Sustainable Cities Programme (SCP)

Building an Environmental Management Information System (EMIS)

United Nations Human Settlements Programme (UN-HABITAT)
United Nation Environment Programme (UNEP)

UNEP   UN-HABITAT

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The SCP Source Book Series

Building an Environmental Management Information System (EMIS)

Handbook with Toolkit

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What's on the EMIS CD-ROM

The EMIS CD ROM will contain the following:

1. EMIS handbook
2. Software
3. Maplibrary
4. Images and Logos
5. EMIS presentations
6. Background documents

List of Acronyms

EMF Environmental Management Framework
EMIS Environmental Management Information System
EPM Environmental Planning and Management
GIS Geographic Information System
GPS Global Positioning System
PGIS Participatory-GIS
SCP Sustainable Cities Programme
TSU Technical Support Unit

About the SCP Source Book Series

The SCP Source Book Series provides detailed operational guidance for the benefit of people implementing city-level projects within the Sustainable Cities Programme. Each volume in the Series covers either an important part of the SCP process or an important topic which is central to urban environmental planning and management. The volumes currently being produced (1999) include the following:

Volume 1: Preparing the SCP Environmental Profile
Volume 2: Organising and Running the City Consultation
Volume 3: Establishing and Supporting the Working Group Process
Volume 4: Formulating Issue-Specific Strategies and Action Plans
Volume 5: Institutionalising the EPM Process
Volume 6: Urban Air Quality Management Handbook
Volume 7: Building an Environmental Management Information Systems
Volume 8: Integrating Gender Responsiveness in EPM
Volume 9: Measuring Progress in EPM[1]

[1] In general, the SCP Source Books are developed based on city experiences or are developed as operational tools which will then be fine-tuned, adapted and applied in cities. An SCP Source Book can be process-specific (Volumes 1 - 5), topic-specific (Volume 6) or of a cross-cutting nature (Volumes 7, 8 and 9)

The emphasis in this Series is on **relevance** and **realism** These volumes are the *product of experience* - field-level experience gained over the past eight years in SCP city projects around the world. Precisely because it is drawn from the lessons of experience in so many different cities, the information contained in these volumes is not city-specific but can readily be adapted and applied to the tasks of urban environmental planning and management (EPM) in virtually any city context.

The Sustainable Cities Programme (SCP) is a global programme of the United Nations Centre for Human Settlements (UNCHS - Habitat) and the United Nations Environment Programme (UNEP). It is the leading technical cooperation programme in the field of urban environmental planning and management and is the principal activity of the United Nations system for operationalising sustainable urban development and thus contributing to implementation of *the* globally-agreed *Agenda 21* and *Habitat Agenda*.

Further information about the SCP Source Book Series, or about the Sustainable Cities Programme itself, may be obtained from:
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User's Guide

This handbook is divided into three parts. Each part has a different purpose and is designed for a different audience.

Part A – Introduction and Overview

Part A provides a general description of the Environmental Management Information System (EMIS), explaining its role and purpose in urban management. Part A gives a brief overview of the various ways an EMIS can be used, focusing in particular on how the system can be used in the partner cities of the Sustainable Cities Programme (SCP). This section of the book is designed for decision-makers and urban managers involved in the Environmental Planning and Management (EPM) process and for readers with a general interest in the EMIS concept.

Part B – The Guide: Building an Environmental Management Information System (EMIS) Step by Step

Part B is the main body of the handbook. It explains how an EMIS is established, and gives step-by-step instructions for building the system. The explanation is detailed and systematic, and is aimed at the professionals and practitioners who will be using the EMIS on a daily basis. Part B also contains practical advice and tips drawn from experiences in SCP partner cities. Part B is designed as a reference guidebook which project staff and partners can consult again and again.

Part C – Toolkit

The Toolkit offers examples which can be applied immediately to the process of building the EMIS. For instance, Part C contains sample Terms of Reference for contractors and consultants, information on organising support for the system, and step-by-step descriptions for preparing databases and maps. This material is very useful during the EMIS development process. It is designed to save the time and energy of the project staff, and it also ensures a consistency of approach. Part C also includes useful suggestions for further reading, and names and addresses of useful contacts.

The EMIS Handbook and Toolkit is also published on a CD-ROM, which you will find at the back of the EMIS book. This CD also contains additional tools, available in electronic format only.

To get the best from this Handbook and Toolkit, users should have a good understanding of the overall Environmental Planning and Management (EPM) process, of which the EMIS is only a part. It is therefore strongly advised that users familiarise themselves with the SCP Process Source Books and related background material. These materials can be downloaded from the SCP website at www.unhabitat.org/scp, or ordered directly from the Programme.

Part A

Introduction and Overview

Part A provides a general description of the Environmental Management Information System (EMIS), explaining its role and purpose in urban management. It gives a brief overview of the various ways an EMIS can be used, focusing in particular on how the system can be used in the partner cities of the Sustainable Cities Programme (SCP).

A1
Cities and the environment

Cities play a vital role in social and economic development. Efficient and productive cities are essential for national economic growth, and, equally, strong urban economies are essential for generating the resources needed for public and private investments in infrastructure, education and health, improved living conditions and poverty alleviation.

Unfortunately, the development potential of cities is all too often crippled by environmental deterioration. Aside from its obvious effects on human health and well being (especially of the poor), environmental degradation impedes economic development. For development achievements to be truly "sustainable", cities must focus on balancing the needs and pressures of urban growth and development with the opportunities and constraints of the urban environment.

Environmental deterioration is not inevitable. Although many cities – perhaps even most – are still suffering severe environmental and economic damage, there are encouraging signs. Some cities are learning how to better plan and more effectively manage the process of urban development, avoiding or alleviating environmental problems while realising the positive potentials of city growth and change.

All development ultimately depends on environmental goods and services: the management of these resources is therefore an integral concern in urban development planning and management. However, the tools available to decision-makers for influencing development towards optimal and sustainable use of environmental resources are limited. To be effective, they must be applied in a consistent and co-ordinated fashion. Environmental resource management uses information to reconcile competing interests (i.e. environmental policy co-ordination) and to support development decision-making (i.e. policy implementation).

A2
The role of information in planning and management

All planning and management activities require information. The challenge is (a) to determine what data and information is needed; (b) to find out if this already exists and where; (c) how to get hold of it if it exists, and how to collect it if it does not; (d) how to store this information in easily accessible and referenced form; (e) how to interpret the data, resolve questions of quality, contradictions and incompleteness; (f) how to determine who needs the information, when and in what form(s); and (g) how to disseminate it as required.

If these steps are formalised, institutionalised and made sustainable, one can talk of an information system rather than an ad hoc data gathering exercise. By formalised, we mean standardised and explicit procedures and formats, which at the same time are flexible and not rigid; by institutionalised, we refer to the integration of the system into a permanent organisational structure, independent of any critical individual input; by sustained we mean that the system receives ongoing support in the form of necessary resources (funding, staffing, etc.) and "political" backing, that its services are actively sought, and that it satisfies this demand.

Management Information Systems provide concise, to-the-point and timely information which is directly usable by decision-makers in making decisions or formulating actions. The key words are concise: a decision-maker usually is very busy, and does not have time to assimilate more than a page or two at any given time; to-the-point: the manager wants to know what the information means and what she or he can do

with it; timely: if information is not available when decisions are taken, then it serves no purpose; it is better to provide partial information in time, rather than complete information which comes too late; and usable: the information has to be formulated in a way that the intended users can understand and relate to, especially as these users are generally non-specialists.

A3

How an Environmental Management Information System (EMIS) supports better urban management

Urban managers are confronted almost on a daily basis with a number of recurring questions. These questions include: Which areas are available for city expansion? Where can we establish new housing areas? How can we revive certain parts of our city? How can we improve health and recreational conditions for our citizens? Where are the flood-prone areas? How can we stop air pollution in various parts of the city? To which areas shall we guide investors? What are the consequences of building a shopping centre at a particular site? Where can service delivery be improved or expanded?

All these questions relate to the planning and management of space in the city, highlighting the importance of spatial information in urban planning and management. The answers have to be geographically linked. This Handbook aims to help urban managers to give more accurate answers to these typical questions, by improving their capacity to address the spatial aspects of an Environmental Planning and Management process.

The questions have three typical characteristics. They

- are asked frequently;
- have long-term importance; and
- are cross-sectoral in nature.

Spatial information about a city is usually held in several different public institutions, according to their different work areas and specialisations. Data storage systems often differ from institution to institution, making it difficult to compare and combine information. In addition, while typical routine urban management questions refer to specific areas in the city, the way spatial data is stored often makes it impossible to relate the information to specific areas. This means that in answering routine urban management questions, usually only some of the information about the consequences of a management decision has been taken into consideration – only a few possible solutions are considered and assessed. Sometimes this approach works out nicely, but sometimes it turns out to be a very costly decision for developing the city. However, providing a comprehensive answer to typical routine questions may take several days, if not weeks, and in many cases potential investors will by then have turned around to look for better options by themselves.

Example: Lack of spatial understanding leads to poor decision-making:

During the 1970s, the city of Lagos built a road through a wetlands area. This route was chosen because the costs for the plots in that area were very low. This road opened up access to a whole new area in the wetlands, leading to the spontaneous development of housing areas. The city then had to provide more infrastructure such as power, water and a sewer system. This infrastructure was difficult to build, and therefore expensive. When these expenses were added to the initial cost of building the road, this road became by far the most expensive road ever built in Lagos. This example shows the importance of establishing a system of knowledge and information to help decision-makers to avoid making the wrong decisions.

An Environmental Management Information System (EMIS) consists of formalised steps to capture environmental information, and fixed procedures to retrieve it. An EMIS includes the collection of information about the various environmental issues facing a particular city, supports the Issue-Specific Working Group process, continues by supporting strategy formulation and action planning, including mapping, and last but not least covers the gathering of information necessary for institutionalisation of the EPM process. To reach sound solutions in urban management, the EPM process offers an approach for inter-departmental and inter-institutional co-ordination of information through a participatory working method. Therefore, the EMIS is by its nature a participatory information system for managing the collective know-how of relevant stakeholders. Issue-specific Working Groups are the main providers and users of spatial information, and are supported by mapping professionals, cartographers, surveyors and experts in geographical information systems (GIS). EMIS information is stored in archives, databases and maps.

Some short definitions of a Geographic Information System (GIS)

An Information System (IS) stores collected data. This data can be up-dated and manipulated and finally be displayed. In general, an IS stores data about one thematic area. A Bank Information System, for example, stores data about the bank's customers, accounts and transactions.

A Geographical Information Systems (GIS) works with spatial data. It is therefore a specific information system. A GIS has four components: Hardware, Software, Spatial data and Personnel.

Hardware (i.e. Computer, GPS, Scanner, Digitizer, Printer)

Software (i.e. ESRI's ArcView, Integraph's GeoMedia, MapInfo)

Spatial data (i.e. satellite images, routes, rivers, land use data, position of landfill sites)

Personnel (i.e. GIS Officer, GIS Assistant)

As any Information System, a Geographical Information System consists of four phases, the EMAP phases:

Entry (record, prepare, capture)

Manage (store, maintain, update, integrate)

Analyze (manipulate, model)

Present (visualize, display)

For more background information about GIS please use Reference Material A – Further Readings

EMIS is designed to link dispersed data about urban and environmental issues to a series of different types of maps about a particular area or even city-wide. This linkage allows users to combine, query and analyse all this information in an area-specific way and therefore to get more precise answers for routine questions. The proper set-up and operation of the system will – ideally – generate a comprehensive response for a routine question within few hours. Using an EMIS to answer routine questions, many traditional drawbacks, such as dispersed data, incompatible data formats and the sheer volume of data can be overcome.

As the EMIS is a tool for participatory urban environmental management, it concentrates on the interaction between environmental resources and hazards, and development activities. The system is designed to illustrate the various possible results of environment-development interactions. For example, establishing an EMIS in a SCP partner city supports a better understanding of environment-development interaction throughout the various steps of the SCP process cycle. An EMIS can be

operated by using a traditional manual system of storing and displaying information (library, manual drawing of maps). Today, however, a computerised EMIS usually uses a Geographic Information System (GIS) as a tool to handle and process the spatial and non-spatial data.

Geomatics

The rapid development of information technology has revolutionised surveying and mapping towards 'geomatics'. The definition of geomatics is evolving. A working definition might be "the art, science and technologies related to the management of geographically-referenced information." Geomatics includes a wide range of activities, from the acquisition and analysis of site-specific spatial data in engineering and development surveys to the application of GIS and remote sensing technologies in environmental management. It includes cadastral surveying, hydrographic surveying and ocean mapping, and it plays an important role in land administration and land use management.

Please be aware that there is a clear distinction between EMIS and GIS. EMIS is an information system for managing information on the urban environment according to the EPM process. An EMIS can be built incrementally at different levels of sophistication. A highly sophisticated EMIS, however, uses GIS as a state-of-the-art spatial management tool. This Handbook is not designed to give a comprehensive description of GIS. Rather, it concentrates on the concept of environmental planning and management (EPM), elaborating on the particular elements which are most relevant to a well-functioning EMIS.

What makes EMIS special is its participatory approach. Very often a GIS is reserved for specialist use. The system is set up, but is not then fully exploited for urban management purposes afterwards, because the people querying the data are missing. The EPM process, however, uses a participatory approach, and many people are involved in gathering information and setting up the EMIS. All these people become users of the EMIS, and the system grows as they use it. By using the technical capacities of a modern GIS in a participatory way, city planners can draw on local spatial knowledge to understand how cities change over time. Often it can be difficult to establish how urban circumstances change, as issues like disappearing services (e.g. shops, utilities) happen over many years and for many reasons. Local spatial knowledge (which encompasses both local technical knowledge of hazards, problems, potentials, utility uses, and indigenous spatial concepts of culture and space) can provide the reasons. It is important that city planners can access this knowledge, so that they understand the origin of problems. It is equally important for neighbourhoods to ensure that this knowledge is shared and stored. Cities are dynamic and people are very mobile, so the risk of losing this kind of knowledge is quite high. An EMIS combines participatory GIS with the EPM process to create an information system which can provide ongoing decision-making support to urban managers.

An *overview of Participatory GIS (P-GIS)*

P-GIS is participatory spatial planning (PSP), making use of maps and GI output, especially GIS. Although participatory planning can take place without maps – for example, the development of a school curriculum or a cultural policy – spatial planning invariably includes maps. P-GIS is an emerging practice, developing out of both GIS technology and participatory approaches in planning and decision making. The essential issues are: what intensity of participation is there in the GIS construction, design and mapping activities? How participatory is Participatory Spatial Planning – what are the functions, processes, activities, measures, instruments and procedures of spatial planning which involve participation?

A4

How does EMIS fit into the SCP project cycle?

The Sustainable Cities Programme (SCP) is a worldwide technical co-operation activity of the United Nations. It works at city level in collaboration with local partners to strengthen their capacities for environmental planning and management (EPM). Each city-level SCP project is adapted to the particular needs, priorities and circumstances of that city: nonetheless, all SCP partner cities follow a common approach and all are implemented based on the following principles:

- concentrate on environment-development interactions;
- broad-based participation by public, private and community sector groups;
- concern for inter-sectoral and inter-organisational aspects;
- reliance on bottom-up and demand-driven responses;
- focus on process: problem-solving and "getting things done"; and
- emphasis on local capacity building.

The SCP process consists of a sequence of activities, which are logically and practically connected, together with a number of specific outputs, which are important for the progress of the project. By following the SCP project cycle, an effective environmental planning and management process – designed to be integrated into local government practices – is established.

Each step in the EMIS is designed to provide support to specific stages in the Sustainable Cities Programme (SCP) process as outlined in the SCP Source Books, e.g. Environmental Profile (EP), Strategies and Action Plans, etc. You will find that the SCP Source Books refer directly to these EMIS steps. This Handbook supports all the stages of the SCP project cycle that use the mapping element of the information system.

Figure 1: The SCP Project Cycle
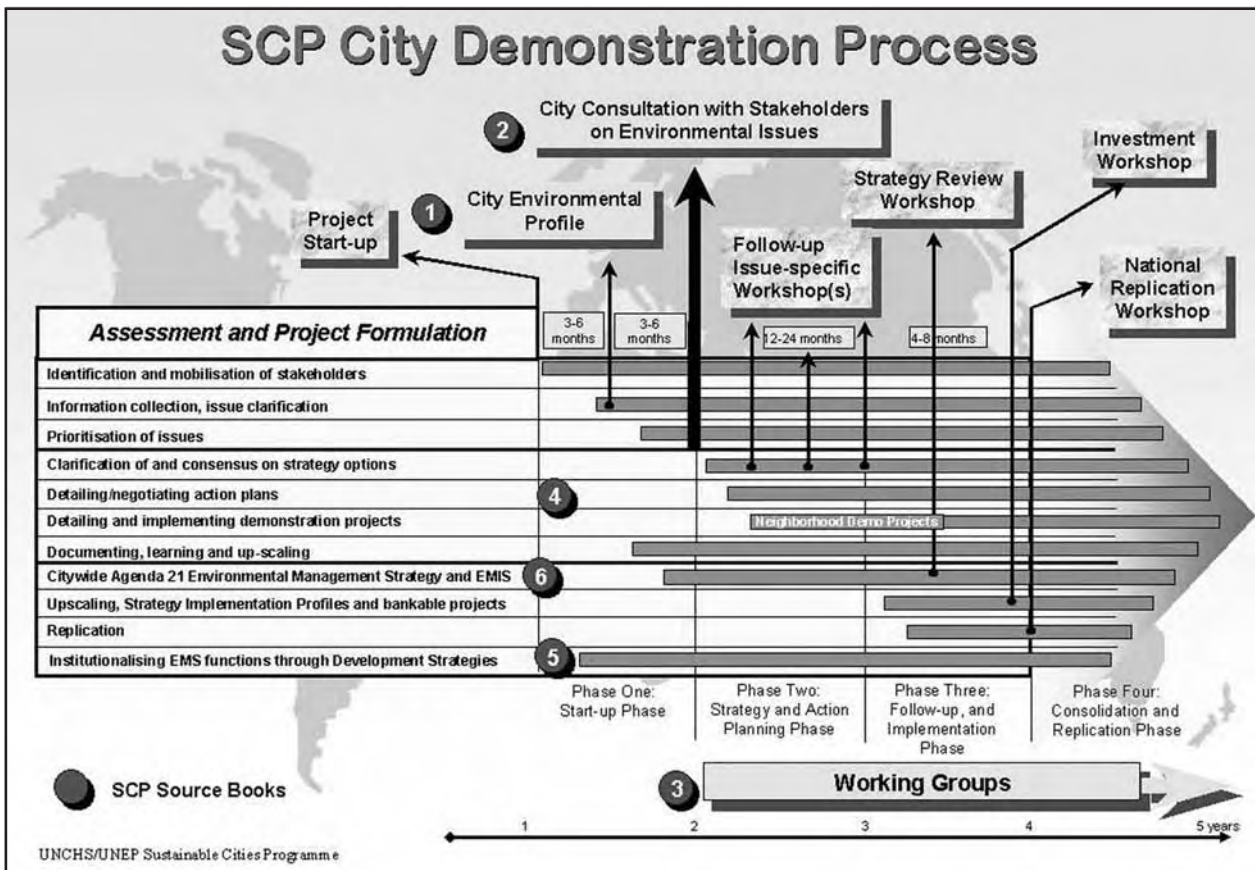
The SCP project cycle has three main phases:

A4.1   Assessment and start-up

The First Phase (Assessment and start-up) is a 6 to 9 month initial period, which normally includes the following main activities:

- identification and mobilisation of project participants and partners;
- familiarisation of project partners with the core EPM concept and SCP approach;
- preparation of the Environmental Profile (EP) and initial identification of priority environmental issues;
- a review of available resources, tools and information and the initial design of an environmental management information system (EMIS) specifically adapted to the city's needs;
- working out the organisational structure, work plan and operational procedures for the project;
- organising and holding a City Consultation; and
- establishing Issue-Specific Working Groups.

Volume 1 of the SCP Source Book Series – Preparing the SCP Environmental Profile – provides detailed guidance

The City Consultation is a major event that brings together the work of Phase One, consolidates social and political participation and support, and launches the SCP project into Phase Two.

The EMIS provides considerable support to the first stage. A basic map, showing the location of the city and some additional thematic maps on environmental and development issues is included in the Environmental Profile (EP), and all the environmental data collected for the EP will be stored in the EMIS. During this period an inventory of existing maps and data is conducted. For the City Consultation, the EMIS can be used to prepare a map exhibition. These maps will help to identify, clarify and prioritise the environmental issues facing the city. The EMIS also supports and interacts with the Issue-Specific Working Groups. Information already compiled during the inventory period can be shared and new information from the members of the working groups can be collected for inclusion in the system. It is advisable to establish a Mapping Group (see Chapter B1.4) early in the first phase in order to have the first mapping outputs ready for the Environmental Profile (EP) and the City Consultation.

Volume 2 of the SCP Source Book Series – Organising, Conducting and Reporting the City Consultation – provides detailed guidance

A4.2   Strategy and action planning

The project's Second Phase (Strategy & Action Planning) is a 15 to 24 month period of intensive analysis, discussion and negotiation within the Issue-Specific Working Groups. The number, focus and membership of these Working Groups will change and evolve as the project proceeds, but they will remain the principal working mechanisms of the SCP project. During this period, each of the agreed priority issues is further elaborated and developed, in order to reach a consensus on appropriate strategies for that issue. The strategies are then developed into action plans which are agreed by the organisations and groups involved in implementation.

It is likely that small-scale "demonstration" projects will be undertaken to test the approaches developed and to show what can be done through the SCP process. In addition, some of the first action plans will produce investment and/or technical assistance proposals which will be developed into properly formulated and "bankable" proposals. All of these Phase Two Working Group activities will be gradual, pragmatic and co-operative, reflecting the real-world conditions for strategy formulation and implementation. During the Second Phase, the main project activities aimed at institutional capacity-building and human resource development will also be carried out.

*See The SCP Source Book Series, Volume 3: Establishing and Supporting the Working Group Process
And The SCP Source Book Series, Volume 4: Formulating Issue-Specific Strategies and Action Plans*

During the Second Phase the EMIS supports the participatory decision-making process in a number of ways. The Working Groups will formulate their needs for specific maps and generate the data for new maps. During this stage a great deal of maps and data will accumulate and the EMIS will evolve rapidly as a functional tool. The system can produce many outputs, such as identifying environmentally sensitive areas ("hot spots"). It can also help to select sites for specific projects and can support project design for a specific site. With the help of the EMIS, detailed strategies can be formulated and action plans prepared and illustrated with maps. The Mapping Group and the Issue-Specific Working Groups will interact closely with each other in order to ensure genuinely participatory mapping.

A4.3 Follow-up and consolidation

The Third Phase of work (Follow-up & Consolidation) is an open-ended follow-up and implementation period, which begins towards the end of Phase Two and carries on for an extended time afterwards. The strategies and action plans coming out of the Working Groups are further elaborated, building towards an overall citywide environmental management and urban development strategy. Investment proposals are worked out in detail, subjected to rigorous analysis, and pursued vigorously with funding sources. The task of institutionalising the environmental planning and management (EPM) process, initiated during Phase Two, is undertaken in earnest. In addition, the remaining training and institutional development activities are implemented. Finally, regional and/or national workshops and meetings will be held to explore ways of extending SCP activities into other cities, building upon the experience gained in the project.

At this stage, the EMIS is fully functional. A considerable amount of data has been gathered, allowing further analysis and the production of outputs such as a development pattern map, issue specific strategy maps and an environmental management framework. In addition, an EMIS can support the monitoring of the environment situation and the evaluation of the achievements of the EPM approach. However, the system still needs input on an on-going basis both to keep it up to date and to make it increasingly comprehensive. This ensures that it will continue to be a powerful urban management decision-making tool in the future.

A5

Specific Applications of EMIS

Different levels of city administration require different urban information. For example, the city assessor needs a detailed, large-scale land information system to improve the collection of property taxes. The water department requires precise spatial information on the water utilities for better operation, maintenance and revenue collection. The planning department is concerned about the expansion of the city, while the environment department needs to manage environmental resources and hazards better. Equally important is the issue of information outreach: for example, the mayor presents a easily-understood "snapshot" of the city's environment and development situation at a conference in order to attract tourism, investors etc.

The EMIS can support all these requirements. Colourful attractive maps make theoretical issues much more immediate for the lay person. They draw attention and can jump-start discussions. The EMIS supports different tasks in urban management decision-making such as project design, site selection or investment planning. It can be further used to attract donors and investors by providing maps which show the best locations for investment in the city.

Supporting a new urban management approach

Over the last decades, it has been recognised that traditional planning practices do not sufficiently address the urban management problems which cities face. The Charter of Athens considered the city as a "masterpiece of architecture" to which functions could be attached on the drawing board. In reality, this approach is unworkable, especially in cities with growth rates of five per cent and above. An open planning tool, however, is able to react quickly to rapid changes in city development. The EMIS complements (but does not necessarily replace) existing planning tools, such as Landuse Plans, Master Plans, Zoning Plans and so on. The strength of the system lies in its capacity for cross-sectoral analysis and the facility it offers for the overlay of multiple environment and development information sets. This approach also supports better urban governance, because it incorporates issues and norms into the decision-making process which will be otherwise ignored. The information stored in the EMIS is a consensus interpretation of information, gathered and discussed in the working group process. The participatory nature of the EMIS responds to a gender responsive EPM by, for example, collecting data and information in a gender disaggregated way where applicable and necessary. The decision-making process is transparent and traceable through the map layers and through the documentation of the working group meetings. EMIS also helps better disaster prevention by providing policy makers with early warnings about hazardous situations regarding the environment.

Which projects can be designed for a specific site?

For project design, information from several maps is combined and the analysis provides options for selecting a site or area of interest. A table shows the information available about that site, including the findings of the working groups about the "rules and regulations" regarding the environmental and development conditions for this specific site. The next step is to prepare a report listing all the information and regulations, making suggestions for the best uses of this plot. If a project document already exists, the information gathered can be used to refine the project design according to the findings. With the inclusion of some more information it is even possible to estimate the costs of different investments at this specific site. Based on the report, the investor can decide on the type of investment she or he will make, or whether the design of the project has to be changed.

Which sites can be selected for a particular project?

Site selection requires some advance considerations and decisions. This is best explained with an example: A site suitable for a sewage plant is needed. The rules applying to a suitable site for a sewage plant are that it is best placed downwind from settlements, but still near housing areas. The site should be accessible by road and the area must have suitable soil conditions and a low water table. To find sites fitting these requirements, several EMIS maps will be queried to locate all the areas with suitable soil conditions, a low water table and good access to roads. From these areas, sites which lie downwind from settlements but not too far from them will be selected. Several sites will match this query. Not all of them will be available. The ones available will have different drawbacks. A report will be prepared describing the advantages and disadvantages of the different available sites.

A city wide view: The Environmental Management Framework (EMF)

An Environmental Management Framework (EMF) is a major EMIS output. It has three major components: spatial analysis; project and investment requirements; and a management framework for effective implementation of strategies. The spatial component refers to the geographic interpretation of competing interests in the use of space and the aggregation of potential strategies for solving those competing interests.

By mapping and overlaying the geographic distribution of the critical environmental resources, areas can be classified or ranked by their degree of exposure to environmental risks, and their sensitivities to particular development activities. This ranking or categorisation of areas helps to determine which development activity is compatible with specific areas, and to articulate rules and principles applicable to development taking place in the different areas. Such rules and principles don't necessarily exclude certain areas from development; but they do enable the incorporation of the long-term costs which should be considered in investment decisions.

The spatial analysis component of an EMF allows the determination and prioritisation of potential development areas for city expansion and growth. The selection of areas for future urban expansion will depend on the interaction between push factors (growth deterring), pull factors (growth stimulating) and the environmental sensitivities prevailing in the different areas of the city. The exercise results in the selection of areas with least foregone opportunities (say in terms of loss of agricultural land), benign environmental risks, higher carrying capacity, least infrastructure development cost and high economic efficiency. The spatial analysis component of the EMF makes extensive use of maps and Geographic Information Systems (GIS).

Land Information Systems (LIS)

The EMIS can directly link into existing GIS applications such as Land Information Systems (LIS) or Utility Management Systems, as long as the different systems are compatible with each other. Those systems contain information about each plot in the city, such as details on houses, tenants, and owner. This information can then be used for property taxation and water and power supply charges.

Figure 2: Definitions of different types of Information Systems

EMIS	GIS	LIS
An Environmental Management Information System is a participatory tool for urban environmental planning and management. It concentrates on the interaction between environment and development activities.	A Geographic Information System helps to store and to manage large amounts of spatially referenced data. It provides analytical tools and therefore helps a better understanding of activities on the earth's surface.	A Land Information System focuses on land parcels as the primary unit of information. It maintains, analyses and disseminates information about land registration, land assessment and land evaluation.
Whole city, including peri-urban areas Scale: 1:10,000 to 1:100,000	Depends on the issue All scales	Mainly built-up areas Scale: 1:500 or 1:5000

EMIS and ISO 14001

The EMIS complements the voluntary environmental management system (EMS) defined through the ISO 14001 series. Used in conjunction with appropriate goals, and with a management commitment, the ISO 14001 series helps to improve environmental performance and reduce negative impacts. It provides an objective basis for verifying claims about a local government's performance in its day-to-day operations. The ISO 14001 voluntary environmental management standards and guidelines address environmental management systems, environmental auditing, environmental labelling, environmental performance evaluation and life cycle assessment. These international standards are voluntary standards for the establishment of a common world-wide

approach to management systems that will lead to better urban environmental planning and management. Even though the standards do not prescribe performance levels, performance improvements will invariably be achieved by any entity if its commitment to environmental care is emphasised and employees are trained and are aware of the policies in place to protect the environment. The ISO 14001 voluntary environmental management standards and guidelines are intended to be practical, useful and usable for organisations of all sizes (Source: ANSI Online, www.soc.titech.ac.jp//uem/)

A6

How to set up an EMIS

Establishing a fully functional EMIS can take several years. The system can be built incrementally from a low-cost set-up to a sophisticated and complex system without compromising the value of the outputs (a bicycle gets you to your destination just as effectively as a car!). The basic EMIS is essentially no more than a set of checklists of questions that should be asked when making decisions, with "pigeonholes" to record and store the answers in simple formats that are directly usable, together with some advice on how to go about it.

After the initial stage of EMIS establishment, a certain amount of information will have been gathered and good outputs may have been produced to improve urban environmental management. However, it must be remembered that the EMIS can never be regarded as final: it has to be continuously updated and maintained. Any new investment will change the pattern of the city's fabric, and this has to be reflected in the EMIS. A city, therefore, has to commit itself to a long-term investment in its EMIS. This commitment includes not only providing the appropriate equipment, personnel and funding to run the system, but also providing clear policy guidelines for the purpose of the EMIS and the use of the results it produces.

An EMIS works best if the following principles are accepted:

An EMIS must be maintained and regularly updated

An EMIS is a dynamic, learning system, and information has to be fed into the system continuously. "Rome was not built in a day". An information system does not have to be complete to be useful, and in any case it takes significant time to assemble and fill. In the meantime, decisions on environmental issues must – and will – be taken. Provided that attention focuses on the priorities of the users, even modest, incremental improvements in knowledge of an issue can be very useful. This tends to be especially valid in the environmental area, where the major problem is not necessarily a complete lack of information, but a lack of awareness of its existence and whereabouts. This fragmentation and dispersal is a reflection of the fact that the environment is not generally recognised as a technical sector in its own right. Over time, as new issues crop up, the information system will increase its coverage and scope, through both "passive" and "active" collection efforts, provided that a framework is in place. In the beginning, the framework can be no more than a set of folders or "message boxes" in which to "pigeonhole" information under different headings. At an advanced stage, the framework can be a sophisticated computerised GIS. The important point is that the system receives regular maintenance and updating.

Some information is better than none

An EMIS accepts the best information available. It is tempting when defining systems to be too ambitious, and to attempt to be complete and all-encompassing. This, of course, can never be achieved, and is more often than not counter-productive, in that time and effort are diverted from content to form. The law of diminishing returns

should be kept in mind: beyond a certain point additional information does not really contribute much to deciding one way or another on concrete actions and policies. However, projects can be often delayed or halted because essential information is missing, while time and resources do not allow in-depth research. In such cases, you may have to rely on estimated figures, common sense or community knowledge. The more the data is partial, missing, inconsistent, etc., the more judgmental expertise is required to convert it into meaningful and reliable information. This is especially likely to be the case for environmental issues (indeed, it is one of the reasons for introducing an EPM process). "Non-scientific" information may be used as long as the source is stated. There is usually a minimum critical mass of information needed to support well-founded conclusions. The challenge is to find the right balance. Of course the aim will be to replace this kind of information in a later stage of the EMIS with more scientific data. But for the moment, what counts is that some information is better than none.

Avoid the data trap

It is important not to fall into the "data trap", i.e. getting bogged down in a large, general purpose, open-ended and unfocused data collection exercise. Such an exercise is almost invariably unsuccessful and therefore largely irrelevant. The purpose of an EMIS is not to substitute for general purpose or even sectoral statistical services or research institutions. Nor is "information" synonymous with "data": only with analysis, interpretation and synthesis does data turn into information. An example to illustrate the difference: a list of sample results – for example, values of "BOD5" from water quality tests – is data incomprehensible to the non-specialist. However, when interpreted, this data may reveal, for example, the information that the values exceed the legal health standards and render the water severely unfit for human consumption due to excessive organic contamination.

An EMIS makes a clear distinction between factual information and policy information.

Factual thematic maps show quantifiable or "countable" data, for example geology maps, soil maps, population density maps, etc. Policy maps show information about certain policy decisions such as national acts, laws and by-laws, global environmental standards or rules and conditions developed by stakeholders during the working group process. Policy maps can be classified as Suitability and Sensitivity Maps. Suitability and Sensitivity Maps interpret information from factual maps and rank areas as "more and less suitable", "good and bad", etc. according to specific rules and conditions. For example, a map on water pollution compares the chemical composition (facts) of the water and relates it to standards, rules and conditions (policies). If a certain chemical exceeds a certain level then we call it polluting. Policy maps are based on an intensive participatory process. They are subjective, as they show policy aims and represent different opinions which have been negotiated during the working group process. These maps will be always disputed and discussed.

Maps must be consistent

An EMIS sticks to a consistent mapping rationale, so that the maps produced are easy to interpret. Many similar maps will be produced, showing, for example, the suitability of areas for different development activities. It will be much easier for the user if all maps use the same pattern for land classed as very suitable.

Information must be accessible to everyone

Information in the EMIS has to be accessible for everyone in the public, private and popular sectors. This is an important principle, because an information system is

derived from many users. The more people use the system, the more information enters the system. This principle addresses the typical "data bank syndrome". The information system should not be viewed as a static hoard of "valuable" information, deposited by its owners to be carefully guarded from "unauthorised" access, like in the vaults of a bank. Rather it should be seen as a continual flow, like a newspaper, where information is continuously and actively sought out, quickly analysed and summarised, and rapidly distributed widely and without restriction. Information is like news, a perishable item that loses value over time. The usefulness and influence of a newspaper comes from immediately disseminating new information, not retaining it. An effective information outreach strategy is absolutely necessary for the success of the EMIS.
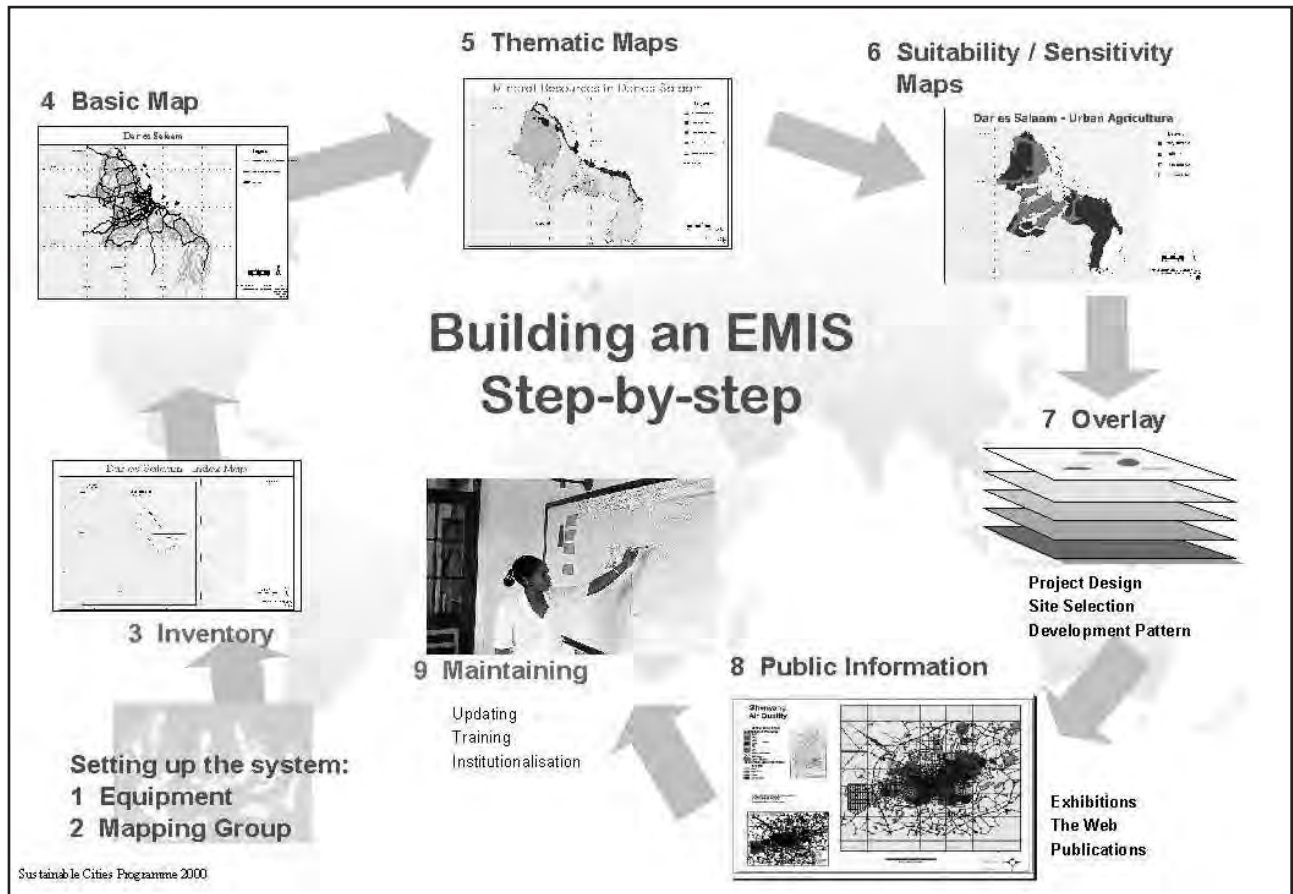
Figure 3: EMIS Step by Step

Step 1: Setting up the EMIS

Setting up an EMIS unit takes considerable resources, and must be supported by an adequate number of personnel: at least a GIS officer and one GIS assistant. An EMIS system can be built without computer equipment, but it is much easier to use a computer-based Geographic Information System (GIS) to handle the amount of data the system will contain. The standard EMIS set-up requires a high-end desktop computer, an A0 inkjet printer, and input devices such as a digitizing board or a scanner. For fieldwork, a Global Positioning System (GPS) receiver will be essential. The office which contains the central EMIS set-up and the filing system (map filing cabinet) should be free of dust, cool and spacious enough to handle large printouts. A light table is essential for group discussions around particular maps printed on transparent material. If the EMIS unit is located where it can take advantage of the services of a nearby Technical Support Unit, this is even better. In any case, an EMIS unit must always be able to call on technical support.

For online contacts please use Reference Material 2 – Web Links

Step 2: Mapping Group

A Mapping Group should be set up as soon as possible to link the EMIS with the stakeholders and users of the system. The major task of such a group is to backstop the EMIS unit and to make sure that minimum mapping standards are kept. This group has to solve problems and decide many things during the EMIS-building exercise. In Step 1 the Mapping Group can advise on purchasing equipment. In Step 3, they can provide information about existing maps and in Step 4 they can decide on the content and layout of the Basic Map. The Mapping Group facilitates the link between the Issue-Specific Working Groups and the EMIS unit. It is this group which discusses the needs of Thematic Maps, the mapping rationale for Suitability and Sensitivity Map, and the overlay procedures. Finally, the Mapping Group provides training during Step 9.

Step 3: The Inventory

The EMIS inventory stage covers finding existing data and maps, setting up a filing system for hardcopies, developing a filing system for the digital data, and establishing a database of all relevant maps and data. It is frequently surprising how many maps already exist, often even in digital format. It is not necessary to reinvent the wheel: it is better to acquire these maps. It is important to file hardcopies properly in a map filing cabinet. This makes the maps easy to find, and keeps them in good condition. It is even more important to create a logical filing system for the digital data. Otherwise it will be soon difficult to find the most recent maps and to be sure what kind of information is stored in a file named "lnsds.apr". A well-designed meta-database stores information on the location, date, status, scale, etc. of the maps.

Step 4: Basic Map

A Basic Map includes the main features of the city such as major rivers, main roads and basic landforms. These basic features should be used in all subsequent maps to give some guidance and orientation on the location. The layers of the Basic Map function as master layers, so rivers, roads or boundaries will never be digitized again unless they undergo physical change. When printing the first Basic Maps, it is essential to decide on a standard layout which can be used for all the EMIS maps.

Step 5: Thematic Maps

In the EMIS, Thematic Maps show strictly factual information. Thematic Maps show, for example, height of water table level in metres underground, soil eroded each year in centimetres, population density per hectare for each administrative sub-unit, and so on. The input for these Thematic Maps will come from existing maps, scientific reports or existing data, which can be found in different city departments or research institutions, or which is generated by the Issue-Specific Working Groups. The information in the Thematic Maps will be displayed as symbols (e.g. location of ground water wells), unique codes (e.g. administrative areas), class ranges (e.g. population density) or charts (e.g. content of chemical substances in water).

Step 6: Suitability and Sensitivity Maps

Suitability and Sensitivity Maps are usually the main mapping outputs of the Issue-Specific Working Groups. To create a Suitability and Sensitivity Map the factual data found in Thematic Maps is interpreted and evaluated. The focus is on drawing conclusions about conditions in specific areas and defining and applying "rules and regulations" according to these conditions. The Issue-Specific Working Groups assign ranks to these "rules" and "conditions" according to the environmental impact on development or the impact of development on the environment. A Sensitivity Map

shows areas which are highly, moderately, less or not sensitive to an environmental issue, whereas a Suitability Map shows areas highly, moderately, less or not suitable for a development activity. At this point, it is crucial to link the map areas to the rules and regulations established by the Working Groups. Storing the "rule" and "condition" information in a database and linking the maps to it makes this possible.

Step 7: Overlaying of fact and policy maps

For some outputs of the EMIS it is necessary to combine information from several maps. The interaction between environment and development issues, meaning the identification of crucial "hotspots", is simulated by overlaying a variety of maps. Meaningful combinations of overlays generate the necessary outputs which are crucial for urban environmental management. Typical outputs include strategy maps, land use maps, zoning maps and spatial management frameworks such as the Environmental Management Framework (EMF). These outputs are designed to answer routine questions in urban environmental planning and management.

Step 8: Information Outreach

Like the Environmental Planning and Management (EPM) process, the EMIS is based on a participatory approach. Therefore public information activities are an important part of the system. These can also bring new information into the system, and can be very effectively supported by the EMIS itself. The EMIS and the SCP process can be promoted through exhibitions, the internet, printed publications and map publications on CD-ROM.

Step 9: Maintaining the System

An EMIS is a learning system. Once the system design is complete, the data content will continue to grow and change over time. In order to maintain the system it is vital to anchor it in the most appropriate department or institution, ensure public involvement and acquire a regular budget on a long-term basis. The anchoring department has to commit itself to update the system continuously (including taking on the costs involved) and must provide an ongoing training programme for the EMIS users and operators.

Part B

The Guide: Building an Environmental Management Information System (EMIS) Step by Step

This section of the Handbook is a step-by-step guide to establishing, developing, using and maintaining an Environmental Management Information System (EMIS). The guide is designed for the immediate user of the EMIS. It concentrates mainly on the spatial presentation component (maps) of the system, and assumes that the reader has good mapping and cartography skills, computer knowledge and a basic understanding of GIS. It is important to read this section in full, as it gives a complete overview of the EMIS process. Later, you can refer to the individual steps as required. The text contains many references to the toolkit which accompanies this Handbook. Additional tools are provided on the CD-ROM. The toolkit is designed to help the EMIS user to implement each step of the process.

B

The Guide: Building an Environmental Management Information System (EMIS) Step by Step

Supporting the overall focus of Environmental Planning and Management (EPM), the information collected in an EMIS is concerned with natural resource systems, development activities, issues and actions. The EMIS does not define the specific resources, issues, etc. which it covers: these are established through the EPM/SCP process. The basic EMIS can be seen as a series of checklists to support this process. The checklists are set up with the EPM organising framework in mind, and cover basic knowledge and background information, issues, actions/development activities, instruments, stakeholders, resource persons and spatial presentation (maps).

Here are some key points about the EMIS to keep in mind while you are reading the more technical descriptions:

- The EMIS is part of the EPM process and it is designed to support every phase of the SCP project cycle.
- The EMIS is, in itself, a tool for better urban management, because it ensures that data is collected and analysed in a participatory and gender responsive way.
- The spatial scope of the EMIS can vary widely. It can cover a whole city, giving a more or less comprehensive picture of urban development. However, an EMIS, by its very nature, aims at connectivity rather than comprehensiveness. Therefore it is more often used to examine smaller "pilot" areas or specific issues from a cross-cutting perspective. It can focus on specific issues such as petty trading, or on specific locations, such as dealing with an urban lake.
- Although the EMIS does not attempt to be comprehensive, it must have a basic set of data which includes information on the natural setting of the city, land use, ongoing development activities and the state of the environment.
- The power of the EMIS lies in its visible outputs. Pinning large, colourful maps on the walls helps tremendously to deliver messages. Saving on printouts jeopardises the usefulness of the EMIS.

For more background on participation please check Tool 1: Participatory GIS

B1

Setting up the EMIS

Before you start drawing maps, some preparatory work is necessary. The EMIS function has to be located somewhere suitable, committed operating staff have to be brought on board, equipment and software must be purchased, and you have to clarify what data you will collect and where it can be found.

B1.1   Finding a place

Locating the EMIS within an organization

It is important to find the right location for the EMIS. It depends entirely on the situation in each individual city: is there already a Geographic Information System (GIS) unit within the city administrative structure, or another office or department with people who can support the EMIS?

Tool 2: Location of the EMIS unit is designed to help you identify the right location for the EMIS unit in your city.

Initially, the EMIS unit is best located within the EPM unit. While the EMIS unit and the EPM unit do not necessarily have to be put in the same department, most cities start off with this structure to ensure that the EMIS is closely linked to the EPM Working Group process. If the EMIS unit is located separately from the EPM unit because a GIS unit already exists in another department, or because it has been decided to place the EMIS function in a particular department, it is still necessary to make sure that the EMIS is linked closely to the SCP process cycle. At the very least, the SCP project

has to be able both to use and input data into the EMIS. The final location of the EMIS unit is best discussed in connection with the institutionalisation phase. When setting up the EMIS unit, check what technical support is already in place in the host unit or department. It is important to have technical support available to ensure the smooth running of the EMIS.

The EMIS system is often located in the planning department. The advantage of this solution is that it provides a pool of staff knowledgeable in urban planning and management and probably also skilled in using GIS. The linkage to the planning department can change the planning procedures in the long term. However, experiences have shown that planning departments can have a negative influence on the EMIS, using traditional static planning methods, or even replacing it with purely cadastral management, without implementing the EPM approach.

The EMIS unit works cross-sectorally, so it may also make sense to place it directly under the head of the city, as a sort of a central information office of the municipality. This location underlines the importance of the system and gives the staff the opportunity to have direct access to all relevant information. Additionally the system would be linked closely to the decision-making process and therefore provide strong arguments for environmental planning and management in day-to-day politics. Being closely linked to the key decision-makers will also provide support to keep the system running. On the other hand, however, with the strong linkage to politics the system can be misused and priorities other than strengthening the EPM may take over. In addition, this position can result in a sense of distance, and the Working Groups, essential partners in the EMIS, could lose touch with the system.

It is also possible to locate the EMIS function within the private sector. In some cases the efficiency of the private sector means that this can be a good solution. However, such a solution can also have serious pitfalls, as the private sector is profit oriented and not necessarily interested in feeding into the existing EPM structure. As a result, you might get little return on your investment.

City	Dar es Salaam	Ibadan	Ismailia	Wuhan
EMIS management	EMIS is with the Sustainable Dar es Salaam Project.	EMIS is with the Technical Support Unit of the Sustainable Ibadan Project.	EMIS is integrated in the Ismailia Governorate Administration.	EMIS is located with the GIS experts of the Environmental Protection Bureau (EPB).
Physical office location	Office is located in the building of the Urban Authorities Support Unit. It is being institutionalised into the new municipalities.	Office is located in one of the local government offices.	Office is located in the Ismailia governorate building.	Office is located in an existing GIS lab, separated from the EPM unit.
Staffing	Employees are seconded from the DSM City Council.	Employees are seconded from the municipality, supported by a mapping group.	Employees are staff of the Governorate.	Employees are part of the EPB office.
Benefits	Closely linked to the EPM Process	Closely linked to the EPM Process through the mapping group.	Integrated in local administration.	Full technical knowledge in running GIS.
Drawbacks	Too much project set-up.	Too much project set-up. Prone to brain-drain.	Depends on interest of decision maker.	Disconnected from the project, sometimes difficult to gain access to the data.

In the SCP Source Book Vol. 5 you will find two examples of the many possible solutions to the location of the EMIS unit, together with their advantages and disadvantages, presented with short descriptions of SCP city experiences.

Physical location of the EMIS

Bear in mind that the EMIS unit must be physically accessible to the general public. The system is participatory, and it is important that people feel that they can have physical access if necessary. Perhaps a public room with a computer can be made available, or maybe the office can be opened to the public at a specific time or on a specific day. Remember that even if the EMIS is located in a purpose built office with full technical and political support, it loses a great deal of meaning if it is isolated from the general public.

The office environment

Just a few remarks about the office environment: the equipment for the EMIS needs to be kept in a place which is clean, dust-free, dry and cool. The technical equipment needs space, and you will be handling large sheets of paper, so you should choose a spacious office. The office should be easily accessible to the relevant stakeholders – it should not be a laboratory used only by few specialised technicians. As well as typical office equipment such as chairs and desks, it is useful to have at least one additional table, preferably a light table on which you can make overlays manually. You may choose to buy a tabletop light table, which is less expensive than a whole light table. However, it is fairly easy to get a light table built locally. You will also need a map filing cabinet. Vertical plan filing cabinets are more space efficient than horizontal cabinets. The size 52" high x 35" wide x 20" deep (for a maximum of 600 drawings, size 40"x 30") is the most appropriate (don't forget to order filing strips with it).
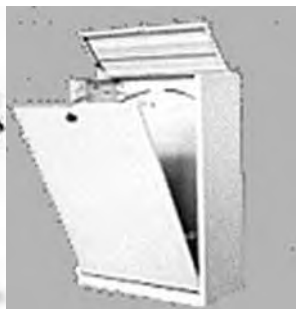
Light table   *Vertical map filing cabinet*   *Horizontal map filing cabinet*

B1.2   Placing and engaging staff

The EMIS unit is responsible for setting up, operating and maintaining the technical equipment, acquiring and analysing data, creating maps, maintaining the data, co-ordinating the process with the Issue-Specific Working Groups and the Mapping Group, and providing or organising sensitisation and training course in EMIS.

Staff must be professionals with a technical background and knowledge of GIS and urban environmental management. They have to have good communication and organisational skills because they will be dealing closely with stakeholders – not only government departments and other institutions, but also at community level. Experience in document design and layout and information outreach strategies are also essential. People who combine all those qualifications are not so easy to find. However, most cities have at least one department where a GIS has been established, so there are people available within the municipal offices with some experience. Additionally, many universities provide basic training in GIS technology and applications. Resource

persons from training institutions or from the private sector can often help to find the right candidates and provide training to fill existing gaps.

How many staff members are needed for a working EMIS? This will depend on the size of the city and the scope which the EMIS is expected to cover. The greater the number of Issue-Specific Working Groups established, the more comprehensive the EMIS will be, and therefore the more personnel will be needed. In most places, two EMIS staff members will be enough for the EMIS unit: an EMIS officer and an EMIS assistant. If a large amount of map digitizing is necessary, it may be useful to employ a second assistant, perhaps on a short-term basis. Briefly, the EMIS officer is responsible for the progress of the EMIS, for acquiring and analysing data and for the design of the databases. Additionally she or he functions as an important focal point to ensure that mapping is genuinely participatory: the EMIS officer will be the link to the decision-makers and politicians as well as to the Issue-Specific Working Groups. The officer will report directly to the EPM Unit Co-ordinator. The EMIS assistant deals with the technical parts of the system: digitizing, inputting data and laying out maps and posters.

All staff working in the EMIS unit should have – or be given – a thorough training in the EMIS concept, using the selected GIS software packages. They should also have a general overview of the functionality of a GIS and the most common applications. The EMIS officer will preferably have some working experience with GIS. The salary for the EMIS officer should be carefully considered, because these skills are in high demand, and quite often employment in the private sector is more financially attractive. If it is not possible to pay the same salary as in the private sector, other incentives such as training and duty travel could be used to attract and retain staff.

B1.3   Selecting and putting in place the hardware and software

If computer technology and expertise are not available a manual EMIS can be set up. Most of the EMIS functions described in this Handbook can be performed manually, and it is certainly not worth investing in inappropriate technology which may rot away idly in a storage corner. However, the function of this Handbook is to describe a computerised EMIS, since computers have now found their way into almost all government offices.

Hardware

Data input/output computer

The key hardware for the EMIS is the data input/output computer. The specifications of desktop computers change rapidly, and it is difficult to recommend a certain type of computer. On average, the capacity of an average desktop computer doubles every two years. You are advised to review the market carefully and to purchase top-end equipment. The computer should have sufficient memory, a big hard disk, preferably fast SCSI interfaces, a reliable back-up system and a large monitor, preferably 19" or even 21" in size. If you use more than one EMIS computer in your unit, the computers should be networked in order to minimise the data confusion that can arise when data is stored in different places ("which was the latest file version again?").

Inkjet plotter

The second important piece of EMIS equipment is an A0 size inkjet plotter. Good quality map displays are essential to the SCP project cycle and the EPM process. Traditional pen plotters are no longer suitable for producing full-colour thematic maps. The inkjet plotter should have enough internal memory to process complex maps, which can use up to several dozen megabytes of memory. The plotter should

also be able to process Postscript files since it will be used not only for maps but also for the production of high-quality, large scale posters. In case of financial limitations, it is also an option to make arrangements with a local printshop or another partner institution with a plotter.

Digitizing board

If you cannot purchase digitized data, or if there are no other digitizing facilities available, it is recommended that you purchase a digitizing board of a size from A3 to A0. Please note that the cost of a digitizing board can be considerable. It is worth assessing how much digitizing work really has to be done. In many cases only a few layers will need to be digitized from scratch, such as basic land forms, boundaries and utility networks. Much of the digitizing of thematic maps is better done onscreen. Smaller cities may consider buying an A3 digitizer only, which is much less expensive.

Scanner

Scanners can help to produce overview maps quickly and to update existing maps. For example, aerial photographs can be scanned and digitized on-screen. A4 size scanners are cheap and reliable. Do not consider purchasing scanners larger than A3 in size. Such scanners are very expensive, and the technology in terms of storage and computer processing capacities still lags behind.

Global Positioning System

A Global Positioning System (GPS) helps for quick surveys in the field and is essential for up-dating maps. A GPS is an inexpensive and useful tool.

Figure 4: EMIS hardware

Data collection	Processing	Output device
• Digitizer (A3 to A0) • Scanner (A4 or A3) • Field survey equipment such as GPS receiver • Light table	• Two state of the art office computers, networked	• A0 plotter for large scale maps and posters • Tape, or CD or DVD writer for archiving of data • LCD projector for PowerPoint presentations

Software

Mapping and GIS software

Many mapping and GIS software packages have been developed over the past few years. They range from very simple mapping programmes with limited analytical tools to highly complex and powerful GIS programmes. Today, most of the software packages work on a Windows-based platform and are fairly easy to operate. The most common programmes are ArcGIS, ArcView GIS, Atlas GIS, MapInfo Professional, Idrisi, Map Maker Pro, TNT Mips and Intergraph. It is difficult to recommend a particular software package since each one has its advantages and disadvantages, and, of course, its price. Experience has shown that in many cities certain programmes are better known and therefore more user support is available. Traditionally, many institutions have built capacities and produced data in, for example, ArcInfo format or AutoCad. Today, the data produced in the various software packages are increasingly

interchangeable so that choice of software is becoming less of an issue. However, before you decide which software package to order, you should still check what GIS packages other institutions in your city are using. It may make sense to use the same one, in order to exchange experiences and know-how.

Most SCP partner cities use ArcView GIS as a good compromise between capabilities, expandability and cost. It is helpful if other SCP projects use the same package, so that lessons of experience can be exchanged easily. ArcView GIS can directly process ArcInfo and AutoCad data. It is a powerful tool, and it operates on the user-friendly MS Windows platform. ArcView GIS has a modular structure, and new "extensions" for more complex analysis requirements can be programmed, downloaded from the web, or purchased commercially. However, ArcView GIS is still rather complex, and requires powerful computers and a good knowledge and training in GIS in general. Alternatively, for small municipalities, NGOs or community organisations, lighter products such as Map Maker Pro could be a better choice. This product was developed in close co-operation with Asian and African municipalities and is therefore more adapted to the particular needs of users in developing countries (rather than the North American business-oriented application bias of the "big" brands). Map Maker Pro is a cheap but powerful tool, which runs on small computers and is easy to learn and to understand. Because of MapMaker Pro's ability to convert many data formats and its extensive analytical capabilities, it complements the use of ArcView GIS. It is not recommended to use architectural or designer packages such as AutoCad or Micro Station. Those programmes are not real GIS programmes and do not allow certain analysis methods necessary for the EMIS. However, AutoCad, for example, does offer a module which can expand the programme into a GIS (AutoCad Map).

