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A Paper entailed:

**Spatial Data Infrastructure towards E-Municipality –
The Case of Beit Sahour Municipality**

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1. ABSTRACT

The paper at hand distillates the experiment of the Applied Research Institute-Jerusalem (ARIJ) in the development of a local Spatial Data Infrastructure (SDI), Also Known As; Municipal Information System (MIS) for the Beit Sahour Municipality. The development of the SDI is introduced as a step towards e-municipality, where all kind of information and communication technologies are realized in an electronic environment, in order to make effective use of spatial or geographic data leading to efficient decision making, through an effective management of resources.

An interoperability infrastructure is at the heart of e-municipality. Therefore, Geographic Information System (GIS) was acknowledged as a core part of the municipality, due to its applicability on the many pertained municipal disciplines, including: administration, management, planning, development, and decision making.

The GIS of Beit Sahour Municipality was built on Cassini–Palestine Grid (1923) coordinate system and was fed through multi channels of data sources, including: CAD files, aerial photos analysis, reports and statistics, hard copy maps, and a special designated questionnaire. However, field work was crucial to check the collected data and to fill the gaps of other missing spatial data. In consequence, phases of data filtration, geo-referencing and rectification, homogenization and restructuring of data were needed to ensure the sound development of the municipal GIS database, which is locally used for field coordination, billing and taxes, capital planning, distribution of infrastructural

lines, digital mapping and information systems, and flexible analysis (spatial analysis, networking, 3-D Analysis, and geo-political analysis) among others.

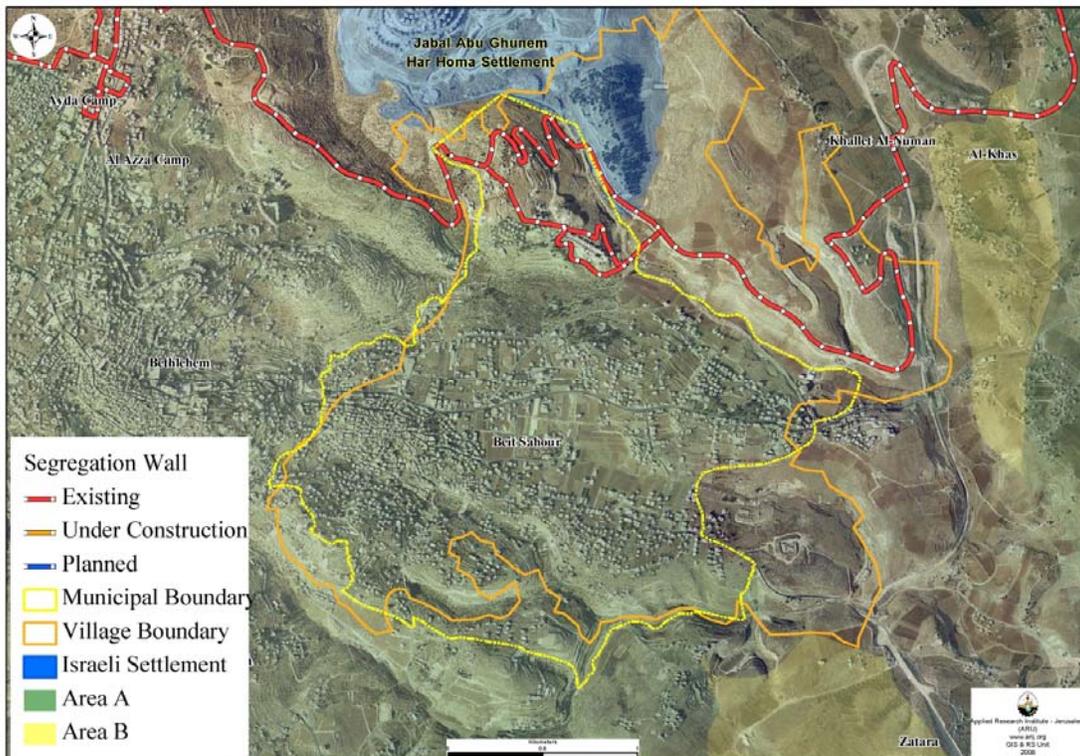
The paper ends in inventorying the main problems facing the municipalities in its way to efficiently manage the SDI. Accordingly, a set of standards, policies, and recommendations in relation to the right to access information and to the use of spatial data are proposed.

2. INTRODUCTION

Beit Sahour is the twin city of Bethlehem. It is 8.5 km south of Jerusalem City and 2 km east of Bethlehem City. Beit Sahour is bordered by Bethlehem and Al'Aza Camp to the west, Khalet Al-Numan and Al-khas and Jerusalem and Jabal Abu Ghunaim to the north, Dar Salah and Al-Ubeidiya to the east and Hindaza and Za'tara to the south ([See Map 1](#)).

