THE POTENTIAL OF A GIS-BASED SCOPING SYSTEM:

AN ISRAELI PROPOSAL AND CASE STUDY

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ABSTRACT

In the EIA life cycle, scoping is regarded as the most important stage for the quality of the entire process. Even though many EIA methods exist, only a few of them are specifically suited for scoping. Despite the well acknowledged potential of Geographic Information Systems (GIS) for EIA, and their seemingly widespread use (Joao & Fonseca,1996), the applicability of GIS for scoping has not been sufficiently analyzed. This paper advances a GIS-based scoping method, and discusses the conditions necessary for its utilization. Two specific issues are addressed: the ability of a GIS based system to identify the pertinent environmental effects on the basis of readily available information under stringent time and budget constraints; and the institutional infrastructure needed for such a system to operate effectively. These issues are analyzed in a case study conducted in Israel. In this case study the proposed GIS-based scoping system identified all the main effects found independently in a comprehensive EIS, as well as issues not analyzed in the EIS. A centralized institutional scoping structure, whereby EIS guidelines are issued by a single entity, is found to be important for the operation of such a system, as it can enjoy the economies of scale and scope involved in setting up and operating a GIS system for scoping purposes.

INTRODUCTION

In the two decades that have passed since the first legal requirements for scoping of environmental impacts were promulgated, scoping requirements have become commonplace. The requirement for scoping came as a response to the mounting criticism of early EISs in the U.S. (Black,1981). The main argument for the promulgation of scoping was to focus the EIS on the important decision making issues. Since the Council on Environmental Quality (CEQ) regulations requiring scoping first came into effect the idea of impact scoping spread quickly, and the scoping stage become an integral part of the EIA process (ECE,1987). Moreover, it is increasingly recognized that the effectiveness and quality of the entire EIA process depends primarily on the scoping stage (Kennedy & Ross, 1992). Unless accurate, quick and low cost scoping is carried out, one of two possible errors are likely to adversely affect the process. The first is that much effort will be wasted on analysis of issues which are later found to have no consequential impact or are unimportant from a decision making point of view. The second possible error occurs when an important environmental element is overlooked, and thus not incorporated into the EIA.

Since scoping is carried out at the beginning of the EIA process, and since impact evaluation cannot begin before completion of the scoping stage, scoping is usually carried out under stringent time and budget constraints. As a result, scoping must fulfill two contradictory requirements: good scoping must be comprehensive and complete, while on the other hand, it must be performed within a short time and with limited resources (ECE,1991). This contradiction determines the range and choice of scoping techniques.

Since EIA was first introduced in the NEPA legislation, many EIA techniques have been developed. Twelve years ago a United Nation Economic and Social Commission for Asia and the Pacific report (ESCAP, 1985) referred to over 100 different techniques for carrying out and implementing the entire EIA process. As a result, many techniques encapsulate a scoping method - either implicitly or (less common) explicitly. Most existing EIA/scoping techniques (such as matrices, checklists, networks and so on) are not explicitly spatial, that is, they are not based on geographic data bases and often do not make use of explicit geographical data. The only spatial technique that is widely used in EIA is the overlay technique developed by Ian McHarg some thirty years ago (McHarg, 1969). One reason for this lacuna is that spatial analysis was considered complex and data hungry, requiring substantial time and money resources (Munn, 1975). Consequently, spatial analysis was used primarily in the advanced stages of the EIA process and not for impact scoping.

In recent years two important developments have reduced the complexity and cost of spatial analysis. Firstly, the advent of user-friendly geographic information systems (GISs); and secondly, the improved quality and wider availability of spatial data sets. Consequently, such sets are now adequate for routine analysis (Batty, 1993).

Recent surveys of the use of GIS in EIA found that while GIS is widely utilized, its use is largely limited to the basic GIS functions such as map production, classic overlay or buffering (Joao, 1998). This utilization does not make full use of the spatial analysis and modeling capabilities of GIS (Joao & Fonseca, 1996). Noteworthy are some more complex, though sporadic reports on the uses of GIS for EIA - such as using GIS in complex modeling representation techniques (Schaller, 1990), or its potential as a repository for data and cumulative impact assessment (Johnston et al., 1988; Scott & Saulnier, 1993).

One factor that limits the usefulness of many existing EIA techniques is their tendency to be monolithic - they advance a method for conducting the entire EIA process and must be followed throughout the EIA life cycle from initiation to EIS publication. Moreover, such techniques usually apply to a limited set of projects, and to the attributes of a specific EIA system. In a critique of these techniques Lee (1988) asserts that many of them are not truly comprehensive, and that they fail to deal properly with all stages of the EIA. Consequently, he suggests that there is a need to use the “Tool box” approach, whereby a collection of methods and techniques are made available for each stage of the EIA. By doing so, the EIA analyst can choose the appropriate technique for the local circumstances (Lee, 1988). This suggestion is commensurate with the general trend from monolithic models to partial models, thus enabling better solutions to be found for local problems (Batty,1993).

The shift to a “tool box” approach requires that specific techniques suited for the scoping stage be identified and developed. Such techniques should allow the main effects to be identified (though not necessarily quantified) quickly, inexpensively, and often based on incomplete information.