Freeware and open source GIS software

Open source and Free software (or software libre) both describe software which may be used, copied, studied, modified and redistributed without restriction". Both terms are summarised by the term "FOSS" – Free and Open-Source Software. Free and Open-Source Software is increasingly used in both public sector and commercial organisations due to its very low cost, high reliability and advanced security features. While proprietary software in the GIS sector is usually very cost-intensive, free and open source products can save licensing costs. As a result, more and more people in developing nations can benefit from GIS technology. There are many different FOSS programmes which are designed to view, modify and publish geospatial content, e.g. GRASS GIS, Quantum GIS, GvSIG, UMN and Mapserver.

Image processing

This handbook does not go into the details of image processing. Most GIS programmes have basic image processing functions which will allow you to use scanned aerial photographs or satellite imagery for your existing maps. The use of images, including satellite images, is described in Chapter B2.2.

Databases, desktop publishing and other presentation software

The data management structure of the GIS programmes mentioned above is compatible with common data base programmes and spreadsheets such as dbase, Lotus, MS Excel or MS Access. If you plan to process very large amounts of data, network server-based products such as Oracle or Sybase may be more appropriate. You may also find desktop publishing programmes such as Adobe Photoshop and Illustrator useful, in addition to GIS software and a database programme. Software for word-processing, slide presentation and web publishing is also necessary to prepare presentations.

For a detailed comparison of these two software packages refer to Tool 5 EMIS software

For more information refer to Tool 5 EMIS software

Please refer also to Tool 6: Remote Sensing.

Figure 5: EMIS software

EMIS/ GIS/ Map-ping	Image Processing	Database	Publication	Network
● ArcView GIS Map Maker ● Pro ● ArcGIS ● MapInfo ● Atlas GIS ● Idrisi ● AutoCAD Map etc.	● ILWIS ● TNTmips ● Erdas/Imagine ● ENVI ● ArcView Image Analyst etc.	● Oracle ● MS Access ● Dbase etc.	● Adobe Photoshop ● Adobe Illustrator ● Adobe Pagemaker ● MS Powerpoint ● HTML editor etc.	● Novell ● Windows NT ● UNIX etc.

Technical Support

See the EMIS CD for details on the EMIS Status Report 2006

A Technical Support Unit (TSU) takes care of the technical set up and maintenance of the EMIS. It ensures that the EMIS staff have the technical capacity to provide the information that is relevant for the EPM process and needed by the Mapping Group. A TSU can also provide useful technical advice when the hardware and software are being selected and installed.

Ensuring appropriate technical support for the EMIS is very important. In the EMIS Status Report for 2006 only a few EMIS cities reported that they had established a Technical Support Unit (TSU). However, many cities reported that their hardware broke down, and that they did not have the capacity to repair it. Their working process was interrupted – for example, due to the breakdown of a printer, they were no longer able to print maps. In such a case, how can the Working Groups operate without the spatial and thematic information provided by the EMIS unit? The TSU (Technical Support Unit) staff can solve these minor hardware and software problems to guarantee the flow of work in the EMIS unit.

See the checklist in Tool 7 to create such an "emergency contact list" and for a sample contract.

A TSU is not part of the Mapping Group, and doesn't necessarily have to be part of the EMIS. Often, you will be able to use the services of the TSU which serves the department in which the EMIS is located – in fact, when choosing the EMIS location, the availability of technical support is an important consideration. Check if a TSU that you could collaborate with already exists in other sections or departments in your city. Identify technicians and people with technical expertise (for example, your local university, or your hardware/ software dealer) that you can contact in case of problems. When you use the technical expertise of an existing TSU in your department, you may not have to pay for it. Perhaps you can find someone who will maintain your hardware and software on a voluntary basis. Otherwise you should employ a contractor who will carry out tasks such as making regular back-ups of your data, and who will provide technical support when problems occur.

B1.4   Linking stakeholders, users and producers: the Mapping Group

If the EMIS is to be successful, it must be linked to its users right from the very beginning. The key users of the system are the men and women in the Issue-Specific Working Groups, who include decision-makers, citizens affected by or concerned with the issue, professionals, experts and scientists and the project team. A Mapping Group is a useful way to keep all these groups informed about the progress of the EMIS, and to get their input.

The Mapping Group consists of representatives from various institutions with a connection to mapping: mapping and survey departments, local authority departments, planning and geography departments of research institutions, the private sector, working group co-ordinators, and, of course, the staff of the EMIS unit. While the Mapping Group can be an informal gathering of "mapping people", it is best established as a formalised group with the status of an Issue-Specific Working Group. It is best to set up the Mapping Group when starting to put together the Environmental Profile.

The main purpose of a Mapping Group is to ensure that information flows smoothly between the providers and the users of the information in the EMIS. The EMIS is a major data repository of the Issue-Specific Working Groups, and the Mapping Group acts as a liaison between the technicians and the users. Furthermore, the Mapping Group makes sure that the inputs into the system are sufficient and relevant to the EPM process and that the outputs of the EMIS are well understood and accepted – for example, that they follow certain required mapping standards. The Mapping Group also plays a role in providing the EMIS Unit with expert support at each stage of building the EMIS:

- Overview of Mapping Activities – The Mapping Group can provide an overview of all mapping activities in the city/town and can explore possibilities for sharing information, data and certain hardware, such as digitizing boards.
- Inventory – All members of the Mapping Group can provide information on existing maps, and where to find them, for the Inventory. The members of the Mapping Group know best about the quality and usability of different maps.
- Community Sensitisation – Sensitisation and building capacities of community groups regarding data production and map reading is best organised by the Mapping Group (remember, the Mapping Group will include community group representatives).
- Basic Map Preparation – The Mapping Group will advise on the scale, data, layout and layers to use for the Basic Maps. The group will also help the EMIS unit to formulate the right Terms of Reference when out-sourcing specific work.
- Thematic Map Production – The Mapping Group will help to structure the major exercise of preparing Thematic Maps. They will discuss which maps will be needed and how they can best be produced with the working groups.
- Suitability and Sensitivity Maps – The members of the Mapping Group will be involved in the development of the mapping rationale for Suitability and Sensitivity maps. They can also give some comments on how to link specific rules and conditions with the maps.
- Overlaying – The Mapping Group will discuss the overlay procedures and will advise on which layers on environment and development issues are best combined in order to get meaningful results.
- Training – Some members of the Mapping Group are potential trainers for other EMIS users. Mapping Group members also know of suitable training facilities.

Please refer to Tool 8: Mapping Group for tips on who should be in your Mapping Group, and how it should be set up.

B1.5 Getting Information and Taking the Inventory

Inventorying information in a meaningful way is key to transparency in the flow of information and avoids unnecessary duplication of work. Many offices already have a system in place for inventorying books, reports, maps and other documents. However, many offices store their maps rolled up in a heap in the corner of a room, or on top of a shelf, or in piles on an office desk. A very important task – even though it might seem dull – is to set up a filing structure that will let you find maps and information easily. Inventorying includes several tasks: (a) finding and purchasing existing data and maps; (b) arranging and filing them; (c) setting up a database; and (d) creating an index map or an atlas. Several tools are available to help you make your inventory.

What information should you collect?

With an EMIS, there is no set minimum level of information detail or disaggregation: the idea is to refine and develop information only as needed, according to priority issues. Nor is there an obligation to be complete and "fill in blanks": a major purpose of the EMIS checklist approach is actually to clarify the lack of potentially relevant data. You must then decide if the missing information (or level of detail, coverage etc) is really critical and if the effort of generating it is worthwhile.

There are two limitations to the scope of your information collection: area and time. Regarding area, "everything" concerning what happens in or affects the city in question is of potential interest, but it only becomes of actual interest if it is related to an issue under consideration. At the national level, outside the city, information related to any issues of city concern is of secondary interest, to explore commonalities or experiences. The definition of what exactly constitutes the "city area" for the purpose of SCP is decided at the start of the project.

As a general rule, information, reports and so on that are more than five years old are of limited value. It is better to concentrate on collecting information from the last three years. The only exception to this rule concerns basic, fundamental compilations and studies such as census reports, master plans and topographic maps. These may not be updated more often than every five to ten years, but they are still valid as a basis for extrapolation and for seeing longer term trends. In addition, you should always try to assemble information about trends and changes over several years wherever possible, rather than just from one particular period (i.e. it is just as important to know that water quality is decreasing as it is to know the absolute level of pollution at a given time).

When collecting information for the EMIS, ensure that data collection is not gender blind – make certain that it takes the needs and wants of both men and women into consideration. In some cases, it will be necessary to disaggregate information according to gender relevance and sensitivity.

Finding existing data and maps

From the point of view of those responsible for maintaining the information system, there are basically two methods of obtaining information for the EMIS. These could be called "wholesale" and "retail". The "wholesale" approach commissions a study or report from resource persons (experts, consultants, researchers etc), according to set formats which are defined as part of the information system (e.g. the Environmental Profile). "Retail" is the day-to-day collection and recording of bits and pieces of information that are either useful in themselves or that may serve as inputs for other purposes (e.g. for working groups). In the "wholesale" case, the practical difficulties of obtaining information are left to the expert; in the "retail" case they have to be confronted directly. While there is no universal recipe, a systematic approach helps. This is all the more important when there is a strong tradition of bureaucratic secrecy and a reluctance to volunteer anything spontaneously.

The most important thing to remember is that you cannot wait for information to come to you. Instead, you will have to search for it actively and continuously. Often direct personal visits to the source give the best results. Secondly, all channels should be used, official and informal, direct and indirect: the important thing is to get hold of the necessary information, not how and in what form. Personal relationships and introductions can be very useful. Sometimes it will be easier to acquire data or a map in another institution rather than at the source. You may not be allowed to take away a physical copy of a report, for example, but you may be allowed to study it on the spot – and even an informal chat may give you enough information about the report's content. In general, people are less reluctant to talk about what is available and to show it in the security of their office, rather than to hand out a document

without "authorization", particularly if it has not been officially finalised but is a draft. Remember that drafts are often the key versions, as final versions may only be made available when it is too late for them to be really useful.

The same principles also apply when you are searching for maps. Before starting to prepare your own maps, take stock of the maps which already exist in paper and or digital format. You may be surprised at how many maps have already been produced by other people and organizations. Collect as many of these maps as you can. If it is not possible to get a physical copy of a map, make a note of where it can be found and what information it contains. The following list provides you with an idea of where to search for maps.

- Mapping and survey departments will provide you with topographical maps.
- Many ministries and central/local government departments have thematic maps focusing on their particular field of work.
- Many maps can be found on the internet.
- And never forget to contact the local university's Geography or Cartography Department.

Always note down any available information about the maps that you obtain, such as, for example, the date of the map, the quality of the map, the scale and the source of the data.

Purchase of maps and digital data

Sometimes you may have to pay for the maps you need; digital data has to be purchased most of the time. Before you start spending money, talk to the Mapping Group, to discuss whether or not the maps are really worth the money. For example, a city purchased a digital basemap in the scale of 1:2500 for USD 60 per square kilometre. The total area covered was 500 square kilometres, so the complete set cost USD 30,000 in total. Only a small portion of about 80 square kilometres was actually relevant to the work of the issue specific working groups. The remaining data sat unused in a well locked drawer. The city could have saved USD 25,000 for other purposes.

Arranging and filing maps

Offices dealing with planning and mapping have a tendency to pile up maps everywhere. The people working there will know perfectly well where to find each map – at least most of the time – but for a newcomer it is a mess. It is also, obviously, not the best way to store maps over a long period of time. In order to be able to find your maps and to keep them in good condition, it is essential to file all hardcopy maps properly in a map filing cabinet. Maps should be labelled and ordered meaningfully before being put away.

There are several ways to create a coding system for all maps. The basic classification of all information is by "topic" – the sections of the socio-economic/environmental profile – and by "issue" – the cross-cutting environmental and/or developmental problem areas identified for analysis and action. However, many institutions and departments already use a standard coding system for any document they produce: ask your local mapping and survey department about their system. Offices which do not have an appropriate filing system in place could use the structure proposed in this Handbook. This coding system follows the steps for creating maps for the EMIS. Codes are prepared for Basic Maps, Thematic Maps, Suitability and Sensitivity Maps.

Whatever coding system you choose, you should always apply the coding to digital maps as well as to hardcopy maps. If you have ever tried to find a specific file on somebody else's computer you will know how difficult they can be to locate. Before you even start to put any digital data onto your EMIS hard disc, you should prepare a

filing structure. This filing structure encourages folders to be labelled with names that actually mean something. When setting up the disk filing system, remember to adjust it according to the local context, for example preparing folders for each Working Group active in your city. There are two main directories in the structure: a folder called "Working" and a folder called "Archive". The "Working" folder is used for any current project under development. Once these are finished, the digital maps are transferred to the appropriate folders in the "Archive". Only finalised layers and maps are stored in the "Archive". The "Archive" will allow you to open a well-designed, ready-made map with just a couple of mouse clicks. Potential investors requesting a map on soil suitability for a certain area may not have the patience to watch you searching for files and building up the requested map. Whenever you need to update a "final" map or layer, copy the particular map or layer back into the "Working" directory, make your changes and bring it into the "Archive" once again.

Metadata databases

Setting up a metadata database is a major step of the inventory stage. Metadata refers to information about the maps and digital data. A metadata database stores information such as the title of a map, the map scale, or the location where that particular map is kept. The metadata database should also include, if possible, information on the source of the map, the reliability of the information used to prepare this map and the physical condition of the hardcopy. The database can be built using a spreadsheet or database programme. On the CD-ROM you will find a ready-to-use MS Access database (inventory.mdb) and a MS Excel file (inventory.xls), which you can adjust to your particular needs. This database allows you to keep track of existing maps and their origin. It also means that non-EMIS people can come to the office to query the database on existing maps in a specific area of the city, or for a specific topic such as waste management. The database has to be updated regularly. This can be on a weekly basis, or the information can be added each time a new map is finished. In any case, you should decide on the time schedule and on who is responsible for the database right now.

Index Map and Atlas

Once the EMIS is up and running, two other items will be helpful for your inventory: an Index Map and an Atlas of the City. An Index Map shows the entire spatial area covered by the EMIS. You just draw boxes on it indicating the areas covered by different maps, with the map's code or file name and the scale noted in the relevant box. If anyone needs information about a specific area of the city, the Index Map provides an at-a-glance overview of what specific maps are available. An Atlas of the City collates the maps you have prepared. This can then be used by many institutions as an easy and accessible reference document. The City Atlas can even be an attractive for-sale publication. More information on the City Atlas is given in Chapter B 5.4.
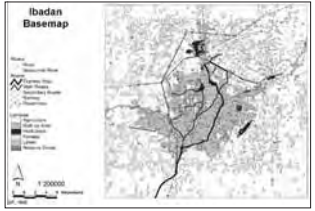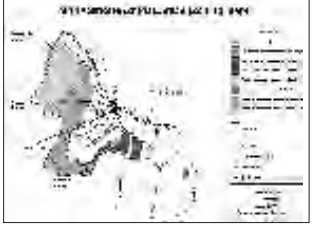
Urban Atlas of Ismailia

The Sustainable Ismailia Governorate Project established a unit to produce maps for its different working groups. First, a Basic Map of Ismailia was produced, using a satellite image and aerial photographs. AutoCAD was then used to make the Thematic Maps for the working groups from the Basic Map. However, the information was still difficult to understand, and was not suitable for presentation to decision-makers. The EMIS officer therefore prepared colourful but meaningful maps in CorelDraw, presenting the results of the working group in a simple way. The maps were compiled in a user-friendly Atlas of Ismailia. The Atlas uses impressive self-explanatory symbols such as differently sized farmhouses or bees and fish to illustrate urban agriculture and fisheries. The Atlas contains seventeen maps showing population density, development activities and the natural set-up of Ismailia. It is printed in full colour in A4 landscape. It has been very useful in informing the public about the environmental situation in Ismailia.

The seven typical EMIS maps

After these initial steps you are ready to produce your own maps for the EMIS.   The table below gives a brief description of the seven typical EMIS maps: Basic, Thematic, Suitability, Sensitivity, Service Delivery, Environmental Management Framework (EMF) and Action Planning. The table offers a short definition of each map, some details of the source maps or data needed for their preparation, and a thumbnail example of how they will look. Map preparation is described in detail in the following chapters. For more examples have a look at some of the maps prepared by SCP cities.

Figure 6: Definitions of the different maps used in the EMIS

Definition	Source of data	Example
Basic Map A Basic Map includes the main features of a city, such as major rivers, main roads, basic landforms and administrative boundaries..	Use a topographical map with a scale of 1:20000, 1:50000 or 1:100000.	
Thematic Map A Thematic map focuses on a specific topic. Thematic Maps in the EMIS will strictly show facts..	Information is provided by institutions or derived from research, and the Working Group process.	
Suitability Maps Suitability Maps show evaluated information or policy rules and regulations for development issues. A Suitability Map might show areas which are highly, moderately, less or not suitable for a development activity like agriculture.	Information is mainly generated through the Issue-Specific Working Groups and the Mapping Group. It includes national and international standards.	
Sensitivity Maps Sensitivity Maps show evaluated information or policy rules and regulations for an environmental issue. They show areas which are highly, moderately, less and not sensitive to an environmental issue like erosion.	IInformation is mainly generated through the Issue-Specific Working Groups and the Mapping Group. It includes national and international standards.	
Service Delivery Map A Service Delivery Map shows the extent and type of infrastructure and services in the different parts in the city such as water, sewerage, solid waste, energy and transport.	Data on water distribution, types of sewerage, road conditions, public transport, management of solid waste, areas serviced by power	

An Environmental Management Framework (EMF) *An EMF refers to the geographic interpretation and aggregation of strategies. By mapping and overlaying the geographic distribution of critical environmental resources, areas can be classified or ranked by their degree of exposure to environmental risks, and their sensitivities to particular development activities. This ranking or categorisation of areas allows the determination of development activities compatible with specific areas, and the articulation of rules and principles applicable to development taking place in the different areas.*	*Suitability and Sensitivity Maps, refined by Service Delivery Maps*	
Action Plan Map *An Action Plan Map shows the site where a demonstration project is planned which is intended to improve the environmental situation at this particular "hot spot". These maps show clearly the existing situation of a particular site.*		

To help you to keep track of your decisions for your Basic Maps, take a look at Tool 13: Creating a Basic Map.

B2

Creating a Basic Map

The first map you will create in your EMIS is a Basic Map of your city. The Basic Map, as the name indicates, serves as a basis for any further maps developed in the EMIS. Therefore, the planning process for the Basic Map should be undertaken very carefully, as all the other maps in the EMIS will depend on it. A Basic Map includes main features such as major rivers, main roads, basic landforms and administrative boundaries. As you can see, a Basic Map is like a topographical map, but with only the key features shown.

Before the Basic Map is digitized or purchased, several important decisions are necessary. First of all you should check on the existing national mapping standards which should be applied for the EMIS. Then you have to decide which area the system should cover and therefore what scale should be used. Many environmental issues are related to the surroundings of the city, as the source of the problem may lie outside the city boundaries. Therefore the area covered by the system has to be greater than the city per se. Also, the features of the Basic Map do not stop at the administrative boundaries, as rivers and roads extend beyond these artificial constraints.

The production of any map is a small project in itself. A carefully structured planning process is necessary in order to avoid surprises while producing maps. When planning and creating maps, remember that a perfect map is not always the most useful map. Timing is important. If a perfect map comes too late to support a decision on a certain issue, it is useless.

The project planning steps in Arc View GIS are as follows:

- Give your ArcView Project a meaningful name (e.g. basicmap.apr)
- Make a clear decision as to what the project will contain in terms of views, tables, charts, layouts and scripts
- Do not overload your project, keep it simple and clear
- Produce views and layouts both in colour and in black & white

Figure 7: Starting an Arcview GIS Project
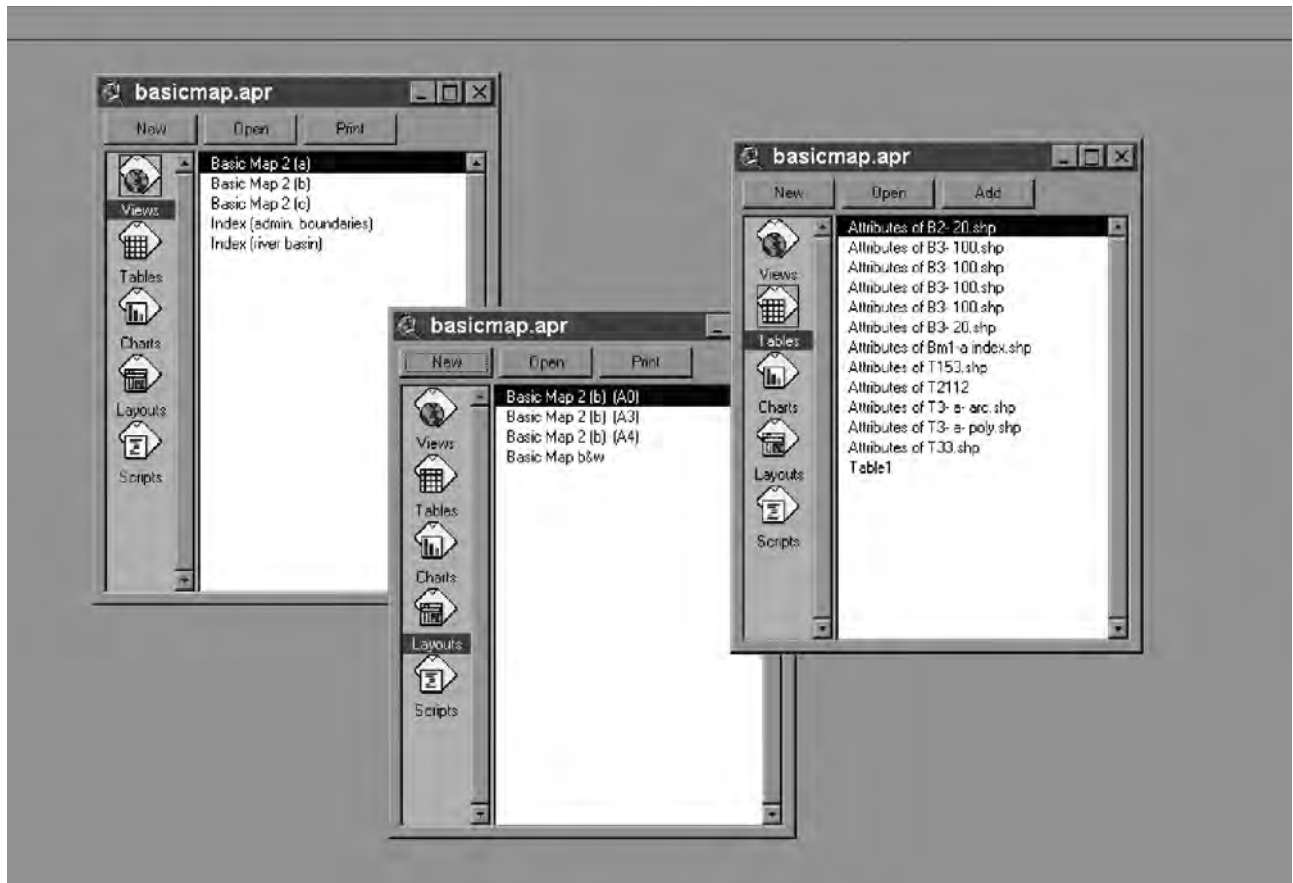
Base Map - Basic Map?

The EMIS Basic Map should not be confused with the term "base map". In many countries, the term "base map" means a very particular kind of map. For example, in Anglophone countries, planners use the term for large scale topographical maps (e.g. 1:2500). However, the scale of the Basic Map will probably be much smaller (1:10000 up to 1:50000) depending on the area the EMIS will cover..

Features of the Basic Map

The Mapping Group will decide which features are important and must be included in the Basic Map. As a rule of thumb, include all the features which are necessary for general orientation in the city: coastline, rivers, roads, landmarks, etc. Even a footpath in the outskirts of the city might be helpful, if there are no other features for orientation. On the other hand, however, do not add too much information, because this might cover up your additional thematic information.

Master Layers

The Basic Map includes landmarks such as a coastline or rivers, or major roads and administrative boundaries which do not change very often. These features are digitized on master layers, which are used to create both the Basic Map and other maps. The master layers are fixed and will only be updated and changed very carefully. Therefore, you never, ever digitize a river, a major road, the coastline or the boundaries of the city a second time. If a certain section of a river is needed for a new map, you make a copy of the master layer which contains the river network and, in the new layer, you delete all the rivers which you do not need. This approach ensures that landmarks and features match exactly in every map. Or another example: you have finalised digitizing the river network of your city. You start digitizing the layer which contains

administrative boundaries. One boundary follows a river which you have digitized before. You want to make sure that both lines match exactly. Either you copy the river stretch into the boundary layer and you continue digitizing from there, or you use the tracing and snap functions of your GIS software.

Figure 8: Tidy Boundaries
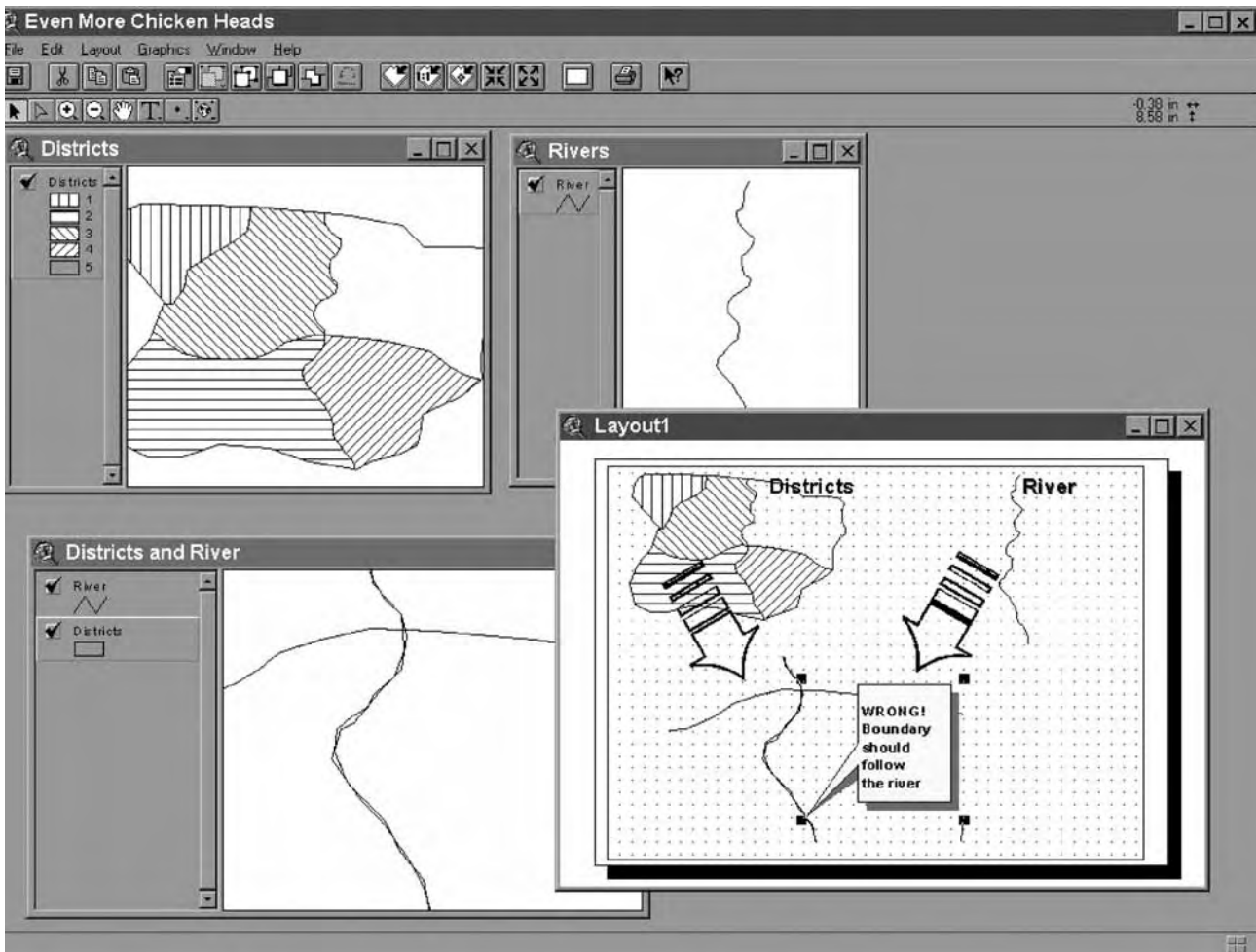
Basic Maps and the digital data for Basic Maps

It is important to be clear about the differences between a Basic Map (which will be printed and put on the wall or used for reports) and the digital data for a Basic Map. As mentioned in the previous section on master layers, the digital data may contain more information or features than those required for the Basic Map. For example, the Basic Map will show the main roads, but the road master layer from which these are taken will show all the roads. In order to be able to filter out the roads that are not needed for the Basic Map, it is important to add attribute data about the roads you digitize in the road layer.

Using attribute data

The attribute data you include on a feature depends on the nature of the feature itself. For example, Figures 9 and 10 show several columns with information about the roads in your maps, covering road type, width, surface and condition. This information can be used to prepare Thematic Maps (please refer to Chapter B31: Thematic Maps). The additional column labelled "Base" in the table refers to the Basic Map. All features with a number in this column will appear on the Basic Map. The different numbers indicate different line symbols. In this case all the major roads will be shown, but in the outskirts of the city some footpaths will also be added for a better orientation in sparsely populated areas.

Figure 9: Typical attribute data table of a Basic map layer

ID	BASE	LENGTH	TYPE	WIDTH	SURFACE	CONDITION
56	1		Primary	10	Paved	Good
57	-		Secondary	5	Paved	Bad

Figure 10: Basic Map Layer with attribute data table and information window
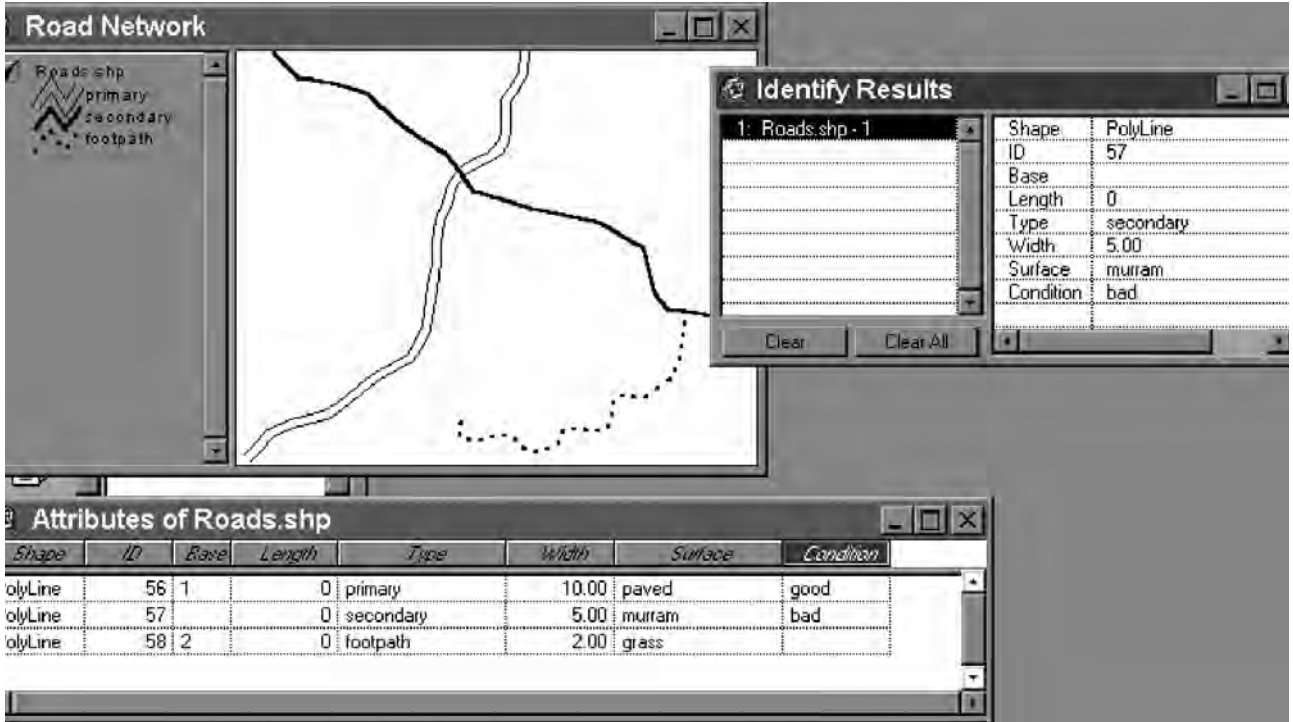
About Basic Map Projections

Since the earth is a three-dimensional sphere (more or less) and maps are two-dimensional and flat, special techniques are required to represent the curved surface on a flat sheet. These techniques are called map projections. Map projections provide rules for converting the numeric values of latitude and longitude to the x and y co-ordinates of a rectangular grid. In this way the precise position of features on the Earth's surface can be obtained from the map. All map projections necessarily make compromises, and distort shape, area, distance or direction to some extent. The impact of this distortion on your work depends on what you will be using your map for, and its scale.

Ensuring the correct map projection for your Basic Map is essential, because otherwise problems will arise later on when you combine data from other sources such as other maps or GPS data. If you purchase your Basic Map from a survey and mapping department make sure the digital data is projected. Very often digital data is provided with UTM co-ordinates, but without a projection. If this is the case, find out which original projection was used and replicate the projection in your map using the conversion tools of ArcInfo or ArcView GIS, for example. Please read the chapter on map projections in the handbook that comes with your GIS software carefully.

Figure 11: Projection selection in ArcView GIS
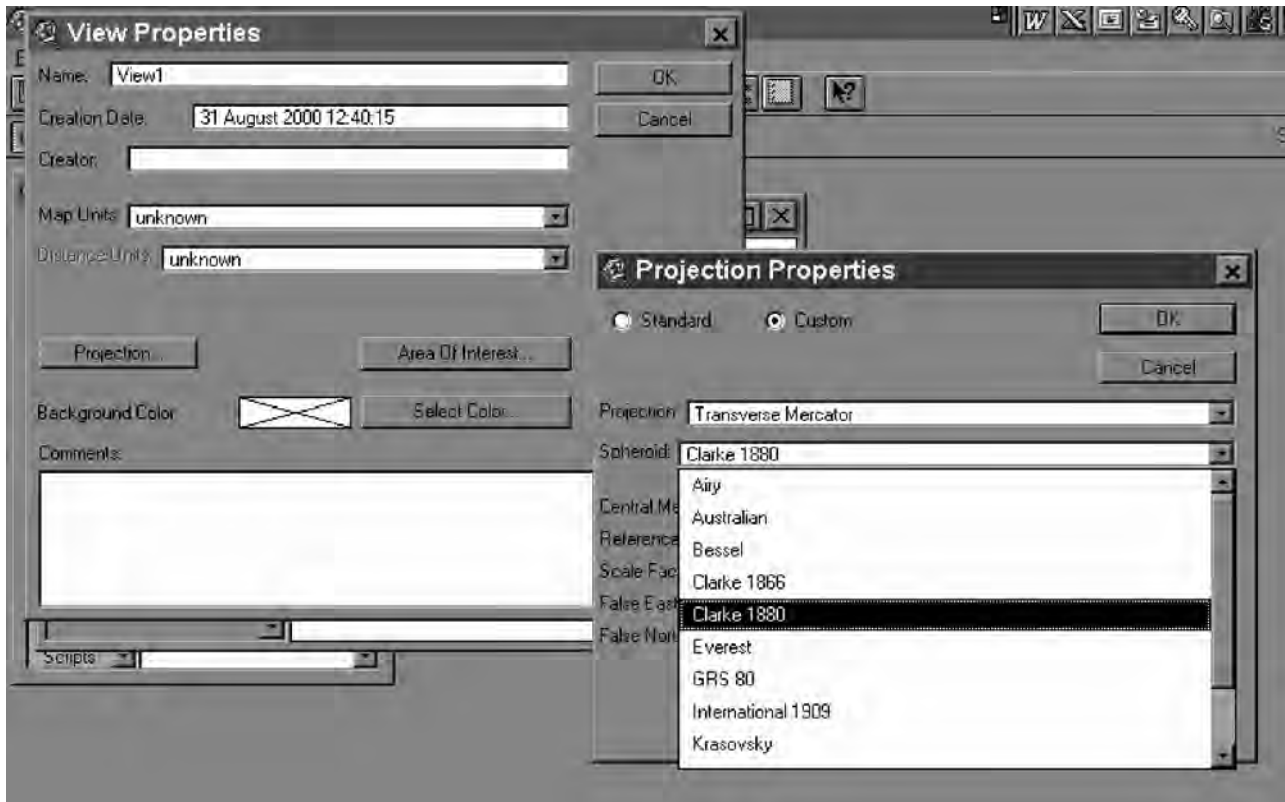
Map Projections and distortion

All map projections distort shape, area, distance or direction to some degree. How this distortion affects your work will depend on what you will be using your map for, and its scale. On large-scale maps, such as street maps, the distortion caused by the map projection being used may be negligible because your map will typically cover only a small part of the Earth's surface.

On smaller scale maps, such as regional and world maps, where a small distance on the map may represent a considerable distance on the Earth, this distortion may have a bigger impact.

Each national Government uses a particular projection for its official maps. A good topographic map contains the following information:

Grid:	UTM Zone 37
Projection:	Transverse Mercator
Spheroid:	Clarke 1880 (modified)
Unit of measurement:	metre
Meridian of origin:	39°00' East of Greenwich
Latitude of origin:	Equator
Scale factor at origin:	0.9996
False co-ords of origin:	500,000 m Easting 10,000,000 m Northing
Datum:	New (1960) Arc

> **Universal Transverse Mercator System (UTM)**
>
> Universal Transverse Mercator (UTM) is a projection which tries to balance the distortion of shape, area, direction and distance with an accurate representation of small shapes and minimal distortion of larger shapes within the zone, while for the areas the distortion within each UTM zone is minimal. Local angles are true and the scale is constant along the central meridian, but at a scale factor of 0.9996 to reduce lateral distortion within each zone. UTM is designed for a scale error not exceeding 0.1 percent within each zone.
>
> The Universal Transverse Mercator System divides the globe into sixty zones, each spanning six degrees of longitude. Each zone has its own central meridian from which it spans 3 degrees west and 3 degrees east of that central meridian. X and Y co-ordinates are recorded in meters. To eliminate negative co-ordinates, the projection alters the co-ordinate values at the origin. The value given to the central meridian is the false easting, and the value assigned to the Equator is the false northing. For locations in the Northern Hemisphere, the origin is assigned a false easting of 500,000, and a false northing of 0. For locations in the Southern Hemisphere, the origin is assigned a false easting of 500,000 and a false northing of 10,000,000.

Layout for the Basic Map

Another important thing to decide on at the beginning is the appearance of your maps. The maps the EMIS unit produces should have a consistent "look". This has several benefits. First of all, people will recognise these maps as coming from the EMIS Unit. Secondly, it helps you not to forget any of the cartographic elements. Last but not least, a standard look saves time, because the layout does not have to be adjusted every time a new map is prepared. In Figure 12 you see a typical map layout.

Figure 12: Typical map layout

You can adjust these templates to your needs by referring to *Tool 14: Standard Layout.*

B2.1 Creating a Basic Map using existing topographical maps

To create the basic layers needed to map your city, most of the time it is best initially to stick to existing topographical maps, even though some of their information may be outdated. These errors can be corrected at a later stage. Once you have decided on the scale you will use, you should acquire the topographical map sheets of your city, ideally on textile or on film. Paper copies should be in perfect condition, and should not be torn or folded. They should only be rolled to transport them over short distances. Before you start digitizing, find out if the maps are already available in digital format. It may seem more costly, but you will save a great deal of time.

If you decided to digitize the maps yourself, there are two ways to go about it:

• Using a digitizing board, or
• Scanning the sheets and digitizing on screen.

Of course there are advantages and disadvantages to both methods. The choice you make may depend largely on the equipment available to you.

Figure 13: Advantages and disadvantages of different methods of digitising

	PROS	CONS
DIGI-TISING BOARD	● Allows highly accurate digitizing. ● The entire map sheet can be placed on the board for a better overview.	● Requires expensive equipment and space. ● It's necessary to cross-check continually between the digitizing board and the screen. ● Takes more time to prepare. ● With some GIS software, setting up a digitizing board is difficult or even impossible.
ON-SCREEN DIGITIS-ING	● Allows fast digitizing and the production of "quick & dirty" maps. ● The output is visible immediately.	● Requires a lot of computer memory (RAM), because the scanned files are very large. ● Scanning can distort information.on ● More effort is required to geographically reference the map.

Digitizing using a board

Using a topographical map sheet directly on the digitizing board or screen is confusing – after two hours of digitizing it becomes difficult to distinguish between contour lines, roads, rivers, utility lines and administrative boundaries. The possibility of digitizing errors increases. Therefore, the different features have to be separated by tracing them onto different sheets, ideally using film. For each digitized layer you prepare a new sheet showing only the features needed for that layer: for example, all rivers and streams, or all streets. Take the time to mark the features according to type (e.g. all major rivers are marked with 1, all perennial rivers with 2, the seasonal rivers 3, and so on), as this will make the step of attaching attribute data to your drawings easier. Once the sheet has been prepared, fix it on the digitizing board using masking tape. Select at least four geographic reference points (which should be the same for all layers) for registering the map with the respective geographic co-ordinates. Refer to the handbook of your GIS software for information on registering your map. Now you can start digitizing.

Onscreen digitizing

To digitize onscreen, the map sheets must be scanned with a resolution of at least 150 dpi (dots per inch), or, even better, 300 dpi. The maps can easily be scanned in several sections, using an A4 or A3 scanner. The next step is to attach geographical co-ordinates to your scanned maps. Open the scanned map with the GIS software and select the tool for geographically referencing maps. Generally it is necessary to select at least three points on the map, to which you attach the correct geographical co-ordinates. The image will be adjusted according to the correct geographic co-ordinates. Map Maker provides an additional tool, Rubber Map, which allows a basic rectification of your scanned images in order to fit them together with your existing layers.

This procedure depends on the GIS software: with certain GIS software this procedure may be more difficult than it sounds, and errors, such as shifting of the co-ordinates, can occur. The Mapping Group will have to decide whether the errors are within the acceptable limits or whether other digitizing tools, such as using a digitizing board, have to be used. After preparations you can start to trace the features for each layer.

Remember how important it is to keep track of additional information. If, for example,

you have digitized all the rivers in the city, all you will see on your screen are connected lines. This is called the "geometry". To make sure that all users will recognise these lines as rivers, you have to add this information to a database table connected to your geometry. This attribute data has already been mentioned in the earlier section on Basic Maps.

Attribute data is added to layers for two reasons. First, it allows the data to be queried. If you click on a "geometry" line on your screen you should be able to read all the information about this specific road in a pop-up window.

Figure 14: Information Pop-up Window (ArcView GIS)
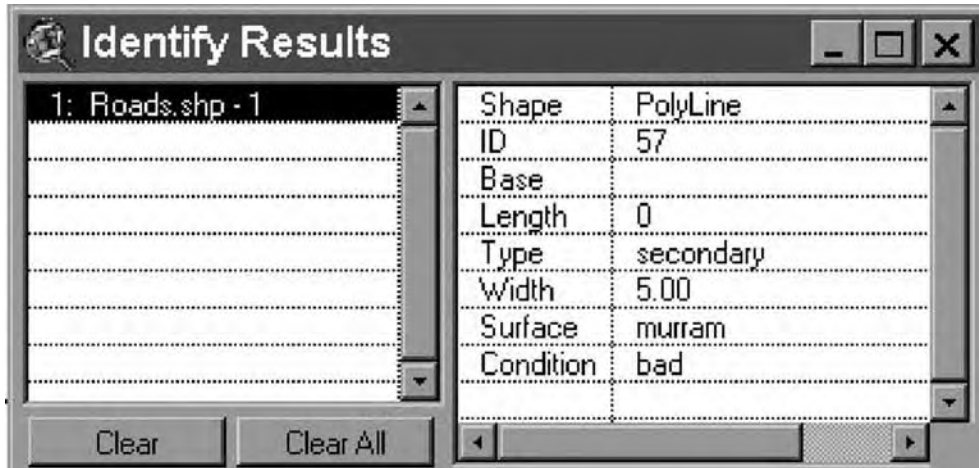
Secondly, attribute data allows you to prepare attractive maps with different line symbols for the different types of elements, such as roads or rivers (see Figure 10).

In a smaller municipality, the whole area will probably be covered by one topographical map sheet. However, with a larger town or city, it may be necessary to use several sheets of topographical maps. If you create, for example, six layers for each of the sheets, you will have to digitize quite a large number of maps. As you can imagine, this will take quite a lot of time and effort, especially if you are working on your own. If you decide to outsource the task of digitizing to an institution or to a private company, follow the digitizing progress closely to make sure you get the output you expect.

As mentioned before, you may be lucky enough to find that the basic digitizing exercise has already been carried out. However, the data may need refining and processing. Mapping and Survey Departments usually store digital data in an AutoCad-like digital exchange format (dxf). The different layers are separated by colours (as they are used for printing plates in order to produce topographic maps) rather than by theme, so the layers will have to be separated. The data has to be transferred to another digital format suitable for your GIS software.

B2.2 Updating a Basic Map with Images

Images can be used in many different ways in the EMIS, but they are most useful for updating maps. Images allow you to add recently built-up areas, roads or to reflect the changes in the course of a river.

Two different types of images are used for this task. Aerial photographs are taken by planes flying at a specific height. Aerial photographs offer very detailed pictures at high resolution. However, while a single aerial photograph is inexpensive, you might need quite a lot of them for full city coverage. In many cities, the available aerial photographs may be out of date, and the municipality may not have the resources to take and process their own. Satellite images can be a cheaper solution. Satellite images are taken from earth-orbital satellites. One "scene" will normally cover a

whole city. It is very useful to purchase satellite images on a regular basis every few years. This will allow maps to be updated regularly, and also allows you to detect changes in the city over time. To process satellite data you should consult an expert, or, better still, purchase imagery already customised to your specifications, which you provide when you order the images. Up until recently, the two major satellites for imagery were SPOT and LANDSAT TM. During last few years, however, more satellite images have become available from different sources. Images from SPOT and QUICKBIRD are very suitable for urban management purposes. Finding the right image for your city may take some time. In general, images can be ordered through the web, or by writing to the companies. Today, a single satellite image (covering up to 500 square kilometres) costs around 4,500 US Dollars (IKONOS) and 11,000 US\$ (QUICKBIRD).

Tool 6: Remote Sensing, you will find some addresses where you can start looking.

Satellite images and aerial photographs can be used in a similar way to scanned topographical maps. However, there are some important differences to bear in mind. It is possible to purchase a satellite image which is already geo-processed. If you don't purchase geo-processed images, you will have to identify accurate locations to adjust your image to known co-ordinates. On a topographical map you will find points marked around the map itself which refer to the co-ordinates used. With images, you will have to identify suitable spots on the image, such as road crossings, specific buildings, airports etc. These locations should not change in the near future and should be easy to locate on the satellite image. Their co-ordinates should be available on a topographical map. After georeferencing your images you can add new streets to your street layer, define the built-up area of the city and even distinguish between different types of settlements. You can also use former digitized layers to adjust your images. However, georeferencing a picture can have drawbacks. The picture may be distorted and may not match entirely with your digital maps. For more specific instructions refer to your GIS software handbook.

B3

Using maps to analyse environmental issues

Each Issue-Specific Working Group gathers a large amount of information about the environmental issue they are dealing with. Using maps can sharpen their understanding of the issue. Maps can clearly indicate areas where the situation for a particular environmental issue is hazardous. Analysing maps which show the development activities of the city can help to identify the activities causing or affecting the issue. With all these maps at hand, the working group can specify which areas are the best locations to start improving the environmental situation in the city.

EMIS and the Environmental Profile

ideally take place at the same time. The EMIS can provide maps to illustrate the EP and make visible the current environmental and development situation and problems. On the other hand the EP provides a great deal of factual information for the EMIS.

Generally the four main chapters of the EP can be illustrated with maps. Basic maps are used in the introduction to give an idea of the general city setting. The second chapter focuses on development activities and their location can be shown in maps. Their interaction can provide some ideas about the growth pattern of the city. In the third chapter, maps can be used to illustrate the natural setting of the city, highlighting natural resources and hazards. Even the fourth chapter of the EP, which discusses the main actors in urban management, can be illustrated by maps which, for example, show the location of community based organisations (CBOs). In fact, a map can be prepared for each subchapter. This sounds like a lot of work, but it means that you build an initial library of Thematic Maps for the EMIS and the Working Group process which follows.

An interesting example of an Environmental Profile which uses maps is the "Environmental Profile of Zanzibar Municipality". The EP is 80 pages long and includes 21 maps. All maps are printed on one A4 page either in scale 1:100000 or 1:15000. The whole EP is printed in black and white, so that it can be copied. Therefore the maps are also in black and white, and use patterns to distinguish the different areas. The Basic Maps shows the settlement pattern and the different administrative boundaries. The Thematic Maps include topics such as population density, city expansion, tourist attractions, trade activities, fishing, the transport network, road conditions, drainage and sewer systems, the sanitary situation, waste collection points and open spaces. Regarding natural resources and hazards, there are maps showing marine resources, water distribution, land use and flood-prone areas.

B3.1   Mapping Facts: Thematic Maps

In general a Thematic Map focuses on one specific topic, rather than simply representing the earth's surface. Unlike a Topographical Map, a Thematic Map shows issues such as traffic or population density. In the EMIS, thematic maps are divided in two types: Thematic Maps and Suitability or Sensitivity Maps. Thematic Maps in the EMIS show only facts, while Suitability or Sensitivity Maps show either evaluated information, or policy rules and regulations. It is useful to separate map types this way during the Working Group process, in order to distinguish the decisions and evaluations of the Working Group from facts derived from other sources.

See Tool 16: Standard Set of Thematic Maps

Just to give you an idea of what Thematic Maps can be about, they can cover topics such as the amount of waste generated in different communities, the height of the water table in metres beneath the ground, soil eroded each year in centimetres, types of crops planted 1997, city land use, population density per district, and so on.

Refer to Ref 3: Sample Maps from SCP Partner Cities

Thematic Maps are built on existing maps, existing data, research and fieldwork. Thematic Maps already exist in many government departments and research institutions, for example, geology maps or soil maps. Remember that factual information is often mixed with policy information in these maps. You will have to separate the relevant information and features from these maps and digitize them into new thematic layers.

Where to find data for Thematic Maps

Often, huge amounts of digital data are stored in centrally located database servers. These data are often collected through – and refer to – monitoring activities, such as air quality monitoring, cadastral information, or utility management. Socioeconomic data may be collected and stored in statistical institutions. This data is often related to existing administrative boundaries (districts, wards, arrondissements, etc.) and can easily be linked to the basic administrative boundary layer in your system. Remember that administrative boundaries only have to be digitized once. Afterwards several Thematic Maps can be prepared by linking the basic administrative boundary layer to the relevant database or spreadsheet. The attribute data of the administrative areas and the information from the database server require a matching column each. The information in these columns must match, either using names for areas or districts or special codes for them. This is normally either an ID or the name of the feature (a ward, a street, or a river). Just make sure that both columns are defined identically, either being Integer or Text. If you use text columns, the names should be spelled correctly.

Tool 17: Attribute Data explains how to connect a database or spreadsheet with a map in greater detail.

There are four ways to search for specific information:

1. "Hunting": inquire about particular information of interest (e.g. a water quality study of a particular lake).
2. "Fishing": ask what other information the informant has related to any of the specific issues or topics of concern (e.g. on water quality in general).

These first couple of approaches could be called the active, specific part of the search, i.e. the contact is made for these purposes. In this context, one should not take anything for granted, but try to physically see what exists (e.g. the allegedly "complete" file of industrial polluters may in fact only contain an odd, outdated notice). The following two approaches can be called passive, incidental search, which would not justify a visit per se but might by chance turn up something worth pursuing.

3. "Extending the chain": asking if the informant knows of or could suggest anybody else worth contacting about the issues or topics raised.

4. "Widening the net": asking about what the informant's organization has done, is doing or is planning to do in general and/or in the area of concern (the city).

Information for a Thematic Map can also be drawn from an Issue-Specific Working Group. A great deal of "common sense" information can be gathered just by querying the Working Group members, who are experts in that particular environmental issue in the city. As explained earlier, it is more important for the EMIS to have some information than no information. This Handbook encourages you to include non-scientific information in the EMIS: information derived by rule of thumb. Of course, this source should always be mentioned in the inventory database and also, even more important, on the printed map. If information on in issue is lacking, always try to gather it in close co-operation with the Issue-Specific Working Group.

See Tool 18:
Collecting Data in
the Field

If, however, the Working Group does not agree on borders between different areas, it may be necessary to go and check in the field. This kind of fieldwork must be done carefully, to ensure that the results can be used in the EMIS. To make sure the information gathered can be translated into maps, some preparation is needed:

• The EMIS unit prepares "working maps" to trace and update the findings in the field. The "working map" will indicate clearly the specific survey areas and allocates the individual surveying teams accordingly. This makes it easier to add the new information into the system.

• The data types to be collected should be defined in advance. It is best to prepare a model spreadsheet and to print out some sheets for the researchers to fill in. This means that the data will be consistent, and you will only have to type in the information later on.

See Tool 18a:
Global Positioning
System (GPS)and
Tool 18b: How to
download GPS
data

• A Global Positioning System (GPS) is useful, especially in remote areas. The researchers can keep track of their position while collecting data.

• To co-ordinate the work of data collection, you will probably have to call at least three meetings with the Working Group members who will collect the data. The first meeting will discuss which area the research will cover, what kind of data will be collected, and so on. During the second meeting, the research maps and spreadsheets are distributed to the members of the surveying groups, and they are taught how to use a GPS. For complex surveys you should consider a test survey, so that you can adjust the questionnaire according to the problems encountered. The final meeting takes place after the research has been carried out to discuss the findings and to note any unexpected problems in data acquisition. Obviously, this type of data collection requires resources in terms of time, transport, and even fees. Therefore it is important to budget for this kind of activity well in advance.

What is a Global Positioning System (GPS)?

GPS is a navigation and positioning system on earth based on satellites. 24 satellites orbit the earth within 12 hours at a distance of roughly 20,000 km. They send out radio signals. GPS receivers obtain the signals of satellites within reach. To calculate an exact position, the signal of at least four satellites is necessary (three satellites to calculate the x-, y- and z-position and a fourth one to minimize errors in time difference). Position is calculated by measuring the distances between the GPS receiver and the satellites through the travel time of the signal sent by the satellites. The GPS receiver compares the time when the signal was transmitted with the time it was actually received. The time difference shows the distance from the satellite to the user. The more satellites are in reach the more precise is the calculated position. Originally,

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What is a Global Positioning System (GPS)...contd?

GPS was designed by the US Department of Defense for military purposes only, to enhance the effectiveness of the US military forces and weapons. Today GPS is used in a broad range of civilian applications such as for traffic management, mapping or the navigation of airplanes and boats.

Once the information has been collected and put into the system, you can prepare a Thematic Map in one of several different ways, depending on the type of data you have.

- Symbols: The simplest way to display thematic information in a map is by using descriptive symbols, showing waste collection points, mining pits, ground water wells, museums, hotels, and so on. This provides useful basic information. In an EMIS, those points also need to be converted into areas of extent (e.g. the accessibility of waste collection points, etc.)

- Codes: Certain areas or polygons in your map show different types of a topic representing unique values. Thematic Maps typically include land use maps, vegetation maps, soil maps or geological maps.

- Classes: Certain areas or polygons in your map show a numerical figure for each area. The data is represented in classes using specific graduated ranges. Typical maps of this sort are population density maps, traffic flow maps, chemical contents in water, air and soil, etc. Most of the Suitability and Sensitivity Maps represent classes.

- Charts: These maps show complex information such as changes over time or different chemical concentrations in water or air.

Tool 19: Preparing Thematic Maps provides a step-by-step description

A typical Thematic Map, which will probably be prepared in every EMIS, shows city expansion over a period of time. This map can be used for further analysis. You can examine why the city expanded in the directions it did. Analysing the growth pattern together with a map showing hazards or other environmental situations will show some areas where further expansion is unsuitable or even dangerous, and other parts where it is safe.

B3.2   Mapping Policies: Suitability Maps and Sensitivity Maps

In an EMIS, factual data should be strictly separated from policy information. To prepare a policy map you have to interpret factual data, evaluate your findings and come to a conclusion about conditions in different areas. Then rules and decisions about regulations for these areas according to the situation there have to be added.

Factual Thematic Maps and Policy Thematic Maps in brief

Air quality Monitoring Stations measure the concentration of various chemicals in the surrounding air (e.g. 150 μ SO per cubic metre air). A factual Thematic Map will show areas with ranges of, for example 0-49 μ/m3, 50-99 μ/m3, 100-149 μ/m3 and 150 and above μ/m3. This map does not show "pollution" yet. A pollution map, which is an environmental Sensitivity Map, is the interpretation of the factual Thematic Map. For example, the chemical concentration can be compared to international or national standards. If a concentration exceeds a certain value, then we call it "polluted". If there are no official standards or rules, the issue specific working group will have to come up with standards, e.g. acceptable levels of air pollution.

For development issues, policy maps are called Suitability Maps. A Suitability Map might show areas which are highly, moderately, less or not suitable for a development activity such as agriculture. For environmental issues these maps are called Sensitivity Maps. They show areas which are highly, moderately, less and not sensitive to an environmental issue, such as erosion. Policy maps can also show existing regulations

See Tool 20: Ranking Environmental Issues

and rules such as the minimum distance for housing areas from dumpsites or water reserves. The suitable or sensitive areas will be ranked according to the level of the rule or condition for each area. The more suitable an area is for development or the more environmentally sensitive it is, the higher the number.

The buffer function of your EMIS software is useful when creating policy maps. Many bylaws exist which refer to required distances to features such as points or lines. With the buffer function you can create maps showing these restricted areas. For example: A bylaw exists prohibiting building underneath a power line. If you have created a map showing all the power lines you can create buffers around these lines showing the areas where building is not allowed.

