Journal of the Islamic University of Gaza, V. 10 no.2 p -p ,2002

Geographic Information System (GIS) for Environmental Infrastructure Management (EIM) in Gaza Strip

Karim Jouda[1], Zaher Kuhail[2]
UNRWA, Gaza Islamic University of Gaza
p.o 108 , Gaza, Palestine

نظام المعلومات الجغرافي (GIS) لإدارة البنية التحتية البيئية في قطاع غزة

ملخص البنية التحتية البيئية تشمل القطاعات الأربعة: المياه، المجاري ، ميـــاه المطـــر والنفايات الصلبة.

الهدف من هذه الورقة تقديم نموذج لاستخدام نظام المعلومات الجغرافـــي لإدارة البنيـــة التحتية البيئية في قطاع غزة، من خلال وضع أطر تطبيق هذا النظام. اعتمد البحث علـــى التقييم لما نشر في هذا الموضوع لتاريخه، و البحث الميداني والاتصال الجاد مع الجهات والمؤسسات الرسمية وغير الرسمية في قطاع غزة، والتي لها علاقة بالبنيـــة التحتيـــة البيئية. الغرض من النموذج المقترح هو استخدام نظام GISكوسيلة لإدارة البنية التحتية البيئية في قطاع غزة.

وللوصول لنموذج علمي وعملي يمكن تطبيقه، تم تصميم استبانتين وبأسئلة دقيقـــة عـــن الاحتياج والإمكانيات المتاحة و الترتيبات والوضع المؤسسي والقيود والظروف المحيطـــة فقد تناولت الإستبانة الأولى الوضع الحالي لنظام المعلومـــات الجغرافـــي بينمـــا تناولـــت الإستبانة الثانية الاحتياج الدقيق ل GIS وعناصر النموذج المقترح .

وقد تم تقديم النموذج متكامل في نهاية الورقة مع النتائج الخاصة بمخرجات البحث.

ABSTRACT **Environmental Infrastructure involves four sectors: namely; wastewater sector, water sector, storm water sector and Solid waste sector.**

This paper aims at presenting a model on Geographic Information System (GIS) for environmental infrastructure management in the Gaza Strip through establishing conceptual framework on how GIS should be implemented. It is based on scientific literature assessment, field evaluations and active contacts with concerned environmental infrastructure management institutions in the Gaza Strip. The model is intended to serve as a management tool for the environmental infrastructure in the Gaza Strip.

To reach a practical yet scientific model, a carefully designed two questionnaires were distributed and analysed, with definite questions on the need, potential, institutional matters, constrains

[1] Head, Special Environmental Health Programme, UNRWA, Gaza
[2] Associate Professor in Civil Engineering, The Islamic University.

and conditions for applying such a model to the Gaza Strip. The first questionnaire formed a background and general understanding of the GIS situation in the EIM in the Gaza Strip, while the second questionnaire pin pointed the actual; what elements of the model.
The GIS EIMS model has been introduced at the end of the paper with conclusions.

Keyword Infrastructure management, GIS application, Decision Support System, GIS, EIM

EIM	Environmental Infrastructure Management
DSS	Decision Support System
GIS	Geographical Information System
MENA	The Ministry of Environmental Affairs
MLG	Ministry of Local Government
MoH	Ministry of Housing
MOPIC	Ministry of Planning & International Co-operation
NEIIC	National Environmental Infrastructure Information Centre
NGO	Non Governmental Organisations
O&M	Operation & Maintenance
PWA	Palestinian Water Authority
SWMC	Solid Waste Management Council
WU	Water Utility

1. Background on the use of Geographic Information Systems in EIM

GIS is a computer-based tool to handle spatially referenced information. Many definitions of GIS make reference to the four basic functions of input, output, storage and analysis [1] . Networking as relevant institutional component is sometimes added. Therefore GIS could be defined as computer based tools for the inventory, analysis and visualisation of geographical information.

Today, the role and position of the aspects outlined above are widely being discussed:

- Is GIS mainly an analytical tool;
- Is it a vehicle for the inventory and monitoring of geographic information;
- Is the principal purpose of the technology the visualisation of spatial information or;
- Is the purpose the capability to bring people together?
- Through this paper an attempt has been made to answer the above questions in the context of Gaza Strip's technical and institutional constrains in the field of Environmental Infrastructures.

2. Existing GIS Facilities used for EIMS in Gaza Strip

Table 1, shows a summary of the institutional survey for those who are using GIS and to what purpose. It is evident that Gaza municipality, MOPIC, MEnA and the Ministry of Housing are the only institutions using the GIS. Table (1) shows the existing GIS facilities and its Infrastructure related activities in the Gaza Strip

Table (1) Existing GIS facilities

Community or Organisation	**Infrastructure Management component / Application**	**Information on GIS database**	**Purpose**
Gaza City	Non	-demographic distribution -land use	base maps with some database
Ministry of Housing	Non	-Housing projects details	Maps for
MOPIC	Non	-Land use for urban planning	base maps with some database
MEnA	Non	-land use coastal database	

To summarise, the present use of the GIS is restricted to production of base maps and does not represent an effective management tool. Moreover, the institutional set-up has overlapping and conflicting roles and responsibilities lacking any proper and effective decision support system (DSS).