The first question addressed in this paper is to what extent GIS can serve as a basis for such techniques. This question, however, is not merely a technical one. The use of GIS requires constant maintenance and incurs costs, therefore, the second and central question that this paper addresses is what are the institutional requirements for the effective use of GIS in the scoping stage.

To address these questions the paper first describes and evaluates a GIS based method proposed for scoping environmental impacts in Israel. The paper then goes on to discuss how widely such methods may be used. This is done by examining a general taxonomy of the institutional aspects of scoping. The Israeli EIA system is then described. A GIS-based scoping method is described followed by an outline of the case study on which this method was tested. In the final part of the paper the generality of the GIS approach is discussed.

SCOPING IN EIA SYSTEMS: A CLASSIFICATION

EIA and EIS are essentially tools geared to improving the decision making process by introducing the environmental implications of different actions at the planning stage, (Munn, 1975). hence, the form and structure of the EIA process is tightly coupled with the policy setting within which it is used. Thus, despite the seemingly common goal and roots of EIA processes, no two EIA systems are identical. As scoping has evolved often as an implicit and sometime informal stage, it is not surprising that there is a very wide variety of forms and procedures for conducting scoping. Nevertheless, it is possible to create a classification of different scoping methods.

Scoping systems can be differentiated according to two basic dimensions, or criteria. The first is the extent to which they are conducted according to an expert-based or a participatory approach; and the second the degree to which they are conducted by the project initiator (whether a public agency or a private entrepreneur) or a regulatory agency. In the U.S. for example, the scoping procedure of both Federal projects (affected by the CEQ regulations) and local projects (not affected by them) emphasizes the participation of stakeholders in the process, regardless of the level of their expertise. The scoping exercise tries to identify stakeholders` concerns, and assure that those concerns are later addressed in the EIS, thus reducing the probability of dispute over the project (Kennedy & Ross, 1992). In contrast, an expert-based system takes a public management approach, whereby the issues to be addressed are based on professional judgment[1]. This approach has the advantage of allowing for identification of issues that may not be widely known to current stakeholders, or may be of interest to groups that are not well represented among the current stakeholders (such as groups across jurisdictional boundaries or future generations).

The second dimension pertains to the question of who leads and makes the decisions in the scoping process. At one extreme, the scoping process can be within the full authority of a regulatory agency that stipulates what has to be addressed in the EIS. This agency can base its decision on expert opinion, or elicit the opinions and concerns from stakeholders. In this case the "ethical dilemma" of most EIA systems, where the proponent is responsible for the EIA process (Gilpin, 1995) is somewhat mitigated, as the proponents do not set the agenda for the EIS. At the other extreme, the scoping process can be the responsibility of the project initiator, public or

[1] For a recent discussion and analysis of the implications of taking this approach, in a different context see Montgomery and Nunn (1996).

private. They also base their decisions on either expert opinion or public input. These two dimensions are therefore orthogonal, at least conceptually.

In Figure 1, the two dimensions are depicted orthogonally, and the scoping systems of several countries are placed on the plane defined by the two dimensions. The horizontal axis depict the degree to which public input is elicited relative to the reliance on expert judgment, while the vertical axis shows the degree to which the decision rests with the project initiator relative to regulatory agencies.

[Figure 1 about here]

The top-right quadrant depicts EIA systems where scoping is the purview of regulatory agencies, relying primarily on expert judgment. This is the case in a significant number of countries. In Norway and Israel, for example, a professional team from the environmental authority is responsible for the scoping stage (ECE, 1991; Ministry of Environment, 1992). The combination of a regulatory agency led scoping system with a participatory process, the top-left quadrant, is rare. Actually, only the Netherlands has striven to include stakeholder input into a scoping process essentially dominated by a regulatory agency. However, also in the Dutch case the outcomes of public hearings are augmented by professional analysis of an independent EIA agency (ECE, 1991).

The bottom-right quadrant depicts systems where the project initiator leads the scoping process, and relies on expert judgment. Such systems are common in several western European countries. The most extreme case may be Flanders where the project initiator has the primary role, and tends to rely exclusively on the input provided by the professional consultants preparing the EIS (Devuyst et al., 1993). The bottom left quadrant depicts the more decentralized systems where the project initiators lead the scoping process by eliciting stakeholder participation to identify the concerns that should be addressed. The USA NEPA system is such a system (CEQ, 1978).

THE ISRAELI EIS AND SCOPING SYSTEM

EISs, introduced in the mid-Seventies, were formally incorporated into the Israeli Planning and Building Law in July 1982 (Rotenberg, 1986). Since then EISs have become part of the routine of land use planning within Israel (Brachya, 1993; Enosh, 1993). EIS is required either because the type of project is included in the list of project types defined in the regulations, or a planning commission (at the local, district or national level) has determined that the project might have substantial environmental effects, or one of the ministry representatives in the district commissions (where most decisions are made) has requested that an EIS be prepared.

