taken place as a form of new residential zone.

In order to comprehend the distribution of the present land use pattern, the Community is classified by several zones. Under the present land use plan of Ariana Community, the proportions of the land use in the study area are composed of residential (11.2km2), commercial (0.1km2), administrative / institutional (0.8km2), industrial (0.1km2), agricultural (21.8km2), green area (10.6km2), open space (10.7km2) and Sebkhet Ariana (36.5km2) within a total area of 117.5km2 as shown in Table 1.

Residential Zone

In the Ariana Community, Ariana Medina is considered as the most urbanized area. This zone is occupied by most of residential areas (71%). Also, Bori Louzir accounts for 38% of residential areas. The Raoued is dominated by agricultural fields. Nevertheless, the rapid increase of urban expansion is observed toward this agricultural sector. The trend of urbanization in the Ariana Community encouraged the creation of new residential areas in the agricultural land of Soukra. However, spontaneous habitants are spread in this area same as the Raoued area. According to the source of INS in 1984, 18% of population in Soukra and Raoued area of the Ariana Community inhabit spontaneous housing. In case of Ariana North and Choutrana from the study by the District of Tunis in 1988, the area of 2.2km2 is considered as spontaneous settlements among the total urbanized zones of 5.0km2. This expansion of spontaneous habitats is one of the serious problems along with the urbanization in this Community.

Commercial Zone

The commercial area accounts for 0.1km2, located only in the Ariana Medina. This unbalanced spatial allocation causes traffic congestion and inconveniences for the residents. The well- balanced distribution of the facilities is required in accordance with the urbanization.

Administrative/ Institutional Zone

Administrative and institutional zones are also partially distributed in the Ariana Media , occupying in an area of 0.5km2 (63%) . The institutional area consists of mainly health, educational and cultural facilities. Only well-balanced distribution of public facilities will meet the needs of the residents and enhance the quality of people's life.

Agricultural Zone

The Choutrana and Soukra zone contain mainly agricultural areas. The agricultural fields in the Ariana Community accounts for 21.8km2, of which the proportion of agricultural zone in Raoued and Soukra plain encompass 19.1km2 (88%) in the study area. The agricultural land evolves along the RVE533 reaching in the North and the hill of Gammarth in the East. Nevertheless, the illicit occupation of spontaneous housing in this agricultural zone became serious problem. More than 6.0km2 are covered with spontaneous settlements nowadays in this zone. This illicit occupation was derived from several factors such as speculation of land price, uncontrolled land use policy and big division of properties. In addition, as arising spontaneous housing areas in this agricultural field, devastation of natural environment and ecological system, and lack of drainage infrastructure have become major reasons of the flood inundation.

The zones of Henchir Jaafar and Sidi Slimane are also mainly for agricultural use. Nevertheless, it has changed to the flood inundated area by spontaneous housing.

The Borj Khessous area is partially agricultural zone with flat and low ground, surpassing 1m above sea level. The area becomes inundated area all the time in rainy season.

Green Zone

The green zone covers in a total area of 15.1km2 of which most of them are natural green areas. In this regard, the Ariana Community has no public park and has a few green

space that is planned by the old land use plan. Nevertheless these areas are exposed to the danger of urbanization such as the zone of Sidi Abdallah and Sidi Ahmed Jebali in the West of the site.

Open Space

The open space accounts for 10.7km2 that allocates 19% of the total area in the Ariana Community excluding Sebkhet Ariana. Nevertheless, much of the open spaces are considered as flood prone area where construction is not allowed. With the future development in these areas, sufficient infrastructure facilities should be provided along with urbanization.

Road Infrastructure

The Community is well-equipped with primary roads such as the GP8, GP10, RVE533, RVE543 and RVE546. The primary roads are linked to all the urban centers. The condition of the roads is generally good for primary roads. Nevertheless, some of the roads become impassable that lead to the residential zone and spontaneous settlement areas after heavy rain.

2.1.5 Flood Inundation Zone

The flood inundation zone in this Community creates great constraints to urbanization. This is because the ground water flows close to the ground level by 5m. Moreover, this Community has absence of natural slopes and poor drainage facilities. This phenomenon is witnessed conspicuously along the Oued Ennkhilet and in flat agricultural zones of Ariana North and Soukra as illustrated in Fig. 7. In this aspect, the zone suffers flood inundation, particularly during the rainy season due to the increase of water level in the lowest part of the agricultural plain. Furthermore, the occupation of spontaneous settlements and construction of road infrastructure around the Sebkhet Ariana is one of the reasons of flood inundation by poor infiltration capability of the rainwater. Also, this is because many of those illegal habitat constructions are not accompanied with sufficient drainage and sewage facilities.

The zones that are exposed to inundation in the Ariana Community are classified by two types. One is the areas that are not permanently inundated but having constraints of rainwater evacuation. The other areas contain permanent inundation risk after rain. The former one includes Cite Ennozha, Souk Jomma and Cite El Bosten, etc. The latter one

involves Borj Louzir, Ariana North and Soukra depicted as follows. In addition, the location of all the areas is shown in Fig.5.

Cite Ennozha: The condition of road is acceptable except for the entrance of the town. The entrance road from the GP8 is so deteriorated and muddy in rainy days. In addition, stagnation of water is observed in the intersection of the area.

Souk Jomma: Between the GP10 and the RVE 533, the GP8 represents an obstacle to the natural flow of rainwater. In this area, the flows of catchment area cross the urbanized zone of Souk Jomma before reaching the existing canals.

Cite El Bosten: The town is located in the border of Borj Louzir along the GP10. This town is characterized as narrow and muddy roads by rain.

Borj Louzir: Many water stagnations are observed and the ground water level increases in rainy days. Particularly, the spontaneous settlements in the Sebkhet Ariana and Soukra are threatened by the elevation of ground water level and water saturation in rainy season.

Ariana North: As the ditches all along the roads are not maintained in Sidi Salah, the stagnation of water is witnessed. The lacks of drainage channels also cause the stagnation of water along the roads from Sidi Salah toward Raoued. The area of Henchir Jaafar is susceptible to the slight rain. The stagnation of rainwater lasts 2-3 weeks and the water level reaches about 20-30cm from the ground level during the rainy season. Between the road in Raoued and the intersection with the GP8, the fillings of rainfall ditches are witnessed mainly in Cite El Yamama.

Soukra: According to the survey in the plain of Soukra and Choutrana by the GIC Tunisia in 1985, an increase of ground water surpassed ground level by 20cm in certain places in this zone. There is a risk that the increase can cause flood inundation in the whole areas of about 1.2km2. Also, the stagnation of water increase at the level of the ONAS canal represents an obstacle to the flow of water from the agricultural plains to the Sebkhet Ariana. Moreover, the outlet to the sea from the sebhket that is located under the road of RVE546 in Gammarth does not function well.

According to the source from the MOEH, the flood inundation zones are indicated as follows ;

-Around the ONAS purification plant in Choutrana.

-Between the ONAS canal toward Raoued and RVE 533 up to the cross with RVE546.
-North of Sebkhet Ariana area.
-All the low lands in the north of Raoued all along the ONAS canal.

The structures of purification plant, ONAS canal and the road STEG along the Sebkhet Ariana worsen the situation and obstruct the flow of rainwater toward the Sebkhet Ariana. The stagnant water is almost permanent in the zone of Choutrana, Sidi Salah and Bhar Lazrag due to the increase of ground water level.

2.1.6 Problems to be Addressed

1. One of the most conspicuous aspect observed in this area is spontaneous settlements. This reflects the same phenomenon of the Governorate of Ariana that spontaneous housing areas reach 53%. The Ariana Community contains more than 150,000 habitants today from the source of INS. Among this population, one third is living in spontaneous housing areas and rural centers. The areas are occupied about half of urban space that covers 2.0km2 in the total urbanized area of 4.7km2. Those spontaneous housing areas have been constructed particularly in the flood inundation zones, surrounding Sebkhet Ariana that are endangered not only existence of urban property but ecological equilibrium of the lake and its surrounding areas.

2. With the rapid expansion of the new town development from the Ariana Center toward northern part, some problems are observed with this urbanization. These problems involve the expansion of spontaneous housing areas, poor linkage to the old city of Ariana through traffic circulation, lack of public facilities and insufficient basic infrastructure.

3. The zones of Ariana North and Soukra show lack of basic infrastructures and have insufficient socio-collective facilities. This phenomenon is observed in flat agricultural zones such as Raoued, Choutrana and Soukra. These zones are susceptible to flood inundation because of the problems of insufficient drainage system and weak water evacuation capability as well as the proximity of ground water to the ground surface.

4. The Sebkhet Ariana has a poor flow of water into the sea. This is because insufficient facilities of the evacuation canals and creation of sand dunes that lead to the stagnation of the water. Moreover, it is observed saturation occurs by used water from ONAS purification plant.

5. The spatial distribution and formation of urban fabric are not balanced in this Community. As an illustration, the old central city shows high density while spontaneous settlements have poor structures.

2.1.7 Future Land Use

The future land use plan is susceptible to demographic data because it reflects the demands of future population. According to the INS, the population of the Community in 1989-1990 was 131,403. In 1984, the number of population was 98,655 illustrating the annual population growth rate is 6%. From this, the future plan should be made to meet the needs of future population . Moreover, the future land use plan is carried out considering the strengthens and constraints of existing land use.

Figure 4 illustrates the future land use development plan and the Table 2 depicts the future land use proportions in study area. Also, Table below shows the increase of built-up urban areas to meet the demands of the Community.