Objectives of introducing GIS as seen by concerned officials in the Gaza Strip seem to be limited to producing maps and a database system. Sources of information are mainly the billing system of the municipal services of water supply, wastewater, storm water drainage solid waste management, and other services. The municipal staff are also the collectors, analysts and designers. The obvious conclusion is also that, the municipalities never thought in applying techniques for spatial analysis in their activities in delivery of municipal environmental services.

3. Proposed Model for GIS for EIM in Gaza Strip:

Gaza Strip with limited area (365 km^2) and natural resources associated with many environmental problems seem to be ideally suited for this technology. It appears essential for Gaza Strip to master this technology.

How the GIS should be applied to have an impact on the environmental infrastructure management in the Gaza Strip has been split down into four general question areas:

- How the GIS can contribute to the EIMS in the Gaza Strip?
- What are the data requirements for the EIMS in the Gaza Strip?
- What are the institutional requirements for the proposed GIS?
- What are the constraints and conditions for ideal implementation of GIS in the Gaza Strip?

Accordingly, the model will be presented in four sections,

3.1 "Potential",
3.2 "Data requirements",
3.3 "Institutional requirements" and
3.4 "Constraints and conditions".

3.1. Potential

The main potential of the GIS in the Environmental Infrastructure Management (EIM) in Gaza is as a communication interface in the decision-making domain, providing readily usable information to planners, designers, managers, operators, politicians and the general public.

The proposed model of the tool's potential sets priorities among the various GIS functions: inventory, analysis, visualisation and networking. By dividing GIS in its components, which in reality constitute a rather inseparable whole. Therefore, artificial boundaries exist among such GIS components. For instance, visualisation and analysis are in reality always dependent on available data on the inventory domain.

GIS analytical potential can mainly be seen in the management procedures for project implementation, operation and maintenance. However, it does

not attribute the same importance as a policy formulation tool which is more dependant on visualisation.
Figure (1) is an elaboration on the role of individual GIS elements: networking, visualisation, inventory and analysis.

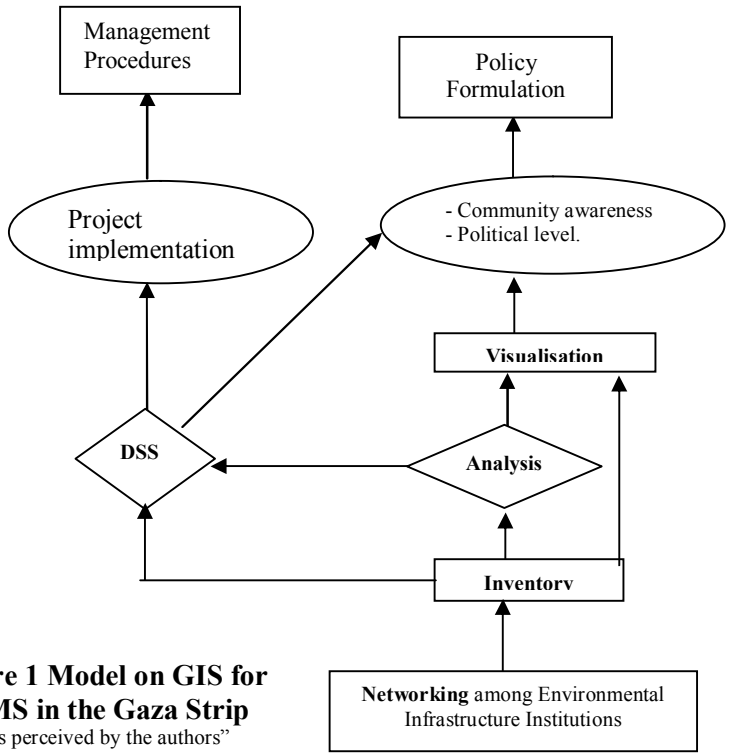

Figure 1 Model on GIS for EIMS in the Gaza Strip
"As perceived by the authors"

3.1.1. Networking

Institutional networking is perceived as the engine of communication regarding the application of GIS at operational and policy-levels in the Gaza Strip. It is, however, the least tangible component of the GIS, least visible, thus rather problematic to describe and to value conclusively. Nevertheless, tremendous potential in the networking domain of GIS is seen.
A classification of the various networking elements of the proposed GIS model in Gaza Strip with the potential to establish efficient data flow within the institution and through the different institutions.

3.1.2. Visualisation

The relevant elements of the visualisation potential of GIS are: awareness visual aids, illustrative graphics, analytical graphics and user tailored base maps.

