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# IMPLEMENTATION OF GEOGRAPHIC INFORMATION SYSTEMS IN DEVELOPING COUNTRIES: THE CASE OF BARDO MUNICIPALITY, TUNISIA

by

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B. Architecture, American University of Beirut
(1987)

Submitted to the Department of
Urban Studies and Planning
in Partial Fulfillment of the
Requirements for the Degree of

MASTER IN CITY PLANNING

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February, 1991



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ABSTRACT

This thesis addresses the main question of viability of a GIS in a developing country municipal setting and how such a system might support municipal development. It addresses three secondary questions that are crucial to any successful implementation of a GIS: 1) What institutional restructuring is required? 2) What are the relevant maps, databases, and informational procedures and how must they be reinterpreted? 3) What are the technical considerations for computer hardware and software configurations?

Following a review of urban planning and management as it relates to GIS, the context of Tunisian municipalities is studied in terms of authority, institutions, and services. General feasibility of GIS in developing countries completes this background review. The case study of Bardo is then analyzed, including its historic, socioeconomic, physical, and budgetary conditions. Special emphasis is placed on the three central components of institutional, informational, and technical contexts.

The scope of the recommendations presented is followed by a detailed explanation of the initial measures needed in the three central components. These include staff requirements and roles, training, internal and external information needs, and specifications for hardware and software configurations. Recommendations are then made for the succeeding phase of GIS implementation.

In conclusion, the feasibility of a phased GIS implementation in the municipality of Bardo is argued. Recommendations and necessary national policies to enable the replication of such a venture in other comparable Tunisian municipalities are then outlined, followed by suggestions for future research.

Thesis Supervisor: Lyna Wiggins
Title: Assistant Professor, Urban Studies and Planning

# ACKNOWLEDGEMENTS

This thesis was started in Washington, researched in Tunis, and completed at MIT. I therefore relied on the help of a lot of people during this period whom I would like to thank.

At Bardo Municipality, several people need to be thanked. Mr. Bechir Bakhrouf, the secretary general who consented to having the research conducted within the municipality, Mr. Hussein El Karwi who donated much of his precious time to answer my countless questions, Mr. Heidi Majzoub for overseeing that everything went smoothly, and Mr. Hassan Jarrass who went to much effort to send me necessary data.

A number of people in other agencies were very helpful in generally according me interviews, in establishing contacts for me where necessary, and of course in providing me with data and maps. Among those are Mr. Morched Chabi and Mrs. Radiah Ferchichi (District de Tunis), Mr. Fathi Ennaifer (DGATU), Mrs. Ben Ammar (ONAS), Messrs. Jeddi Chedly and Ben Othman (STEG), Mr. El Meddeb (SONEDE), Messrs. Chedly Trifa and Ali Trabulsi (INS), Mr. Mokhtar Hammouda (OTC), Mr. Shergui Meskini (Rades Municipality), and Messrs. Naceur Chemam and Majed Khalfallah (IRSIT).

Several people assisted my efforts at various stages and places during this eight month period. I appreciate the sincere help and interest of Abdellatif Baltagi (SIDES, Tunis) and Lucien Godin (Groupe Huit, Paris) whose knowledge of the Tunisian municipal context proved very useful. Marie-Agnes Bertaud (PADCO), Wayne Luscombe and Pierre-Noel Pascaud (World Bank) who gave me constructive criticism at a critical stage, for which I am grateful.

At MIT, I wish to thank Professor Lyna Wiggins, my thesis supervisor, for her continuous and intensive support, insight and comments throughout the duration. I similarly thank Professor Paul Smoke, my thesis reader, for his efforts and advice. Rob Smyser, in his continued efforts to keep the Computer Resource Lab smoothly functioning, has my gratitude for having this unique working environment.

This work would never have been undertaken had it not been for Bernard Veuthey of the World Bank who offered me the opportunity to conduct this research. His candidness, warmth, and openness made this a truly enjoyable and rewarding experience.

Lastly, I would like to thank my family for their support, especially my parents. I increasingly learn from the principles on which my parents brought me up and the education they provided me. I can only hope to achieve part of what they continue to strive for in social justice and economic development.

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# CHAPTER I

## INTRODUCTION

The focus of government projects and programs in developing countries has tended recently to shift away from underwriting large-scale construction. This has been especially true in programs for urban development, where donor agencies currently look towards efficiency-enhancing institution-building as the answer to solving the chronic problems of many booming Third World cities. One such case is Tunisia, where the World Bank is attempting to start a municipal development project. The expectation of the Bank is that by redefining municipal responsibilities, financial setups, internal and external institutional linkages, human resources, and cartography, municipalities will be able to assume and fulfill a wider range of tasks. In this thesis we will use Tunisia, and in particular the city of Bardo, as a case study.

Enhancing the efficiency of municipal development can be tackled along a number of dimensions. One may distinguish among these dimensions based on a time scale, lateral or vertical scope, and external linkages, among others. In the United States, Geographic Information Systems (GIS) are rapidly being implemented in public agencies, often with efficiency goals, at the local or municipal level. But the motivations, or dimensions, of such adoption are not constant throughout these municipalities. In this thesis we will examine the potential of GIS technology for urban development in Tunisia.

In many developing countries, planning, whether exercised at a central or local level, is constrained by poor training and insufficient resources. In some cases, the process is reduced to simple tasks, such as implementing zoning regulations. Other important planning processes and development factors are ignored or underdeveloped. Although GIS, or computerization in general, cannot hope to be the ultimate panacea, its usage helps produce both increased and richer information. This information enhances the abilities of planners to analyze spatially-related events, consequently leading to more informed decision-making.[1] In this chapter the objectives of this research are identified. Then the institutional setting of the research, Tunisian municipalities, are described. Next is an introduction of some of the core concepts of GIS technology. Finally is a summary of the research methodology used in this study.

## A. Objectives

Geographic Information Systems, at their simplest level of application, can definitely be applied to cartography, with a variety of maps as the most obvious outcome of such a system. However, other components of municipal development (e.g., finance, planning) should eventually lend themselves to more policy-oriented GIS applications. But such a system also has certain inherent advantages which go beyond any information that could be produced manually by well-trained staff: a GIS has an unmatched ability to store, manipulate, and display geographically-referenced data.

In exploring the relevance of GIS in a developing country context, the main objective of this thesis is to answer the following question: How viable is a GIS in a developing country municipal setting and how might it support municipal development? In addition, three secondary questions will have to be answered before proposing the adoption of a GIS: 1) What institutional restructuring is required? 2) What are the relevant maps, databases, and informational procedures and how must they be reinterpreted? 3) What are the technical considerations for computer

[1] Richard E. Klosterman, The Appropriateness of Geographic Information Systems for Regional Planning in the Developing World (Ohio: Department of Urban Studies, University of Akron, 1990), 1.

hardware and software configurations?

The introduction of computers, let alone GIS, in developing countries is relatively novel and still considered technology transfer. Taking into account the GIS experience of developed countries is therefore advisable, although its relevance has yet to be ascertained. Such technology transfer cases are starting to appear in the literature. Implementing any new system or process into an institution requires adaptation of existing processes, with implications for the staff composition and skills as well, and building a GIS is no exception. If it is to be a success one must fully understand its linkages to all relevant procedures and actors in the municipal development process: finance, staff (and training), information/data, and cross-institutional linkages.

A common procedure in GIS implementation in the U.S. is the building of a prototype system based on information and material gathered during an initial research phase. The objective of the prototype is to simulate certain local conditions and test the feasibility of GIS using local data and maps. Although the institutional and human resource context is not directly dealt with by the prototype, these factors must also be simultaneously researched. The prototype will then provide a clearer understanding of both technical and institutional aspects of GIS implementation. In this thesis, we develop and evaluate a prototype GIS for a neighborhood in Bardo, Tunisia.

**B. Tunisian municipalities**

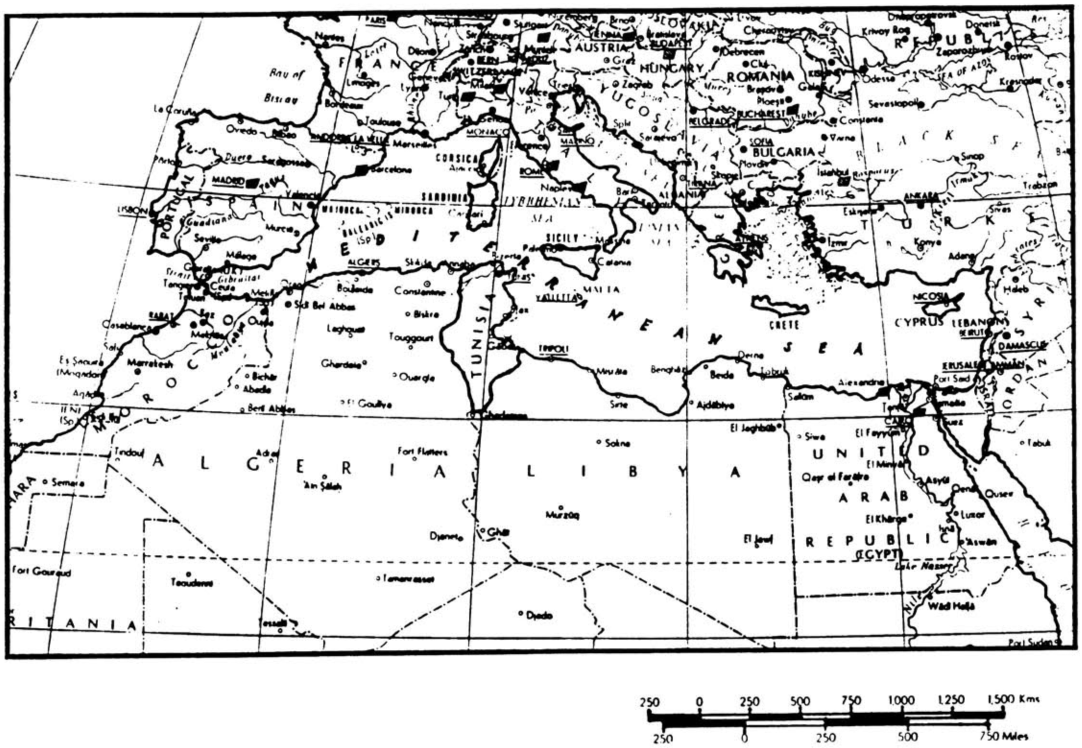
Tunisia is not unique among developing countries in being handicapped by weak local authorities. The central government attracts competent staff and does little to enforce coordination among concerned agencies, often leaving the municipalities unable to cope with their limited resources. As in other developing countries, local authority strengthening in Tunisia has become a necessity, and in some cases international development/donor bodies have joined in these efforts. See Figure 1 for a map of the region.

Tunisian municipalities have certain responsibilities within their territory for infrastructure and urban development. These are legal obligations set down by various national regulations. The main infrastructure networks (e.g., water, electricity, sewerage) are, unlike the U.S., outside the municipalities' jurisdiction and are operated by parastatal agencies. At a superficial level, the fact that municipalities are not responsible for major infrastructure, transportation, and health, allows them a certain luxury of not having to be better organized and generally reinforces their weaker role in the institutional setting. Currently a number of municipalities (including Bardo) are introducing computers, mainly for the tax system, but also for other areas. This factor, assuming that the ongoing efforts will continue to be uncoordinated and possibly poorly executed, may only increase municipal-level disorganization. However, this study will show the clear potential usefulness of a GIS in the municipality of Bardo, although the strategies for successful implementation may differ from the majority of experiences in developed countries.

In Tunisia, parastatal agencies are often responsible for functions that might otherwise be entrusted to or coordinated by local authorities. Various parastatal bodies (such as SONEDE or STEG[2]) have certain obligations and consequent advantages (in the sense of financial viability) due to their status as commercial

[2] For example: National Authority for Water Exploitation and Distribution (Societe Nationale d'Exploitation et de Distribution des Eaux, SONEDE) or Tunisian Authority for Electricity and Gas (Societe Nationale de l'Electricite et du Gaz, STEG). See Appendix 7 for a list of acronyms.

Figure 1. Regional Map




Source: <u>Pergamon World Atlas</u> (Pergamon Press, 1968), 271.

enterprises. This raises the issue of a widening gap in planning capabilities between municipalities and some parastatal agencies, as the parastatals become more efficient, especially in the computer area. What this bodes for the municipalities is that, even if the parastatal agencies were willing to hand over maps and data, as these maps improve and become more complex (especially if they are in electronic/magnetic format), the municipalities will be simply unable to use them. Municipal incompetence fuels the relegation of functions to more efficient, parastatal bodies, that in turn build their competence as a result of having to carry out these functions. This is clearly a vicious circle. Such a gap can also be seen relative to central government authorities such as the 'District de Tunis', which often assumes the role of planner for municipalities in the Greater Tunis region.

Municipalities in Tunisia typically have a small number of clerical staff that manage well such functions as tax assessment, civil registry, and construction permits. They also have a large number of unskilled staff that handles garbage collection, and the maintenance of streets, pavements and public spaces. Regulations relating to municipal governance include stipulations as to the number and responsibilities of staff. In most cases, the organizational structure of Tunisian municipalities are the same. So in looking at Bardo from the context of urban management, the focus in this study will be on the Technical Services (TS) division (the most essential division to services and planning beyond Administration). The TS divisions have no budgetary autonomy and no independent revenue raising capacity. Without enhancement of municipal planning, the capability for local control of the development and growth of the commune, let alone planning for the future, is likely to be increasingly unattainable.

## C. Realm of GIS

### 1. What is a GIS?

As Huxold states, there are as many definitions of GIS "as there are disciplines involved in using geographic information systems."[3] And in today's technologically advancing world, there are as many different GIS packages available as there are different applications for geographic information. However, it is necessary to narrow down the spectrum and arrive at how we will interpret GIS in this study. The most general definition is one put forward by the largest GIS research center in the US in 1988:

> " A geographic information system is a computerized data base management system for capture, storage, retrieval, analysis, and display of spatial (locationally-defined) data."[4]

In other words, such a system tries to combine the analytic, storage, and retrieval capabilities of a database management system (DBMS) - not necessarily a dedicated one - with graphic representation capabilities. Naturally the data must be spatial in nature (i.e., keyed to locations that can be spatially referenced) so that the underlying structure will be topological. It is topology as structure that allows for the manipulation of data according to the requirements of the user; this would not be possible if the data were simply graphical in nature. The topological data structure, when operated on by computational geometry, allows the correct reconfiguration of topology for a variety of spatial analyses.

There are four minimum requirements which differentiate between lower-end mapping software and more capable GIS. These may be fulfilled by one program or

[3] William E. Huxold, An Introduction to Urban Geographic Information Systems (New York: Oxford University Press, forthcoming 1991), 27 (in manuscript).

[4] Quoted in Huxold, An Introduction to Urban, 38.

a set of linked and compatible programs:[5]

a. Automated mapping, which consists of three elements: 1) digitizing; 2) topology; and 3) graphics. The first element includes digitizing and/or simply entering the coordinates of map elements, edge matching to allow the joining of adjacent map sheets, transforming maps between alternative coordinate systems, and snapping (fuzzy tolerance) to determine the minimum distance below which an entity can be trimmed. The second element (topology) gives these systems the capacity to distinguish between polygons, arcs, and points (i.e., topological structure) and to do area and length calculations. The third element, graphics, includes the addition of labels, shading, windowing, map layout and composition, and proportional labelling.
b. Data entry. The overall system must allow for attribute data corresponding to the geographic features to be transferred from other packages as well as for manual data entry within the GIS software.
c. Data querying. Limited statistical queries are needed. Where necessary, data should be able to be extracted and manipulated externally (in dBase, or preferably in a Structured Query Language [SQL] environment). A GIS should allow both "forward" and "backward" queries. A forward query allows a user to point to a feature on the screen and retrieve the data available for that feature. A backward query allows a user to select geographic features whose attributes fulfill certain criteria (e.g., select all parcels larger than one hectare or whose tax is less than 2000).
d. Spatial analysis and manipulation. These functions include proximal analysis for points; buffering around points, lines and polygons; and network functions (flows, shortest paths) for arcs. These features, in

[5] For example, images created in AutoCAD or ATLAS*DRAW can be transferred to ARC/INFO. Similarly, some GIS's can dump attributes which could be manipulated in LOTUS and vice versa.

combination with overlaying functions that use Boolean, logic are needed for analysis of coverages (e.g., to complete a suitability analysis).

The evolution of computer technology has made GIS increasingly available. The range of software products has widened, and competitive market forces have pressured originally unwieldy products to be redesigned.[6] But the most important factor in availability is the decreasing costs and increasing capability of hardware that now enable impressive GIS achievements on microcomputers instead of minicomputers and mainframes.