The work of future land use map was carried out mainly based on the maps of "The General Direction of Development" and reports of "The Review of Development Plan of the Ariana Community" by the MOEH completed in September 1993.

	Residential	Commercial	Administra-tive / Institutional	Recreational	Industrial	Total
Raoued	2.7km2	0.05km2	0.25km2	1.3km2	-	4.3km2
Ariana Superior	1.3km2	-	0.2km2	2.5km2	-	4.0km2
Bori Louzir	3.0km2	0.05km2	0.2km2	0.15km2	-	3.4km2
Ariana Medina	0.2km2	-	-	-	-	0.2km2
Soukra	0.4km2	-	-	0.2km2	- 0.1km2	0.5km2
La Marsa	2.5km2	-	0.1km2	0.8km2	0.45km2	3.85km2
Total	10.1km2	0.1km2	0.75km2	4.95km2	0.35km2	16.25km2

Source: Calculated by the study team

Urbanized Area

The urbanized zones are composed of various forms in urban fabrics. The development has been undertaken in different ways in this zone compared to that of Ariana Center. El

Menzah new town, new residential town of Ennozah, Mostakbel, etc. and authorized city of El Madina, Wl Fadhila, Borj Louzir and El Bosten are cases in point where urban landscape changed completely. Accordingly, some problems of the urbanization in these new towns should be solved by providing efficient countermeasures as follows;

-to control spontaneous housing expansion and plan for the solution of the existing spontaneous settlements.
-to allow smooth linkage from new town to the old city of Ariana through efficient traffic network
-to offer well-balanced distribution of public facilities in the community.
-to promote basic infrastructure facilities particularly drainage and sewage network system
-to provide public parks in community to enhance the quality of life.

The Zone of Soukra

This zone will be allocated for a mixed urban zone with activities and residential areas for the closeness to the recreational park of Soukra.

The area along the GP10 is considered as an Air traffic zone. Because of the increase of spontaneous habitants, this area will be relocated as a mixed zone that incorporates medium-density housing and unpolluted industries.

The land that can be urbanized in the North of the recreational park is allocated to low-density housing. The northeast of the recreational park will be maintained as a zone of agricultural preservation.

The Zone of Ariana North and Choutrana plain

The study on this sector was conducted by the District of Tunis, but the real situation in this area requires a revision of study concerning spatial reorganization and planned road network to consider the evolution of spontaneous habitats and to integrate the continuation of the planned road X20 through Soukra and Choutrana plain. However, the program of public facility allocation and the projection of the activity zones that were planned by the District of Tunis, is maintained.

The whole area of 18.0km2 allows to allocate the area of 9.0km2 for future urbanization after excluding the flood inundated zone of 1.5km2, the large public facilities of

4.0km2, existing spontaneous settlements of 3.0km2 and the plots authorized or to be authorized of 3.5km2 in " La Gazahla".

The sector of the Ariana North and Choutrana is one of the most important core and its evolution is very rapid. Therefore, the complexity of its problems should be solved and require the necessity to give its priority for all of future development program to equip it with the adequate infrastructure facilities.

The Zone of Raoued

The zone is planned to a new urban project. It will integrate existing houses, surrounding areas of Sebhket Ariana and flood inundation areas. This new zone will incorporate as follows;

-The medium-density housing zones, suitable for individual housing or isolated collective housing.
-The zones of dense housing toward seaside and suitable for collective housing.
-With the urbanization, the zone between touristic area and residential area is planned for the commercial center in Raoued where the RVE546 cross.
-New residential area with isolated housing pattern will be created along the sea. This will enhance the quality of touristic atmosphere in this zone.

Under the future land use plan of the Ariana Community, the proportion of the land use in the study area incorporates residential (18.8km2), commercial (0.2km2), administrative / institutional (1.5km2), recreational (4.6km2), agricultural (13.5km2), green area (6.9km2), Inundated zone (11.4km2) and Sebhket Ariana (36.5km2) within a total area of 117.5km2 as shown in Table 2.

Residential Zone

In compliance with the urbanization, the development of residential area is one of the most conspicuous aspects. The future land use plan allows the Ariana Community with the 20% of residential zone increase in the area of 18.8km2. This implies the increase of residential areas is 60% compared to existing land use. The characteristics of housing are composed of high-density, medium-density, low-density and mixed use patterns. In addition, Medina density type and detailed plan of the Ariana Center type were allocated by the residential zoning regulation.

The high-density residential areas incorporate collective and horizontally grouped housing patterns. These areas will have 60-80 houses in 1 ha. The medium-density areas contain isolated and collective housing types with 30-60 houses in 1 ha. The low-density areas are composed of isolated individual houses with 5-10 houses in 1 ha. The mixed use areas consist of medium-density housing and facilities for quiet activities. Also, Medina density is a residential type of old city of Ariana that involves grouped housing. The characteristic of this housing type will be maintained in the future plan. Residential zone of central Ariana is subject to the PADAC (Plan d'Amenagement de Detail de l'Ariana Center : Detailed Land Use Plan of the Ariana Center).

The western zone of the GP 8 covers approximately 1.4km2. The number of houses will be reached to about 4,000 houses considering the planned collective houses project. The zone is composed of multiple operations, of which "Riadh El Andalous" is the most important.

The Dal Fadhal area is located in the northeast of the Tunis-Carthage Airport. This zone covering in an area of 0.9km2 has already spread spontaneous settlements in agricultural fields. Nevertheless, this will be a new residential zone with the capacity of 2000-2500 houses.

The zone of Raoued and the surrounding area of the RV533 occupies in an area of 6.0km2. The number of housing will be reached approximately 15,000 houses in this zone.

Commercial Zone

The commercial area will be allocated throughout the Community with mainly medium-size shopping centers in a total area of 0.2km2. To make commercial area (municipal market) of Ariana less unsaturated, it is necessary to create two commercial areas in El Menzah and Ariana North, respectively. Nevertheless, it is necessary to review the authorizations concerning the establishment of services and commercial areas along the public road in the residential zones that are not suitable to those activities. The well-balanced distribution of commercial use will meet the needs of the residents in the Ariana Community along with urbanization.

Administrative/ Institutional Zone

These zones account for in an area of 1.5km2 including the governmental offices, schools , hospitals and cultural centers. This balanced spatial distribution of public facilities is expected to promote the activities of the people.

Recreational Zone

This zone covers an area of 4.6km2 including sports /entertainment facilities, urban green parks and touristic places. As urban parks do not exist in the Community, these recreational parks should be created to provide amenities to the residents in accordance with the development of other built-up urban areas. In this sense, the future land use plan will offer the urban parks in an area of 3.8km2 in Raoued, Ariana Superior and Soukra by utilizing existing green areas. The other recreational zone includes sports facilities covering in an area of 0.8km2. This zone allows well-balanced allocation and enhances activities within the Community. In addition, the touristic areas are involved in the recreational zone that is located in La Marsa Community.

Agricultural Zone

The main objective of the land use plan of the Ariana Community was to maintain the agricultural preservation zone by the Ministry of Agriculture that is susceptible to urban development . This zone evolves from the RVE 533 of Raoued, crossing Sidi Salah to Soukra. It is delimited by the RVE543 and border of Ariana North urbanization zone. The zone is directly linked with the Sebkhet Ariana in the North and with the limit of La Marsa.

Despite scattered spontaneous houses in this zone, the status of the agricultural preservation zone will be maintained and future constructions will be subject to agreement of specialized commissions and mainly to the agreement of the commission of agricultural lands. The land use plan was classified by an agricultural zone that is not liable to inundation and does not exist spontaneous settlements between the RVE533, RVE546 and the Sebkhet Ariana as well as the lands in the side of Bori Touil area.

Sebkhet Ariana

The creation of supplementary canals that allows faster evacuations of the Sebkhet water to the sea. Moreover, deviation method of the used water discharged to the Sebkhet Ariana through irrigation canals can enhance the function of drainage.

Flood Inundation Zone

The construction will be prohibited in this zone to prevent urban properties from flood damage. The existing houses and buildings in this zone will be maintained but the habitants will not obtain any authorization for extension. The control of the spontaneous settlements in inundated zones and agricultural zones by the authority is imperative. As a countermeasure of eliminating these spontaneous settlements, the supplying of public housing to illegal inhabitants is required. Moreover, provision of new infrastructure facilities against flood damage such as irrigation and sewage system through this study minimize possible damages . In order to reduce the damages from the flood inundation in the Ariana Community, several methods are recommended based on the advanced technical study to analyze the mechanism of hydraulic function of the study area both agricultural zones and built-up areas as follows;

-to prevent the discharge of used water by the ONAS purification plant.
-to maintain the drain at the level of the agricultural plains.
-to reinforce outlet facility of the Sebkhet Ariana to allow smooth discharge to the sea.
-to provide safe border dune in the seaside.
-to improve drainage system and secure retarding ponds against possible flood damage.
-to halt spontaneous settlements in the zone.
-to maintain agricultural protection zones in Choutrana to promote the function of hydraulic structures such as drains and canals.

Green Zone

The Northwest and Western parts of Ariana are delimited by a buffer zone of forests. The natural characteristic of this zone will be maintained. The preservation program will be planned which concerns the reafforestration of Jibel Nahli and the creation of a big natural park for the protection of Djebel Ammar and Sidi Amor, situated near quarries that are destroying this zone and polluting the environment. The natural green zone of the Ariana center near a hospital and the old GP8 will be preserved as a green space in this Community. The natural recreational park will cover approximately 3.0km2. An important program will be made concerning reafforestation and creation of entertainment and activities. A recreational park in Soukra occupying in an area of 0.3km2 will be a green space for activities of entertainment. Having easily accessible location of this park along the GP10 and the on the border of agricultural preservation zone, this park is expected to be an attractive point.