The Geographic Information Systems have an enormous potential in visualising environmental infrastructure information especially those related to land use and resource management. Images usually have a much stronger appeal than words or statistics, thus special care has to be taken when visualising environmental infrastructure information.

3.1.3. Inventory

In the model, a priority to the communication of EIM information over inventory has been assigned. While in reality, visualisation within a GIS is closely interconnected with inventory. Inventory will be driven by the communication demand. A concept of an integrated overall EIMS inventory for the Gaza Strip is shown in figure (2).

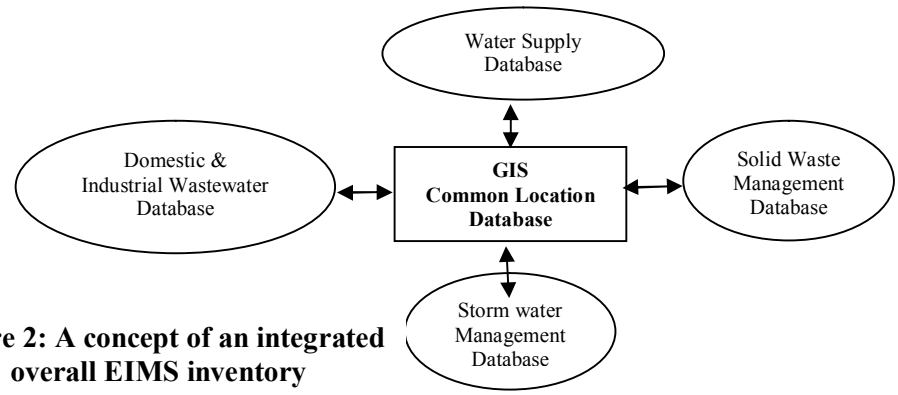

Figure 2: A concept of an integrated overall EIMS inventory

3.1.4. Analysis

In spatial modelling, where multiple layers of information associated with uncertainties are being processed, the results are becoming vague, highly hypothetical and associated with errors beyond scientific error estimation. The introduction of Geographic Information Systems can be regarded as a data processing system aiming at supporting the analysis of spatial data and consequently formulation of management procedures. The analysis domain of the GIS has two main potentials; in "***summary statistics" and "Decision Support System (DSS)"***

§ Summary Statistics

In Gaza Strip, where, for instance, basic census units undergo frequent changes, the technology's capability to aggregate data is a valuable asset. Also, simple overlay functions joining various layers of data can have a tremendous information potential, by performing simple GIS operations involving several layers of data, there is already a tendency to quantify uncertainties.

§ Decision Support System

GIS will have a role as DSS primarily in conjunction with planning, design, budgeting, operation and maintenance. Some applications allow to rationalise decision-making into simple procedures and to integrate into a GIS.

The biggest assets of DSS may be their value to structure processes and thinking in general, rather than actively taking decisions.

Decision Support Systems (DSS) implies data processing and analysis, which generates results to be used in decision making.

The proposed model for Gaza Strip pertains the establishment of DSS in the water, wastewater, storm water and solid waste sectors.

DSS should be designed to meet the needs and resources available to each sector. The following considerations should be taken into account when designing a DSS:

- DSS must function within the organisational structure of a given institution.
- DSS must consider the flow of requests for decision support from the decision-maker to the technical staff.
- DSS must generate meaningful results from data to support decision making.
- The database for DSS should have temporal and spatial identifications. Conceptual frameworks of the EIM sectors in the Gaza Strip are shown in figure 3.
- Level of accuracy or uncertainty should be known or estimated and within acceptable limits for each decision.