The range of software products differs based on which of the functions described above can be performed. For example, the Computer-aided Regional Planning (CARP) system, has been developed at the Department of Geography, Pennsylvania State University. CARP links off-the-shelf packages through routines written in BASIC and allows data entry, report writing, statistical and spatial analysis, digitizing, and map production. This is achieved through the capacities of the linked packages, such as Lotus 123 and AutoCAD, all of which are widely known and available.[7] Another example, ARC/INFO, the largest market-share GIS, is built around modules, and runs on a variety of hardware platforms. For the microcomputer version, the basic starter kit and INFO module (which handles the attribute data and topology) are vital. For the sake of completeness, descriptions of a range of microcomputer-based products on the market are presented in Appendix 1. These products, in some cases, are not considered to be full-fledged GIS. Some are

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[6] A prime example is ARC/INFO from Environmental Systems Research Institute (ESRI) which is soon to release an ARC/dBase version, dropping its own INFO data manager for the widely used dBase.

[7] L.S. Yapa, "Computer-aided regional planning: a study in rural Sri Lanka," Environment and Planning B: Planning and Design 15 (1988): 290-3.

closer to network analysis packages, others are simply thematic mappers.

## 2. GIS as a tool

Geographic Information Systems are a new and potentially useful tool for urban planning and management. The applications that have been documented are still few, and the academic discourse around GIS's disciplinary foundations ongoing. The existing literature tends to be either oriented around single cases or theoretical, and it typically centers on developed countries. However, there is an emerging trend to discuss GIS in the context of Decision Support Systems or even Relational Database Management Systems (RDBMS) in the more data-heavy institutions. Studying the implementation of GIS goes far beyond technical considerations and the immediate output of maps and must, as with the introduction of any element that is so strongly dependent on organizational capacity, place institutional rearrangements at the core of an analysis of feasibility.[8]

GIS is a technology that is still young in developed countries. But as with other new computer applications, some developing countries are already trying to strengthen their capabilities and are not far behind relative to the typical technological gap (in terms of applications, not development or research). More important, is the issue of whether GIS may provide developing countries with an easier way to surmount problems in urban planning/management. Foremost among these problems is the lack of capacity to produce adequate paper maps and the lack of coordination among relevant agencies. The acquisition by several developing countries of satellite image treatment centers is also relevant for GIS implementation since these technologies provide relatively cheap and quick ways to fill spatial data needs.

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[8] See, for example, Heather Campbell, Organisational Issues and the Utilisation of Geographic Information Systems, University of Sheffield.

## D. Research methodology

The research design for this work broadly follows the format of a user-needs assessment survey, which typically concentrates on three aspects of GIS (hardware/ software; institutional setting; and data and mapped information).[9] This approach is pervasive in the developed country setting, but its effectiveness has yet to be evaluated in developing countries. Cartwright suggests that appropriate technology for the latter context needs to be "cheap, effective, reliable, and easy to use" rather than non-complex.[10] Klosterman takes this point further to argue that appropriateness of GIS in the developing world "is dependent on the availability of all four [he disagregates the hardware/software aspect] components of the GIS technology package."[11]

Although it was found in this study that these four 'components' were already present in varying degrees in Bardo, the municipal staff rarely used any of the information at their disposal beyond basic routine processing. The user-needs assessment was not extended to measure the constraints on planning and managerial capacities as perceived by staff. Although this may make the institutional component of the proposal less responsive to demand-driven considerations, it is true that TS staff in Bardo currently have few decision-making powers that involve planning and management. It was therefore difficult to question them about such constraints. As for the hardware/ software and data/ information issues, these were dealt with from

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[9] PlanGraphics Inc., Geographic Information System Requirements & Conceptual Design for Northampton County Assessor's Office (Kentucky: PlanGraphics Inc., 1988) or GIST Research Unit-School of Architecture and Environmental Design, San Luis Obispo County User Needs Assessment for Automated Mapping/ Geographic Information Systems (San Luis Obispo, CA: California Polytechnic State University, 1989).

[10] Timothy J. Cartwright, The Management of Human Settlements in Developing Countries (London and New York: Routledge, 1990), 265.

[11] Klosterman, The Appropriateness, 4.

both demand- and supply-driven perspectives.

The underdeveloped state of Tunisian municipalities has significant implications for the application of GIS. Very basic elements of data/information are missing; where such data was found it was neither continuous in time nor consistent in definition. There is also a clear lack of computer-literate staff and of well-organized staff and work routines. It seems that the emphasis on viability, and consequently on municipal GIS development, should be first on basic maps/information, or cartography, to put it in more disciplinary terms. The implications for the typical user needs assessment methodology, as practiced in the U.S., are that the proposal will not focus so much on computerizing existing processes as it will be to see how far the institutional context of a developing country permits a GIS to enable the municipality to fulfill its responsibilities, planning and otherwise. The full implementation of a GIS would require the acquisition, definition and ordering of spatial data that does not currently exist.

Following is a brief account of the field research procedures. A total of seven weeks was spent in Tunisia during two visits in the summer of 1990. During the first visit preliminary field work was carried out. In the second visit I concluded interviews and data collection. The field work as a whole was completed in three phases. The first phase was to conduct interviews with a number of officials from various national agencies to discuss the study in general and to help me determine a short list of municipalities for a potential case study. In the second phase, I visited municipalities on the list of potential cases and conducted several interviews in two of them. The municipality of Bardo was chosen for three main reasons. The first reason was institutional in that Bardo was recognized for its independent stature (by blocking some public works projects had not been coordinated with the TS division) and might be more receptive to the idea of GIS as a tool. The second reason was its relatively small size, combined with a fairly dense land use pattern. The third reason was the availability of information and maps sufficient for the purposes of this study.

Having chosen Bardo, I began a second phase of field work by conducting more in-depth interviews and collecting data, maps and other relevant information. In parallel, I began collecting information from other agencies, mainly from the 'District de Tunis' and from the parastatal agencies responsible for water, electricity and sewerage. In the last phase I conducted a field survey over a portion of Bardo to gather primary data such as street names and address data for a prototype GIS.

As mentioned, information collection was intended to follow the rationale and procedures of the typical user needs assessment survey in the US. Eventually, collection of relevant material was done in a 'cruder' fashion: first,from the various divisions in Bardo; and second, from other related institutions. The material eventually collected falls into two categories:

1) Cartographic (roads, subdivisions, zoning, water lines, electricity grid, sewerage, aerial photo, public lighting, built area plan);
2) Data (national census of 1984, land tax records, electricity grid database, sample of the municipal budget, municipal staffing, partial road data).

The most crucial task of the field survey carried out on the chosen area for the prototype was determining the geographic identifiers. In this case these were street addresses. A map prepared by the 'District de Tunis' shows streets, though not completely. The initial task of the survey was to check the correctness and fill in the gaps for street-names. In addition, the starting and ending addresses, both for odd and even sides, were determined for every street segment in the study area. The prototype is limited to the south-eastern part of Bardo in terms of maps, data, and information. The study area measures around 111 hectares (one sixth of the total area) and is fairly representative of Bardo in terms of vacant land, availability of information, presence of public facilities, types of land use, and mix of housing.

## E. Expanded outline

Chapter I identifies the objectives of this research. This is followed by a description of the institutional setting of the research, Tunisian municipalities. Next some of the core concepts of GIS technology are introduced. Finally the research methodology used in this study is summarized.

Chapter II presents the background for this study in reviews of three related literatures. The first review deals with relevant points on urban planning and management as it relates to GIS. In the second, the context of Tunisian municipalities in terms of authority, institutions, and services is studied. In the third review, feasibility of GIS in developing nations is discussed.

Chapter III makes the necessary links between the general context of Tunisian municipalities, the implementation of GIS in developing nations as discussed in Chapter II, and the particularities of Bardo municipality. After presenting an overview of the history, socioeconomic, physical, and budgetary conditions of Bardo, three main issues of institutional concern are analyzed: human resources, information, and technical setup.

Following the summary of problems at the end of Chapter II, the elaboration of the institutional context of Bardo, and the GIS issues discussed previously, Chapter IV lays out the proposal. The scope of the proposal is discussed first, after which is an overview of the three components dealt with: staff, information issues, and technical configuration. Finally, a description of the various layers recommended for a GIS is presented.

Chapter V makes some brief conclusions about the implementation of GIS in Bardo and its replicability in Tunisia, and suggests areas for future research.

# CHAPTER II

## LITERATURE REVIEW

Background for this study is provided by reviews of three related literatures. The first review summarizes relevant points on urban planning and management as it relates to GIS. In the second, the context of Tunisian municipalities in terms of authority, institutions, and services is dealt with. In the third review, feasibility of GIS in developing nations is discussed.

### A. Planning and management

Urban and regional planning in developing countries is typically constrained by a lack of the resources required to meet the objectives of providing an adequate urban environment. Better planning tools and practices will affect what Harris calls the three essential requirements of effective planning:

1) There must be agreement on goals at any one point in time;
2) An idea of the elements of action (e.g., laws, investment, taxes) must exist before planning procedures can be adopted;
3) A capacity to predict the impact of actions and their value is implicit in the decision to plan.[12]

Harris stresses that there is a management side to planning, not only through a typical planning process (as in classical what-if projections) but also in 'on-the-spot' decisions. For such decisions, "coordination of management with policy-making will ... be seen as a particularly effective use of GIS."[13] Ultimately, planning as an activity must integrate the evolution of events that occur within a jurisdiction into a larger development picture. Such a broadening of outlook can act as a catalyst for

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[12] Britton Harris, "Urban and Regional Planning in the Third World with Geographic Information System Support," Regional Development Dialogue 11, 3 (Autumn 1990): 21.

[13] Ibid., 25.

agreement among the local actors to be reached; but it is also necessary due to the interconnection between the different parts of management functions and because planning management can provide a monitoring function.[14]

Within the realm of management as an urban planning activity, records in general are a fundamental part of the information base. Such records typically deal with land parcels, construction, tenure, occupancy, licensing, and inspection. Of relevance here is that such records will necessarily have attributed geographic identifiers, such as addresses or parcel identifiers. Records will be required not only for managing and enforcing laws, zoning and land-use regulations, but also for any forward planning.

Certain planning processes may be relatively simple at a local level, such as siting of a kindergarten to reflect in a rational manner the distribution of potential users. But if one is to take into account the strategic components of planning in a more comprehensive urban context, the complexity increases as one starts to take into account additional sectors, agencies, and tiers of government. These may include precincts (or 'arrondissement' in Tunisia), zoning districts, business locations, and various systems, both manmade and natural (water, ecology). This makes a siting exercise more complex, and requires a process that is much more interactive and dynamic, providing a situation in which a GIS can perform useful 'what-if' analyses. An example would be siting a school given the criteria of desires to be near significant green spaces, far from industrial zones, within the rapidly growing neighborhoods, and within walking distance from main transport routes.

[14] Ibid., 26.

## B. Tunisian municipalities[15]

In this section we first consider the distribution of authority between levels of government, then look more closely at the local institutional context. Finally, we examine the provision of urban services in some detail. See Figure 2 for a map of Tunisia.

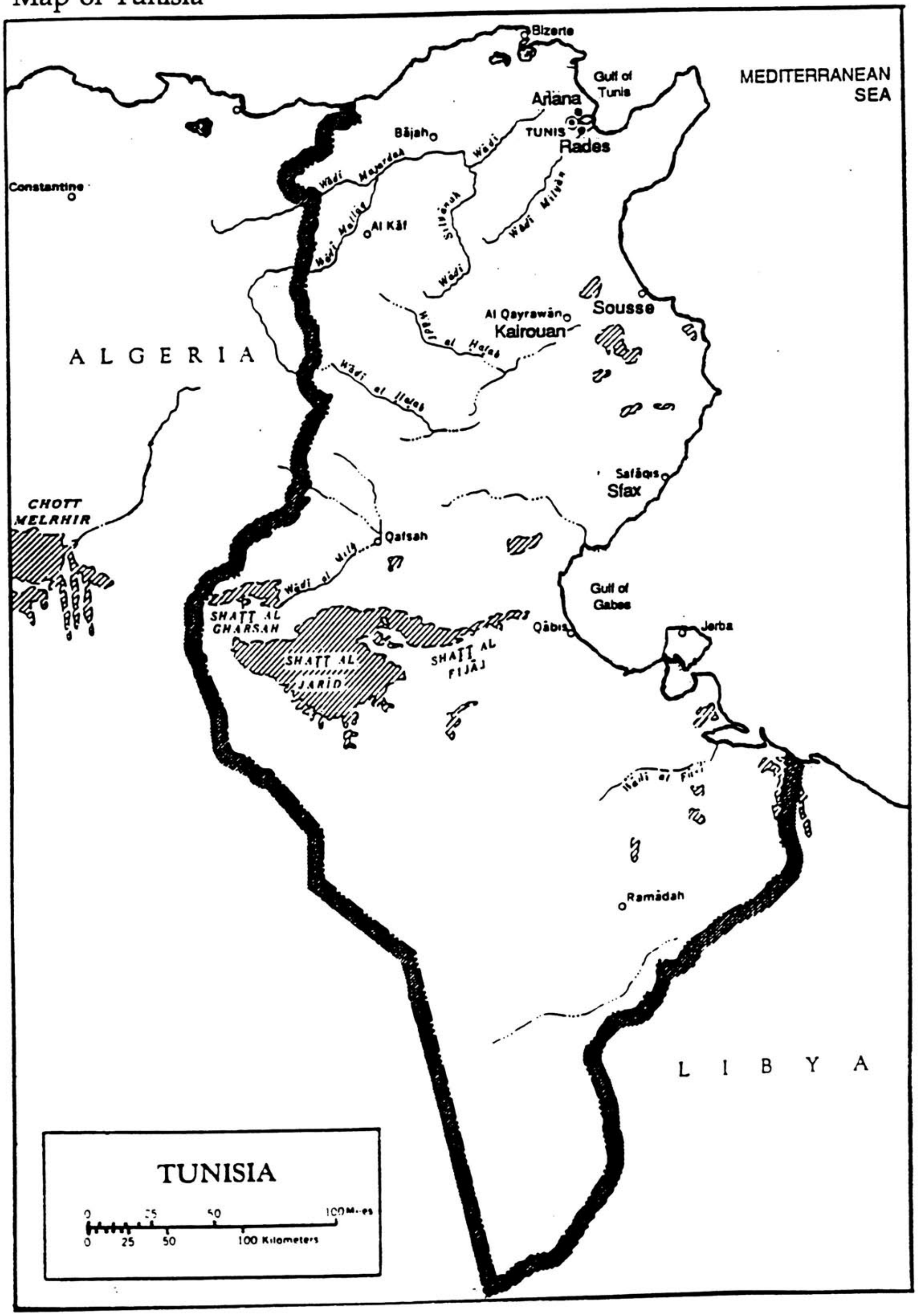
### 1. Distribution of authority

In Tunisia, general management and services provision responsibilities are relegated to various bodies depending on the nature of the task. The Ministry of Equipment and Housing (MEH) is responsible for urban management. Policies relating to urban development are set by the Ministry of Interior, the General Office for Local Authorities (Direction Generale des Collectivites Publiques Locales, DGCPL) (which is itself within the Ministry of Interior), the three governors from the three governorates that make up greater Tunis, the three corresponding regional councils, and the 25 municipalities in greater Tunis. As for the service operations sphere, various parastatal bodies are in charge of services, including electricity, sewerage, water, while the Ministry of Transport is responsible for all public transport.

The relationship between municipalities and other levels of government needs to be clarified with respect to administration, finance, and technical matters. **Administratively**, municipalities fall mainly under the authority of the Ministry of the Interior, though the governor, by virtue of his being a representative of the central government, has authority over the municipal council, municipal services, and to a certain extent over personnel. The degree to which this authority is exercised and how it overlaps or contradicts the authority of the Ministry of the Interior are unclear. The Ministry of Interior is called upon to approve various development and

[15] The main reference for this section is the study prepared for the World Bank Municipal Development Project mentioned in chapter I: SIDES - Groupe Huit, Projet de Developpement Municipal, Rapport Intermediaire (1989), Volumes 1 and 2.

Figure 2. Map of Tunisia




Source: Joy Hecht, "Introducing Information Technology in Third World Cities: The Tunisian Experience" (Ph.D. diss., Massachusetts Institute of Technology, 1988), 114.

investment plans drawn up and other decisions reached by the municipal councils. Of more routine, but far reaching importance, is the Ministry of Interior's authority over municipal personnel whom, being part of the national civil service, are recruited and hired based on standard classifications. The Ministry also approves the creation of new staff positions. The fact that municipal staff are civil servants eligible for central government positions (that are more lucrative) leads to difficulties in recruiting and retaining competent municipal staff.

The Ministry of Interior also controls municipalities through the DGCPL which is responsible for:

- creation and suppression of communes;
- change of municipal name and borders;
- dissolution and/or suspension of municipal council;
- dismissal and/or suspension of mayor and other members of municipal council;
- arbitration of conflicts between the council and the governor;
- advising of the secretary general, a Ministry of Interior employee (who may encroach on the sovereignty of the municipal council).