Reserved Zone

The Community will secure the reserved lands for future urbanization by the PDU(Plan Directeur d'Urbanism : Urban Development Plan). The reserved lands including the zone PDU of the Ariana North are sufficient for future demands for 15 years. In taking the period of 20 years, the reserved lands will meet the needs by using unplanned lands, not using the preservation zones. Reserved zones are represented by three categories as follows;

*reserved lands that are unplanned:

El Menzah A.F.H (Agence foncier d'Habitation : Land Agency of Housing)

near Nasr I&II	: 3.0km2
West of GP8	: 1.4km2
North Ariana	: 9.0km2
(Lands that cannot be disposable after deduction of spontaneous house)	
Dar-Fadal and surrounding area	: 0.9km2
Total	:14.3km2

*reserved lands that are unauthorized and situated in zones that are subject to authorization by the agricultural preservation plan: Raoued and its surrounding area is 6.0km2

*reserved lands that are unauthorized and situated in agricultural preservation zones: Soukra and Choutrana plain is 10.0km2

Considering of population growth and urbanization, it concerns the pressure on the agricultural zone after the integration of the PDU area of the Ariana North in urbanization. In addition, it also concerns the demand of the houses on the national level. This demand is uncontrolled and the Ariana Community remains an attractive area for middle-class and upper-class residents. From above two factors, there will be variables to maintain these reserved lands under the pressure on the agricultural preservation zones in the plains of Soukra and Choutrana.

Road Infrastructure Network

The road network of the Ariana Community is based on many trunk roads that allow the link to the rest of the District of Tunis.

GP8 divides community into 2 parts by North and South. The road will be linked to all the servicing trunk roads of Raoued, Ariana Center, La Gazahla, Borj Louzir and Choutrana through the GP10 and will distribute them from the North to Bizerte and from the South to Capital, then to the rest of the southern part of the District of Tunis through the links to the Express Road Z4.

GP10 will be modernized by evolving from the entry of Ariana Center to Choutrana and Soukra plain by crossing the GP8 till arriving to the intersection with the GP9. Therefore, this trunk road will ensure an East-West link between the Ariana Community and northern suburbs such as La Marsa, La Goullet and Carthage.

With the evolution of new quarries in Nasr and reconstruction in the Ariana North, new trunk road is planned. This road will be road X20 that will reduce the traffic congestion of Nasr, El Menzah and Ariana Superior toward the GP8 and will continue through Choutrana and Soukra plains till merging the GP10 as shown in Fig.6.

2.1.8 Conclusion

The development of Ariana Community has problems in urbanization. This is mainly because of inundated zones and spontaneous settlements. The problem of spontaneous housing is closely interrelated to the flood damages because much of spontaneous settlements are constructed in agricultural zones and flood inundation zones where are susceptible to flood inundation . To settle these problems, the authority must control the expansion of anarchic habitats particularly in the flood inundated zones and offer social housing for the spontaneous habitants as a countermeasure of eliminating the existing spontaneous housing problems. Furthermore, the sufficient social-collective facilities and basic infrastructure system should be provided. These are the ways to minimize the damages from flood inundation and to serve the necessity of existing and future urbanized area.

2.2 *La Marsa Community*

2.2.1 General

The Community of La Marsa is unique one in Greater Tunis with attractive points with high-quality natural environments and historic places among tourists as well as local residents. The Community of La Marsa is characterized as follows:

-A modest population growth
-A waste of space by low-density
-Good housing conditions but accompanied with the development of spontaneous housing
-Good socio-collective facilities but required better spatial distribution and improvement
-A central area of local characteristic that is not adapted to the regional context
-Centrifugal tendencies of urbanization in agricultural lands
-A potential of tourist activities that may offer a new characteristic of the community

The population growth rate has been observed as moderate one for several decades in La Marsa mainly due to the increase of land price. The average population growth rate has observed as a 2.2% from 1984 to 1988 in this Community. From this growth rate, the population of La Marsa Community will be expected to reach 55,629 inhabitants in the year of 2001. Nevertheless, the urban fabric has developed in uncontrolled state and disorganized way. This phenomenon created waste of land and low densities. Because of its numerous assets of La Marsa, it is necessary to improve this Community by controlling the constraints and providing effective spatial distribution through the land use plan.

2.2.2 The Urbanization

According to the source of the District of Tunis in 1990, the annual rate of space occupation by legal housing evolved from 14ha to 19ha per year respectively between 1975-85 and 1985-88. As to the illegal housings, it occupied in the Delegation of La Marsa an area of 9ha per year during 1985-88 that is almost twice of occupied area between 1975-85. Moreover, La Marsa Community is predominance of isolated housing on a big plots. This form of urbanization that prevailed during the last 20 years has led to the extensive spread in urban fabric as illustrated in the Fig.2. This uncontrolled urban development became an origin of centrifugal dynamics of the urbanization in this Community. With the saturation of the zone in the sea front, urbanization reaches to the area situated between Bou Seelsla and RVE550. Also, the area between the GP9 and MC33 and the zone of Sidi Daoud are boosting to urbanization. The pressure of urbanization also exists mainly along the GP9, GP10 and in the West of RVE550 where Slama is located. Along with that, the zone of Harrouch, which was defined as an agricultural zone by the land use plan in 1981 is subject to the development of spontaneous housing areas. The spatial dynamics of urbanization mainly in the outskirt of the Community such as Sidi Daoud, Bhar Lazrag and Gammarth area involves spontaneous housing problems. In this regard, the decision of future land use plan should be made by providing the method of legalization of the illegal constructions.

2.2.3 The Site

La Marsa Community is located in eastern part of the study area that occupies in an area of 25.1km2 as shown in Fig.1. The Northwest of the site is linked with the Sebkhet Ariana. La Marsa Community is composed of 2 hills, the hill of Gammarth and the hill of Sidi Bou Said. The town of La Marsa has been evolved on the lands surrounded by these 2 hills towards the South of community where the land is completely flat.

2.2.4 Present Land Use

A work of present land use map for the La Marsa Community was carried out based on the topographic maps by the MOEH and site survey. For the better understanding of present land use distribution, the study area in the La Marsa Community is classified by several zones. Under the present land use plan of the Community, the proportions of the land use in the study area incorporates residential (6.4km2), commercial (0.2km2), administrative /institutional (0.4km2), industrial (0.05km2), recreational (0.5km2), agricultural (8.1km2), green area (4.5km2) and open space (3.0km2) within a total area of 25.1km2 as illustrated in Fig.3 and Table 1.

Residential Zone

The residential zone in La Marsa Community covers an area of 6.4km2. The characteristic of residential zone along the main road of the RVE 550 or natural zone of Harrouch is isolated constructions with low density. The residential zone with higher densities (grouped houses) is situated alongside either Bhar Lazrag or Gammarth area. Also, it is observed that even a certain zone where urban fabric is homogeneous consists different types of houses. Moreover, the feature of residential area in La Marsa Community is the predominance of isolated housing on the plots that surfaces are large, ranging 500m2 to 1,000m2. This phenomenon has led to inefficient land use in the form of low density and waste of space. In addition, the anarchic housing represents 21% of residential sector. In 1988, the area of spontaneous housing were estimated as 0.9km2 in this Community. The location of anarchic settlements are depicted as follows ;

-The Slama sector contains 200 houses that are located in southwest of the Community. Recently, PAD (Plan d'Amenagement Detaille : Detailed Development Plan) of the area was made to ensure its integration and legalization.
-Harrouch area in the South of Gammarth contains 400 houses. The PAD of this area is now elaborating by the District of Tunis.

-The area near the SATPEC in Gammarth includes 80 houses and around Sidi Daoud.

The proliferation of the anarchic housing areas results from mainly the lack of land supplies for the middle income people.

Commercial Zone

There are 4 commercial areas in La Marsa covering in an area of 0.2km2. The areas are mainly located in central town of La Marsa and the other local commercial centers are in Gammarth and Sidi Daoud. This zone involves mainly commercial areas and administrative areas. Nevertheless, the structures and facilities of the zone do not correspond with the regional scale of the Community.

Administrative/Institutional Zone

Administrative and institutional areas are also partially allocated in La Marsa, covering in an area of 0.4km2. The administrative zone including municipal office, embassy and guest house is mainly located in the central area The institutional areas consist of schools, colleges, craft centers and hospitals.

Industrial Zone

Industrial activity zone in La Marsa covers an area of 0.1km2 in the entrance of the Community along the GP9. Recently, coherent plan was elaborated by the MOEH that aims at creating activities, matching residential characteristic of its surrounding areas.

Recreational Zone

This zone covers an area of 0.5km2 including sports /entertainment facilities and touristic places. A recreational urban park will be created in this zone to provide amenities in this Community. Since the development program of tourist zone was planned in 1976, the zone has developed by providing more tourist facilities. This development program of northern coast is expected to offer various changes concerning function of the La Marsa.

Agricultural Zone

The agricultural zone incorporates three sub-divisions in the plain of Soukra, Gammarth and Sidi Daoud covering in an area of 8.1km2 . The area between the RVE550 and GP9 and the area in South of Bou Seesla have reserved for vegetable agriculture. Also, the

hillside of Gammarth has developed the arboriculture and the plain of Sidi Daoud has cultivated cereal product.