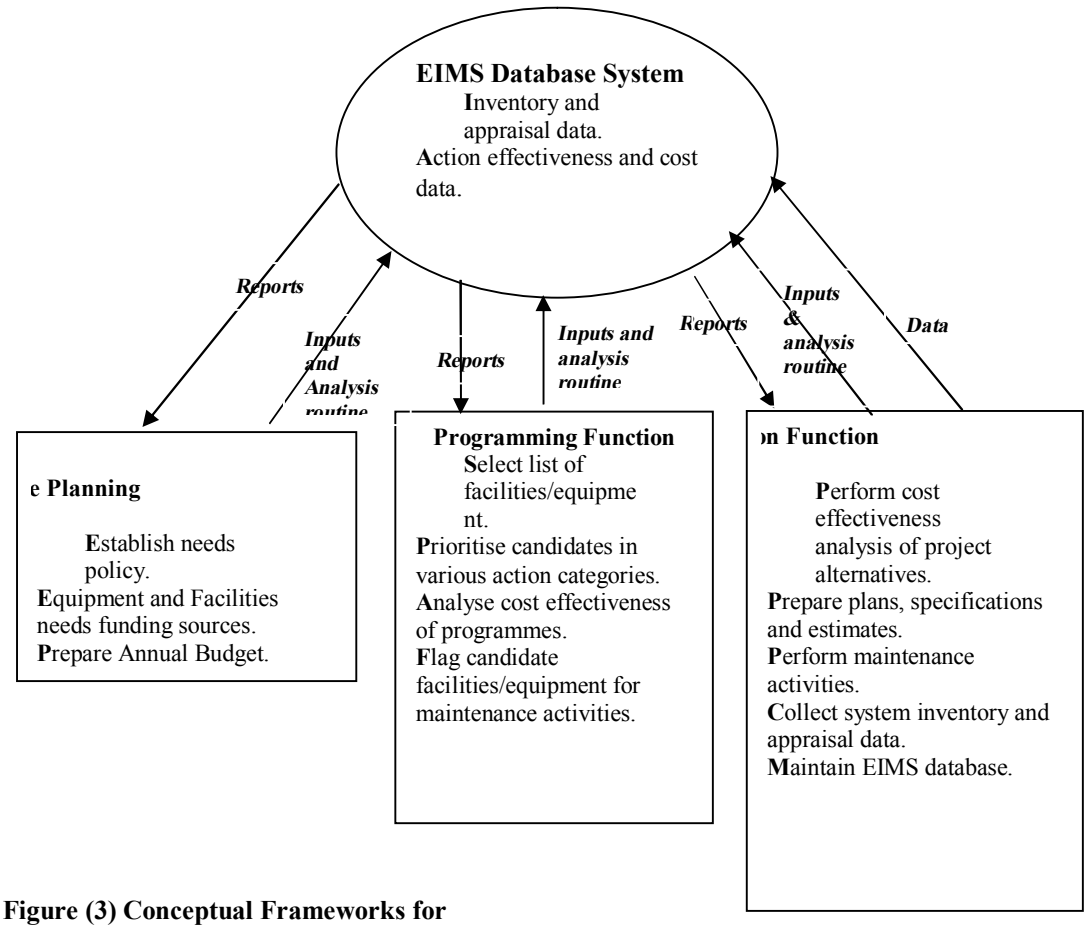

Figure (3) Conceptual Frameworks for EIM Sectors for the Proposed DSS

3.2. Data requirements for Environmental Infrastructure Management in the Gaza Strip

A principal goal here is to compile a national EIMS database from various sources to best meet the information needs for the formulation and implementation of EIMS. The contents of such a database has to be closely related to Gaza Strip principal EIMS problems and issues. Main data needs are as follows:

- Inventory data
- Usage history of the infrastructure
- Condition monitoring and evaluation data
- Maintenance history and operation data
- Maintenance intervention criteria, decision criteria, maintenance policy, unit cost and budget data
- Design and analysis data
- Maintenance and construction priority list data

3.2.1 Data Details

Levels of data details are important because cost of data collection and maintenance accounts 60% to 80% of the total cost of GIS implementation [2] . For the Gaza Strip the following levels of data details should be followed throughout the proposed GIS/DSS model:

- Sectorial level
- Network level
- Project level
- Operational level
- Research and Development level

3.2.2 Types and aspects of inventory data

- Inventory data for water group service
- Drainage basin
- Construction and structure data
- In-service monitoring and evaluation data
- Water supply (evaluation of water pipelines)
- Levels of analysis of leakage and breakage data
- Analysis of break trends over time to determine the problem areas
- Data on network partitioning
- Institutional jurisdiction and zone boundaries
- Location Referencing Methodology
- Inventory of physical assets
- Construction and M, R & R History
- Geometry, Structure and material data
- Cost Data
- Environmental Data
- Usage History
- In-Service Evaluation
- Structural Evaluation

3.2.3. Performance Modelling

Performance modelling is an important part of infrastructure management at both project and network levels. The proposed performance model relates a selected performance indicator to a set of casual variables such as age, load. load repetitions, usage history, material properties, environmental factors, and M, R&R history.

Comprehensive performance indicators can be grouped into the following broad categories [3] :

- Service and user rating
- Safety and sufficiency
- Physical condition
- Structural integrity/load-carrying capacity

Satellite Remote Sensing

Satellite remote sensing is a source for EIM data. It belongs to the inventory domain of the GIS. The satellite remote sensing has a longer standing tradition than GIS in developing countries. GIS and remote sensing systems are increasingly integrated at a technological level.

The use of satellite imagery in Environmental Infrastructure Management is quite widespread. The technology's main potential lies in the easy and inexpensive establishment of cartographic bases for large areas. Overview images covering project regions can serve as an excellent planning tool.

3.3. Institutional requirements for the EIMS in Gaza Strip

It is increasingly being recognised that the problems connected with GIS applications in developing countries are of institutional as well as of technical nature (Williams et al, 1994).

The implementation of a GIS-based EIMS for the Gaza Strip should be done in 2 stages:

Creation Stage

The creation stage should be in the form of acentralised institution focusing on generic issues and strategic planning activities. All institutions should be included.