As for **financial authority**, all municipalities with a current budget greater than TD 2 million or showing a deficit are controlled by the Ministries of Finance and Interior. Municipalities with a total budget under TD 350,000 have their budgets approved by the regional governorate. The Ministry of Finance maintains a local office, the 'recette municipale', which in fact serves as the cashier, treasurer, and accountant for the municipality.

**Technical authority** is subdivided into three categories. 1) urban services; 2) management of land; and 3) spatial planning. The planning and implementation of public urban services is carried out at the central government level for basic infrastructure in conjunction with various agencies, such as the Housing Land Agency (Agence Fonciere d'Habitation, AFH) or the National Building Society of

Tunisia (Societe Nationale Immobiliere de Tunisie). Regional branches of the parastatals responsible for infrastructure (SONEDE, STEG, ONAS[16] and others) have regional authority. Communes are responsible for roads, public lighting, slaughterhouses, markets, garbage collection, cemeteries, and fire-fighting.

Management of municipal territory follows the hierarchy described above with the addition of regional supervision of the municipal Technical Services (TS) division in the case of construction and subdivision permits. These permits are supervised through the regional branch of the MEH. Spatial planning also falls under the MEH, which acts as planner for municipal territory, and decides which municipalities require an Urban Development Plan (Plan de Developpement Urbain, PDU) or Urban Management Plan (Plan d'Amenagement Urbain, PAU) and, along with the 'District', assists the municipalities in its preparation.[17]

Property tax in Tunisia, known as 'taxe locative', is based on the rental value of residential properties and is legally the responsibility of the property owner. The rate is fixed at 24 percent of the annual rental value: 20 percent is the tax itself (only 10 percent for the first five years) and four percent that goes towards a national housing fund. Effectively, the assessed value is independent of whether the property is rented or not, and rules do not seem to be followed in the assessment procedure. The municipal tax service is responsible for assessment and producing the tax roles, while the 'recette municipale' is responsible for billing and collection. However,

[16] The National Office for Sewerage (Office National d'Assainissement, ONAS) is technically under the MEH.

[17] There is ambiguity on this point. In some cases the 'District' is found to prepare such plans even though its own agenda and jurisdiction in such matters is unclear.

computerization tends to leave the latter with only the task of collection.[18]

The expertise gap between municipalities and parastatals can also be seen between the municipalities and the 'District de Tunis'. The 'District' prepares the PAU's but often hands them over to municipal personnel trained only to use the part dealing with specific regulations. Clearly the PAU analysis section, with its implications to long-term planning, remains under-utilized by the municipalities, unless the 'District' is trying to plan by proxy. In fact, the 'District' is not mandated (and shows no sign of wishing) to ensure the implementation of PAU's.

## 2. Local institutional context

Local authorities vary widely across the world, not just in terms of levels of centralization but as importantly in terms of internal resources. So it is useful to quote the official definition of a Tunisian municipality, or commune as it is termed there:

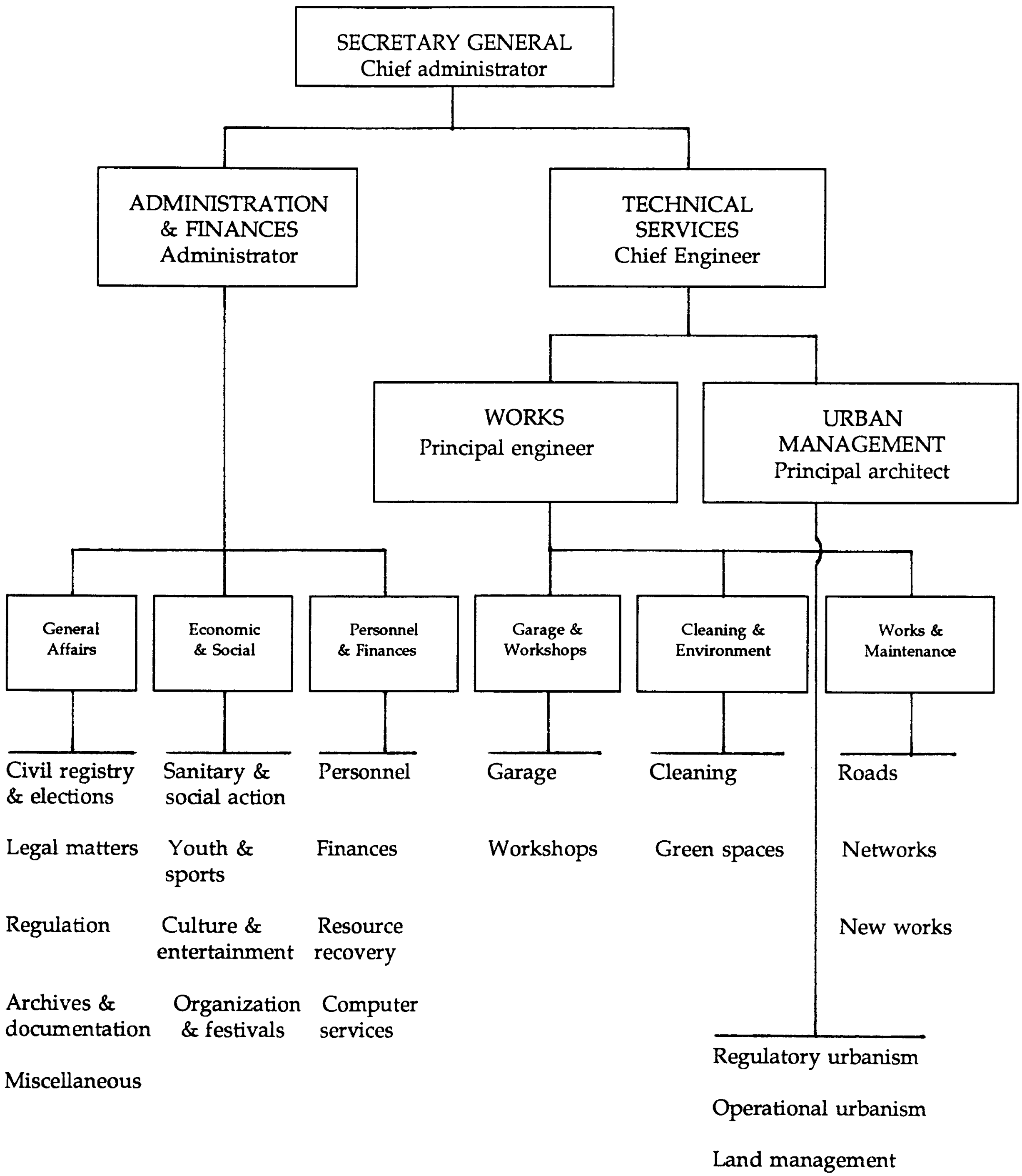
> "A commune is a decentralized local collective....charged with the management of municipal interests, it [the commune] participates in the framework of the development plan for economic, social and cultural advancement in the regions."[19]

Municipal activities can be grouped into three broad categories. First are the technical services: roads, cleaning (including garbage collection), public lighting, sewerage, green spaces, land-use management, investment studies and projects, workshops and buildings maintenance. Second are administrative duties: civil registry, inspection services, culture. Third is resource management: personnel and financial management, resource recovery. See Figure 3 for an organizational diagram.

[18] Joy Hecht, "Introducing Information Technology in Third World Cities: The Tunisian Experience" (Ph.D. diss., Massachusetts Institute of Technology, 1988) 129-135.

[19] Article 1 of the 'Loi Organique des Communes', May 14 1975, as quoted in SIDES, Projet de Developpement Municipal, 1, A, 7.

FIGURE 3. ORGANIZATIONAL STRUCTURE: Municipalities between 50 to 100,000




Source: SIDES, Projet de Developpement, 1, C, 91.

Within a municipality, the municipal council and mayor have authority, and are respectively deliberative and executive bodies in nature. However, it is crucial to note that neither has any obligations to work in the municipality for any period of time. The municipal council, a body elected by the citizens, has decision-making powers as well as a consultative mission. Among its important responsibilities are to review all projects relating to the municipal domain, to prepare the infrastructure and Public Facilities Development Plan (Plan d'Equipement de la Collectivite), to define the actions for development within the framework of the national development plan, and to approve the budget. The mayor is elected by the municipal council and is its president as well as the representative of the state. This creates a certain degree of contradiction in that the mayor represents the **central** government and heads a **decentralized** collective. The mayor typically delegates most or all authority to the secretary general, who is the highest civil servant in the municipal staff and an employee of the Ministry of Interior, as is the case with the rest of the staff.

Decision-making does not seem to be carried out on the basis of established rational procedures. What may be found is something close to a rationale that gets defined around the accumulation of tasks of certain staff members. This seems especially true for the tasks of the head of the TS division. This definition is structured by the limiting of activity to four main tasks: the civil registry, garbage collection, road maintenance, and construction permits. The nature of decision-making is strongly affected by the clarity of definition of responsibilities. With respect to the Municipal Council responsibilities, these do not completely cover the municipal jurisdiction and in some cases overlap with other authorities. At the level of the municipality as a whole and to staff members as individuals this leads to "the notion of local interest becoming a residual notion that depends on the density of other interventions."[20]

Planning is piecemeal, to say the least. In the case of the Investment Plan (Plan d'Investissement Communal), there is not much participation between concerned parties. Furthermore, the methodology does not follow the basic iterative process of identifying needs (laying out a program, evaluation of resources, and readaptation of program). As for the preparation of staff proposals, no linkages with budget preparation are in evidence.

Concerning the automation of some of these tasks, certain municipalities attempted to introduce computers as far back as 1978 and the National Center for Computerization (Center National de l'Informatique, CNI) has been formulating policies concerning computerization since 1983. But the pace of progress is still slow. The CNI is the prime governmental agency responsible for computer research, standards specification, and software development, but the appearance of other bodies with similar objectives, though much smaller in scale and targeted on specific applications, can only be seen as a positive development. The DGCPL has one such unit, as does the Ministry of Interior. The 'District', which has a computer department, seems to be actively engaged with certain municipalities in the promotion of computers for certain services (such as taxes) and has developed software to that effect. In 1987, the CNI was given a mandate of determining training, development of software, choice of hardware, implementation and maintenance of hardware for municipal computerization plans. A municipality therefore usually needs CNI approval for any such plan. However, there does seem to be some leeway granted, especially when municipalities have a strong budget. The size of the budget determines what types of hardware the municipality may acquire and which CNI

[20] SIDES, Projet de Developpement, 1, A, 19.

software packages they can access. In the case of Bardo, networked personal computers or stand-alone mini-computer and 11 software packages are the current specified limit.

By far the most important municipal resource with regards to municipal development is that of staff. It is useful to point out that national staff laws determine the number of staff in each category and their minimum educational requirements. But the determination of numbers and levels is through a stratification of municipalities based on the total value of the budget, with 'richer' municipalities, which are no more populous than others, entitled to hire both more and higher skilled staff.

There are four employment categories: administrative, technical , special, and worker. The five specified educational levels are, in theory, independent but effectively correlate. These educational categories are: one cycle of higher learning (between 2-6 years of post-secondary education), the baccalaureate or school leaving diploma, four years of secondary school, six years of primary education, and no education.

The latest survey indicated that for the country as a whole there was an average of four municipal staff per 1000 population. In Bardo the number is 2.5.[21] Of a total of 18,176 staff in Tunisia, over a third of them were in the three largest cities. When studying human resources in Tunisia, it is useful therefore to compare the municipality to those of similar size.

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[21] A survey carried out by the DGCPL in 1987.

The overall picture reveals some startling results. In the country as a whole, the technical staff make up the smallest group (2.7 percent), followed by the almost equally sized special and administrative sections (5.7 and 6 percent respectively). It is the workers that make up the bulk of staff at 85 percent. When this is compared to educational background, the picture is even more dramatic: only seven percent of municipal staff have at least a secondary school leaving diploma, 25 percent had not more than four years of secondary education, while 66 percent had little or no education. Given such statistics, extra hiring to make up for the average 25 percent national shortfall, between current staff numbers (Administrative and TS) and what is mandated as an upper limit by law, may be seen as ineffective. Little benefit for automation could be earned from hiring additional staff if their educational composition was to follow existing proportions. However, a disaggregation of the shortfall reveals that extra hiring may indeed remedy some of the problems. The administrative sections are the most discrepant; they could be increased by 47 percent while the technical sections could grow by 38 percent. The special and worker categories are close to the legal limits, and could be increased by 15 percent and 24 percent, respectively.

### 3. Services

The proposal presented in Chapter IV addresses various types of infrastructure, and it is useful background to look in detail at the various types of infrastructure and services in terms of municipal responsibility. Table 1 presents a comprehensive summary.

#### a. Roads

Planning, construction and maintenance of primary roads, national or regional, are the responsibility of the MEH and/or regional councils. Planning of secondary roads is jointly conducted by the MEH and municipality during the PAU or Detailed Management Plan (Plan d'Amenagement de Detail, PAD) stages. The construction

## TABLE 1. MAIN ACTORS BY TYPE OF PUBLIC URBAN SERVICE

| | Main actors | | | | | |
|---|---|---|---|---|---|---|
| | Ministries | National Agencies | Regional Councils | Municipalities | Local Operators | Source of funds |
| **Basic Infrastructure** | | | | | | |
| National & regional roads | 1 | | 1 | | | N |
| Local roads | | | | | | L |
| Public lighting | | | | 1 | | L |
| Water, electricity, gas | | 1 | | 1 | | U/N |
| Telecommunications | 3 | | 3 | | | U/N |
| Sewerage | | 3 | | 3 | | U/L/N |
| Garbage collection | | | | 1 | | L |
| Public transport | | 1 | | | 1 | U/N |
| Parking | | | | 1 | 2 | U/L |
| Security, fire-fighting | 1 | | | | | N |
| **Socio-cultural Facilities** | | | | | | |
| Primary, sec. education | | 1 | | | | N |
| Higher education | 1 | | | | | N |
| Training | 1 | | | | | N |
| Hospitals | | | 1 | | | U/N |
| Cultural facilities | | | 3 | 3 | | L/N |
| Sports facilities | | | 3 | 3 | | L/N |
| Youth centers | | | 3 | 3 | | L/N |
| Kindergartens | | | | 1 | 3 | U/L |
| Mosques | | | 1 | 2 | | N |
| Cemeteries | | | | 1 | | L |
| Parks, gardens, beaches | | | | 1 | | L |
| **Economic Facilities** | | | | | | |
| Markets & slaughterhouses | | | | 1 | | U/L |
| **Administrative Facilities** | | | | | | |
| Regional administration | | | 1 | | | N |
| National administration | 1 | | | | | N |
| Spatial planning | 1 | | | | | N |
| Works coordination | | | | 1 | | N |
| **Management** | | | | | | |
| Housing zones | | 1 | | 1 | | U |
| Industrial zones | | 1 | | 1 | | U |
| Touristic zones | | 1 | | | | U |
| Rehabilitation | | 2 | | 1 | | U/L/N |

Notes: 1= Direct control of works; 2= Delegated control of works or interventions on delegated credit; 3= Shared control of works; U= users; L= Local fiscal; N= National fiscal.
Source: SIDES, Projet de Developpement, 1, A, 68.

is up to the municipality, but if the road crosses a subdivision project the construction expenses are paid for by the private developers. Tertiary roads are planned by the municipality and regional councils of the MEH, and in the case where they cross a subdivision project are constructed by the developers.

**b. Sewerage**

ONAS, the sole agency responsible in this domain, softened its monopoly of this service in 1974 by allowing the limited participation of other institutions such as the AFH, the Rehabilitation and Urban Renovation Agency (Agence de la Rehabilitation et de la Renovation Urbaine, ARRU),[22] as well as municipalities. However, maintenance remains the responsibility of ONAS, as does planning. As for financing and cost recovery, main networks are covered by the central government, other networks by ONAS and users, and connections are paid for completely by users. Construction of main networks is carried out by ONAS while that of secondary networks is flexible depending on the nature of the intervention (see above footnote).

**c. Water and electricity**

Planning, usage, and maintenance are the responsibility of the respective agencies, SONEDE and STEG. Construction is also their responsibility, although it may be subcontracted to approved private contractors. Primary networks are financed by the central government, distribution networks are partially covered by the users, while connections and actual usage are covered by users.

**d. Public lighting**

All aspects of public lighting are the responsibility of the municipalities, with costs captured by a tax collected by STEG through the general electricity bill. The municipality receives a transfer from STEG after any debts it may owe are cleared.

**e. Household garbage**

The responsibilities for infrastructure and services are clearly outlined in

[22] Such institutions are often engaged in the planning and financing of housing and other development projects, and must design and pay for basic infrastructure.

various legislative articles. For household garbage, there is a general statement under municipal responsibility.