To implement the EIS requirements the Ministry of Environment (MOE) has devised a structured procedure (Ministry of Environment, 1992)[2]. The first stages of this procedure form the Israeli version of scoping. After the decision that an EIS is required is made the relevant planning commission requests the 'environmental consultant' to provide it with guidelines for the EIS. The guidelines are a statutory document that stipulates the structure of the EIS, the environmental issues that should be evaluated as part of the EIS, and in some cases evaluation methods that should be used. Although the regulations state that the "environmental consultant" is the director general of the MOE, in practice the Department of Environmental Planning in the MOE is the unit responsible for the preparations of all EIS guidelines. The environmental planning department consults with other professional departments within the MOE, with Non Governmental Organizations (NGOs) and other local and regional authorities in order to determine which aspects and issues should be incorporated in the EIS. The complete guidelines are sent to the planning commission, and following its approval, forwarded to the developer. Usually, the environmental planning department uses previous guidelines for a similar project and adapts them to the specific circumstances of the project under review. Figure 2 summarizes the current scoping process in Israel, culminating in the issue of guidelines for an EIS.

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[2] For a complete description of the Israeli EIS process see Brachya (1993).

[Figure 2 about here]

In the taxonomy presented in Figure 1 the Israeli scoping process fits in the upper-right quadrant. It is done by a central regulatory agency, basing its decisions on the best available knowledge of its professionals.

In the 15 years that have passed since the EIS were incorporated into the planning legislation, more than 300 guidelines have been issued by the MOE. In recent years, about 50 guidelines have been issued every year. These guidelines encompass a wide variety of issues. However, this process does not apply equally to all types of projects. It does not pertain to residential projects – an omission with important macro-spatial implications – it has also been shown to be liable to manipulations by the district commissions, as a function of power relations within them (Feitelson, 1996). These limitations do not detract, however, from the importance of EISs within the Israeli planning system, as they have succeeded in improving the overall EIA process conducted within this system (Brachya, 1993; Rotenberg, 1992).

Before turning to the description of the scoping method that was developed in the Israeli context, a short description of the use of GIS in EIA is given. For a comprehensive discussion see Joao (1998).

THE INCORPORATION OF GIS IN EIA SYSTEMS

Geographical Information Systems (GIS) are computer systems that can store, integrate, analyze and display spatial data (Joao & Fonseca,1996). The first systems evolved in the late sixties, and by the mid seventies were already being used for EIA. The overlay technique mentioned above was adapted to a computerized environment by 1972 and used for siting power lines and roads (Munn, 1975). It is noteworthy that one of the applications of the so called "first GIS" (Canada GIS or CGIS) was in the preparation of an EIS for a dam on the river Thames in the late seventies. Yet this application was limited. As Griffith (1980, P. 22) reports, the information from CGIS was used "to obtain an understanding of the association between agricultural and recreational land utilization and the project".

Following improvements in GIS systems they have been widely used for EIA in recent years, however, these applications have not made full use of current GIS capabilities (Joao, 1998). This may reflect the lack of comprehension of GIS capabilities by EIA practitioners. For example, in a recent major EIA textbook (Canter, 1996) GIS is mentioned only as a tool for land use and soil impact evaluation. Such oversights may contribute also to the lack of awareness of GIS capabilities within organizations staffed by EIA practitioners.

The fact that GIS is not used in practice to the extent that it could be used in principle may also be the due to a number of limitations of the GIS. Several such limitations were noted in a recent survey conducted by Joao and Fonseca (1996). The first is the substantial time and cost required for setting up a GIS, compiling the necessary data and analyzing the system's output. These well-known features create economies of scale in the use of GISs (Huxhold & Levinsohn, 1995). Such economies may be of particular relevance for the use of GIS for EIA, as in many cases EIAs are conducted by private consultants operating in a highly competitive market. In such circumstances EIAs tend to be relatively low-budget projects that may not create the necessary surplus to fund the fixed cost of GIS. This may be an even greater liability in the case of scoping, if conducted separately from the EIA process, as scoping would need to be conducted within tighter cost and time constraints than analysis at the impact evaluation stage.

A second factor that raises the fixed cost of GIS is the need for specialized personnel. High quality training and technical expertise are needed to operate a GIS and to maintain it. Consequently, only relatively large organizations can successfully operate and maintain a GIS. When using GIS for EIA the personnel would need to be versed not only in the technical side of GIS operation and maintenance, but also in the environmental issues that it would have to address.

A third feature of GIS that hinders its use for EIA is the lack of digital data, the cost of such data, and often it's level of accuracy. In several countries, such as the UK and Israel, national mapping agencies charge high rates for digital data sets that are a crucial base for impact analysis. This reduces the possibilities for using GIS for low-cost small-scale projects, such as local EIAs or impact scoping. EISs are legal documents, thus accuracy and reliability of data are of particular importance in an EIS context (Joao and Fonseca, 1996). Since EIA is a multidisciplinary process by nature, the GIS data base is usually based on various sources with different levels of accuracy and reliability, thus increasing the data accuracy problem. Yet, many GISs are not accurate enough for legal purposes. There are several reasons for the inaccuracies, such as: limitations of the photogrammetric process; errors in the process of digitizing existing maps; inaccuracies inherent in the maps; the incorporation and use of maps of different scales; different levels of cartographic representation and cartographic generalization[3] .

In summary, while the potential of GIS for EIA analyses is well-known, and GIS has been used for EIA, the actual applications of GIS have not made full use of the analytical capabilities of GIS. However, such use would require a higher level of expertise and probably higher cost. At present, such advances appear to be hampered by the lack of awareness by many practitioners on the one hand, and by the high fixed costs, data accuracy and reliability problems of GIS, on the other. These problems can be expected to be an especially significant constraint on the use of GIS for scoping, given the stringent time and cost constraints under which scoping needs to be done.