Proliferation Stage

In this stage conversion to a distributed system and dedication to specific tasks should take place. The stage should also be exclusive (limited range of stakeholders). Focus should be on either local planning or clearly identified sectors.

Development from the creation stage to the proliferation stage will present enormous challenges and, perhaps, these need to be considered whilst

designing the creation stage so as to permit the smoothest possible transition.
At the creation stage, with the principal objective to support policy-level EIMS activities, the following three broader institutional domains as relevant for the implementation of GIS in the Gaza Strip:

- The National Environmental Infrastructure Information Centre (NEIIC) as the core of the activities;
- The Parental Ministry to host the centre which is in this case MEnA.
- The National Steering Committee and the Environmental Infrastructure Information User Group

These constitute an umbrella organisations to formulate policy and integrate a broadly defined group of users from service utilities, municipalities, sectorial governmental agencies, international development organisations and NGOs. Figure (4) shows the proposed institutional set-up model. For this information cell explicit guidelines can be made, whereas for the broader institutional context it can only be indicative, if not speculative.

3.3.1. National Environmental Infrastructure Information Centre (NEIIC)

The model aims at a strong, central GIS facility in the Gaza Strip because the communication of environmental infrastructure information to decision-makers in all levels is considered as GIS's main potential. Figure (5) illustrates the framework for the proposed NEIIC.
On the other hand, geographically decentralised GIS sites such as those in MEnA, MOPIC, Ministry of Housing and Gaza Municipality are with a specific mandate close to the actual problems and information available in each of them. Therefore, the newly proposed institutions namely, the WU and the SWMC will not benefit from institutional set up as such. Here, one has to be pragmatic. At this stage, the implementation of the still quite experimental technology at decentralised sites in Gaza Strip is considered as inappropriate. GIS, being rather sophisticated tools with high financial and manpower demands have the potential to weaken small, decentralised institutions more than a strong central unit. Today the national level is most suitable for implementing GIS in Gaza Strip, allowing a certain degree of sustainability. There is evidently also the potential to integrate decentralised, bottom-up models into a central GIS site, for instance by making it generally accessible and supporting decentralised information collection activities.

Due to the multi-hierarchical nature of environmental infrastructure problems, the issue of centralisation and decentralisation will always be persistent in the field. Here time is considered as another vital element Future developments in the GIS use in the Gaza Strip will allow transition to more decentralised options than they are today.

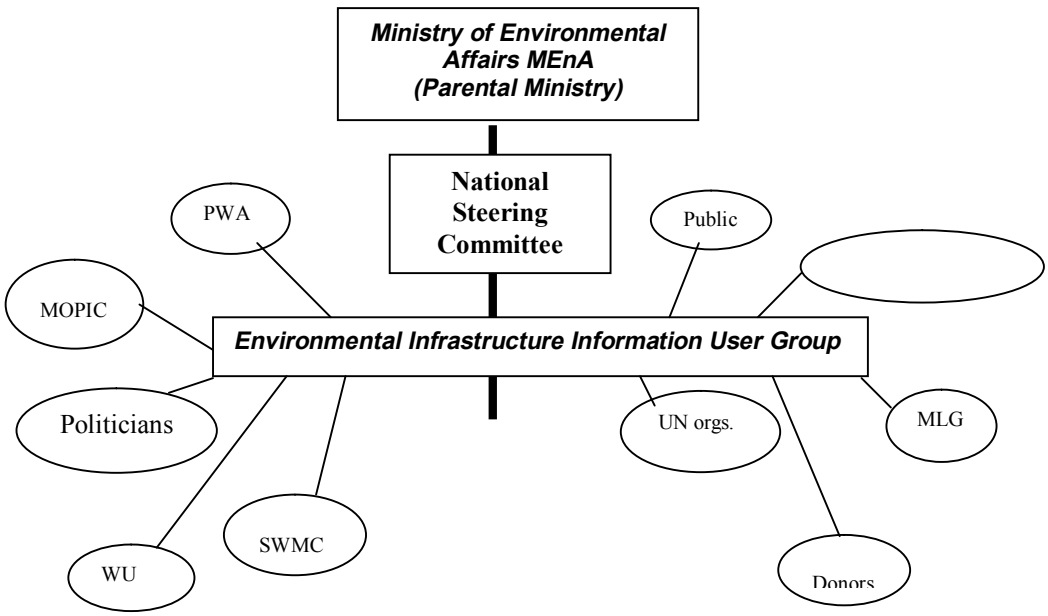

Figure (4) Model on Institutional Set Up for National Environmental Infrastructure Information Centre

3.3.2. Institutional Placement of the NEIIC

Two aspects are relevant to the placement of the GIS centre. "***Autonomy and open access***". Autonomy from the parental organisation (MEnA) is important for the networking activities. The GIS facility should be free to independently establish inter-sectorial and interdisciplinary contacts at the operational level. In addition, autonomy is also envisaged to prevent a single governmental body from monopolising the facility. Open access, enabling a large group of organisations and individuals making use of the centre's services should above-all guarantee the integration of bottom-up and decentralised activities into national policy and support GIS networking at all levels.