**f. Social services**

Almost all social services are the responsibility of the central or regional governments. In the case of youth centers and sports facilities, municipalities share the burden (mainly through partial financing). Kindergartens, public markets, green spaces, and performance halls are solely the responsibility of municipalities.

**g. Land registration**

Though land registration is not a service in quite the same sense as those discussed above, it is important to the land planning process. The national Property Tribunal (Tribunal Immobilier) runs the judiciary procedure that establishes land titles. The Topographic and Cartographic Office (Office de la Topographie et de la Cartographie, OTC) proceeds to fix the physical boundaries in map form.[23] Finally, the Conservation of Land Ownership (Conservation de la Propriete Fonciere) registers the necessary information.[24]

**h. Permits and codes**

It is up to the municipal TS staff to enforce compliance with building and subdivision permits that are issued by regional governments, in addition to general enforcement of the building and zoning codes.

## C. GIS in developing countries

When a new technology or procedure is transferred to developing nations, its sustainability and adaptability are principal concerns. Harris identifies the "conservative tendency to caution the developing nations to make haste slowly, and

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[23] During the field research, it was found that the actual maps held by the OTC were few and not consistent in coverage.

[24] Philippe Billot, Systemes d'Information et Banques de Donnees pour la planification et la gestion territoriales en Tunisie (World Bank, 1989), 2.

in a sense to let their growth recapitulate the history of technological advance in the more industrialized nations."[25] He maintains that such a view fails to accommodate the learning capacity from the experience of others. Such learning should allow bypassing or mixing of development steps and strategies. Relating this to planning, the conclusion is that an accumulation of capital (productive facilities, infrastructure, and human) needs to be invested (or developed) until the surplus can be expected to reap developmental rewards. Another 'conservative tendency' is to assume that the main factor determining successful implementation of computer applications is the application's simplicity. However, certain case studies point to the significance of the application as the prime factor and to the degree to which the administrative capacity to institutionalize the implementation is indigenous.[26] Leonard provides a framework for analyzing such administrative capacity and includes public policies, organizational leadership, internal administration, and external control systems.[27]

Another critique of computerization in developing countries is that it will increase dependency. By and large, developing countries are indeed dependent for computer technology on industrialized countries, although India is a notable example of burgeoning self-sufficiency. Of more importance is that developing countries are quickly producing their own computer-skills in terms of operators, software, and maintenance. A quantitative refutation of the dependency argument is that microcomputer prices are expected to drop below $250 by the turn of the century.[28]

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[25] Britton Harris, "Does the Third World Need Computers?" Environment and Planning B: Planning and Design 16, 4 (1989): 371.

[26] Stephen B. Peterson, "Institutionalizing Microcomputers in Developing Bureaucracies: Theory and Practice from Kenya," (Kenya: Ministry of Planning and National Development, 1989): 2.

[27] David K. Leonard, "The political realities of African management," World Development 15, 7 (1987) 899-900.

[28] Harris, "Does the Third", 374. One modest estimate is that all 600,000 villages in India could each be supplied with a PC for less than the cost of a dozen fighter planes.

Beyond that, a qualitative justification with a microeconomic aspect is that "contrary to expectations, it seems that the use of computers will be a labor-intensive rather than a capital-intensive industry."[29] This is clearly contrary to the assumption that advanced technology in developing countries is primarily capital-intensive. The fundamental high quality of computers as an educational tool, gives them a central place in the potential development of a nation's human capacity, providing a further counter-argument to dependency. Harris succinctly rejects conservative fears by saying that, "development without computers will in most cases prove to be nondevelopment ... and nondevelopment will be the primary cause of dependency in the decades ahead."[30] However, this optimism needs to be tempered. Undoubtedly the attempts of developing countries to introduce computers into the public sector will, as has happened in other areas of technology transfer, continue to be failures. Many of these failures are due to implementation problems, often institutional in nature.

There are a number of cases in the US where GIS has been successfully implemented incrementally and this may make the above point on the speed of technology transfer a moot one. There are some advantages to incremental implementation of GIS. The most important advantage, promoted in developed countries but especially true in a developing countries context, is that incremental implementation provides for 'learning-by-doing' and allows flexibility. Flexibility is necessary given the pervasive lack of data that makes it difficult for builders or users of a GIS to anticipate how, and how much, such a system will be used in the future and therefore what data sources and format it should rely on initially.[31] Therefore,

[29] Ibid., 374.

[30] Ibid., 375.

[31] Klosterman, The Appropriateness, 13.

in the early stages, developing a system around existing conditions (those pertaining to information, institutions, and hardware/software setup) is highly recommended. Another advantage to the step-by-step approach is the lighter strain expected on the political and institutional context of motivation, commitment, dispensation of resources, and power struggles.

It is useful to remember that at the core of a GIS is the system that manages and stores all the attribute data. The usage and management of large volumes of data can be a daunting task given the variety of sources, structures, and usages intended. Sophisticated DBMS's are becoming widely available in the developed countries. In some instances, large institutions have developed systems that are custom made. This has, in certain cases, led these custom programs to become viewed as a system totality, with functions that are so rigidly determined that they sometimes prevent the system from adapting to changing institutional needs. In essence, a DBMS ought to "computerize record-keeping activities, including storing data, querying a file to find a particular piece of information, and statistically analyzing a data file."[32] In fact, the DBMS should not be one system in the sense of its being a single-purpose software package. In a context where computerization is still new, and where database skills are not very developed, it is necessary to plan for versatility and diversity in data types and requirements to ensure that the system can expand without duplication of effort and future bottlenecks. This is especially true in GIS implementation because a GIS needs to integrate and use many data sets in a variety of combinations.

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[32] Richard K. Brail, Microcomputers in Urban Planning and Management (New Brunswick, NJ: Center for Urban Policy Research, 1987), 31.

## D. Summary

A number of issues concerning municipal capacity need to be raised when recommending GIS implementation strategies. The leading concern identified for Tunisia is the lack of competent municipal staff resulting from two institutional factors: national staff hiring quotas and the unattractiveness of municipal employment relative to private sector or central government positions. Decentralization of planning or decision-making to municipalities is a broad issue that cannot be adequately addressed here since it involves not only the existing lack of planning tools and data at the municipal level but also the unclear differentiation between the responsibilities of the mayor versus the secretary general.

Another identified concern is the capacity of municipalities to raise revenues whose source is limited to property taxes (and in some cases tourism taxes). The lack of revenue generating capability increases municipal dependence on the central government. Tax sources and budgets for Bardo are discussed in more detail in Chapter III. The Technical Services staff are hard put to coordinate, let alone plan and control, the public works and services within their jurisdiction. This is partly due to institutional determinants; but where local initiative is such that these constraints could be overcome, the lack or disorganization of maps, data, and information make this action almost impossible. Finally, the same problems with data quality and availability effectively curtail the public's access to information, and limit the role of the public in local control over land and development.

# CHAPTER III

## BARDO CONTEXT

This chapter makes the necessary links between the general context of Tunisian municipalities and the implementation of GIS in developing nations discussed in Chapter II and the particularities of Bardo municipality. These particularities are detailed, keeping in mind the issues raised in the literature review of the preceding chapter. After presenting an overview of the history, socioeconomic, physical, and budgetary conditions of Bardo, three main issues of institutional concern are analyzed: human resources, information, and technical setup.

### A. Overview

Bardo is the ninth largest commune in Tunisia,[33] and the second largest commune excluding capitals of governorates. A commune of this scale is susceptible to the effects of urban growth, and any constraints on the municipality's managerial capacity have far-reaching and serious consequences for the current and future residents of Bardo.

### 1. History of Bardo[34]

The modern city of Bardo lies 4 km West of Tunis. Its origins date to between 1249 and 1277 AD, when the regional ruler Hafsi decided to build himself a palace in the green area of Bardo. This was quickly followed by structures built by his entourage. As such, Bardo first took on characteristics of a recreational zone. The

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[33] Institut National des Statistiques count on 1/1/1989. The DGCPL 1987 survey placed the commune as sixth largest. Both are quoted in SIDES, Projet de Developpement E, 121.

[34] Bardo Municipality, Projects and Achievements, 1985-1990 (Tunis: L'Art de la Composition, 1990). This is the most important source used for the History, Socioeconomic, and Physical sections of this chapter.

emergence of the Husseiniyah era in 1705 turned Bardo into a governmental seat, with defensive structures built to repel attacks from the West. This action started the first major increase in population. With the French invasion of Tunisia in 1881, Bardo experienced an increase in building activity, most of it barracks and housing for the French military personnel and their families. The fact that green spaces remained predominant endeared the suburb to foreigners and wealthy Tunisian families, who also took advantage of the easy transport to and from Tunis via the roads and the tramway. The municipality of Bardo was established on May 8, 1909. Post independence, the population increased manifold, and Bardo could no longer be considered a suburb but became a city. See Figure 4 for a map of Bardo and surrounding areas.

## 2. Socioeconomic

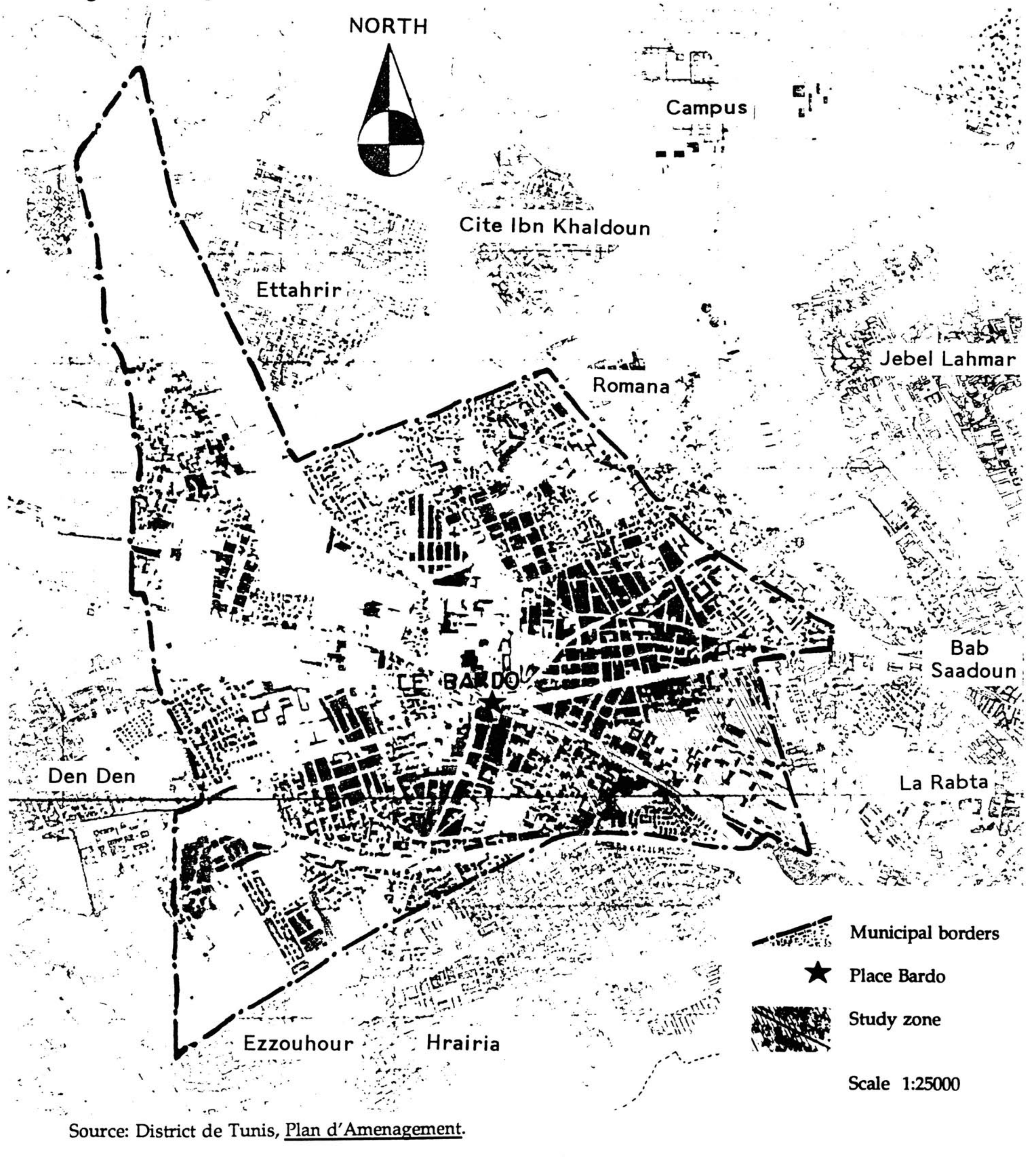
Bardo, according to a 1990 municipal publication,[35] has a population of around 79,000. This figure, which is not referenced, is most likely an estimate based on the 1984 census conducted by the INS which placed it at 63,019 (and 73,500 in 1989), apparently increasing at a yearly rate of 2.13 percent since 1975. A survey held by the DGCPL in 1987 placed the population at 100,000. The municipality estimates the number of families to be 15,800 in 1990 (12,556 in 1984 according to the INS), yielding an average family size of 5.0 persons per household during the last decade.

Bardo is not a very economically active community, its economic base being mainly services that cater to local residents and few alternative employment sources. The 'District de Tunis' found that there were just over one thousand commercial and service activities.[36] Of these activities 28 percent were commercial alimentary, 18

[35] Ibid., 15.

[36] District de Tunis, Plan d'Amenagement de la Commune du Bardo, Rapport de Representation (Tunis: District de Tunis, 1989), 9.

Figure 4.. Map of Bardo




Source: District de Tunis, Plan d'Amenagement.

percent commercial non alimentary, five percent alimentary service, 15 percent repair shops, and eight percent furniture. These shops are well dispersed throughout the city, mostly situated along the main roads. The survey found one major industrial complex, while there were 18 small factories, half of which were in the textile industry.

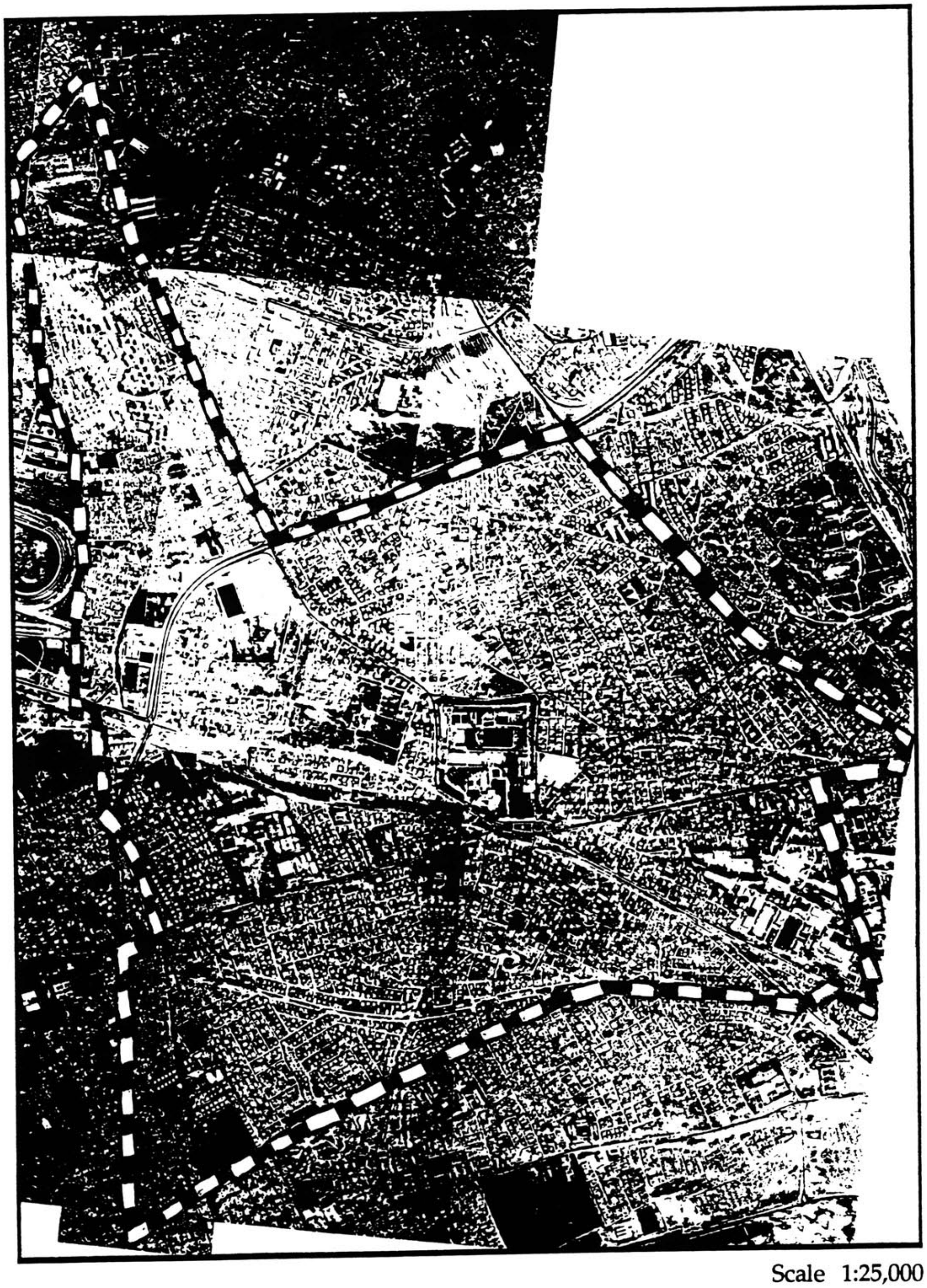
Bardo is not a commune with a substantial lower income population if one measures this through the typical plot size, which is large. A visual survey of neighborhoods indicated that working class families are common, with a few areas that are middle to higher income, and some slum-like areas south-east of the center of Bardo.