The total area of Beit Sahour city under the British Mandate in 1948 was about 7,035 dunums. Now, the municipality of Beit Sahour has sovereignty over only 4,780 dunums, of which currently 2,736 dunums are built-up area, 1,511 dunums are agricultural area, 2,107 dunums are open space area with little or no vegetation ([See Map 2](#)). The plummet rate in sovereignty over land in Beit Sahour is interpreted due to the Israeli colonization activities since 1967 ([ARIJ GIS-Database, 2008](#)).

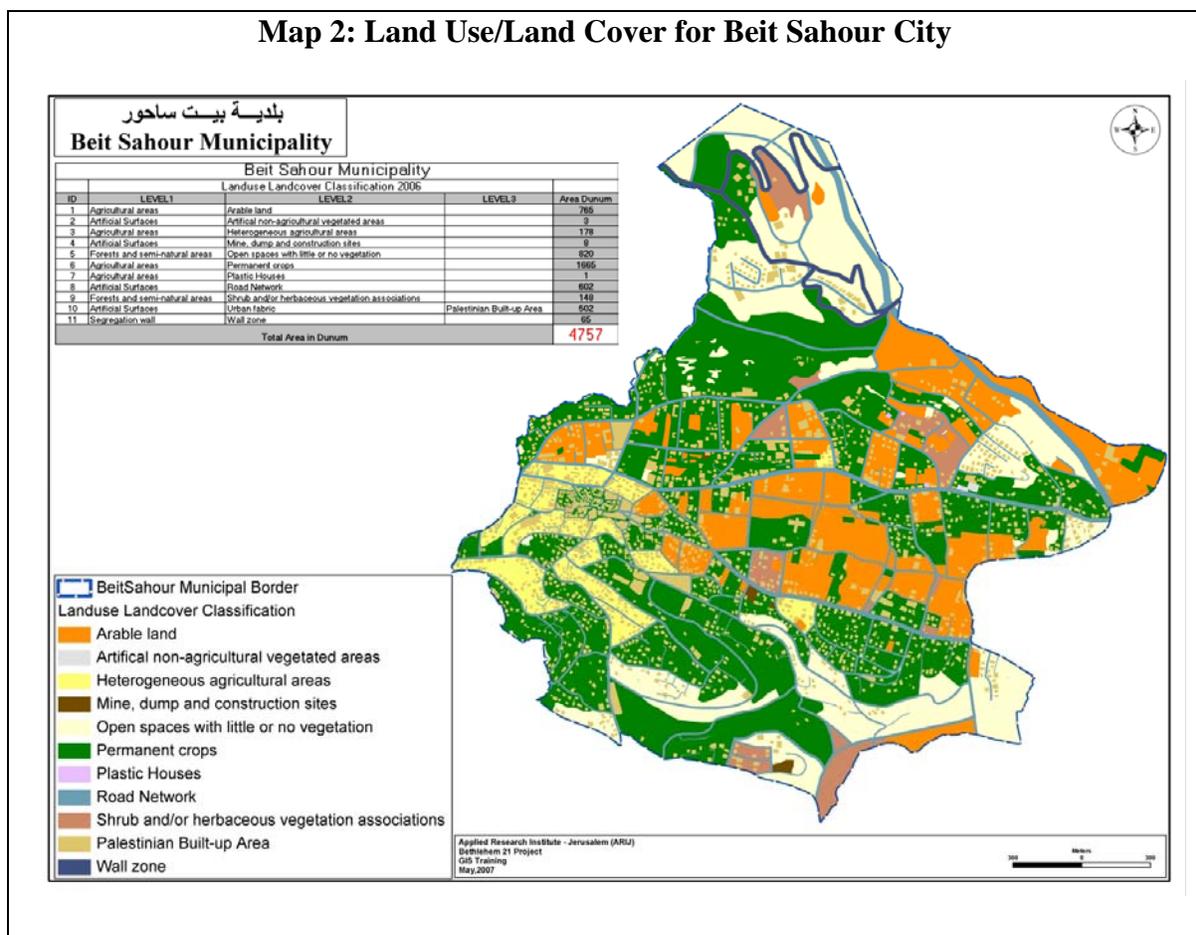
Map 1: Beit Sahour Location and Boundaries



According to the Palestinian Central Bureau of Statistics (PCBS), Beit Shaour City is the home of 15,830 inhabitants, which makes the gross population density of Beit Sahour 3,312 person/Km² in 2008. This population density is considered to be very high when compared to other Palestinians cities such as the political Capital City of Ramallah, which is 2,154 persons/Km², with other Arab neighboring cities, such as Amman where the density is 246 persons/ Km², or with the largest Arab agglomeration City of Cairo, which reaches 3,158/km² persons/ Km² (PRA, 2007). It is worth mentioning that the population density is projected to increase further as the population growth rate is high and the access to open land is limited because

of the land grab policies that the Israeli occupation is implementing in Beit Sahour area.