In an EMIS, preparing Suitability or Sensitivity Maps is an even more important activity of the Working Group process than the preparation of Thematic Maps. Suitability and Sensitivity Maps synthesise the results of a Working Group process on a specific environmental issue in the form of a map. Developing and applying rules and regulations to the different areas on maps will help the Issue-Specific Working Groups to develop issue specific strategies and "bankable" investment projects. To get the right data for Suitability and Sensitivity Maps, it is important to work closely with the Issue-Specific Working Groups. They will provide essential information about existing rules, conditions and laws. The easiest way to create and discuss Suitability and Sensitivity Maps is by using a light table. Prepare printouts of all the Thematic Maps related to a specific topic, and the Working Group can examine the themes by overlaying the relevant maps on the light table.

Please refer to the text box on ranking and hotspots in Chapter B4.1 and to Tool 21: Preparing a Suitability Map and Tool 22: Preparing a Sensitivity Map).

To create Suitability and Sensitivity Maps a few things should be kept in mind.

- Decide on the number of ranks (e.g. four types of areas like highly, moderately, less and not suitable) and the intervals according to importance (e.g. 1 = good, 2 = moderate, 3 = less, 4 = not suitable or 1 = good, 3 = moderate, 5 = less, 7 = not suitable).
- Keep to one mapping rationale: always use the same pattern or level of brightness for the same type of areas across all issues (highly suitable or sensitive areas use a dark pattern, and areas not suitable or not sensitive use the lightest pattern). This makes overlaying easier.
- Even though there may be several areas which are less suitable for agriculture, the reasons why these areas are less suitable are all different. Therefore the attached rules and regulations are also different: make this clear in your database.

Tool 17: Attribute Data explains how to connect the map to the database.

If you haven't done so yet, it is high time to consolidate the Working Group results in a concise database. The various rules and regulations are mostly documented either using word processing software or by keeping them in a memo field in your database. For example, in MS Access the field type Memo can store up to 64,000 letters. This is equal to 16 pages of text. Apply an ID number to connect the data with the map. This ID number will allow you to link the different areas to the rules and regulations agreed upon by the working group. Once the map is linked to the database, clicking on an area on the map will show all information related to it.

How to create a Suitability Map

A Working Group on urban water quality will use some of the following Thematic Maps: watercourses and lakes, sanitation situation, solid waste situation, built up areas, land use, agricultural areas, drinking water availability, chemical elements in a water body. Using these maps, the current water quality situation can be captured and evaluated. Working Group discussions on these maps will also confirm whether or not the information they contain is valid. In addition, the Working Group members will be able to provide information

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How to create a Suitability Map

about existing rules and standards and create new maps showing river pollution, water reserves with restricted land use or areas along the rivers which have to be kept free from buildings. To ensure that maps are developed in a participatory way, the Working Groups should use a light table to overlay the various maps. This allows the whole group to identify conflicting uses of the water network, trace sources of water pollution, and see hazardous areas. The Working Group members examine the different areas, looking for areas with similar situations. They then discuss what has to be changed in these areas to improve the situation of the rivers and lakes, or examine which uses can be allowed to use existing environmental resources sustainably. During this discussion, the Working Group members can also decide where to start demonstration projects, basing their decision both on the degree to which the situation is threatening, and on the level of support from inhabitants and community based organisations. This process leads to the preparation of action plans

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A Service Delivery Map is a special type of a Suitability Map. This map combines Thematic Maps – such as infrastructure maps of power lines, sewerage system, water pipes and waste collection system – with the Suitability Maps for accessibility, sanitation and drinking water. This combined map therefore shows the overall situation of infrastructure and services in the city.

Please remember to check with the Working Group representative of the particular utility department or company regarding their own "utility master plan" in terms of a particular utility extension or improvement. This information will be crucial for developing strategies for possible areas of city expansion.

See also Chapter B 4.4 Further use of the system: Using EMIS for monitoring and evaluation

B4

Applying mapping to decision making: Outputs through Overlaying

An overlay is – to describe it simply – putting two sheets of paper with different maps on top of each other, analysing the interaction of the features and summarising the ranking from the individual Suitability or Sensitivity Maps. This is how overlays were done before digital mapping existed, and it is still a good idea to do overlays manually if you want to involve all the relevant stakeholders in the exercise: you prepare printouts of the maps and everyone gathers around a light-table; overlaying the maps and discussing the outcomes. The results can be traced on a new sheet and can even be digitized again. The same participatory principle must be applied when you use the computer for the overlays. All GIS software packages provide overlay tools. Certain overlay functions are quite powerful and several layers can be easily combined into one new layer with all the information from the overlaid layers. The map will probably look very scattered but it does allow you to query one single map to get all the necessary information about a specific site.

Please see also *Tool 24: Overlaying Maps* for a further description.

Dar es Salaam, Tanzania

Sample Maps for practising manual overlays can be found in *Tool 24: Overlaying Maps*

An overlay only makes sense if you use the right layers for it. The Mapping Group will help you to decide which layers are appropriate. Only overlay polygon or area maps. Of course you can also overlay line or point features, but you will not be able to intersect other polygons with points and lines in order to get new polygons with certain characteristics. The main outputs of the EMIS are produced through the map overlaying process.

The outputs of an EMIS will differ from city to city according to both the urban context and the selected focus – area-wide or area-specific, issue specific or more comprehensive. Therefore this chapter should be read carefully, and the descriptions taken as examples. You have to relate the different analysis tools of the EMIS to your own database. If your EMIS focuses mainly on specific areas or covers only some environmental issues, the outputs proposed in this Handbook will be fewer. Not every city needs to prepare, for example, a city-wide Environmental Management Framework.

Check Tool 19: Preparing Thematic Maps for more tips to produce clear and readable maps

The EMIS, containing a great deal of data and information, is now powerful enough to provide multifaceted answers to complex questions. At the same time, it will be able to provide decision-makers with "simple" maps, so that they can defend their strategies and proposals by convincing the constituency with crisp and clear arguments. In order to provide maps for both purposes, the system calls upon the professional cartographic skills of the EMIS Officer to "tailor" and simplify complexity to produce clear and readable outputs. A highly sophisticated map which tries to give the ultimate answers to problems is useless if it is not easily understood. Remember that the Mapping Group plays an important role in advising on the readability of a map.

Possible queries

- Example 1: An investor has bought a plot and wants to build a car repair centre. What consequences can be expected?

- Example 2: The city needs to build a sewage treatment plant. Where is the best site?

- Example 3: Data on population growth shows that new housing estates are needed. What areas of the city are available for expansion or densification?

To answer more complicated questions, the EMIS uses your GIS software to provide you with a number of sophisticated spatial analysing tools. Some of them you have already used for preparing Thematic Maps (e.g. querying the tables and buffering features). Other GIS tools will help you to split areas, make complex queries and overlay maps. But before you start to use any of these tools you should analyse the type of problem you wish to address. Decide which data you need to answer the questions related to the problem and define the steps you will take.

B4.1   Hotspots and Action Plans

As maps capturing different issues and strategies are overlaid on each other, areas where conflicts are sharp, or where actions to remedy environmental damages are needed, will come into sharp focus immediately. These are the "hotspots", which need to be addressed through immediate action plans and investment projects.

Once the "hotspots" are identified, action is needed. The issue specific Working Groups will discuss the strategies for a bankable investment project. Demonstration projects to improve the environmental situation at this "hotspot" will be planned. The EMIS will be able to present a number of "hotspots" with similar characteristics. The Working Group's aim is to start a demonstration project on a site where it will have the optimum impact at minimum cost. The EMIS will help you to identify this particular site. It will also identify similar sites for replication of the demonstration project.

This might also be the right time for a change of scale in your system. Up to now you have probably used a scale of 1:25000 or 1:50000. If you have started to prepare the first action plans, the scale you had to use was 1:1000 or 1:2500. You can build on these first maps in this latter scale to add more and more maps in this scale. This, over time, can link into a type of Land Information System, storing data on plots and houses (if this is not already done by a different department). Such detailed maps will show clearly the existing situation, and allow you to simulate the situation as it will look after the demonstration project has been implemented. As these maps illustrate strategic goals, their aim is to promote change, or the preservation of, for example, endangered natural and cultural features in an area. The maps will also help to describe the necessary steps to implement the strategy.

Some examples for typical action plans are:

- Network of new solid waste collection chambers;
- River Basin Action Plan - How to improve polluted rivers;
- Protection of the cultural heritage in the city centre;
- Revitalisation of a neighbourhood, etc.

Using Ranking and Identify Hotspots

The higher the ranking value in an overlay is, the higher the competition is for development activities on that spot. We call these areas "hotspots". Sort out overlapping conflicting strategies and competing issues to find out the most optimal pattern of development and to reconcile the strategies pertaining to the different issues. This can be done through overlaying the relevant strategy maps of the different issues. For example, the land determined as most suitable for urban agriculture may fall on the land determined as most suitable for mining, making further prioritisation of activities necessary. Or some of the land suitable for urban agriculture may overlap with hazardous land, making it necessary to qualify the type of agricultural practices permissible in such areas. To make the exercise straightforward and to get a sensible result out of it, the overlaying should proceed step-by-step, overlaying no more than two topics at a time, and should be confined to the issues and strategies whose combined interpretation is required to project an overall growth pattern. This step is best done on a light table, so that everybody involved in the negotiations can take part. The results can later be transferred back to digital format.

From this exercise, area-specific rules and principles for each "hotspot" will evolve. Addressing the "hotspots" and resolving conflicting strategies requires an in-depth analysis of area-specific rules and principles. Strategies that were meant for a specific issue and area may need to be modified or modulated through a series of rules and development conditions to ensure the compatibility of different development activities in the different geographic areas. Overlaying a sewage network development strategy map over a ground water management strategy map may for example, highlight areas characterised by a lack of sewage networks and a high water table. Such areas need further prioritisation in sewage network development, and further specification of the type of sewage technologies which are appropriate for such areas.

After all these maps have been overlaid, the results will be aggregated into one map. By overlaying the overlaid maps, including key service delivery maps, it is possible to generate an aggregate picture of suitability or development priority areas. In a situation where many variables or spatial attributes are involved in determining such an overall suitability map, it may be necessary to attach weight to each of the attributes on a given scale, so as to allow the generation of a composite. Areas with many rules or conflicting issues will pose many constraints to development and will rank lowest among the potential development areas, and vice versa.

Mobility Action Plan in Bayamo Cuba

In 2002, a Localizing Agenda 21 project was launched in Bayamo, Cuba. Urban residents identified mobility as a key issue of concern. Traffic conflict points were increasing, and the 90s crisis had brought petrol shortages and a lack of spare parts for omnibuses. The public transport system had become very unreliable. As a result, all sorts of transport alternatives such as "all-purpose" bicycles and horse-drawn carriages were familiar parts of the transport system. These two modes of transport ultimately took care of 85% of local needs. However, the densely built northern part of the city was left out.

The Environmental Profile pointed out this situation, so that it was debated during the city consultation. Several thematic maps had been prepared and the issue specific working group brought all the concerned stakeholders together to discuss ways to improve the transport situation. Following negotiations in which maps of different scenarios were used; an agreement was reached between the municipal authorities, police, private transport associations, informal sector representatives and community leaders.

Appropriate lanes and signalling were set up to facilitate bicycle and pedestrian mobility. New lanes were inaugurated for horse-drawn carriages and bicycle carts, which now operate on a regulated fare system.

B4.2   Project design and investment at a specific site

This is the easiest type of querying an overlay map. After you have overlaid several Suitability and Sensitivity Maps, all you have to do is to query the site or area for which you plan an investment. The table of information will show you the links to all the rules and regulations for the different environmental and development issues. The next step is to prepare a report listing all these regulations and make to suggestions for the best use for this plot.

If a project document for the use of this site already exists, the information gathered can be used to refine the project design according to the findings. Later on, when you have built up a more comprehensive database, it will even be possible to estimate the costs of different investments at this specific site. The report will help decision-makers to present well-prepared proposals to interested investors. Based on the report, the investor can decide on what kind of investment to make, and whether it might be better to change the design of the project in order to avoid additional external costs.

B4.3   Site Selection

This type of querying an overlay map requires some consideration in advance. This is best explained with an example: the task could be to find a site suitable for a sewage plant. To find such a site, you have to consider several questions.

1) What are the rules for a site suitable for a sewage plant?
- Downwind from a settlement in order to minimise negative effects (smell) on residents;
- Near to the built-up area in order to reduce infrastructure costs;
- Good access by road for supply and maintenance;
- Low environmental sensitivity of the soil and geology in order to protect the groundwater table;
- "Downhill" in order to reduce the need for pumping stations.

2) What kind of data is therefore needed?
- Built-up area and buffered map for distance;
- Service Delivery Map (accessibility areas of the utility system);

- Land use map for determining conflicting areas;
- Sensitivity Maps on ground water table, soil, geology and terrain;
- Contour line map

3) How do you query your overlay of these maps?
- Select all areas with low ground water table and least sensitive areas in terms of soil and geology;
- From these areas select all areas in low terrain;
- From these areas select all areas with high or moderate access to roads
- From these search areas downwind from housing areas
- From these, select sites in areas with no sewage treatment system, and there you are!

You will find that several sites match this query. Not all of them will be available. The ones available have different obstacles. Your final step will be to prepare a report on the different sites, explaining their advantages and disadvantages, and the level of restrictions which will affect the cost of building a sewage plant there. Once given these sound technical arguments, it is now up to the decision-makers to choose a site.

B4.4   EMIS and Urban Planning

The main focus of the EMIS, as we said earlier, is to synthesise the outputs of the Issue-Specific Working Groups into a database structure, and to provide relevant maps in order to support the EPM process. Therefore the EMIS outputs will differ as the EPM process differs in every city. Consequently, this handbook does not provide a standard set of

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The Drawbacks of a Traditional Master Plan

Although a master plan can provide a useful spatial framework for guiding the future growth and development of a city, its implementation is easily frustrated and limited by a number of issues. These include:

- its seemingly comprehensive nature, which results in idealistic but unaffordable proposals for infrastructure, social services and development, often with no clear relation between planning, implementation options and resource availability;

- its control orientation, with rigid standards and conditions which are very difficult to enforced in a context of rapid urbanisation;

- its sectoral approach to development issues, which concentrates on land use activities and thereby undermines the need to strengthen management capacity through cross-sectoral co-ordinating arrangements;

- its almost invariable dependence on expatriate preparation with limited national and local participation, thereby reducing the understanding of local conditions and lessening the commitment to implementation by the key agencies involved;

- its limited strategic focus on operationalisation and implementation of its various proposals; and

- its indifferent attention to environmental issues and the need for sustainable utilisation of natural resources and management of hazard-prone lands.

EMIS outputs. Instead, it provides some synthesised lessons of experiences from cities applying the EMIS. Your own EMIS will be focused and adjusted to the expectations of those who take part in your local EPM and city management. Remember that an EMIS does not aim to be comprehensive, but rather connective.

The simplest analysis of the overlays is a city-wide land use pattern of the existing uses and their impact on the environment. This map will give you a good overview of the status quo at a fixed time. It offers a basis for a framework for managing your city's environment-development interaction.

Many city administration planning departments have an office concerned with planning. Traditionally, urban planning has been carried out using a master planning approach. Nowadays, however, the drawbacks of the master planning approach have led to new developments in planning practices, such as Strategic Development Plans, "Open Planning", participatory GIS and other concepts. The Environmental Management Framework (EMF), one output of the EMIS, is an alternative to traditional planning approaches. The participatory nature of the EMIS gives the EMF a strongly participatory character and therefore builds a high sense of ownership among the stakeholders.

Developing an Environmental Management Framework

If you decide to develop a city-wide EMF, ensure that your data and maps cover the entire city area, and that at the same time they cover a broad number of environmental and development issues. Before you feel overwhelmed by the amount of the work to be done and the complexity of the preparation, please check whether an EMF is really needed, supported and likely to be implemented. Otherwise it is not worth spending time on it. Some SCP partner cities, such as Wuhan and Shenyang in China, focus on a few carefully chosen environmental issues, such as air quality management. Other cities, among them Dar es Salaam, have decided on city-wide strategies for a variety of issues. Dar es Salaam has prepared an EMF, called the "Strategic Urban Development Plan", which substitutes for the traditional master plan.

The local EPM Unit is the main driving force for the management and co-ordination of the preparation of the EMF. The Mapping Group has a strong advisory role. It is important to keep key decision-makers, such as the director of the planning department and the city executive, regularly informed on the progress of the EMF. With their commitment and their constructive inputs, the EMF will become a powerful decision making tool.

The EMF can be used to compile all the strategies and investment opportunities drawn up by the Issue-Specific Working Groups. Working Group findings can be compared, and contradicting strategies can be adjusted. Finally, a broad strategy for city growth and expansion can be developed.

An Environmental Management Framework (EMF) has three major parts: (a) spatial analysis; (b) projects and investment requirements; and (c) a management framework for effective implementation of strategies.

(a) The spatial component refers to the geographic interpretation and aggregation of strategies. By mapping and overlaying the geographic distribution of critical natural resources, areas can be classified by their degree of exposure to environmental risks and ranked by their sensitivities to particular development activities. This ranking of areas allows the determination of which development activities are compatible with specific areas. It also supports the articulation of rules and principles applicable to development taking place in the different areas. Such rules and principles may not necessarily exclude certain areas from development: rather they enable the incorporation of the necessary long-term costs in investment decisions.

The spatial analysis part of the EMF allows potential development areas for city expansion and growth to be determined and prioritised. The selection of areas for future urban expansion will be the result of the interaction between push factors (growth deterring), pull factors (growth stimulating) and the environmental sensitivities prevailing in the different areas of the city. The exercise results in the selection of areas with the fewest foregone opportunities, with benign environmental risks, with a higher carrying capacity, with the least infrastructure development costs and with high economic efficiency.

(b) The section on projects and investment requirements includes the list of priority investment projects, with brief descriptions or profiles attached, and their estimated costs, including an estimation of investments required to scale up successful demonstration projects. It will also include a list of potential investment sources, together with strategies for mobilising resources.

(c) As an aggregation of issue-specific strategies negotiated by the stakeholders concerned, the EMF provides a broad management framework which builds on the experience and achievements gained in creating a better understanding of issues, in co-ordinating implementation, and in establishing stronger linkages and connectivity between the different sectors and stakeholders. Based on this, the preparation of the EMF will be used:

- to summarise the roles of the major stakeholders in implementing the proposed strategies;
- to highlight co-ordination and implementation mechanisms that were tested and proven to work effectively; and
- to synthesise the lessons of experience gained and principles developed through the implementation of demonstration projects, and from there, to develop a management framework and strategies which would allow further consolidation and up-scaling.

Zoning

The aggregated map can also be used to prepare different scenario maps, focusing on different political aims such as, for example, what are the development opportunities if all environmentally sensitive areas will be protected? Or, new housing estates are needed, but densification has priority to prevent further spreading of the city. These maps can evolve into Zoning Plans, but should not be promoted as final solutions (remember, the EMIS is an open-ended system). They can help to clarify the impact of different policy and strategy decisions.

See Tool 21: Preparing a Suitability Map, Tool 22: Preparing a Sensitivity Map and Tool 25: Environmental Management Frameworks

Technically, the EMF is an aggregate of relevant Suitability and Sensitivity Maps and makes intensive use of ranking.

B4.5   Further use of the system: Using EMIS for monitoring and evaluation

The EMIS can also be used as a monitoring and evaluation tool for measuring progress in EPM. Information about the status of different environmental issues and ongoing development activities should be fed into the system regularly. This gives you the opportunity to show how the situation is changing – for better or worse – over a certain period of time. Thematic Maps can be prepared showing the current status of the situation and the change over the last few months. It is very useful to make this kind of information available to the Working Group co-ordinators, perhaps by displaying the maps on a wall that everybody passes regularly. In this way, the information is publicly available and taken into consideration in making decisions on urban development. The UrbanInfo software developed by the Global Urban Observatory offers a useful tool to store your data and create indicators to measure progress in your city.

See Tool 26: Monitoring Urban Indicators (UrbanInfo) and Tool 26a: Cities State of the Environment on EMIS CD-ROM (CEROI)

B5

Promoting public information

Public information outreach activities are an important part of the EPM process and of the SCP project cycle. The EMIS can be used to support these activities.

It is often said that a picture speaks a thousand words, and the same can be said of maps. Maps are eye-catching, and will add immensely to any information outreach activity. Whenever you plan a public information campaign (an exhibition, publications,

lectures, conferences) think about which maps can be used to support the topic. A map allows you to show complex interactions on one sheet of paper. However, even though some things may look obvious on a map, always have to bear in mind that reading a map needs some skill. It is always an interpretation of the features shown. Not everybody is used to reading a map. Therefore maps should be kept clear and simple. It is usually better to present several maps, rather than one overloaded one.

Here are some rules you should be aware of when publishing a map, whether as a printed or digital image:

See the harmonic adjustable colour circle in Tool 19: Preparing Thematic Maps

- Always make sure that the map includes all the information necessary to read it, including cartographic elements like the scale, scale bar, north arrow, a clear legend, geographic co-ordinates and the source of the information.
- The layout should be make visual sense:
- The area covered by the EMIS goes beyond administrative boundaries, which means that there is a hinterland. For example, rivers or environmental issues do not stop at boundaries. Don't produce maps which make the city look like an island.
- Colours should be easy to tell apart.
- Always check if the colours print out as you intend. Just a tip: Prepare a small printout with samples of all the colours you are using, so you can check how they are going to look.
- In general show only one topic on each map.

Besides being eye-catching, there is another purpose to showing maps in public. The EMIS follows a participatory approach, so maps should be used and reviewed by as many stakeholders as possible. Perhaps the condition of a road has changed during the last rainy season. The people who can tell you that are the people living in the neighbourhood of that particular road. As the EMIS includes maps derived from the Working Group process or from estimated data, feedback from the public is necessary. People have to verify the information. The process of publishing information will certainly improve your data.

B5.1   Exhibitions

During the SCP process cycle, several special events take place. It is useful to prepare an exhibition to support the launching of the project, the City Consultation and Working Group meetings. For public information outreach it is also useful to hold small exhibitions in the project office building or in other public buildings such as the local library or the city hall.

Tool 27: Information Outreach contains a detailed description of how to prepare a city panel based on the poster templates on the EMIS CD

A range of software is available to prepare posters and exhibition panels. You can use desktop publishing software such as Adobe Pagemaker, Photoshop or Illustrator, computer slide presentation software such as MS PowerPoint, or your GIS software package. Have a look at the city panels from Bayamo, Cuba (in Spanish), Saint-Louis, Senegal, (in French) and Lusaka, Zambia, (in English). These were all presented at the Global Meeting in Havana, Cuba, in 2005. They will give you an idea of how other cities have presented their SCP project and how they have modified this template creatively to meet specific local needs. It is also quite easy to prepare a poster in ArcView GIS, using the layout mode. Your poster can include several maps as well as pictures and text. The Shenyang Air Quality poster will give you an idea of the possibilities.

A computer slide show offers plenty of possibilities for a presentation. The slides can be used to underline the main points of a speech, or it can be set to run by itself. In all cases, each slide should be self-explanatory – it should not need someone to explain what appears on the screen. Remember that if you are making a PowerPoint presentation for a computer slide show, you can reduce the resolution of the map JPEGs considerably, because most screens only have a low resolution. This will save you a good deal of storage space, and will ensure that the presentation will run smoothly.

B5.2   The Web

A web site can be a very effective way to present your city's EMIS to a wide audience. Perhaps the simplest approach is to give a brief explanation of the EMIS, a description of recent projects and to add some maps as images in JPEG format to illustrate the site.

For a more sophisticated website, you can use clickable maps. These maps are saved as pictures, and contain several links to additional information, such as pictures, other maps, and written information. You could use your index map as your clickable map. If a reader clicks on one of the boxes on the index map, a list of all the existing maps in this area could appear. A Thematic Map could also be used, with information popping up for each selected area. If you intend to give details about ongoing projects, a map showing the hotspots and demonstration projects would work well with pictures and project descriptions attached. Of course it is not possible to prepare all your maps in this way. You can only offer some examples in the form of clickable maps.

Tool 27: Information Outreach **gives you an example of how a web page might be structured.**

Alternatively, you can use the Interactive Map Publication approach, which gives selected people – in this case usually decision-makers – read-only access to the EMIS database. In this case, the data, maps and related tables are copied to the selected recipients' computers, together with map viewing software such as the free ArcExplorer. The recipients are given a short introduction on how to use the software and open the maps. They can then explore the data by themselves to find out more about the city. This data should be updated regularly every two months. Interactive Map Publication makes the progress of the system very visible, and is therefore an excellent way to promote the EMIS among high-level decision-makers.

The most sophisticated way to present an EMIS on a website is to give users access to your database to query and view the maps. This is quite a difficult task which requires additional resources and specialised expertise. Some GIS software developers provide web publishing tool of different levels of sophistication (e.g. ArcView Internet Map Server (IMS) of ESRI).

Please read *Tool 28: Mapserver***, for a description of how mapservers work.**

B5.3   Publications

Throughout the SCP project cycle, a number of key publications are produced. These include the Environmental Profile, reports from Consultations, Working Group reports, Urban Development Frameworks and investment plans. Several maps will probably be included in these publications, ranging from the Basic Map which gives an overview of the city to Thematic Maps and Overlays. For many publications it is wise to use black and white maps instead of coloured ones:

• Black and white maps can be as neat as coloured ones. It is better to have sharp black and white maps rather than smeared coloured printouts.
• A black and white layout forces you to prepare simple maps.
• A black and white layout is much cheaper to have printed.

The Sustainable City Atlas

The Sustainable City Atlas is an important EMIS publication. A Sustainable City Atlas is useful for both public and private institutions, and can also be sold in bookshops. It is useful to have a short version to give to investors. The Atlas should combine maps with written information about the city. For example, a soil map of the city should be accompanied by text on the facing page which gives information on mining activities and agricultural usage.

Environmental Atlas of Lima

Lima, capital city of Peru, home to more than 8 million people and the economic and cultural centre of the nation, is experiencing uncontrolled growth at an unprecedented pace. As a result, environmental concerns have become central to attempts to improve living conditions and direct the future development of the city. Unfortunately these attempts are hampered by a lack of complete and concise environmental information. The environmental atlas project facilitates the provision of such information.

The principal aim of the atlas project was to build the capacity of relevant organisations at the national and local level to enable them develop a GIS-based system to access and exchange environmental information. An important concrete output of the project was the production of an environmental atlas in paper and digital format

The project was carried out by public institutions in Peru that produce and use environmental information and that are responsible for environmental policy, planning and management. The various products in the atlas have been developed by experts from these organisations, working in various disciplines. This has ensured that the information used is of high quality and up to date. The project participants have acquired the skills necessary to develop the products of the atlas through training programmes in geographic information systems, spatial and environmental analysis, cartography, information system development and spatial data infrastructures.

The atlas presents a wide variety of environmental themes covering the geographical area of the greater Lima region, grouped into the chapters Natural System (geology, geomorphology, hydrology, climate, the El Niño phenomenon, natural hazards, ecosystems), Human System (spatial development, demography, services, identity and economic activity), Man and the Environment (quality of water, soil, air and natural and human induced risk), and a section that discusses past, ongoing and planned projects and initiatives to protect the environment. It contains over 100 full colour maps at various scales, hundreds of photos and graphics and elaborate descriptions of the environmental phenomena occurring in the region.

The atlas provides the first comprehensive high quality overview of environmental information in the Lima region. The information in the atlas is being used by professionals in urban environmental planning and management, policy makers, academics, students and the general public. It is helping to build the necessary understanding of a complex environmental reality and is helping to shape the future of the city.

A sample chapter from the Atlas on air pollution (p.104-113 of the atlas, provided by ITC and IMP) can be found on the EMIS CD. The map gives an example on the concentration of lead in the air of Lima city. (www.munlima.gob.pe/imp)
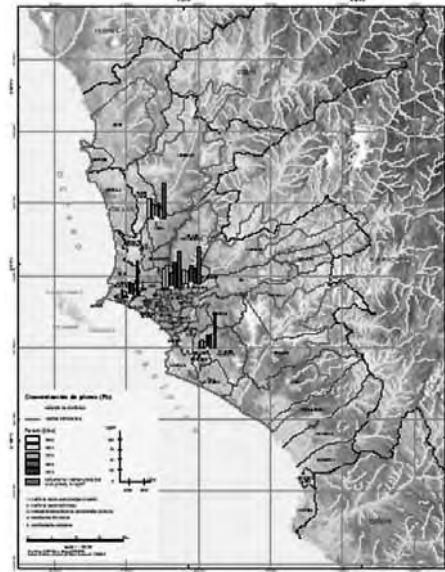
Project Newsletters

See Tool 27: Information Outreach for some general tips on the preparation of publications.

Project newsletters can be used to tell stakeholders and members of the Mapping and the Working Groups about the progress of the EMP process on a regular basis. A newsletter will also help to keep the general public and people interested in the work of the Sustainable Cities project in your city. A newsletter can be distributed in hardcopy or in electronic format via email or your web site. It can also be distributed in partner institutions and during exhibitions as well. However, be aware that the preparation of a newsletter – writing articles, asking Working Group members for input, laying it out and printing and distributing it – consumes a great deal of time and effort. You also have to be sure that the articles are newsworthy and interesting. A newsletter template (in Adobe Pagemaker format) is included on the EMIS CD-ROM.

Project flyers

A flyer or a short brochure requires less work than a newsletter because it only needs to be prepared once, unless important changes take place. Flyers and brochures are easy to distribute, and can be used to inform a wide range of people about EMIS and the SCP project. Use the flyer prepared by Lusaka on the EMIS CD as an example.

B6

Maintaining the EMIS

To maintain an information system like the EMIS, you must consider several things. First of all, the EMIS is a learning system, so it will never be "finished". Of course after you have taken all steps described in this Handbook, the major part of the work is done. The tasks will change. Beforehand, the most important task was to gather data, now it will be to analyse the data. The EMIS staff will now focus on updating the data, filling gaps, analysing the information and preparing different outputs. This chapter concentrates on the process of institutionalising the EMIS – of making it a routine part of the urban EPM process. This process includes updating the information of the system, training staff and users and fitting the system to the city structure.

See Tool 29: Decision Support Systems.

EMIS a spatial planning or decision support system

In the planning and decision making process we distinguish three phases, i.e. problem understanding, formulation of options, and choice amongst options. Models are often used to understand and experiment with these complex systems and generate information. Given the complexity of systems, the large volume of (spatial) data, the high variability of (spatial) judgment … AND the weak human cognitive capacity to process data and judgment, (computerized) planning and decision support systems are used in spatial planning and decision processes.

Decision support systems are defined as "an interactive, flexible, and adaptable computer-based information system, especially developed for supporting the solution of a non-structured management problem for improved decision making. It utilizes data, provides an easy-to-use interface, and allows for the decision maker's own insights." It allows decision makers to express how they structure, value and trade-off various objectives and criteria. If we have decision support systems that support decisions about planned options, then we should consider planning support systems to be the tools to help us develop these planned options.

For example, if a transport-air pollution model simulates different scenarios with different factual impacts on economic development and air pollution, the evaluation of what the most suitable location is for an air quality intervention will vary between people since they have different appreciation for economic development and air quality. Always when we use the EMIS we need to be aware whether we are supporting problem analysis, development of solutions, or choice between options and whether we support with factual assessment or subjective evaluation models.

First of all, its data address relevant questions for these processes, in other words the data are informative or can be made informative. Second, it helps large amounts of data to become informative by structuring and aggregation of data. Third, it should facilitate resource analysis in the widest possible meaning (e.g. natural, human, financial, etc.) helping to understand characteristics of resources, and the processes through which they are allocated and utilized. Fourth, your EMIS should also allow different valuation of data in order for different stakeholders to express what the critical values are and what critical criteria are. Fifth, your EMIS should support decision makers in structuring and analyzing trade-offs, where they may for instance express a trade-off between economic versus environmental development objectives, but just as well a trade-off between the impact of an intervention on its spatial environment and the impact of that same environment on the intervention. And finally, if you really want to make it supportive, think of the EMIS as a collaborative spatial planning and decision support system, since most processes require communication and negotiation between interest groups.

B6.1   Updating the information in the EMIS

Preparing the Thematic Maps and Suitability and Sensitivity Maps needed by the working groups provides the first opportunity to update the information in the EMIS. New development activities are taking place all the time, and the environment-development interaction changes continually. Each new road or sewerage plant will change the pattern of the Environmental Management Framework. Like the EMIS, an EMF is not static and will never be a "finished" document. Keeping track of the changes and updating the system will be the main challenge facing the mapping unit in the years following its establishment. For example, some information may go out of date or the system may still contain estimated data because of a previous lack of exact scientific data. This information will have to be replaced incrementally by more accurate and up to date information.

One way to acquire new information is to work closely with your local university. You can make an arrangement whereby they can use your data for free, as long as they give you their results in exchange. It is probable that many students will prepare theses on all sorts of issues in your city. Keep in touch with them! Students will probably be as interested as you are in this relationship, as it adds value to their work if their findings are used.

Investors or donors who do not agree with the findings of the EMIS may also be a means of updating the EMIS maps. They might argue that some of the information is not scientific. If this is the case, they are very welcome to provide additional information or funds for conducting detailed research, so make sure that your system is attractive enough for them to feed into it.

It is important to save a backup version of the EMIS regularly. There are a variety of different ways to do this: CD-ROM or DVD-writers, tape drives, zip-drives or another hard disc. These devices have to be stored in a secure place, preferably not in the same office as your computer.

B6.2   Building and maintaining skills

Training is one of the main prerequisites for making the EMIS work. It is essential to provide sensitisation courses and training in the overall EPM process to all EMIS users. These training sessions should not focus on particular GIS software, but should emphasise the general use of the EMIS, and how it can support the work of the trainees. It is more important to learn how an EMIS works and the possible applications of a GIS for urban planning purposes than to learn commands and software package menus.

The EMIS has different users: decision-makers, planners and GIS administrators. All these users need to know about the EPM process, the principles of an EMIS and how they can use it effectively in their day-to-day business. The type and the extent of information needed differs from user to user:

• The GIS administrator needs a broad knowledge of GIS and EMIS and their possible applications, as well as detailed technical knowledge of the hardware and software. GIS applications and software change rapidly, so the staff of the EMIS unit will need regular training sessions and intensive exposure to information through relevant magazines/publications and Internet access.

• Planners and other users of the data need training in GIS and applications, as well as basic knowledge in using the GIS software package for analysing data.

• Decision-makers and other interested people need a general overview of the possibilities of the EMIS and its outputs, so they can use and support the system.

The case example of Ibadan, Nigeria, offers a good example of a training agenda which takes different needs into consideration.

Training of the EMIS staff in Ibadan, Nigeria

The introduction of Geographic Information Systems to management practices in Ibadan, Nigeria, required a comprehensive training programme. The workshops and training for sensitisation and for initial capacity building targeted two broad groups of people. The first group consisted of senior level government officials who needed to be aware of the role of GIS. The second group consisted of people for whom a GIS facility might actually be set up. ctually be setup.

First Sensitisation Workshop

Duration: One-day event

Participants: sixty participants drawn from a cross-section of the stakeholders

Objectives: The workshop aimed to sensitise the top level management of government offices and international donor agencies on the role of GIS in the management of the urban environment. Therefore, it was designed to provide a down-to-earth description of what GIS is, to show the relationship between the formulation of action plans and the attainment of sustainable management of the urban environment, and to demonstrate potential uses of GIS at the local level.

Second Sensitisation Workshop

Duration: two-day workshop, a follow-up to the previous workshop

Participants: 54 participants consisting mainly of staff selected from the eleven Local Governments in Ibadan Metropolis.

Objectives: he workshop aimed to demonstrate the GIS facility and to stimulate the interest of potential operators and users. It was also necessary to teach the basic principles of using GIS to produce maps, illustrate issues and support decision-making. The approach adopted by the workshop involved plenary sessions and smaller group meetings. In order to facilitate the interaction of participants with the facilitators and GIS equipment, four computers were provided, all equipped with GIS peripherals such as digitizers, printers and different GIS software.

It is very important to prepare a long-term EMIS training strategy. First of all GIS is changing rapidly, so there is always something new to learn. Secondly, the "brain-drain" of well-trained personnel is a very common problem for public administration. Several SCP partner cities have experienced the loss of well-trained staff members. Often, when people are well trained and have the opportunity, they will move to the private sector, as most of the time this offers better pay. The mapping group must develop a pool of potential EMIS experts in order to avoid a break-down in the EMIS operations if the EMIS officer leaves.

You will find a list of possible training institutions in Tool 31: Training

B6.3   Making the system routine

The institutionalisation of the EMIS unit is an essential part of the institutionalisation of the SCP process. The unit needs an appropriate permanent location (see section B1.1), preferably integrated in an existing department. There are three things to be considered: the main focus of the EMIS, the key persons for the system and the existing structure of institutions in the city.

See Tool 32: Financing EMIS

What does the EMIS cost?

An EMIS consists of four components: hardware, software, data and users, and with each of these components the costs increase. A full-fledged EMIS set-up is expensive. If you have budget constraints, build your EMIS incrementally. The beauty of the system is that it allows different levels of sophistication without losing the quality of

the end products. Purchasing the hardware is actually the cheapest part of the set-up. Software, including regular updates, which are necessary, can cost up to ten times more. Data acquisition is also expensive. The costs include buying maps, acquiring rights to digitize data and purchase of digital data. The most expensive part of the system, however, will be employee salaries and training for users of the system. This is something you should keep in mind, if you intend to generate money from your EMIS to recover its costs. Because of the high level of financial inputs necessary it is essential for the EMIS to have strong political backing.

Of course the costs for an EMIS can be lower. Most of the time software can be purchased at a cheaper rate for non-commercial projects. Also data cost will be considerably less, because a great deal of data can be provided free of charge by the different stakeholders from different government departments and ministries. It is in their own interest to provide the EMIS with data, because with better urban management all stakeholders will "win" from the combined information. The Working Group process also generates free data for the EMIS. However, funds are still - as always - crucial for the success of the EMIS, so you should start to lobby for funding for the EMIS from the very beginning. Try to get a realistic picture of the costs of the system for each year, translating donations into true costs.

While the system should be kept open to the public, and everybody should have access to the data, this does not mean that the EMIS unit is obliged to give out printouts to everybody free of charge. Nor does it mean that the unit has to create maps or make changes to existing ones according to everybody's wishes, as this can become very time consuming.

It must be admitted that to run the EMIS as an open system is a real challenge. Accepting donated data carries with it the responsibility of providing access to this data for all users. Two things can help you to provide this access: a computer and a time schedule. You could make available a computer running ArcExplorer, be connected to the EMIS. Open access to this will allow all the users to view the data and make some queries. Maybe your budget even allows the users to make some black and white printouts of the maps. Of course, the people coming to query the data would need a short presentation on how to use ArcExplorer, but then they should be able to carry on by themselves. Another possibility to reduce pressure from outside visitors is to limit visits to specific times. The EMIS office could be open to the public perhaps two days a week.

Monitoring effectiveness of the EMIS

The ultimate effectiveness of the EMIS cannot be judged independently from the effectiveness of the EPM and working group as a whole: "the proof of the pudding is in the eating". Furthermore, as EPM/SCP is a learning process and contents and scope are progressively evolving, one cannot automatically use the criteria of concrete impact on the handling of environmental issues in general.

To begin with, one can focus on the communication elements (particularly relevant to the EMIS): internally and subjectively through user satisfaction as expressed by the stakeholders: externally and "objectively" (or perhaps "normatively" might be more accurate) by evaluating whether the environmental and crosscutting nature of issues has been effectively made explicit.

For the EMIS, a priority starting point for monitoring might be the former aspect, through the following indicative questions:

• Are the EMIS contents updated regularly?
• How many times have decision-makers or other stakeholders requested or received information presented in the EPM framework formats?

In these instances, did they:

- find the information understandable?
- find the information relevant and/or useful to their concerns/activities/decisions? If so, how?
- gain a better comprehension of the issues in question?

Part C

The Toolkit: Key Steps in Building an Environmental Management Information System (EMIS)

Tool 1: Participatory Geographic Information Systems (PGIS)

How to use participatory elements in the SCP process

- PGIS and Environmental Planning and Management
- Guidelines of 'Good Practice' for P-Mapping and PGIS (Tool 1a on EMIS CD-ROM)
- Step-by-step to implementing P-Mapping and PGIS
- PGIS case studies

PGIS and Environmental Planning and Management

Participatory GIS is an emerging practice, which has developed out of both GIS-technology and participatory approaches to planning and decision making. The essential issue is the intensity of participation in the GIS construction, design, and mapping activities. The key question relates to the idea of participation – which functions, processes, activities, measures, instruments, procedures of spatial planning involve participation?

Participatory GIS is not about the popularisation and downscaling of GIS-technology. Nor is it 'doing' GIS (or mapping) with some degree of public participation in data collection, or some community involvement in choosing data sources, types of analysis or presentation of data. PGIS is participatory spatial planning (PSP) which uses maps and Geographic Information outputs, especially GIS. Although some participatory planning, such as planning a school curriculum, can take place without maps, it is virtually impossible for participatory spatial planning not to include maps.

What is special about PGIS in the context of Urban Environmental Planning and Management?

Eliciting Local Knowledge.
City dwellers establish activities and lifestyles in their neighbourhoods that depend partly on adaptation to changing circumstances. The origin of these specific circumstances is often difficult to establish, as issues such as deteriorating services (shops, utilities) and environmental conditions happen slowly and for reasons which are not recorded in official planning documents. These reasons may however be deeply embedded in local (spatial) knowledge, which encompasses the local technical knowledge of hazards, problems, potentials and utility uses, as well as indigenous or local spatial concepts of culture and space. Bringing out this knowledge is important if urban planners are to understand the origin of problems, and it is equally important for communities to ensure that this knowledge is shared and stored. As cities change rapidly and people are very mobile, the risk of losing local knowledge is quite high.

Raising Awareness

Discussions of many community issues can be facilitated by adding a visual, spatial component to participatory techniques. Working with participatory mapping and participatory GIS, or 3-D physical models, can create community bonding and awareness. The resulting visual impressions can motivate people to act on local issues like pollution or traffic hazards. Interactive maps provided by the authorities that show risks and hazard locations in cities, for instance, can similarly raise citizen awareness.

Extracting local knowledge with the use of aerial photographs

Environmental Planning and Management (EPM) and the SCP approach is an advantage. Experience with community work and participatory planning concepts is an asset.
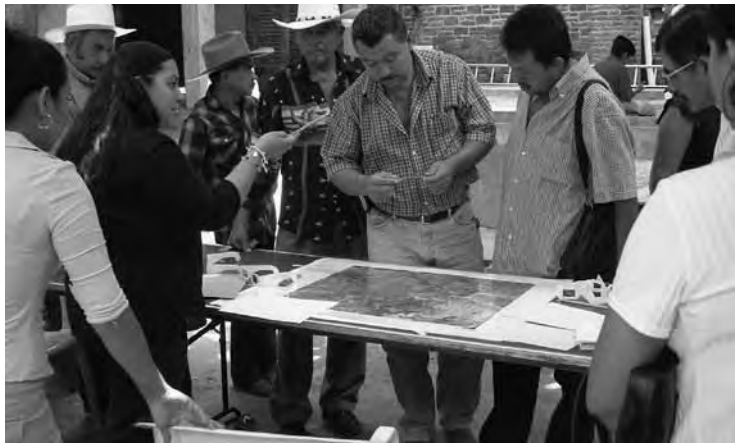
Case study

Interactive Urban Watershed Model Stewardship & Education: Streamkeepers Community Outreach Program (SCOP)

Non-point source pollution occurs when rainfall, snowmelt or irrigation runs over land or sub-surface, picks up pollutants, and deposits them into rivers, lakes and coastal waters, or introduces them into ground water. Agriculture, forestry, grazing, septic systems, boating, urban runoff, construction, physical changes to stream channels and habitat degradation are potential sources of non-point source pollution.

Using satellite images of Vancouver Island and 1:20,000 topographic maps of the local watersheds as well as a model of a local watershed, SCOP introduces children to their local environment and shows them how non-point source pollution affects the quality of water, air and the plants and animals that live there.

Demonstration of runoff modelling during the 3rd World Urban Forum

For more information please see www.pyr.ec.gc.ca/EN/_pdf/NPSP_English.pdf and www.iapad.org

Source: www.pyr.ec.gc.ca

Disseminating spatial information to citizens through the media of internet, newspapers, radio or television gives a degree of transparency to planning processes. But inclusion of local interests and priorities is better achieved, if communities can represent themselves to an actively 'listening government' and its institutions. Making neighbourhood maps by combining maps (overlays) with aerial photos or satellite images can show local interests and thus motivate initiatives, e.g. websites like maps.google.com or software like Google Earth can be used to measure distances to services, healthcare or markets. Interactive information access and use of GIS through the internet can provide a two-way flow of ideas and knowledge.

Please refer to table at page 75 for linkages between the SCP project stages and participatory GIS methods. A poster giving examples of participatory elements of EMIS can be found on CD-ROM.

SUITABLE APPLICATIONS TOOL OR METHOD	Boundary mapping	Environmental issues	Land allocations	Land use planning	Location marking	Risks & Hazards	Safety & security	Service and utility planning	Slum upgrading
RRA & PRA methods (for spatial info)		o		o		o	o		o
P-mapping with: Sketch mapping				o		o	o	o	
P-mapping with: Topo maps	o		o	o	o			o	o
P-mapping with: aerial photos	o	o	o	o	o	o	o	o	o
P-mapping with: satellite images	o	o		o		o	o	o	o
P3DM	o	o	o	o	o				
Mobile GIS, GPS, Cyber Tracker	o				o	o		o	o
GIS	o	o	o	o		o		o	o
Visualisation, Graphics software		o		o		o	o		o
Digital camera, Video, Multi Media		o				o	o		
Dynamic GIS (web-based GIS)				o		o	o	o	
Virtual reality		o		o			o		o
Interactive Planning Tables	o	o	o	o	o	o			

Step-by-step to implementing P-Mapping and PGIS

1. *Make full use of participatory non-conventional information and knowledge acquisition* – semi-structured interviews, open-ended discussions, stories, songs, pictures, chance meetings and the whole range of RRA/PRA methods, especially sketch maps, diagrams, historical time lines, time-space diagrams, etc. The table on Page 72 can assist in deciding on the appropriate tools and methods.

    A more elaborate overview of these tools and their strengths and weaknesses is given in the tables at the end of this tool.

2. *Acquire sufficient prior knowledge* (but without striving to reach prior conclusions about the situation and problem.) Make a reconnaissance of the area in the company of local experts, before beginning the full process. Acquire professional geospatial information – base maps, aerial photos, remote sensing imagery, as well as conventional a-spatial information sources – documents, censuses, reports, etc.

3. *Identify and attempt to understand local (indigenous) spatial knowledge* including: concepts of neighbourhoods, and of boundaries (property or cultural), conflict zones and risk zones, priority areas (e.g. for upgrading or rehabilitation), time-distance relations (e.g. between home and livelihood), dynamic spaces (e.g. empty or crowded streets or markets) and landscapes. Collaborative selection of the appropriate spatial scale for geo-data inputs, and especially for the map and GIS products, based on social and political as well as geographic criteria is important to gain the acceptance and interest of community people.

4. *Consider the pros and cons* of using the following materials, where and when appropriate: See Table on Page 76.
    *   Enlarged aerial photos or air photo mosaics; (great for detail, though difficult to acquire).
    *   Topographic maps (1:10,000 scale); (very accurate, but showing only official information)
    *   Satellite imagery; (easy to acquire, expensive at high resolution)
    *   Ephemeral maps (drawn on the ground, in sand, etc.); (Great fun for group exercises, but it is hard to save them before the maps are walked or rained on).
    *   Translation of the local spatial knowledge visualisations into mobile GIS software, e.g. ArcPad.
    *   Physical three-dimensional models.

Participatory mapping with enlarged aerial photographs

5. *Plan for, acquire, and gather together the field and office equipment,* such as GPS, Personal Digital Assistant (PDA) (Pocket PC for mobile GIS); and the necessary materials, such as paper, plastic overlays, coloured pencils, markers.

Extracting local knowledge with the use of aerial photographs

6. *Ensure that a broad (representative) range of local people are involved.* Include women, children, elderly, people with specialised knowledge (such as local experts) and representatives of the power-deficient or marginalised and the inarticulate or disadvantaged. Thus, in an urban community these are property owners, the landless / homeless, renters, absentee landlords, local authorities, political representatives, NGOs, technical staff and business people will be among those included.

7. *"A picture says more than a thousand words",* thus, showing photos or sketches of damaged building fronts or waste dumps or leaking pipes makes for better arguments. Participatory maps can be transferred into appropriate graphics visualisation software like Macromedia Freehand FX or Adobe Illustrator which may be better attuned to local spatial knowledge characteristics of indeterminacy, fuzziness, and emotion, and which can show rich, qualitative, holistic information. Make use of interactive visualisation software for development and for participatory spatial planning with user groups. Supplement spatial information sources with digital photography, video or sound recordings, and with sketching if photography is ineffective. The results of this should be better presentation and visualisation, interpretation of outputs and understanding.

8. *Let the people do the activities* – Keep the instructions and the interference to the necessary minimum. Do not over-emphasise details, or you risk losing the big picture. External professional experts should always have patience. Observe the P-mapping process to increase understanding on both sides. Ask questions, probe, ask for explanations, e.g. why are there regularities and why anomalies in the results? The process should be clearly useful to the local participants (in what way depends on the purpose!), but it should also be enjoyable, as well as being systematic, sensible and scientific.

9. *Make the fullest use of the spatial analysis functionalities of GIS*, i.e. exploit the added value of using GIS. Such added value includes the ability to handle multiple data layers for analysis and presentation, the ability to work across multiple scales and topologies, and the spatial analysis capabilities e.g. proximity, threshold distances, routes, land uses, networks. GIS has major strengths in recording, protecting, exchanging and sharing spatial information.

10. *A key idea in PGIS is triangulation, which refers to checking and double-checking 'everything'* – the data sources, the opinions, the analysis, the conclusion, the recommendations – by using alternative sources and measurements and analytic methods. Cross-check local spatial knowledge visualisations and geo-referenced indigenous technical data with geo-information from standard maps, topographic maps, etc. But do not treat the local spatial knowledge maps or 'mental maps' simply as 'games'. Do not take the standard official maps as the only authentic base against which to measure.

11. *Use the map products* - take them on further in transect walks, etc. Show and discuss the groups' maps in joint meetings – for triangulation, and for awareness, and for applications in conflict management, for empowerment, etc.

12. *The final outputs may be printed maps (of many scales)*, hardware models (e.g. 3-D models), CD-ROMs (GIS), websites (e-maps), etc. Each type of output has specific and detailed requirements, and different 'ownership' conditions. The delivery and dissemination of spatial information and other outputs should be pre-planned collaboratively so as to meet people's expectations of transparency, accountability and equity. To encourage a clear sense of ownership, multiple, full-quality copies of the output & intermediate maps should remain in the community, preferably with several organisations. Copies should also go to local governments and local NGOs. Include the names of the contributors to the maps.

13. *Follow-ups, monitoring and evaluations* should be designed into the PGIS process from the outset. The spatial information, the maps, are never final, static, they are not 'set in stone' – they should be continuously triangulated and improved. Later they should be updated. Think about how to ensure updating when the activity is over – especially when it is an externally-set project.

Stages in the SCP Project Cycle		Start up Phase		Strategy & Action planning Phase		Follow up, Implementation Phase	Consolidation & Replication Phase		All Phases	
Tools and Methods		Awareness raising and Discussion	Acquire & Record Spatial Knowledge	Analyse Spatial Information	Participatory Planning using PGIS	Consensus building	Scenario Assessment	Conflict Analysis & Management	Represent, Communicate & Visualise	Preserving ILK
RRA & PRA methods (spatial information)		**	**		**	**			**	
Participatory Mapping with:	Sketch maps	**	**			**			**	
	Topo maps	**	**	**	**	**			**	
	Aerial photos	**	**	**	**	**			**	
	Satellite images	**	**	**		**			**	
3DM		**	**	**	**	**	**	**	**	**
Mobile GIS, e.g. Cyber Tracker			**						*	
GIS				**	**			**	*	
Visualisation, Graphics software									**	

Stages in the SCP Project Cycle	Start up Phase		Strategy & Action planning Phase		Follow up, Implementation Phase	Consolidation & Replication Phase		All Phases	
Tools and Methods	Awareness raising and Discussion	Acquire & Record Spatial Knowledge	Analyse Spatial Information	Participatory Planning using PGIS	Consensus building	Scenario Assessment	Conflict Analysis & Management	Represent, Communicate & Visualise	Preserving ILK
Multi-media, Digital camera, Video, audio	**	**						**	**
Dynamic GIS (web-based GIS)			**					**	
Virtual reality	**		**			**		**	
Interactive Planning Tables	**			**	**			**	

Tools and Methods	Summary description	Specific Applications	Strong Points	Weak points	Further Info
RRA & PRA methods (for spatial info)	Sketch Mapping; Transects; Historical profiles; Time-space diagram semi-structured interviews, discussions, stories, songs, pictures, serendipity	Safety & security Environmental issues Risks & Hazards	Very participatory, based on well established methods	Can be time consuming	World Bank, Book "21 steps" by Chambers
P-mapping with: Sketch mapping	Ephemeral maps are drawn in the sand or on blackboard (they don't last) Sketch maps are done on more lasting media like paper or board.	Service and utility planning Environmental issues Risks & Hazards	Easily available materials Paper and felt pens (or anything available)	Cross-checking. Impermanent	www.iapad.org www.greenmap.org www.CSDMS.in
P-mapping with: Topo maps	Topographic survey map as base map on top of which sketch maps or survey data are drawn with or without plastic overlay	Slum upgrading Boundary mapping Service and utility planning	Maps usually easy to obtain	Maps are incomplete, inaccurate, Irrelevant	www.iapad.org www.greenmap.org www.greeninfo.org www.Orton.org www.CSDMS.in

Tools and Methods	Summary description	Specific Applications	Strong Points	Weak points	Further Info
P-mapping with: aerial photos	Aerial photos (AP); Photo mosaics. Small format oblique AP; can serve as base map with or without plastic overlay	Slum upgrading Boundary mapping Service and utility planning Safety & security Environmental issues Risks & Hazards	Very accurate, users can easily orient themselves	APs: Infrequent Out of date Costly to fly new AP Weather	www.iapad.org www.CSDMS.in
P-mapping with: satellite images	Satellite images can serve the same purpose as the above but are more suitable for large scale interpretations.	Land use planning Risks & Hazards Environmental issues	May have higher frequency coverage than AP	Cost Image Resolution Colours	www.iapad.org www.greenmap.org www.greeninfo.org www.Orton.org www.CSDMS.in
P3DM	A physical geo-referenced scale model made of cardboard or Styrofoam showing a three dimensional map of an area.	Boundary mapping Land use planning	Participation during construction, as well as for analysis	Lots of construction materials needed Time consuming Many people Static	Rambaldi & Tallosa Carr, www.iapad.org
Mobile GIS, e.g. Cyber Tracker	GPS with PDA (Palm) and/or Tablet PC,	Slum upgrading Boundary mapping Service and utility planning Location marking	Easy to apply – for simple data recording (eg. using CyberTracker, no literacy requirement)	Data link GPS to iPaq can be problem. Battery life	www.Cybertracker.co.za
Digital camera, Video, Audio Multi-media,	Usually as supplementary source. Sound and (moving) images	Safety & Security Environmental issues Risks & Hazards	Contains narratives and visuals of actual situation	Difficult to add spatial information	Corbett www.CSDMS.in
GIS	Analysing spatial information using GIS	Land use planning Boundaries Land allocations	Designed to handle large datasets	Software Hardware Computer skills Fixed conventions on data use and representation	www.ESRI.com www.itc.nl www.greenmap.org www.greeninfo.org www.Orton.org www.CSDMS.in
Virtual reality	Electronic 3D environment to visualise the surroundings	Safety & Security Environmental issues Land use planning, Slum upgrading	Strong visual impression	Software, Expensive hardware, Computer skills	www.Txchange.nl

Dynamic GIS (web-based GIS)	Animated GIF, JPG MPEG, Quick Time Macromedia Flash, Javascript, SVG (scalable vector graphics)	Safety & Security Risks & Hazards Service and utility planning, Land use planning	Access to vast amount of info.	Fast internet connections	www.esri.comb
Visualisation, Graphics software	Using graphics software to create maps outside of the conventions of GIS	Environmental issues Safety & Security Risks & Hazards, Land use planning Slum upgrading	Easily tailored to best representation (cultural values)	Software Hardware Computer skills	www.macromedia.com www.adobe.com
Interactive Planning Tables	Large screen or projection with touch sensitive surfaces that can be used to interactively work with digital maps and images	Environmental issues Safety & Security Risks & Hazards Land use planning Slum upgrading	Multi-player Interactive Collaborative Real time	Expensive Equipment: 4-8 Laptops, Projector, 32" LCD screen with active display	MapTalk table: www.maptalk.nl Diamond Touch: www.merl.com

P-GIS case studies

Case study

'Mapping the Neighbourhood' exercise in Delhi

Students of Standard 9 class were first trained to prepare maps on paper during surveying, then instructed on how to transform survey sketches into proper paper maps, and finally on digitization aspects. The exercise started with a few hours of presentation and the introduction of key concepts, and was then followed with a three day field survey. Each group was allotted part of a mainly residential area with a few open spaces like parks, and car parking. Some shops, water and electricity infrastructure, and temples were also in the vicinity.

Representatives of CSDMS (Centre for Science Development and Media Studies, New Delhi) and school teachers assisted the

Explaining mobile GIS to neighbourhood kids

students in conducting the mapping exercise. The students were asked to draw the outline of the selected area on graph paper at a predefined scale of 1:1000. Details and measured mapping of features were done in the field, marking roads and roadside features like the buildings, shops, car parking, etc.

A majority of the students involved now have the concept of how a map is made and understand the features and elements that give shape and character to a place. They became proficient with the concepts of scale, direction and measurement, although the concept of direction had to be emphasized, as they faced difficulties with road directions at sharp bends. The students were quite successful in completing the survey within the fixed time. They became quite capable in carrying out the mapping exercise with precision. This sort of basic mapping exercise was very helpful to the secondary students, to help them in future to better recognize their locality. At the end of the exercise students learnt to appreciate both traditional mapping methods and mobile mapping with the use of GPS.