3.3.3. Organisational arrangements of the NEIIC

The proposed umbrella to the NEIIC (figure 4) consists of two bodies: The steering committee and the inter-institutional environmental infrastructure information user group. The steering committee is viewed mainly as the policy-formulation body issuing guidelines on the centre's operations and assuming co-ordination tasks at the political and operational levels. Members of the Steering Committee are proposed to be MEnA, MOPIC, PWA, WU, SWMC, MLG, and representatives of the public, industry and commerce. Co-ordination will primarily be necessary for higher-level ministerial co-operation, donor harmonisation, education and training. Ideally, this steering group would have an official status, with high-level government endorsement, composed by senior officials from the ministries, councils and utilities providing environmental infrastructure service.

The environmental infrastructure information user group represents another vital element with respect to networking between the ministries at a professional level. It helps to bridge the gap between the technology and its applications. This user group, envisaged to be a highly motivated and competent working team, is composed from the WU, SWMC, municipalities, PWA, MLG, donors, politicians and UN Organisations.

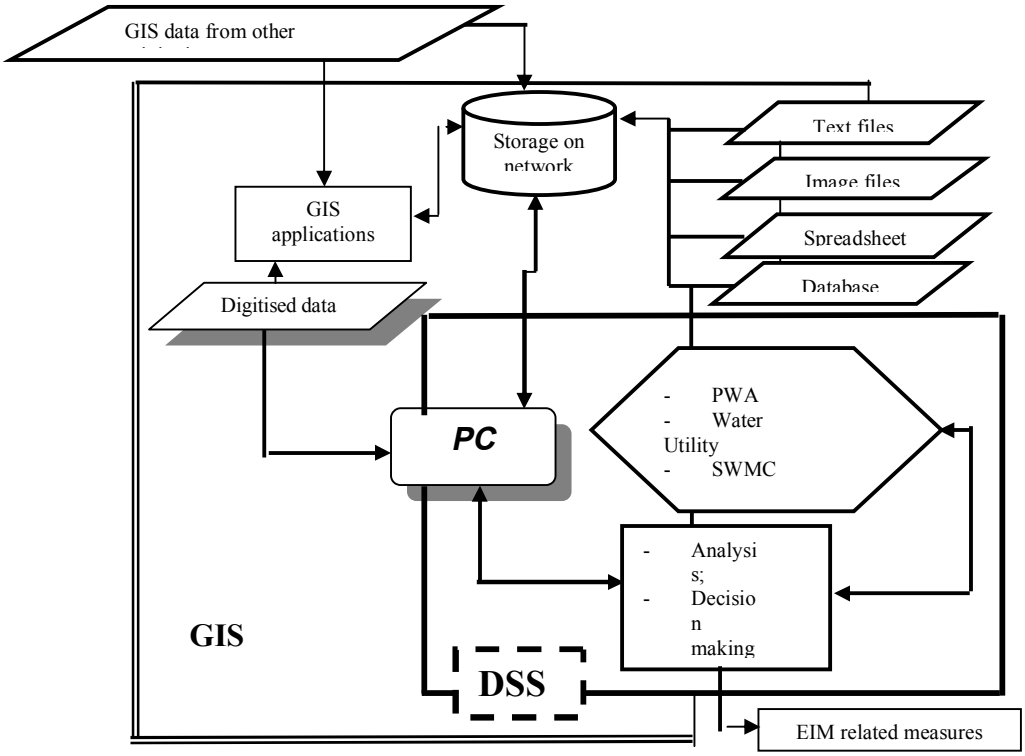

Figure 5 Framework for the National Infrastructure Management Information Centre

3.4. Constraints and conditions for ideal implementation of GIS in the Gaza Strip

Having outlined the potential role of the GIS, the data and institutional requirements, now we want to present the guidelines on how the technology could be implemented in the Gaza Strip.

3.4.1. Constraints impeding introduction of GIS [4]

The potential constraints can be summarised as follows:

- § Financial and technical dependence
- § Isolation and remoteness
- § Adverse working conditions
- § Political, social and economic instability
- § Hierarchical organisational structures
- § Multiple organisations

3.4.2. Ideal conditions for GIS

The ideal conditions for the proposed GIS model will be outlined elaborating on financial, professional, training, technology and data aspects of GIS for EIMS.
Table (2) summarises the constrains and conditions facing the implementation of the GIS EIMS model.