A GIS BASED SCOPING PROPOSAL WITHIN THE ISRAELI CONTEXT

The GIS based scoping technique proposed for Israel is described in Figure 3. It is based on two databases: a thematic database, which stores links between environment elements and the

[3] For a comprehensive analysis of the sources of inaccuracies in GIS see Burrough (1986).

potential impact of proposed projects using the checklist metaphor; and a spatial database, which contains the spatial data sets. The sources for those data sets can be physical data (such as topographical data in the form of a Digital Elevation Model - DEM), coverage data (buildings, infrastructure etc.), ecological data (sensitive species) and results of environmental studies (such as aquifer sensitivity).

[Figure 3 about here]

Checklists are a well established mechanism and widely used for EIA, especially for screening and scoping (Bisset,1987). In the proposed system, the concept of checklists is used to relate project type to it's possible environmental impacts, and the environmental impacts with the affected environmental elements. Next, each impact-environmental element pair is related to the appropriate spatial analysis technique. Such techniques could include overlay of a set of predefined layers, spatial statistical analysis, etc. It should be noted, that spatial analysis might not be adequate or possible, due to lack of a well defined model, lack of data or in cases where the impact and component relations are a-spatial (as in many socioeconomic impacts). In these cases the checklist can include a remark the impact-element pair and instruct that the issue should be in the EIS. Finally, for several spatial analysis techniques, if the decision whether the issue should be incorporated in the EIS is based on comparing the results with a predefined threshold, that threshold is stored as another relation. The thresholds are based on existing regulations (as in the noise exposure level for public buildings) or an index that relates to the spatial analysis technique (for example slope percentage in the evaluation of the need for cut and fill operations). As the information for these checklists can be represented by a set of relations, it is possible to implement it in any commercial Relational Data Base Management System (RDBMS). In the proposed system the thematic database hold this information.

The mechanism proposed for scoping impacts is based on a computerized checklist in which the user selects the appropriate option through menus, scrolled lists etc. The user uses the software interface to scroll through the lists of possible impacts and affected environment elements, and can select and mark the relations that might be relevant for the specific project.

Some relations might be set automatically - according to the project's type (for example, NoX emissions analysis is a compulsory part of roads EIS). This selection methodology is similar to the one developed as part of previous research by Antunes and Camara (1992). It is possible to construct the checklists according to the existing EIS practice and according to the regulations.

The scoping process would usually require that a basic data set be received from the developer. This data set will include the spatial properties of the project - the general location and layout - and data on the physical attributes of the project - such as the type of energy source for a power station. Since the use of software packages for mapping is commonplace in Israel, the MOE can demand that the spatial data set be submitted in a digital form. For the physical attributes data, the MOE will design a specific form for every project type. However, the data set that a developer can be expected to submit at this stage would be rather general as the finer details of proposed activities are usually determined only in the detailed planning stage, and most developers would not undertake such expensive detailed planning before they have some assurance that the project is likely to proceed and a good idea of what may be required of them.

The operator (who should have knowledge about the proper use of GIS and in EIS guidelines preparation) would use the checklist to determine which spatial analysis techniques are suitable for the current type of project. The next stage will be the implementation of the computerized analysis by selecting the analysis procedure and applying it the developer's data set against the appropriate layers from the spatial database. For impacts that are threshold dependent, the output is compared against the thresholds and the results will help the operator in the decision to include the topic in the guidelines. Another role of the output maps is to help the MOE in defining the spatial extent of the EIA - by presenting the layout of possible affected sites (such as natural reserves, sensitive facilities etc.) and the maximum extent to which possible impacts may reach (such as noise level or air pollution).

Since the basic checklist mechanism has proven successful in other research (Antunes & Camara, 1992) and is now incorporated into a commercial system called Calyx (Webb, 1995) we concentrated on the GIS modeling component of the proposed system. This is the main new component introduced into the selection mechanism.

In order to evaluate the contribution of a GIS based scoping technique, from a technical perspective, a case study has been tested with a technique similar to the proposed one. Since the largest number of EIS guidelines in Israel were prepared for roads (Ministry of Environment, 1992), the proposed technique was tested on a planned highway in central Israel. The selected project is sited in the central part of Israel, in the outer ring of the Tel-Aviv metropolitan area. The proposed road passes near an urban area, agricultural settlements and open land. This combination is well suited for checking a relatively wide variety of environmental issues. As a full EIS was prepared for this road, this allowed us to compare the issues identified through the GIS based scoping technique with those identified and analyzed in the comprehensive EIS, and thus verify the extent to which the GIS-based scoping identifies the main issues.