Source: *www.csdms.in/NM/index.htm*

Case study

Mapping lost homes after the Tsunami

Drawing "mental maps" of their former home and life spaces can have long-lasting benefits, especially for children. The physical neighbourhoods cannot be recovered materially as they were, but something might be done to reinforce and reinvigorate the spiritual life of the communities.

Drawing Therapy
Children can express feelings and emotions that are difficult to describe in words though drawings, paintings and other art forms. These forms of expression have no language barriers. The idea of children making paintings has been used with children after major traumatic events, such as after the Bam earthquake in Iran, the 9/11 attack in New York, earthquakes in China, civil wars and hostage atrocities in Serbia and Chechnya, etc.

Home Maps as a Record
Making 'mental maps' of where they used to live has an additional important benefit. It would be the opportunity to re-create some life heritage for all the survivors of this tsunami generation, children and adults alike. In years to come, people will struggle to remember what the streets and community looked like in their neighbourhood which used to be so familiar. These reconstructed mental maps of their old home areas are like keeping photographs of loved ones.

Making the Maps
The basic ideas of drawing Home Maps are straightforward. However, they

depend on the children being in a school or club group or with individual teachers in whom they have trust and confidence. Some children will just get on with it easily and will make the maps, but others will be shy and uncertain and will need some structured activity to get started. Children's maps include mapping the positive happy side of their neighbourhood – play areas, gardens, areas for cricket or football and games, favourite shops and stands, or "secret places" where they play. The Maps can also include the less happy locations, places where children felt afraid for real reasons or just in their imagination.

The children's maps can be of many types. The simplest can be imaginative sketch maps made with crayons, paints, marker pens, colour pencils, on paper or card, or painted on children's boxes. There is no necessity to make the sketch maps to a consistent scale, or to be concerned with geographical exactness or precision. Precision is not the point – what is essential is the content and how the child shows it. The children's images can be drawn upon standard (topographic) maps of the locality, or on aerial photographs, if they are available, on which the children can mark their home areas, and their happy and unhappy places.

It is important to record and (digitally) preserve the mental home maps that the children make, if they are to be kept as a record or memory for the future.

Conclusion

Of course pictures and maps are not everything, but, recorded and preserved, they can be one part of the survival and recovery process and of an inheritance. Local people's (adults and children) participatory maps can also be used for participatory planning of preference areas and for making selection maps for the new settlement sites. These maps would allow local people to reconsider and rearrange any elements of the locality because the spatial layout is starting anew. se of GPS.

Source and full text: *http://www.gisdevelopment.net/magazine/years/2005/jun/homes.htm*

Case Study

Application of Participatory GIS in the Environmental Information Management Systems of Kotte Municipality, Sri Lanka

Email rangajeewa_ra yahoo.com/Kotte mc a sltnet.lk

Introduction

Sustainable Cities Programme (SCP) was introduced to Sri Lanka by United Nations Centre for Human Settlements (UN-Habitat) in 1999 to support planning and management capabilities of cities. SCP follows a participatory decision making process in environmental planning and management affairs of cities.

SCP Process

The SCP consists of sequence of logically connected activities. They are Stakeholder identification, City Profiling, City Consultation, Identification of key issue, Strategies, Action Planning, Follow up and Consolidation

EMIS and GIS in the SCP Process

Information has to be collected and properly managed in the each step of the above process. The Environmental Management Information System (EMIS) is a tool for collecting, organising and applying information relevant to urban development and the environment. Well-established EMIS will produce maps, which are vital for preparing city development strategies. GIS is one of the tools that may be used for applying the EMIS. Properly managed and maintained EMIS facilitates the local authorities in analyzing locations for housing schemes, flood prone areas, areas we can guide investors, selection of site for a shopping complex etc.

Establishing an EMIS in a SCP city supports a better understanding of the SCP process cycle.
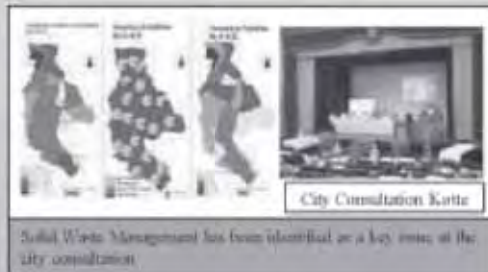*Case Study Kotte MC*

EMIS Training Sessions

Major Challenges in Building an EMIS
* To change the mind set of important people
* Lack of devoted staff for this job
* Need of equipments and software
* Red tape
* Motivating the staff

1. Environmental Profiling

Basic Maps for CP

2. City Consultation & Issue prioritization

City Consultation Kotte

Solid Waste Management has been identified as a key issue at the city consultation

3. Thematic Working Groups in operation

At a SWM WG Meeting

WG identified locations for composting bins distribution by analysing the major waste generation clusters.

Bins distributions

4. Formulation of Strategies & Action Plans

For the first time the EMIS road inventory was used to prepare the SW collection tender. Conditions of the contract was based on the data available in the EMIS

1. Basic Maps and Thematic Maps are prepared for the EP

2. The EMIS can be used to prepare an exhibition for the City Consultation. Such a map exhibition will help to identify, clarify and prioritise the environmental issues of the city

3. The Working Groups decide on their needs for specific maps

4. With the help of the EMIS detailed action plans can be prepared and the maps will help to formulate the strategies.

Tool 2: Location for the EMIS unit

Where to place the EMIS unit: closely to the decision makers and connected to technical expertise in GIS

- Checklist of institutions involved in the EPM process
- Checklist of institutions working with GIS
- Checklist of the office environment

Checklist of institutions involved in the EPM process

- **City Government/ Municipal Departments**
  (i.e. Planning Department)
  Contact person and address:

  _____

  _____

  _____

- **Regional/ Provincial Departments**
  (i.e. Department for Regional Development, Department for Transportation)
  Contact person and address:

  _____

  _____

  _____

- **Ministries**
  (i.e. the Ministries of Housing, Ministry of urban Development)
  Contact person(s) and address(es):

  _____

  _____

  _____

- **Private Sector Organisations**
  (i.e. Chamber of Commerce, Trade Associations)
  Contact person and address:

  _____

  _____

  _____

- **Civil Societies (CBOs, NGOs)**
  (Geography or cartography department)
  Contact person and address:

  _____

  _____

  _____

- **Working Group Coordinators**

  Contact person and address for each Working Group:

  _____

  _____

  _____

- **Members of the Working Group Steering Committee**

  Contact person and address:

  _____

  _____

  _____

- **Members of the Working Groups**

  Contact person and address:

  _____

  _____

  _____

_____

Checklist of institutions working with GIS

- **Technical Support Unit (TSU)**

  (i.e. the technical unit in the department in which the EMIS is located. Please refer also to Tool E: Technical Support Unit).

  Contact person(s) and address(es):

  _____

  _____

  _____

- **Survey and Mapping Department/Institution**

  (or any other institution which is responsible for the survey and mapping function in the city or country).

  Contact person and address:

  _____

  _____

  _____

- **Municipal Departments, such as the Planning Department**

  (Department in city or country which is responsible for urban planning)

  Contact person and address:

  _____

  _____

  _____

- **Ministry of Lands, Housing etc.**

  Contact person and address:

  _____

  _____

  _____

- **Other Ministries, such as Energy, Water, Health, Environment**
  (that might use GIS to design specific thematic maps)
  Contact person and address:

  _____
  _____
  _____

- **Universities and other research institutions**
  (Geography or cartography departments using GIS)
  Contact person and address:

  _____
  _____
  _____

- **Private Sector**
  (working with GIS, familiar with analyzing spatial data and data
  management)
  Contact person and address:

  _____
  _____
  _____

When a GIS unit is identified, check:

- **which GIS software package they are using.**
  (Collaboration and data exchange will be easier using the same software
  product. Also funds for buying extra software and training staff can be
  saved)

  _____
  _____
  _____

- **which hardware they have.**
  (Computer, printer, scanner, light-table, etc. so it will be easier for you to get
  support in case of problems)

  _____
  _____
  _____

- **if the GIS unit knows about the SCP project, the EPM process
  and EMIS. Discuss how this GIS unit could be linked to the EPM
  process and how it can support the EMIS unit.**

  _____
  _____
  _____

Checklist of the office environment

- **clean, dust free, dry and cool**

  _____

  _____

  _____

- **easy accessible by stakeholders**

  _____

  _____

  _____

- **enough space for office equipment**
  (desks, chairs, computer, printer, scanner, map filing cabinet, light-table etc)

  _____

  _____

  _____

- **further remarks**

  _____

  _____

  _____

Tool 3: Terms of Reference for the EMIS Employees

Qualifications and tasks of the employees of the EMIS unit

• Sample Terms of Reference for the EMIS Officer
• Sample Terms of Reference for the EMIS Assistant

_____

Terms of Reference EMIS Officer

Project title:	*EMIS Officer*
Duty Station:	*Sustainable Cities Project X*
Starting Date:	*immediately*
Duration:	*To support the establishment of the EMIS (Environmental Management Information System) with expertise and knowledge. To coordinate the mapping task of the Sustainable Ibadan Project*
Purpose:	*to support the establishment and consolidation of an Environmental Management Information System (EMIS) in city x and other cities/towns in country x*

Context

An Environmental Management Information System (EMIS) is a fundamental tool for decision makers and planners in promoting sustainable urban development. EMIS supports effective urban environmental planning and management (EPM), including routine land use and investment decision-making, area specific action planning and overall monitoring of the state of, and improvements in, the physical environment. In the context of the Sustainable Cities Programme (SCP), EMIS is the system used for collecting, organising and applying information relevant to urban EPM in clarifying issues, formulating strategies, implementing action plans, monitoring progress and updating changes.

Broadly, the EMIS includes two components: (a) mapping and GIS applications and (b) managing the database and information modules related to environmental resources/hazards and cross cutting issues affecting the long term growth and development of the cities. The EMIS Officer will be responsible for both components, and for the overall functionality of the EMIS. The EMIS Officer will work under the supervision of the local EPM unit co-ordinator.

Activities

The EMIS Officer will assist the local EPM unit with the EPM process and will ensure the step-by-step application of the EMIS within the process. The EMIS Officer will perform the following duties:

1. SCP/EPM Process

- support the local EPM unit in the preparation and updating of the Environmental Profile in terms of information capture and maps;
- support the local EMP unit in the preparation and conducting of the City Consultation, through, for example, exhibitions and illustrations;
- provide Issue-Specific Working Groups with the relevant information for the development and implementation of strategies and action plans;
- gather relevant information from Issue-Specific Working Groups and other stakeholders;
- provide substantive support in the institutionalisation of the EMIS function within the local EPM unit and within the overall institutional structure.

2. EMIS step-by-step

- supervise and to work closely with the EMIS Assistant;
- procure the hardware and software for the EMIS, install the equipment and keep it good running condition;
- link the different stakeholders, including people from the community level, in the mapping process and create an enabling environment for constructive exchange of experiences;
- take inventory of all institutions and specialised firms who have the relevant expertise in mapping, GIS, remote sensing and database management in the context of urban environmental planning and management;
- set up and co-ordinate the EMIS Mapping Group;
- develop a structure for the EMIS database, build an inventory of existing maps and non-spatial data on environment-development interaction and set up a meta-database;
- together with the Issue-Specific Working Group co-ordinators, view the information used for the EMIS and develop a routine for updating it regularly;
- acquire relevant data (spatial and non-spatial data on environment-development interaction) for the EMIS;
- analyse the data in co-ordination with the issue-Specific Working Group co-ordinators and, if applicable, prepare an Environmental Management Framework;
- together with the local EPM unit team, develop an information outreach strategy and contribute EMIS "products" to the various outputs of the local EPM unit including a website;
- organise and conduct briefing sessions with decision-makers and stakeholders to familiarise them with the EMIS;
- organise and, if necessary, execute practical training programmes on the EMIS use of mapping, including demonstrations on mapping analysis for urban development planning.

Qualifications

A degree in geography, urban or regional planning (with background in social sciences) is required with extensive working experience (at least 3 years) in designing and operating participatory management information systems and in database management. General knowledge and experience at user level in GIS and experience in desktop publishing as well as web design is desirable. Knowledge of environmental management and familiarity with Environmental Planning and Management (EPM) and the SCP approach is an advantage. Experience with community work and participatory planning concepts is an asset.

Terms of Reference EMIS Assistant

Post title:	*EMIS Assistant*
Duty Station:	*Sustainable Cities Project X*
Starting Date:	*immediately*
Duration:	*one year (with possible extension)*
Purpose:	*to support the establishment and consolidation of an Environmental Management Information System (EMIS) in city x and other cities/towns in country x.*

Context

An Environmental Management Information System (EMIS) is a fundamental tool for decision makers and planners in promoting sustainable urban development. EMIS supports effective urban environmental planning and management (EPM), including routine land use and investment decision-making, area specific action planning and overall monitoring of the state of, and improvements in, the physical environment. In the context of the Sustainable Cities Programme (SCP), EMIS is the system used for collecting, organising and applying information relevant to urban EPM in clarifying issues, formulating strategies, implementing action plans, monitoring progress and updating changes.

Broadly, the EMIS includes two components: (a) mapping and GIS applications and (b) managing the database and information modules related to environmental resources/hazards and cross cutting issues affecting the long term growth and development of the cities. The EMIS Assistant will support both components. The EMIS Assistant will work under the direct supervision of the EMIS Officer.

Activities

The EMIS Assistant will assist the EMIS Officer in the step-by-step application of the EMIS within the environmental planning and management process. The EMIS Assistant will perform the following duties:

• conduct an inventory of existing maps in close collaboration with the EMIS Officer. This task includes ordering, storing and labelling printout maps. The EMIS assistant will feed this information into the meta-database together with information on the digital data available, and will

update this database regularly;
* prepare the maps of the EMIS while digitising or updating. He or she will also be responsible for the preparation of Thematic Maps for the working groups;
* enter data to the database on specific themes, in particular on the priority environmental issues; continuously update information of the system and use the new data to prepare additional maps;
* as part of the Information Outreach Strategy of the Sustainable Cities Project and especially the EMIS, prepare maps and posters for presentations and exhibitions; lay out digital maps and prepare printouts.

Qualifications

The EMIS Assistant should have a background as a cartographer, surveyor or in a related field. Considerable work experience in mapping and database management is necessary. Knowledge of the use of GIS software packages would be an advantage.

Tool 4: EMIS Hardware

What type of hardware to purchase

_____

Computer hardware specifications change rapidly. The specifications given below reflect the situation in 2006 in Kenya and the US (note that prices vary considerably from country to country). For international procurement you must specify your local requirements such as voltage, frequency, plug type, etc.

_____

1.Computer hardware:	Desktop, HP computer
Processor	800 MHz+ Intel Pentium IV processor or Intel Pentium D processor
Memory	512 MB RAM (expandable)
Graphics	PCI local-bus 3D graphics accelerator with 512 MB RAM
Frontside Bus Speed	minimum 800 MHz
Hard Drive	minimum 40 GB
DVD/CD-ROM	16-52x speed CD-RW Drive (Writer) or 16-18x DVD R/RW
Expansion slots	At least 2 USB slots and 2 PCI slots
Ports	USB, Parallel, Serial
Monitor	Colour SVAG, minimum size 19", preferably flat screen
Built-in Modem	High-speed Modem (56K)
Other Cards	Network Card (if network planned), Audio Card and speakers
Backup	Internal Tape drive (optional) for regular backup
Operating system and office software	MS Windows XP Professional (Windows NT 4.0, if networked), MS Office 2003
Costs	approx. US$ 1,500-2,500
2. Plotter:	A0 Inkjet colour plotter
	e.g. Hewlett Packard HP DesignJet 1050C, or the cheaper HP DesignJet 800 C7780B or 500 C7770B
Size	minimum A0 (36 inch wide) printable area
Resolution	1200 dpi (black)/ 600 dpi (colour)
Memory	at least 64 MB
Language	Adobe PostScript Level 3
Drivers	AutoCAD 13, 14, AutoCAD 2000-2004, Windows (95, 98, NT 4.0, XP, 2000, Server 2003, Me),
Print Media	sufficient ink cartridges (e.g. 4 each colour for first order);
	Paper: Heavy Weight Paper, Coated Paper, Clear Film, Matte Film
Cost	from US$ 5,000 (HP DesignJet 800 C7780B) to US$ 7,000 (HP DesignJet 1050C) (US prices only)
3. Scanner	A4 or A3 flatbed scanner
	A4 (or A3, if resources are available) flatbed, colour (48 bit) and greyscale, high resolution (3600 dpi optical), USB interface
	e.g. HP ScanJet 4370 Photo Scanner or HP ScanJet 4490 Photo Scanner
Cost	US$ 100-400 (A4)
3. Printer	A4 Inkjet colour printer
	e.g. HP DeskJet 6000 Series

Resolution	1200 dpi (black)/ 4800 (colour)
Price	US$ 200-300
4. Digitiser	A3 to A0
Size	active area from 12 in x 18 in to 44 in x 60 in
Accuracy	0.005 in (0.127 mm)
Device	16-button pointing device (cordless)
Driver	Windows 95, 98, ME, NT, 2000, XP, WinTab compliant
	e.g. Calcomp, Summagraphics (e.g. AccuTab II Series, Drawing Board V)
Stand	Manual Lift/Manual Tilt Base Model for large scale digitiser
Cost	A3: US$ 600; A0: US$ 3,000 (US price only)
5. Global Positioning System (GPS)	Hand held GPS receiver
	Compatible with PC mapping software, NMEA/DGPS data interface, with Combo PC Interface / Power Cable, with lighter adapter & 9 pin serial connector
	e.g. Garmin (eTrex Series), Magellan eXplorist 200, Trimble
Cost:	US$ 100-300 (US price only)
6. Others	Backup
	Backup Power for each computer, e.g. UPS 1.000VA or equivalent To be checked locally

Addresses
For computer equipment:
www.hp.com
www.gateway.com
www.compaq.com
www.buymicro.com
www.circuitcity.com
www.dell.com

For scanners and digitising boards
www.gtcocalcomp.com/calcomproducts/default.htm

For plotters (Hewlett Packard or Calcomp)
www.hp.com
www.budde.com/calcompsupplies/indes.htm

For Global Positioning Systems:
www.garmin.com
www.magellangps.com/en/
www.lowrance.com
www.eaglegps.com
www.trimble.com
www.silva.se/
www.brunton.com/catalog.php?subcat=16

For digitisers
sales.gtcocalcomp@atnet.at
other inquiries office.gtcocalcomp@atnet.at
http://www.gtcocalcomp.com/

Tool 5: EMIS Software

What are the typical software packages to run an EMIS
- Comparison between Map Maker Pro and ArcView GIS 9.1
- Free and Open Source GIS Software
- Addresses

Comparison between Map Maker Pro and ArcView GIS 9.1:

	Map Maker Pro	ArcView GIS 9.1
Range	Not so well known, developed for small scale applications in developing countries.	Widespread and well known.
System Requirements	Windows 98/ME/NT4/2000/XP, 128Mb RAM, 512Mb recommended, min 800 x 600 display, 24 bit colour recommended.	At least 1 GHz processor and Windows 2000 or Windows XP, 512 MB RAM, PC-platform.
Purchasing	Simple, inexpensive Map Maker Basic fits on one diskette and can be obtained through the internet. Map Maker Gratis with basic functionality is downloadable from the internet for free.	Expensive: contact regional ESRI authorised dealer.
User Interface	Acceptable, menu is too extended.	Icons to click and a menu, icons sometimes have unusual symbols.
Handbook	Handbook is easy to understand with additional information about mapping and surveying. Basic online help with links.	Tutorial is easy to follow and explains more or less all the features included in ArcView GIS, as well as additional information about mapping and projections. Extensive online help.
Import	ArcView Shp, MapInfo MIF, AutoCAD DXF, USGS DRG, Ordnance Survey NTF, Ordnance Survey MasterMap (GML) etc.	ArcInfo shp, e00, DXF, MapInfo Interchange Format, sdc, vpf, dwg.
Export	SHP, MIF, DXF, BMP, JPG, TIF, Geo-Tiff, and ECW images.	Latest version exports shapefiles to DXF, otherwise in graphic output (jpg, bmp, eps, tiff, pdf, png, svg, ai, gif, emf).
Table Data	dBase, Access, Excel or edit in Map Maker Pro; limited connectivity to external databases (Map Maker's weakest point).	Easy to handle, easy SQL connectivity to external databases, dBase, Access.
Images, Raster Data	BMP, TIF, Geo-Tiff, JPG, and ECW raster data, view only, can be used as background.	BIP, Erdas, JPEG, Tiffs can be used and processed..
Digitising	Concept: two digitising possibilities. Symbols, lines and polygons (can be drawn in one layer), or node and link drawing. It is very easy to change between both drawing modes – after each new object, you have to indicate which layout. You can change polygons to lines and vice versa.	Concept: point, line or polygons in one shapefile, can use screen as well as digitising board.

Overlays	No overlays.	Possible with different options (split, merge, intersect), also offers a buffer option.
Thematic maps	Inheritance, data surface produce 3-D maps.	Easily done with legend editor.
Layout	Different styles have to be saved in files, a little bit uncomfortable, but manageable.	Very easy to handle, offers the possibility to create your own symbols, can be a combination of several views, text and charts, but produces large files.
Printing	Can print large formats on an A4 printer; print-outs on several sheets possible (tiles).	Requires plotter for large formats.
Others	Live data capture (Garmin), download waypoints and tracks, ortho-rectify aerial photography using GPS control points.	Avenue is the internal language to write scripts and design own symbols; good description.
Strengths	Low system requirements, low price, double concept for geometric data, import/export facilities; image registration; some useful extensions (e.g. rubber map); software can be tested free of charge for a limited period, free software for certain institutions in Africa.	Easy to use, many people know it, many additional extensions for specific uses (however, expensive), good database connectivity.
Weaknesses	Not a nice user interface, sometimes requires commands to be typed, no overlay, no good database connectivity.	Expensive, sophisticated system requirements, no direct image registration.

Free and Open Source GIS Software

Open source software and free software are two terms for "software which comes with certain rights, or freedoms, for the user. They describe two approaches and philosophies towards free software. Open source and Free software (or software libre) both describe software which may be used, copied, studied, modified and redistributed without restriction. Both terms are summarised by the term "FOSS" – Free and Open-Source Software. Free and Open-Source Software is increasingly used in both public sector and commercial organisations due to its very low cost, high reliability and advanced security features.

The principles of Free and Open-Source Software are guaranteed through licenses. Two well-known licenses are the GNU-GPL and the BSD license (http://www.opensource.org/licenses/). The original author of a program remains the copyright holder. It is important to point out that FOSS does not necessarily have to be cost free: "In fact, the freedom to sell copies is crucial: collections of Free Software sold on CD-ROMs are important for the community, and selling them is an important way to raise funds for further development" (http://www.gnu.org/gnu/thegnuproject.html).

What makes FOSS so interesting?

• FOSS is often less expensive than proprietary software
• FOSS enables the tuning and improvement of a software product as the source is available
• peer production" can yield better results
• FOSS is considered to be more secure than proprietary software

- Independence: not only one software company can produce updates
- No black-boxes. Opportunity to understand the core aspects of the software that is used.

While proprietary software in the GIS sector is usually very cost-intensive, free and open source products can save licensing costs. As a result, more and more people in developing nations can benefit from GIS technology. There are many different FOSS programmes which are designed to view, modify and publish geospatial content. The freegis-database (http://www.freegis.org/) lists about 213 packages. Only some examples should be mentioned here:

GRASS GIS
A very powerful and probably the most complete FOSS-GIS programme is GRASS GIS. GRASS is available for Linux as well as Mac OS/X, Windows and a variety of other unix flavours.
http://grass.itc.it

Quantum GIS
Quantum GIS (or shortly QGIS) is a Desktop GIS, which can be used either as a standalone programme or as a user-friendly interface for GRASS GIS.
http://www.qgis.org

GvSIG
A tool "for handling geographical information. It has a userfriendly interface, is capable to access several (raster and vector) formats. gvSIG is java-based and platform-independent. The programme is available for Windows, OS/X and Linux.
http://www.freegis.org/database/viewobj?obj=896

UMN Mapserver
Mapserver of the University of Minnesota (UMN) provides internet map services for vector and raster data. It can read most geodata formats and is programmable through Application Programmer interfaces for C, perl, python, php and java.
http://mapserver.gis.umn.edu/

ILWIS
ILWIS is a remote sensing and GIS software which integrates image, vector and thematic data in one unique and powerful package on the desktop. ILWIS delivers a wide range of features including import/export, digitizing, editing, analysis and display of data, as well as production of quality maps. In order to create better opportunities for the reuse and deployment of GIS functionality in a wider community, the closed source ILWIS software migrated to 52°North as open source software as of July 1, 2007.
http://52north.org/index.php?option=com_content&task=view&id=131&Itemid=155

Addresses

- **ESRI ArcGIS, ArcView**
  www.esri.com
  PC (Windows 2000 and XP only), developed by ESRI in USA, good in vector- and raster-based data analysis, widely used, expensive, basic functions (Arc Map, ArcCatalog, ArcToolbox), relatively expensive extensions (Networkanalyst, 3DAnalysis, etc)

- **Map Maker - Desktop Mapping:** http://www.mapmaker.com/, info@mapmaker.com
  Map Maker Pro is a low-cost map making and Geographic Information System for Windows. The software is available for free for evaluation for 21 days and for projects in Africa. Extensive tools, data and further links.

- **MapInfo:** http://mapinfo.com
  This mapping software comes in two packages: MapInfo Professional and the smaller package MapInfo MapX. Free trial versions are available for both packages.

- **IDRISI:** http://www.clarklabs.org/, idrisi@clarku.edu
  Clark University in USA, PC, raster better than vector-based data, less expensive, used by universities worldwide

- **ILWIS:** http://www.itc.nl/ilwis/default.asp, ilwis@itc.nl
  Developed by ITC in Netherlands, PC, better in raster-based data than vector-based, specialized in remote sensing data, less expensive

- **TNT** - Microimages: http://www.microimages.com/, info@microimages.com
  GIS Software for all types of computer platforms (Windows, Linux/UNIX, Macintosh). Reduced Version available as downloadable free product.

- **Intergraph GIS**: www.intergraph.com, services@intergraph.com
  Intergraph USA, Windows based and designed, good in raster- and vector-based data analysis, relatively expensive, widespread, C/C++ Interface

- **Leica Geosystems**: http://gis.leica-geosystems.com/default.asp
  Software designed especially for satellite and aerial image analysis in ArcGIS also 3D Analyst available.

- **ERDAS:** http://www.erdas.com
  Software for remote sensing image processing.

- **FOSS GIS Software** http://www.freegis.org/
  For a current overview of probably most of the, please refer to the FreeGIS-Database http://www.freegis.org/ on the internet.

Tool 6: Remote Sensing Data Sources for EMIS

How to purchase and use Satellite Images for the system

- Introduction
- Remote Sensing in a nutshell (Tool 6a on CD-ROM)
- Aerial Photography (Tool 6b on CD-ROM)
- Overview of relevant remote sensing data sources for EMIS
- Level of object recognition
- Principles of visual image interpretation

Introduction

Satellite images and aerial photographs provide an excellent way to obtain or update basic maps for urban areas. With the introduction of high resolution imagery, remote sensing has become a very suitable method of data acquisition for urban areas. The main advantage of remotely sensed images is their ability to provide data for an entire area, or for areas that are difficult to access. In addition they offer the possibility of using time series (e.g. images of different years) which allows changes in the physical fabric of the city to be analysed, they can be reused for different projects, and they can be cost efficient (e.g. compared to detailed ground-surveys). One main limitation of remotely sensed images is that we can only obtain information about the actual land cover, and not about the land use. For example, when we see an industrial complex on an image we cannot be certain that it is still being used for industrial purposes (it could have been converted into another use).

Overview of relevant remote sensing data sources for EMIS

The selection of an appropriate remote sensing data type should be driven by three main criteria. First, the **spatio-temporal characteristics** of the phenomena to be studied is important, e.g. what level of spatial detail is required, are very-high resolution data that give information on individual objects (e.g. buildings) necessary or is a more general distinction between land-cover classes (such as areas of different vegetation cover or the general urban growth pattern) sufficient? For which time period are images required, e.g. several images for analysing changes, or images of a specific season? One main limiting factor here is the availability of cloud-free images. This leads to the second main criterion for selecting image data, the **availability of image data.** Plenty of image data are easily available as they area stored in archives/libraries and can be requested (some data can be also downloaded: see list of websites in table 2). Another limiting factor is the temporal availability of image data, e.g. the very-high resolution sensors have only been operating since the end of the 1990s (Ikonos since 1999 and QuickBird since 2001). And finally the third main criterion is the **cost of image data**. The costs of image data varies from free downloadable images (e.g. certain Landsat images) up to approximately 50 US$/km2 (for very high resolution images). The cost also increases when the requested data are so far not available in the archive. To request such recording of data is possible for high resolution sensors.

The space-borne sensors commonly used in an EMIS context and their main image characteristics are listed below:

System / Sensor & Internet link Launched in	Bands	Swath width	Price[1] in US$ per km2	Spatial & Temporal Resolution	Sample Image
QuickBird www.digitalglobe.com since 1997	3 VIS 1 NIR 1 PAN	16.6 km	Archive[2] 16 Order[3] 21 Bundle 20 -45	PAN: 0.6/0.7 m MS: 2.4/2.8 m 1-3 Days	
IKONOS OSA (Optical Sensor Assembly) www.spaceimaging.com since 1999	3 VIS 1 NIR 1 PAN	11 km	Archive 16 Order 21 Bundle: 21 - 27	PAN: 1 m MS: 4 m 1-3 Days	
IRS-1D - LISS 3 (Linear Imaging Self Scanning System) www.isro.org IRS-1D since 1999 (first IRS 1988)	2 VIS 1 NIR 1 SWIR 1 PAN	140km LISS 70km PAN	LISS: 0.22 PAN: 0.84	LISS: 23.5 m PAN: 5.8 m 24 (5) Days	
SPOT 5- HRG (High Resolution Geometric) www.spotimage.fr SPOT 5 since 1999 (first SPOT 1986)	2 VIS 1 NIR 1 SWIR 1 PAN	60 km	1.2	VNIR:10 m SWIR: 20 m PAN: 5 m 5 Days	
Terra ASTER http://edcimswww.cr.usgs.gov/pub/imswelcome/ since 1999	2 VIS 2 NIR 6 SWIR 5 TIIR	60 km	0.05	VNIR: 15 m SWIR: 30 m TIR: 90 m 16 Days	
Landsat 7 ETM (Enhanced Thematic Mapper) http://glovis.usgs.gov http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp Landsat 7 since 1999 (first Landsat 1972)	3 VIS 1 NIR 2 SWIR 1 TIR 1 PAN	185 km	0.026 some free images (GLC catalogs see link)	Band 1-5,7: 30 m (VNIR and SWIR) TIR: 60 m PAN: 15 m 16 Days	

The list above does not claim to be complete – other sensors also might be of interest, such as another high-resolution sensor called OrbView-3. A comprehensive overview of satellites and sensors presently operating can be found on: http://www.itc.nl/research/products/sensordb/searchsat.aspx. Here a sensor database is provided besides a list of operating sensors. More details on prices e.g. the additional costs of a pansharpened image (where the high spatial resolution is combined with the multispectral bands) can be found on http://www.geoserve.nl/products.htm.

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[1] The price refers to approximate costs of a geo-referenced image for one square kilometre. The prices can vary for different regions and depend if achieved images are available etc.

[2] Prices here refer to either MS image or PAN. The lowest price is given.

[3] PAN and MS together!

Steps to follow when obtaining an image:

a) Decide on the required image data characteristics (spatio-temporal, availability and budget).

b) Either search for available data in the image catalogues (use e.g. links to data provider above) or contact a national reseller (using a reseller can increase the costs).

c) Check carefully if available image data fulfil the requirements, i.e. area coverage, no clouds over area of interest etc.

d) Check level of pre-processing (e.g. geo-referencing), data format (without Remote Sensing try to get a Geo-TIFF).

e) Download/order images, mostly one file per band will be downloaded, together with a metadata file (contains information like acquisition date, bands etc.)

f) Import bands into a Remote Sensing software package and stack (combine) the individual bands to one image data file.

g) Next steps would be now e.g. to enhance the contrast and decide on a certain colour composite.

h) Finally geo-reference image if it was not already obtained as a geo-referenced image.

It must be said that conventional vertical aerial photographs, at scales 1:5,000 or larger, offer more visible details than the images of the very-high resolution sensors presently operating. Aerial photos can give detailed information on roof or street surface materials: false-colour infrared photos in particular give details about vegetation (types, health etc.). Aerial photographs in combination with airborne laser height measurements allow the building of detailed 3-dimenstional models of cities. But the costs of planning and executing a survey with aerial photographs should not be underestimated if no recent data can be acquired from, for example, national mapping agencies. In most cases such photos will be still be provided in analogue format. In order to use them in a GIS package together with other spatial data, these photos will have to be scanned at a sufficiently high resolution (e.g. 600 dpi), geo-referenced and resampled. This is possible with all standard GIS/Remote Sensing software packages.

One relatively low cost image data source are 'do-it-yourself' small format oblique or vertical aerial photographs (SFAP), made from low-flying small airplanes with hand-held cameras. The resulting images are of high spatial resolution and give valuable details for large-scale urban basic maps (see figure 6 for an example of using SFAP to update building footprints). Using image processing software (or standard GIS packages) these photos can be georeferenced and resampled. Of course, depending on the degree of obliqueness of such images, they will

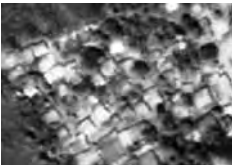Figure 6: SFAP overlaid with outdated building footprints

Figure 7: Google Earth CBD of Dar es Salaam

have geometric problems (distortions) which can be only partially corrected. One new source of information readily available is Google Earth (http://earth.google.com/index.html), which offers a freely downloadable 'viewer software' and very-high resolution images of most cities. Figure 7 shows an example of a Google Earth image of the centre of Dar es Salaam. Such a view extent can be saved as a jpg. In principle, it would be possible to save the view of a small area and to use it pictures as an illustration, or also to import into a GIS software package. Of course this picture will only have the displayed resolution at the moment it was saved and has no geo-reference. Using Google Earth Plus (which can be purchased for $20) own data (e.g. GPS data) can be important. So far only the Pro-licence ($400) has a GIS data importing module.

Level of object recognition

Traditionally remote sensing has been used to classify areas of homogeneous land cover (surface material) and to relate this to a specific land use (function). However, urban areas are so complex that large areas of homogeneous land cover often cannot be detected, even when using high-resolution images. Most urban land uses contain combinations of buildings, vegetation, roads, water, bare soil etc. It is therefore not possible to relate land cover to a specific land use with digital image classification techniques using digital techniques. Data extraction based on visual interpretation by trained human interpreters, who supplement spatial and spectral information with contextual information (such as local knowledge), is better. Given the availability of very high spatial resolution data, feature recognition and object based approaches for data extraction are becoming more important for urban applications. A basic consideration in these approaches is the ability to recognize and demarcate separate objects. An object with a discrete spatial extent such as a building can be

	QuickBird (100 by 100m) showing a building complex
	QuickBird (100 by 100m) Showing residential buildings
	QuickBird (100 by 100m) Showing squatter development in a fringe area
	QuickBird (100 by 100m) Showing slum settlement into the sea

detected and demarcated subject to the spatial resolution of the image (e.g. a large building of 50 x 50 m can be delineated in an image of 5 m spatial resolution but if spatial resolution is improved the accuracy and precision of the delineation will also improve). However the ability to detect and demarcate objects is also affected by other properties of the object (e.g. the complexity of its shape) and its surroundings, such as tree cover. One example displayed in figure 8 shows the limits of a very high resolution sensor to extract information in a very densely built-up urban environment. In the image showing a slum area, individual buildings cannot be distinguished accurately any more.

Steps for updating a basic map:

a) Make sure that the previous steps (Steps to follow when obtaining an image) have been successfully completed.
b) Check if all data to be updated and the obtained image share the same spatial reference.
c) Define interpretation rules (minimum mapping unit or minimum object size, consistent interpretation classes etc.).
d) Overlay a copy of the outdated basic data (vector format). Do not modify the original data in order make an analysis of changes later.
e) Update the outdated base data through digitising (follow the defined rules).
f) Field checks might be necessary to obtain information that is not visible on an image.
g) Ensure good documentation of the process in the form of metadata for future use.
h) A final check of the accuracy using an independent sample data set is required.
i) Visualise the output as a map with a comprehensive legend and information about the process.

Principles of visual image interpretation

Usually, information in urban areas will be extracted by visual interpretation, e.g. for updating a land-use map. The urban environment is mostly too complex for (automatic) digital image classification. Still, digital image classification could give a first overview of the main urban growth pattern. Two images of different years could be used to derive, through an automatic change analysis, the major land cover changes (this requires REMOTE SENSING experience, software and has mostly relatively low resulting accuracy). Detailed analysis of urban changes requires visual interpretation.

Before starting with the visual extraction of information from an image, several techniques can/ and should be applied to improve the ease of interpreting. For the case of MS images, the most suitable combination of bands must be decided: e.g. natural colour displays are more suitable for persons not used to working with remotely sensed images, while

false colour displays are more suitable to differentiate between areas of vegetation cover and roads or buildings. Secondly, the contrast of the individual bands has to be enhanced (various other enhancement techniques such as filtering can also be applied). One standard technique to assist visual interpretation is the combination of the panchromatic band (which has a higher spatial resolution) with the multispectral band called pansharpened (such enhanced images can be also ordered from providers for an additional fee). The technique is called image fusion (or resolution merge). This function can be found in Remote Sensing software packages. The example displayed in figure 8 is a pansharpened QuickBird, the resulting spatial resolution is 0.7m.

The actual extraction of information depends very much on the purpose, it is important to define consistent interpretation guidelines in advance, e.g. minimum mapping units, or minimum size of objects to be mapped (e.g. minimum size of a building), classes of objects or uses and additional information required (e.g. ground-truth information). For detailed steps see the text box.

As a final step, the quality of the visual interpretation should be given attention. The quality depends on several factors: the experience of the interpreter(s), the image data and the guidelines provided. Here a cross-check with ground-truth information is required. Finally, essential information on the data sources and the process of information extraction need to be well documented to assist data sharing.

Hints to get started

Several **online-tutorials** are available which provide more information on remote sensing. The Canadian Centre of Remote Sensing offers a quite well structured web tutorial:
in French: http://cct.rncan.gc.ca/resource/index_f.php#tutor
in English: http://ccrs.nrcan.gc.ca/resource/index_e.php#tutor

Free downloads of basic **Remote Sensing software**:

Chips software developed at University of Copenhagen offers basic satellite image processing tools and to some extent GIS tools such as vector editing: http://www.geogr. ku.dk/chips/

Spring provides raster and vector data tools in a single environment. It is a product of Brazil's National Institute for Space Research http://www.dpi.inpe.br/spring/english/

Free downloads of **Remote Sensing images**:
http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp

Tool 7: Setting up the Technical Support Unit

When setting up the EMIS, it is essential to identify technical support
- Checklist of contacts for technical support
- Sample Contract

Checklist of contacts for technical support

- **GIS unit in your city/ country, which could identify and solve your GIS-software related problems**
  Contact person and address:

  _____
  _____
  _____

- **GIS/ Technical unit in your city/ country, which could identify and solve your hardware related problems**
  Contact person and address:

  _____
  _____
  _____

- **GIS unit at the geography/ planning department of the local university/ college/ research institutions**
  Contact person(s) and address(es):

  _____
  _____
  _____

- **Local software dealer**
  (for GIS software, operating system, office software)
  Contact person and address:

  _____
  _____
  _____

- **Local hardware dealer**
  (for computer, printer, scanner, plotter, light table etc)
  Contact person and address:

  _____
  _____
  _____

- **Private sector**
  (Local electronic/ computer engineering consultants)
  Contact person and address:

  _____
  _____
  _____

- **Internet support provided by the software/ hardware company**
  Website and contact person:

  _____

  _____

  _____

_____

Sample Contract

between the EMIS unit of the Sustainable Cities Project X (hereafter called SCP X EMIS) and Company Y (hereafter called the contractor).

The contractor will support the establishment of the SCP X EMIS unit, and will provide ongoing technical support and maintenance services (for both hardware and software) to the unit.

The contractor will provide the following services to the SCP X EMIS unit:

- Install the hardware and software of the SCP X EMIS unit, making sure that it meets the technical requirements necessary to fulfil the tasks of the EMIS unit
- Advise the EMIS unit on the purchase of hardware and software
- Back-up data on a weekly basis
- Check hardware functional capacity once a month
- Identify and solve problems with computer hardware, software and networks
- Maintain the computer equipment
- Collaborate with other TSUs within the city administration
- Provide on-call emergency technical support as required

The contract will start on DD/MM/YYY, for a duration of one year, with possible extension. The contractor will be on-call during normal working hours (8.30 am to 5.30 pm daily, Monday to Friday). The monthly contract fee will be XXX.

Name: Y
Address:
Bank account:

_____   _____

EMIS Officer EMIS Unit SCP X   Y

Tool 8: The Mapping Group

How to establish a Mapping Group
- Checklist of Members of the Mapping Group
- Sample Terms of Reference for a Mapping Group
- Sample Meeting Invitation Letter

Checklist of Members of the Mapping Group

- **Survey and Mapping Institution/Department**
  (or other institution which is responsible for mapping in the city or country)
  Contact person and address:

  _____
  _____
  _____

- **Planning Department**
  (Department in city or country which is responsible for urban planning)
  Contact person and address:

  _____
  _____
  _____

- **Community Representatives**
  (Relevant people who have a stake in participatory mapping and planning methods)
  Contact person(s) and address(es):

  _____
  _____
  _____

- **Representatives of the Issue-Specific Working Groups**
  Contact person and address:

  _____
  _____
  _____

- **University and other research institutions**
  (Geography or cartography department)
  Contact person and address:

  _____
  _____
  _____

- **EMIS Unit**
  (staff working to build up the EMIS)

  _____
  _____
  _____

Sample Terms of Reference for a Mapping Group:

Mapping Group

Project title:	*Sustainable Ibadan Project*
Post title	*Sustainable Cities Project X*
Expected start:	*August 1998*
Purpose:	*To support the establishment of the EMIS (Environmental Information system) with expertise and knowledge. To coordinate the mapping tasks of the Sustainable Ibadan Project*

Expected Outputs

- Ensure the establishment of the EMIS in line with accepted national mapping standards
- Share knowledge of existing data
- Support for training in GIS and EMIS

Duties & Tasks

The Mapping Group will meet each month, and will hold additional meetings as needed. It will:
- Advise on map coding (see Tool 6: Map Coding)
- Define basic map (content, accuracy, intervals between up-dates)
- Set standards for the layout of maps produced by the EMIS Unit
- Set standards for spatial and non-spatial data
- Discuss maps with the Issue-Specific Working Groups
- Support participatory planning methods in demonstration areas
- Make recommendations on the use of international and national standards, and on the rules and conditions developed by the Issue-Specific Working Groups
- Make recommendations for outsourcing digitising, image interpretation, printing etc.
- Ensure the establishment of the EMIS in line with accepted national mapping standards
- Share knowledge of existing data
- Support for training in GIS and EMIS

Qualification of Members

Members of the mapping group should be familiar with mapping (producing and/or reading) and participatory planning methods, such as transects, Participatory Rapid/Urban Appraisals, etc.

Sample Meeting Invitation Letter:

Sample Contract

To: Members of the Mapping Group
From: EMIS Officer
Date: 26 July 1999

Subject: Invitation to Mapping Group Meeting, EMIS Unit, Sustainable Ibadan Project, 15 September 1999, 16:00.

Dear Ms. Kamau,

The next meeting of the Mapping Group will take place as planned on 15 September 1999, in the EMIS office, Laikipia Road 15, room 12, at 16:00. Please find attached the minutes of the last meeting.
The agenda will be as follows:

1)   Approval of minutes of the last meeting
2)   Report on progress since the last meeting
3)   Data from the Ministry of Water has arrived: discussion on how to transfer this into the EMIS using ArcView GIS
4)   Discussion with Working Group on Waste Management
      - what maps should be prepared?
      - data collection
5)   Preparation of exhibition for public library
6)   EMIS Training
7)   Any Other Business

Please notify me of any additional agenda items by [date].
I look forward to seeing you at the meeting. Please let me know if you are unable to attend.

Yours sincerely,

EMIS Officer

Tool 9: Finding Maps

Where existing maps and/ or digital data can be found
*   Checklist of institutions

Checklist of institutions

*   **Survey and Mapping Department/Institution**
    (or other institution which is responsible for the survey and mapping function in the city or country).
    Contact person and address:

    _____
    _____
    _____

*   **Municipal Departments, such as the Planning Department**
    (Department in city or country which is responsible for urban planning)
    Contact person and address:

    _____
    _____
    _____

*   **Ministry of Lands, Housing etc.**
    Contact person and address:

    _____
    _____
    _____

*   **Other Ministries, such as Energy, Water, Health, Environment**
    (for specific thematic maps)
    Contact person and address:

    _____
    _____
    _____

*   **Universities and other research institutions**
    (Geography or cartography departments)
    Contact person and address:

    _____
    _____
    _____

*   **Existing projects which might have relevant maps**
    Contact person and address:

    _____
    _____
    _____

- **Private agencies**
  (may deal with utilities, transportation networks or similar, and will therefore use maps)
  Contact person and address:

  _____

  _____

  _____

- **Internet resources such as map libraries or map server (see below)**
  Additional websites and contact person:

  _____

  _____

  _____

- **Atlas of the city, province, country**

- **Internet**

It is possible to locate maps on the internet. However, most of the maps are in small scale and serve as background and reference maps. A valuable source is the Digital Chart of the World (DCW) which was developed from satellite imagery in 1993. The base scale of the DCW is 1:1000000.

Global Resource Information Database: GRID-Arendal's Online Maps and Graphics Database: http://www.grida.no/db/index.htm

The GISDataDepot at the Geo Community:
http://www.gisdatadepot.com

GISLinx - Over 1,700 Categorized GIS Links:
http://www.gislinx.com/

Multimap: http://www.multimap.com/world/places.cgi

Green Map System: http://www.greenmap.com/

CGRER NetSurfing- Maps and References:
http://www.cgrer.uiowa.edu/servers/servers_references.html#mapforeign

Hart Environmental Data - Search the Indicator Database:
http://www.subjectmatters.com/indicators/HTMLSrc/KeySearch.html

GISnet Geospatial Data. Sells CVGMAP worldwide map data and MapInfo software. Free downloads available:
http://www.gisnet.com/catalog/data/ByGeography.htm

Various old and current maps, city maps, thematic maps, historical maps downloadable:
http://www.lib.utexas.edu/maps/

Digital Chart of the World – national boundaries reflect the political situation of 1992: http://www.maproom.psu.edu/dcw/

Map Libraries: http://www-map.lib.umn.edu/map_libraries.html

Maps and Cartography:
http://www.lib.berkeley.edu/EART/MapCollections.html#web

Best City Maps - sells various city maps in freehand, illustrator, corel data format: http://www.bestcitymaps.com/

Map Quest: http://www.mapquest.com/

Map Blast: http://www.mapblast.com/

Links to World City Maps - University of Texas: http://www.lib.utexas.edu/maps/map_sites/cities_sites.html

Earth Science and Map Collection. Various links to other map libraries: http://www.lib.berkeley.edu/EART/MapCollections.html#electronic

Mapfacts. Results for Maps on search engine: http://www.mapfacts.com/lander/index2.php?name=mapfacts.com&term=mapfacts

Tool 10: Purchasing Maps

How to outsource map production
- Sample Contract letter
- Terms of Reference
- Data conversion (10a on EMIS CD-ROM only)

Sample Contract

To: Head of Department (e.g. local EPM Unit or Department in which the EPM Unit is located)
From: EMIS Officer
Date: 5 November 1999

Subject: Recruitment of a consultant for the preparation of the Basic Map

Further to discussions between the local EPM Unit and the Head of Department on the selection of the consulting firm, please find attached the terms of reference for the local consulting firm GEOMap Ltd. GEOMap Ltd. will support the preparation of a series of maps as an input to the preparation of the Environmental Management Framework (EMF).

GEOMap Ltd. is undertaking development activities in the field of rural and urban development, management and natural resources and has worked with organisations including UNDP, Danida, the Netherlands Embassy and the European Unity (EU).

The consultant(s) will undertake the following activities:

1.	Digitising of 4 sheets (incl one final print)	US $ 2,600
2.	Printing of 50 A0 sheets (to be identified later)	US $ 800
3.	10 days of technical backstopping to the EMIS Officer	US $ 2,000
	Total	US $ 5,400

Kindly authorise Finance Office to spend US$ 5,400, charging budget line xxx.

With best regards

EMIS Officer
Local EPM Unit

Terms of Reference

1) The consultant(s) will produce a set of 6 digital maps (in ArcView GIS format) of the following topographical maps in scale 1:50.000:

> Kawe, sheet 186/1 (1993); (full sheet)
>
> Dar es Salaam, sheet 186/4 (1993); (full sheet)
>
> Kisarawe, sheet 186/3 (1993); (full sheet)
>
> Shungubweni, sheet 204/2 (1993); (full sheet)

All digital maps will show the situation as shown on the topographical maps listed above. The maps will be prepared in the following sequence and will contain the following layers:

a) Digitise the coastline of sheets 186/1, 186/4 and 204/2 and prepare a map showing the coastline of Dar es Salaam region.

b) Prepare a map showing the traffic network including streets and railroads.

c) Prepare a map including the powerlines and pipelines.

d) Digitise the river network and distinguish three types of rivers (perennial, seasonal, torrential).

e) Prepare a map showing land use. For the different types of land use, please see attachment.

f) Prepare a map showing height above sea level by digitising the contours and the trigonometrical stations. Use only sheets 186/1, 1864/186/3.

g) Use UTM grid, Transverse Mercator Projection, Clarke 1880 (modified) Spheroid and New (1960) Arc Datum (as on original map).

2) The consultant(s) will prepare a draft of the digital maps to facilitate discussion of the finalisation of the maps with the EMIS Officer. The consultant(s) will provide 2 copies of the data on CD-ROMs, and one final printout per layer.

3) The consultant(s) will connect and set up the digitiser within the EMIS Unit using the available software driver.

4) The consultant(s) will print 50 supplementary colour sheets of maps (A0 size) to be identified later by the EMIS Unit.

5) The consultant(s) will provide technical support to the EMIS Unit for GIS techniques, using the software used by the EMIS Unit. The programmes used by the EMIS Unit are ArcView GIS and Map Maker Pro. The support will be undertaken on request of the EMIS Unit and will be not less than 10 days, in minimum units of half a day, over a period of one year.

Tool 11: Organising Maps – Data Filing System

How to establish a system, where maps can be retrieved easily
- Hardcopy map filing system
- EMIS Inventory: overall structure
- Structure of the EMIS map inventory
- Coding for the EMIS map inventory (Tool 11a on EMIS CD-ROM)
- Developing and updating the EMIS inventory structure
- Using the template for the EMIS inventory (Tool 11b on EMIS CD-ROM)
- Inventory Archive Folder Working Folder

_____

Hardcopy Map Filing System

You will need:
- a map filing cabinet for A0 Maps
- a hanging file for A3 maps
- a wide backed ring binder for A4 maps

Next steps:
- Decide on a coding system to label your maps, for example according to the following proposed system:

Images	I - I
Basic Map	BM-I
Thematic Map	TM-I
Suitability Map	SM-I
Overlay Map	OM-I

  (for further details see Tool 11 Map Coding, on the EMIS CD)
- label all the map and layer folders properly
  e.g. Base Maps and Suitability Maps, A4 size
- label the drawers of the mapping cabinet
  e.g. Thematic Maps
- put the A4 maps in clear plastic folders or poly-pockets
- attach hanging registry to large maps
- attach information and code to map (pencilled note or post-it) and add this information to your Inventory Database
- file the maps.

_____

EMIS Inventory: overall structure

Many GIS software programmes - and in particular ArcView GIS - ask you to save your information in two different formats:
- layers, which contain the geographical information - in ArcView GIS these layers are also called themes or shape files
- maps or projects, which contain information on the layout of a map, the appearance of the colours, the placement of objects, etc. - in ArcView GIS 9.0 maps are stored as ArcMap documents (.mxd-files), in ArcView GIS 3.2 data is stored as projects (apr-files).

Layers can be used in several maps and a map normally contains several layers. Therefore, it is important – especially when you save them in the same archive folder – to use unique and clear names to distinguish between them in the file system.

Structure of the EMIS Map Inventory

● Aerial Photographs and Satellite Imagery

- ❒ Aerial Photographs
- ❒ Air Photos
- ❒ Satellite Images
- ❒ Scanned Images (e.g. maps)
- ❒ Site Records (e.g. photographs)

● Basic Maps Layers

- ❒ Area
- ❒ Background
- ❒ Rivers
- ❒ Streets
- ❒ Topography

● Thematic Maps Layers

● Administrative Boundaries

- ❒ Regional Boundaries
- ❒ District Boundaries
- ❒ Ward Boundaries

● Infrastructure

- **Transport Systems**
  - ❒ Road Network
  - ❒ Railways
  - ❒ Airports
  - ❒ Pedestrian and Cycle-ways

- **Energy and Power**
  - ❒ Electricity
  - ❒ Renewable Energy

- **Water Supply**
  - ❒ Water Distribution
  - ❒ Water Treatment

- **Drainage Systems**

- **Waste Management**
  - ❒ Liquid Waste
  - ❒ Sewerage Network

- **Solid Waste**
  - ❒ Collection Points
  - ❒ Collection Pattern
  - ❒ Dump Sites
  - ❒ Recycling and Reusing
- **Telecommunications**

● Land Use

- **Primary Sector**
  - ❒ Agriculture
  - ❒ Fishing
  - ❒ Mining

- **Industry**
  - ❒ Light Industry
  - ❒ Heavy Industry
  - ❒ Informal Industry

- **Commercial**
  - ❒ Central Business District
  - ❒ Consumer Services
    - Shopping
    - Markets
    - Restaurants
    - Petrol Stations
    - Banks
    - Wholesale and Storage Warehouses
    - Informal Business

- **Institutional**
  - ❒ Public Administration Facilities
    - Government
    - Post Offices
    - Police
    - Military
    - Community Facilities
    - Health Facilities
    - Education Facilities
    - Cemeteries

- **Housing**
  - ❒ Housing System
    - Legal Residential
    - Semi-legal Residential
    - Illegal Residential
    - Co-operative Housing
    - Housing Density
    - Housing Condition

- **Recreation**
  - ❒ Open Spaces
    - • Playgrounds
    - • Public Parks
  - ❒ Sport Facilities
  - ❒ Entertainment
    - • Cinemas and Theatres
  - ❒ Leisure
    - • Social Clubs
  - ❒ Tourism Facilities
    - • Hotels

- **Conservation**

- **Informal Sector**

- **Urban Renewal**
  - ❒ Up-grading
  - ❒ Replacement

- **Construction Categorisations**
  - ❒ Building Codes
  - ❒ Building Economics
  - ❒ Building Materials
  - ❒ Building Maintenance
  - ❒ Building Systems

- ● **Socio-economic Patterns**

- **Population**
  - ❒ Absolute Population
  - ❒ Population Density
  - ❒ Population Growth
  - ❒ Age Distribution
  - ❒ Gender Distribution
  - ❒ Migration and Origin

- **Education**
  - ❒ Formal Education
  - ❒ Informal Education
  - ❒ Training

- **Employment and Income**
  - ❒ Public Sector
  - ❒ Private Sector
  - ❒ Informal Sector
  - ❒ Self-employment
  - ❒ Income Distribution

- **Health**
  - ❒ Diseases
  - ❒ Sanitation

- **Land Issues**
  - ❐ Ownership
  - ❐ Land Economics
  - ❐ Land Policy

- **Economy**
  - ❐ GDP
  - ❐ Primary Sector
  - ❐ Secondary Sector
  - ❐ Tertiary Sector

- **Employment**
  - ❐ Primary Sector
  - ❐ Secondary Sector
  - ❐ Tertiary Sector

- **Municipal Finance**

- **Organisations**
  - ❐ CBOs
  - ❐ NGOs
  - ❐ Political Organisations
  - ❐ Religions

- **Heritage / History**
  - ❐ Cultural Heritage
  - ❐ Ethnic groupings
  - ❐ Natural Heritage
  - ❐ Ethnobotany
  - ❐ Ethnozoology

- **Natural Resources**

- **Geology**
  - ❐ Minerals

- **Geomorphology**
  - ❐ Landforms
  - ❐ Dynamics
  - ❐ Unstable Slopes

- **Soil**
  - ❐ Composition
  - ❐ Soil Types

- **Climate**
  - ❐ Rainfall
  - ❐ Temperature
  - ❐ Humidity
  - ❐ Wind

- **Hydrology**
  - ❒ Ground Water
  - ❒ Rivers
  - ❒ Lakes
  - ❒ Swamps
  - ❒ Storm water and Flooding

- **Biodiversity**
  - ❒ Vegetation (Flora)
  - ❒ Fauna
  - ❒ Ecotypes (Ecological Zones)

- ● **Natural Hazards**

- **Degradation**
  - • Pollution
  - • Air
  - • Water
  - • Soil
  - • Noise
  - ❒ Erosion
  - ❒ Over-use

- **Depletion**
  - ❒ Non-renewable Resources
  - ❒ Renewable Resources
  - ❒ Disasters
    - • Flooding

● Suitability Maps Layers

- **Environmental Issue One (e.g. Air Quality Sensitivity)**
  - ❒ Environmental Sub-issue (e.g. Heavy Metal Air Pollution)
- **Environmental Issue Two (e.g. Quality of Water Resources)**
  - ❒ Environmental Sub-issue (e.g. Suitable Areas for Drinking Water

● Overlay Maps Layers

  - ❒ Environmental Management Framework
  - ❒ Service Delivery Map

● Action Plans

  - ❒ Working Group Air Quality: One-Way Street System in the CBD
  - ❒ Working Group Water Resources: Protection of Water Intake Areas

Developing and Updating the EMIS Inventory Structure

The template file EMIS Inventory Structure.dot on the EMIS CD allows you to create your own EMIS inventory

Note: that the extension *.dot designates an MS Word template.