### 3. Physical

The number of dwellings increased from 7,469 in 1975, at a yearly rate of 4.3 percent, to reach 12,303 in 1987. Vertical densification not withstanding, an analysis of aerial photos of the area (see Figure 5) shows that there remains very little vacant land available. Vacant land accounts for only nine ha, or 1.3 percent of the total area. The distribution of dwellings is as follows: 48 percent villas (large houses on large plots), 28 percent single houses, 21 percent apartments, two percent other. Clearly the vast proportion of units are villas, with most of them occupying lots between 300 and 500 $m^2$, while single houses are found on lots under 200 $m^2$. Note that in Tunisia in general, few apartment buildings exceed four floors since they would then be obliged by law to be equipped with an elevator. Virtually all dwellings have electricity and potable water connections, while 84 percent are connected to the sewage system and 38 percent to the gas lines.

Concerning the residential units, 56 percent of Bardo's inhabitants own their units, while 36 percent are renters. In terms of unit size, 13 percent are 1-room units,

Figure 5. Aerial Photo of Bardo



Scale 1:25,000

27 percent are 2-rooms, 51 percent are 3 to 4-rooms and nine percent are 5-rooms or more. The average occupancy rate decreased from 6.6 in 1975 to 5.1 per unit in 1984 since units have been growing at almost double the rate of the population growth. Virtually all units have a kitchen and WC (94 percent and 98 percent respectively), while only 52 percent have a full bathroom.

As already noted, the majority of lots are quite large in size. Residential density varies of course, but three quarters of the city has a density less than 30 dwellings/ha while the average is 24 dwellings/ha. In the spontaneous settlements, this goes up to 50/ha. Green spaces are almost nonexistent in Bardo, and those that can be found are not public.

The area of Bardo is around 660 hectares. There are one municipal and 14 private kindergartens, 15 primary and five secondary schools, four medical centers, 13 mosques, the National Museum, two youth centers, and three covered markets. These buildings are mostly publicly-owned, and they cover around 11 percent of the city area. Some of these facilities require full or partial maintenance, funding, and staffing by the municipality. There are seven public sites of a military/ security nature which are self-sufficient.

Several national arteries go through Bardo. The GP5 and GP7 are main routes to the North and West of the country, and both pass through Place Bardo. Also located there is the 'Assemblee Nationale' or Chamber of Deputies, and the Bardo Museum. A railway skirting the Place Bardo adds further to local traffic congestion there.

There are 53 bus lines serving the community, some of them running beyond the municipal borders. This transit service is not run by the municipality. Under construction is the western line of the 'Metro Leger' which is planned to pass under the Place Bardo providing a major link to the center of Tunis.

The Canal Khaznadar runs along the Western border of Bardo, and is an open canal that principally takes care of rain water. However, other wastewater ends up in it, forming both a breeding ground for mosquitos and a health hazard. There are two rain water collection basins with an area of four hectares, located in the north-western part of the city.

## 4. Budget summary

The 1990 budget was set at TD 2,871,222 with 63 percent and 37 percent making up the current and capital budgets respectively (see Appendix 2 for a summary). The total budget has been growing in nominal terms at around 3.4 percent since 1985, while the current budget has been increasing at 6.2 percent over the same period. The largest component of current expenses (TD 1,102,261) covers municipal costs (salaries, administrative, equipment, and maintenance). This is followed by a transfer of TD 425,000 to capital expenses, and then by local interventions (mainly for cultural and social purposes). Interest from local debt represents only 1.5 percent of the total budget. As for the capital expenses, the largest portion is for direct investment (TD 985,647), followed by amortization of the debt principal (almost three percent of the total budget).

An important point to be drawn from the 1990 budget is that the central government grant (current receipt) represents 37 percent of the total budget. The next largest receipt is from the reserves (capital receipt) at 22 percent, followed by direct taxes (current receipt), which are almost entirely property taxes, at 21 percent. The municipality is clearly heavily dependent on external assistance, a fact that is less pronounced in municipalities with access to tourism as a resource. Another point is that around 60 percent of the capital expenses must be precisely assignable to specific locations if the various activities are to be efficient, timely, and well budgeted. These expenses total around TD 575,000, or 50 percent of the capital budget and 20 percent of the total budget, representing a sizeable portion. Finally direct taxes which in 1990 came to TD 530,000, are another category where spatial location must be clear so that these taxes can be efficiently identified and levied.

## B. Human resources[37]

As is the case in most municipalities, Bardo's staff are mostly (92 percent) laborers with little or no professional skills. The majority of these staff take care of cleaning and general outdoor maintenance, while the rest have some specific skill such as welding or carpentry. The remaining are administrative staff, out of which only a few are in the Technical Services (TS) division. The staff total 224 and are distributed as follows (see Appendix 3 for details): 25 administrative staff; nine technical staff; two medical staff (delegated from Ministry of Health); 188 laborers.

There are 29 people serving on the municipal council and consultant's board; these people are the policy makers although they have no extensive working knowledge of how the municipality functions. The mayor, as in most Tunisian municipalities, holds a political position and is rarely present. He does not seem to be acquainted with the detailed functions and staff of the municipality.

Of the 12 administrative staff who have specific responsibilities (not counting the educational staff), most of their formal training consisted of several years in an administrative academy. In certain cases, the staff would, after leaving school,

[37] Data concerning number of staff as well as some aspects of formal education and training are from Mr. Omar Khadri, interviewed by author, Tunis, September 7, 1990. See Appendix 8 for a list of interviews.

undergo an entrance exam to enter a governmental training program. As for the TS division, the three engineers have university degrees, while the other staff either underwent some sort of specialized training at a polytechnic or a governmental one year program (as in the case of the Regulation Inspectors).

With respect to the TS staff, the technical skills are limited, especially for the non-engineers. Not only have they been trained to perform specific tasks, but the training itself is geared towards municipal requirements. Though this may save the municipality on-the-job training, it does produce limitations on the staff versatility, even within their specialized domains.

Currently Bardo has no staff qualified to use GIS. Of more importance is the absence of staff with computer training. The person responsible for the tax system has only been trained to operate a few menu-driven customized packages. As for the routine practices in the TS division, it is only the head that is clearly qualified to prepare, interpret and alter maps. By virtue of his position he is also aware of certain problems relating to municipal management but has no time to correct them.

## C. Information[38]

By and large, information that could serve as a base for a GIS is lacking, at least in a condition where it could be immediately applied. The tax office has recently completed entering data for the 1990 tax forms, and this data set is currently the only available database suitable for GIS applications because the data are already in a dBase format. The data appear consistent and cover all of Bardo, and increasing the efficiency of taxation offers financial incentives for a GIS. However, there are some modifications that are necessary before this data can be used. These modifications are

[38] All the information in this section was collected by the author during interviews with officials from the relevant institutions, held from July 11 to August 4 and August 27 to September 11, 1990.

detailed in Chapter IV. An external data set is the 1984 census, a digital copy of which was obtained from the INS. This data contains a number of interesting fields, mostly relating to housing characteristics, although there is a limited amount of demographic data available as well.

In a more comprehensive GIS implementation, a permit tracking component might be considered. An attempt was made by the TS division to establish a tabular file on the conditions of all roads; unfortunately this never got beyond a small proportion of the roads. No file is available on the management, maintenance, or condition of the public lighting either. However, the municipal warehouse, a responsibility of the TS division, has a computer where inventory activities are carried out.

The municipality prepares few maps, and there are no draftsmen among the staff that could take on normal drafting tasks if required. The few maps prepared internally deal mostly with road building and are done following a field survey. However, the majority of maps for road building tender documents are prepared, along with the final documents, by private consultants.

The main map used in Bardo by TS staff is the 1:2000 PAU prepared by the 'District'. Its usage appears to provide the means for locating the zones as defined in the "PAU, Reglement". In fact, this map is based on the SONEDE maps, and the 'District' is not independently equipped to supply municipalities with original data or maps, either on a temporary or continuous basis. The second most used map was the garbage collection zone map which indicates collection scheduling by area. The municipality must, by law, approve all lot subdivisions and it has maps showing the intended subdivisions which are submitted by the lot owner. These maps are of mixed quality, and are not consistent in scale, detail or even types of information presented. Furthermore, the municipality has no map to indicate the actual situation of construction of subdivisions (approved or otherwise). However, this seems to be done by the 'District' in certain cases, though not for Bardo. In fact, there is no cadastral map showing land ownership. The TS division is the body that issues construction permits (whether new or renovations) and this forms some sort of registry. Since 1985, the TS division has been issuing around 340 such permits a year, of which 86 percent are usually for new construction. The most consistent collection of records are these construction permits. These will not form part of the scope of the prototype because they are not a significant resource-consuming service and a GIS application in this area would be premature. If a GIS is implemented, the inclusion of information on construction permits provides a mechanism for forcing the updating and maintenance of building records.

The SONEDE has made base maps at a scale of 1:2000. These maps are based on 1983 aerial photos contracted by the OTC. Referencing is a 100m horizontal/vertical grid. Streets are indicated but not numbered or named, and in some cases the limits between a street and an empty lot are omitted. In certain cases building footprints are marked but the actual landuse is never indicated although certain structures are defined (wells, cemeteries, mosques, schools, military buildings, museums, railroads, water tanks, and governmental buildings).

The 'District' has a map dating from 1987 at a scale of 1:5000 which indicates the majority of street names, in addition to most public facilities, and has contour lines. This map shows the INS 1984 survey zones as they relate to Bardo. The 'District de Tunis' also has a plan showing massing at a scale of 1:5000 and an aerial photo dating from 1988 at 1:10000. These documents, in conjunction with the PAU zoning and the SONEDE maps, can currently take the place of a existing land use map.

ONAS prepares maps of its sewerage networks at a scale of 1:2000. The maps are generally organized around a project, or network, but these coincide closely with the municipal limits in the case of Bardo. However there is a discrepancy between the claim that 83 percent of dwellings have sewage connections and the maps, which show far fewer areas served. Whether this is a matter of maps not being updated or that the above figure is inflated (obtained from the 'District') is unclear.

An indication of information related problems could be seen in the difficulties encountered when I simply tried to find out what maps existed. Probably the most important handicap in the TS division is that most work is task oriented, and most of the elements that either constitute a specific task, or are relevant to it, never get studied or interpreted outside that tasks' domain. For example, the municipality undertakes construction and maintenance of a number of roads, mostly all by tender to private contractors. All the data from that project can be found in the tender documents, and seemingly only there. One cannot find the physical characteristics of that road stored in a separate file that might have been created upon project completion. Instead one finds a mixture of projects all in the same pile; completed, underway, planned. Not only would a detailed profile of service needs and provisions be a valuable source, but it would also serve as an 'infrastructure inventory', indicating project completion and successful disbursement of funds (or lack thereof).

The above description reflects the situation for most other activities in the Technical Services division. As such, distinctions of informational needs in terms of collection, usage, storage and retrieval cannot be found. In summary, the data/information aspect of municipal capabilities makes it extremely difficult for the staff to properly manage their affairs. Had the senior TS staff been employed for a long time, acquiring knowledge through personal experience, one could rely on experience and professional memory to make up for the lack of data. However, most technical staff in Bardo have been there for a short period of time, and the only qualified person (the head) is too busy doing site visits and completing administrative duties to remedy these gaps.[39]

## D. Technical configuration

Bardo's computerization efforts are still minimal. There are currently applications for taxes, payroll, and inventory in the municipal warehouse. The possibility of including the civil registry and Technical Services is under study. The tax system originally used was one prepared by the CNI (see Appendix 4 for a listing of the components). There is one staff member who uses this system;[40] fortunately this person was originally responsible for the taxes and has the necessary experience. He originally trained at CNI on the system and used it on an experimental basis for a year before it was discontinued. The main reason given for the discontinuance was that the amount of on-site information needed to complete each entry, and thereby perform the assessment, made the process unfeasible. Whatever the validity of that argument, it is clear that the new system adopted (see Appendix 4 for components), which is currently becoming operational, is far from problem-free. One drawback is that the identifier/code is not related to any geographic reference such as block, street, or street number, but is simply a 'counter' type number. The coding that the tax service intends to use in the future corrects part of the problem but is not perfect. In the future, the code will be formatted to consist of around 10 digits. The first six will denote the zone and street, the remaining refer to a parcel number that will start from the number one at the beginning of each street. However, within a street, once a new taxable unit is placed between two previous units on the same street, all the

[39] The head of the TS division was promoted to this position during the last few days of the field study. He was previously the assistant head (a post he had held for one year).

[40] Mr. Hassan Jarrass, interview by author, Bardo, July 11 and August 31, 1990.

succeeding units will have their code offset by one. Theoretically speaking, the only units to maintain the same code forever are those that are on the first parcel of each street. Since each structure on a parcel must be taxed, there may be several tax roles for a given address. Addresses, therefore, are not unique identifiers even if address spelling were to made consistent. Staff are obviously unable to determine what the tax history of the lot is, unless a landlord shows them the tax forms. Another drawback is that the system does not allow for statistical analysis beyond some basic summations. The benefits from improving the coding, and including the basic CNI categories (land use, tenure), would go beyond the tax services. Such land-use data, plus its correlation to tax revenues, could become key components of a GIS system.

# CHAPTER IV
# PROPOSAL

Following the problems for GIS implementation summarized at the end of Chapter II, the elaboration of the institutional and physical context of the municipality of Bardo in Chapter III, and the GIS-specific issues discussed previously, Chapter IV presents recommendations for a feasible implementation of such a system. The scope of the proposal is discussed first, then an overview of the three components is presented: staff, information issues, and technical configuration. Finally, more detailed descriptions of the various layers recommended for a GIS are presented.

## A. Introduction

Though it can be argued that a GIS in Bardo could lead to enhanced municipal development and increased local control, the main conclusion is that such a system would not be feasible under current institutional conditions and definitely not sustainable without institutional restructuring. However, the successful implementation of a one to two year program involving some basic and preliminary actions would pave the way for a GIS.

Three major areas for recommendations can be identified through this analysis: 1) recommendations concerning staff hiring and training; 2) recommendations concerning changes in existing practices; and 3) technical recommendations. The first area includes the recruitment and employment of additional staff who will, along with some of the current staff, undergo basic training. The second area includes the modification of certain procedures relating to data and maps, and the introduction of others such as collection of maps from other agencies and relaunching of the road network database. Finally, recommendations for the acquisition of computer hardware and software necessary to implement the program will be made.

## 1. Scope

The minimum requirements needed by a Geographic Information System are currently absent in the municipality of Bardo. Therefore a two-phase proposal is necessary to realize the prerequisite staff, computer skills, data, maps, and technical issues. In the initial phase, staff hiring and computer acquisition will only directly affect day to day operations in the Technical Services division. However, the municipality's decision-making capability, revenue raising capacity, and territorial control will be increased in the long run. The only area outside the TS division to be altered in the initial phase is the property tax computer system. Once the initial staff acquisition and training and procedural changes have been implemented, the second phase will be initiated. The first element of this phase should be an evaluation conducted by a consultant to measure the degree of success of the first phase. Based on this, recommendations for implementation of a GIS and the final choice of software can be made.

It is recommended for the initial phase that three additional staff be recruited and employed in the TS division. The training for the staff that will be using the system will be geared towards data and map issues through computer applications. A consultant would also assist in the several phases of implementation. In terms of procedures that will have to be altered or introduced, these include road inventorying, property taxation, garbage collection, public lighting, municipal property management, and granting and recording of construction permits.