Green Zone

In La Marsa, green area occupies in an area of 4.5km2. Most of green area is located in the natural forest in Gammarth and Harrouch. Some of this green zone is planned for recreational urban parks to offer activities and amenities for the residents.

2.2.5 Problems to be Address

1. Expansion of uncontrolled spontaneous housing

The Community also contains uncontrolled spontaneous housing areas in the outskirts of the Community. The proportion of anarchic habitat in La Marsa is 21% in an total area of 0.7km2 in 1988. Furthermore, most of these spontaneous settlements are located in the agricultural zone in Harrouch , Gammarth , Bhar Lazrag and Sidi Daoud near the GP9. The proliferation of anarchic housing areas results from the lack of land supplies for middle income people.

2. A waste of space by low-density

The population in La Marsa increases by a thousand of persons each year. This incorporates approximately 200 houses on the assumption that one household has five family members. Nevertheless, the annual space consumption is about 20ha that concerns average density is 1 house per 1 ha. Although this disparity is different from the areas in the Community, it illustrates the waste of space. In this aspect, some problems are occurred by these phenomena such as expensive investment in infrastructure and incapability of the Community to cover an urbanized area for expansion

3. Centrifugal tendencies of urbanization in agricultural lands

One of the phenomena in the Community is the expansion of urbanization in the agricultural zone. As an illustration, the areas of Sidi Daoud and mainly along the GP9 and GP10 are witnessed for new constructions. Also, the Bhar Lazrag area is observed the invasion of urbanization. This uncontrolled expansion in urban fabric makes urban management more difficult in the Community.

4. A central area of local characteristic that is not adapted to the regional context

The characteristics of the Community with beautiful seaside and historic sites attract many tourists from the Greater Tunis area as well as local inhabitants. However, the central areas provide only local level for visitors rather than regional level in terms of functions and facilities that create saturation and much congestion. According to the future spatial expansion, the central area is required to be planned for restructuring of the Community.

5. Inundated zone

The wide flood inundated zone around Sebkhet Ariana covers all the northwestern part of the community as shown in the Fig. 7. Moreover, as the built-up areas are situated in the upper side of the catchment area, this causes the flow and stagnation of rainwater in the flat zone, where is located in downstream and near the GP9.

2.2.6 Future Land Use

The Figure 4 illustrates the future land use development plan. In addition, the Table 2 shows the land use proportions in the study area.

The work of future land use map in La Marsa has been conducted mainly based on the maps of "The Development plan of the La Marsa Community" and reports of "The Development Plan of the La Marsa Community (4th phase) " by the MOEH completed in June 1992.

Urbanization

Like Ariana Community, the uncontrolled urban expansion by the spontaneous habitats is one of serious problems. In this sense, the future land use plan was made to minimize anarchic housing development and to optimize the land use by presenting southern limit of urbanization to the RVE550.

Urban Central Areas

This zone consists of mixed-use such as residential and commercial purposes extending from central Marsa to Marsa beach. The zone encompasses concentrated tertiary activities of the Community such as residential , commercial and service. The central zones are composed of 5 sub-zones.

1.UC1: The area in front of seaside along the Bourguiba Avenue.
2.UC2: Marsa town
3.UC3: Marsa beach
4.UC4: Between the border of sea and Bourguiba Avenue.
5.UC5: Administrative zone

The redevelopment of the central area is necessary to reduce congestion and enhance the accessibility to the sea front. In this aspect, the future expansion of central zone should be made by smooth linking to the seaside and archeological sites to meet the demands of tourists as well as inhabitants by reinforcing the characteristic of the La Marsa .

Moreover, supposing the rapid development of touristic zone in a period of 20-25 years, this central zone has still local level facilities in the Community. In this regard, the Community should intensify the characteristic to the regional level.

Residential Zones

The characteristic of the residential area is isolated residential type with low density along the border of road RVE550 or along the natural green area such as Harrouch. The dense habitants (grouped houses) exist in Remila and Bhar Lazrag as planned by the PAD of this zone or Gammarth. Nevertheless, the composition of residential area is not homogeneous with different types. In this sense, the future residential area is categorized by housing types as follows;

1.UA zone
This zone involves the individual housings in the form of row or grouped with commercial and public use.

2.UB zone
This zone concerns individual housings with low density that consist of mixed-use purposes such as commercial and public use. This zone will be located in La Corniche, Upper Gammarth and Marsa Cubes.

3.UC zone
The urban fabric in this zone is composite. This zone includes individual, and collective houses with service activities.

One of the features of residential area in the La Marsa Community is allocation of big housing plots in an area of 500m2-1000m2 per a house. This causes inefficient land use and waste of space. Therefore, it is imperative to optimize the urban land use by rearranging and reducing the area of a plot to 400m2 for the balanced future land divisions. The average density will be 18-20 houses per one ha to reduce the waste of land and make the most of existing infrastructure facilities.

Furthermore, it is necessary to plan for the review of a social housing program to eliminate the spontaneous settlements. The implementation of social housing program in Harrouch, North of the RVE550 will halt the phenomenon of spontaneous habitants, supposing the improvement of plots in the average area of 200m2 and encouragement of housing self-promotion.

Industrial Zone

The Industrial zone is developed as an independent sector near Sidi Daoud along the GP9. Also, this zone encompasses two features of the activities in an area of 0.5km2. One aspect is exclusively for the activity of industrial production. The other one is the integrated facilities to enhance the industrial activities.

Recreational zone

This zone occupies an area of 1.3 km2 involving sports /entertainment facilities, urban green parks and touristic places. In this zone, an urban park will be created in an area of 0.2km2 in Gammarth green area. The other recreational zone includes sports facilities covering in an area of 0.3km2 near Sidi Daoud along the GP9. New sports facility development is planned along the GP10, where is expected to be future sports center of the La Marsa. In addition, the touristic areas involve in three sectors in an area of 0.8km2 that are Gammarth, Chott El Ghaba and Chott Errih along the seaside. This zone includes the facilities of the hotel, residence, animation and green area. The development program of touristic zone is proposed in an area of 5.3km2 for next 15 years.

The touristic land use plan of the northern coast was elaborated between 1975 and 1985. However, the achievement rate of the program reached just 18.8%. With the potential of touristic activities, the implementation of the program is significant by the year of 2010.

In view of the development of touristic zone, the touristic activity center is expected to require big number of labor forces. Considering current situation in terms of land price

and supply of housings, there is a high possibility to create another spontaneous housing spread, particularly in the agricultural zone of Bhar Lazrag.

Agricultural Zone

The major agricultural zone is located in the South of the RVE550. Nevertheless, the agricultural predominance in these areas is threatened by the pressure of urbanization. In this sense, it is necessary to control these areas to use as a reserved one to meet the demands of community for long-term urbanization.

Green Zone

The green zone involves natural green areas and facility green areas. The natural green area is mainly composed of natural forests. As an illustration, the forests of Gammarth, Jebel Khaoui and up to the limit of Harrouch is the case. The green area with facilities is classified by the recreational zone in this land use plan that contains recreational urban parks along the GP9. The forests and natural green areas between touristic zone and urban fabric are considered as an interdiction zone for development by the Agricultural Zone Act. This zone must be protected as a buffer zone between touristic zone and urban fabric.

Non-defined Zone

This area is presented as a zone where construction is not suitable for. The zone is not allowed to construct buildings due to infrastructure service, quarry, slopes, inundated areas, cemeteries or archeological sites.

2.2.7 Conclusion

This centrifugal tendency of urbanization by spontaneous housing should be controlled in securing the appropriate land supply and optimal land use plan. For this solution, the social housing operation project is proposed on an area of 0.3km2 in Harrouch by the PDU. This implementation of the project will provide the reducing centrifugal tendencies of urbanization that is a consequence of spontaneous housings.

The central area of La Marsa has local characteristic that does not correspond with regional contexts. The community contributes to the creation of activities and entertainment in the region. Despite these attractions, the central area remains as a local

level with small area compared to the expansion of community development. Therefore, it requires a planning to redevelop the central area in the context of the regional scale.

The urbanization has been arisen mainly in the zone of Bhar Larzag and Harrouch that are situated between the Gammarth area and the RVE 550. This unplanned expansion toward agricultural zone leads to an improper utilization of land and unnecessary infrastructure cost. To optimize and rationalize the land use, the urbanization should be limited to the southern part to the RVE 550.

3. Regional Sousse

A work of present and future land use map for Regional Sousse was carried out on the basis of the land use map "Sousse Urban Development Plan" by the Land Development in the Ministry of Environment (scale 1/25,000) accomplished by March 1993 as well as site reconnaissance as shown in Fig.8 and Fig.9. In addition, Table 3 shows the present urbanized proportion while Table 4 shows future urbanized proportion in the study area. The presentation of this land use plan was approached to regional concept, considering rapid changing urbanization in the context of conurbation in the Regional Sousse.

3.1 Hammam Sousse

3.1.1 Introduction

Hammam Sousse is a coastal town, composing of gentle slopes and undulated lands. The town is located 5.7km away in the North of the Metropolitan Sousse as shown in Fig.10. This town has developed in the Sehloul plain between the Mediterranean Sea and the hills of Kalaa Kebira. Also, the GP1 provides linkage between main urban centers such as Tunis and Gabes.