The structure of your EMIS inventory will depend on the particular needs and uses of your city or organisation. You may find that maps you are creating do not fit into any of the groupings provided (default), and therefore you may need to add new subcategories or indeed to create new categories. On the other hand you may find that some categories are redundant or simply unnecessary, such as 'Marine Resources' in an inland city. For this reason the template file EMIS Inventory Structure.dot is easy to edit. In addition, if you wish to start designing an inventory structure from scratch, you can use the template provided.

You can base your inventory structure on the map coding system (for more details, see Tool 11a: Coding for the EMIS map inventory on the EMIS CD). However, the filing system will be easier to understand if you use full names, as shown in the EMIS Map Inventory structure above. This system has its limits, however, when several versions or similar topics are saved. Therefore, the contents of a file must be clear from its name – even for people who have never used this filing structure. The file name must be chosen carefully. It has to be precise and unique, so that it doesn't get confused with other files of similar topics. For example, a project saved as population density.mxd can refer to the population density for the city as a whole, the density per district, ward or housing block. If you have information about the population density of different administrative units, this information has to be included in the file name. For example, the population density per district will then be named population density_district.mxd and the file with the population density per housing block: population density_houseblock.mxd. Under to the EMIS Inventory Structure, these three maps (together with the population layers) will all be saved in the folder Archive/ Layers Maps/ Thematic/ Socio-economic patterns/ Population/ Population Density.

In the Inventory structure, layers and maps are saved in one folder. You can easily differentiate them by the file format (in ArcGIS .shp for layers and .mxd for maps/projects). But keep in mind that it is not only the file format which makes the difference: a map can combine several layers with different spatial information (i.e. roads, wards, rivers and railway lines). One layer includes the information of one spatial element only (i.e. roads). This difference in information has to be reflected in the file names as well. For example the layer that contains all the streets of your city is saved in the folder archive/ maps layers/ basic/ streets and is named streets.shp. The map that shows all the streets in your city (streets.shp) and the boundary of your city (boundary. shp) will be saved in the same folder as the streets layer but called BM-streets. mxd (Basic Map-streets.mxd).

An individual map or layer should not be assigned to more than one category. For this reason the EMIS team should decide from the beginning what factors determine and distinguish between basic, thematic and suitability maps.

e.g. A Street layer that only shows the different kinds of streets or roads (highways, secondary roads, dirt roads, tracks, etc.) and their names is a Basic Layer. If more sophisticated attributes are included to show what kind of surface the street has, or the amount of traffic found on each road and the noise pollution resulting from it, then this layer would be categorised separately as a Thematic Layer.

Inventory, Archive Folder, Working Folder

The digital data will be stored in three main folders: inventory, archive and working. The inventory folder stores the meta-database of the EMIS (see Tool 12 Meta data), the archive folder stores the up-to-date, finalised layers, maps and tables, and the working folder stores current projects and layers. Once a project or layer is finalised in the working folder it is transferred to the archive folder. In the same way, if a map or layer stored in the archive folder needs to be updated, this file is copied to the working folder, where the necessary changes are made. Once you are satisfied with the update, the old map or layer remaining in the archive is replaced with the updated one. Remember that the purpose of the archive folder is to allow you to open ready-to-use maps immediately without changing layout, scale or print size.

Figure 1:
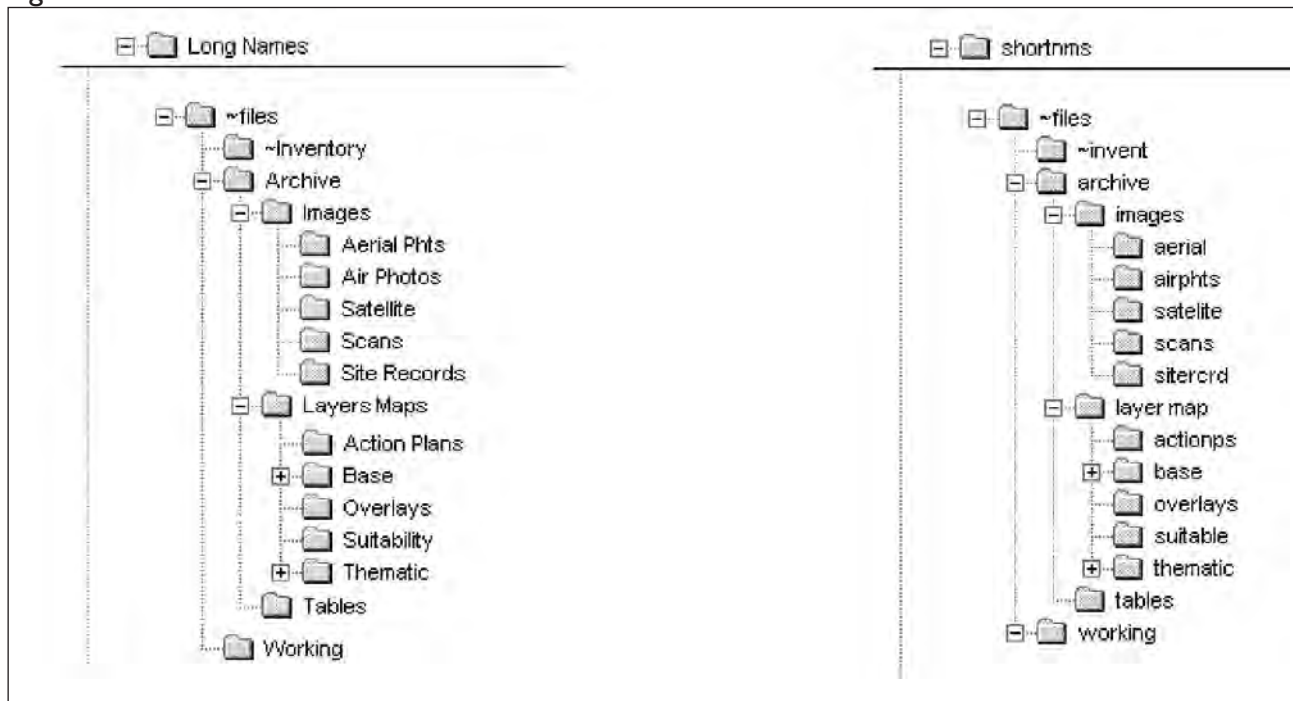
As you can see in Figure 1, the archive folder has three subdirectories: Images, Layers/Maps and Tables: Aerial photographs, satellite images and scanned maps are stored in Images. Tables contains the databases of environmental and development issues, ideally categorised according to each cities' environmental priority issues. The spatial data and the ready-to-use maps (in ArcView GIS: Project [*.mxd] files, in Map Maker Pro: Map files) are stored in the folders Layers/Maps.

The difference between the data structure on the left (long names) and on the right (shortnms) is that the shortnms data structure uses names for folders and files which are no longer than eight letters (the MS DOS concept of eight plus three file names). This can be important if your system is still based on an MS DOS operating system or if you exchange data frequently with people using other systems such as UNIX. Also, ArcView's internal file manager ("Manage Data Sources") cannot handle long file names.

Figure 2 shows an example of the file tree in more detail:
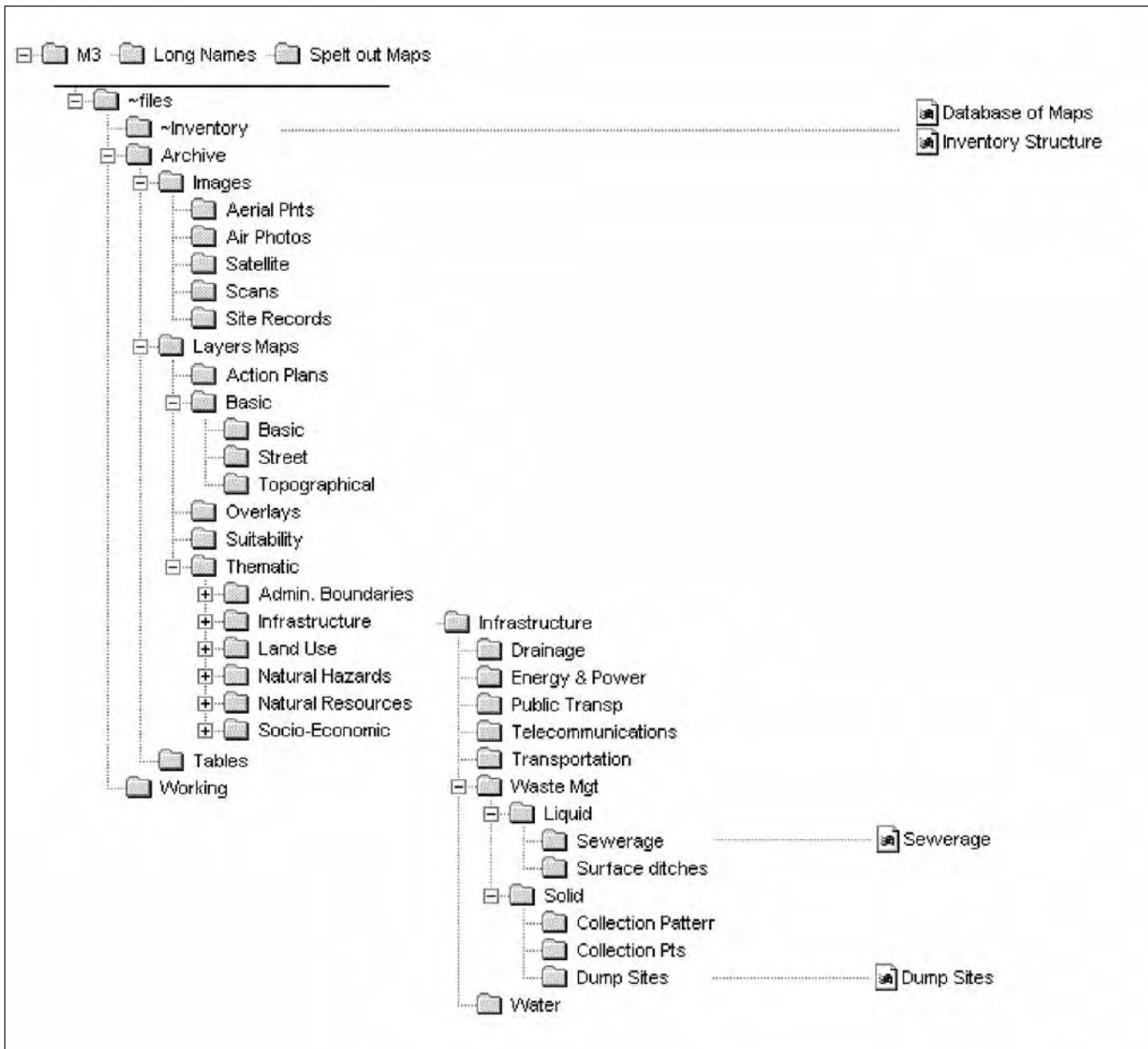
Tool 12: Metadata Database

- Metadata
- How to store metadata
- Metadata standards
- The Inventory database included in the EMIS CD

Metadata

In Tool 11: Organising Maps – Data Filing System, the EMIS inventory structure also includes a folder called "Inventory". What kind of information is stored in this folder? The map inventory gives an overview of the existing maps in the EMIS city and other institutions. Apart from the general information (such as the map title, the location where the map is filed and the date it was created), the inventory also contains detailed information about the data that was used to create the map. This includes the data format (raster or vector data), the geographic coordinate system and the projection of the map. This type of data is called metadata.

Metadata is data that describes a set of data. It is basically "data about data". Metadata gives information about the content, the structure and condition of the data set. It helps to standardize data. This leads to an increase in interoperability and therefore makes it easier to exchange data. Having more information about the available data also decreases the risk of collecting the same data set twice.

A common example of a metadata base is a library catalogue. This catalogue stores information about all the books that can be found in a library. It contains information about the author and the content of the book, when it was published and also its location within the library. The Map Inventory of the EMIS section can be compared to this library catalogue, in the sense that the inventory file also contains metadata about all the maps and geospatial data of the EMIS section.

How to store Metadata

The metadata is typically stored separately in a special database. This can be a simple MS Excel table or a relational database such as MS Access or Oracle. A relational database allows you to make complex queries within a short time. The EMIS CD-ROM contains a sample database on the Nairobi River Basin Programme and a template for developing a customised database. The database is best separated into two main sections: firstly, the map and layer database; and secondly, according to the environmental priority issues identified through the Environmental Profile and the City Consultation. Each Issue-Specific Working Group will have its own space to slot in information related to its priority issues. Much information can be extracted from the minutes of the working group meetings. Other tabular/

numeric information can be directly linked to map layers.

Regarding the geospatial data that will be stored in the metadata base in the inventory folder, it is important that the user has information about the data format (raster or vector) and the geographic coordinate system used, as well as the time period for which the data is relevant. It is also useful to have contact information for the person providing the data. The more detailed the metadata, the better the user can identity if the data meets his needs.

Metadata Standards

Two standards for metadata have been developed. In 1998, the US FGDC (Federal Geographic Data Committee) published the Content Standard for Digital Geospatial Metadata (CSDGM). The standard is mandatory for all US departments filing geospatial data. The standard contains around 200 metadata elements and fixed rules to describe the metadata. Five years later, the International Standard Organization developed ISO 19115, the Metadata Standard for Geospatial Datasets. This standard defines over 400 metadata elements but not all of them have to be filled; only 20 are mandatory.

Metadata base for geospatial data should contain, among others, the following information:

1. **General information about the metadata entry person (EMIS section), filled in once:**
   - Organization (i.e. EMIS section Sustainable Nairobi Project)
   - Contact person (i.e. Matthew Ngora)
   - Address (street, city, state, postal code, country, phone, E-mail address)

2. **Metadata elements regarding topic, title, storage location**
   - Code *(i.e. TM45)*
   - Title of map *(i.e. Status of Sanitation in Kibera – Nairobi, Kenya)*
   - Type of map *(Topographical Map, Suitability Map etc) (i.e. Thematic Map)*
   - Date of Publication *(YYYYMMDD) (i.e. 20060117)*
   - Presentation form *(digital, paper based etc) and format (.pdf, jpg, size of print-outs) (i.e. digital, .pdf, .jpg, print-out, A0)*
   - Publication place, data storage information *(location of the file on the computer, location of where the paper version is stored in the EMIS section) (i.e. d:/maplibrary/Kenya_nairobi/maps/thematic/maps/TM45_ sanitation_kibera.jpeg*
   - Notes, explanations about the stored data *(i.e. Map shows houses with access to sanitation, data was collected by Sanitation Working Group members)*

3. **Metadata elements: geospatial information, dates**
   - Geographic coordination system *(i.e. WGS 84)*
   - Projection *(i.e. UTM)*
   - Bounding lat/long coordinates east, west, north, south
   - Data format *(vector, raster) (i.e. vector)*

- Scale *(i.e. 1:2500)*
- Data set maintenance and update frequency *(i.e. every two years)*
- Time span for data capture *(beginning YYYYMMDD and end YYYYMMDD) (i.e. beginning 20051007 end 20051124)*
- Attributes included in the data *(map, layer) (i.e. roads.shp, rivers.shp, administration.shp, sanitation.shp, population.shp)*

4. **Purchasing information (where did the EMIS section get the data from?)**
   - Originator organization *(private company, other department, Working Group member) (i.e. Ministry of Land and Physical Planning, Geography Department of the International University, Nairobi, Kenya)*
   - Originator contact person *(i.e. Katrina Smith)*
   - Address *(street, city, state, postal code, country, phone, E-mail address)*
   - Dataset name as known by Originator *(i.e. Nairobi_districts.shp, Nairobi_road network.shp)*
   - Date of last metadata entry or update *(YYYYMMDD) (i.e. 20050220)*

The Inventory database included in the EMIS CD

A template for a metadata base (in MS Access file format inventory. mdb) can be found on the EMIS CD. This database includes the following metadata:

- Code   *(i.e. Basic Map: BM1)*
- Type   *(i.e. Topographical Map)*
- Title   *(i.e. Jang'ombe)*
- Area Cover *(i.e. Jang'ombe)*
- Format   *(i.e. Print)*
- Scale   *(i.e. 1:2500)*
- Date   *(i.e. 01/01/1999)*
- Source   *(i.e. Aerial Photo)*
- Location   *(i.e. Commission of Lands)*
- Quality   *(i.e. Good)*
- Remarks   *(i.e. easy available)*
- Filename   *(i.e. d:\~files\mohammed\..)*

You can use this database to enter the metadata of your maps. This database can be customised to your local conditions. The EMIS CD also offers the option of an MS Excel table (inventory.xls) that you can fill in with the necessary data

Tool 13: The Basic Map

How to create the basic map layers for EMIS
• Checklist for creating a Basic Map
• Examples of basic layers

Checklist for creating a Basic Map

This checklist is used to identify which map source the Basic Map is based on, and to define which layers are produced and what the Basic Map will look like. For more information about the standard layout of EMIS maps, refer to Tool 14: Standard Layout.

• **Area to cover:**_____
  (Which area should your maps and analysis cover? Indicate landmarks)

• **Scale:**_____
  (If you want to use different scales, indicate which ones for which area/ purpose)

• **Source map(s):** _____
  (Which sources will you use as a basis for your Basic Map?)

• **Projection:**_____
  (What projection and datum you will use in the Basic Map? Does this match other existing data?)

• **Layers**
  (Which layers should be included in your Basic Map?)
  Rivers
  Roads/Streets
  Landforms
  Administrative boundaries
  Contour lines
  Built-up area

• **Layout**
  (What will your standard map layout look like?)
  Paper size:_____
  Orientation: landscape _____ or portrait _____
  Cartographic features (layers or selected features of layers like major roads, major rivers and streams etc.)_____
  _____
  Typical title _____
  Standard source_____
  Colour and/or black & white_____

• **Images** _____
  (Do you have to update layers with more recent images?)

Typical Basic Map Layers

Background, such as coastline, hinterland, ocean and islands.
Note: all features are polygons which share a common boundary in the coastline:
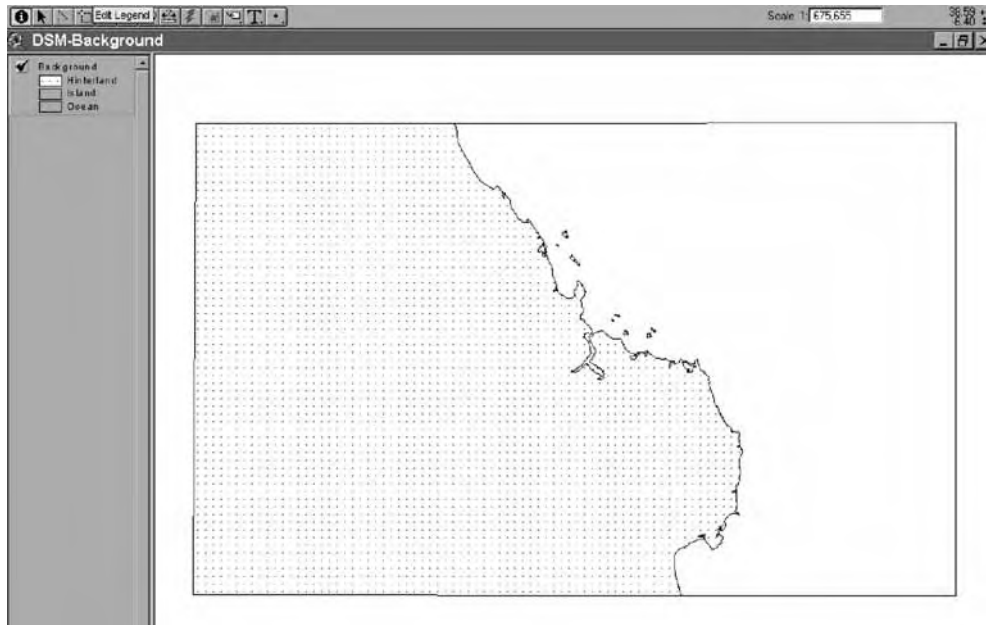
River network:
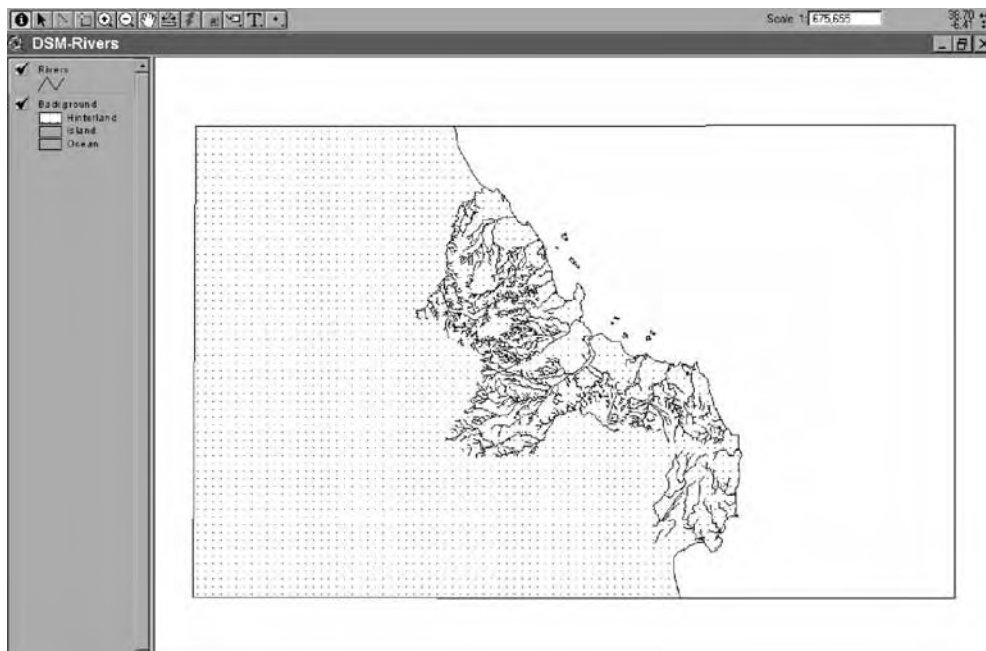
Road network:
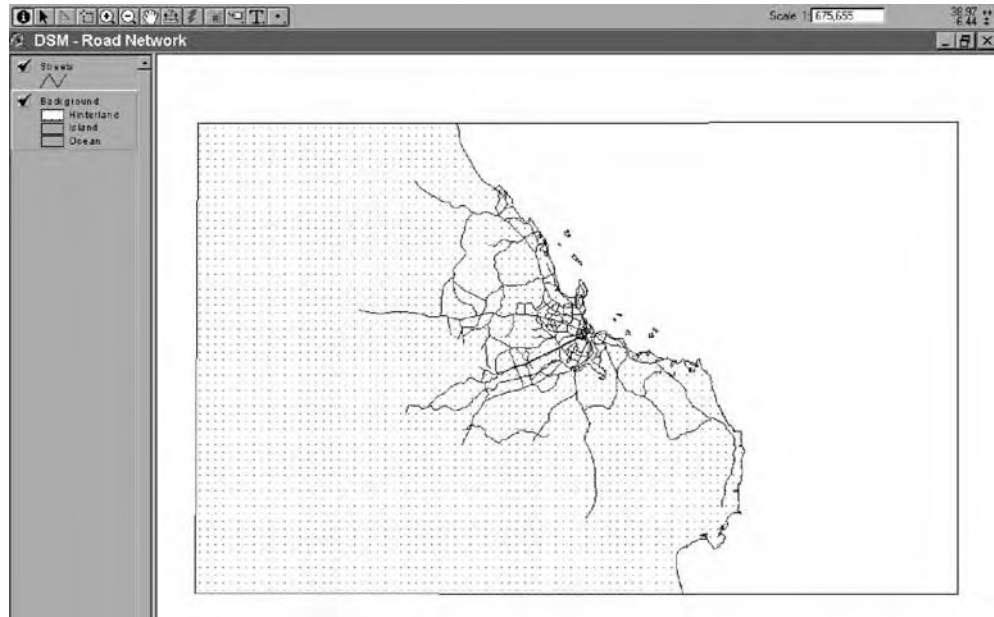
Administrative boundaries:
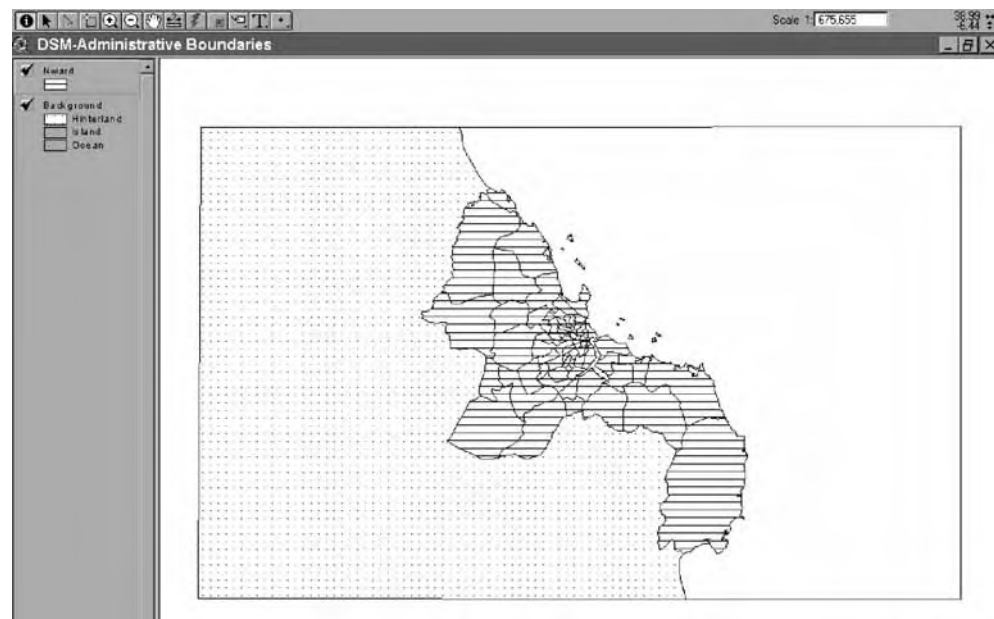
Tool 14: Standard Layout

How to use a template to lay out a map
- Standard layout
- How to create a layout template in ArcView 3.2
- How to use a template in ArcView 3.2
- How to create a template in ArcView GIS 9.0
- How to use a template in ArcView GIS 9.0

Standard layout

In Tool 13, Creating a Basic Map, we looked at some of the decisions to be taken in developing a standard map layout. Tool T9 provides greater detail on how to make these choices.

All the maps prepared for the EMIS have the same standard layout and appearance. This will save you time when you are producing maps, and will also help to create a clear and recognisable visual identity for EMIS unit products. The EMIS CD contains customised templates, which look like this:
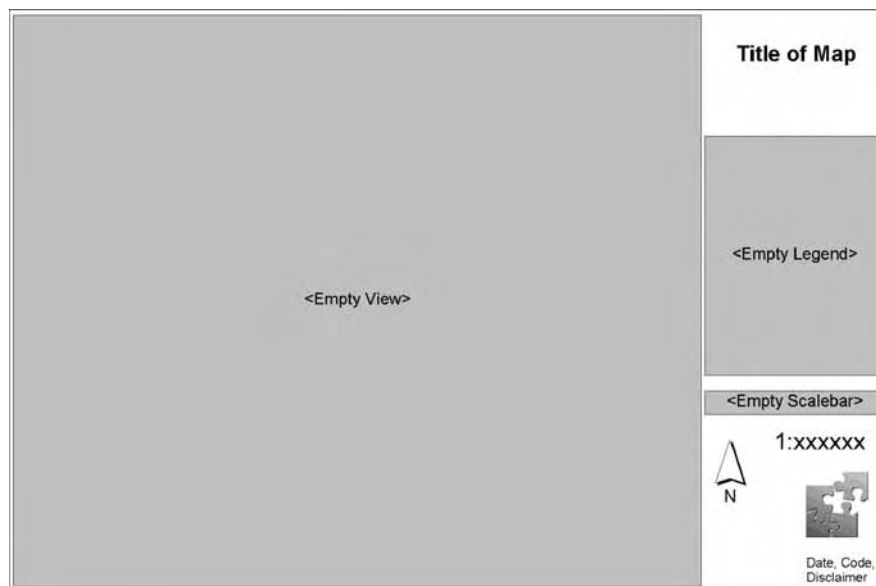
Standard questions when developing a layout:

- Paper size and orientation
  Which size will the map normally be printed? Which paper orientation is most suitable for the area to be shown on the map (landscape or portrait)?

- Cartographic elements
  What will the north arrow look like?
  Where will the legend be placed, what will the title of the legend be, and which measuring units will be indicated?
  What type of scalebar will be used? It is best to use both a scalebar and the scale in 1:n (e.g. 1:50000)

- Title of the map

  The map title should make the topic and the geographic area covered clear immediately (e.g. 'Landuse in Dar es Salaam' or 'One Way Street System in the City Centre of Dar es Salaam'. Please use the same title properties (font, size, colour, etc.) for different maps.

- Logo

  Usually the maps produced by the EMIS Unit contain the unit's logo or the official logo of the municipality.

- Disclaimer

  The disclaimer includes project name, map code, date of the map, author(s) of the map, source of the information and the data used (including date of the source information) projection used, and filename.

  For example:

  > Project: Nairobi River Basin Project; TM4-3
  > Cartography: Peter Kibe, Inti Trujillo
  > Source of information: Mapping and Survey Department, Data from Issue-Specific Working Group on Sanitation
  > Date: December 1999
  > Projection: UTM Zone 37, Clarke 1880, New (1960) Arc
  > File name and location: C:\nairobi\archive\maps\thematic\landuse.apr

---

How to create a layout template in ArcView GIS 3.2

Any layout can be saved as a template. You can use the standard templates provided with the software to create your own customised EMIS layout template.

1. Open the Project Dialog Box in ArcView GIS
2. Click the Layout icon
3. Click New Layout
4. Go to menu Layout -> Use Template
5. Choose the template you want to adjust
6. Now you have to:
   - Define the page set-up
   - Type in a title
   - Type the disclaimer
   - Make any other changes necessary (frames, logos etc.)
7. To save this layout as a template, go to menu Layout -> Store as Template
8. In the Dialog Box, give your template a name and choose an icon to represent it
9. Press OK
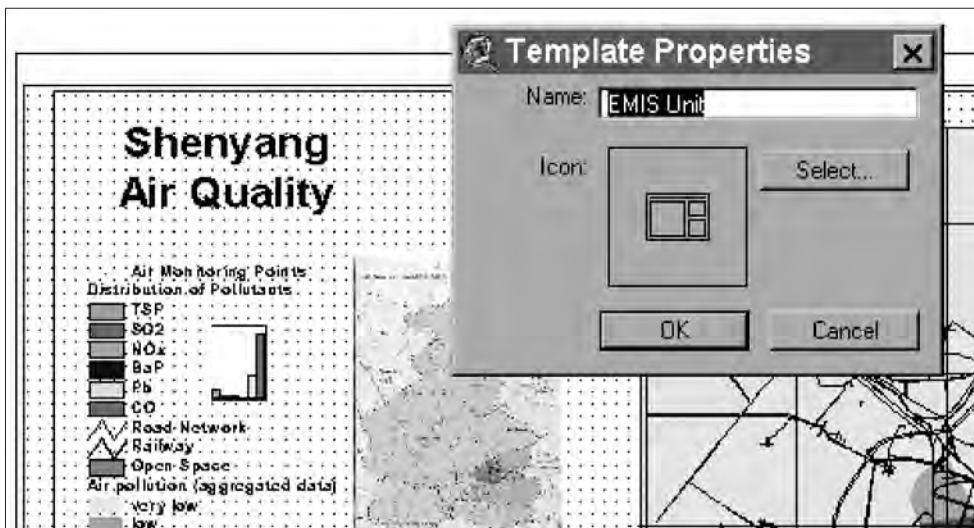
How to use a template in ArcView GIS 3.2

Once you have prepared a particular view in ArcView GIS, you publish this view using your customised layout template. Make sure you have defined the map projection and set the map units. Under the Theme Properties, you can customise the names of the individual themes in the way you want to see them appear in the legend.
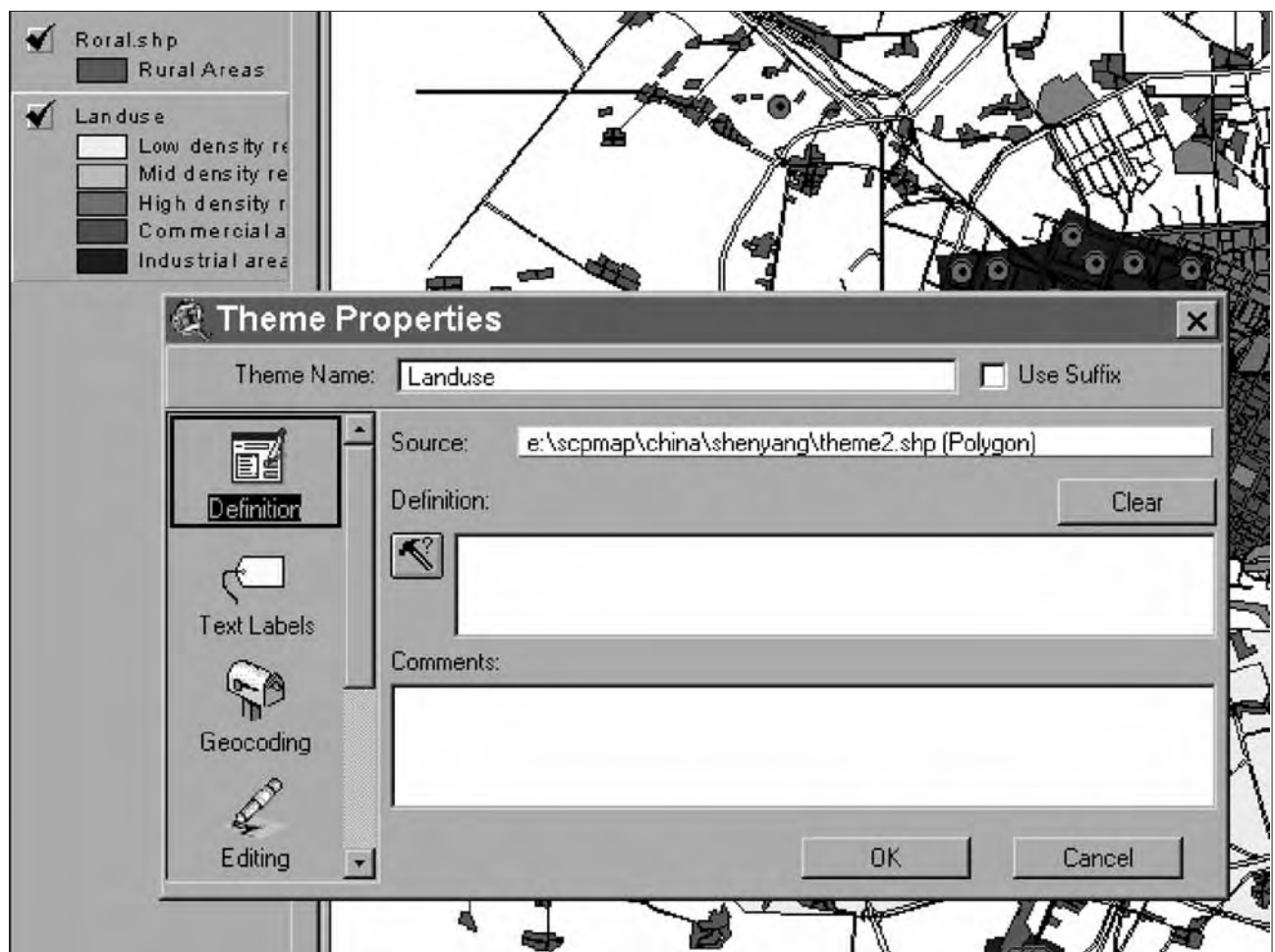
1. **From the View menu choose Layout**
   Select the template you want to use
2. **Check the scales**
   There is a live link to the view to which your layout refers. You can adjust the scale in order to make the map extent fit on the page, or to show a 'round' scale, e.g. 1:20000.
3. **Adjust the legend**
   You may have to simplify the legend to change the text and the arrangement of the symbols. If you want to change the size of the text and boxes evenly you have to select all boxes and text. Group them and resize them. Do not forget to mention the units of the measurement of what is shown on the map. Note: If you "simplify" objects on the layout they will loose the live link to your respective view.
4. **Type the title**
   Change the title according to the subject of the map and the map extent.
5. **Change disclaimer**
   Please type in the correct date and filename, and probably the source of the information. Do not forget to mention the year of the data shown on the map.
6. **Add gridlines**
   Load Extension "graticules and measured grids"
   A new tool button appears on the right side of the icon bar
   Click on the button while you are in the layout and follow the instructions of the wizard.
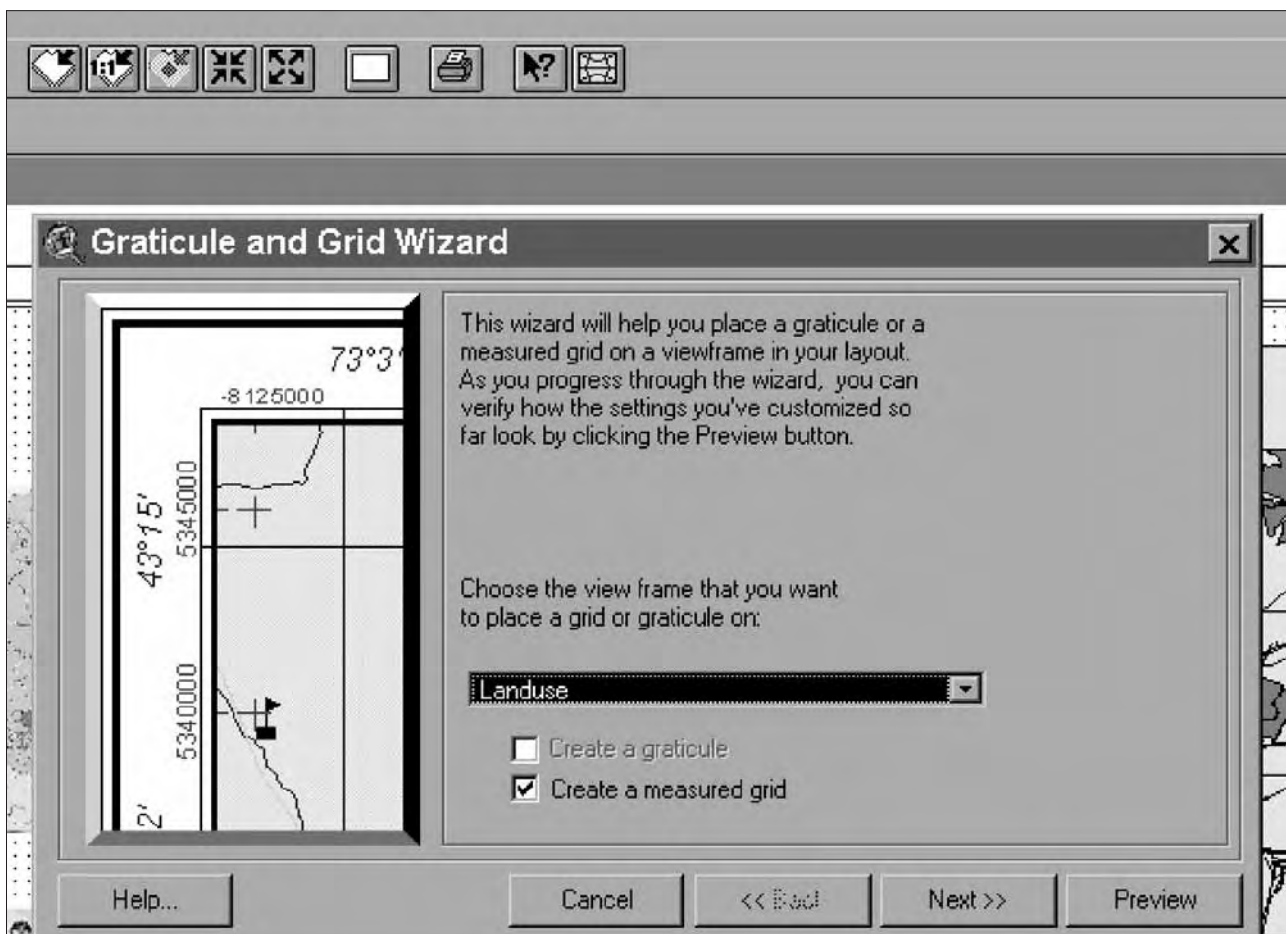
How to create a template in ArcView GIS 9.0

ArcView 9.0 provides you with a number of ready-to-use templates. They include map elements such as legend title, north arrow, and scale bar.

You can also design your own standard layout and save it as map template. Please note that once a project is saved as a map template (.mxt) it cannot be saved as a map document (.mxd). The next time you open the map template it will be opened as an untitled map document (.mxd). This means that you have the standard layout in the layout view but you can change, add or delete layers to design a new map, and then save this map either as a map document or a map template.

1. Change from data view to layout view
2. Click on Change layout button
3. Choose the template you want to adjust
4. Now you have to:
    • Type in a title
    • Type the disclaimer
    • Make any other changes necessary (frames, logos etc.)
5. To save this layout as a template, go to File -> Save As
6. In the Dialog Box, give your template a name and choose ArcMap template as the file type
7. Press OK

How to use a template in ArcView GIS 9.0

1. Change data view to layout view
2. Click on Change layout button
3. Under My Templates, click on the folder for browsing and select the template you want to use from your files
4. Right click on the data frame -> Properties -> Data Frame to check the scales. You can adjust the scale, in order to make the map extent fit on the page ("automatic") or to show a 'round' scale, e.g. 1:20000 ("fixed scale").
5. Adjust the legend by right clicking "convert to graphics" -> "ungroup" the legend to change the text and the arrangement of the symbols. If you want to change the size of the text and boxes evenly you have to select all boxes and text. Group them and resize them. Do not forget to mention the units of the measurement of what is shown on the map.
6. Type the title: Change the title according to the subject of the map and the map extent.
7. Change disclaimer: Please type in the correct date and filename, and probably the source of the information. Do not forget to mention the year of the data shown on the map.
8. Save the map as a map document. To export the map as an image file go to File -> Export map and choose the folder and map name as well as the image format. Click ok.

Tool 15: Digitizing Maps

How to digitize maps using a digitizing board or onscreen using a scanned map or imagery

- Digitizing with a digitizing board (Tools 15a on EMIS CD-ROM)
- World file – GeoTiff (Tool 15b on EMIS CD-ROM)
- Scanning existing maps or images
- Georeferencing with Map Maker
- Digitizing in MapMaker
- Georeferencing with ArcView 3.2 GIS
- Digitizing onscreen in ArcView 3.2 GIS
- Digitizing in ArcView 9.0 GIS

Scanning existing maps or images

1. Preparation

a)   Study and discuss the original map with the Mapping Group, regarding the quality of the original, acceptable errors, the area to be scanned and mechanisms for calibration.

b)   Determine the features (e.g. roads, rivers, houses, contour lines) which should be digitized and converted into points, lines and polygons after scanning.

2. Scan paper map

> **Note:** You will have to find a good balance between good resolution and reasonable file size. An A4 map should have a minimum resolution of 100 dpi, and should fit on a diskette. GIF or JPG formats are compressed graphic formats. A 1MB TIFF file can be converted to a 100 KB JPG file.

3.   **Rotate the scanned image** to its original direction, if necessary. You can use a graphic programme, such as MS Photo Editor (part of MS Office).

> **Note:** Scanned images (maps, aerial photographs) can not be directly calibrated and adjusted to real world co-ordinates in ArcView GIS. Without calibration your final map will not have the right scale and will not show valid distance units. Use uncalibrated maps for producing "quick and dirty" maps only. Otherwise use ArcView extensions or Avenue scripts such as Register and Transform Tool (on CD-ROM), Image Warp, etc.

Georeferencing with Map Maker

Map Maker software offer a simple but useful tool for calibrating scanned images. In order to calibrate the scan, you need the following information:
• a BMP or TIFF file;
• one reference point;
• the x-y co-ordinate of the reference point (in meters, such as UTM);
• the original scale; and
• dots per inch of the scanned image.

You also have the option of inserting a value for rotation.
1. **Click on File - Clear screen** to ensure that no file is loaded into the Live Layer. A bitmap file can only be calibrated if it is the only layer present in the Live Layer.
2. **Go to File - Open and select the bitmap file (BMP or TIFF)** to be calibrated. Use the navigation tool, Pan by Dragging, to manoeuvre the image so that a location with known co-ordinates is visible on the screen. If you are using a scan of a paper map, for example, you might use a grid intersection as the known reference point.
3. **Select Tools - Calibrate scan.** The cursor changes to crossed hairs. Locate the cursor over the known point. Click once with the left mouse button and release. A dialogue box appears. Enter the co-ordinates of your reference point, then the scale of the scan in the third field down. The next field down (dots per inch) should already show the resolution you chose when you made the scan. You may have an aerial photograph, which has not been produced to scale, a sketch map or a bitmap that you acquired digitally. You can use a known distance. To
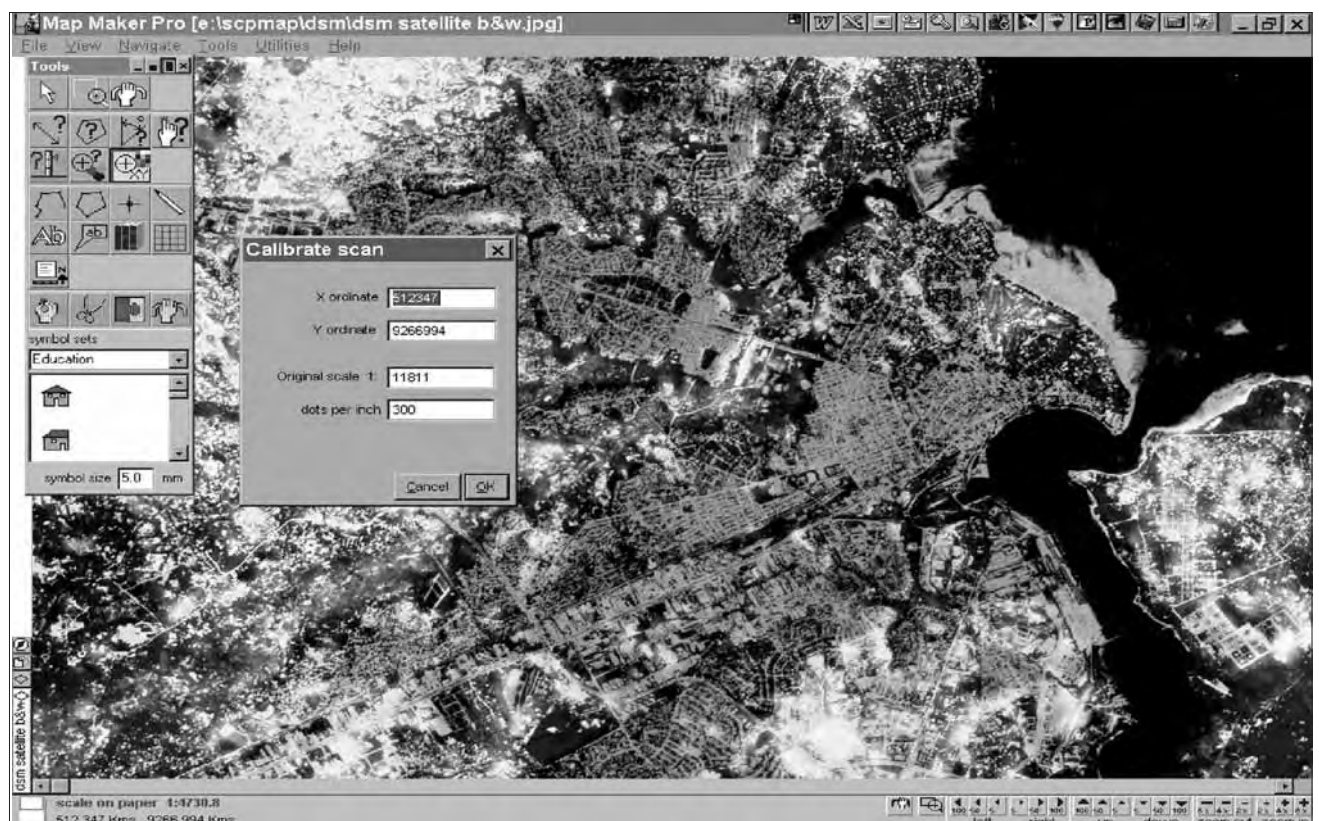
determine the scale in such cases, you must know the distance between two fixed points. Double-click on one known point. Now drag the cursor to the second point and click again. A dialogue box similar to the box described above will appear but here you enter the distance in metres between the reference point and the second point.

4. Click OK. The scan automatically reloads in order to accommodate the scale. Now distances, areas, and co-ordinates should be correct.
5. Choose an appropriate drawing tool and start digitizing the features you need.

Map Maker offers an additional useful extension for more accurate image registration called Rubber Map.

Briefly, this operates in two modes: "Four control points" and "Rubber sheet". The four control points are self-explanatory, you simply locate four known points and enter their true co-ordinates.
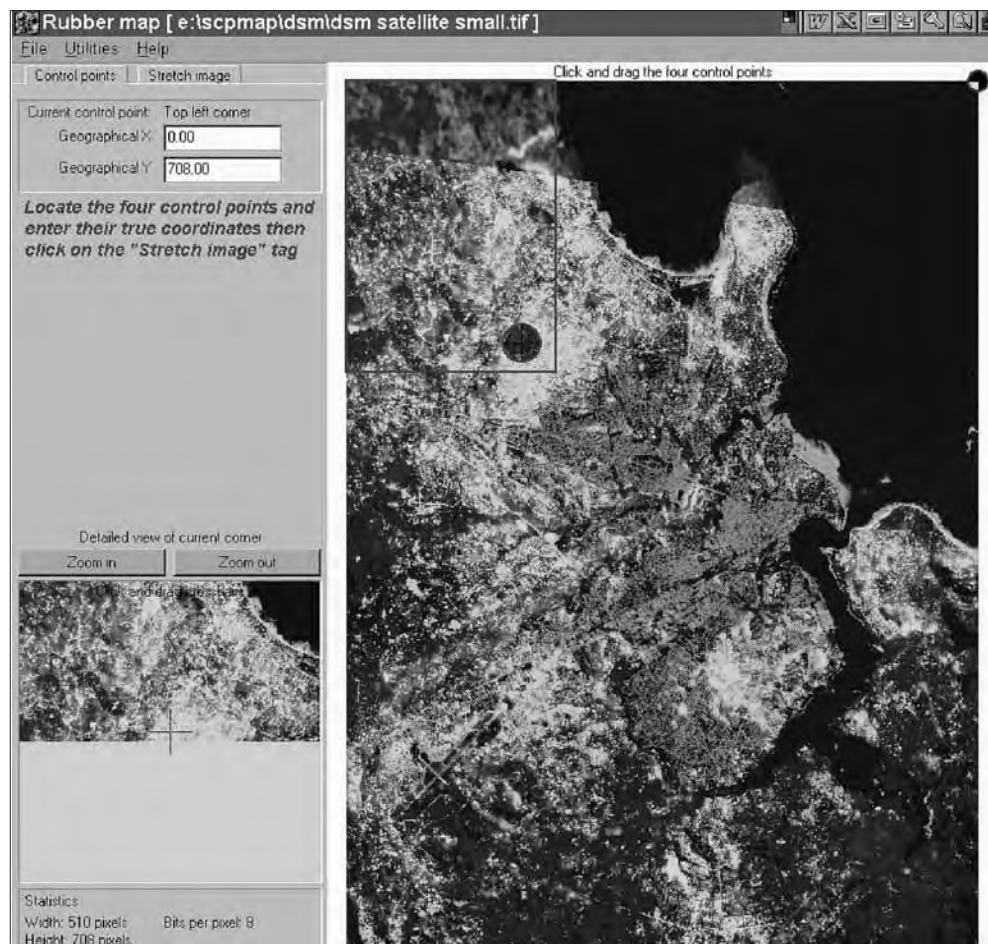
"Rubber sheet" requires Map Maker Pro from version 2.3 (dated after 26th Oct 1998). Load the bitmap in Map Maker Pro and use the "calibrate bitmap" tool to approximately calibrate the image. Then overlay the correct vector data, which may be a few known points or the complete vector data of roads and boundaries etc. Load these vectors into the "live layer". Go to the Live layer -Transform menu and click on "add rubber sheet". Now use the "edit object" tool to drag the intersections of the rubber sheet grid to distort the vector data to make it fit the bitmap. When you have a good fit go back to the Transform menu and click on "save rubber sheet".

Now go back to "Rubber Map", choose your bitmap, choose rubber sheet distortions, and choose the rubber sheet data you just saved in Map Maker Pro. When you click on "generate bitmap" the bitmap will be distorted using the rubber sheet distortions in reverse to make it fit to the correct vectors.

Those rectified images have a fairly high accuracy. Since ArcView GIS does not offer accurate image rectification, you can use Map Maker Pro for digitizing and then export the drawings to ArcView GIS.

Digitizing in Map Maker Pro

Digitizing
- Choose the drawing tool you need.
- Digitize
- Save Live Layer as a drawing (dra-file)

Note: in some cases the digitized drawing does not appear on the screen while digitizing In this case, just draw one small polygon, save the live layer, clear the screen and open the saved drawing into the live layer. From now on, the objects are visible while digitizing.

Clean your geometry

Choose the edit tool to clean the geometry or use the various functions of the "live layer transforms" such as "Tidy Line Junctions", "Tidy Common Boundaries" etc.

Add information to the attribute table

Adding attribute data to a table is easier in Map Maker than in ArcView GIS. After digitizing, follow these steps:
1. Go to File>Data and choose "Generate data file";
2. Select the previously digitized dra-file;
3. Choose "dBase III dbf" in the next dialogue box and specify the number of columns you intend to fill;
4. Type a name for the new dbf file (take the same as the dra file);
5. Click OK and the new Attribute Table to your drawing will appear.

Once you have created the table, your Query Tool allows you to edit the attributes directly by clicking the particular object.

Georeferencing with ArcView 3.2 GIS

ArcView 3.2 supports the following image formats as themes: ARC Digitized Raster Graphics (ADRG) (with extension), BMP, BSQ, BIL and BIP, Compressed ARC Digitized Raster Graphics (CADRG) (with extension), Controlled Image Base (CIB) (with extension), ERDAS, GRID, IMAGINE (with extension), IMPELL Bitmaps (Run-length compressed files), Image

catalogues, JPEG (with extension), MrSID (with extension), National Image Transfer Format (NITF) (with extension), Sun raster files, TIFF, TIFF/LZW compressed.

> **Note:** ArcView GIS does not rotate, or warp, images. If your world file has non-zero rotation terms (D and B parameters), the image may change its position relative to vector data in the same view when you zoom or pan.

To register an image in ArcView 3.2 the script "register.avx" can help. This extension can be found on the EMIS CD-ROM. This extension was created to register aerial photos that are already ortho-rectified. This extension works with jpg and bmp type images, as well as with tif, bsq, bip, bil and sun image types.

This extension will create a world file for an image by picking control points between the image and a projected feature theme. The first order fit can shift the image up or down and stretch the image both vertically and horizontally. Keep this in mind, because it will not "warp" or "rubber sheet" the image.

1. To use this extension place it in your **ext32 directory** and from the File -Extensions menu select the Image to Map World File Creator.
2. You should see a blue diamond on the Project Button Bar. Press this button to begin and you will be asked for the name of the image you want to create a World File for and the name of the Feature Theme you want to register it to.
3. On the left side of your tool bar you will see a new tool that looks like a flag. Choose this tool and with it pick Ground Control Points (GCP's) that have the same spatial location for both the image and the feature theme, To do this, select a point on the image. Select a point on the feature theme that is the same location. This constitutes 1 GCP pair.
4. Now continue: select a point on the image, select a point on the feature theme that is the same location.
5. Continue doing this until you have at least 6 GCP pairs.

> For a first order fit you need a minimum of 3 pairs. However, it is recommended that you have twice the minimum, so the code is set up so that you have to pick 6 pairs.

6. Once your GCP's are chosen minimise the two views and open the table called Ground Control Point Table.

> This table has 6 fields:
>
> | | |
> |---|---|
> | Use Pnts | You will notice every record has this field ON |
> | Input x | For the image x co-ordinate |
> | Input y | For the image y co-ordinate |
> | Output x | For the output x co-ordinate |
> | Output y | For the output y co-ordinate |
> | rms | Will display the Root Mean Square for each record |

7. You will notice a new button "C" on the Table Button Bar. This button will calculate the fit and rms values for your control points. Press it and then look at the rms values in the RMS field. Typing OFF in the Use Pnts field can turn off any one record that gives you a high rms value.

8. Keep calculating the rms and turning records off until you are satisfied with the total rms. Just keep in mind that you have to have 6 GCP pairs ON for it to work.

9. Once you have completed this task you should see a new button on the Button Bar that looks like a pencil and paper. This button will write the world file. Press it and you will be ask where to save the file. You should save it in the same directory as the image itself.

10. The next time you open the image and feature them into a new view, both will register correctly.

Avenue Script programmers are continuously developing new scripts for georeferencing images in ArcView GIS (for example ImageWarp, Image Georeferencing, Rift). The scripts usually are in zip format and contain a text document explaining the tool and the installation procedure. Please check the ESRI homepage (http://www.esri.com/arcscripts), where you can download hundreds of scripts for free.

Digitizing onscreen in Arcview 3.2 GIS

ArcView 3.2 GIS does not allow the calibration of scanned images. However, for producing "quick and dirty" maps, a scanned map can be loaded for digitizing in ArcView GIS.

1. **Activate your JPEG and/or TIFF image EXTENSION**
    Under File> Extensions >; put a checkmark (✔) on "Image Extension"

2. **Open your scanned image**
    (Select IMAGE SOURCE, instead of FEATURE SOURCE)

3. **Create a NEW THEME**
    Specify the type (POINT, LINE or POLYGON) and give it a meaningful name

4. **Start digitizing on-screen.**

> SAVE EDITS while you are digitizing to avoid loss of data in case of computer problems.

5. **STOP EDITING** when finished.