Map 2: Land Use/Land Cover for Beit Sahour City



Beit Sahour is an urban city surrounded by olive trees which not only are significant to the Olive wood industry, but also constitute the historic “Shepherd’s Field,” where tradition holds that the angel bodes to the shepherds the birth of Christ.

3. PROBLEMS JUSTIFICATION

Beit Sahour City, along with both Bethlehem and Beit Jala cities constitutes the urban fabric of Bethlehem Governorate, which is one of the largest of the eleven Governorates of the West Bank as it occupies an area of 607.86 Km² (ARIJ GIS-Database, 2008).

Beit Sahour City is no exception of other urban Palestinian cities, which is characterized as a model of the complex interrelationship between military occupation, environmental degradation and socio-cultural pressures.

In light of the last 41 years of Israeli occupation of the West Bank territory, Beit Sahour city was directly affected by the Israel practices against its land and people. The first of which was in 1967, when the Israeli Jerusalem Municipality disclosed unilaterally a new town planning scheme that illegally expands the boundaries of Jerusalem City by the annexation of the Arab eastern part of the city. This expansion was accomplished on the expenses of peripheral Palestinian communities in the north (i.e. Rammallah) and the south (i.e. Bethlehem). Consequently, Beit Shaour lost a total of 1,210 dunums (i.e. 17% of the city's total area). Furthermore, the construction of the Separation Wall to the north of the City, have resulted in the isolation of additional mass lands; totaling the confiscated area to 1,902 dunums (i.e. 27% of the entire area of 1948 - Beit Sahour's village boundary). Of this area, 15% (291 dunums) contains arable lands or permanent crops ([ARIJ GIS-Database, 2008](#)).

In addition to this, the Separation Wall impedes the movement of goods and people; Palestinians are less able to maintain social ties outside of the immediate Beit Sahour area, and the movement of agricultural and manufacturing products is severely limited, resulting in the influx of Israeli goods and thus the marginalization of the Palestinian economy.

Israeli colony practices are similarly disruptive. In 1997, construction began on the settlement of Har Homa "Jabal Abu Ghuneim" on what was once forest land north of Beit Sahour. Of the project's 2,056 dunums, at least 33% was confiscated from Palestinian owners ([FMEP, 2008](#)). At the same time,

since the second *Intifada* three Palestinian homes have been incinerated, 26 have been totally demolished, and 359 have been partially destroyed or severely damaged.

In parallel to that, the Palestinian National Authority (PNA) in the West Bank territory and in Bethlehem Governorate especially runs an inefficient and non-transparent current system of land administration that hinders and undermines the process of sustainable development of the Palestinian communities. This includes the construction and rehabilitation of an adequate infrastructure system that has been severely affected by the Israeli non-stopped and aggressive practices.

To this end, historical significance of Beit Sahour, combined with its proximity to Bethlehem and Jerusalem, make it a popular tourist spot, but the Israeli occupation has posed a number of obstacles to socio-cultural-economic prosperity in the area. For that, the necessity to revive and sustain the development in Beit Sahour through the efficient management of scarce natural resources emerged as a top priority for the municipality of Beit Sahour. Thus, the introduction of professional GIS to the municipality in order *to make effective use of spatial or geographic data* leading to efficient decision making, through an effective *management of resources* (UNECA, 2004) was acknowledged and adopted.

4. OVERARCHING GOAL AND SPECIFIC OBJECTIVES

The overarching goal of building the GIS in Beit Sahour is to efficiently manage the natural resources of the City and ensuring the sustainable development of the community. Thus, the GIS will become the core part of the municipality, as it is concerned with the multi-disciplines prioritized within the municipal fields of interest, including capital planning, financial reporting and taxation, field coordination, and infrastructural operation and maintenance.

The specific objectives are summarized as follows:

- To provide the decision makers in the municipality of Beit Sahour with current, accurate, and consistent basic spatial data, including digital data and hardcopy maps, and deliver spatial information that is current.
- To update the spatial data sets of the Beit Sahour's base maps¹.
- To create new data sets where new physical features established.
- To populate spatial data with tabular data (road type, urban names, Israeli colonies names etc.).
- To publish and distribute consistent and complete geographic data sets and, thus reducing data duplications and redundancy.

¹ Base map constitutes the basis and joining surface of the multi-purpose use, of which

- Reference and projection system is strictly determined,
- Contents consist of objects of cartographic subject and of their attributes and relations, which are built-up of the joint set of the properly defined data requirements of a broad and well determinable segment of users
- Data quality characteristics are fitted to the technically and economically properly justified demand of top level of the would be users and applications to be expected.