The reference database was based on the currently available digital sources in the Israeli Mapping Agency, the Central Bureau of Statistics and in environmental authorities such as the Natural Reserve Authority, the MOE, the GIS center at the Hebrew University and the Jewish National Fund (JNF) which serves as Israel's forestry bureau. It should be noted, that these data sources are similar to those that were used during the EIA. After digitizing the project map (taken from the EIS), spatial analysis techniques were used for several possible generic impacts of roads: noise, visual impact, land use effects, cut and fill sites and effects on water resources. The spatial analysis techniques include a calculated variable width buffer based on the IUCZ model (Canter, 1996). This buffer was overlaid with the sensitive building layer - taken from the classification of buildings that is part of the census maps. Traffic forecasts that were available as a background for the road's plans were used as a basis for the noise impact analysis. Another example of spatial analysis technique was used to predict the cut and fill sites by extracting the height value from the DEM and through a multiple regression on the longitude and latitude the average slope was calculated. The average slope layer was overlaid over the original DEM and the sites that were below the "average" slope were classified as fill sites, while sites above the average were calculated as cut sites. All techniques were based on simple evaluation methods, that can be implemented on the basis of readily available tools in a commercial GIS package (ARC/INFO).

[Table 1 about here]

The results of comparing the issues identified through the GIS based scoping effort with those identified in the comprehensive EIS are summarized in Table 1. Several aspects of this table are worth further discussion:

Firstly, the results show that the GIS based scoping study identified several issues not addressed in the EIS - such as the possible impact on a water reservoir in the vicinity of the road. Secondly, the results of the GIS based scoping effort provide clearer and more specific guidelines with regard to several issues than the guidelines prepared by the MOE for the actual EIS. For example, the EIS guidelines missed one rural settlement, due to human error in the specification of noise measurement and assessment points. In the GIS version the areas where the noise buffer intersect built up areas are identified automatically, thus reducing the possibility of such an error. Another example is the possibility in the GIS to identify the areas from which the proposed road may be seen, which thus suffer from a loss of visual amenity. This allow for better guidelines focusing on the most sensitive points when asking the developer to provide a landscape analysis of the road. While the scoping study did not identify some impacts (such as noise) as accurately as the comprehensive EIS, it did not overlook any of the issues identified in the EIS.

Another important finding in the case study was that by combining several digitized data sources - including a national plan, regional plan and the information from the Natural Reserve Authority, discrepancies were found with regard to the boundaries of a natural reserve. By overlying several layers from different resources that refer to the reserve, it was found that the boundaries do not match. Although the sources for the discrepancies were not identified, it is clear that in a non-GIS environment it is unlikely that such a discrepancy will be identified because of the complexity of non computerized overlay. Such a discrepancy can serve as a basis for a more detailed inquiry about the exact borders of the reserve, which is a positive externality of the scoping process. It should be noted that the EIS ignored this discrepancy.

While the case study also helped identify some technical issues regarding the practical sides of GIS modeling within the context of EIA scoping, and raised some issues with regard to specific gaps in the Israeli data bases (in particular it helped focus the attention on the lack of data on fauna and on the implications of inaccuracies of the DEM layer) these are largely beyond the scope of this paper, and are described elsewhere (Haklay et al., 1997).

DISCUSSION

In discussing the Israeli case there is a need to differentiate between the technical and institutional aspects of the proposed system.

From the technical perspective the results of the case study suggest that a GIS based analysis can improve the quality of the scoping effort. The GIS based effort identified several issues and sites of concern not identified in the regular scoping effort that preceded the EIS for the road that was examined. It seems, therefore, that GIS based scoping may help in reducing the probability of ignoring an important environmental issue, or overlooking potential effects of a specific site. The analytic capabilities of the GIS also allow for more specific guidelines, as was shown in the examples above. Moreover, since the data that was used in the GIS analysis came from several environmental stakeholders in Israel (such as the Natural Reserve Authority), it represents their combined knowledge and interests regarding the project site surroundings. Moreover, by using multiple sources it was possible to identify a wider set of issues than those in the purview of any single authority or stakeholder, as well as discrepancies regarding various natural resources.

The use of GIS has an additional benefit in systems based on expert knowledge. By accumulating the data in a single repository, it makes the quality of scoping efforts less susceptible to personnel changes in the MOE. In essence, the proposed system introduces a central “knowledge base” that can store current practice.

A GIS based scoping procedure also improves the visibility of the scoping stage to the developer. In a “best available knowledge” system, some developers may always argue that their projects have been judged in a stricter manner than other projects. A structured GIS based procedure can supply a “standard scale” by which all projects are measured.

From an institutional perspective the ability to conduct scoping on the basis of a GIS, separately from the conduct of the EIS, is premised on the fact that all scoping is carried out by one central body - the planning department of the MOE. This body also maintains the GIS which serves as the repository for the two central databases shown in Figure 3. In this situation, most of the problems associated with the use of GIS for this purpose, identified earlier, can be overcome. The costs of start up, system maintenance, database construction and purchase of hardware and software are spread over the entire EIA system, and thus need not be borne by a single project. Moreover, the MOE does not operate in a competitive environment such as a private consultant, and thus has the necessary surplus to build up a GIS, even if the return period of the investment is long.

A second important factor is the availability of digital data. The results of our research suggest that much of the necessary data is already available in Israel. This is a result of rising GIS awareness in most environmental bodies in Israel. For example, in the last 7 years the MOE GIS unit has been operating as an integral part of the environmental planning department and in this time the environmental database necessary for scoping analysis has been created.