> **Note:** : for digitizing polygons, you can use three types of digitizing modes for:
> *   normal polygon drawing
> *   splitting existing polygons into smaller polygons
> *   adding new polygons to existing polygons with common boundaries

Digitizing in Arcview 9.0 GIS

1. Before you start digitizing, a new layer for the data has to be created. This will be done in ArcCatalog.
    On the left hand side choose the folder you want to store the new shape file in (in general this would be the "Working" folder in your inventory).
2. Right-click on the mouse and go to New > Shape file.
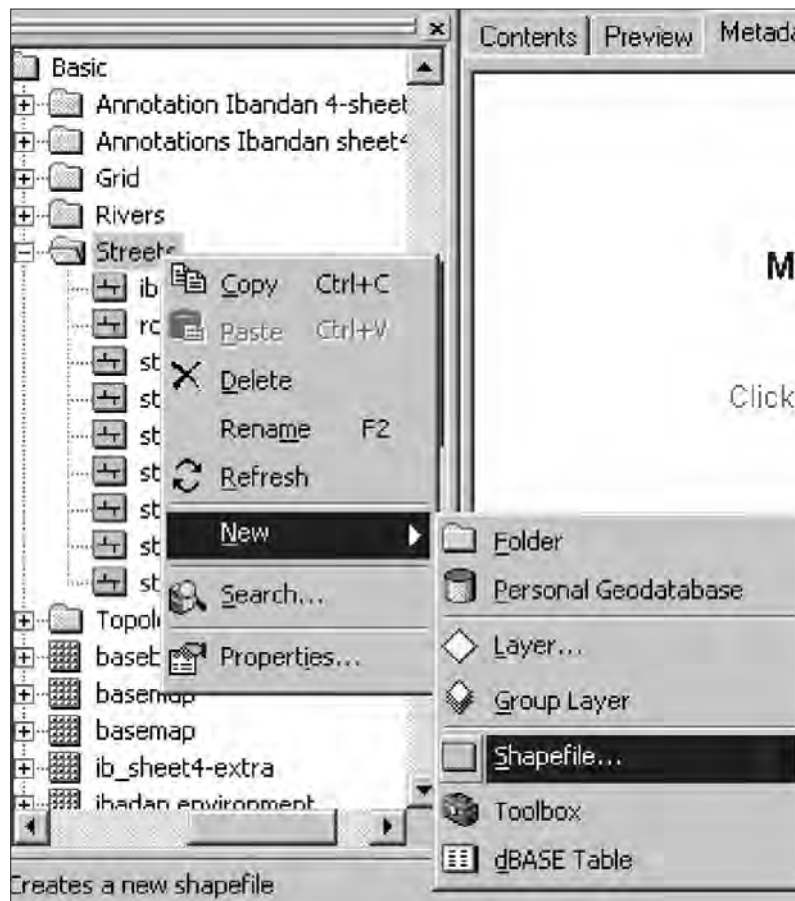
3. Set the parameter of this layer by giving it a meaningful name and selecting the feature type (point, line, polygon). Afterwards the spatial reference has to be set as well. This is done by selecting a co-ordinate system from the list and clicking ok.

4. Now open ArcMap. The new shape file will appear in the folder in which you stored it and therefore can be added to the view.

5. Load the scanned map to the view.

6. For digitizing go to the Editor toolbar > Start editing

7. On the editor toolbar, three settings have to be specified: the task, the

target and the tool. The task is Create new feature and the target is the new shape file you created in ArcCatalog and added to the view. You can choose between 4 editing tools:

Create new feature tool – draws point, line or polygon features.

Distance-to-Distance tool – places a point at either of two locations made by the intersection of two circles

Trace tool – creates features that follow the contours of selected lines or polygons

Intersection tool – places a point at the location where two lines would cross if they extended far enough

Choose the pencil – create new feature tool. Start digtizing on-screen.

SAVE EDITS while you are digitizing to avoid loss of data in case of computer problems.

8.   Click on Stop Editing (in the editor toolbar) when finished.

Tool 16: Standard Set of Thematic Maps

A non comprehensive list of Thematic Maps for the EMIS
• Standard set of Thematic Maps
• Examples of additional Thematic Maps

This list offers some topics for EMIS Thematic Maps. The list is derived from the more comprehensive inventory list in Tool 11a: Map Coding. The first part of the list details a number of maps and topics, which provide the core of most EMIS. These maps are usually required to illustrate the Environmental Profile (EP). The second part of the list provides more map titles, just to give an idea of the topics which the Thematic Maps should cover.

Standard Set of Thematic Maps

Environmental Setting:
Geology
Typical landforms
Soil composition and soil types
Amount of yearly rainfall in mm
Typical wind pattern during the year
Ground water table in metres below the ground
Rivers and lakes (usually part of the Basic Map layers)
Natural vegetation (Flora) and surroundings

Chemical content in the air
Chemical content in water bodies
Soil erosion in mm per year
Flood prone areas
Land-slide prone areas
Other environmental hazards and time of occurring

Development Setting:
Administrative boundaries (usually part of the basic map layers)
Land use pattern
Industrial sites and type of industry
Location and types of markets
Health centre and hospitals
Types of housing
Age and condition of housing areas
Road network (usually part of the Basic Map layers)
Electricity and water supply network
Sewerage network
Waste collection points and schedule of collection
Amount of solid waste in tons per week
Population density per hectare (per administrative unit)
Population growth (e.g. from 1990 to today)
Land value
Income distribution
Distribution of CBOs, NGOs, political organisations and religious groups.

Examples of additional Thematic Maps

Geomorphology
Temperature iso-hypses
Ecological areas – ecotones and surroundings

Urban agricultural land use
Mining sites and amount of building material mined in tons
Location of aggregation of informal activities
Storm water drainage and flood control
Open spaces and cemeteries
Tourism facilities – location of hotels and number of visitors per year
Traffic flow over the day
Public transport – bus routes and areas serviced

Age and gender distribution per administrative unit
Migration between the administrative units over the last five years
Students per school per administrative unit
Number of patients per doctor per administrative unit
Number of cases of cholera, malaria and other diseases per administrative
unit per year
Employment rates per administrative unit

Example of a Thematic Map:
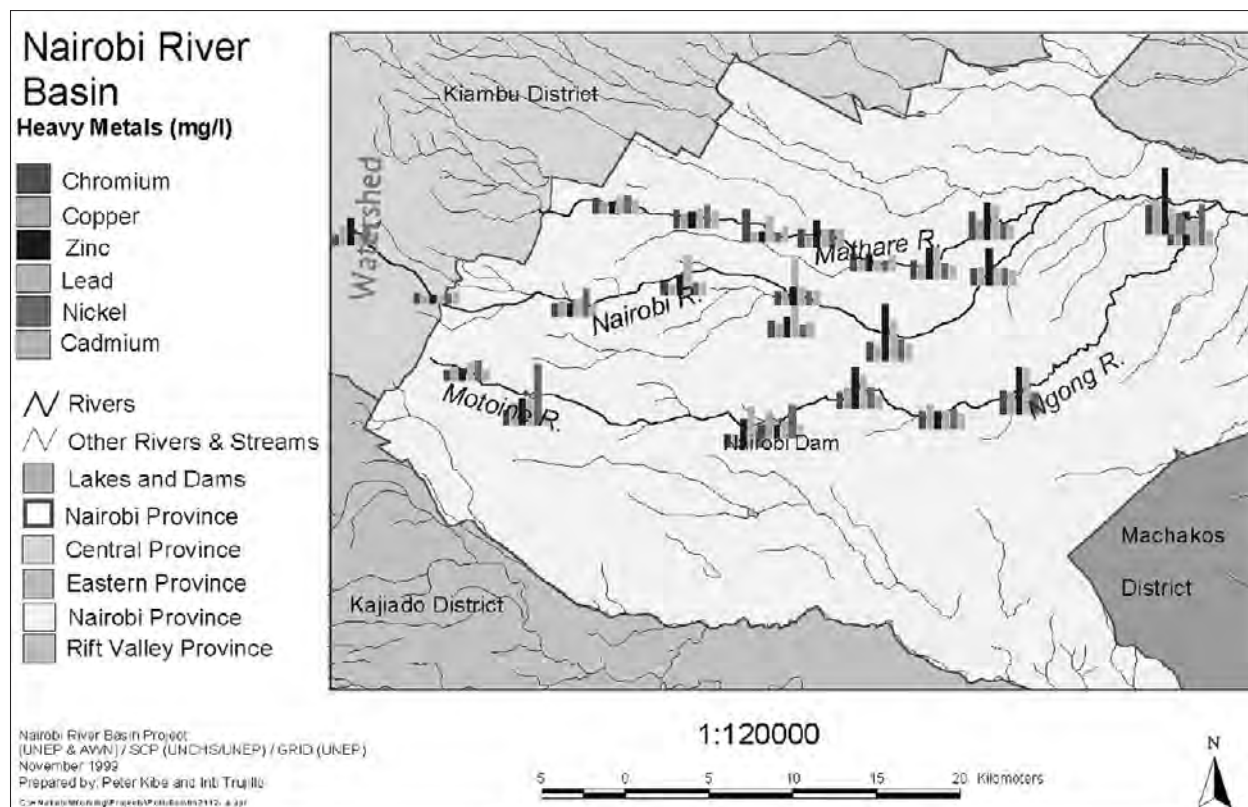
Tool 17: Attribute Data

How to connect information to a map
- What are Attribute Data?
- How to develop a Environmental Planning and Management (EPM) database
- Linking an ArcView GIS attribute table with an external database

What are Attribute Data?

A line on a map can be a road, a river or an administrative boundary. The lines are usually distinguished from each other by the use of different line styles and colours. In a Geographic Information System (GIS), however, each point, line or polygon has a unique identification number, automatically added during digitizing, which connects it to a specific record in a database of attribute data. In GIS, attribute data is commonly described as non-spatial data. An attribute data database allows information to be attached to a point, line or polygon. The database can be seen as an electronic card index in which one "card" – or record – contains a set of information and a reference number to link the card to a particular object. Over time, information in this attribute table is expanded and up-dated.

Example of an attribute table in Map Maker Pro with a population map based on the attribute table:
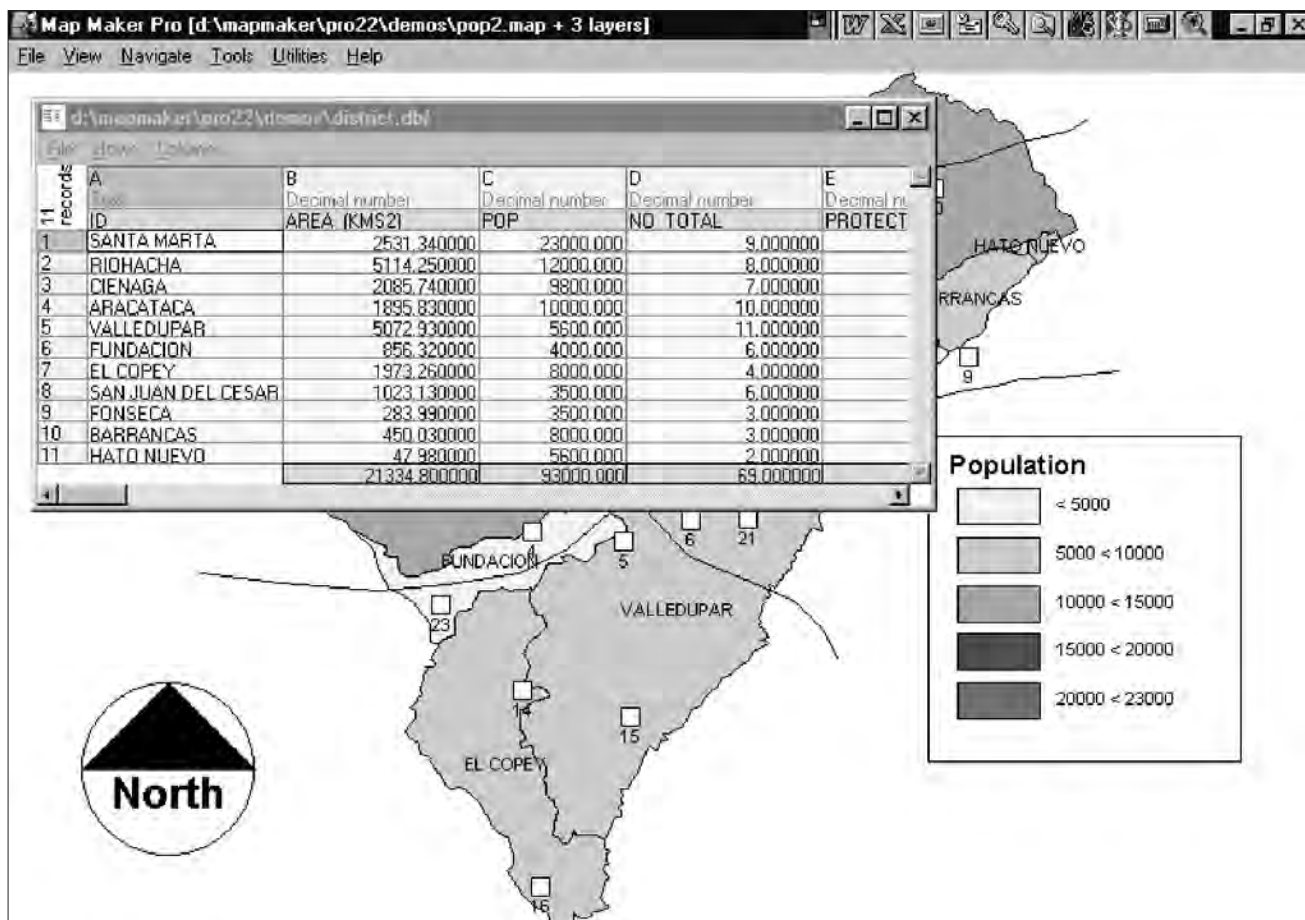
How to develop an Environmental Planning and Management (EPM) database

Most of the information generated during the environmental planning and management (EPM) process, and in particular during the SCP process, is stored in reports (e.g. the Environmental Profile), minutes (from Issue-Specific Working Group meetings) and tables (e.g. statistical data from field research). The EMIS Officer supported by the Mapping Group, converts the relevant information into a format which can be used to prepare maps.

For example, the Sanitation Working Group discusses the groundwater levels in the city. Since there is no scientific data available on the depth of the groundwater table, the Working Group contracts the Geology Department of the University to prepare a report on the geological situation in the city and the expected impact regarding the groundwater situation. At the same time, members of a community organisation complain about the difficulty of getting drinking water because it is too expensive to drill deep boreholes. In another area, a construction company is struggling with the construction of solid foundations because of the high water table. The EMIS Officer takes note of all these different fragments of information and enters them into the sanitation database. The compiled information already gives an idea of the different groundwater tables in the city which the EMIS Officer can convert into a map for the Sanitation Working Group.

Another example: A Slum Up-grading Working Group plans a transect (walking through the area of concern and taking note of the observations of the community members) and a participatory rapid appraisal (PRA) in order to assess the problem of flooding during the rainy season. The members of the community gather underneath a tree and start developing a "map" of their neighbourhood in the sand. The EMIS Officer had been invited by the community to observe the PRA so that she/he can include the information in the municipal EMIS (for this, the EMIS Officer also takes the geographic co-ordinates of relevant points with a GPS during the transect). With both the GPS generated co-ordinates and the PRA discussion, the EMIS Officer is able to produce a detailed map of the problems in the specific neighbourhood and to match it with the existing EMIS maps for further overlays and analysis.

Linking an ArcView GIS attribute table with an external database

Often, attribute information is already available in spread-sheet or database format. In order to avoid re-entering information into the attribute table of the GIS, techniques have been developed to link attribute tables to an external database. ArcView GIS provides a sophisticated way of linking various databases.

Connecting to a database

1) Open the map you want to link a database file with, and make the Project window active.
2) Under Project menu > SQL Connect > the SQL Connect dialog box appears.

SQL stands for "Standard Query Language."

3) Under the Connection title, choose the type of database file you wish to link up with (the application it was generated with) > press the Connect button > find the database file you wish to link to your map.
4) In the SQL Connect dialog box you can now see the different tables in the database file > click on any one of them and you will see the columns within that given table > choose the columns you wish to link with > by pressing Enter or double clicking on them you transfer them to the Select box; if you want all columns linked, choose <All Columns> which is represented by an asterisk (*) in the Select box.
5) When you have finished selecting the fields (columns) you want to link with, press the Query button.
6) You now have the selected information from the database converted into an ArcView Theme Table. However, this method creates a table additional to the Attribute Table of your map, so you now have to combine the two.
7) To work with the database in the source application (e.g. MS Access) again, press Disconnect in the SQL Connect dialog box.

Combining two tables:

1) Select the windows of the two tables you wish to combine, making sure you do two things:
   • click first on the table you want to extract information from (the "old" table), and then on the table you want to import information into, which will remain in the end (the "new" table);
   • highlight in each table the columns that correspond to each other, i.e. the "key" field which identifies each entry on an individual basis.

Important: The tables will not join if the "key" field entries do not coincide or are not set as the same type of fields (e.g. numbers vs. text fields).
The contents of the corresponding "key" field of each of the two tables must be identical (including lower case/upper case, and spelling) otherwise they won't be recognised as being the same, even if only one of the entries (such as a name) is written differently. Those entries that do not match each other will not be included in the new table.

> **Hint:** to avoid problems of given entries not being identical due to spelling errors or the like, it is useful to use codes (such as numbers) to represent the different entries. You can use these codes to link tables, thus reducing typing errors.

2) Choose the Join tool from the toolbar.

Tool 18: Collecting Data in the Field

How to prepare for data collection in the field
- Checklist of equipment to take to the field
- Preparation of Data Sheets
- Preparation of Working Maps
- Global Positioning Systems (GPS) (Tool 18a on EMIS CD-ROM)
- Using a GPS
- How to download GPS data to your Computer using Ozi Explorer (Tool 18b on EMIS CD-ROM)

Checklist of equipment to take to the field

- ❏ Pencil
- ❏ Writing Tablet/Notepad
- ❏ Working Maps
- ❏ Paper, Data Sheets
- ❏ Plastic document cover
- ❏ Global Positioning System handheld receiver (GPS)
- ❏ Laptop Computer (if available), including all wiring for connecting the GPS
- ❏ Rubber boots
- ❏ Chocolate

Preparation of Data Sheets

The sheets for filling in the data collected depend on the type of data to be collected. The sheets will have at least three columns:
- one to define the location,
- one for the data measured, and
- another one for any remarks and observations.

There are several ways of fixing the location. Either the XY co-ordinates found on a map, or by using a Global Positioning System handheld receiver (GPS) are noted, or a map is used to mark the location and the number of this location is noted in the sheet. If none of these possibilities work (for example, because the map is not precise and the GPS doesn't connect properly to the satellites) a detailed description of the location should be written down – ideally with a geographic to a known location (for example the distance in meters or a certain angle). Map Maker Pro provides you with some basic but very useful surveying instruments (angle measurer, distant estimator, clinometer, and a plane table base)

Example: Collection of water samples from a riverine system with a description of the state of the water:

Greentown Municipal   Sustainable
Greentown
Council   Project

Sanitation Working Group

Water Quality Survey

Surveyor Name: ……………….
Date: ……………….
Form No.:   ……………….

This data collection form is intended to assess the water quality of Green River. Please enter the location from where you take the water sample, describe the colour and the smell of the water and note down any other relevant information:

No	Location X,Y or figure	Location Description	Data	Remarks
1.	y: 265343.70 x: 9863611.54		Water colour clear	
2.	y: 265350.70 x: 9863612.54		Water colour brown to grey, smelling	
3.		Approximately 20 meters from the junction of street a and b to the north, just underneath an acacia tree	Water colour dark with oil on surface	Industrial complex nearby

Preparation of Working Maps

The maps prepared for fieldwork are working maps. People will write on them, the maps will be folded and torn. Therefore the layout doesn't have to be very attractive, but it does have to be practical and easy to read. A map in black and white showing the research area is fine. The layers shown should be mainly for orientation: for example streets, buildings, contour lines and rivers and, very importantly a grid with co-ordinates. The paper used should be heavier than normal, so it will last longer.

Using a GPS

Many different companies supply GPS receivers, such as for example Trimble, Magellan, Garmin. Addresses can be found in the list at the end of this tool.

If you have purchased a GPS receiver you will also receive a detailed description of how to use it. Take your time to learn how to use it properly. Here is just a short description of how to use one of the GPS receivers from Magellan to give you an idea of how a GPS works:

You need to determine the extent of a flooded area during the rainy season. Put on your rubber boots and walk towards the water. Switch on your GPS and wait until it connects to the satellites. The screen will show you the latitude-longitude co-ordinates. Store this location with a unique name in the GPS memory (basic GPS receivers can save 100 locations, mid-range receivers up to 1000 locations). Now, walk around the flooded area, and repeat the storage of your position after every 20 meters (or less or more, depending on the desired accuracy) until you have returned to the point of origin. Back in your office, you can download the GPS data to your computer using a serial interface and the appropriate software (see software link list in this tool) or you can transfer the stored co-ordinates manually into an attribute table or a spreadsheet table such as MS Excel. ArcView GIS and Map Maker can translate those points into a map which can be overlaid with your existing maps. Some GPS software products allow you to export your GPS waypoints and tracks in text file or even in shape file format (see Ozi explorer as an example).

Please note: In many cases, maps are projected in other projections than degrees of latitude-longitude (for example in UTM). Handheld receivers can switch to different projections. You have to make sure that the projection which you use for your GPS is exactly the same as the one you use for your maps. Otherwise you may get errors of up to several hundreds of meters.

The same method can be used to assess the latest expansion of rapidly growing informal settlements. Some GPS receivers come with an external antenna which can be mounted of the roof of a car. If you have a portable computer, you can connect the GPS receiver to the computer and the GIS programme will draw the map while you are driving (usually with a position every second).

The **UP/DOWN** Buttons:

- Select options on pages and menus
- Adjust Contrast on the SkyView Page
- Zoom in and out on the Map Page
- Cycle through trip computer data on the Pointer Page

The **ENTER** Button:

- Confirms data entry or menu selections
- Displays Options on main pages
- Press and hold the **ENTER** button to activate the Mark Waypoint Page

The **PAGE** Button:

- Switches display pages
- Allows you to exit/quit a function

The **POWER** Button:

- Press and hold to turn the unit on/off.
- Press to turn the display backlight on/off.

SkyView   Map   Pointer   Trip Computer   Menu
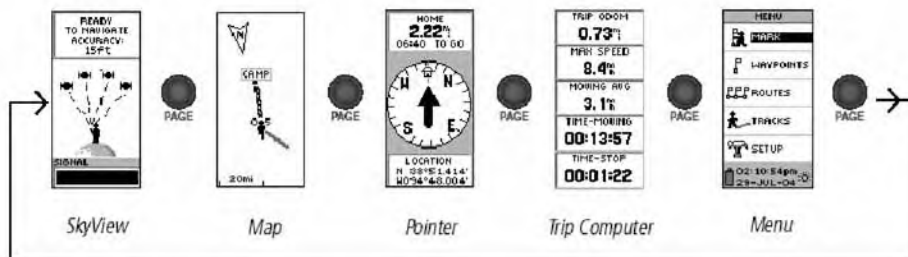
Tool 19: Preparing Thematic Maps

How to create a Thematic Map
- Types of data
- Some basics about visualisation
- A word on symbols and colours
- Creating Thematic Maps with ArcView GIS
- Creating Thematic Maps with Map Maker Pro

Types of data

Spatial data: Quite a number of Thematic Maps can be created directly from the Basic Map layers of rivers, roads or administrative boundaries, by linking the objects on the map with the relevant data in the database. However, for certain thematic maps, the data needs to be collected from secondary sources such as soil or geology maps, or obtained from fieldwork (see Tool 18: Collecting Data in the Field).

Non-spatial data: Data in the attribute data table is stored as text (string), numbers, dates, or Boolean (yes/no). For example, a map showing the districts of a city can be presented as a political map with each district in a separate colour. The names of the districts are stored as text in the attribute table. To show the population in the different districts (which is stored as numbers in the attribute table) it is more useful to use classes instead of the absolute numeric value to show areas with denser population. Charts are used to add multiple pieces of information to your map, such as the amount of different chemicals in a river.

Some basics about visualisation

Before you start designing your first maps, think about what you would like to visualize. What information is needed to make a certain topic understandable to the map user? In a map, all the information is visible at the same time, unlike a book, where one piece of information follows the next, sentence by sentence. Because a map presents a lot of information at the same time, you should avoid complexity and not overload it with unrelated material. A reader needs to be able to understand the topic of the map and its message easily. If you follow some basic cartographic rules, your maps will be easy to understand.

Sample Map 1
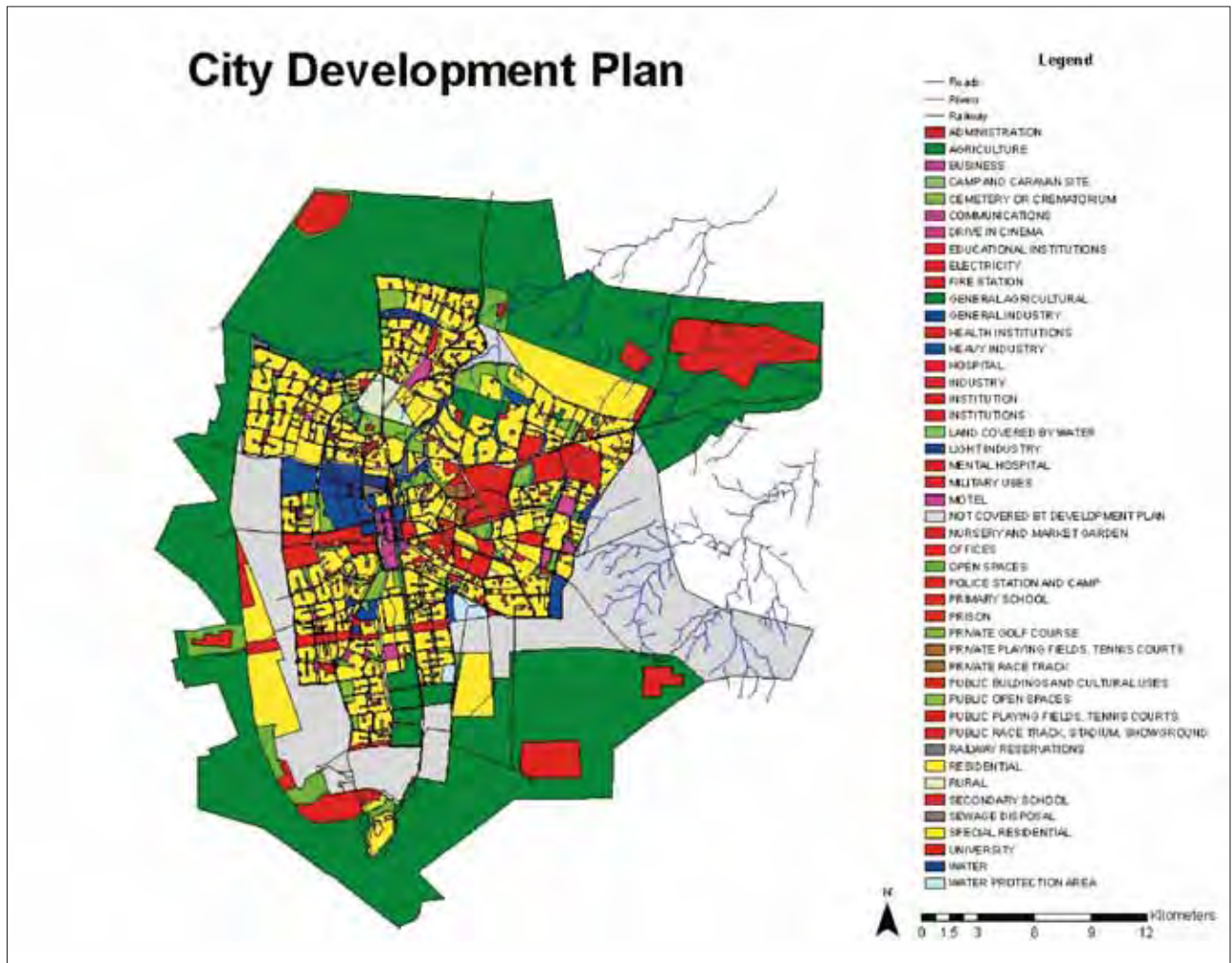
Look at Sample Map 1.

Can you identify any plot in the city that is used by a hospital? The legend goes into great detail, differentiating between hospitals, health institutions and mental hospitals. However, the range of colours used in the legend does not reflect this detailed classification. Hospitals, primary schools and areas for military use are all represented by the same red colour. In maps, colours should be used to make it easier to understand which spatial elements (or zones in this example) belong together or should be differentiated from each other.

Sample Map 2

Development Plan 2
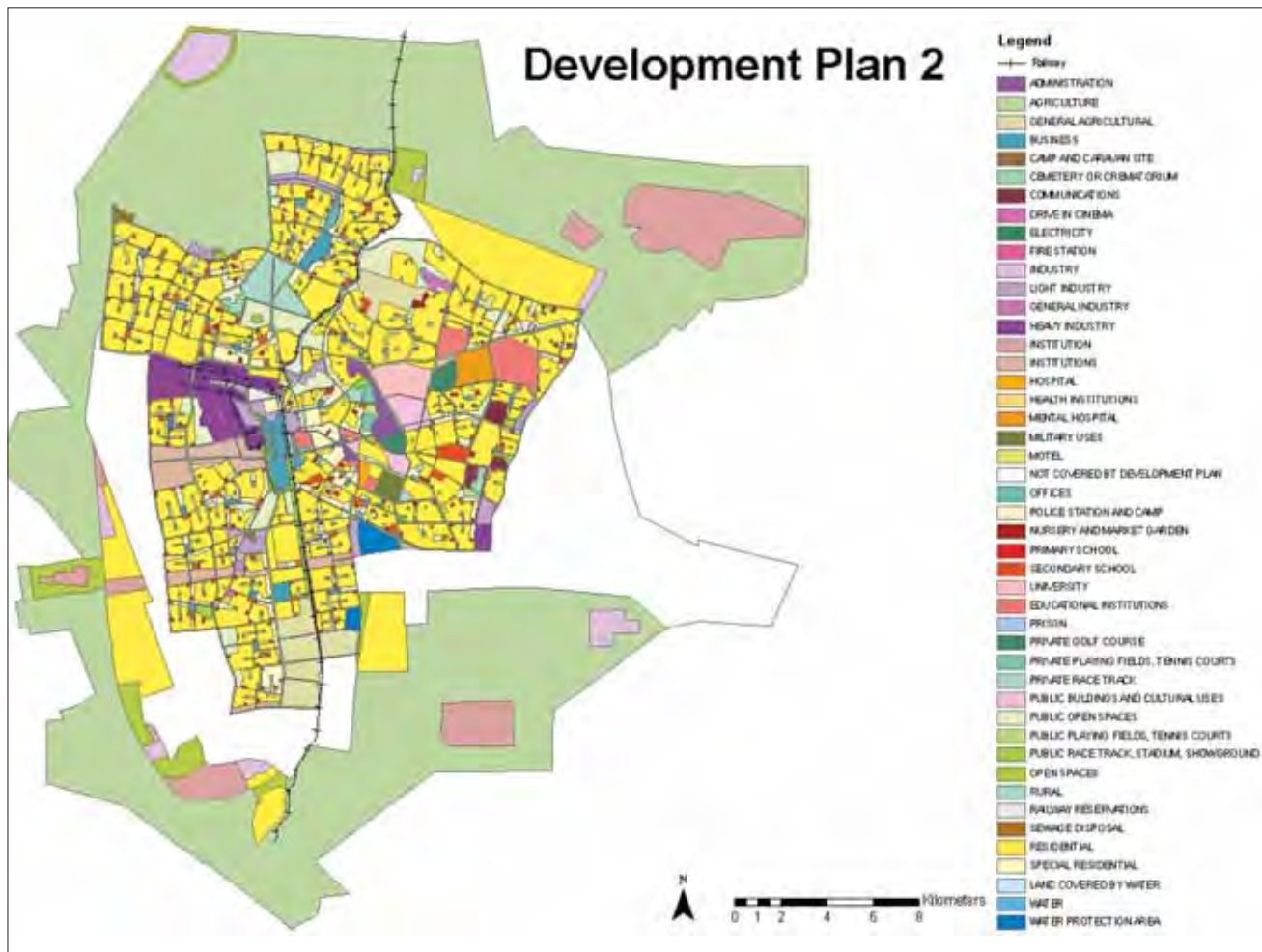
In Sample Map 2, every zone is represented by a different colour to underline the different functions (i.e. one zone represents residential areas and another one primary schools). However, all zones with related functions are displayed in similar colour shades (i.e. all industrial zones are represented in purple colours, all water areas in different shades of blue). But is Sample Map 2 easier to understand than Sample Map 1? The legend is still very complex. To improve the quality of the map, the number of classes shown in the legend should be reduced. For instance, educational institutions, primary schools, secondary schools and universities could be joined into one class. For example, have a look at Sample Map 3. The number of classes overall has been cut by more than half – from 46 to 19 classes. Map 3 includes less information, because the observer can no longer differentiate between the location of a primary and a secondary school. Sample Map 3

Sample Map 3

City Development Plan 3

Legend
- Railway
- Rivers
- residential
- industrial
- business
- offices
- public administration
- educational (primary and secondary schools, univer)
- public parks
- private parks (golf courses, tennis courts)
- open space
- police, fire department, military camps
- hospitals
- utilities (sewage, electricity, communication)
- cemetary
- railway reservations
- areas covered by water
- agriculture
- rural area
- streets
- not covered by development plan

N

Kilometer
0 1.25 2.5   5   7.5   10

At this point, map scale becomes important. A map with a small scale (i.e. 1:100,000) cannot display information with the same detail as a map with a large scale (i.e. 1:5,000). Take a settlement for example: in a large scale map every single house can be displayed on the map. With a decrease in scale, generalization increases and the houses are no longer shown individually but as an area of settlement. On a world map – a map with a very small scale (i.e. 1:25,000,000) – only the largest cities are visualized, as small points. Don't try to overload your map with details that are not appropriate to the scale of the map.

In Sample Map 3, the scale is too small to differentiate between the different types of schools. If you intend to show this differentiation, it might be useful to design additional maps at a larger scale, showing the centre of the city only. In these more detailed maps classes can be subdivided, so that, for instance, the different school types can be identified (see Sample Map 4).

Sample Map 4
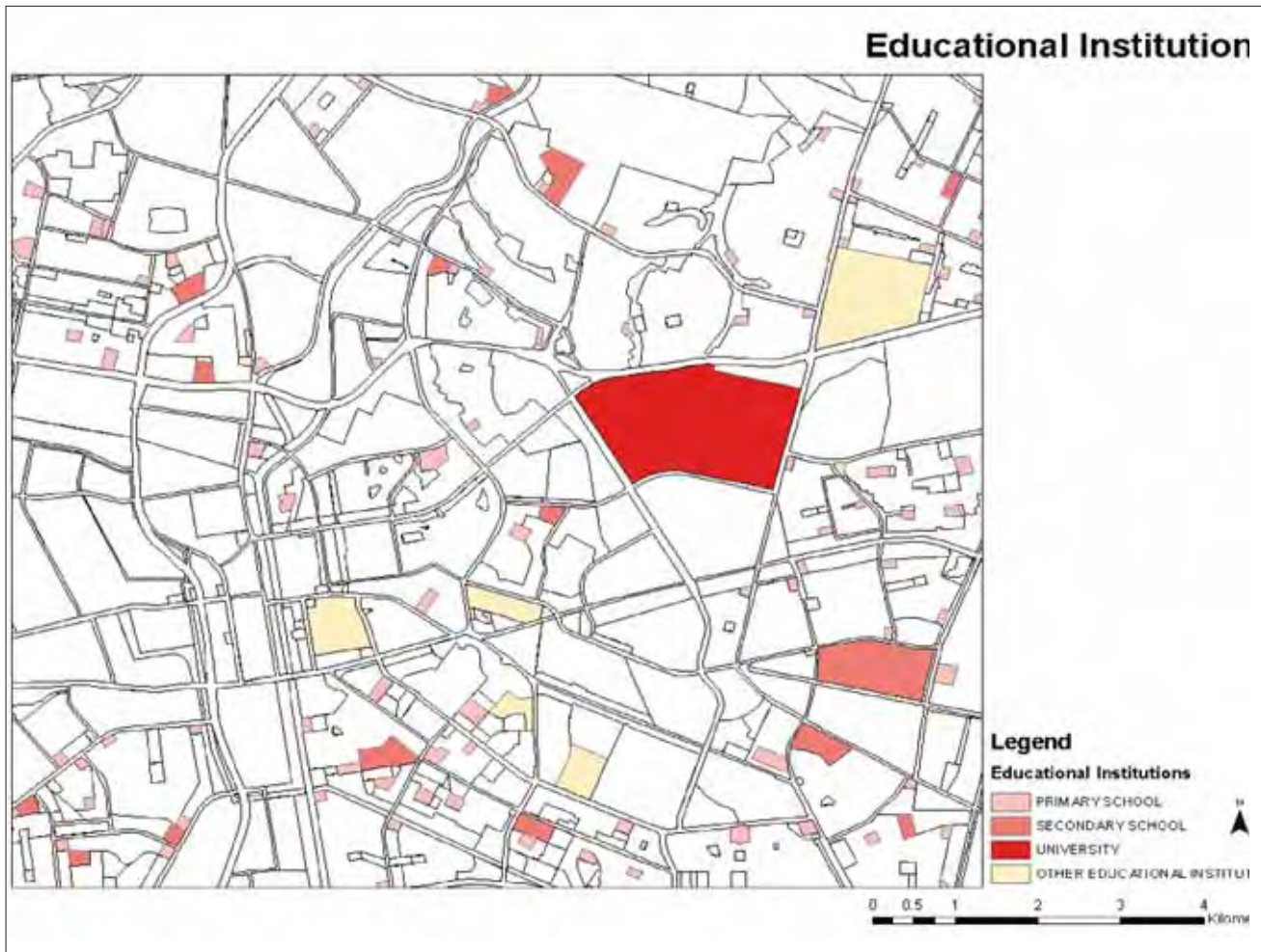
In Sample Map 4, schools are all shown in different shades of red because they all belong to a single class: educational institutions. At the same time, the shading allows them to be ranked. On this map, a secondary school is considered to be ranked higher than a primary school and a university higher than a secondary school. Geospatial objects are ranked or ordered by using variations in the size of the geographic objects, the grade of hue (grey value) or the type of grain (texture). High hue and dense texture are used to visualize high quantities, while low grey values and transparent grain show low quantities. Therefore, the red colour of the primary school is lighter than the red chosen to display secondary schools and universities. Keep in mind that, in general, no colour is considered to be more important than any other on a map. However, there are some aspects to keep in mind when using colour in maps, and these are described in this tool in the section "A word on symbols and colours".

Sample Map 5

Landuse and population on district level
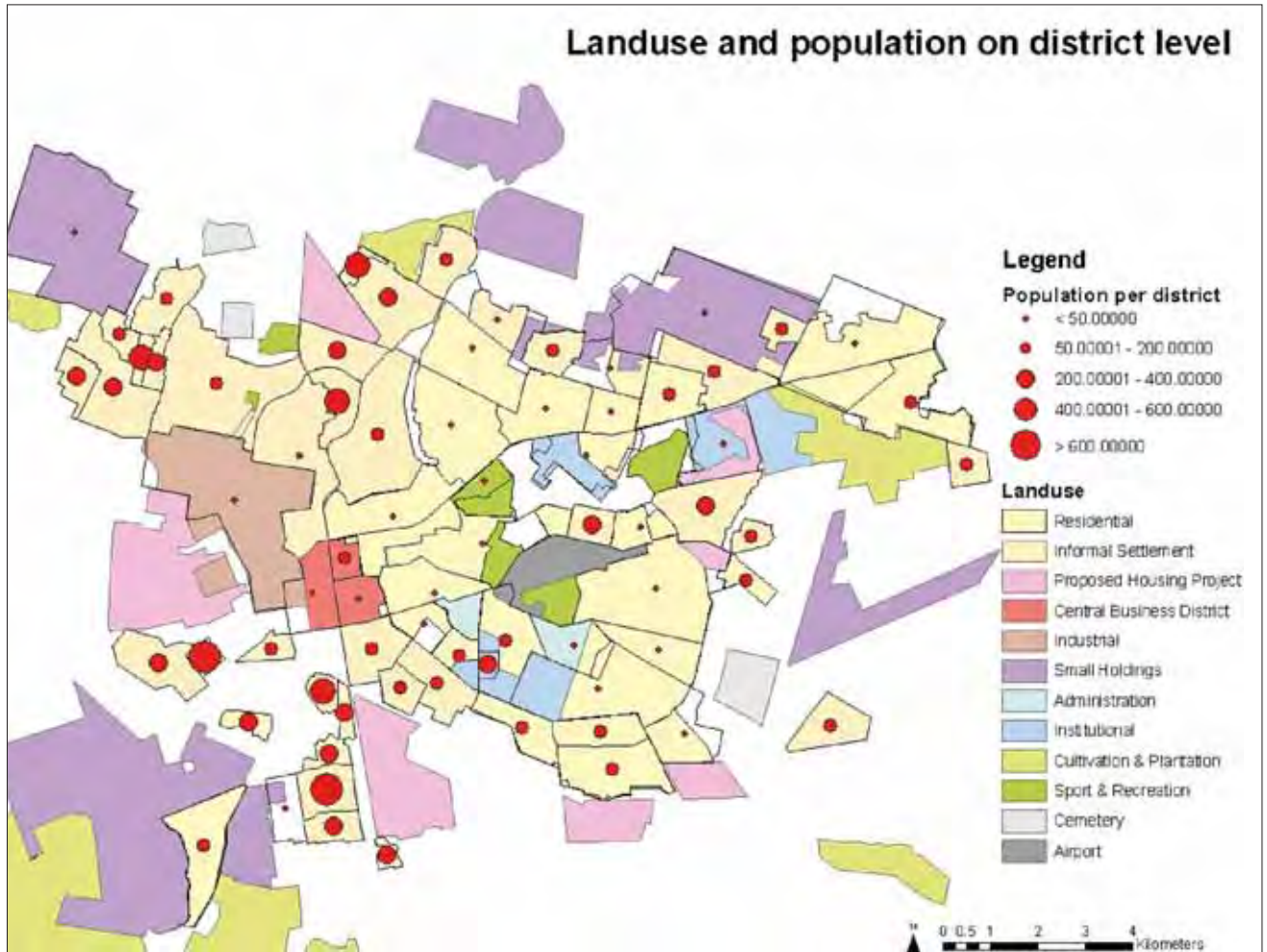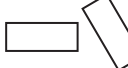
Variations in size underline different quantities, in contrast to variations in the shape of a geographic object. An example for the expression of quantities through differences in size can be found in Sample Map 5. In this map, the population per district is represented by circles. The larger the circle, the more people live in a district. The size of the circle represents a certain number of people.

The table below sums up the cartographic rules described above. Just keep the variables and their visualizing effect in mind when designing a map and you cannot go too far wrong.

Variable	Graphical Element			Visualization
	Point	Line	Area	
size	○ ◯	▬▬▬ ―――	▫ ◻	to quantify data
hue/ grey value	○ ⬤	――― ―――	◻ ◼	to rank/ order or quantify data

grain/ texture	● ●	- - - - - - -	⊞ ▦	to rank/ order or quantify data
colour	🔴 🟢	━━━ ━━━	🟥 🟩	to show similarities or differences in data
orientation	△ ▷	╱ ╲	▭ ▱	to show similarities or differences in data
shape	○ ▢	〰	▱ ⬡	to show similarities or differences in data

A word on symbols and colours

Using symbols and colours in a map is a science by itself. Maps have a highly political relevance – just imagine how maps have been used to push specific political agenda in the past. The choice of colours and symbols can radically change the power of a map. It is very important to consult the mapping group on the appearance of a map.

The various GIS software packages offer a reasonably broad palette of symbols. You should choose symbols carefully, making sure neither to overload the map n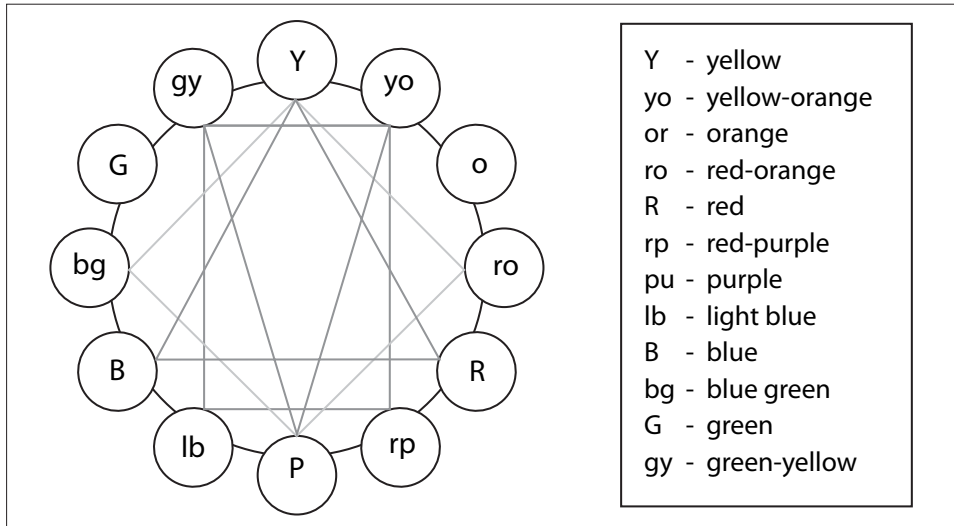or to reduce its readability. Efforts have been made to harmonise the use of symbols in cartography world-wide. This includes cartographic grids, isolines, the appearance of water bodies, the display of hill shading, geological-tectonic/morphological features, the representation of built-up areas, agricultural symbols and self-explanatory symbols.

Producing multicoloured maps is a difficult area of cartography. Often, the map layouts are disappointing because they are colourful but ignore any law of colour compositions. The EMIS Officer must have the ability to assess the colour associations which the end user of the map can be expected to have. It is not the place of this Handbook to describe the chemical, physical, physiological and psychological aspects of colouring. However, there are some major colour aspects to bear in mind when producing maps.

1. The choice of "close to nature" colours - over time, people have developed certain associations with particular colours: light green for open green land, dark green for forests, red for settlements, grey for dumpsites etc.
2. The "sensitivity value" of the colours - we distinguish between "warm" and "cold" colours. The respective colours should be chosen according to the warm or cold areas (e.g. thermal effect of industrial effluent into a water body). Certain colours have collective or folkloristic associations (e.g. purple for the church), or some colours have symbolic associations (yellow for gold).

3. "Harmonic adjustable" colours - there is no common law of colour harmony. However, various researchers have developed principles for different purposes. Two or more colours are considered as harmonic if they result in a neutral grey if mixed together. The colours linked by lines in the diagram below are harmonic.

Y	- yellow
yo	- yellow-orange
or	- orange
ro	- red-orange
R	- red
rp	- red-purple
pu	- purple
lb	- light blue
B	- blue
bg	- blue green
G	- green
gy	- green-yellow

There are many more factors which influence the appearance of a coloured map, such as (a) the mutual influence of two strong neighbouring colours; (b) the colour weight (e.g. the higher the value the greater weight of the colour - yellow is considered to have least weight, then orange, red/blue-green, red-purple, blue-purple and black); (c) the luminescence of the colour (yellow is the highest); (d) and the contrast effect of neighbouring bright and dark colours.

Thematic Maps with ArcView GIS

Numeric data maps

These maps are designed to illustrate numeric data with a progression or range of values such as temperature or number of tourists. The information is represented by a colour ramp. A colour ramp has a beginning and an end colour and a range of colours in between which show the intervening colours of the spectrum.

1. **Double click the theme** in the Table of Contents to open the Legend Editor.
2. Change the Legend Type to **Graduated Colour**.
3. **Select a Classification Field.**
4. Either select a Colour Ramp, click Ramp Colours, or double click Symbol to open the Symbol window.

Codes Map

Unique Value maps display data values such that the symbol for one value is no more or less prominent than the symbols for any other value. To help make the seemingly confusing task of differentiating data in an anonymous way easy, each unique value in a theme is represented with a unique symbol. This is the most effective method for displaying categorical data like land use or soil-type.

1. **Double click the theme** in the Table of Contents to open the Legend Editor.
2. Change the Legend Type to **Unique Value**.
3. **Select a Values Field**.
4. Either click Random Colours, and select from the list of Colour Schemes, or doub lick Symbol to open the Symbol Window to change the colours of your feature's symbols.

Example of the legend of a codes map showing land use:
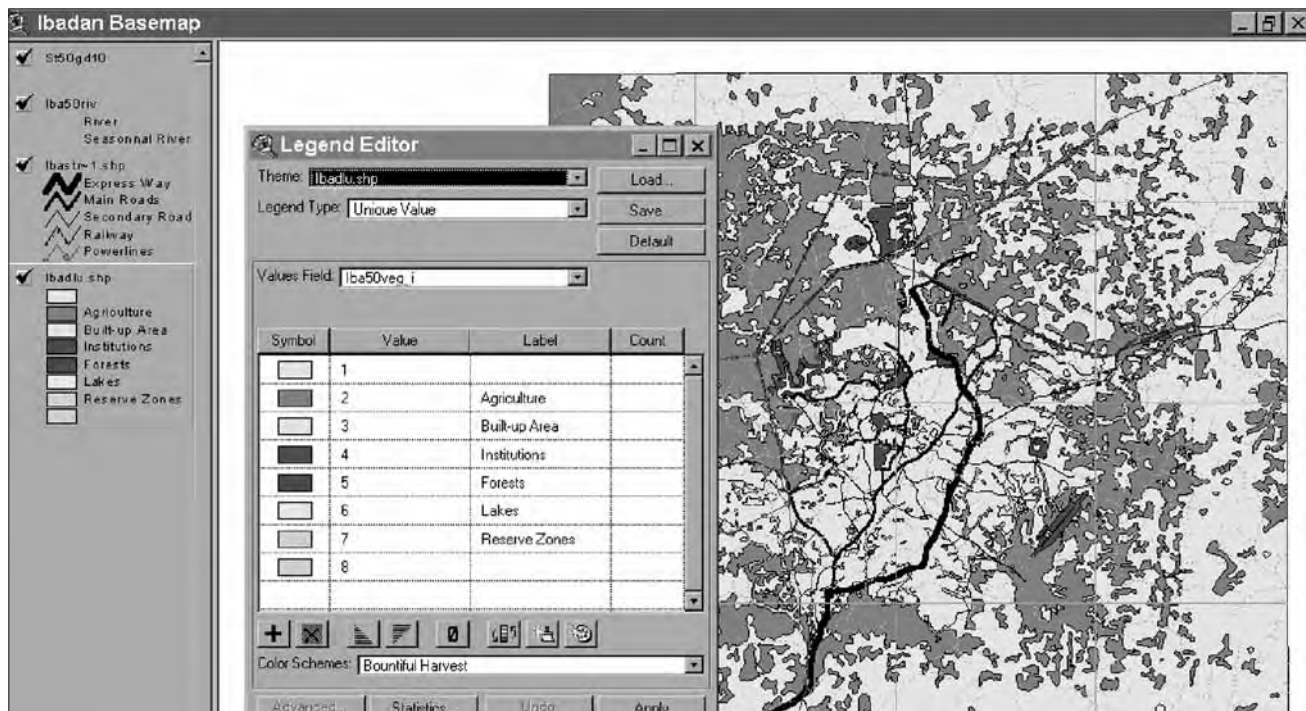
Chart Map

Certain kinds of information, such as a range of chemicals in a river, are displayed with a chart. The components of the chart correspond to data attributes which you specify, and the size of each section of the chart is determined by the value of each data attribute. Chart maps allow you to display the values of many data attributes at once. This is a particularly powerful tool because you can clearly show the relationships of different but related data with one clear symbol. For instance, you can map the income distribution by income ranges for a given population and clearly state which areas are dominated by a particular income.

1. **Bar Charts**
   When you present information in bar charts, you can control the width, and minimum and maximum height of each chart symbol. You can change these properties in the properties window.

2. **Pie Charts**
   Pie charts begin with the first field you have chosen and rotate counter-clockwise from the three o'clock position. A size field can be set in the Pie Chart Properties window, the values of which control the size of each feature's pie chart symbol. The minimum and maximum radius for the pie chart symbols can be set in the Pie Chart Properties window as well.

> **Note:** :When you select a normalisation field, each field's values within your chart map are normalised by that field.
> You cannot change where the chart symbol is positioned on the feature it represents.
> Remember to check the units the data are recorded in for each of your fields. You should not include a mix of percentages and raw counts.

Example of creating a map with bar charts:
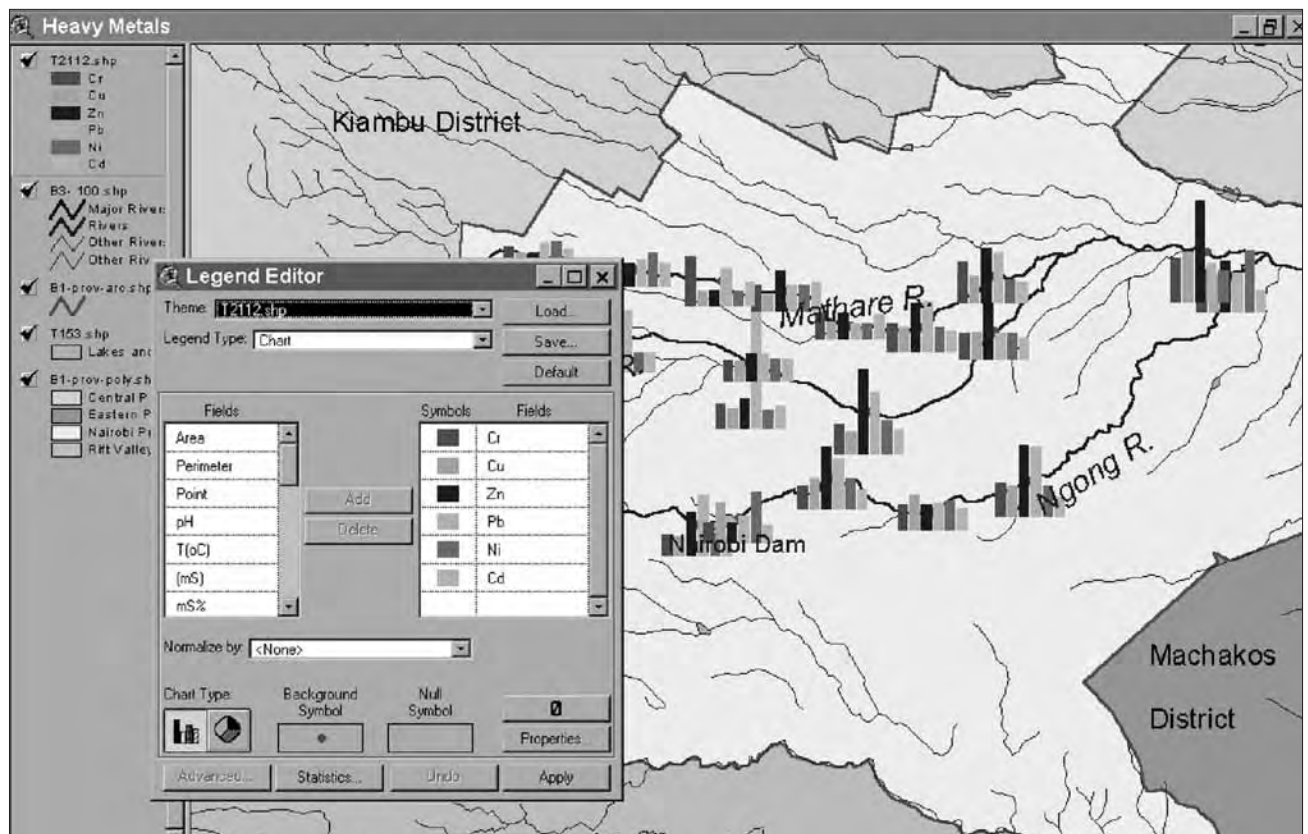
Creating Thematic Maps with Map Maker Pro

Creating Thematic Maps with Map Maker Pro is less straightforward than with ArcView GIS. Opening a layer (dra-file) will prompt you with a dialogue box in which you choose "external data link". In the "style link column", select the desired column. This enables you to use the numerical values in one field of each database record to control the display style of the corresponding map object. Map Maker uses predefined style numbers which are linked to specific colours. You have to use "data bands" to link a range of values or bands of values to a style. With the option "data points from external data" you can create pie charts, histograms and other charts from data points. Map Maker allows you to create you own preferred style list with your own preferred colours. The legend for these Thematic Maps is created through Tools > Furniture Makers. For more details and a step-by-step description please refer to the chapter 'Attaching Data' in the book 'Teach yourself Map Maker' which you will find on the EMIS CD-ROM.

Further reading

Slocum, T. A. et al. 2004. Thematic Cartography and Geographic Visualization. 2nd ed. Prentice Hall

Website to the book with further information on visualization. Includes weblinks and resources for further reading (2004).
http://www.prenhall.com/slocum/

Kraak, M.-J., and Ormeling, F., 2003. Cartography - Visualization of Geospatial Data. 2nd edition Prentice Hall

SmartCart - A learning software tool and slides for cartographic design created by the University of Kansas. http://www.geog.ku.edu/smartcart/ (can be found on the EMIS CD)

Cartographic Communication – Website of the University of Austin, Texas (1995), providing information about mapping a geographic visualization.
http://www.colorado.edu

Tool 20: Ranking Environmental Issues

How to rank environmental issues manually and in a GIS
* Examples of manual ranking
* Example of ranking using the ArcView GIS attribute table

Example of manual ranking

(from Eigen, J.: Information Management System for Environmental Planning and Management (EPM) in Cyprus, Nikosia 1987)

Ranking of maps involves subjective value judgements, such as determining which areas pose a more severe constraint to development, for example, critical water catchment areas close to an intake for municipal supplies, or areas along the coast with unconsolidated dunes. Ideally, this ranking should be based on decisions made jointly by all co-operating agencies.