5. METHODOLOGY

The development of the GIS system in Beit Sahour was accomplished following three hierarchal stages, which can be categorized as follows:

- Stage One: Building a basic GIS.
- Stage Two: Data updating and improving.
- Stage Three: Linking descriptive data collected by a designated questionnaire to the developed basic GIS.

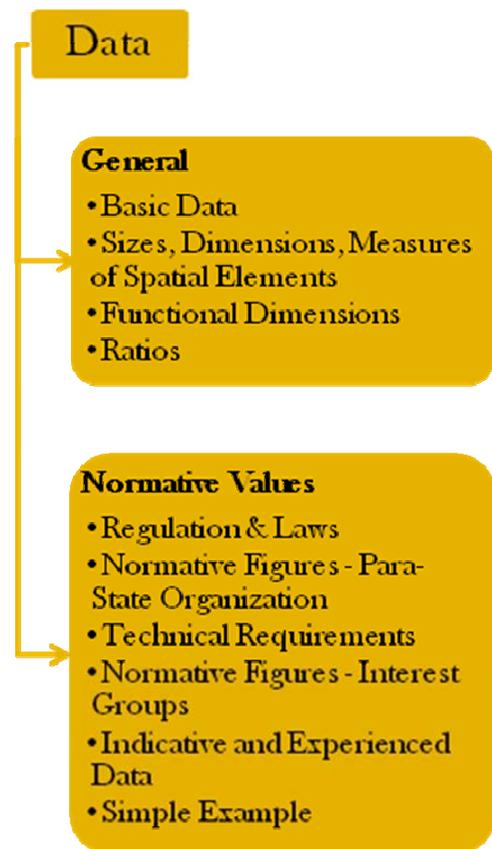
The three stages are scantily but substantially elaborated beneath.

5.1 Stage One

The first stage started in 2002 as an on-job GIS training at ARIJ premises. Two Engineers and a surveyor participated in the training course. The objective was to develop a basic GIS for Beit Sahour using a high resolution Aerial Photos as a base map. However, seeking efficiency hard copy maps at the municipality, along with available CAD-files have been converted into the GIS. Accordingly, GIS data, such as: road system, main features, land parcels and others have been developed.

During this stage the type of data needed for building the GIS was identified as general and normative values (See Figure 1).

Figure (1): Types of Data



5.1.1 Data Format

The data format of the GIS system was shape-files (.SHP). To ensure interoperability and compatibility the developed GIS was built on Cassini – Palestine Grid 1923 coordinate system, where other Palestinian stakeholders can make benefit from the stored data.

5.1.2 Data Sources

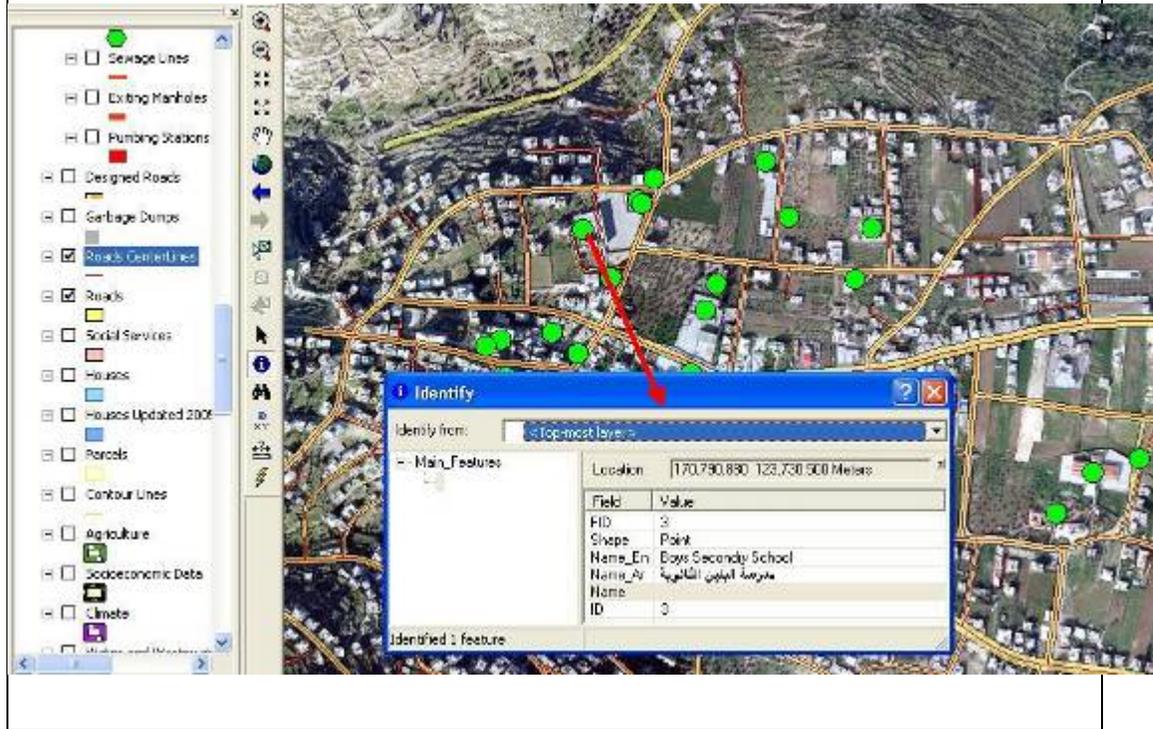
The data sources (See Figure 2 in Annex) used in developing the GIS system of Beit Sahour municipality were mainly:

- CAD Data.
- Aerial Photos (1998, 2004, and 2005) Analysis.
- Reports and Statistics.
- Hard Copy Maps.
- Field Work.
- Questionnaire.

5.2 Stage Two

In self-sufficiency, the municipality of Beit Sahour continued its concerted efforts to updating the GIS at this stage. The focus was exerted in gathering and entering the attribute data related to the identified geographic features (See Figure 3). At this stage sufficient time was allocated to data entering of the re-structured land parcels including; owner name, parcel and block number, among others.

Figure (3): Shot of the Beit Sahour GIS-Database



5.3 Stage Three

Within the framework of the Bethlehem 21 project "*Environmental Sustainability for a Better Life: An Integrated Approach for Localizing Agenda 21 in the Bethlehem District*," the technical crew of Beit Sahour municipality was capacitated with a second basic and advanced on-job GIS training, which lasted for 7 months. Two employees from the municipality were trained on how to get starting from theoretical courses. The main aim of this stage was focused on the questionnaire data linking and coding of buildings in order to join these data with the GIS system using a primary key code.

5.3.1 Questionnaire

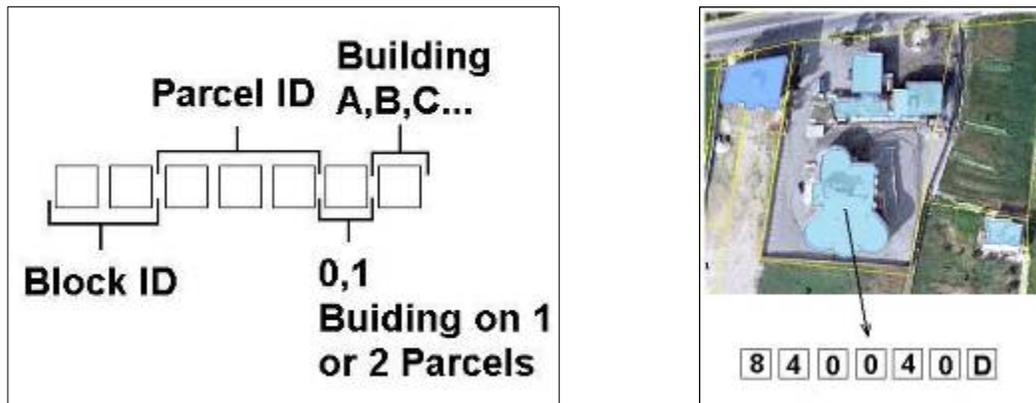
In order to get comprehensive and up-to-date information, Beit Sahour Municipality in association with ARIJ designed a designated questionnaire in Arabic language. This questionnaire contained socio-economic data for each building within the municipal boundary. Then field verification was done on the collected data. Finally, a huge amount of attribute data, which was entered digitally into tables and computer data bases were classified and stored.

5.3.2 Coding System

As GIS is a computer based science, every geographic feature must be identified by a unique ID. The MIS of Beit Sahour provided a linkage between the collected data via the questionnaire with their relatives on the digital map (i.e. the buildings layer).

The coding system was designed to be a 7-digits number; 2-digits for the block number, 3-digits for the parcel number, 1-digit for the case when the building located on 2 parcels "1" or the default "0" for the common case in which the building located on 1 parcel. The final digit is an alphabetical digit for the case when more than one building is located on parcel "A, B, C, etc." The default alphabetical digit is "A" (See Figure 4).