3.1.2 The Urbanization

Hammam Sousse has evolved from an agricultural village to an urban agglomeration. The town had developed in the form of a comprehensive spatial expansion from 1973-1988. In this period, the urbanized area doubled from 98ha to 211ha. The urban growth was directed toward the southeast in continuity with the Sehloul plain. Also, development is witnessed along the GP1 in the North as shown in Fig.12. The most spectacular growth is in the Bir Moussa and zone of touristic road (RVE845) in the East of the GP1. Another aspect in the 1980's is spatial consumption of reserved land in the

urban expansion. This ineffective land use result from the waste of land in urbanized area is still observed in Hammam Sousse at present.

3.1.3. Present Land Use

Residential Zone

The residential area covers in an area of 250ha including housing, public and activities. This zone has evolved both sides of the GP 1 from an old central area toward the southeast in the zone of Sahloul. However, a phenomenon has been witnessed in the residential zone that is segregation. The residential zones are characterized three patterns. The upper-class residential zone is situated in the East of the GP1 (sea front), while the modest inhabitants occupy in the West of the GP1 (Oued El Ksiba area and No. 114 area). The other zone of middle-class is located between these zones in the area of Sehloul and Medina. In addition, influx of motivated people by employment from out of town is witnessed with rapid development of tourism and industry. As a result of this, anarchic housing areas have created by these occupants in the surrounding urban zones and agricultural zones, where are prone to flood inundation.

Agricultural Zone

Agricultural zone covers in an area of 620ha, of which 170ha is distributed for irrigated cultivation and the rest of 450ha is occupied by dry cultivation. The agricultural sector produces mainly olive fruits (dry arboriculture) and vegetables. The boom of touristic and industry activities since 1980's was the origin of the urban growth of the town. However, this development was occurred at the expenses of the agricultural sector. For recent years, there has been a tendency that agricultural sector has decreased for the benefit of the tourism and industry in Hammam Sousse. The encroachment of agricultural zone by spontaneous settlements is observed in the area of Ghrabi in the West of GP1 By-pass, El Bhaier, El H'mada and El K'bira.

Public Facilities

Hammam Sousse has known as an international touristic place with attractive sea front. The road infrastructure has developed with the touristic boom such as the GP1, GP1 By-pass and RVE845 (Touristic road). Nevertheless, the socio-cultural facilities do not correspond with the image of the town. The lack of public facilities is characterized mainly library, museum and youth hostel.

3.1.4 Flood Inundation Zone

Hammam Sousse is a catchment area of the Oued Hammam. The Oued crosses in the northern part of urbanized area in the town. Because of this geological situation of the town, many areas are exposed to inundation by run-off river basin along the Oued Hammam. Also, because small oueds that is flowing from the border of the town have ill-defined river bed in the urban zones, the water in the oueds is carried to the lower areas through roads. The urbanized zones in low area where are prone to flood inundation are situated in the East of the GP1 and alongside the Oued Hammam as shown Fig.11.

3.1.5 Future Land Use

1. The high-density old town center has been deteriorated with insufficiency of public facilities. Along with this, the high price of land in the old central town led to the increase of spontaneous settlements in surrounding urban zones. In this aspect, the redevelopment plan of the old town is proposed in accordance with urban expansion.

2. The anarchic housing areas that increased in the zones of No.144, Oued El Ksila, El Ghrabi and El Bhaier have constructed in agricultural zones without procedure of plot division. Moreover, these zones are prone to inundation and have poor road infrastructure. The strict controls of spontaneous settlements are required to protect the agricultural zones and reserved land for public facilities. In addition, public housing program is proposed as a countermeasure of eliminating spontaneous housing habitats.

3. Hammam Sousse lacks sufficient public spaces because of mainly high price of the land in the central town. Moreover, the transformation of public facilities into residential area is witnessed. With the urban expansion, socio-cultural, institutional facilities that could not secure the space in the central area are located far from the residential zones. In this perspective, it is required to provide balanced spatial distribution with the development.

4. The existing industrial zone occupies only 30% in the town because the industrial units prefer to be established on the major trunk roads such as the GP1. In this view, the allocation of future industrial zone should be distributed in the easily accessible area from the major road.

5. The poorly maintained archaeological sites in the West of the town can be utilized for the cultural and touristic purpose. In addition, strict control of environmental protection

against water pollution around Oued Hammam should be carried out to enhance the touristic activities.

6. A provision of rehabilitation of infrastructure facilities against flood controls is imperative. The improvement should involve drainage, sewage systems and retention ponds. The retention ponds can be utilized for parks and sports grounds in dry season as an alternative purpose.

7. The development scheme of Center-East areas in Hammam Sousse should be carried out in the context of region that is under the influence of the Metropolitan Sousse.

3.2 Akouda

3.2.1 General

The town of Akouda has changed from an agricultural village to an urban agglomeration since 1970's. This town is located in the border of the GP1, 9km away in the North of the Metropolitan Sousse. Concerning with scale of the town, it ranks fifth next M'saken, Kalla Kebira, Hammam Sousse and Kalaa Sghira among the agglomeration in the Regional Sousse. The town has developed in the Sehloul plain between the Mediterranean Sea and the hills of Kalaa Kebira, comprosing of gentle slopes and undulated lands.

3.2.2 The Urbanization

The urbanization of Akouda has taken place in all the direction around the old town. The development has consolidated the linear growth along the RVE815 during 1980-1988. However, the most spectacular growth was occurred in the East and in the North of MC48 as depicted in Fig.13. The additional housing development is represented by grouped-type in continuity with existing constructions and occupation of the area of the Oued Larouk. Many groups of residential areas were developed along the GP1 By-pass. The expansion of housing areas is noticeable in the West, while the growth is confined to only some plots in the South. The space consumed during this period was biggest and the urbanization doubled from 93ha to 202ha in 1980-1988.

3.2.3 Present Land Use

Residential Zone

The residential zone covers in an area of 180ha. This zone has evolved from an old town center and become an origin of the formation of the urban fabric. The residential zones in Akouda are represented four types. The old town has a traditional housing type while the extension residential zone in Southeast involves isolated residential areas. Moreover, mixed-type of housing that consists of grouped, row and isolated housing types exists both sides of the RVE815 in the North and under the M48 in the South. Like other surrounding towns, spontaneous housing problem is observed in this town. These spontaneous settlements are mainly located in agricultural zones and flood inundation zones such as the Oued El Arouk, Oued El Halem, Oued Djenen and Oued Errommane.

Agricultural Zone

Despite of industrialization for recent years, Akouda has retained rich agricultural fields. The total areas cover in an area of 4,460ha, of which 1,020ha is irrigated and the other 3,440 is dry cultivated agriculture. The principal agricultural products are olive and grenadine. Nevertheless, this town also shows the decrease of agricultural sector due to the low-income from agricultural work and industrialization.

Public Facilities

In this town, insufficiency of public facilities is observed that include social, sports, cultural, green area, administrational and institutional purpose. In this aspect, new development should be accomplished to satisfy public demands both qualitative and quantitative ways.

Industrial Zone

New industrial zone has created such as firms and companies in the agricultural zone in a form of anarchic way. Moreover, the space of industrial zone does not follow the industrialization in Akouda. This implies the industrial service facilities are not accompanied with the expansion of industrial zone.

Road Infrastructure

Akouda is linked with principal roads that involve the GP1 By-pass in the East and Auto route in the South-West. Also, the MC48 and the RVE815 are running in the South and North, respectively. Also, the RVE815 is merging into GP1 as shown in Fig.10.

3.2.4 Flood Inundation Zone

The major reason of inundation in this town is overflow of water along the Oued Kebir in the southern urbanized area as illustrated Fig.11. Moreover, run-off from the catchment basins in the North of the town flows on the roads. The water is gathered on the MC48 and causes flood inundation up to the GP1 By-pass. Also, the town has ill-defined oued bed in the urban zones and lack of water evacuation facilities from rainwater.

3.2.5 Future Land Use

1. The old town center has deteriorated with high density. The absence of social facilities and social houses for low-income people is witnessed. Along with that, the high price of land in the old central town led to the increase of spontaneous settlements in Akouda. In this aspect, the redevelopment plan of the old town is necessary in accordance with urban expansion.

2. The occupation of spontaneous settlements should be controlled. The expansion of anarchic housing led to some constructions under high-electric cables as well as agricultural zones. In order to avoid this danger, the creation of underground network of electric cable should be provided. Also, the spontaneous habitats should be eliminated in the agricultural zone by offering public housing program and administrative control in the consideration of agricultural protection.

3. The town has become an industrial center at a regional scale. Although this industrialization created much employment, the transport infrastructure does not correspond with the scale of industry. In addition, the lack of industrial service facilities in the industrial zone is observed. This has led to the establish some firms in the residential or agricultural zones. In this view, future land use plan should incorporate necessary infrastructure and industrial service facilities in consideration of agricultural protection. Moreover, the industrial zone should be allocated on the main road to reduce traffic congestion.

4. The qualitative and quantitative shortage of public facilities is witnessed, particularly in the old urban center. This is mainly resulted from the high land price and lack of space. In this regard, provision of well-balanced socio-collective facilities should be provided in this town in consideration of approaching socio-economic aspect as well as physical spatial distribution for the benefit of all the residents.

5. The inundation of the main roads blocks traffic after heavy rain. The program of infrastructure improvement against flood inundation should be implemented such as drainage, sewage systems and retention ponds. Moreover, water pollution along the oueds should be prevented because the deposits of rubbish on the river bed lead to elevate water level and impede the flow of water toward the outlet.