After the initial implementation phase, the scope of the GIS system will naturally extend beyond its constituent parts because a GIS allows for combining, comparing and overlaying different sets of data that correspond to the same spatial area. It might be extended eventually to aid municipal planning by highlighting the current situation relative to the PAU and to provide valuable insights for achieving the PAU goals. Such comparisons of the existing to the PAU could involve zoning, satellite images, census data on demographics, and land use from tax roles.[41] Also, environmental planning would be possible by relating industrial siting to the relevant infrastructure networks and water bodies and other sensitive area. The basic exercise of studying zoning maps and analyzing the communes' infrastructure, public facilities and other functions would be a first step towards introducing planning skills to the municipality.

## B. Staff requirements and roles

The TS division in Bardo clearly needs additional staff if it is to develop into a body that can manage, plan, and deploy its resources. One of the main problems currently is that the principal engineer does not have enough staff and must devote his time to a number of activities, leaving little time for coordination. He is unable to adequately delegate tasks. One such case is the frequent site visits, which could feasibly be relegated to the assistant engineers. A relevant symptom is the road condition database that was started, but not completed or maintained, due to lack of time. Another chronic problem is that staff are not trained to be flexible, and a number of them have been trained exclusively for completing a single task.

As indicated in Chapter III, Bardo municipality can employ an additional six staff in the TS division under regulated quotas. The additional full time staff members should be as follows; a principal engineer or architect, a technical assistant, and a technical agent. The latter two job classifications fall within the mandated

[41] As previously explained, Bardo municipality's tax information system does not include any data except address, rates, and the assessed tax (see Appendix 4). Changes include new attributes and modifications to existing ones, but the modified system would not need to become as complicated as the system developed by the CNI.

shortfall while the first case is not accounted for in the legal ceilings and might need special authorization for employment. Their roles in system adoption are described in more detail below. An estimation of the total salaries for these three personnel is TD 5000 ($5900) based on 1990 figures (40 percent of the total TS salary budget for a one third increase in staff).

The role of the current principal engineer in a GIS implementation would be coordination, and assisting the staff in identification and provision of maps and data from other institutions. Such a person would also be responsible for the project schedule, and will be the only person involved with the system in the initial phase other than the three system users. These users are the new principal engineer, the new technical assistant, and an existing technical assistant.

In addition to the technical assistant, it is recommended to hire a technical agent, of which there are none currently employed, and not two technical assistants. This is suggested because there are currently three technical assistants and the hiring of an additional one would fill that category to its regulated quota. The person in this position will not have a role in the GIS application, but is intended to take up possible slack that will result from the incorporation of one of the current technical assistants into the initial phase.

## 1. Full Time

### a. Principal engineer

The proposed GIS is a modest one, not a complex system with many users within one department or a system networked across departments. For such a system, one staff person needs to be recruited as a GIS system manager. The qualifications of this person are crucial. Many lessons have been learned from cases in the U.S. where GIS implementation was done unilaterally by the information/data systems department rather than the planning or public works departments (the latter two being essentially the major users of the system). Among the lessons are that the main users find access difficult and time consuming and, more importantly, that computer specialists are less likely to appreciate issues of concern to planners and to design a system that will satisfy planning needs. In line with this, it should be remembered that the aim of this proposal is not to set up a data department, but to enhance municipal development through improved planning. Therefore, the recommendation is to hire a principal engineer or architect (the head of the division is also a principal engineer but will maintain seniority), and provide the necessary training. The responsibilities of this principal engineer would include supervising all modifications to existing data collection (except taxation), creation of new databases, managing the divisional computer, and coordinating surveys. This person would report to the head of the division.

**b. Technical assistant**

Technical assistants usually hold a post-school diploma in some field of construction. This additional person, plus one of the current technical assistants who would be relieved of his existing responsibilities, would be responsible for the actual data collection and entry. Data collection would range from conducting surveys, described in section C.1, to coordinating with relevant agencies for the timely delivery of maps and other material. Data entry, which would begin after the necessary training period, would include entering the results of surveys into simple spreadsheets (Lotus 123), and later on to the digitization of maps. An intermediate step would involve preparing maps acquired in advance of digitizing.[42]

## 2. Consultant

The use of an outside consultant is primarily needed in the initial phase. The

[42] Checking the maps for accuracy, updating where necessary, identifying possible problems, such as correspondence between street blocks and census blocks, misplaced streets, etc.

consultant would oversee overall implementation and coordination, and perform the following tasks:

a. Review computer training requirements. The consultant would determine the details of a training program which may be a combination of locally taught courses and custom-designed training.
b. Review local hardware costs in detail and recommend possible changes to the configuration proposed in this research.
c. Review the design of a municipal-wide field survey prior to its initialization.
d. Research availability of parcel maps and parcel-level information. If suitable, propose phased implementation of such material into the GIS.
e. Conduct evaluation at the end of the program and make further recommendations.

### 3. Training

Crucial to improving the role of the TS division in planning will not be specific GIS training but increasing basic skills and computer literacy. The pedagogic methodology of the training is to combine basic planning/ public management skills with computer skills. Five modules are envisaged, although this is dependent on the availability of adequate courses and workshops through local educational institutions. Participating in the training would be the principal engineer appointed as the system manager, the two technical assistants who will use the system, and the tax system manager. The modules should contain:

a. Broad hardware concepts such as processors, hard drive, disks, bytes, input, output;
b. Operating system principles, commands, formatting, storage, filing system, text editing, structured applications;
c. Divisional data requirements, surveying procedures and data collection,

data formatting, use of spreadsheets (Lotus 123 or Excel);

d. Data usage, flat files, relational files, data manipulation (dBase), basic programming, data transfer;

e. Map essentials, digitizing.

As for the GIS training, this will be developed pending the successful implementation of the initial phase of this proposal. Currently, the only indigenous capability in Tunisia is at the Regional Institute for Computer Science and Telecommunications (Institut Regional des Sciences de l'Informatique et des Telecommunications, IRSIT) which trains interns on ARC/INFO. This should not preclude the possibility of other consultants undertaking training on other GIS packages.

**C. Information issues and acquisition**

The plan for initial GIS implementation must address certain internal functions and their current weaknesses. Adoption of new standards is central, including standardization of certain procedures, both within the TS division and across the municipality. For the time being, it is impractical to attempt this across agencies at other levels of government.

**1. In-house**

In the second phase, one of the basic requirements of a GIS is geographic referencing or indexing. For a geographic reference, a unique identifier is needed that links an entity to a specific geographic reference (for example, a unique land parcel number that allows us to link data for that parcel to a specific two-dimensional polygon with known boundary coordinates). Another example is from the TIGER files from the U.S. Census, which provide a link between street addresses and their approximate latitude and longitude. Here the link is to a point in space rather than to a polygon. In fact, geographic referencing is necessary for the early stages of the program, but a GIS would require a more rigorous execution. In the case of Bardo, street addressing is the most convenient form for two reasons. First, most of the municipal functions currently use a street address as identification. Second, there is no other available index such as unique parcel numbers. Data collection, formatting, and storage in the first phase should be done with the anticipated needs of a future GIS in mind. One immediate product of future data collection is establishing what the aggregate situation is with respect to various entities for planning of land use and infrastructure. In other words, what is the total length and area of paved roads, parcels, streets, lighting fixtures, etc.

**a. Survey**

A survey would have to be carried out for all of the city. Such a survey would best be carried out by municipal staff. Although work loads and budget priorities may favor subcontracting this, the municipal staff's closer accountability and knowledge of the area make them the first choice. The data to be collected is elaborated in the following paragraphs. All items recorded pertaining to parcels require a street address. Where an address or street name is ambiguous or missing, each case will have to be investigated using construction permits, parcel deeds, and other means, and on-site correction will have to follow.

**b. Land use**

Land use will first be determined using secondary information such as existing maps and other information from the relevant government agencies. For example, the Ministry of Education will definitely have records of public schools, while the Ministry of Health similarly must have lists of infirmaries, dispensaries, and hospitals. First-hand information from the survey will verify both the address and location (on a map) of all relevant entities: educational, health, religious, industrial, educational, athletic, governmental, security, firehouses, parastatal (STEG, SONEDE, ONAS), commercial, illegal land use, parks, tourist, and public spaces.

**c. Roads**

The road survey previously undertaken by the municipality can serve as an adequate base. The fields to be identified are: type and state of road surface, date of last maintenance, width, odd and even sidewalks, presence of road name signs, even starting address, odd starting address, even ending address, odd ending address, presence of infrastructure such as storm drainage, electricity, gas, telephone, sewerage, and drinking water lines. The length can be measured from existing maps, from which the areas of road surface and sidewalk can be calculated. The unit is not the whole road but rather each road segment determined by intersections.

**d. Public lighting**

The survey can identify the number of all lamp posts, in addition to any malfunctioning lamps. It should identify the distribution of lamp posts by street segments but not necessarily their exact location along a street segment. The results should be matched to maintenance records, if such records exist.

**e. Municipal property**

Municipal documents need to be studied to find records of all municipal land and building properties. These properties should be entered in a single file and noted on a separate map, as well as being included on the land use map.

**f. Subdivisions**

All subdivisions that have not been completed and sold need to be delineated on a map showing their legal and construction status. In addition, unbuilt road and utility infrastructure should be indicated to help ensure its construction since each case may have different parties responsible for its execution.

**g. Property tax**

The existing system needs to be modified, both in terms of existing attributes and others to be added. The current form of parcel number, as previously explained in Chapter III. C., is inadequate since it is not necessarily a unique number.

Therefore, a numbering system such as that used by the CNI (which includes the block number and a parcel number) should be adopted. The address field needs to be split such that the street name is separate from the street number, and an additional field containing the code number for the street should be introduced. New attributes to be included are type of construction, type of occupation, and usage.

**h. Budget**

All investment and current expenses in the municipal budget that are spatially fixed should have a geographic identifier, preferably the block or block-parcel number. This item is of lesser importance but can nevertheless be useful in establishing a basis (for a GIS) on which to make resource allocation decisions.

**2. Contracted**

In the initial phases, the main item to be contracted out is map printing. In the later stages, if the TS staff are unable to perform some of the computer data manipulation necessary for the INS census or property tax data, then these very specific tasks could also be contracted out. This will not occur more than once a year in the case of the tax data and less frequently for census data. As for parcel maps that have been prepared on occasion for certain municipalities, presumably the DGCPL is mandated to prepare or acquire such maps, chiefly through the OTC. As such, the municipality could request the maps through the 'District' on a periodic basis.

**3. From other institutions**

In cases where an agency implementing a GIS has an ongoing exchange (possibly one-way) of information/maps, the issue of how the new system will relate existing information flows is important. However, it was noted that in the case of Bardo the only map acquisition is currently from the 'District'. The municipality also does not currently acquire or use census data from the INS. Based on the field work in this study, there seems to be little data exchange even within the municipality. For example, the TS division does not use the tax data collected by the municipal tax office.

A number of maps could be obtained from the local offices of the parastatal agencies including SONEDE, STEG, and ONAS. Arrangements for maintenance would be necessary to ensure that updated maps would be automatically provided. However, there seems to be ambiguity as to the obligations of such agencies. Central government and 'District' officials expressed their opinion that municipalities could not acquire maps, and this was corroborated by municipal staff in Bardo. However, when maps were requested from SONEDE and STEG for the purposes of this study, they were only issued to the author after a request from the municipality was issued to that effect. Furthermore, the maps were required to be handed over to a municipal employee, and not to the author. The ironical aspect is that the municipality then proceeded to make copies of these maps, but did not consider that they, in fact, had the capacity to obtain additional maps in the future.

## D. Technical configuration

This study will not compare different software/hardware requirements in depth. Instead issues of software and hardware will be spelled out, and several software packages and hardware configurations options will be described.

As Brail points out, hardware and software choices are interdependent. He goes on to say that:

> "there are four issues which the planner and manager will face in hardware and software selection:
> a. The rapid evolution of microtechnology;
> b. the availability of "off-the-shelf" software;
> c. the viability and costs of custom-designed software;

d. the selection of a particular package for a task."[43]

For the purposes of this study, the third point (custom-designed software) is not considered since it is an unlikely option in Tunisia, and the second and fourth points will be taken together.

## 1. State of technology

An examination of the state of technology is well taken across all computer application choices, and even more so in a developing country context. Evaluation of the technology should be based on three points: 1) its position in the technology race; 2) its ability to incorporate or work alongside existing systems; and 3) its track record. Whether the system is 'state of the art' or not is more crucial in developing countries given greater maintenance and support needs. Thus a system that is still new (such as the 80386 processor machines), but that has already proven itself in developed countries, is an acceptable choice in Tunisia given its current capacity to make use of software on 8086 (XT) and 80286 (AT) machines. The fact that the majority of the public sector in Tunisia has already selected IBM compatible systems or minicomputers makes it more difficult to recommend using Apple systems. In addition, the Apple-based GIS software does not, to date, have a strong market position in either GIS or advanced database management.

## 2. Hardware

Given the need for minimum maintenance and the existing low computer literacy among Bardo municipal staff, the initial proposal is to have the system on a stand-alone machine and to avoid more complex networking. Having a single machine also simplifies maintenance and updating of the database, since everything is handled in one place. System recommendations are for an AT class IBM compatible

[43] Brail, Microcomputers, 40.

or above (386SX or 386 processor). This is in line with the existing machines used in the municipality (AT's), and with that used for the prototype in this study. Preference is for 80386 class machines. The price differential between 80386 machines and the 80286 or 80386SX class is not sufficiently large. The 80286 machines are, on the average, $1000 cheaper than the 80386 ones, but they are being phased out. There is a 10 percent difference in cost with the 80386SX class, but these have the disadvantage of a very specific architecture. Furthermore, the future releases of GIS software are likely to have more requirements than can be met by the 80286 class machines. A 100 Mb hard drive is advisable to allow for all initial coverages as well as some of the GIS functions that need free space for temporary storage. An average estimate for such a machine in 1991 is $3000. See Appendix 5 for current computer price ranges.

A digitizing tablet (such as the Summagraphics SummaSketch 12x18) currently costing around $600 is required to edit coverages that have been digitized outside the municipality. A small plotter, costing around $1000, comparable to the IBM 7372 Color Plotter is sufficient to produce maps for reports. In addition, a regular printer priced at $300 would be needed for routine printouts. These items, in addition to a power supply protector, should cost around $2500, bringing total hardware cost to $5500.

For large-sized map sheets, digitizing requires a large digitizer table (the one used for the prototype was a Summagraphics MICROGRID 36x48) costing between $3-4000. A large plotter can range between $5-15000, depending on specifications. Such equipment is too expensive for the municipality to procure. However, the 'District', given its mandated role in regional planning, might provide a solution, especially since it already has substantial computer equipment (namely a digitizing table and AutoCAD). In a sense, such a move is simply automating the current situation where the 'District' already prepares a large number of maps for municipalities. An alternative is to subcontract digitizing and/or map printing to the private sector. In this case the IRSIT, which has a large plotter, is one likely choice.

## 3. Availability and selection criteria for GIS software

It would be safe to say that GIS software is by and large unavailable in Tunisia. Availability is used here in the broader sense - having a local or regional support facility, toll-free help line, user-groups, etc. However, one package, ARC/INFO, does stand out for three reasons: 1) ESRI (the mother company) has been marketing quite aggressively in developing countries, and they have a regional office in Cyprus; 2) there is at least one ARC/INFO system up and running in Tunisia;[44] and 3) IRSIT has been training interns on ARC/INFO. Although a specific software recommendation will not be made here, it is useful to present a summary of rules proposed by Brail:[45]

> First, the chosen package should be guaranteed to work on current or future configurations. Second, the general reputation of the product should be obtained from other users, sellers, and literature reviews. Third, not only should the package have sufficient capacity, but it should also have appropriate features for efficient operation. Fourth, attention should be paid to the interaction with other programs. Fifth, the package should have a low cost-effectiveness ratio.[46]

Given the recommendation to gradually introduce computer skills into the TS division, it is recommended that ATLAS*DRAW be the starting graphics package rather than AutoCAD. There are three reasons: 1) the former package is a very simple package; 2) it costs substantially less than AutoCAD; and 3) drawings can be

[44] The IRSIT is a well equipped parastatal institute that is developing skills in many fields. In addition to ARC/INFO, they have GRASS and image treatment software.

[45] Brail, Microcomputers, 43-5.

[46] Appendix 1 describes a number of GIS packages.

transferred to ATLAS*GRAPHICS, a low cost thematic mapper, and from there to ATLAS*GIS or to ARC/INFO. This sequencing would be a low-cost way in which procurement could be gauged to the municipality's and staff's performance and motivation. One alternative would be to use ARC/INFO instead of ATLAS*GIS; this would depend on the evaluation at the end of the initial phase.