Figure (4): Coding System

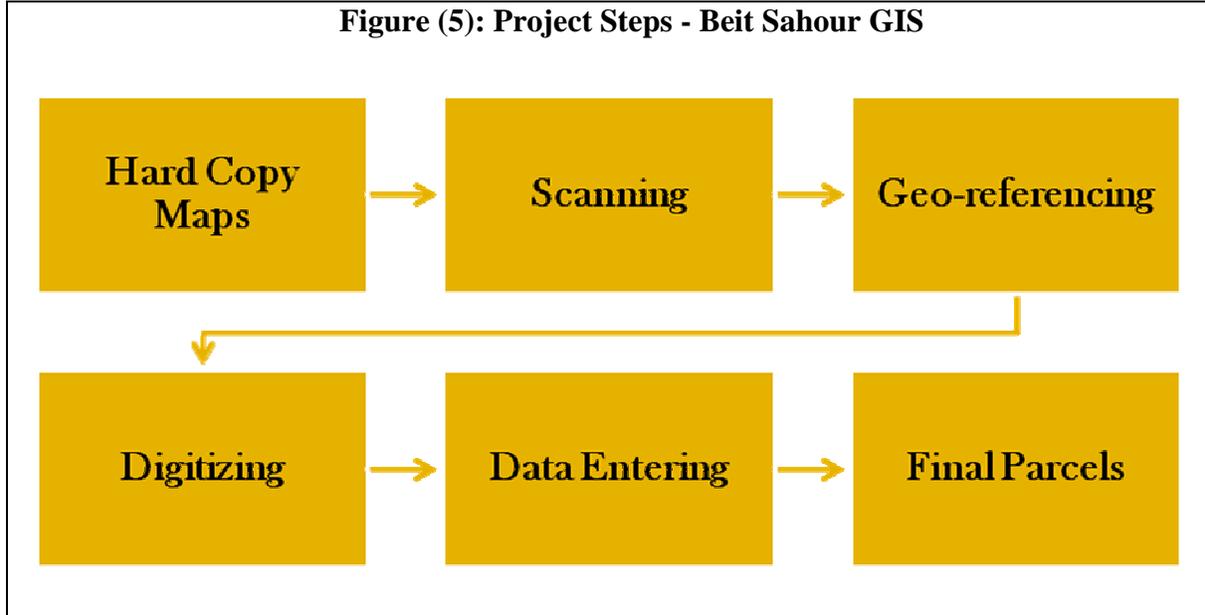


5.4 Project Steps

Figure 5 summarizes the technical project steps, namely:

- Digital data converting, such as CAD-data.
- Hard copy maps scanning and digitizing.
- GIS data collection.
- GIS data editing.
- Attribute data entering, then homogenization.
- Data updating.
- Data displaying querying and analyzing.