Two additional factors contribute to the feasibility of the proposed method in Israel. The first is the emergence and dissemination of user friendly GIS software, and the second the rapid growth in the number of professional who are “GIS literate”. All functions that were used in our research are currently available in a desktop package (ArcView GIS 3.0). GIS courses are now part of almost every university curriculum. For example, in the graduate program for environmental planning, management and policy at the Geography Department of the Hebrew University of Jerusalem (with over 60 students enrolled), “Introduction to GIS” is a mandatory course and many students take advanced GIS courses. Those courses are using the ArcView package, mentioned above. Increasingly such courses are also taken by undergraduate students. Similar courses are also available to students in other departments and specializations.

Naturally, not all of these enabling factors exist elsewhere. In many developing countries the level of digitized data may be inadequate, and the awareness of GIS capabilities and numbers of GIS literate professionals may be insufficient. Still, some of these may be overcome with the help of international aid and international consultants, if adequate funding were available.

A more serious problem may be finding the appropriate institutional lodging for the centralized GIS that would serve for scoping. While in some countries there is a central EIA unit, such as in the Netherlands and in Norway, in other systems no such unit exists. In such situations it may be difficult to find a center for a GIS that will be used primarily for scoping, and it is likely that GIS established for different reasons would be used also for scoping. However, if these are commercially-based they may be sensitive to the level of transaction costs involved in data base sharing, thus reducing the likelihood of such sharing. As such sharing has proved valuable in our case study, this may detract from the quality of GIS based commercially-based scoping.

Finally, the results of our research show that even low quality data can be used for scoping - provided that this aspect is carefully considered during the analysis. The main reason for this, is that the scoping exercise focuses on the indicators for environmental impacts and does not involve fine scale modeling. For example, scarce species observations reports - even with questionable accuracy - can serve as an indicator for the existence of those species in the project area.

Another role of uncertain data sources is to indicate and locate areas of uncertainty in the project area and to instruct that the EIS should address them. Such uncertainty was found in the case study in respect to a natural reserve boundary (see table 1). Nevertheless, some data layers that are used throughout the spatial analysis (such as the DEM) must be accurate and up-to-date.

CONCLUSIONS

This paper suggests that GIS can serve as a basis for scoping of environmental effects, despite the high initial costs of GIS, the inaccuracy of some layers of digitized data, and the severe time and money constraints under which scoping is carried out. From a technical perspective, the case study reported here shows that once the basic data bases are available a GIS based system may indeed provide better targeted guidelines for EIS, and reduce the probability of either unnecessary site-specific data being collected or important effects being overlooked. It should be noted that while several data layers need to be accurate - e.g. it is imperative that the DEM is of the highest quality as it used in many environmental models and an error in it will propagate throughout the system, - low quality data can augment the database and be used to prevent the second possible error of overlooking a major environmental component. This can be done in a relatively transparent manner, at least in comparison to other expert-based systems, and with lower risk than at later stages - as once a possible effect is identified it will be further scrutinized in the EIS.

The main factor that may limit the application of GIS based scoping is the structural-institutional set-up of EIA systems. As GIS involve substantial economies of scale and scope, their usefulness is contingent on the ability to bear the fixed costs of such systems, and the extent to which such costs can be distributed over a large number of EIS guidelines. In this respect centralized structures, whereby a single regulatory agency prepares or directs all scoping activities, and is ultimately responsible for issuing EIS guidelines, have an advantage. In such situations data can accumulate over time in a single repository maintained by (or for) such an agency, that would thus also be able to introduce feedback as results come back from EISs prepared according to the guidelines issued by the agency. Such a unit can also have the necessary technical and professional expertise to use a GIS successfully, and increasingly to use the more sophisticated capabilities of a GIS. Countries with an appropriate institutional setup include, in addition to Israel, the Netherlands and Norway. In such situations, the availability of an 'objective' procedure that uses the same data bases and same techniques for different projects may help the EIA units stave off pressures by stakeholders to modify guidelines, such as those noted by Feitelson (1996).

While a centralized regulatory agency may not be a prerequisite for implementing a GIS-based scoping system, such systems may be less applicable in cases where the emphasis is on stakeholder input to project initiators, as in the U.S.. Even if the sufficiently large project initiating agencies (such as the Corps of Engineers in the U.S.) or consulting firms do have the economies of scale and scope to maintain the necessary GIS systems, these systems are not likely to portray stakeholder interests.

This study focused on the possibility of using GIS as a basis for scoping at the project level. It did not address issues pertaining to policy level strategic impact analysis, or ways by which a GIS based scoping may affect decision making. These are issues that need further work. This study, however, has shown that within the limited scope of project level EIA and where appropriate institutional structures exist, GIS can serve as an important and highly useful tool for environmental impact scoping, and that this potential has not yet been tapped.