ARC/INFO, the leading software in sales worldwide, is a high end package with several advantages, in addition to those mentioned in the previous section. There may be need to link up a municipal-based GIS with a regional or centrally based system. In such a case, ARC/INFO would be a good choice for the implementing agency (such as the 'District') where presumably there would be more complex requirements (compared to municipal requirements). ARC/INFO comes in modules[47] and although it is not as user-friendly as other GIS's on the market (especially the Macintosh-based systems), Bardo could pace its acquisition of modules as its staff builds up proficiency, while the 'District' could acquire the complete set of modules.[48]

In addition to GIS software, additional packages are useful for data entry and processing. These supporting packages currently cost approximately $2350. These include Lotus 123 ($400) for data manipulation and supporting analysis, dBase ($500) for similar functions (and for manipulation of the tax data which is currently running on dBase), a text editor such as Emacs ($100), a programming language such as Pascal ($100), ATLAS*DRAW to digitize maps ($750), and ATLAS*GRAPHICS as a thematic mapper ($500). As mentioned, GIS software acquisition would follow a

[47] One of those modules, ARC/EDIT, could be used for digitizing maps but this is not advised as it is cumbersome and not user friendly.

[48] For the purposes of the pilot study, digitization was done using ATLAS*DRAW, after which coverages were translated to ARC/INFO.

program evaluation, and would be based on phased decisions about implementation of a full GIS. This second phase would take place between one to two years after starting the first, at which point a specific choice of GIS software would be made. Since the technology is changing rapidly, any detailed evaluation completed now would need to be redone in two years. However, it is useful to note current costs in 1991: Arc/Info is for $9000, GEO/SQL for $9500, while ATLAS*GIS costs $3000 (with possibly an extra $750 for a hardware key).

## E. System layers

The inherent strength of a GIS is in its capacity to overlay different layers of information where using manual means would be too time consuming. Identification of the attributes and structure (geographic referencing) of layers is crucial and must be forward-thinking so that future analysis and manipulation is possible. Given Bardo's current and predicted planning needs, the following layers are recommended.

These recommendations are based on the prototype discussed in Appendix 6. Prototypes are useful because they are a proof of concept, and because they test and verify recommendations especially in terms of the layer specifications (source material, scale, attributes, aggregation, coordinates, geographic referencing) and technical configuration (hardware and software).

### 1. Base

This layer, as the name suggests, will act as a base for other layers that hold specific information. It will consist of blocks, where the limits are defined by groups of parcels. The space separating blocks will be the streets, including pavements and undefined areas. The source to be used is the SONEDE base maps at 1:2000, which in certain cases will need field as well as office verification where undelineated vacant land adjoins a street. Currently, the only block numbering system is that used in the census. In addition, the tax office should adopt a block numbering system. For conformance and usefulness, it is recommended that the TS division and the tax office adopt the census block numbering system.

**2. Block**

This layer will be created from the base layer but will contain more attribute data fields, depending on the existence and availability of census data from the INS. Since the units of analysis of the census are both individual dwellings and households, data first will have to be aggregated to the block level. There are several ways this aggregation could be done. These range from manually summing the various data groups into blocks using a calculator, to using a Structured Query Language (SQL) database management system. A middle solution is the use of a combination of text editors (eg. EMACS) and some custom-written program (eg. Pascal). Some attribute fields for the layer are: zoning category (the categories will be modified to allow for multiple zoning within a single block), 1984 census data (code, lodging type, wall type, roof type, date of construction, sewerage type, number of rooms, unit occupancy, number of people in unit, household type, water source, energy source, kitchen, heating source, wc type, bathroom type, number of rooms per household, household occupancy, agricultural land usage, births by sex, deaths by sex, handicapped, illiteracy level, educational level, unemployment level). The description of the prototype in Appendix 6 elaborates on the fields and how they may be aggregated.

**3. Streets**

This coverage will be based on the TIGER files (US Bureau of Census). TIGER stands for Topologically Integrated Geographic Encoding and Referencing; the files are perceived as a geographic support system for census-taking purposes. The data structure includes information about tracts, blocks, street names, address ranges, and zipcodes.[49] The advantages of creating an address-based street coverage, in addition to blocks, is that all the pertinent applications identified so far have a street address as the primary identifier, and given that address ranges are attributes, approximate spatial location becomes possible. Ideally, a coverage indicating the limits of parcels and holding attribute data concerning title number, land use, utility connections, and tax data would serve property taxation as well as land use and infrastructure planning. However, in the absence of such parcel data, TIGER-type files provide an alternative to a full parcel-based layer.

In the TIGER data structure, street segments are arcs, not polygons, and it is suggested here that Bardo could duplicate this format. Creating an additional coverage where streets are polygons has the main advantage of treating streets as a two-dimensional space where various activities take place. This would be useful if the intention was to show exact locations of pavement and various utility lines, providing a tool to coordinate public works. However, even assuming regular flows of information from the parastatals to the municipality, the map sources are at a scale (1:1000 to 1:2000) which does not provide sufficient accuracy for tasks requiring engineering accuracy. The 1:2000 SONEDE maps, recommended for use in the base map, do not clearly outline the street limits versus open land (unbuilt plots). Though this limitation does not seriously affect the TS division's anticipated usage of a base map (especially if field surveys can make limited corrections), the accuracy of these maps is not sufficient for infrastructure applications. Digitizing the street layer in arcs has additional advantages. One advantage comes from the task of digitizing, which will be easier given the fact that two intersecting arcs create a point (which can be

[49] For further reference on TIGER files, see: Donald F. Cooke and Stuart Levasseur, "TIGER/3193," URISA Journal 2, 1 (Spring 1990): 74-9 or Bureau of the Census, TIGER/Line PreCensus Files, 1990, Technical Documentation (Washington, DC: 1989).

disregarded), whereas two intersecting polygons will create a third polygon that can have one of two street names. Also, this coverage can serve as a base for the approximate location of public utilities. Finally, if in the future a centralized GIS[50] is set up, most likely the scale of the task will require streets to be in arcs and not polygons.

An arc-based street network is a network structure. Such structures have several useful applications, such as address matching, pin mapping, and network analysis. For example, given both an odd and even address range on a particular segment, that segment can be allocated the corresponding number of individual addresses on either side. As for network analysis, which has obvious applications for the utility layers, this includes calculating the shortest path between two points and can take into account one-way flows, restrictions at certain nodes, and friction factors, among others.

This layer is a multi-purpose one in that it is not restricted to road maintenance, but allows for data for other functions. In addition, a street network defines the geography of the city and influences the structure of the functions that occur there. The main fields are: street code, address from even, address from odd, address to even, address to odd, pavement odd, pavement even, surface, condition, garbage zone, presence of utilities (water, sewerage, gas, electricity) and public lighting.

A correspondence table between street names and street codes, which the tax office has developed but not yet implemented, seems adequate. Street codes will be

[50] This is in line with Billot's study Systemes d'Information in which a metropolitan GIS would be coordinated by the General Office of Urbanism and Land Management (Direction Generale de l'Amenagement du Territoire et de l'Urbanisme, DGATU).

used instead of street names in this and succeeding layers. The INS zoning map made by the 'District de Tunis' would be used to determine street names. A site survey would be used to fill the gaps and to determine certain field entries that are not available in the municipality.

**4. Public lighting**

This public utility was given over to municipalities in 1986 and is sizeable in terms of costs and management burden. Expenditures from 1985-90 for Bardo were TD 217,054 (around $250,000); the number of poles is approximately 2600. Bardo municipality did not receive maps of the existing network, and has not attempted to produce any. This layer is also based on street segments (i.e., a copy of the Streets layer). Attributes include number of poles per segment, address attributes, date of last maintenance, number of poles requiring maintenance, street code, range of pole number (assuming each pole is numbered).

**5. Water, sewerage, and electricity**

These coverages are definitely optional given the complete lack of municipal responsibility for these areas. However, if the municipality considers that additional information (compared to that present in the Streets layer) would be of use, then it might consider using the Streets layer as a base. After necessary modifications,[51] the coverage would be used in the ARCNET[52] module where nodes, valves, pressure, and flow directions could be added. The Streets layer should indicate the basic utilities, whereas these layers would include more detailed information. Ultimately a decision could be made to produce engineering maps that precisely

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[51] In the streets layer, street segments are the basic unit. However, a utility line may have attribute changes anywhere along a segment and thus the unit of analysis will be each segment as determined by the attributes of each utility. This is known as the 'dynamic segmentation' problem.

[52] This is a network analysis package that is one of the modules in the ARC/INFO package.

position the various utilities.

## 6. Parcel

Similarly, it is not clear whether this coverage should be undertaken, particularly in the initial phase. Further research is required to determine the presence and consistency of necessary maps and information, especially at the OTC which is theoretically the depository for such maps. Limited searches conducted for this study failed to find any except one partial map of Bardo dating from the 1950's. One possible source is the SONEDE, since their base maps do indicate parcels in certain cases. The decision of whether to attempt a complete registration of parcels (that would necessitate combining all sources and primary surveys and/or air photos) depends on the availability of parcel boundary information. Other parcel data could come from the tax roles although the data is limited (see Appendix 4 for details). The INS census data, though it is at the household level, only has a block identifier and thus cannot be used in this layer.

# CHAPTER V
# CONCLUSIONS

## A. Overview

The recommendations presented in Chapter IV for GIS implementation in Bardo address the secondary questions identified in Chapter I: 1) What institutional restructuring is required? 2) What are the relevant maps, databases, and informational procedures and how must they be reinterpreted? 3) What are the technical considerations for computer hardware and software configurations?

### 1. Institutional considerations

Essentially, the heart of the institutional problems for GIS implementation in Bardo are current staff capabilities. The factors most relevant to current staff weakness are a result of institutional constraints. First, the attractiveness of the central government and private sector relative to the municipal sector discourages high-level staff acquisition and retention. This is an externality that cannot be dealt with in the specific context of GIS implementation, but an issue that needs fundamental and centralized policy changes. Second, nationally imposed staff ceilings also impose an institutional constraint. If the central government seriously adopted a policy of municipal development, this limitation could be redressed with the approval of the Ministry of Interior.

At another level, the municipalities' lack of revenue generating capacity adds further to its dependence on the central government. Lack of resources affects the level of services detrimentally and adds a fiscal dimension to the above-mentioned problem of unattractiveness of municipal employment. Except for areas where tourism is an important tax base, municipalities rely to a large extent on central government grants while their main revenue raising capability is through the property tax. Thus any municipal development policies that include fiscal decentralization must address property taxation.

## 2. Informational considerations

Databases and maps are in short supply in most municipalities, leading to lower levels of service and inefficient management of public services, and limiting the public's access to information and consequently, their control and participation in local planning issues. This information shortage also constrains the municipalities' coordination with parastatal agencies responsible for provision of utilities and infrastructure (SONEDE, STEG, ONAS...). There are currently two serious institutional constraints on data and map acquisition. The first is a corollary of the more general constraint of having staff assigned to specific responsibilities (in addition to the limits on the number of staff and the legal ceilings on municipal staff). Unless the balance between skilled and non-skilled workers is redressed, the situation cannot be changed, short of reverting to relegating the GIS project to a private consultant or, more applicable, a regional or national governmental agency. The second is the absence of data sharing between the municipalities on the one hand, and the parastatal agencies on the other. For the most part, these agencies continue to regard their maps for internal use only, and in extreme cases as 'sensitive documents'. Whether such misgivings are justified is besides the point; municipalities continue to suffer from their denied access to these maps.

## 3. Technical considerations

There seem to be no serious institutional constraints in terms of municipal hardware/software acquisition (beyond financial, of course). This is most likely due to the fact that the cost of microcomputers are currently much less than other equipment typically procured by a municipality (such as vehicles which fall under the same budgetary category) and hence make any guidelines drawn by the CNI harder to enforce. Given that the CNI's framework and agenda is more geared to Management Information Systems (MIS) than to flexible computing environments that serve municipalities' planning and management needs, the ability of municipalities to bypass the CNI is not without its advantages, if not actually pointing in the right direction as far as the role of computers in municipal development goes.

Potential hardware and software problems will actually come from where these components are acquired: the private sector. There is a need to assure maintenance for all hardware and peripheral equipment from the vendors since staff are typically not capable of taking on such responsibilities. This is true in the U.S. and even more so in Tunisia and the developing world in general. As for software, maintenance is not at issue, but rather 'user support'. This term refers to the possibility of a user getting help from software companies for problems relating to that software, questions concerning the compatibility with other packages, and ensuring access to newer versions.

## B. National policies/goals

The main question posed in this thesis was: How viable is a GIS in a developing country municipal setting and how might it support municipal development? In addressing this question, the assessment of the municipal context in Tunisia brought to light several discrete but interrelated goals that a municipal GIS could address:

a. Decentralize specific planning activities such as land use planning, resource distribution and allocation to municipalities in order to increase mandated decision-making and planning capacities (for example, making local decisions about locating various public facilities based on population distribution or tax revenue);

b. Systematize information that is currently lost or not easily obtainable to improve citizens' access to information and generally add to municipal organization and decision-making capacity;
c. Study spatial relationships between expenditures and tax revenues to ensure fair distribution and increase revenues, assure land use and zoning law compliance for permits and subdivisions to ensure the municipality's performance of responsibilities, and implement procedures that allow for greater control of municipal property which should prevent possible loss or mismanagement of such property;
d. Increase map acquisition capabilities by implementing procedures that allow for acquisition of infrastructure data/maps so that TS divisions may coordinate and supervise public works, and establish map creation capabilities for enhanced organization and decision-making.

Municipal development is an objective that may be reached along a number of dimensions, and the recommendations offered here go a certain distance in attaining that objective. However, a number of issues must be addressed at the central government level if Geographic Information Systems are to be successfully replicated to aid municipal development for medium to large urban agglomerations. Of paramount importance is that the central government, mainly both the ministries of Interior and Planning and Regional Development, be sincere in adopting a municipal development project which would include comprehensive institutional restructuring. The implicit relinquishing of power that would result from reforms would be at the forefront of any central government misgivings.

The two most crucial areas of restructuring necessary for sustainable GIS implementation are human resources and revenues. As previously explained, the rigid determinants of municipal staff structure and hiring must be reinterpreted, at the same time taking into account tenure and salaries. With a decentralization of power, there needs to be a corresponding shift of career perceptions in the civil service. Municipal finance must also be redefined. Although this study does not venture into issues of central versus local forms of finance, it is clear that decentralization would necessitate increasing the local authorities mandate for revenue raising. However, the need would remain for the central government to transfer grants where such funds originated from local levies. In addition, a review of property taxation in terms of assessment, rates, and base is necessary if municipalities are to be equitable in their tax levying. This levying is currently fraught with variations among municipalities due to lack of clarity and incompatibility with market conditions.

## C. Future research

Two issues follow from the discussion in the above section concerning national policies necessary for GIS implementation in Tunisia. First is the issue of coordination among the various municipalities and agencies. Second is the issue of a regional GIS and how this might best be implemented and coordinated. This is an area that is relevant in Tunisia, both because it poses as a beneficial background for further work on municipal-based GIS, and also because several agencies that operate at the national and regional levels have begun to investigate and implement databases, mapping tools, and GIS.[53]

Concerning municipal GIS for Greater Tunis, the 'District' is suggested as a coordinating body given its mandated role in planning. A possible obstacle is that the 'District' may not be inclined to take on such a role and/or to adopt GIS. This may

[53] The STEG have set up network databases and, along with ONAS, are investigating mapping facilities. The DGATU have studied GIS at three levels of government, while the National Agency for the Protection of the Environment (Agence Nationale pour la Protection de l'Environment, ANPE) seeks to acquire both GIS and satellite imagery packages.

be due to budgetary considerations, to lack of political support (it is part of the Ministry of the Interior which may have other priorities), or to internal lack of support (especially at a time when the future of the 'District' appears unclear). If, at a more general level, the central government formulates a policy on GIS, then the rationale would be for all municipalities to adopt the same hardware/ software configuration. This was attempted for the tax computerization efforts and failed, and it is not clear that in this case standardization would fare any better. If this parallel were to repeat itself, then municipalities may again reject standards for certain tasks. The IRSIT is a prime likely private contractor for the municipalities. In fact, the IRSIT is already a GIS consultant to the city of Sousse and negotiating such an arrangement with the capital, Tunis. There are precedents where municipalities contract various studies, including their PAU, to private consultants and not to the 'District'. Billot's study proposes the DGATU to be a coordinator for national and, more relevant here, regional GIS's. However, the current institutional context does not fully justify such a recommendation since no mention is made of the DGCPL. The former is responsible for urban management, the latter is responsible for urban development, and the distinctions are not clear. It is far from obvious that the former should lead the GIS initiatives as suggested by Billot. Added to that is the fact that DGCPL has more authority over municipalities than DGATU.