Table (2) Constraints and Conditions for Ideal Implementation of GIS in the Gaza Strip

Constraints	**Conditions**
Financial and Technical Dependence	**Funds** adequate to tasks adequate ratio technology/operations sustained core funding locally managed
Isolation & Remoteness	**Staff** science-oriented analysis communication specialists technical specialists foreign experts
Adverse Working Conditions	**Training** adaptation of contents longer-term forms
Political, Social and economic instability	**Technology** adequate size and functionality
Hierarchical organisational structures	**Data** coordination and networking meta-data services real-time monitoring data data quality control & mgt.
Multiple organisations	

Funding Issues

Funding for GIS installations in Gaza Strip is generally coming from outside donors. With the growth of the field, aid agencies are increasingly confronted with the task to spend money on information technology. Considering the current level of uncertainty surrounding GIS, this is not at

all an easy task. Therefore the design of a central GIS facility is regarded attractive to donors. It offers the opportunity to share the costs among donors, making the investments of a single donor agency in a NEIIC relatively small compared to the potential returns.
Four aspects of GIS funding are essential:

- Adequate funding to tasks
- Adequate ratio between technology and operational cost
- Sustained core funding
- Locally managed funds

Professional Issues
Staffing of the NEIIC should take into account GIS networking, the integration among the three poles GIS, science and administration, as well as the technology's professional and technical demands.
The model of an adequately staffed NEIIC translates considerations outlined above into the three following profiles:

- § Science oriented GIS Analysts
- § Communication Specialists
- § Technical specialists
- § Foreign experts

Training Issues
The professional issues are related to training, which with regard to Geographic Information Systems in developing countries has evolved to a field on its own Systems for Natural Resource Management. The importance of such event-focused training activities is obvious. However, it is believed that the relevant issues of continuity, such as motivation, the generation of useful applications and experience are basically un-trainable and have to be developed over longer time periods in sustainable, institution-building processes.

> The necessary educational institutions for a sustained application of GIS technology will have to be established. The Universities should be the most relevant reservoir for skilled GIS professionals, as well as for GIS developments as a whole

Technology issues
The technology issues up to now have been far too much at the centre of the introduction of GIS in the Gaza Strip. Fortunately, with GIS becoming more ubiquitous, technological aspects can be moved more into the background. Relevant in the proposed GIS model are above-all considerations of

adequacy the relation between the goals of the NEIIC and its hardware and software configuration. Here, because information technology is a field of rapid changes, general guidelines will be issued:

Adequate size and functionality [5,6]

Central requirement is the approximate ratio of 20:80 between technical and operational costs of a facility. To find a balance here can be an extremely sensitive task: Under- or over-furnished GIS facilities are quite ubiquitous. In terms of functionality, the following considerations can serve as indicators regarding hardware and software:

- State-of-the-art systems
- Local maintenance
- Commercial and integrated software
- Limited number of software packages
- Adequate number of workplaces
- Graphics and desktop publishing
- Peripherals and supplies

Data issues

The data issues are closely related to the inventory domain discussed earlier. Here the discussion will be on a more concrete level. The tasks of the NEIIC will primarily be in the coordination and networking domain, the establishment of a meta database and data acquisition in relation with the environmental infrastructure information issues.

Coordination and networking

The NEIIC will first have to conceptually define its data integration tasks and then identify and coordinate with potential sources. Concerning these coordination and networking mandates, the steering committee and the user group will be quite vital.

Meta-data services

More important for a centre than actually holding the data is to know where to get it from. In the Gaza Strip, the fragmentation of environmental infrastructure information is quite common, since there are often multiple players involved in environmental infrastructure projects. NEIIC is envisaged to play a key role in the spatially referenced collection of information as well as the source of data. A catalogue through the user group will ensure the spread of this vital list of information sources in the Gaza Strip.

Real-time monitoring data

In conjunction with sensing techniques, a potential to acquire a real-time monitoring data is seen. The GIS facility has to be ready to fulfil quick data demands in the case of quick decisions needed, such as natural disasters or sudden failure of an infrastructure service system. Work on such projects can be very attractive and relevant, however, an eye should always be kept on adequacy. Otherwise, an installation could be completely tied up by such requests and degenerate to a procurer of quick information for politicians in power or for operators in the field.

4. Evaluation Questionnaire:

Figure 6 shows a questionnaire designed by the authors to evaluate the GIS/DSS model proposed for the GIS/DSS in the Gaza strip. The results have been shown to highlight the inclination of each institution and the ideal model proposed in this paper.

Figure (6)Questionnaire for Evaluation of the Proposed GIS/DSS Model

No	Survey Component	Results	Organisation					Weight**	Model
			MOPIC	MEnA	PWA	MOLG	WU		
1.	What are the objectives of introducing GIS	Production of base maps	X	X	-	X	X	4	5
		Inventory data	X	X	X	X	X	5	5
		Networking of information	-	X	X	X	-	3	5
		4. Visualisation	X	X	-	-	-	2 5	5 5
		5. Decision Support Tool	X	X	X	X	X		
2.	How to introduce GIS	Central unit	-	X	-X	-	X	2	5
		Decentralised system	X	-	X	X	-	3	0
		Specialised units	X	-		X	X	4	5
3.	GIS networking potential for EIM in Gaza strip	Data flow among involved institutions	X	X	X	X	X	5	5
		Data flow within each institution	X	X	X	X	X	5	5