6. The road infrastructure among Akouda and the nearby agglomerations such as Sousse, Hammam Sousse, Kalaa Kebira and Kalaa Sghira should be improved. This road rehabilitation involves the MC48, RVE815, GP1, GP1 By-pass and the RVE819 as shown in Fig.10.

3.3 Kalaa Kebira

3.3.1 General

The town of Kalla Kebira is situated 12km away in the northwest of the Metropolitan Sousse. Because of the location on hills, the town has a view of neighboring towns that are Akouda, Kalaa Sghira and Hammam Sousse toward South and Southeast as illustrated in Fig.10. In terms of the scale of population, the town ranks third next to Sousse and Musakin in the governorate.

3.3.2 The Urbanization

Kalaa Kebira has transformed from an agricultural village to an urban town. The town is mainly directed to agriculture and the urban area has expanded since recent few years that concerns primarily residential development. The urbanization of the town has taken place based on two successive land use plans. The first plan was made by an Italian city planner to improve and restructure the old city during 1965-1975. This plan drew the line of evolution of this town. During this plan, the town was characterized as rural life with traditional urban fabric of predominance of narrow roads. Moreover, the existence of two oueds (oued El Kebir and Oued Seghir) surrounded the town influenced the choice of urban expansion. To solve these constraints, the plan was directed to the two points. One is not to disorganize the old urban fabric by any development and the other is not to

block the oueds that is spillway and rainwater for security and health problems. This plan involved the division of two major zonings, socio-cultural and residential. The second land use plan was elaborated by a group of the Study Team of Center that was approved by decree in 1976 and intended to be achieved the plan during 1975-1985. Nevertheless, this land use plan was not respected because it lacks severity of controls. The town evolved during this decade according to the land use plan by the Study Team of Center is represented as follows ;

- The form of zoning division with different allocations constitute constraints and restrictions for the residents.
- Unequal distribution of land use facilities
- Distribution pattern of zoning on total planned area such as residential zone and road (409.5ha), industrial zone (50.5ha) and facility zone (40ha)

3.3.3 Present Land Use

Residential Zone

The residential area includes housing, public and activity facilities with a size of 571ha. The old city is composed of solely grouped traditional houses. The types of housing are characterized by the zoning regulation such as isolated, pair, continued and grouped for the expansion of urbanization. At the same time, Kalaa Kebira shows the highest spontaneous housing rate of 70% in the total residential area in Sahel .

Agricultural Zone

This town is mainly rely on agriculture for its rich fields. The major agricultural product is olive in Kalla Kebira. However, the urban expansion has taken place in many agricultural properties in an anarchic way.

Public Zone

This area concerns both existing and planned public facilities that involve service, education and sports with an area of 27.8ha. Moreover, parcels of land for public facilities have reserved in accordance to the zoning regulation. The green zone covers a total area of about 113ha, of which 11ha is reserved for the oueds and protection zones. This zone also includes 14ha that is allocated for municipal park and 4ha for cemetery.

Industrial Zone

Industrial activity zone is for promoting tertiary activities and jobs within urban fabric of the town. There is an industrial zone of 9ha, located on the road of "Ghdir El Ajla". The activities in this zone are not developed and concerns light industry. Along with this, there is an industrial activity zone with an area of 3.2ha.

3.3.4 Flood Inundation Zone

The inundation zones are located along the downstream flows of oueds. As the spontaneous settlements and traversing roads in this area obstruct the natural flow of the oueds, this becomes one of the reasons of the flood inundation in this town. Moreover, two oueds of the Oued Kebir and the Oued Seghir surround the town completely that are running from Hammam Sousse beach as illustrated in Fig.11. This causes a serious risk of flood inundation by overflow of the oueds and pollution due to stagnation of water.

3.3.5 Future Land Use

1. Among the total area of 500ha by the Kalaa Kebira land use plan, 442ha (88.4%) is already occupied and only 58ha (11.6%) is available. Apart from the illegal constructions, some constructions are situated in non-urbanized zones by the land use plan. The constructions are scattered all around the area, amounting to 500 houses in the size of 60ha. Moreover, the saturation of space in the areas of East Zaarna, West Zaarna, Oued M'hamed and Jeradaa is witnessed. From the phenomena above, the land use was disorganized and initial allocations of zoning were changed by constructions in non-urbanized areas and spontaneous settlements. In this view, the future land use proposed by the town is integration of the development plan of 4 zones ; the residential zone of "Ghdir El Ajla", the zone of El Mansoura, the zone behind a station and industrial zone of A.F.I. In addition, the improvement for expansion in the eastern side of the railroad is included.

2. Most of the inhabitants live in house with large ground surface. This type of housing requires a big space at the expanse of agricultural lands. Therefore, it is required to intensify the land occupation of less space for the housing that leads to harmonious qualitative development.

3. The evolution of town was quantitative rather than qualitative one. The existing public facilities in Kalaa Kebira are insufficient and unequally distributed. The future land use should be planned to contribute in the development of the town on the basis of these

aspects. Providing more public facilities, green spaces and development of constructions on both sides of main road will give an urban amenity to this town.

4. This town is mainly rely on agriculture for its rich fields. For this, the agriculture zone must be protected on the basis of foodstuff from urbanization because many agricultural properties have urbanized in an anarchic way. In addition, public housing program should be implemented to halt the spontaneous housing problem.

5. The inundation of the main roads blocks traffic after heavy rain. The program of infrastructure improvement against flood inundation should be implemented such as drainage, sewage systems and retention ponds. Moreover, water pollution along the oueds should be prevented because the deposits of rubbish on the river bed lead to elevate water level and impede the flow of water toward the outlet.

6. Industry sector is a significant factor to encourage job employment. As the region is concerned with mainly agriculture, it is desirable to develop food industrial zone in this town to vitalize economic life and provide job opportunities for local residents. Moreover, the industrial zone should be located on the main road.

7. The road system should be organized into hierarchy. Also, traffic in the town should be improved by widening of the following roads : Rue 1 Juin, Rue Ali Bel Houane, Rue Hedi Chaker and Rue Beater Ben Aicha. Other roads will be widened to reinforce traffic system, as well.

3.4 Kalaa Sghira

3.4.1 General

The town of Kalla Sghira is situated 12km away in the West of the Metropolitan Sousse. This town includes undulated lands and a number of hills. These hills are exploited for the urbanization of the town. However, urban expansion led to discontinued spatial occupation by the Oued Laia and the Oued Kharoub.

3.4.2 The Urbanization

Since independence of the country, the urbanization of Kalaa Sghira has occurred in the North and East towards Sousse, Hammam Sousse, Akouda and Ennaguer. After the town became a county town of the Delegation of Kalaa Sghira in 1982, the population has moved to the surrounding areas of the town. After the creation of industrial sector,

the expansion was occurred in a form of urban sprawl by spontaneous settlements because of the lack of control. In addition, as this expansion had not accompanied with sufficient infrastructure, majority of this town remains as a small-medium size town. The urbanized expansion has taken place toward the area presented as follows:

-The Medina with its traditional houses in the center
-The area between Oued Laia and Oued Kharoub in the North
-Ras El Oued and Erroumania in the South
-The zone of railway station in the East
-The City of Ibn Khladoun in the West

3.4.3 Present Land Use

Residential Zone

The residential area covers in an area of 220ha with the relevant public facilities. The most of urban evolution is accompanied with residential development. However, much of urban expansion along the RVE819 has taken place without any prior divisions. The type of existing house is traditional grouped in the old center and isolated flat houses in all around center. At the same time, spontaneous habitats have appeared in the El Harik and along the Oued Aoun.

Agricultural Zone

The agricultural sector remains important activity in this town. The agricultural fields cover 3,500ha for olive trees and 7,000ha is reserved for main cultivation and breeding of sheep and cattle.

Public Facilities

The town of Kalaa Sghira has a certain number of administrative, socio-collective and cultural facilities at present. Nevertheless, they are still insufficient state for the development of the town.

3.4.4 Flood Inundation Zone

The inundation zones are mainly in the South and in the center of the town. The causeway with 3m high that supports the railway and surrounds the town in the South is a constraint of run-off. While this causeway plays an efficient protection role for the

town, it leads to the inundation of built-up low areas in the upstream as shown in Fig.11. This town has also uncertain oued bed that can be overflowed after heavy rain in the urban zones and lacks of water evacuation facilities from rainwater.

3.4.5 Future Land Use

1. The revision of old land use plan of Kalaa Sghira is necessary because the situations are modified in certain zone. As an illustration, the future urbanized area by the old land use plan does not correspond with current situation. This is because the constructions in non-urbanized zones. Also, the new auto route is linked with the GP1 By-pass while crossing upper residential area of Kalla Sghira from the West to East. The new land use plan should concern the integration of new industrial zone by land use plan and modification of the open space and green zone of Ejjorf by the zoning regulations into residential area.

2. The future land use plan of Kalaa Sghira should ensure the protection of rich agricultural fields. In this regard, the urban expansion will be reached to the field of pomegranate trees and irrigated areas of Sabbaghine and Echeragui. Moreover, the urbanization should be occurred by equilibrated distribution of public facilities and organized road hierarchy to intensify urban fabric.

3. The inundation of the main roads blocks traffic after heavy rain. The program of infrastructure improvement against flood inundation should be implemented such as drainage, sewage systems and retention ponds. Moreover, water pollution along the oueds should be prevented because the deposits of rubbish on the river bed lead to elevate water level and impede the flow of water toward the outlet.