## D. Summary

Tunisian municipalities suffer from a number of constraints to GIS implementation that are mainly institutional in nature. The analysis of the case of Bardo in Tunis revealed that these constraints are, in the context of a comprehensive program of municipal development, sufficiently changeable to allow successful implementation of a GIS. These can be summarized as follows:

Additional new staff in the TS division, accompanied by procedural changes and staff training in the area of data and map compilation, would provide the requisite staff capabilities for GIS. The introduction of planning and managerial procedures, more versatile staff, and data and maps pertaining to municipal territory and resources would eventually enable increased coordination with other agencies, increased revenue-raising capacity, reduction in certain operating expenses, and potential improvements in the public's access to information.

In addition, these recommendations are likely to be equally applicable to most medium to large size urban agglomerations in Tunisia, thus presenting a model by which other municipalities may, through a series of phased steps, effectively develop their resources and skills.

## Appendix 1. GIS Software Notes *

This list is not exhaustive by any means, but concentrates on packages that operate on IBM-compatible hardware plus some examples of Macintosh-based systems.

AMIS, UK. Data storage is raster and vector; geometry is a geographically indexed database. Hardware configuration: IBM-AT & compatible, MS-DOS.
Comments: Axis mapping information system is a customizable GIS handling raster and vector mapping. The integrated full function database is geographically indexed for fast response times. Related software includes surface modelling.

ARC/INFO, USA. Data storage is raster and vector; geometry is topological vector; attributes in relational (INFO) or interface to RDBMS. Hardware configuration: IBM-AT & compatible, MS-DOS.
Comments: A general purpose GIS of modular construction. In addition to the main system , modules are available for terrain analysis, network analysis, coordinate geometry input, and raster display and editing.

Atlas*GIS, USA. Data storage is vector; geometry is topological; attributes in an internal (spreadsheet format). Hardware configuration: IBM-AT, MS-DOS.
Comments: A menu driven package with 6 modules for mapping and spatial analysis. Capabilities include digitizing, map editing, polygon operations and map projection, can import data using DIF and ASCII formats. Wide range of map annotation and plotting options supported.

DOGS Mapping, UK. Data storage is raster and vector. Geometry is hierarchial vector; attributes are hierarchial/relational (Oracle or ADABAS). Hardware configuration: IBM PC & compatible, MS-DOS.
Comments: Pafec's design office graphics system (DOGS) is a CAD system for digital mapping and includes an IGES interface. DOGS mapping provides a GIS which can hold both raster and vector images over a continuous map base. Auto conversion of OS NTF data and linked to MOSS.

ERDAS, USA. Data storage is raster. Geometry is raster coded; attributes are internal (interface with dBase III). Hardware configuration: IBM compatible, MS-DOS.
Comments: A modular image processing system with GIS capabilities. Facilities include digitizing, raster map operations, terrain analysis, and wide plotter support. Can import Landsat TM, MSS and SPOT data directly and supports various formats including ASCII.

GIMMS, USA. Data storage is vector. Hardware configuration: ATARI ST, IBM PS/2, Macintosh, various operating systems.
Comments: GIS and high quality mapping software. Has capabilities for good choropleth and point symbol mapping, including histograms , bar charts, etc.

INFOMAP, UK. Data storage is raster. Geometry is non-topological and run length encoded; attributes are managed internally. Hardware configuration: IBM-XT/AT or PS/2, MS-DOS.
Comments: A PC-based mapping system for the display and analysis of spatially related data. Facilities include: library management, facility for editing and map retrieval. Spatial analysis for regression, cluster and distance functions of map attributes. Health/police authorities are the main users.

Map manager, UK. Data storage is vector. Geometry is topological (?); attributes are external. Hardware configuration: IBM compatible, MS-DOS.
Comments: An integrated set of micro-based mapping programs. Capabilities include digitizing, display of area and point data and the interface with other cartographic software.

Map 2, Canada. Data storage is raster. Geometry is by raster coding; attributes in an external (flat files). Hardware configuration: Macintosh, MAC-OS.
Comments: A micro based GIS with full map analysis functions. Multiple maps can be open at once and displayed at various resolutions. Import of data via ASCII, TIFF and SYLK formats, and can also read in SPOT and Landsat images.

Mastermap, UK. Data storage is vector. Geometry is non-topological vector; attributes are handled externally. Hardware configuration: IBM PC or compatible, MS-DOS
Comments: A PC-based system which utilizes the Autocad software.

NORSK data, UK. Data storage is vector. Geometry is topological; attributes are relational (Oracle, Sybase). Hardware configuration: IBM PC, MS-DOS.
Comments: NORSK data mapping is a vector based system for map production, surveying, thematic mapping and utility management. The system can read in OSTF and NTF format. Surface modelling and network analysis modules are also available.

SPANS, USA. Data storage is raster. Geometry is quadtree; attributes through links to external databases. Hardware configuration: IBM PC and compatible, MS-DOS.
Comments: Tydac's spatial analysis system is a PC-based menu-driven mapping system. The system allows complex data modelling and the conversion and editing of vector data. Tydac technology also markets the Geovision software.

SPSS/PC mapping, UK. Data storage is vector. Geometry is non topological (boundary files); attributes in external flat files. Hardware configuration: IBM XT/AT or PS/2 and compatible, MS-DOS.
Comments: A PC based system for mapping statistics: a module of the SPSS statistics package.

* Source: GIS Trade Directory, release 1.0 12/88. Compiled by Nick Green and Jonathan Raper, Department of Geography, Birkbeck College, UK.

## Appendix 2. Bardo Municipality Budget* Summary, 1990

| | | Total: 2,871,222 |
|---|---|---|
| **Current Receipts** | | **1,802,000** |
| I. Direct and assimilated taxes | | 530,000 |
| Assimilated and rental taxes | 460,000 | |
| Duty on non-built lots | 15,000 | |
| Taxes on industrial, commercial lots | 55,000 | |
| II. Indirect taxes | | 75,000 |
| Electricity surtax | 50,300 | |
| Right of way | 17,000 | |
| Slaughterhouse tax | 5,000 | |
| Tannery tax | 1,000 | |
| Street vendors tax | 400 | |
| Non-farmed products | 1,300 | |
| III. Central government transfer | | 1,050,000 |
| IV. Returns from assets | | 74,000 |
| Building rentals | 12,000 | |
| Sale of improved buildings | 10,000 | |
| Public way concessions | 8,000 | |
| Building sales | 27,000 | |
| Other | 17,000 | |
| V. Receipts from mitigating services rendered | | 70,000 |
| Reimbursements from repairs to roads | 15,000 | |
| Administrative fees | 5,000 | |
| Kindergarten fees | 22,000 | |
| Animal pound revenues | 12,000 | |
| Other | 16,000 | |
| VI. Accidental and diverse receipts | | 3,000 |
| Sanitary contraventions | 3,000 | |
| **Current Expenses** | | **1,802,000** |
| I. Representative indemnities | | 3,245 |
| II. Interest from local debt | | 45,238 |
| III. Departmental resources | | 1,102,261 |
| Salaries and benefits | 630,861 | |
| Equipment and administrative costs | 392,800 | |

| | | | |
|---|---|---|---|
| Infrastructure maintenance | | 78,600 | |
| IV. Local public interventions | | | 217,576 |
| Interventions in economic domain | | 2,000 | |
| Cultural and social domains | | 205,020 | |
| Direct interventions | 37,370 | | |
| Indirect interventions | 167,650 | | |
| Inter-communal cooperation | | 10,556 | |
| V. Diverse and unforeseen expenses | | | 433,680 |
| **Capital Receipts** | | | **1,069,222** |
| I. Contribution from current expenses | | | 425,000 |
| II. Previous deductions from reserves | | | 643,936 |
| **Capital Expenses** | | | **1,069,222** |
| I. Direct investment | | | 985,647 |
| Street paving | | 330,767 | |
| Sports buildings | | 255,129 | |
| Public cleaning | | 105,884 | |
| Vehicle procurement | | 80,800 | |
| Pavement | | 51,897 | |
| Cleanliness campaign | | 37,195 | |
| Public lighting | | 32,022 | |
| Green spaces | | 30,426 | |
| Building acquisition | | 22,437 | |
| Expropriation | | 18,238 | |
| Residential zone improvement | | 17,358 | |
| Other | | 3,489 | |
| II. Amortization of debt principal | | | 83,289 |

* All values in Tunisian Dinars.

## Appendix 3. Bardo Municipality Staff

| | |
|---|---|
| **Administration** | **25** |
| Secretary General | 1 |
| Administration Head | 1 |
| Administrative Secretary | 1 |
| Administrative staff | 8 |
| Managerial Secretary | 1 |
| Typists | 3 |
| General staff | 3 |
| Kindergarten teachers | 7 |
| **Health** | **2** |
| **Technical Services** | **9** |
| Works Engineer | 1 |
| Assistant Engineers | 2 |
| Technical Assistants | 3 |
| Regulation Inspectors | 3 |
| **Workers** | **188** |
| Drivers, Cleaning, Construction, Welding, Carpentry, Electrical | |
| **Total** | **224** |

In the case of Bardo, the law limits the staff as follows:

| | |
|---|---|
| Administrative | 29 |
| Technical Services | 15 |
| Engineer | 1 |
| Assistant engineer | 2 |
| Technical assistants | 4 |
| Technical agent | 3 |
| Special | 1 |
| Regulation inspector | 4 |
| Workers | 296 |
| **Total** | **340** |

## Appendix 4. Tax Forms Components

CNI Tax Form

| | |
|---|---|
| Area of lot | Water |
| # of sides | Electricity |
| Built-up area | Gas |
| Habitable area | Sewerage |
| | Parking |
| Lot owner code | Asphalted street |
| Lot owner name | Public lighting |
| Lot value | Pavement |
| | |
| Unit owner code | # of rooms |
| Unit owner name | # of windows |
| | # of balconies |
| Declared unit value | # of bathrooms |
| Estimated unit value | # of floors |
| Approved unit value | Garage |
| | Telephone |

Type of construction (villa, apartment, house, low income unit, other)
Construction date
Type of occupation (owner, renter, free, vacant, ruins)
Usage (residential simple and multiple, office, school, health, mosque, industry, other)

Taxee type (owner, mandatory, communal, commercial, diplomatic, public)
Taxee (identifier, name, address, role #)
Renters name
Rent

1990 Bardo Tax Form

| | |
|---|---|
| Rental value | Form number |
| Tax rate | Previous form number |
| National Housing Fund rate | Name |
| Back taxes (1985-89) | Address |

## Appendix 5. Hardware Cost Estimates.

Three system architectures are reviewed: the 80286 (or AT), the 80386SX, and the 80386 processor. Several brand names are compared, except IBM (although all models are IBM-compatible). The prices are for the US market, are taken from the makers advertisements and not dealerships, and in most cases include maintenance and guarantees.

80286 machines
**Range: $1000 - $ 2000**
Prices can go as low as $1200 for a 20Mhz 40Mb (monochromatic). At the top end of the scale, an upgrade to 70Mb (color) would come to $1800.

80386SX machines
**Range: $1100 - $3400**
This market is quite competitive and are there many brand names coming on the market right now. The low end has a 40Mb (monochromatic) for $1300 while a 25Mhz 100Mb (color) comes to $3100.

80386 machines
**Range: $1600 - $3500**
This category is to be the standard for the next few years the way the AT machines were during the last five years. There are several models that are impressive and not too expensive such as a 20Mhz 71Mb (color) for $2300, or even a 25Mhz 110Mb (color) for $2900.

## Appendix 6. Prototype

The main steps undertaken will be summarized along with the time spent and computing environment. The benefit is not only to be able to measure what a complete attempt at setting up a GIS would take including some of the 'bugs', but can serve as an insight to those with little GIS knowledge.

Digitizing paper maps: **Entering the elements on maps into digital format (computer readable) (23 hrs).**
- SONEDE base maps at scale 1:2000 were digitized using ATLAS*DRAW on an IBM PS/2 using a Summagraphics Microgrid 36x48 digitizing table.
- Street center lines were drawn on the same maps and digitized into a different coverage using the same hardware/software configuration.

Coverage transformation: **To carry the coverages from one package to another (5 hrs).**
- The two coverages mentioned above were exported from ATLAS*GRAPHICS as ASCII files. An ASCII file holds data in a raw format without any of the structure or formatting relevant to the software package from which it was exported.
- The ASCII files of the coverages were manipulated using the AT2ARC package.
- These files were then imported into ARC/INFO where the coverages were reconstituted. Once reconstituted, these coverages were 'cleaned' and 'built', which involves setting up the topology and feature attribute tables.

Census data: **Preparing data for manipulation, data aggregation (20 hrs).**
- The census data was in EBCDIC format on a magnetic reel. It was translated into ASCII format and loaded onto a workstation (Unix operating system).
- The data was read into EMACS (a text editor) where the records covering the part of Bardo under study were extracted using macros (a method by which a string of commands may be repeated).
- Also in EMACS, the data required checking for possible faulty entries (such as characters in a numeric field) of which a non-negligible quantity was found. In addition, macros were used to divide the data into fields (or columns) via the addition of 'delimiters'.
- The data file was read into Informix-SQL (a Structured Query Language relational database system). Several routines were run to aggregate the data in different ways (explained later) and the results were stored as ASCII files.

Tax data: **Manipulation of property tax data (15 hrs).**
- This data set was originally a backup dBase file. It was read into EMACS where macros were used to divide the data into columns and check for entry mistakes.
- The data was then imported into Informix-SQL where all the records relating to the study area were extracted and exported to an ASCII file.
- Using manual means, the taxes were aggregated by street segment using the field

survey results which indicated the address ranges for each street segment.

Block layer: **Adding attribute data (8 hrs).**
- Tax data aggregated by block and zoning categories were added to this layer's attribute table.
- In ARC/INFO, fields were created corresponding to the resulting aggregation from SQL, and the files were imported into the coverages.
- The attributes in this layer are: area, perimeter, census block number, zoning category. The following attributes, except where indicated, are for 1984: estimated tax returns (1990), # of units, # of families, population, unemployed, empty units, units being constructed, agricultural land in hectares, male and female births from 6/83 to census date, illiterates above five years of age, employed above 15 years of age, units with one household, units with two households, units with more than two households, households with less than three rooms, households with three rooms, households with four rooms, households with more than four rooms, units occupied by owner, rented units, courtyard units, villa units, apartments, other units, units connected to sewerage, units with septic tank, units with flush toilet, units with flushless toilet, units with bathroom, units without bathroom, units with less than three rooms, units with three rooms, units with four rooms, units with more than four rooms.

Streets layer: **Adding attribute data (4 hrs).**
- Street codes, street address ranges (both odd and even), and tax aggregated by street were added to the attribute table.

## Appendix 7. List of Abbreviations

| | |
|---|---|
| AFH | Housing Land Agency, MEH |
| ANPE | National Agency for the Protection of the Environment |
| ARRU | Rehabilitation and Urban Renovation Agency, MEH |
| CNI | National Computerization Center |
| DBMS | Database Management System |
| DGATU | General Office of Urbanism and Land Management, MEH |
| DGCPL | General Office of Local Authorities, Ministry of Interior |
| GIS | Geographic Information System |
| INS | National Institute of Statistics, MPDR |
| IRSIT | Regional Institute for Computer Science and Telecommunications |
| MEH | Ministry of Equipment and Housing |
| MPDR | Ministry of Planning and Regional Development |
| OTC | Office of Topography and Cartography, MEH |
| ONAS | National Office for Sewerage, MEH |
| PAD | Detailed Management Plan |
| PAU | Urban Management Plan |
| RDBMS | Relational Database Management System |
| SONEDE | National Authority for Water Exploitation and Distribution |
| STEG | Tunisian Authority for Electricity and Gaz |

## Appendix 8. List of Interviews*

Bardo Municipality
Bakhrouf, Bechir
El Karwi, Hussein
Majzoub, Heidi
Jarrass, Hassan
Khadri, Omar

Rades Municipality
Ben Ramadan, Heidi
Hajri, Chedli
Meskini, Shergui
Ben Kaab, Mohamed

Ben Arous Municipality
Ben Othman, Fathi

District de Tunis
Chabi, Morched
Ferchichi, Radiah
Machad, Monsef

SONEDE
Marzouk
Kharrak
El Meddeb

IRSIT
Chemam, Naceur
Khalfallah, Majed

INS
Fekih
Trifa, Chedly
Trabulsi, Ali
Bougdei

OTC
Hammouda, Mokhtar
Mistiri, Mourad

ONAS
Gennoun
Maacha
Ben Ammar

STEG
Issa, Mohamed
Chedly, Jeddi
Ben Othman

Other

| | |
|---|---|
| Baltagi, Abdellatif | SIDES |
| Baouendi, Abdelkader | National Agency for the Protection of the Environment |
| Ben Hadid, Amina | |
| Ennaifer, Fathi | General Office of Urbanism and Land Management |
| Gafsi, Enda | Ministry of Planning and Regional Development |
| Godin, Lucien | Groupe Huit, Paris |
| Laabidi, Mohamed | General Office of Local Authorities |

* All interviews were conducted between July 5 and September 12, 1990.

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