The following example is derived from the EPM activities for the Metropolitan Lagos Master Plan, 1978, for establishing a common scale for overlaying resource and hazard maps. A pattern map was prepared in four steps:

1 Overlay of all maps showing those environmental constraints that can normally be overcome with engineering measures (e.g. flood prone areas, unstable soils);
2 Overlay of all maps showing those environmental constraints that relate to the preservation of resources and to often less tangible, but no less important environmental concerns (e.g. recreational areas, fishery resources)
3 Overlay of the two resulting maps that show combined engineering and preservation constraints;
4 Rank of constraints shown on the overall environmental constraint map so that it is possible to define for each rank of constraint a maximum permissible development intensity (e.g. natural state, recreation, or urban use.

As shown in the following figure, maps were overlaid by sorting the levels of constraint shown on each suitability or sensitivity map on a common scale. This common scale was then the basis for establishing levels of constraint on the combined map resulting from the overlay. For example, in terms of engineering constraints (Map 11 in the following figure) the most severe development limitations were presented by floodplains that are close to existing intakes for municipal water supply. The second most serious constraints were present if the areas had either unconsolidated dunes or were in the floodplain of critical catchment areas, but not close to an existing or planned intake. The combined ranking on the combined resulting maps can no longer be associated with specific environmental features such as alluvial plains of flooded areas. The different ranks of constraints on these maps remain therefore un-named and are instead identified with symbols such as degrees of shading, only. In producing the overall constraint map (Map 13) a common scale is again introduced so that engineering and preservation constraint maps can be combined.
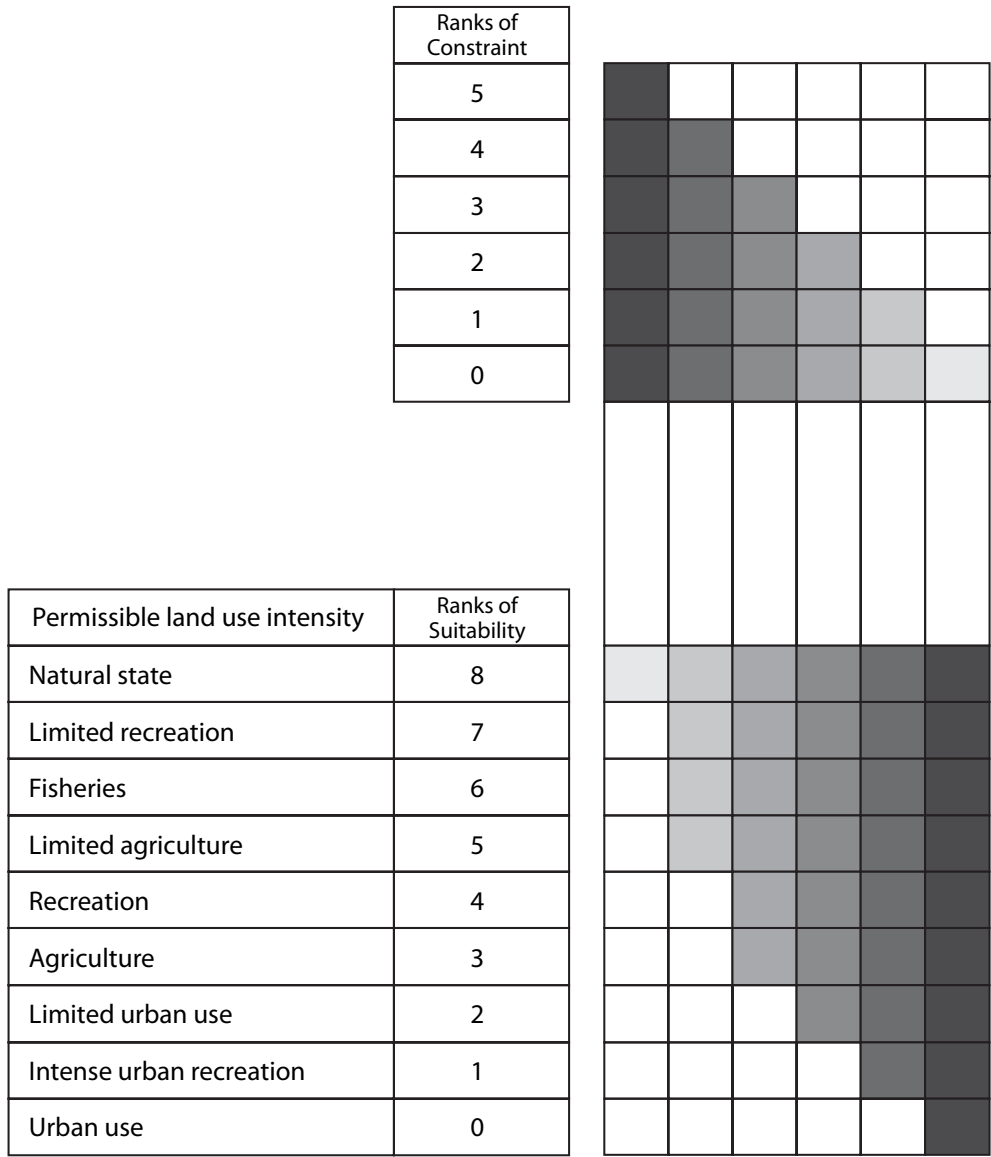
Map 1 Land Formation: Consolidation	Map 5 Catchment Areas: Water Supply	Map 2 Soils & Subsoils: Stability	Map 4 Drainage: Flooding		Map 11 Engineering Constraints	
					Ranking	Symbols
	in floodplain near intake				5	
unconsolidated					4	
		serious constraint	difficult to reclaim		3	
alluvial plain	in critical catchment	soils constraint	flooded		2	
older dunes			reclaimed		1	
coastal plain sands	outside catchment	no constraint	drylands		0	

Map 3 Soils & Subsoils: Agriculture	Map 9 Existing Agriculture: Agriculture	Map 6 Fauna-Flora: Fisheries	Map 7 Landforms, Fauna: Recreation		Map 12 Preservation Constraints	
					Ranking	Symbols
			urban recreation		4	
	forest reserves		natural state and scenic		3	
	modern agriculture	wetlands			2	
agriculture soils	traditional agriculture	subsistence fishing	natural state or scenic		1	
no signficance	no significance	no significance	no significance		0	

Map 11 Engineering Constraints	Map 12 Preservation Constraints		Map 13 Overall Constraints	
			Ranking	Symbols
			5	
			4	
			3	
			2	
			1	
			0	

In the final step, the levels of constraint on the overall constraint map can be translated into a ranking scale that can be associated with levels of development intensity. The process results in a reversal of the ranking rationale. In areas with high environmental constraints only low intensity development is permissible and vice versa. This makes the map immediately applicable to land use planning. Of course, the meaning of each rank of suitability should be documented in a report that explains and interprets the development pattern map.

Transforming ranks of constraint into ranks of suitability:

Ranks of Constraint
5
4
3
2
1
0

Permissible land use intensity	Ranks of Suitability
Natural state	8
Limited recreation	7
Fisheries	6
Limited agriculture	5
Recreation	4
Agriculture	3
Limited urban use	2
Intense urban recreation	1
Urban use	0

Example of ranking using the ArcView GIS attribute table:

The ranking of a certain environmental or development issue is the result of an intensive working group process supported by the EMIS Officer. The method applies for Suitability Maps, Sensitivity Maps and for Service Delivery Maps. Areas with a certain condition receive a ranking number which refers to the importance of the issue. The rank will be entered as a number (with number characteristic) in the attribute table of the relevant map. This allows you to generate a thematic map using colour ramps. In Suitability Maps the rank is highest for most suitable areas for a certain activity. In Sensitivity Maps the rank is highest for most sensitive areas (e.g. high pollution).

Attributes of Potmcl

Area	Name	Rank
0.000170	Designated Sand extraction	2
0.000498	Designated Sand extraction with mining claims	3
0.000047	Designated Limestone extraction with mining claims	5
0.000331	Designated Limestone extraction	4
0.000066	Illegal Sand extraction	0
0.000057	Illegal Sand extraction highly affected	0
0.000110	Designated Sand extraction	2
0.000041	Illegal Sand extraction	0
0.000065	Illegal Sand extraction	0
0.000008		0
0.000828	Designated Limestone extraction	4
0.000100	Designated Limestone extraction with mining claims	5

Attributes of Hazard

Area	Name	Name2	Rank
0.000361	Beach erosion	highly	5
0.001238	Flood Prone	moderatly	3
0.020810	Soil erosion	highly	5
0.000205	Beach erosion	moderatly	3
0.000210	Beach erosion	moderatly	3
0.021678	Soil erosion	moderatly	3
0.000168	Beach erosion	moderatly	3
0.000048	Beach erosion	moderatly	3
0.000196	Flood Prone	moderatly	3
0.000172	Flood Prone	highly	5

In some cases there is very little information regarding an issue which, however, is very relevant to the analysis of the environment-development interaction in a certain area. For example, the groundwater table plays an important role in city development strategies. But there may only be information available on areas with high groundwater tables and low groundwater tables. The EMIS Officer would probably classify the high groundwater table with the rank 1 and the low groundwater table with the rank 0. However, the working group might consider a high groundwater table as a serious environmental issue since people use it for drinking purpose and it is easily polluted though open car repair garages or pit latrines. Therefore the working group will probably decide on a rank of 5 for the high groundwater table and the rank 1 for the low groundwater table.
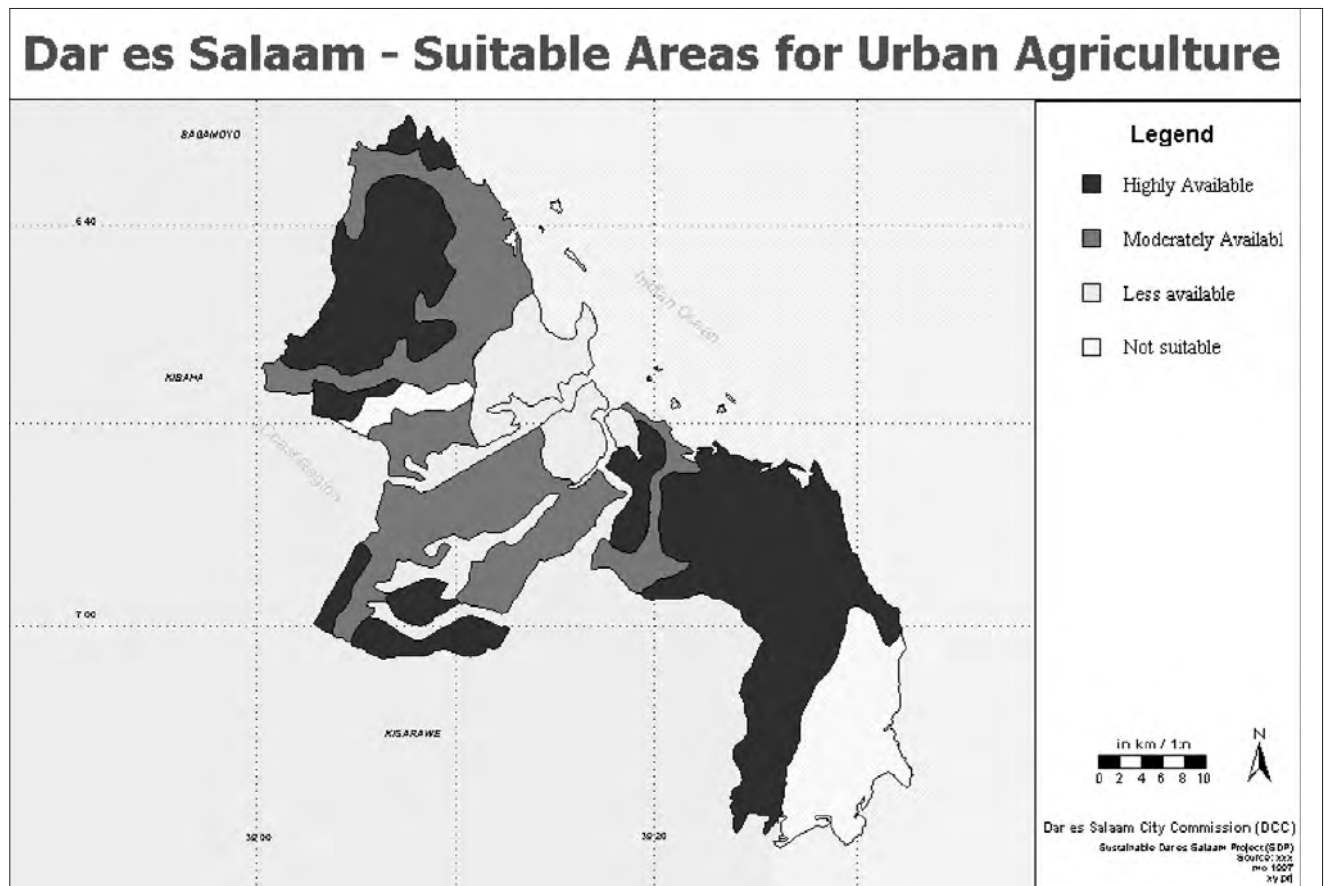
During overlays in a GIS programme the attribute tables of the various maps will be combined. The ranks of each individual map will be summarised into a new column (see Tool 24: Overlaying maps).

Tool 21: Preparing a Suitability Map

How to prepare suitability maps

An Issue-Specific Working Group – for example on Urban Agriculture or on Mineral Resources and Mining – develops a suitability map which shows areas that are suitable for a particular usage. The proposed usage is based on the analysis of relevant thematic maps and on an intensive working group process.

Suitability maps can be generated from data collected by survey teams in the field, who collect ground co-ordinates with a GPS (see Tool 18: Collecting Data in the Field, and Tool 18a: Global Positioning Systems). In most cases, however, the analysis necessary for the development of suitability maps can be done through the overlay of thematic maps (see Tool 24: Overlaying Maps) on a light table – for example, a certain type of soil in a certain type of micro-climate on a certain type of hazardous land can be classified as suitable for urban agriculture or not suitable for urban agriculture. The Suitability Map is then drafted manually and later digitised on a digitising board (see Tool 15: Digitizing Maps).

Dar es Salaam - Suitable Areas for Urban Agriculture

Legend
- Highly Available
- Moderately Availabl
- Less available
- Not suitable

Dar es Salaam City Commission (DCC)

The Issue-Specific Working Group should already have developed justifications for the standards, rules and regulations which will apply to the particular areas which the map describes as suitable or not suitable. Those standards, rules and regulations are recorded in the working group minutes or in external or internal reports. The Mapping Group will decide which

information should be linked to maps and how the information should be stored to make it accessible for maps. Usually, a database programme, such as MS Access, will allow you to store an extensive range of information which can be directly linked to a map (see Tool 17: Attribute Data)
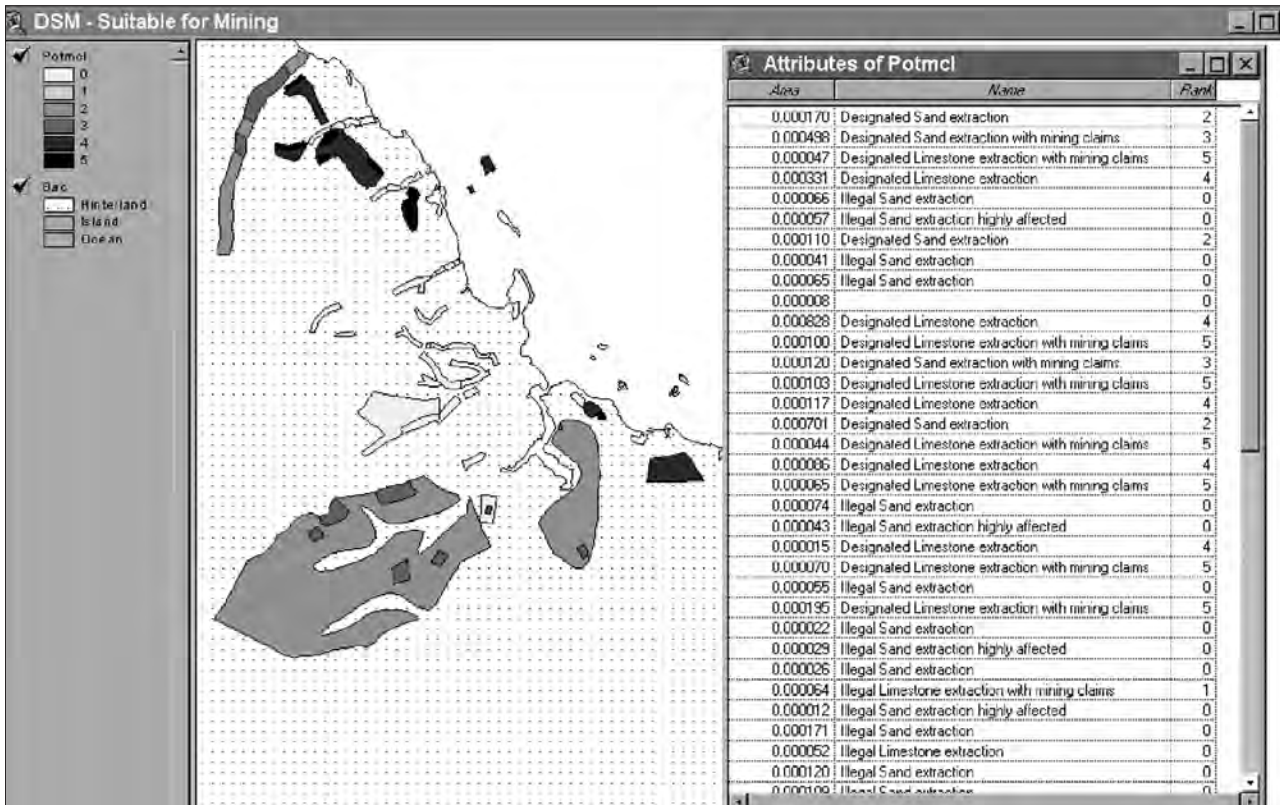
Tool 22: Preparing a Sensitivity Map

How to prepare environmental sensitivity maps (using air quality as an example)

Sensitivity Maps show environmental constraints which can be overcome with engineering measures (e.g. unstable slopes, air quality problems) or which relate to preservation (e.g. areas with endangered species). Sensitivity Maps are developed through an analysis of the thematic maps relevant to this issue, and through an intensive working group process.
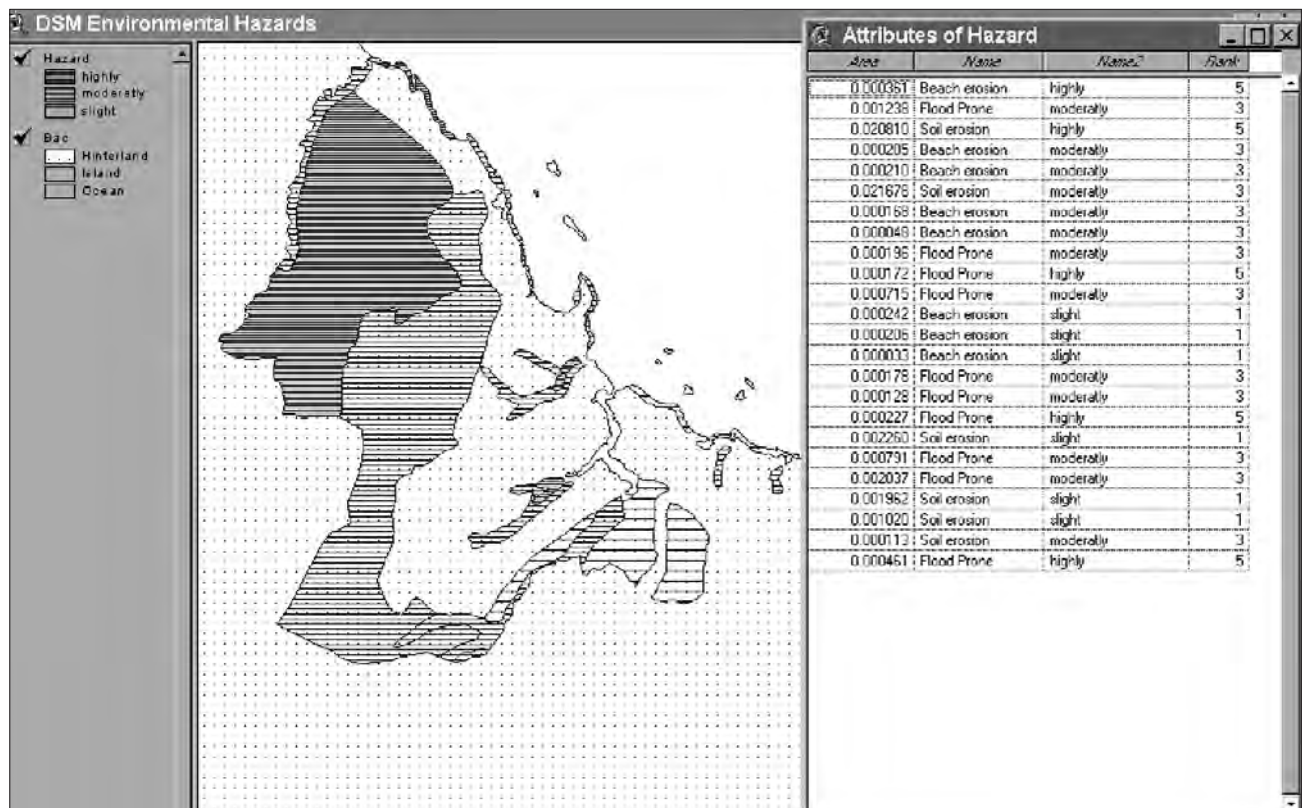
Sensitivity Maps are prepared in the same way as Suitability Maps (see Tool 21: Preparing a Suitability Map). This tool, therefore, will concentrate on the generation of a sensitivity map from point sources, focusing on air pollution.

For example, an industrialised city monitors the air quality situation through monitoring stations. The data from the monitoring stations are continuously collected and entered into a database system. The most common analysis method is to compare recent values of certain chemicals in the air with values from previous years. This analysis shows if a situation is improving or worsening, and can also be displayed on maps.

The EMIS uses this kind of monitoring data to determine areas of pollution, i.e. to show highly polluted areas and less polluted areas in the city. The process is closely connected to the working group process. The Issue-Specific Working Group on Air Quality sets the standards, rules and regulations which will apply for the particular areas which the map describes as suitable or not suitable. Those standards, rules and regulations

can usually be found in the working group minutes or in external or internal reports. The Mapping Group decides which of the information should be linked to maps and how to store the information to make it accessible for maps. Usually, a database programme, such as MS Access, will allow you to store an extensive range of information which can be directly linked to a map (see Tool 17: Attribute Data)

The SCP Handbook and Toolkit on Urban Air Quality Management describes appropriate air quality models for specific circumstances. The base module of ArcView GIS does not have the tools for translating these models directly into maps. However, many procedures can be done 'manually' in ArcView GIS, or, even better, in Map Maker Pro. The ArcView extension Spatial Analyst allows you to perform simulations from the parameters you have derived from air quality management models.

The following example shows areas of low to high air pollution in Shenyang, China. The working group on air quality derived an aggregated value of pollution from the concentration of various chemicals in the air which were measured through a monitoring exercise.
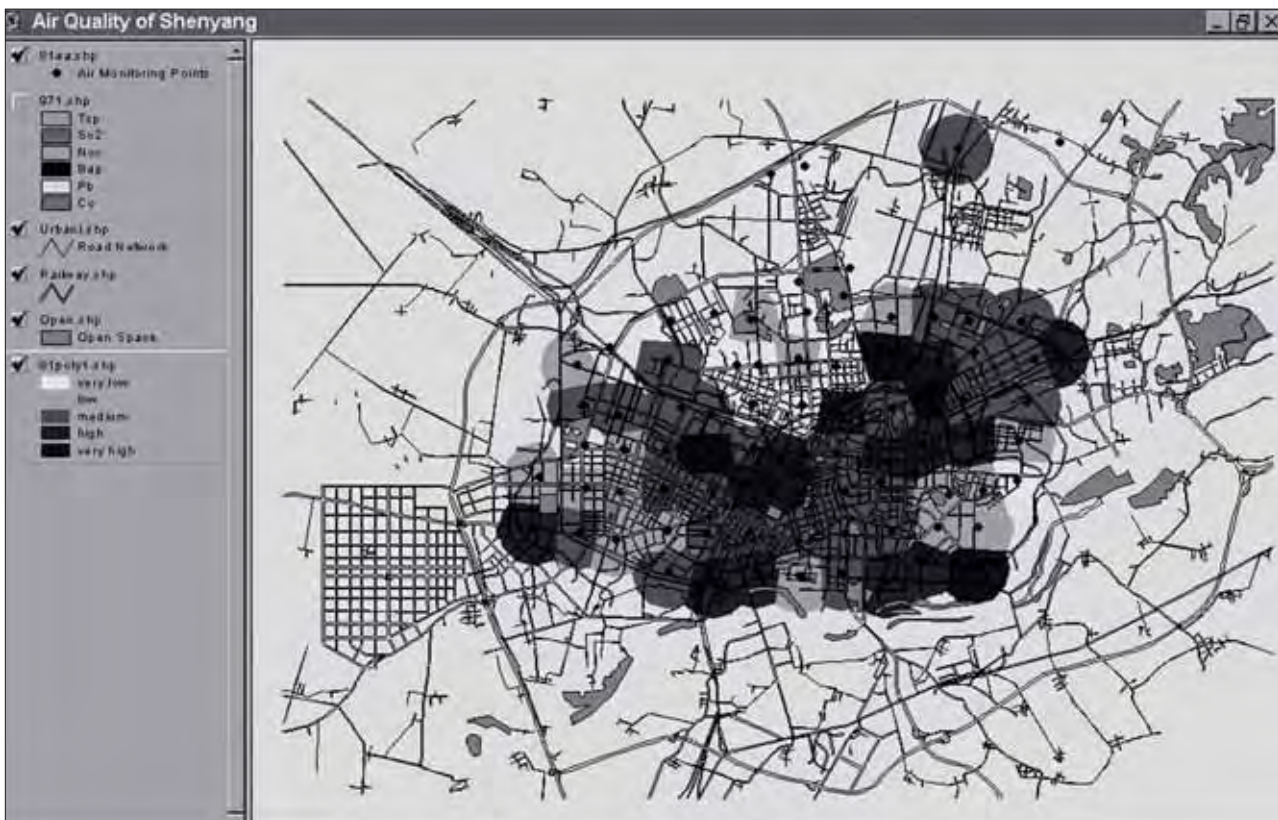
This map was produced with ArcView GIS ver. 3.0a and Map Maker Pro. The working group on air quality derived an aggregated value of pollution from the concentration of various chemical in the air measured through a monitoring exercise.

The EMIS team used the 'Polygons from Seeds' tool from Map Maker Pro in order to get polygons of equal distance around each monitoring station. The new geometry was exported to ArcView GIS and the attribute table of the

monitoring points was attached to the new shape-file. The aggregate value of air pollution was used to generate the colour ramp.

ArcView's Spatial Analyst (see next map) allows you generate a raster/grid map directly from points and it allows you to enter parameters which suit particular circumstances such as wind directions.
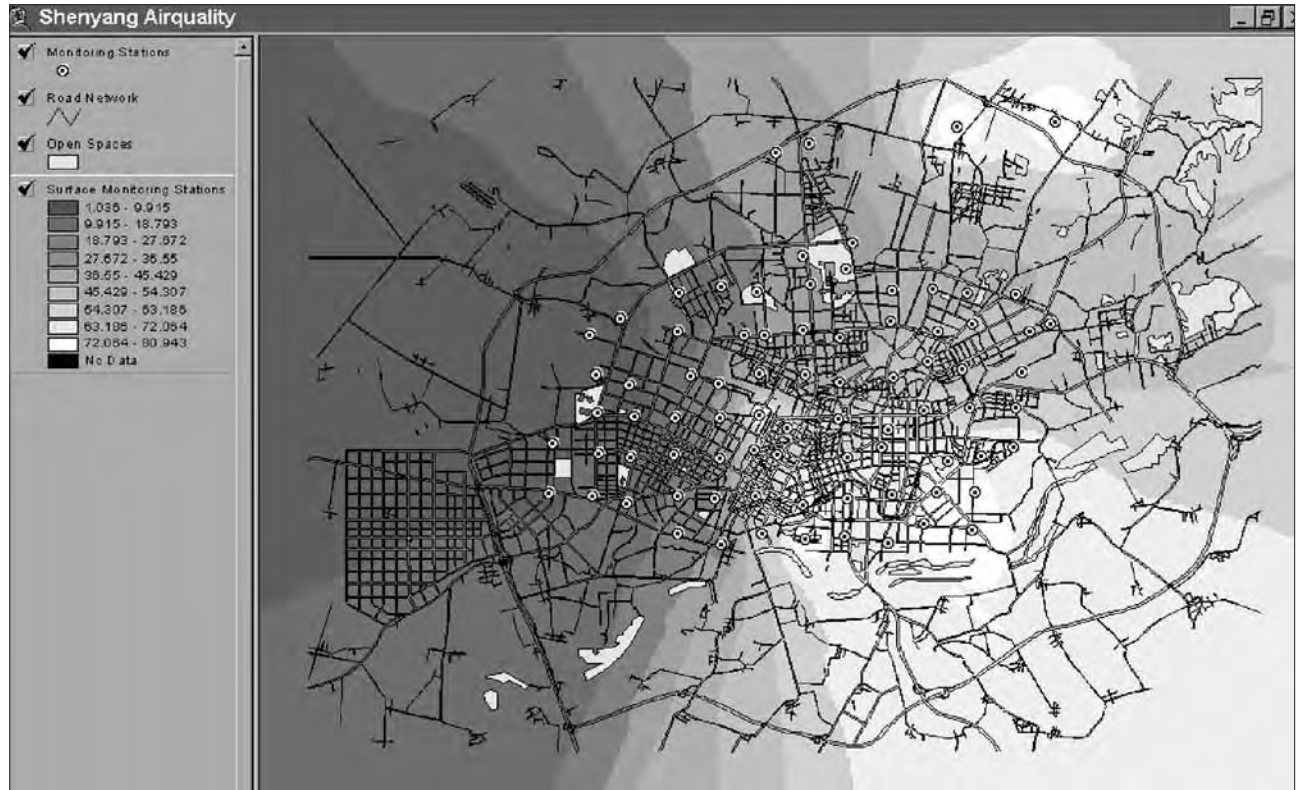
This map creation mechanism can be used to build a range of sensitivity maps for issues such as water quality, soil pollution and biodiversity (e.g. habitats of endangered species).

Tool 23: Preparing a Service Delivery Map

## *How to prepare service delivery maps from utility networks*

The Service Delivery Map is a special type of Suitability Map. A Service Delivery Map shows what services are available in an area in terms of utility supplies such as, for example, access to roads, sanitation coverage and electricity supply.

Service Delivery Maps are based on thematic utility maps which show the road network, the sewerage network, the power grid and distribution points and others. Again, the Mapping Group will decide on which utilities are relevant to combine in a Service Delivery Map. If there is an Issue-Specific Working Group dealing with infrastructure issues, it will be requested to decide on acceptable standards in term of the accessibility of a certain utility.

After the Mapping Group has decided on the utilities to be mapped, the EMIS unit prepares a buffer map for each utility. For example, a working group on transport decides that a distance of up to 300 m from a road is considered as good access, up to 600 m is considered as fair access, up to 900 m poor access and beyond 900 m unacceptable access. In ArcView GIS (release 3.1 and newer) you will find a simple tool for creating the necessary buffers along the roads. The map below shows the buffer zones of the road network of Dar es Salaam.
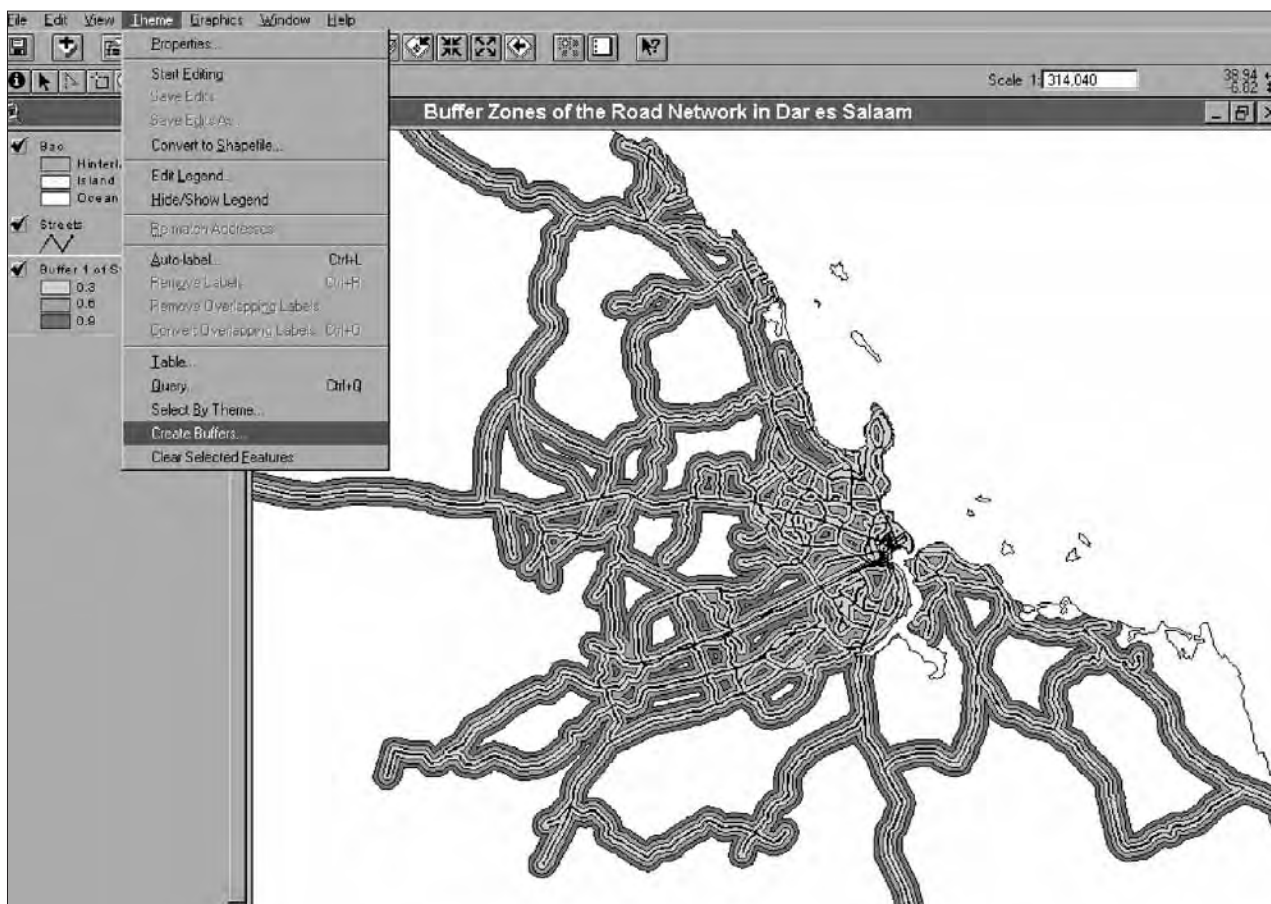
The various utility maps can be ranked according to their importance in the city development strategy. Individual utility maps are overlaid and combined in a Service Delivery Map, showing the areas of good, medium and poor utility supply. The map below shows service delivery in Dar es Salaam.

Dar es Salaam - Service Delivery
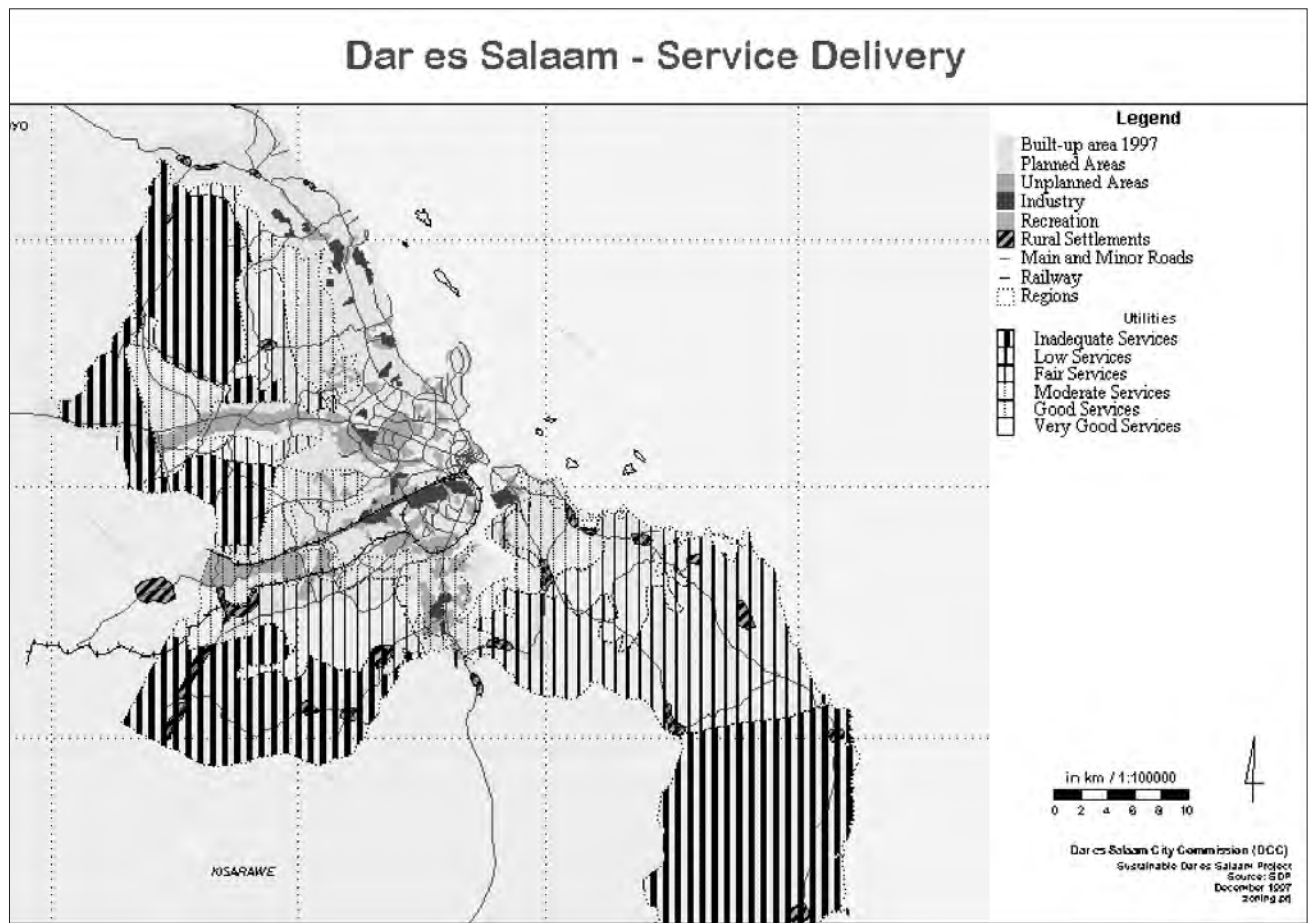
Tool 24: Overlaying Maps

How to manually and digitally overlay maps
*   Manual overlays
*   Overlaying functions in GIS applications
*   Overlay functions in ArcView 3.2
*   Overlay functions in ArcView GIS 9

Manual Overlays

Overlaying maps is best done manually. The cartographer of the EMIS unit prepares the necessary maps on tracing paper, or the EMIS Officer prints digital Suitability, Sensitivity and Service Delivery Maps onto a transparent medium. Those maps are then discussed at a light table by the co-ordinators of the individual Issue-Specific Working Groups, together with the EMIS Officer. The group starts by overlaying two environmental issues and traces the new boundaries onto a third, blank sheet of tracing paper. The group then adds a number code for each area and the summary of the ranks which are taken from the original maps. The third new map is then overlaid with another relevant environmental issue and another new map will be developed. This exercise can be repeated, ideally, for no more than six environmental issues, in order to produce a legible final map. The final map will be made up of small areas, each with its particular coding.

The CD-ROM contains eight sample maps from Dar es Salaam, Tanzania:

1.   River network
2.   Road network
3.   Ward boundaries
4.   Soil map
5.   Land use
6.   Suitable mining areas
7.   Hazard sensitivity
8.   Population per Ward

These maps can be printed on transparent material and used to practise manual overlaying.

Overlaying functions in GIS applications

Before you start overlaying maps with a GIS, please be very sure that the key representatives of the Issue-Specific Working Groups fully understand the process and the desired end result. The process follows the same steps as manual overlaying – the only difference is that the light table is replaced by the computer monitor. The overlaying will be carried out in a group which includes the relevant working group co-ordinators and the EMIS Officer, in front of the computer monitor. In some cases you will have to make a printout on transparent paper and go back to the light table in order to discuss complex areas of conflict.

Overlaying maps is a core computational activity in many GIS applications. They are used to combine two or more data layers occupying the same location to obtain new information in a new layer. The following table gives a brief description of the different operations available in the ArcView Toolbox to overlay spatial data. Before choosing one of these functions for your data make sure you fully understood the process of each overlay operation.

Function	Process Description	Illustration
OVERLAY **Union**	builds a new feature class by combining the features and attributes of each feature class. All features will be written to the Output Feature Class with the attributes from the Input Features which it overlaps. All inputs must be of a common geometry type and the output will be of that same geometry type. This means that a number of polygon feature classes and/or feature layers can be union-ed together. The output features will have the attributes of all the input features which they overlap.	
Intersect	builds a new feature class (Output Feature Class) from the intersecting features common in both feature classes (point, line or polygon). The intersections are written as features (point, line or polygon) to the output. The input feature classes can be any combination of geometry types (point, multi-point, line, polygon). The output geometry type can only be of the same geometry or a geometry of lower dimension as the input feature class with the lowest dimension geometry (point = 0 dimension, line = 1 dimension, poly = 2 dimension). The second graphic illustrates the result of intersecting a line and polygon feature classes with the Output Type parameter set to LINE. The output line features are where line from one of the input feature classes overlap a polygon from the other input feature class.	
EXTRACT **Clip**	is used to cut out a piece of one feature class using one or more of the features in another feature class as a 'cookie cutter'. This is particularly useful for creating a new feature class that contains a geographic subset of the features in another larger feature class. The Output Feature Class will have the attributes of the Input Features. The feature class that is clipped can contain points, lines, or polygons. The clip feature class, however, must be a polygon feature class. For example, suppose you are studying the transportation needs of a particular county. You would like to work with a feature class that contains only the roads or segments of roads that fall inside this county boundary, but all you have is a feature class containing roads for the whole state. You can clip the roads in the state roads feature class using the county polygon as the 'cookie cutter' to create a new feature containing just the roads in the county. The output from the clip function will be in the same coordinate system as the input feature class.	

Overlay functions in ArcView 3.2

The technical procedure for making automatic overlays in ArcView 3.2 is straightforward and easy. First, you load the maps to be overlaid into your view and you activate the GeoProcessing extension.

Under View you will find the GeoProcessing Wizard. The wizard contains six GeoProcessing operations. For overlaying we can choose the operation 'Intersect two themes' or 'Union two themes'.
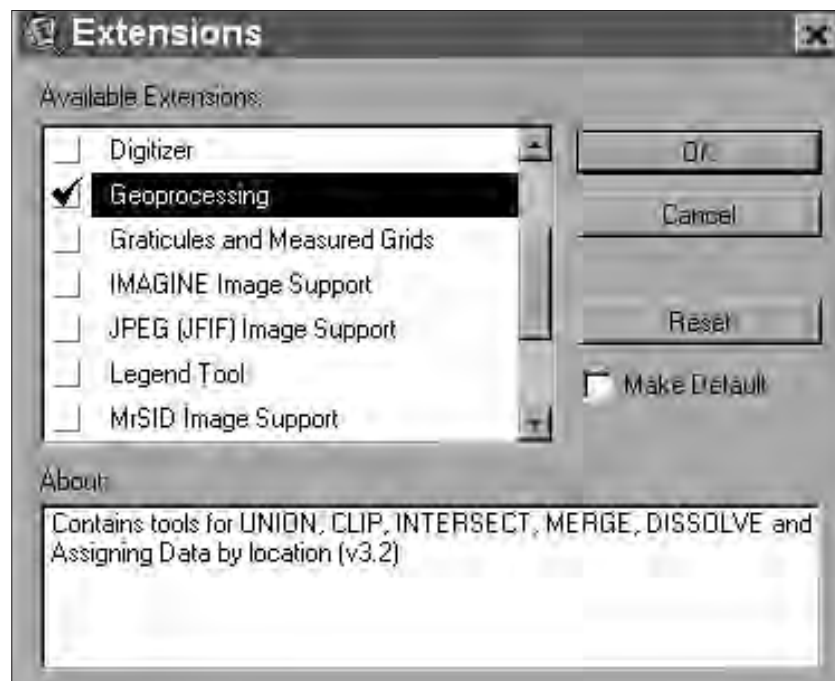
In the next step, the wizard will ask you which shape files to combine and what the new shape file should be called. Press the Finish button and ArcView GIS will generate the new geometry as shown in the following map.
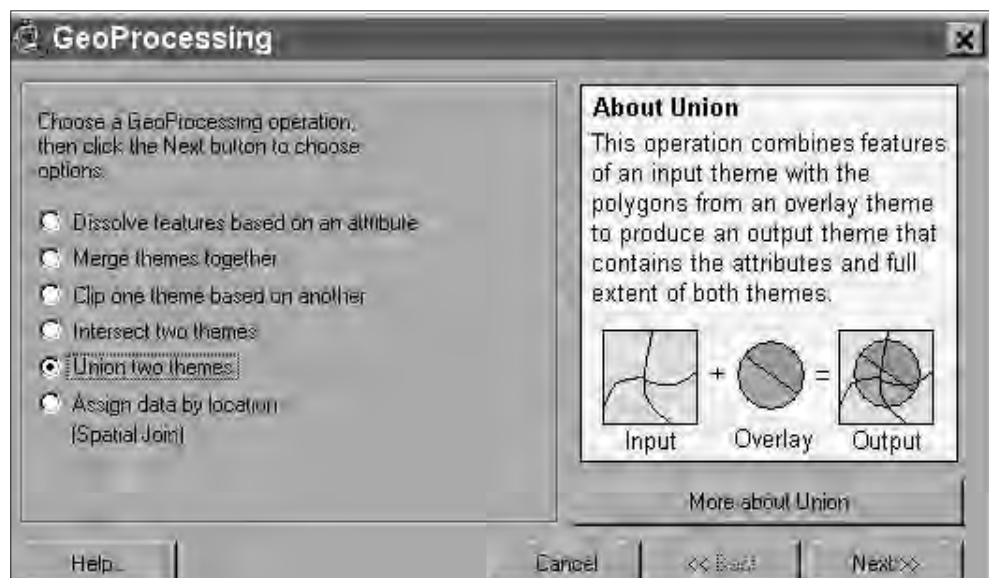
ArcView 3.2 also combines the two individual attribute tables into one, putting the overlaid themes into sequence. Please note that you will have several columns containing the ranking of the individual Suitability / Sensitivity Maps. These will have to be summarised into a new column.

ArcView 3.2 allows you to perform an automatic calculation of the new summary column. First, put your table into the editing mode ('Start editing'), add a new field (with number characteristic) and select all records. Open the field calculator and type the formula which you would like to perform in the new field, for example the following:

Attributes of Min-haz.shp

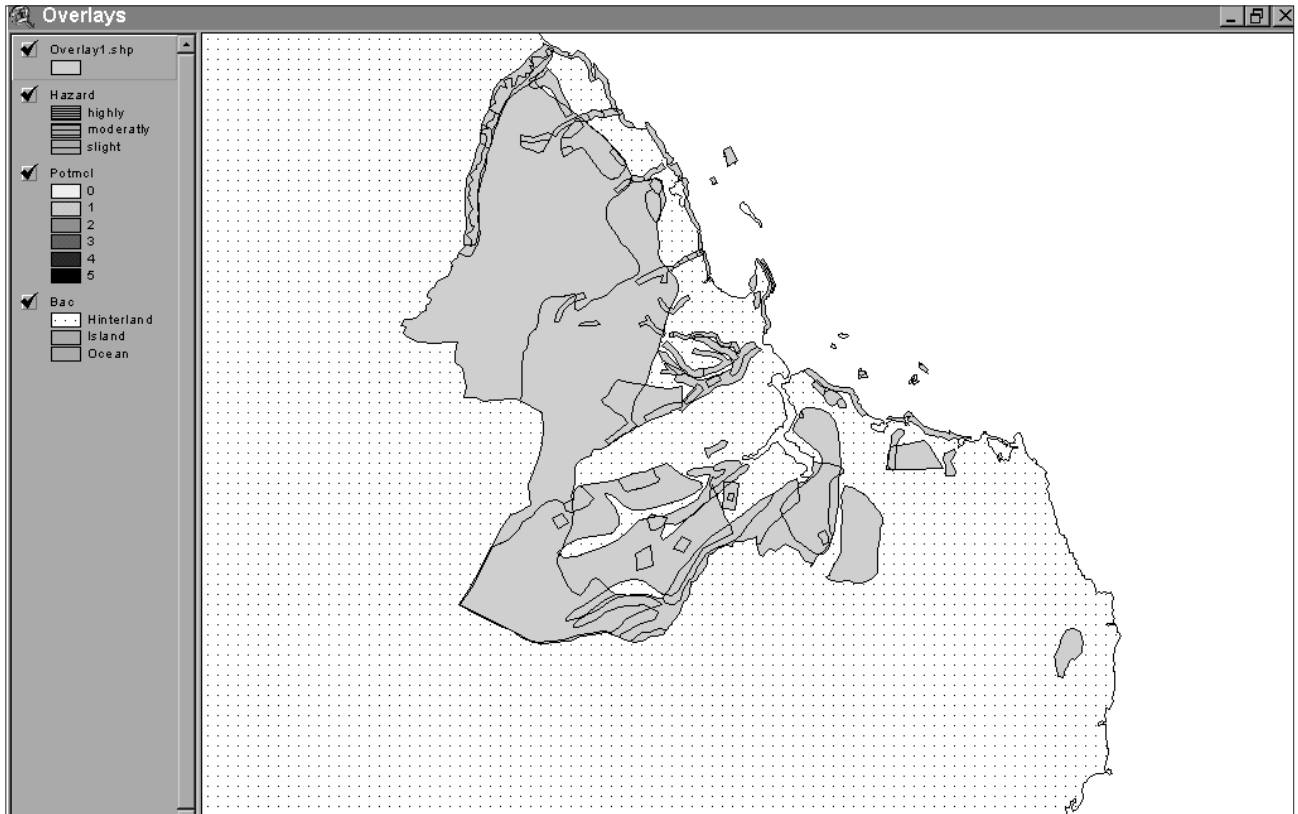| Shape	Area	Name	Rank	Area	Name	Name2	Rank	SumMin-Haz
Polygon	0.000170	Designated Sand extraction	2	0.000361	Beach erosion	highly	5	7
Polygon	0.000170	Designated Sand extraction	2	0.001238	Flood Prone	moderatly	3	5
Polygon	0.000170	Designated Sand extraction	2	0.000000			0	2
Polygon	0.000498	Designated Sand extraction with mining claims	3	0.001238	Flood Prone	moderatly	3	6
Polygon	0.000498	Designated Sand extraction with mining claims	3	0.000000			0	3
Polygon	0.000047	Designated Limestone extraction with mining claims	5	0.001238	Flood Prone	moderatly	3	8
Polygon	0.000047	Designated Limestone extraction with mining claims	5	0.020810	Soil erosion	highly	5	10
Polygon	0.000047	Designated Limestone extraction with mining claims	5	0.000000			0	5
Polygon	0.000331	Designated Limestone extraction	4	0.001238	Flood Prone	moderatly	3	7
Polygon	0.000331	Designated Limestone extraction	4	0.020810	Soil erosion	highly	5	9
Polygon	0.000331	Designated Limestone extraction	4	0.000000			0	4
Polygon	0.000066	Illegal Sand extraction	0	0.000361	Beach erosion	highly	5	5
Polygon	0.000066	Illegal Sand extraction	0	0.000000			0	0
Polygon	0.000057	Illegal Sand extraction highly affected	0	0.000000			0	0
Polygon	0.000110	Designated Sand extraction	2	0.001238	Flood Prone	moderatly	3	5
Polygon	0.000110	Designated Sand extraction	2	0.000000			0	2
Polygon	0.000041	Illegal Sand extraction	0	0.020810	Soil erosion	highly	5	5
Polygon	0.000041	Illegal Sand extraction	0	0.000000			0	0
Polygon	0.000065	Illegal Sand extraction	0	0.020810	Soil erosion	highly	5	5
Polygon	0.000008		0	0.020810	Soil erosion	highly	5	5
Polygon	0.000828	Designated Limestone extraction	4	0.020810	Soil erosion	highly	5	9
Polygon	0.000828	Designated Limestone extraction	4	0.000000			0	4

Press OK and the sum of the columns Rank_ and Rank will be calculated for each record in the new column. The new overlay map will use the new column to show areas of high conflict.
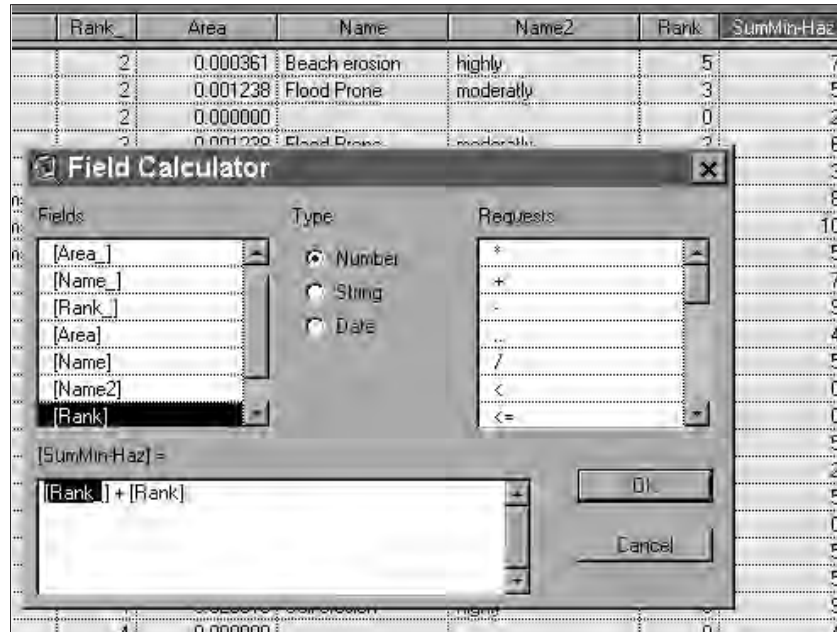
Overlay functions in ArcView GIS 9

In ArcView GIS 9, the manipulating and analyzing functions have been broadened and structured in a different way. Now all tools and functions for geoprocessing can be found in the ArcToolbox. The overlay functions are part of the "Analysis Tools" ("Overlay" and "Extract"). The toolbox is embedded in ArcMap and ArcCatalog.