4. The future land use plan by the Town of Kalaa Sghira will incorporates as follows to meet the needs of the Town ;

- The industrial zone will be developed in an area of 25ha in the Northeast.
- The residential zone will be created with schools and public facilities in an area of 48ha.
- The agricultural zone of "Saint le Roi" in the North will be transformed into a residential zone, covering an area of 55ha.
- The agricultural zone of "Ras el oued" in the West will be classified by residential zone in an area of 50ha.

3.4.6 Conclusion

Land use plan is very important because it provides the future vision of the region in the context of socio-economic aspects as well as physical development. Although the towns have different natural conditions, the characteristics of the region have maintained agricultural activities. Nevertheless, the geological situation near the Metropolitan Sousse has encouraged urban development of these towns. The most conspicuous urban expansion is accompanied with residential development from the old town centers. However, the disparity between this old town and new urban area are one of the problems in the development of the towns and it also creates the phenomenon of spontaneous settlement in surrounding urban areas. In this sense, the rehabilitation of these old towns is necessary along with improvement of anarchic housing problems.

Much of this rapid expansion has led to disordered development in the agricultural protection zones and flood inundation zones in a form of anarchic way by spontaneous habitats. Also, much land use distribution was carried out without previous divisions of land such as the construction along the RVE819 in the town of Kalaa Sghira. In this perspective, the reclassification of existing land use plan is necessary that is not appropriate for present situation. In terms of spontaneous settlements, a provision of public housing program should be considered.

In addition, the region is prone to flood inundation zone, situated in all the catchment areas of the Oued Hammam. Moreover, it is observed that the existing public facilities and infrastructure in this region are insufficient and unequally distributed. In this regard, the future development should be accomplished by well-balanced spatial distribution of public facilities and basic infrastructure in order to be self-sufficient towns in the region.

4. Conclusion

The land use planning must be implemented in accordance with mechanism of the urbanization. Nevertheless, the conflict between urban development and preservation of agricultural zone in Ariana Community and Regional Sousse is a difficult aspect to deal with. This is why the efficient and controlled policy through strategic land use planning is necessary for the development of a community.

Table 1 Present Land Use Proportion in the Study Area of Ariana Community

	Goveronorate of Ariana						Goveronorate of Tunis	
	Raoued	Ariana Superior	Bori Louzir	Ariana Medina	Soukra	Sabkhet Ariana	La Marsa	Total
Residential	4.5km2	0.5km2	2.3km2	2.2km2	1.7km2	–	6.4km2	17.6km2
Commercial	–	–	–	0.1km2	–	–	0.2km2	0.3km2
Administrative / Institutional	0.1km2	0.1km2	–	0.5km2	0.1km2	–	0.4km2	1.2km2
Recreational	–	–	–	0.1km2	0.3km2	–	0.5km2	0.9km2
Industrial	–	–	–	–	0.1km2	–	0.05km2	0.15km2
Agricultural	10.1km2	–	2.7km2	–	9.0km2	–	8.1km2	29.9km2
Green Area	6.3km2	4.3km2	–	–	–	–	4.5km2	15.1km2
Open Space	9.0km2	0.4km2	1.1km2	0.2km2	–	–	3.0km2	13.7km2
ONAS	0.2km2	–	–	–	–	–	1.0km2	1.2km2
Historic sites	–	–	–	–	–	–	1.0km2	1.0km2
Sebkhet Ariana	–	–	–	–	–	36.5km2	–	36.5km2
Total	30.2km2	5.3km2	6.1km2	3.1km2	11.2km2	36.5km2	25.1km2	117.5km2

Source: calculated by the study team

Table 2 Future Land Use Proportion in the Study Area of Ariana Community

	Goveronorate of Ariana						Governorate of Tunis	Total
	Raoued	Ariana Superior	Bori Louzir	Ariana Media	Soukra	Sebkhet Ariana	La Marsa	
Residential	7.2km2	1.8km2	5.3km2	2.4km2	2.1km2	-	8.9km2	27.7km2
high density	0.4km2	-	0.6km2	0.2km2	0.2km2	-	-	1.4km2
medium density	6.6km2	1.6km2	4.7km2	1.2km2	0.9km2	-	2.0km2	17.0km2
low density	-	-	-	-	0.8km2	-	6.7km2	7.5km2
Mixed use	-	-	-	0.2km2	0.2km2	-	0.2km2	0.6km2
Ariana center	-	0.2km2	-	0.7km2	-	-	-	0.9km2
Media type	0.2km2	-	-	0.1km2	-	-	-	0.3km2
Commercial	0.05km2	-	0.05km2	0.1km2	-	-	0.2km2	0.4km2
Administrational / Institutional	0.35km2	0.3km2	0.2km2	0.5km2	0.1km2	-	0.5km2	1.9km2
Recreational	1.3km2	2.5km2	0.15km2	0.1km2	0.5km2	-	1.3km2	5.9km2
sports/activities	0.5km2	-	0.15km2	0.1km2	0.05km2	-	0.3km2	1.1km2
parks	0.8km2	2.5km2	-	-	0.45km2	-	0.2km2	4.0km2
touristic	-	-	-	-	-	-	0.8km2	0.8km2
Industrial	-	-	-	-	-	-	0.5km2	0.5km2
Agricultural	5.2km2	-	-	-	8.2km2	-	6.3km2	19.7km2
Green area	6.2km2	0.7km2	-	-	-	-	3.1km2	10.0km2
Inundated zone	10.7km2	-	0.4km2	-	0.3km2	-	1.6km2	13.3km2
Reserved/ cemetry	-	-	-	-	-	-	0.2km2	0.2km2
Historic sites	-	-	-	-	-	-	1.0km2	1.0km2
ONAS	-	-	-	-	-	-	1.0km2	1.0km2
Petrolium storage	0.8km2	-	-	-	-	-	-	0.8km2
Sebkhet Ariana	-	-	-	-	-	35.4km2	-	35.4km2
Total	31.8km2	5.3km2	6.1km2	3.1km2	11.2km2	35.4km2	24.6km2	117.5m2

Source : Calculated by the study team

Table 3 Present Land use Proportion in the Study Area of Regional Sousse

	Hammam Sousse	Akouda	Kalaa Kebira	Kalla Seghira	Regional Area	Total
Urbanized Area	2.5km2	1.8km2	4.1km2	2.2km2	-	10.6km2
Agricultural (olive)	-	-	-	-	171.3km2	171.3km2
Agricultural (orange) / Open Space	-	-	-	-	40.4km2	40.4km2
Total	2.5km2	1.8km2	4.1km2	2.2km2	211.7km2	222.3km2

Source : Calculated by the study team

Table 4 Future Land use Proportion in the Study Area of Regional Sousse

	Hammam Sousse	Akouda	Kalaa Kebira	Kalla Seghira	Regional Area	Total
Urbanized Area	3.7km2	2.5km2	5.9km2	3.8km2	-	15.9km2
Industrial	-	-	-	-	2.3km2	2.3km2
Urban Green	-	-	-	-	4.3km2	4.3km2
Agricultural (high irrigated)	-	-	-	-	114.1km2	114.1km2
Agricultural (mid, low irrigated)	-	-	-	-	85.7km2	85.7km2
Total	3.7km2	2.5km2	5.9km2	3.8km2	206.4km2	222.3km2