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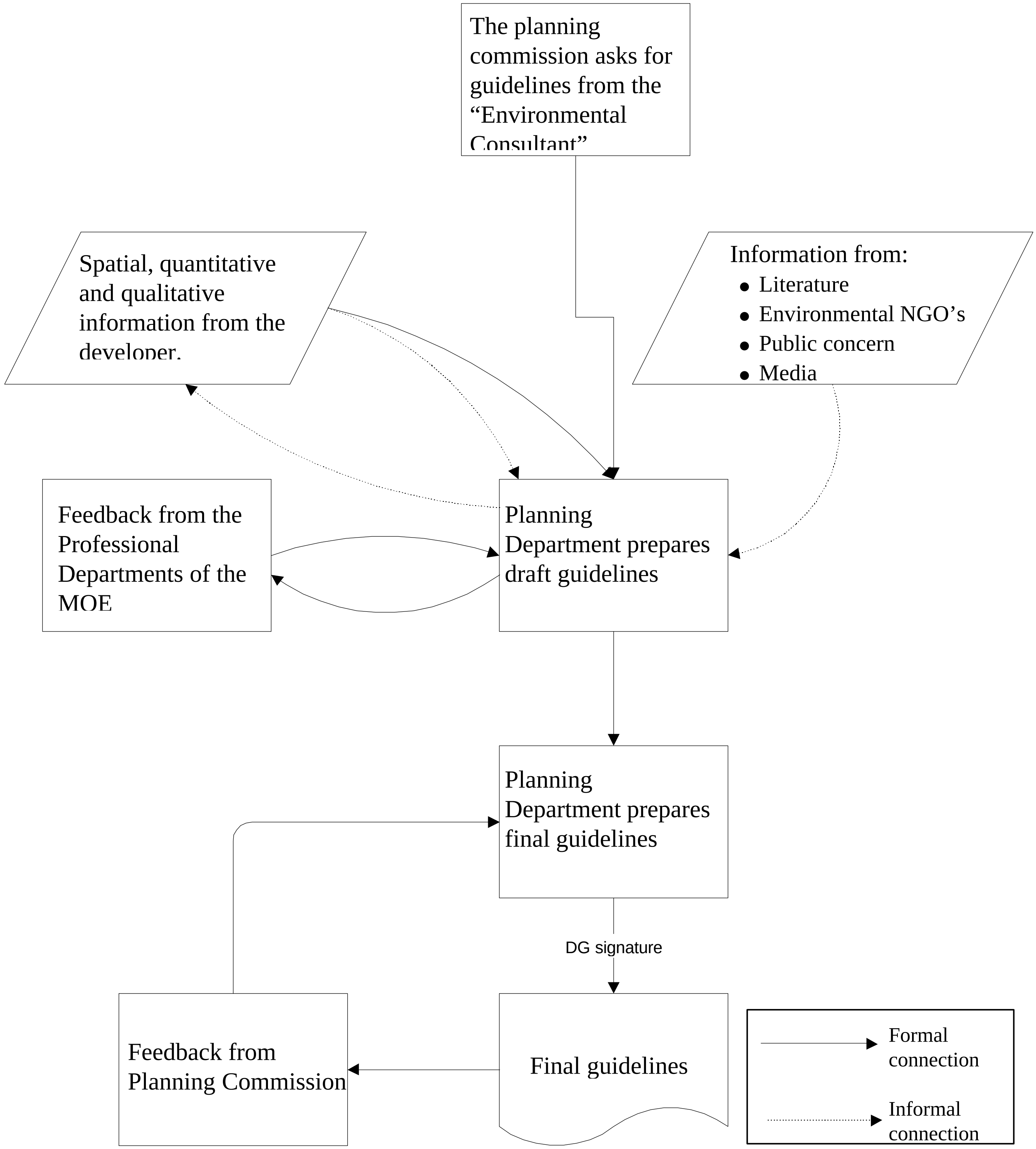
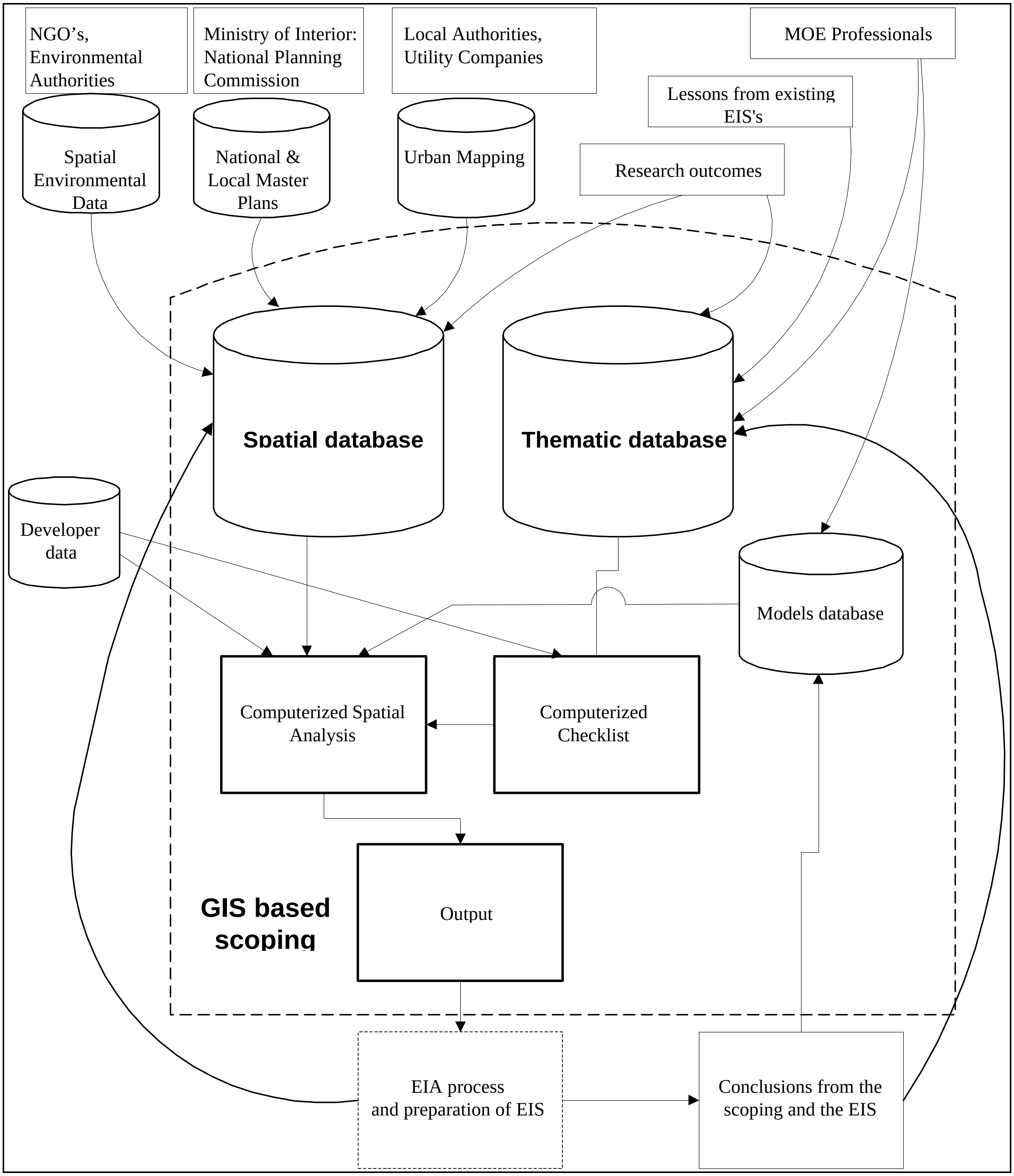
LIST OF FIGURE AND TABLE CAPTIONS