No	Survey Component	Results	Organisation					Weight**	Model
			MOPIC	MEnA	PWA	MOLG	WU		
4.	GIS Visualisation potential for EIM in Gaza strip	Awareness aids	-	X	-	-	-	1	5
		Illustrative graphics	X	X	X	X	X	5	5
		Analytical graphics	-	-	-	X	X	2	5
		Specific purpose base maps	X	X	X	X	X	5	5
5.	GIS Inventory potential for EIM in Gaza strip	Communication of data with other institutions	X	X	X	X	X	5	5
		Data focus mainly on DSS	-	-	-	-	X	1	5
		Minimise data collection (avoid duplication)	X	X	X	X	X	5	5
6.	GIS Analysis potential for EIM in Gaza strip	Summary statistics	X	X	X	X	X	5	5
		DSS	X	X	X	X	X	5	5
7.	Data needs for EIM in Gaza *level of data*	Sectorial level	X	X	X	-	X	4	5
		Network level	X	X	X	X	X	5	5
		Operational level	-	-	X	-	X	2	5
		Research level	-	X	X	-	-	2	0
8.	Types & aspects of inventory data	1. Structures data	-	-	X	X	X	3	5
		2. In-service monitoring & evaluation data	-	-	X	-	X	2	5
		3. Operation & maintenance data	-	-	-	X	X	2	5
		4. Usage history	X	X	X-	X	X	5	5
		5. Cost data	-	-		-	X	1	5
9.	*Source of data*	6. Customer bills	-	-	X	X	X	3	5
		7. Field survey	X	X	X	X	X	5	5
		8. Shared data with other organisations	X	X	X	X	-	4	5
		9. Remote sensing	-	X	-	-	-	1	0
		10. Real time data	-	-	-	-	X	1	0

No	Survey Component	Results	Organisation					Weight**	Model
			MOPIC	MEnA	PWA	MOLG	WU		
10.	Performance Modelling	Service and user rating	-	X	X	X	X	4	5
		Safety and sufficiency	-	-	X	-	X	2	5
		Physical condition	-	-	X	-	X	5	5
		Structural integrity	-	-	-	-	X	1	5
11.	Institutional placement of GIS, Gaza Strip	MEnA	-	X	-	-	-	1	5
		MOPIC	X	-	-	X	-	2	0
		PWA	-	-	-	-	-	0	0
		MLG	-	-	-	-	-	0	0
		WU	-	-	X	-	X	2	0
12.	Constraints impeding introduction of GIS	Financial	X	X	X	X	X	5	5
		Isolation and remoteness	X	X	X	X	X	5	5
		Adverse working conditions	X	X	X	X	X	5	5
		Polities, Social and Economic instability	-	-	X	X	X	3	5
		Hierarchical Organisational Structures	X	-	X	-	X	3	5
		Multiple Organisations							
13.	Ideal conditions for GIS	Adequate funding	X	X	X	X	X	5	5
		Adequate staff	X	X	X	X	X	5	5
		Adequate training	X	X	X	X	X	5	5
		adequate access to technology	X	X	X	X	X	5	5
		adequate access to data	X	X	X	X	X	5	5

*"**" Weight: is the summation of scores given by each organisation, "*"Model Weight; as seen by the researchess*
"X" ; agreed by the concerned organisation, disagreement/irrelevant to the concerned institution

5. Conclusions:

The GIS model for environmental infrastructure management in the Gaza Strip is a central issue to this research. A conceptual framework for implementing the GIS technology in the Gaza Strip has been designed accordingly.

The applicability of GIS in this context depends on the one hand on the tool's potential and on the other hand on the prevailing conditions. Therefore, the model is based on the potential of GIS in the Gaza Strip and on the conditions required for the GIS in the Gaza Strip to reach their potential.
The GIS/DSS model on the use of GIS/DSS for environmental infrastructure management in the Gaza Strip have been designed taking into consideration the existing institutional set up and GIS-related technical capabilities. It has been concluded that a central GIS/DSS centre is much more efficient than decentralised fragmental units.

7. GIS References:

- G.P. Clarke, M. Birkin and M. Clarke, (1999), "GIS as a Management Tool" , vol2, 2nd edition, pp 709-727, John Wiley
- Benderson , (1999), "GIS" , vol2, 2nd edition, pp 589-600, John Wiley Publ.
- Stan Aronoff, (1995), "Geographic Information Systems, A Management Perspective", WDL Publishers Ottawa, Canada.
- Cadoux- Hudson, (1994), "Geographic Information, the source book for GIS", D.R. Green and Taylor & Francis.
- Heather Campbell, (1991), "Impact of Geographic Information Systems on Local Government", Department of Town and Regional Planning, Faculty of Architectural Studies, the University of Sheffiled.
- A.C. woodfine, (1995), "Geographical Information Systems as Appropriate Technology in developing countries".