Source : Calculated by the study team

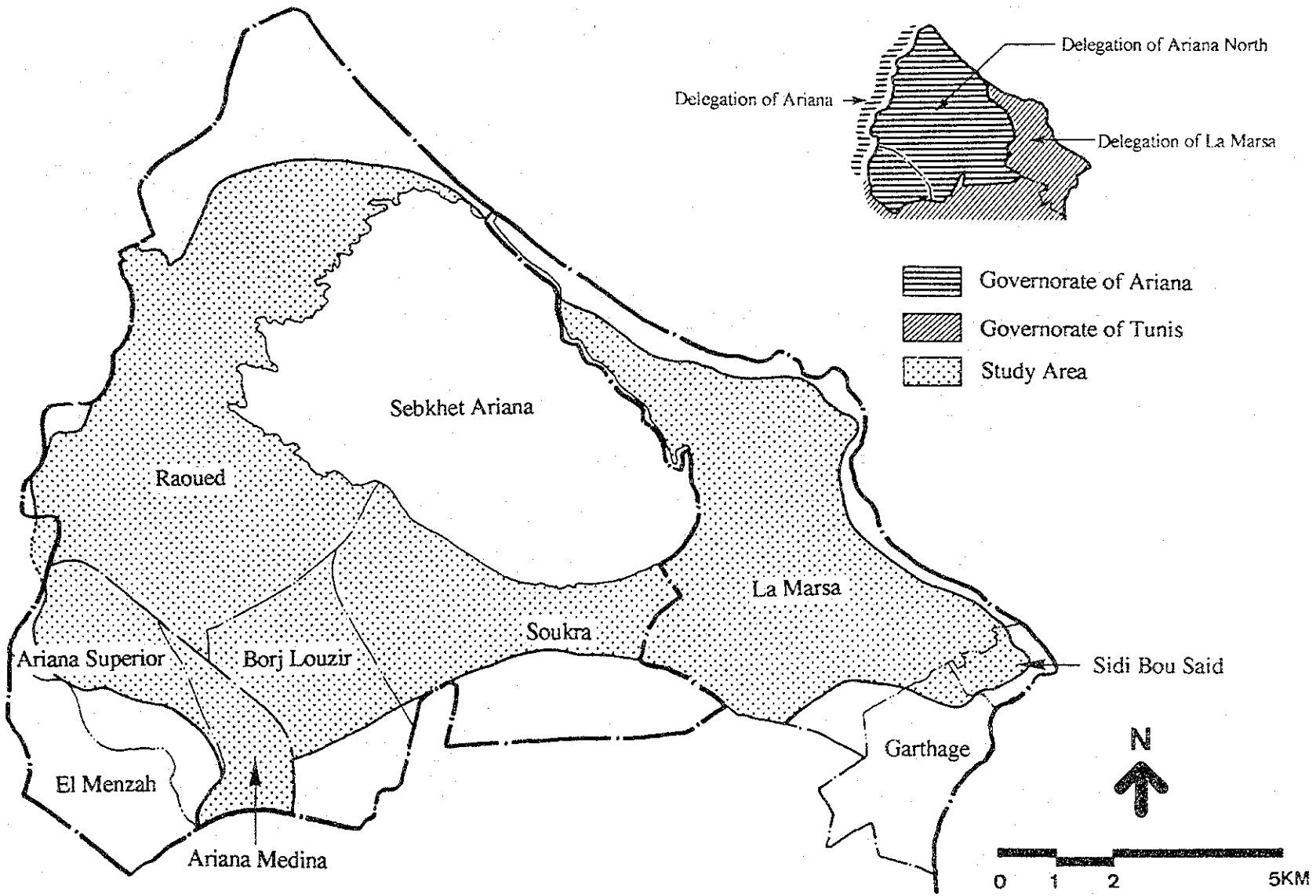

Fig. 1 The Location of Study Area

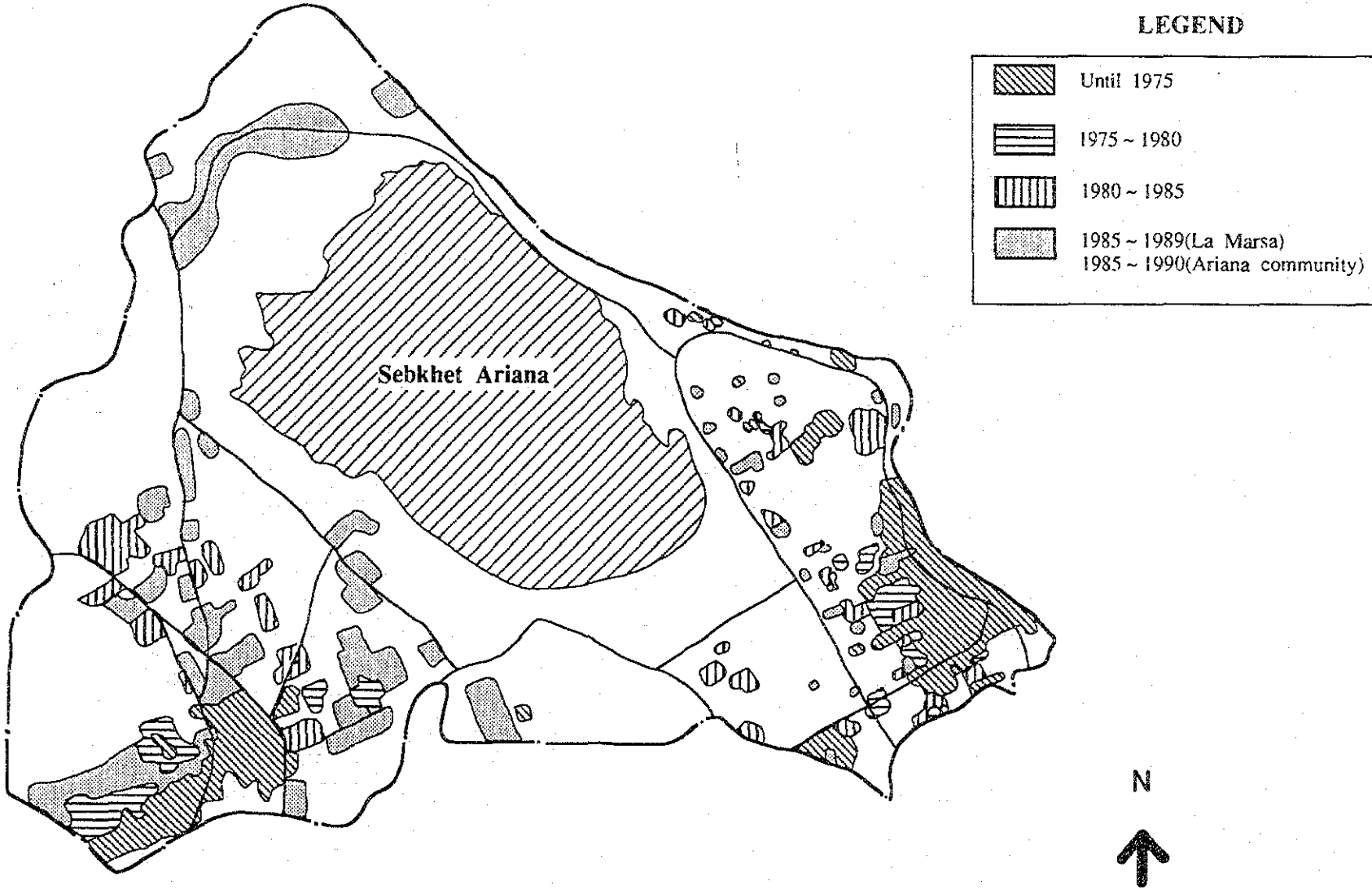

Fig. 2 Development of Urbanization in Ariana Community

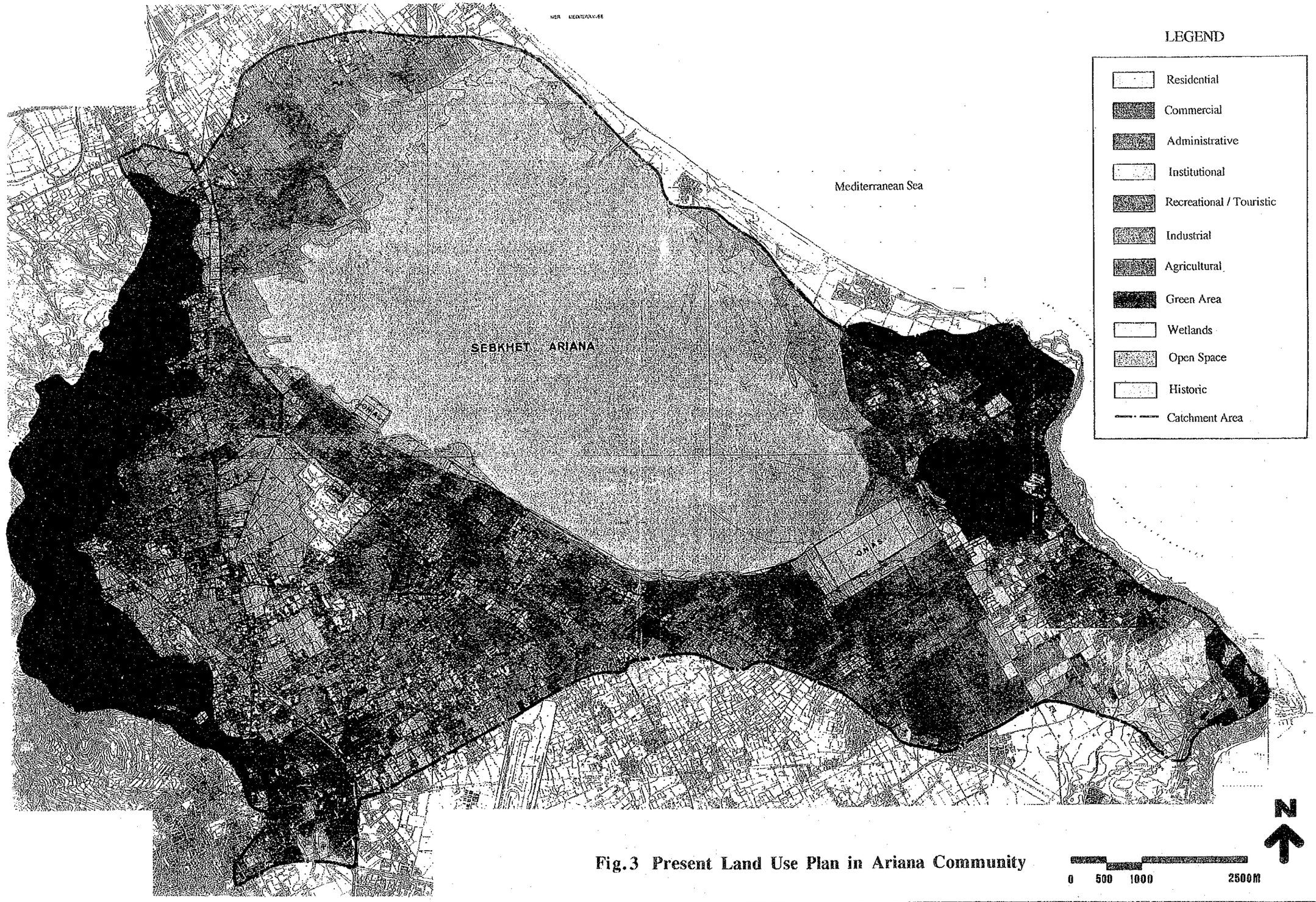

Fig.3 Present Land Use Plan in Ariana Community