Figure (5): Project Steps - Beit Sahour GIS

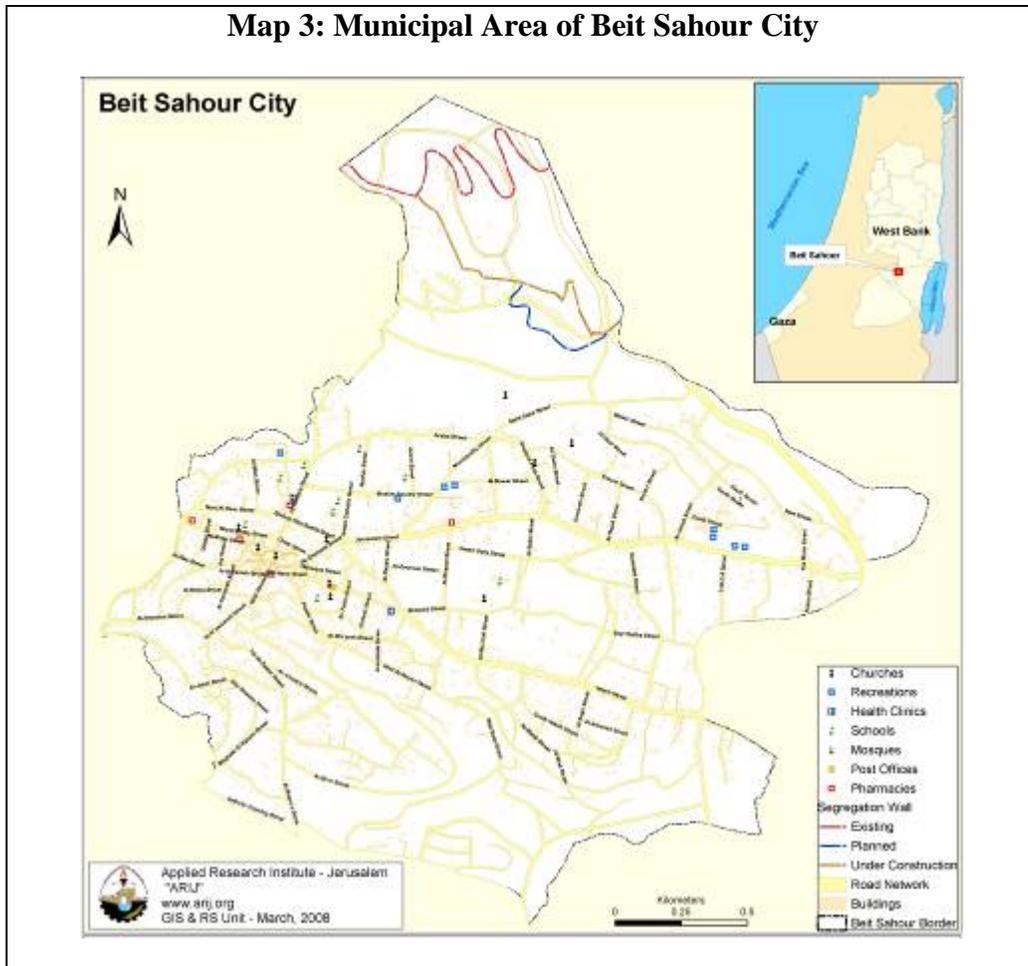


6. RESULTS

The Functionalities of the developed GIS of Beit Sahour Municipality (See Map 3) includes:

- Dynamic production of maps;
- Digital Mapping and delivery of MIS for decision makers;
- Flexible analysis: (Overlying, Spatial Analysis, Networking, 3D Analysis Geo-statistical and Geopolitical analysis, Surveying, GPS, Remote Sensing;
- Database Querying; and
- Reporting.

Map 3: Municipal Area of Beit Sahour City



The main layers (See Figure 6) contained in the Beit Sahour GIS are:

No.	GIS Layer	No.	GIS Layer
1	Land Parcels	11	Electric Network
2	Road Network	12	Water Network
3	Buildings	13	Sewage Network
4	Municipal Boundary	14	Separation Wall
5	Contour Lines	15	Schools
6	Master-Plan Landuse	16	Churches
7	Blocks	17	Mosques
8	Main Features	18	Pharmacies
9	Landuse / Landcover	19	Cemeteries
10	TIN	20	Aerial Photos

7. STANDARIZED POLICIES

Standards are usually developed through a consultative process (with other "experts") and provide a basis from which to develop national or discipline-oriented profiles that would ensure the adoption of policies and legislations relating to the *right to access information* (Pricing); *use of spatial data*; (Copyright & Liability); and legislation and policy relating to *other pertinent areas* such as Environmental Impact Assessment (EIA).

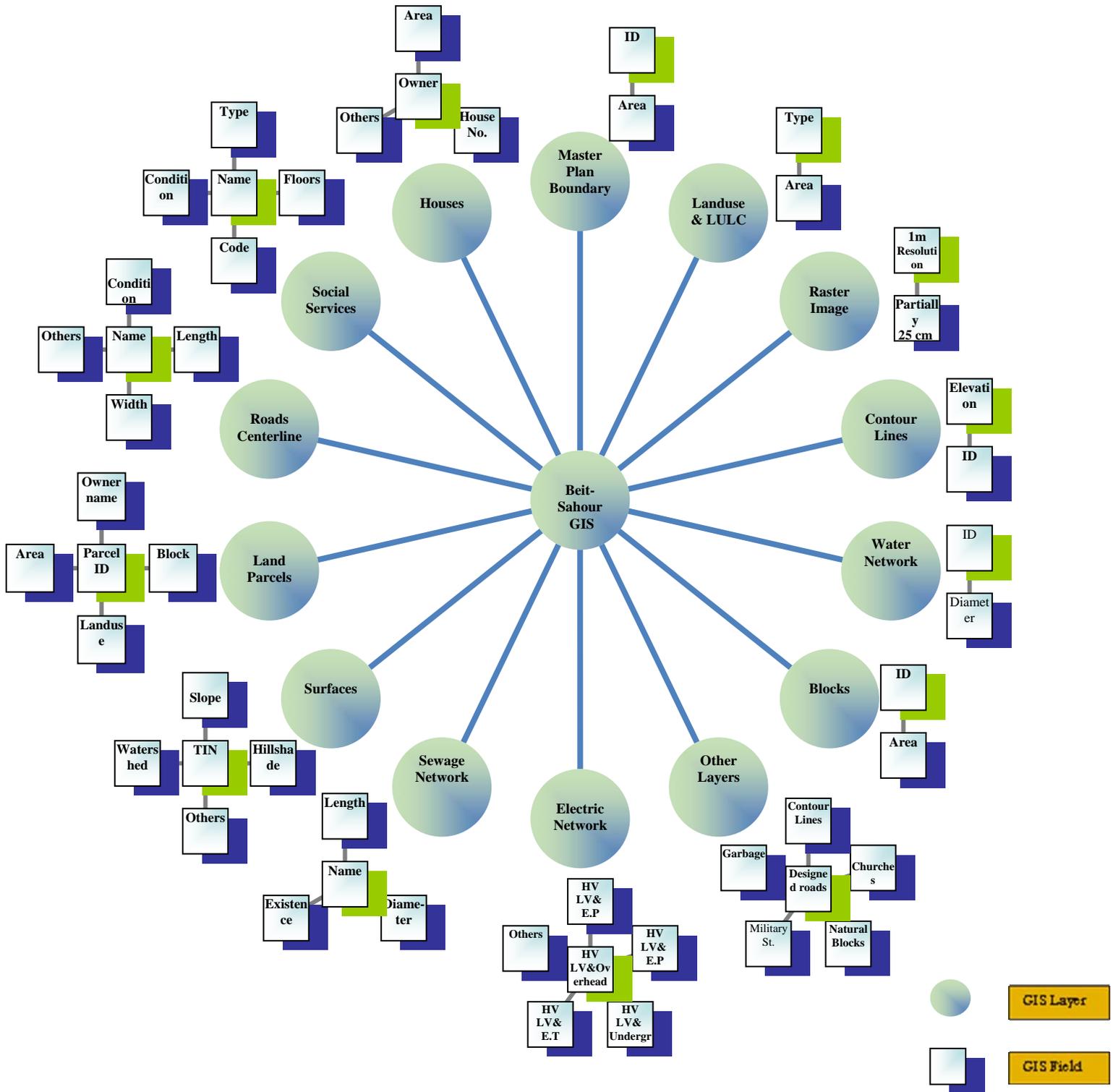
However, during the development of Beit Sahour local SDI, the project team encountered several problems that could undermine the project. These problems are summarized as follows:

- Lack of data (infrastructural lines)
- Lack of coordination (between department & between levels of government)
- Gaps in spatial data
- Lack of use of standards (incompatible information, fragmentation of information & redundancy)
- Lack of documentation
- Data policy restriction (pricing, access rights, non-sharing policy between departments, licensing policy)

8. OUTLOOK & RECOMMENDATIONS

- Highest involvement of key stakeholders (users, producers and transformers of spatial information) is crucially needed to have a manageable and efficient SDI.
- A Consultative process would guarantee openness and transparency in drafting implementing measures “Cookbook.”
- Research and development needed
- Demo & Pilot Projects.
- Conducting Cost/benefit analyses and EIA for the adopted projects.
- Address technical topics like “Conceptual Schema Languages.”
- Expert Group meetings.
- Improving GIS systems; carry out in entering and updating of attribute data for already built GIS databases.
- Developing a detailed and accurate Land Information system, including Building a Naming and Numbering system.
- Designing a Questionnaire that can be used as a comprehensive source for data in the GIS system.
- Adopt a Palestinian national profile of the exiting pertained ISO’s.
- Plan for a calculated data collection process.
- Outreach and Capacity Building.

Figure (6): Beit Sahour GIS Layers



9. PROJECT SUSTAINABILITY

In collaboration with other governmental, non governmental agencies, academia, and the public, Municipality of Beit Sahour will coordinate, integrate, and where needed, produce and maintain geographic database. The success of this local geographic database will depend heavily on sustainable partnerships. Municipality of Beit Sahour will lead the development and maintenance of the geographic database by being the:

- Guarantor of geographic data completeness, consistency, and accuracy.
- Owner and data producer.
- Leader in the development of geo-spatial data standards

To continue to be relevant, it is important that the geographic database be developed and improved in response to users' needs, as well as to changing technical and organizational requirements. Technical roundtable meetings and workshops will be the mean to obtain feedback from users and to respond to reported deficiencies and changing needs.

10. RESOURCES & SUGGESTED READINGS

- Africa: An Implementation Guide – SDI (2004)
<http://geoinfo.uneca.org/sdiafrica/default1.htm>
- Applied Research Institute-Jerusalem (ARIJ) (2008) – GIS Database
<http://www.arij.org/>
- DIRECTIVE 2007/2/EC - Infrastructure for Spatial Information in the European Community (INSPIRE)
http://inspire.jrc.it/directive/1_10820070425en00010014.pdf
- Environmental Sustainability for a Better Life: An Integrated Approach for Localizing Agenda 21 in the Bethlehem Governorate
<http://proxy.arij.org/bethlehem21/>
- Foundation for Middle East Peace (FMEP) <http://www.fmep.org/>
- GIS Worlds - Creating Spatial Data Infrastructures (2005)
- Research and Theory in Advancing Spatial Data Infrastructure Concepts (2006)

ANNEX (1)

Figure (2): GIS Data Flowchart