	Public input		Expert judgment
Regulatory agency		The Netherlands	Zimbabwe Uganda Israel Norway Canada
Project initiator	USA		Italy France UK Flanders


The planning commission asks for guidelines from the "Environmental Consultant"
Spatial, quantitative and qualitative information from the developer.
Information from:
Literature
Environmental NGO's
Public concern
Media
Feedback from the Professional Departments of the MOE
Planning Department prepares draft guidelines
Planning Department prepares final guidelines
DG signature
Feedback from Planning Commission
Final guidelines
Formal connection
Informal connection


NGO's, Environmental Authorities
Ministry of Interior: National Planning Commission
Local Authorities, Utility Companies
MOE Professionals
Lessons from existing EIS's
Research outcomes
Spatial Environmental Data
National & Local Master Plans
Urban Mapping
Spatial database
Thematic database
Developer data
Models database
Computerized Spatial Analysis
Computerized Checklist
GIS based scoping
Output
EIA process and preparation of EIS
Conclusions from the scoping and the EIS

Topic	GIS Based Scoping Outcome	EIS Results	Notes
Effects on Land Use Plans	The proposed plan split the municipal area of two rural settlements.	The EIS states that a proper passageway will be defined in due course.	
	For the part of the plan where detailed mapping exists, all buildings that should be demolished were identified	The buildings that should be demolished due to the proposed plan were identified using an aerial photo.	
Effects on Open Land	A landscape reserve was identified through a national level master plan	The landscape reserve identified through a regional master plan	
	A nature reserve was identified. Furthermore, uncertainty about its precise border was discovered.	The nature reserve is not mentioned in the current EIS.	The EIS editor claimed that it should be dealt with in another EIS for a different part of the road.
	A man-made plantation site was identified.	In the same area, a small grove of eucalyptus was identified in the flora research.	
Land and Soil	Soil types were identified on the base of existing survey material.	Soil type were identified during a local survey.	Though the types match, there is a shift in borders.
	Cut and fill sites were identified in a simplified model.	Cut and fill sites were identified in the EIS (by a civil engineer) .	All but one site were matched.
Hydrology	Possible contamination of a local reservoir.	The EIS ignores this subject.	The EIS editor stated that the road is not a contaminating body.
	The local watersheds were identified using a Digital Terrain Model (DTM)	The local watersheds were identified in a local survey	The DTM forecast was inaccurate, due to the poor quality of the DTM data source.
Noise	Public buildings (school, hospitals etc.) in the vicinity of the proposed road were identified.	The guidelines order each probe site. By mistake, the guidelines did not include one settlement.	
	Noise levels were identified using the IUCZ model (Canter, 1996)	Noise levels were predicted with special purpose software.	A deviation of 5 to 10 db(A) between the two model, as result of simplification of the scoping model.
Visual Amenity	Several sites were suggested. The sites are characterized by being sensitive to micro alignment changes in the road scheme.	Several arbitrary sites were chosen to depict the view of the road.	Current guidelines do not force the EIS to give the view of the road from a specific site.
Flora	Several protected species were identified on the base of ecological data.	Several protected species were identified in a local survey.	Survey results match the GIS data.