In the dialog box, select the shape files that should be "unioned" as input features. Then choose the folder and create a name for the output feature class with the unioned shape files to be saved as. The new layer will be added to the view as shown in the following example:
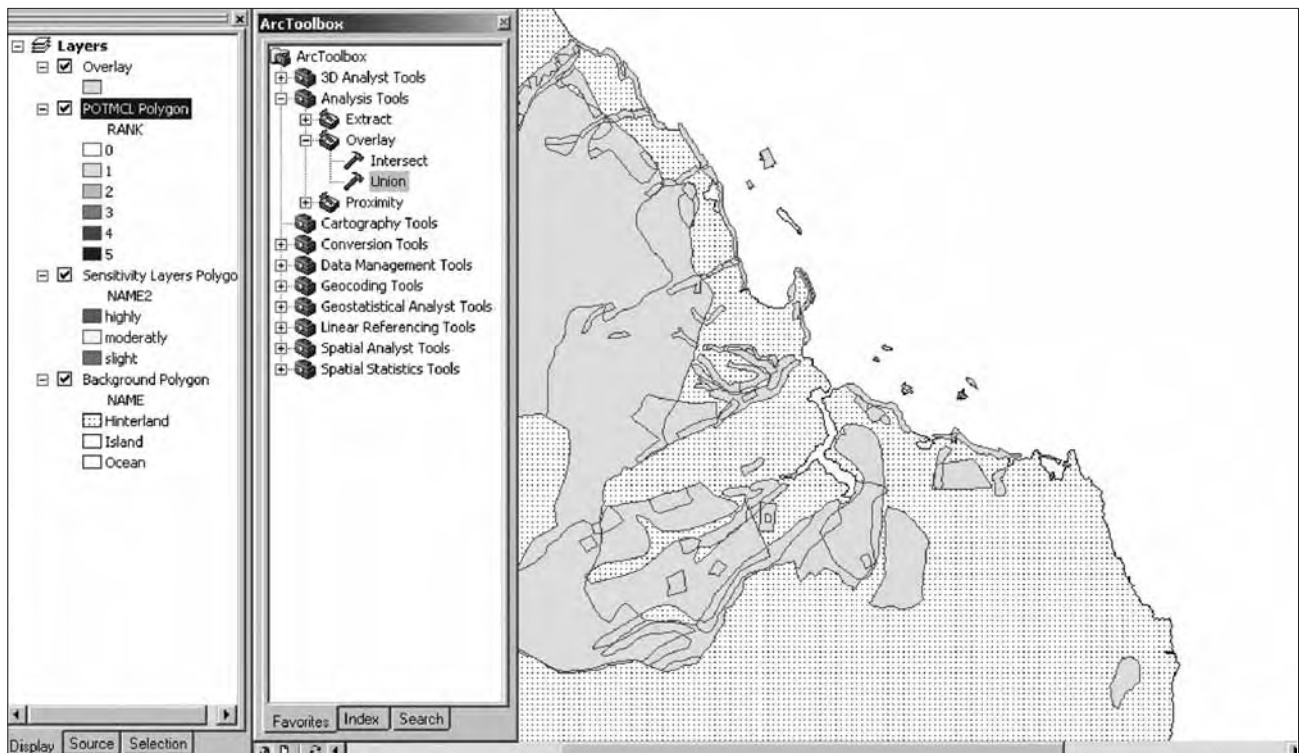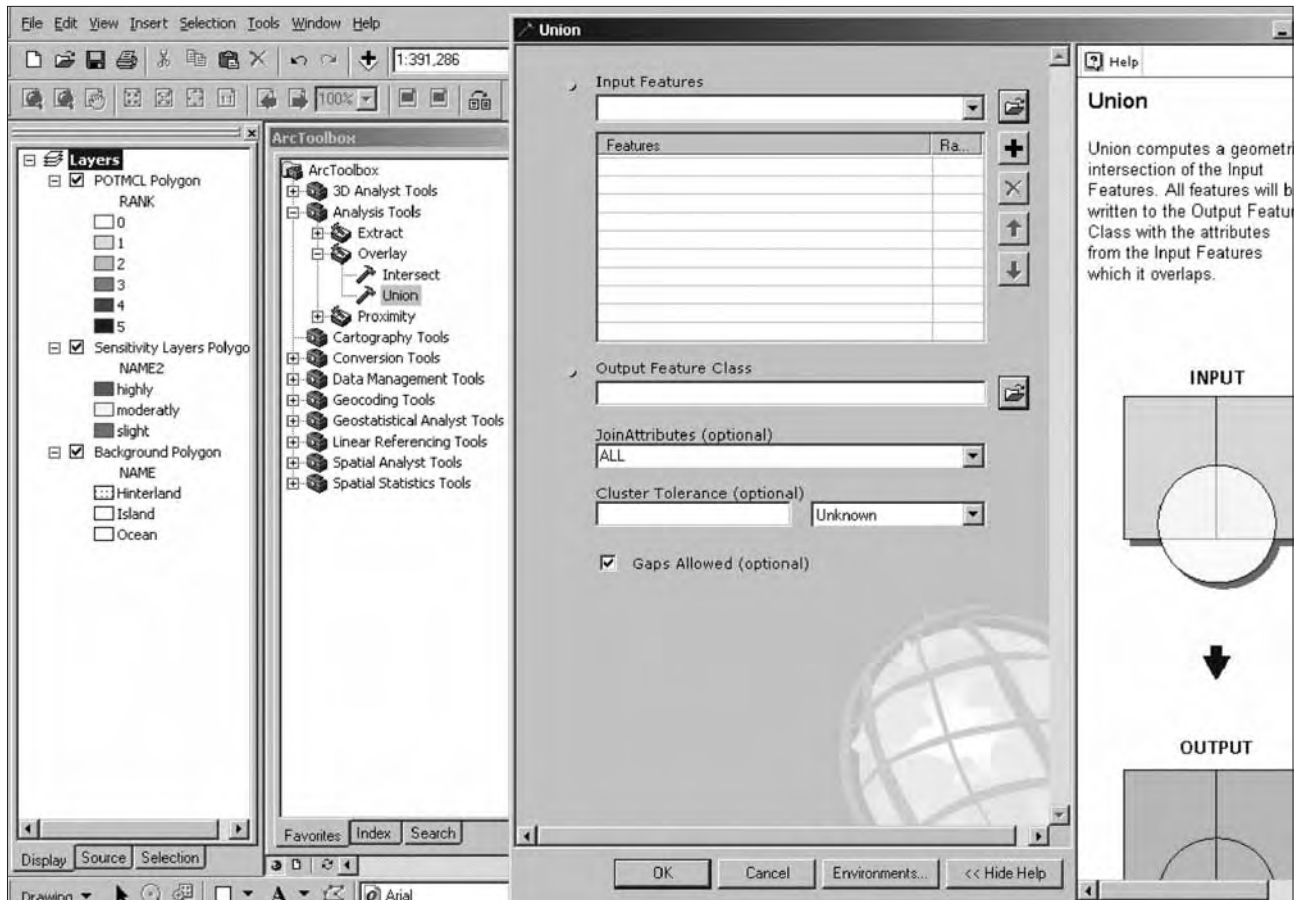
Tool 25: Environmental Management Frameworks

How to develop a map showing the future structure of the city
•   Strategic Urban Development Planning Framework (SUDPF) in Dar es Salaam

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Strategic Urban Development Planning Framework (SUDPF) in Dar es Salaam

Please note that all maps mentioned within this text relate to the document: Strategic Urban Development Plan - The Stakeholders' Edition, UASU, Dar es Salaam, 2000.

The Development of SUDPF in Dar es Salaam
The City Council of Dar es Salaam has been strongly interested in developing a city wide strategic urban development planning framework (SUDPF) since 1992. This is one of the key objectives of the Sustainable Dar es Salaam Project (SDP).

As one of the first SCP cities to develop a SUDPF using a participatory process, Dar es Salaam could not benefit from other practical urban experiences but instead took on the role of pioneer. The working groups analysed and processed the huge stock of issue-specific information they had collected into layers of areas with varying degrees of suitability for different activities. Although it was not an easy task to generate a composite land use pattern developed on the basis of coherent rules and principles, the aggregation of the strategies and the development of the SUDPF for Dar es Salaam followed more or less the steps outlined in this tool.

Dar es Salaam - Groundwater Tables
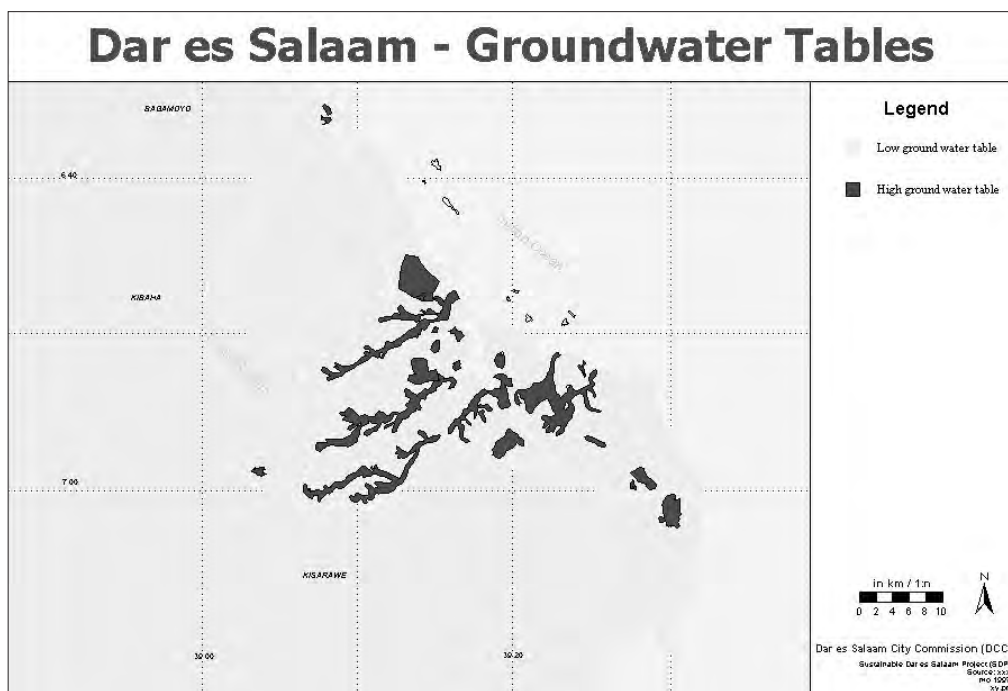
The development of the SUDPF took about two years and is based on local experiences and expertise. The SUDPF is well documented in a six volume report and in a 'Stakeholders' Edition'.

STEP I: Preparation of Suitability Maps (city-wide)
The Dar es Salaam Working Groups started by preparing suitability maps for issues relevant to determining urban expansion and growth in Dar es Salaam. These included urban agriculture, hazard lands, coastal resources, built up areas, transportation networks and the ground water table. Suitability maps, which integrate two issues at a time, were then prepared. All suitability maps for each environmental issue in relation to city expansion were compiled, such as
1. Urban Agriculture
2. Hazard lands
3. Coastal resources (Building materials)
4. Built up areas and transportation network
5. Ground water table

STEP II: Ranking the overlapping land use
The suitability maps prepared in Step I were then overlaid, and the overlapping land uses were ranked. The ranking criteria depend on the level of conflicting uses to each layer. The higher the degree of conflicting uses in the area, the higher the rank or number, and the fewer conflicts of use in the area, the lower the number, as shown below.

No	Environment Issue	Characteristic	Classification & Ranking
1	Hazard lands	Erosion prone	3 - Highly erosion prone 2 - Moderate erosion prone 1 - Slightly erosion prone
		Flood prone	3 - Highly flood prone 2 - Moderate flood prone 1 - Slightly flood prone
		Beach erosion	3 - Highly beach erosion 2 - Moderate beach erosion 1 - Slightly beach erosion
2	Urban Agriculture	Availability	4 - Highly available 3 - Moderately available 2 - Less available 1 - Not available
3	Building Materials	Potentiality	5 - Highly potential sand & limestone (quality) 5 - Highly potential sand & limestone (quantity) 4 - Potential mining (under exploitation) 3 - Potential mining (future) 2 - Potential mining built up)
4	Ground Water Table	Level of ground water	6 - Area with high water table 0 - Area with low water table

The exercise of overlaying the environmental issue suitability maps was done step-by-step. Two maps were overlaid in turn, as indicated below:

Agriculture with building materials (mining)   Map 1
Mining with Hazard Lands   Map 2
Agriculture with Built up areas   Map 3
Built up with Hazard Lands   Map 4
Built up with Mining   Map 5
Agriculture with Hazard Lands   Map 6
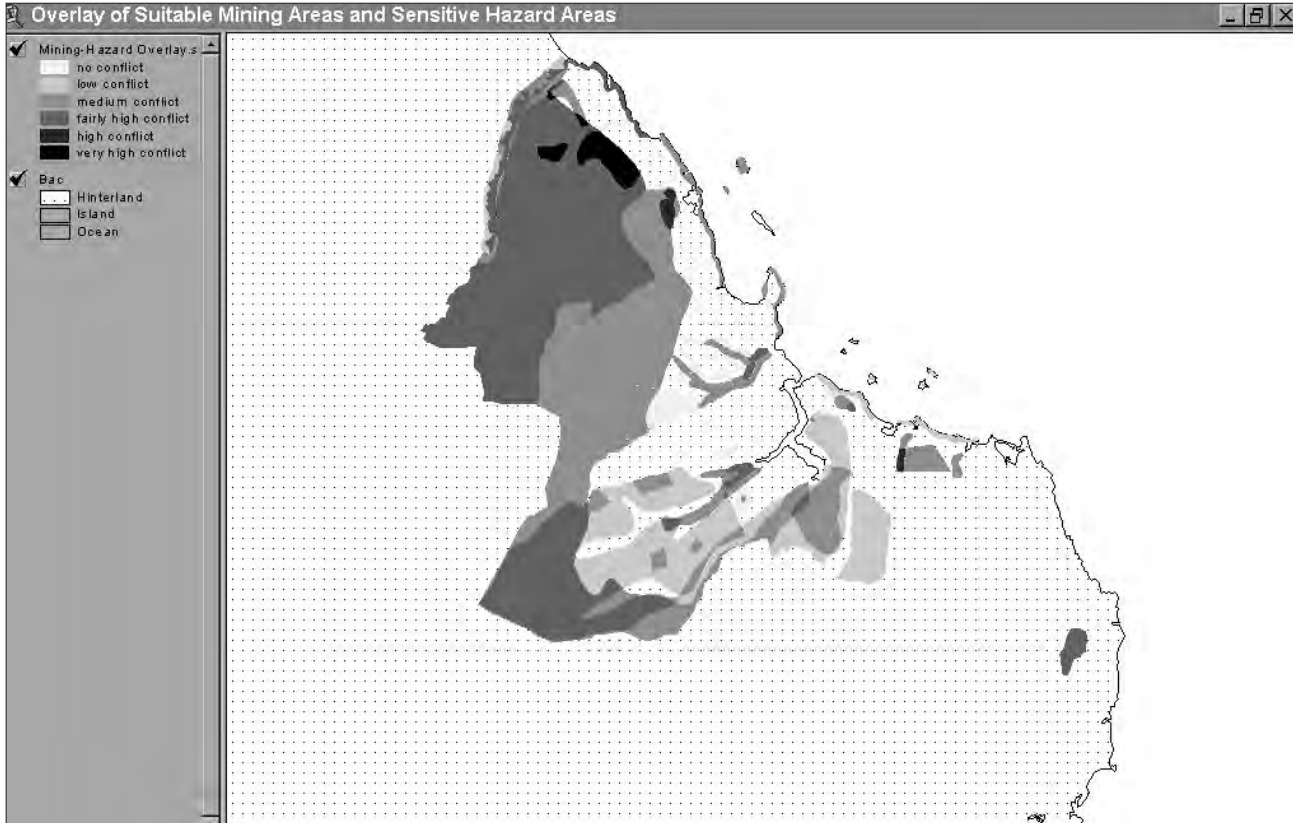
The level of suitability was graded into six categories as indicated in the table below:

LEVEL OF SUITABILITY	OVERLAID ENVIRONMENTAL ISSUES					
	A + M	M + H	A + B	B + H	B + M	A + H
	1	2	3	4	5	6
6						
5	X	X		X	X	X
4	X		X	X	X	
3	X		X	X	X	X
2	X		X	X	X	
1	X			X	X	

Key: A = Agriculture   B = Built up areas   H = Hazard lands   M=Mining (building materials)

By overlaying the resulting six maps, one composite map was generated on which areas were prioritised for development based on the degree of conflicts pertaining to them. For ease of classification, weights were given to the degree of conflict: the higher the number of issues prevailing in an area,

the more constraints for development and the more rules were required to regulate existing or future activities.

STEP III: Production of Priority Area Map

The maps produced in step II were again overlaid to produce one layer comprising all six environmental issues. In this layer areas with total weight ranging between 1 - 5 were considered as less conflicting and were identified as areas suitable or potential for city expansion. The output was a Priority Area map (map No. 7)

STEP IV: Environmental Zoning

In order to qualify the suitability of the potential areas identified for city expansion, map no. 7 was overlaid with the ground water table map in order to identify the limitations of urban development due to the ground water table. Areas with low ground water table were identified as most suitable for development. This exercise refined map no. 7 as an environmental zoning map (map No. 8).

STEP V: Land available for city expansion

This stage further refined map no 8 by overlaying it with the existing land use map to eliminate areas of land already committed. For example, major public institutions like hospital sites, army, schools and colleges, etc. were identified. These sites might otherwise cause conflicts and hinder future development or might not even be available for city expansion. This overlay produced the final map with a suitability level ranking between 1 -5, showing land available for city expansion map (map No. 9)

STEP VI: Utilities

It was necessary to overlay the map resulting from step V (showing free land for city expansion and with potential for development) with the utilities (power and water) map, and later on the road accessibility map to qualify areas with adequate utilities and accessibility as most suitable for city expansion and development. The ranking of areas was based on weights attached to the different levels of adequacy in utilities and accessibility.

As a rule of the thumb, city expansion cannot take place in a co-ordinated manner without an adequate utility supply. Therefore the extent, quality and quantity of the supply of the main utilities were analysed to further support the potentiality of areas identified in map no 9 for future expansion.

The main utilities considered here with their classification criteria and map numbers are:

Map No	Utility	Classification & Ranking
Map No 10	Water Supply	2 - Areas with adequate supply under phase I rehabilitation & upgrading 1 - Areas with inadequate supply & under phase II service expansion 0 - Areas without formal supply system and no immediate plans
Map No 11	Electricity	2 - Areas with adequate supply 1 - Areas with inadequate supply with proposal coverage to year 2000 0 - Areas with no power and no immediate plans
	Accessibility:	2 - Areas with good roads 1 - Areas with fair roads 0 - Areas with poor or no roads

The overlay of the two issues (water and electricity) was again overlaid with the accessibility situation map.

After overlaying the three maps a utility map was produced indicating the level of services (Map No. 12).

Dar es Salaam - Environmental Management Framework
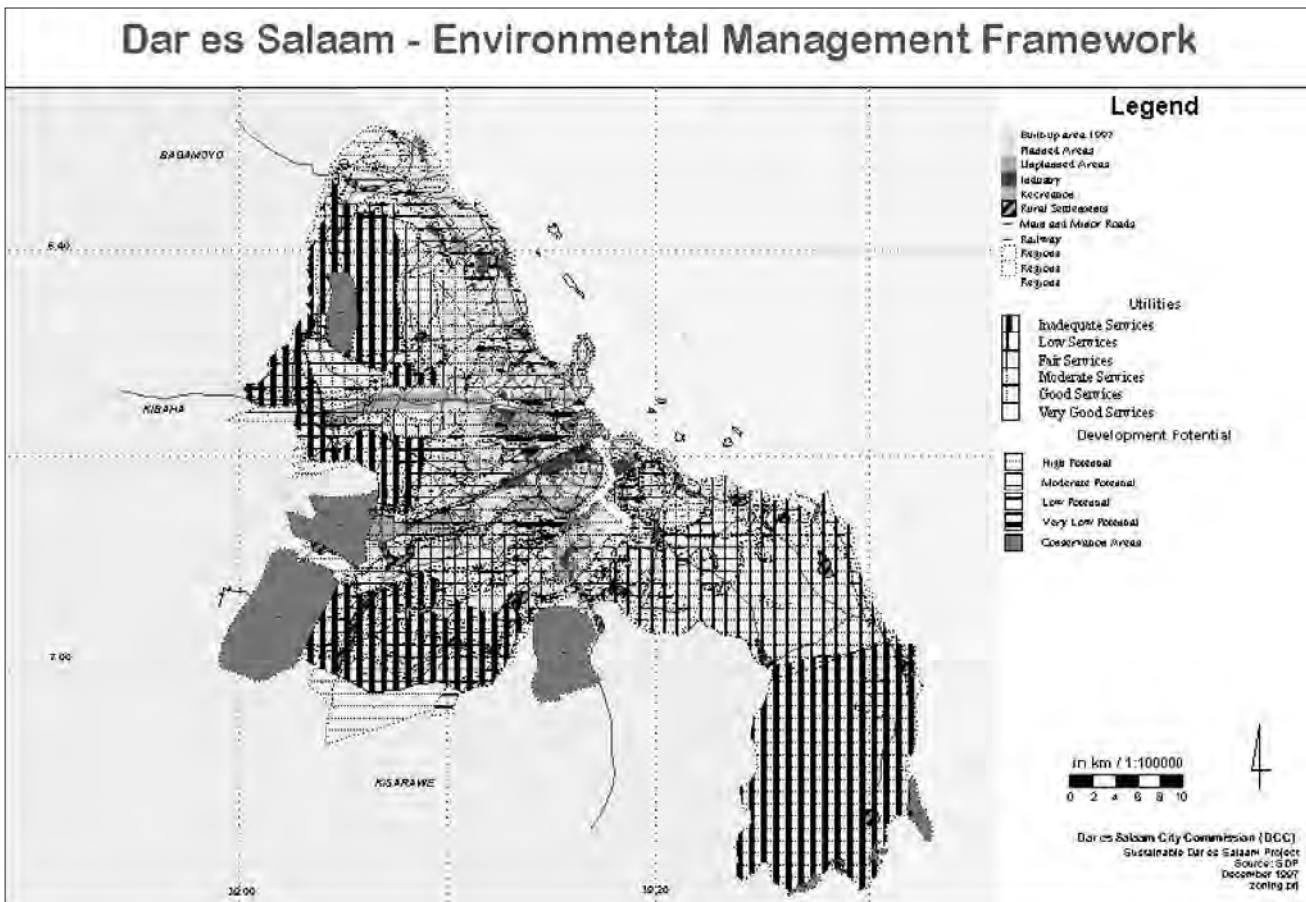
STEP NO. VII: Overlay of Utility Map with City Expansion Map

The next step was to overlay the utility map (no. 12) with the map of land available for city expansion (no. 9) in order to see the suitability of the potential land in terms of service availability. This resulted in Map No. 15 (the final map) which shows the potential areas for future development and investment with the fewest conflicts and the level of utility supply in each area.

STEP VIII: Zoning

Once areas were prioritised for city expansion and development, they were then sub-divided into zones. The city of Dar es Salaam was divided into 21 zones and 41 sub-zones, which were characterised by potential as well as by level of services, existing or planned.

Following the production of map no.12, the potential areas for city expansion were classified into zones. The zones were then categorised as indicated below:

ZONE	CATEGORY/ area	CHARACTERISTICS
1	a	High potential + very good services in pos
	b	High potential + very good services in built up areas
	c	High potential + very good services in planned areas
	d	High potential + very good services in unplanned areas
	e	High potential + very good services in industrial areas
2	a	High potential + good services in possible city expansion areas
	b	High potential + good services in built up areas
	c	High potential + good services in planned areas
	d	High potential + good services in unplanned areas
3	a	High Potential + Fair/moderate services in city expansion areas
	b	High Potential + Fair/moderate services in built up areas
	c	High Potential + Fair/moderate services in built up areas
	d	High Potential + Fair/moderate services in unplanned areas
4	a	High potential + low services in city expansion areas
5	a	High potential + inadequate services in city expansion areas
6	a	Fair potential + Very good services in city expansion areas
	b	Fair potential + Very good services in built up areas
	c	Fair potential + Very good services in planned areas
	d	Fair potential + Very good services in unplanned areas
	e	Fair potential + Very good services in industrial areas
7	a	Fair potential + Good services in city expansion areas
	b	Fair potential + Good services in built up areas
	c	Fair potential + Good services in planned areas
	d	Fair potential + Good services in unplanned areas
8	a	Fair potential + fair services in city expansion areas

ZONE	CATEGORY/ area	CHARACTERISTICS
	b	Fair potential + fair services in built up areas
9	a	Fair potential + low services in city expansion areas
10	a	Fair potential + inadequate services in city expansion areas
	b	Fair potential + inadequate services in built up areas
11	a	Low potential + very good services in city expansion areas
	b	Low potential + very good services in built up areas
12	a	Low potential + good services in city expansion areas
13	a	Low potential + good services in city expansion areas
14	a	Low potential + Inadequate services in city expansion areas
15	a	Very low potential + Very good services in city expansion areas
16		conservation areas
17		recreation areas
18		Villages
19	b	Very low potential + Good services in city expansion areas
20	a	Low potential + Good services in city expansion areas
21	a	Low potential + Fair services in city expansion areas

Dar es Salaam - Strategic Urban Management Framework
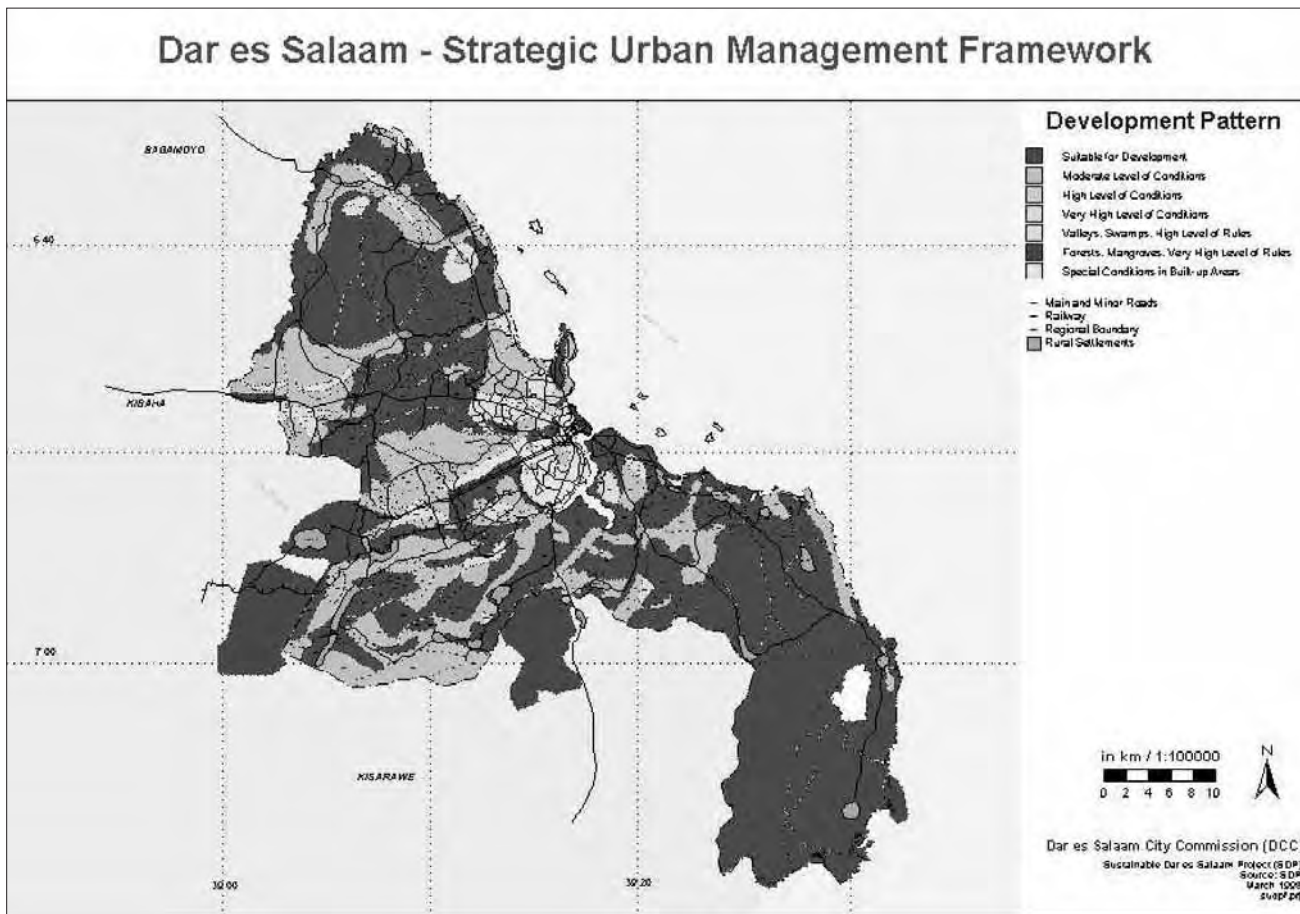
Tool 26: Monitoring the urban environment

How to monitor urban environment indicators
- UN-Habitat UrbanInfo Database Management System
- UrbanInfo and EMIS
- The Cities Environment Reports on the Internet (CEROI) (26a on EMIS CD-ROM)

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UN-Habitat UrbanInfo Database Management System

In 1993, UN-Habitat's Housing Indicator Programme designed the Urban Indicators Programme (UIP) - an urban indicator database. Since 2002, UN-Habitat's monitoring and reporting function has undergone a transformation process in an effort to fulfil the requirements of new international mandates – primarily the Millennium Development Goals (MDGs). A new approach through the Monitoring Urban Inequities Programme (MUIP) produced the Global Urban Indicators Database III. In addition to addressing the needs of the Habitat Agenda, this database provides information on the MDGs, particularly Target 11 – the improvement of the lives of slum dwellers. The data used in the development of the Global Urban Indicators Database III was collected from a range of sources: national censuses, demographic and health surveys (DHS), Multiple Indicators Cluster Surveys (MICS), various national household surveys, and other administrative sources.

The Global Urban Indicator databases, the indicators from the Habitat Agenda and the MDGs (particularly target 11) were combined in the UrbanInfo software. This software allows you to store, analyse and publish the data as tables, graphs and maps. The software package is included in the EMIS CD.

Software requirements:

Windows platform

CPU   Pentium II or higher

Memory   128 MB or higher

Hard disc space   minimum 300 MB

Microsoft Internet Explorer 5 or higher

UrbanInfo and EMIS

The UrbanInfo database is based on MS Access. The version included on the EMIS CD supports the standard indicators of the Habitat Agenda and the MDGs. The information in most cases is based on national or city level data. Not all information is available for all countries. However, the software can be adapted to EMIS and SCP city requirements. Once you attend the UN-Habitat/GUO training modules you will be able to enter the data collected by the EMIS team, the Mapping Group and Working Group members during the EPM process. UrbanInfo also allows you to create your own indicators to monitor the progress and impacts of the EPM process on your city and to export the results as shp-files to ArcGIS, or as graphs and tables to MS Word, MS Excel or MS PowerPoint. UrbanInfo is of particular interest to cities where no local database system exists to store digital data related to the city and the city environment. Furthermore, it offers a useful tool to design indicators that measure the impact of the EPM process.
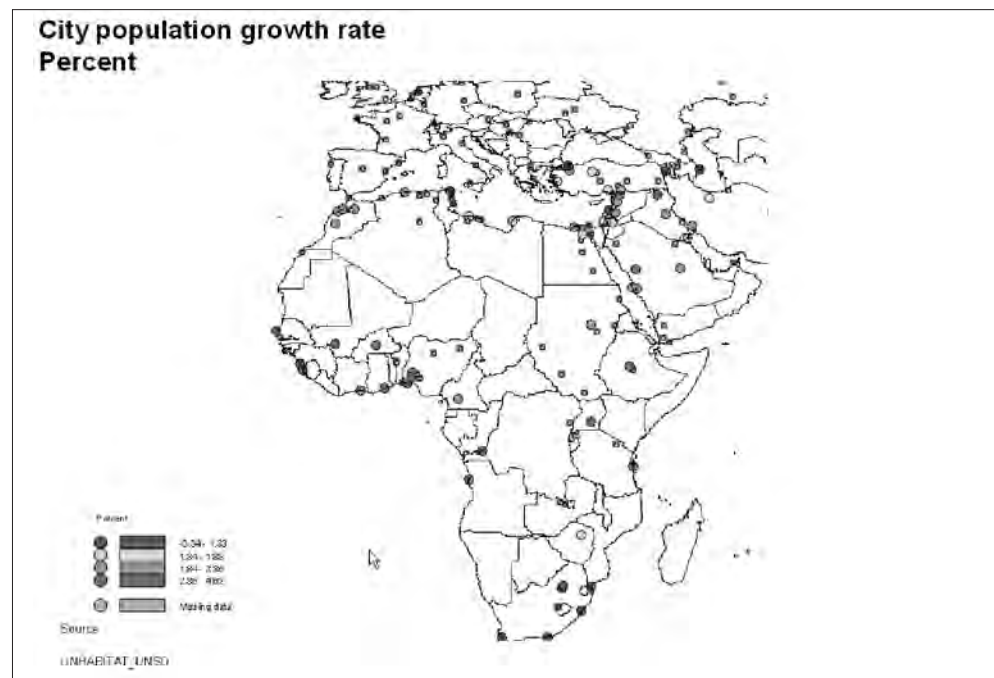
A web based version of UrbanInfo enables you to share your data with other cities and countries and to use their data as well:
http://www.devinfo.info/urbaninfo/

Tool 27: Information Outreach

How to prepare publications and posters for exhibitions and create an EMIS website

- A word on publications
- Preparing publications – a checklist
- File compression and Image file formats
- Save maps as images (in ArcView)
- Exhibition: How to prepare a city/national panel
- Web site development
- Programming the website using HTML (Tool 34a on EMIS CD-ROM)

A word on publications

Why is information outreach so important? The EPM process uses a participatory approach. As many people as possible should be informed about the Sustainable Cities Programme projects and take part in the decision-making process. This ensures that they support the project and feel a sense of ownership. However, the public can get involved only when they know what is going on. It's up to you to tell them.

Publications (such as posters, exhibition panels, flyers, newsletters and web sites) are also a useful way to give partners and possible donors an overview of your project and its achievements. Publications and other information materials can be used to exchange experience with other SCP cities and to present your city at exhibitions, meetings and conferences.

Publications are meant to be read. However, even if you have a lot to say, keep it short. The longer a text is, the fewer people will actually read it through to its end. A poster or flyer consisting of nothing but text may describe your project in detail, but it is unlikely to be read. Readers of publicity material expect to get important information quickly, served in an interesting and appealing way. Maps, pictures and drawings can illustrate your message and save you many words. Try to use practical examples to liven up your text.

Audience and context are closely bound to the message you want to send with the publication. What kind of information do you want the reader to take home? When you can answer the question "Who does/did what when where how and why?" after reading the text of a publication, you can be sure that you have included all the relevant information. However, before you start to prepare a publication, think about your audience and the message you want to send to them. For example, when you are preparing a poster for a Global SCP Meeting on how the EPM process was introduced in your city, you don't need to describe the theory behind the process – the other SCP cities in the audience will already know about this. They will be much more interested in hearing about the particular challenges your city faced, and how these were overcome. However, if you are developing an exhibition on the same topic for an audience not familiar with the EPM process – say, the home population of your city, for example – you will need

to add a short introduction about EPM and the SCP, as your audience may not know anything about either. They will need an overview of the process to understand the objectives of the City Consultation or the reasons for having Working Groups.

Preparing publications – a checklist

❒ Decide on your audience and context
- The exhibition is part of a consultation, e.g. a City Consultation,
- The exhibition is part of an Issue-Specific Mini-Consultation,
- It is a stand-alone exhibition, e.g. in the entrance of the town hall?

❒ Decide about the message you wish to send
- E.g. "participate in working groups"
- "Your neighbourhood will be upgraded and this will happen"
- "The great achievements of project x"

❒ Decide on the content of the exhibition
- Which maps will be helpful to underline the message?
- Which additional illustrations such as photos, drawings, pictures can illustrate the message?
- How much text will you include?
- Which practical examples from the projects could be added to liven up the text?
- Who should be credited?

❒ Include the most important information
- Can you answer all these questions when reading the text: Who? What? When? Where? Why? How?

❒ Make a draft layout
- Prepare a draft of the posters showing how the different parts of the posters will be arranged
- Define characteristics such as page size, orientation, margins, font size and colours

File compression and Image file formats (PDF, TIFF, JPG, EPS)

The PDF (portable document format) is a de-facto standard for electronic information exchange. Because PDF is a vectorscale format, the files are usually a lot smaller than the original file (ie. the original Word document or Powerpoint presentation, etc). Because of its smaller file size, a PDF is easily sent by email or downloaded from the internet. A free PDF-converter is included on the EMIS CD. PDF files do not encode information that is specific to the application software, hardware or operating system used to create or view the document. This feature ensures that a valid PDF will render exactly the same regardless of its origin or destination. While the PDF format can describe very simple one page documents, it may also be used for many pages, complex documents that use a variety of different fonts, graphics, colours and images. After converting a file into a PDF, the PDF can only be manipulated with special software (i.e. Adobe Acrobat). So make sure that you always keep the original file as well.

If you prepare a poster using desktop publishing software you will have to save the maps (including the cartographic elements) as a graphic file. Most of the GIS software packages allow you to export graphic files in a range of different formats. Bitmaps (BMP) and Windows Metafile formats (WMF) are better avoided because of their big file sizes - a full colour, high-resolution screen-sized image in these formats may exceed 10 MB. When you scan an image, it is usually saved in "Tagged Image File Format" or TIFF format (*.tif). Because bitmap and tiff images require so much storage, many techniques have been developed for compressing image data. The most popular graphic formats are the Graphics Interchange Format (GIF) and the Joint Photographic Experts Group (JPEG) which can compress in a ratio of 1:10 compared to bitmaps. The GIF89a format is a compression technique that compresses images without removing details, while the JPEG format compresses images by removing detail. GIF is mainly used for graphics with flat colours such as maps or logos, and JPEG is used for photographic images with graduated colours. Encapsulated Postscript formats (EPS) are also lossless formats which work best with Adobe Illustrator and a Postscript printer/plotter. When changing an image from *.tif format to *.jpg or *.gif format you lose some quality, but this is usually not noticeable.

To save space you can also change the properties of the image. For example, using Microsoft Photo Editor you can access the properties from the File menu. In the properties dialog box you can change the colour format (True Colour, 265 Colours, etc.) and the resolution (pixels per inch). The difference between 256 and True Colour is hardly noticeable, but it is advisable to use 256 Colours because it saves a lot of memory. By reducing the resolution you also decrease the size of the image file.

Save maps as images in ArcView

You can export a map layout to a graphic file, which allows you to use it in other programmes. ArcView GIS and MapMaker Pro support several output formats, such as *.jpg, bitmap and *.eps. To export a map in Arc View GIS, do the following:
1. In the layout mode choose export from the file menu
2. In the dialog box that appears, choose the file format you want
3. Use the option button to change the resolution (according to your needs, highest quality for posters and EPS format for printing in publications)
4. Press OK

Another way to save maps as images is to make a screenshot, especially if you do not need high resolution files, for example when preparing presentations onscreen or very small pictures. This option is also useful for showing the different steps in preparing a map.

1. If the screen shows what should be in the picture, press the <u>**Print Scrn**</u> button. The view of the screen will be saved on the computer's clipboard.
2. Open PhotoShop, MS Photo Editor or MS Word
3. Choose new file

4. Edit > Paste or press **Crtl** **V**
5. Now you can clip the part of the image you need and save the file as in JPEG format

If you wish to select only the active window on a screen, press **ALT + Print Scrn** at the same time. Press **CTRL+V** to paste it into the destination document.

You can also copy an existing map layout and place it in your new layout (i.e. add a map with the location of your city within the country to the basic map you created of your city).

1. Open existing layout
2. Select **all elements** and **group** them
3. Copy or **Crtl** **C**
4. Go to your **new layout**
5. Paste or **Crtl** **V**

If you wish to add any graphic elements, such as boxes or borders:

1. Place the text you want in the text boxes
2. Assign patterns, colours and fonts to the graphics by **double-clicking any graphic in the layout**
3. **Choose the style** you like from ArcView's Symbol Window

When you have pasted all the graphics you want into the layout, you can use a number of different tools to arrange them as needed. Among the actions you can perform on layout graphics are the following: align, bring to front, group.

The Shenyang Air Quality poster (on the EMIS CD) gives you an overview of the possibilities.

Exhibition: How to prepare a city/national panel

The city/national panels are multi-purpose and can be used in various ways, including:
1. For display in the Programme offices
2. As a means for sharing programme information with other projects and with partners
3. For exchange of panels between different projects
4. For the exhibition at SCP/LA21 Global Meetings

These notes provide guidelines on preparing an SCP/LA21 City/National Panel based on the design of the templates that can be found on the EMIS CD. Examples of other SCP city and country panels prepared for the Global Meeting in Havana in July 2005 are also included on the EMIS CD. The panel templates are of a fictitious city - Saripo and country - SKIMA. The Kenyan map has been used for illustrative purposes. These notes are intentionally quite detailed to help those who may not be too familiar with PowerPoint.

Before you start:
1. **Make a copy of the template** so that the original template remains intact. Give your template copy a different name, and use it as your working document.
2. **Make a printout of the template** to guide you as you work on your panel.

Text changes
Please do not change the sub-headings. Take care not to delete all the text in the text box, as you may lose all the formatting, i.e. bullets, font size etc. Remember to save your work as you go along.

Each paragraph is enclosed in a text box. Change the text step-by-step as indicated below:

1. Place the cursor at the point at which you wish to insert your new text.
2. Type in the text.
3. Then highlight the unwanted text from the template and delete it.
4. Go to the next point and repeat these steps.

City/Country Name - text box

In this text box, insert your city's name by replacing 'saripo city' with your city name. (If you are preparing a country panel, replace 'Skima' with your country name.) To do this:

1. Place the cursor at the S and type in your city name.
2. Then delete 'saripo city'.

Concerns/Priority issues - text box

In this text box, list the key concerns and priority issues of your city/country. Keep the text short and clear. These issues will probably have been articulated in the Environmental Profile.

1. List a maximum of 4 issues.
2. Insert the appropriate text and delete any unused bullets.

Programme Activities - text box

In this text box, list the key activities of the programme. Focus on activities that have taken place or are currently taking place. List a maximum of 4 issues.

Up-Close - text box

This text box provides each city/country with an opportunity to share something unique. It could be a new insight, a lesson learned or a challenge overcome. The experience should relate to one of the key programme activities mentioned in the Programme Activities box. A photograph should be included to illustrate the experience. This box should have a maximum of 100 words.

City/Country Background - text box

In this box, give a brief description of the city/country. You may focus on one or two of the following: its geographic, economic, political, social or historic importance. The population and growth rate should be given in figures under the population sub-heading. List the key economic activities of your city/country under the appropriate sub-heading. For the country panel, list the cities participating in your programme. This box should have a maximum of 70 words.

Key Partners - text box

If possible, write out the organisation names in full. List up to four key partners.

Contact Address - text box

This box is important. Please provide complete contact information. Avoid giving names of individuals as these change over time. The box should contain the following information:

- Title of contact person
- Programme name
- Postal address
- Street address (if relevant)
- City, city code
- Country
- Telephone number
- Fax numbers
- Email address
- Web site

Date Printed - text box

Finally, update the 'date printed' box to reflect the correct date (month and year) when the panel was printed.

Graphics

1. Photographs

The top part of the panel is designed to hold 4 photographs. These should be photographs depicting some of the different faces of your city/country. These could include a skyline, a famous landmark, and pictures illustrating some of the city's/country's priority concerns. Because the template is produced in A4 size, and will have to be enlarged during printing, it is important that the pictures used should be in high resolution. The image size should be at least 3000 x 2400 pixels. Images should be 1.08 inches (2.74 cm) high. Arrange the images equally in the space provided. Do not distort the image.

2. The arrow

The arrow is a timeline that represents some of the key dates of the programme. It has space for up to 5 key dates. The first marker could be the city consultation. Think carefully about which dates you would like to include. If possible, relate the arrow to the Programme Activities box. Be

careful while editing the arrow because there are many text boxes around it. Be careful not to distort the shape of the arrow.

For ease, start editing the arrow from the left.
1.   First, edit the date and then the corresponding activity.
2.   Once you have finished inserting the key dates, delete any unused markers.
3.   You may need to realign the markers on your arrow. To do this: Click on the item you want to realign and move it in the desired direction.

3.   Country map

In this space, insert a recent map of the country, pinpointing the city, or cities if relevant. If it is a city panel, you may use a map of the city. Select an outline map of your country/city. The map should be approximately 1.5 inches high (3.81 cm) to fit in the space provided. Do not distort the image
1.   Scan and save the map on your computer.
2.   Copy and paste it into the panel.
3.   Mark the position of the city or cities with bullet points.
4.   Create a textbox next to the bullets and type in the city/country names.

Printing

Once you have completed your edits and saved your work, you are ready to print a copy of your panel in A4 size. Make sure that the print settings are appropriate.
1.   On the main menu bar, **select File**, go to **page setup.**
2.   Under **'slides sized for'**, select paper size A4.
3.   Confirm that paper size orientation is **Landscape.** Exit.
4.   On the main menu bar, **select print**
5.   Go to **print properties**
6.   Click on **graphics**. Under **resolutions,** select 300 dpi (dots per inch). Exit.
7.   Print one copy.

Read through and edit the panel. Print another copy to confirm that you have corrected everything. Now you are ready to print the larger panels. Unless you have a large plotter, you will have to take your panel to a commercial print shop or to a partner institution for the production of the A1 and A2 panels. When you visit the print shop, take an electronic copy (and an A4 hard copy) of the panel. Take these notes along with you because the technical details below – particularly the colour settings - may be required by the print shop.

Technical Details

1.   Package
The template has been designed using Microsoft PowerPoint.

2.   Fonts
Only two different fonts are used: Arial and Comic Sans MS.

Regular text: Arial 11 pt, Normal, Font colour Black.
Headings: Arial 12 pt, Bold, Font colour Beige.
The Arrow: Arial 8pt, Normal, Font colour Black
City/Country Name: Comic Sans MS 54 pt, Normal, Font colour – paper

3. Colour settings
Headings: (beige) Pantone 465 CVC (RGB R 210 G 164 B96 Hue 25 Sat 143 Lum 153; CMYK 18% 30% 56% 0%)
The Arrow, Border Strip and text box borderlines: (blue) Pantone 2645 CVC (RGB R 147 G131 B191 Hue 181 Sat 81 Lum 161; CMYK 43% 38% 0% 0%)

4. Paper Layout
Landscape
5. Panel Size
Template: Designed in A4 size (29.7cm high x 21.0cm wide/ 11.69in high x 8.27in wide)
Final panels: Print your panels in two sizes:
A1 (84.1cm high x 59.4cm wide / 33.11in high x 23.39 in wide) – This is a large panel and is appropriate for large exhibition displays. Print 2 or more copies.
A2 (59.4cm high x 42.0cm wide / 23.39in high x 16.54 in wide) – This is a medium sized panel. It is appropriate for putting up in offices. Print 5 or more copies.

Web site development

Web Site Goals
Before you begin, decide whether or not it would be helpful for the project to have a web site in the first place. Make a quick analysis of what is feasible and what is not possible and decide on who you want to reach, and how.

Materials Checklist
Gather the materials necessary for designing and administering the site. Also, have all the data you gathered close at hand.

- HTML editing software (for example, Netscape Composer or HTMLed)
- Image editors (Adobe PhotoShop, MS Photoeditor or others)
- Browsers (for example, Netscape, Internet Explorer or Mozilla Firefox)
- Flowchart programmes (for example, in MS PowerPoint)
- Pencils
- Paper

Gather Information
The next step is to collect data and information. Compile notes, maps, reports, charts, pictures, and all the other material you think you will need for the web site. Discuss the content of the site with the Mapping Group and with the EPM team. You will probably find a wide range of opinions and ideas, which is why it is particular important to remember just what a web site needs, and what it can and cannot offer in terms of maintenance needs and outreach ability.

Sitemap

There are several ways to go about designing a site layout. An effective way is to sketch out the site on paper. It can be useful to make a flowchart-like layout. It allows you to view the site as a whole and to identify any structural problems. Next, you rough out the actual content of the web pages. You may find yourself going back and forth between this and the overall layout design in order to make everything work well. You will decide where information goes and how it looks as well as positioning images, charts, graphs, etc. You should have a good idea of the structure before you do any coding so make sure the layouts are thorough. Remember that the information structure has to be easy for a casual reader to navigate through, and that download time must be kept to a minimum. A slow and confusing site doesn't get many return visits.

This flowchart indicates the site layout of the EMIS Tool on the Sustainable Cities Website.

Content of the Website
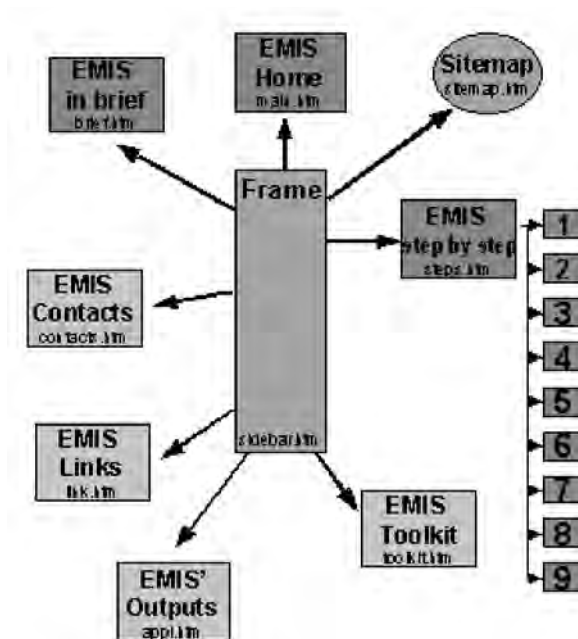
The website should provide precise and up-to-date information in a lively and interesting way. To avoid overloading it the information should be limited to one A4 page maximum. The following guideline helps you to describe the SCP/LA21 programme on local level. Basically, the information should be structured in three parts:

Technical Information

1. descriptive text
2. images
3. attached documents for download

Questions are provided below for each part. It is not necessary to answer all the questions, but they will give you an idea what to write about in the different sections. Try to give a general overview of the project in your city and write in an easy understandable way.

1. **Short presentation of the city (max. 70 words) + 2 images**
   - Geographical location
   - Important historical events in your city
   - Urban structure and political context
   - Economic activities

Image 1: Map of the city/ location of the city in its country
Image 2: Picture of the key element of the city (monument, tourist sites)

2. **Short description of the project (50-70 words)**
   - Why was this project initiated?
   - When did it start?
   - What are the main environmental problems identified in the city?
   - What are the main objectives of the programme?
   - Who are the stakeholders involved in the project?
   - Duration of the programme?

Image 3: Area of intervention showing a specific problem

3. Short presentation and description of the Environment Profile (EP) (max. 70 words)
   - How was information gathered?
   - How were problems identified?
   - Which strategies were prioritized for analysis?
   - How were the strategies developed?

Image 4: one of the city's priority environmental concerns
Document: Environmental Profile (PDF version).

4. Short presentation and description of the City Consultation (max. 100 words)
   - Place and date
   - Number of participants
   - Context of the consultation
   - How were the different discussion forums arranged?
   - How were the environmental issues identified and prioritized?

- How were strategies defined?
- What were the final commitments?

Image 5: Photo of the city consultation
Document: Summary of the consultation i.e. Urban Pact (PDF version)

5. Short presentation of the Working Groups and demonstration projects (50-70 words)
    - Have demonstration projects already been implemented? If yes, which?
    - What kind of problems arose?
    - How could you solve these problems?
    - How was the implementation executed?
    - Who participates in the Working Groups and the demo projects?

Document: Demonstration projects, strategy and action plans (PDF version)

6. Other documents produced (articles, leaflets etc) (max. 100 words)
-       Which documents reflect the commitments?
-       Which evaluation documents were produced?
-       What kinds of documents were produced for information outreach?

7.   Up-Close. Short description of a particular experience
It would be interesting to get an insight in a particular experience or important moment of the programme implementation.

Pictures: The size of the images should be around 100 px by 100 px. However, in order to increase the quality they can be a maximum of 200px by 200px resolution.

Tool 28: Mapservers

How to build up a mapserver
- MapServer Technology
- What is the UMN MapServer?
- The MILES MapServer Application

MapServer Technology

Standard geodata output consists of maps plotted on paper. However, these plotted maps are expensive, and can only be used with small groups in single locations, due to their physical nature. In addition, map printouts are only up-to-date only for a limited time. Web-GIS solutions such as the UMN MapServer can complement plotted maps and overcome their local and temporal limitations. They allow virtual maps to be made available to the general public on the internet, maps which can be updated whenever necessary.

Web-GIS allows the user to open a dynamic map in a web browser. The user can then zoom, pan, or select certain regions to examine the background data. (see figure 1 below for an example: mapserver_unhabitat_map.jpg). Web-GIS uses server-side architecture together with a wWebsServer programme (for example, the open source programme Apache wWebserver).
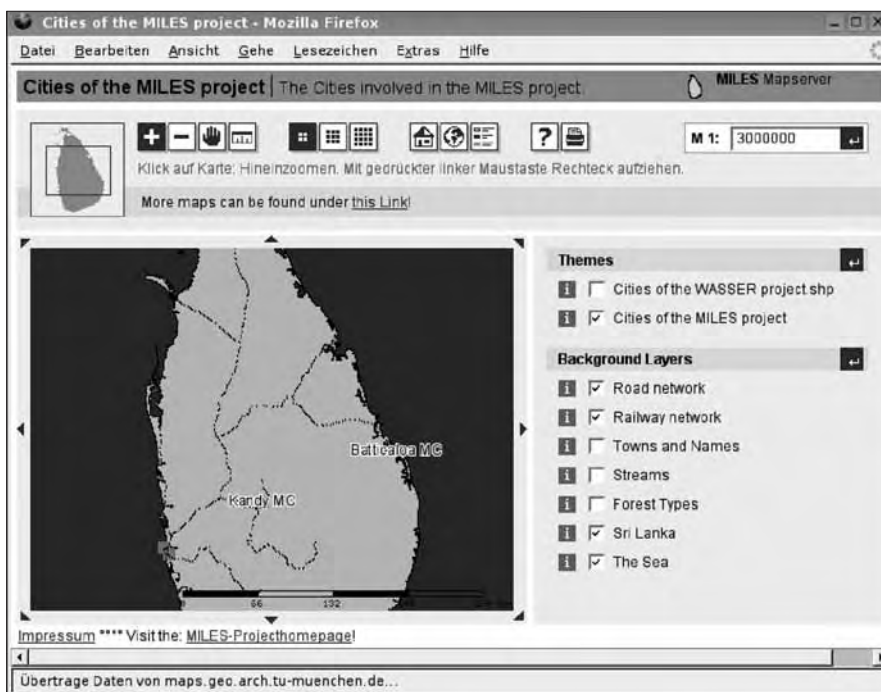

Figure: A MapServer Application (the MapServer of the EU-Project MILES)

What is the UMN MapServer?

The UMN MapServer is an open source development environment for building internet applications with dynamic maps. The UMN MapServer was originally developed by the University of Minnesota (UMN).

The UMN MapServer programme is a CGI-script programme (Common Gateway Interface) which interacts with ais called by the web server (here Apache Web Server) to produce certain outputs for the client. The server passes requests from a client web browser to the external application, and the web server then returns the output from the application back to the web browser. Whenever a request to a matching URL is received, the corresponding programme is called, including any data that the client has sent as input. Output from the programme is collected by the wWeb server, augmented with appropriate headers, and sent back to the client.

Up-to-date and accurate delivery of geographical information can thus enable a new dimension of quality in decision making. In short, the advantages of the UMN MapServer application are:
- Inclusion of all user groups: The maps can be viewed with any browser, regard less its manufacturer or basic operating system. Thus, geospatial data is made available for nearly everybody.
- A MapServer is platform-independent.
- Viewing MapServer maps does not require expensive desktop GIS-software.
- Maximum security for the data: No raw data, but only rendered pictures are transported through the internet. This excludes improper usage of protected geodata
- Optimization for slow connections: Carefull compression and specially selected image format yields small and fast-loading map pages.
- The OGC standards conformity of the UMN MapServer ensures its functionality in a spatial database infrastructure (SDI)

The UMN MapServer Software is available for various Operating Systems, including UNIX/Linux, Microsoft Windows and MacOS. The minimum configuration requires some extra libraries/programmes like Apache, GD and shapelib, and additional functionality can be added to the MapServer with the packages FreeType, Proj.4, GDAL/OGR and many more.

The MILES MapServer Application

The EU MILES project (Managing Information for Local Environment in Sri Lanka) uses a mixture of proprietary and free/open source software for its internet map service. The standard desktop GIS ArcView 3.2 (TM ESRI) is used to produce basic geodata. At this stage the map projection and the map units have to be set correctly. The data files are transferred to the MapServer. Using standard shapefiles or tif rasters, no conversion of the geodata is needed.

A forms-based web interface allows the user to select basic settings such as classes, colours and scale ranges from the ArcView map for the MapServer, and enables the setting of special properties that are applicable only for internet usage (see figure 2: the interface, MapServer_unhabitat_frontend1.jpg).
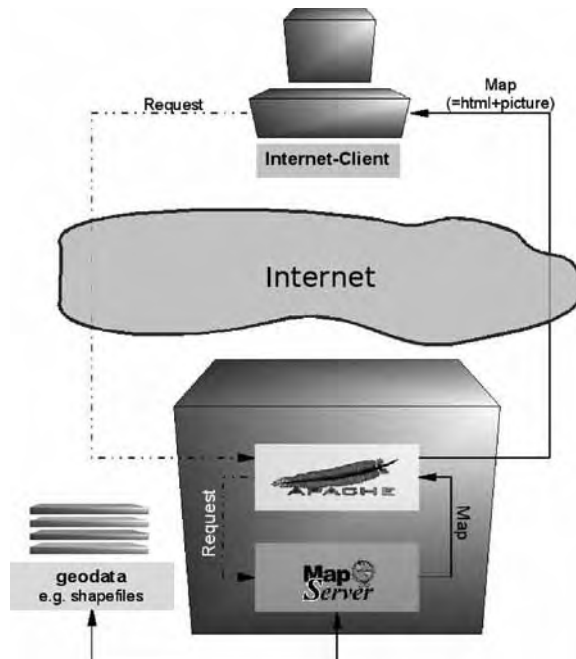
Figure :The web-based form for creating maps

All map definition work is done over an encrypted connection to protect the administration forms. The UMN MapServer is integrated into the Apache web server by means of standardized interfaces. It is connected to a file or database repository of all the relevant geodata.

Whenever a client in the network asks for a map, the MapServer reads the geodata and creates an image file of the requested area and layers. This image file is embedded in an html page with further information such as the map legend, together with functional elements for zooming or searching. It is then served to the client (see figure 3: mapserver_unhabitat.jpg;)
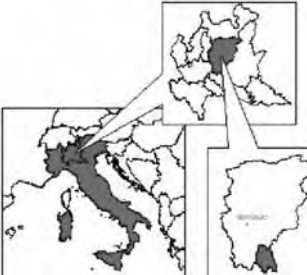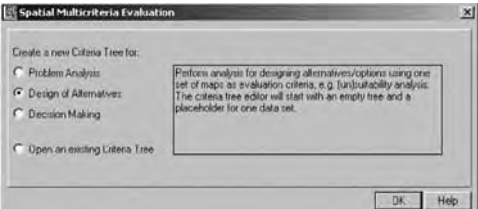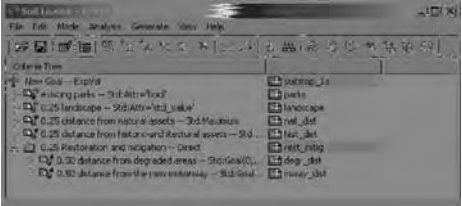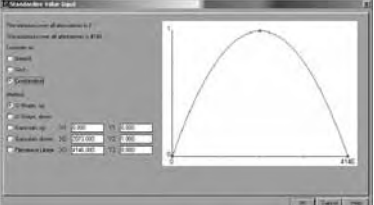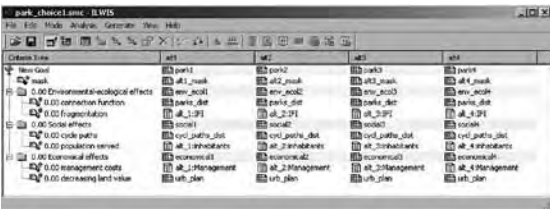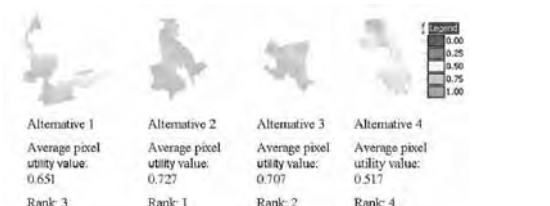
Tool 29: Spatial planning or decision support system

How to use EMIS as a planning and decision support system
- The spatial multi-criteria evaluation (SMCE) module in the Integrated Land Water Information System (ILWIS)

The spatial multi-criteria evaluation (SMCE) module in the Integrated Land Water Information System (ILWIS)

	The province of Bergamo in Northern Italy wants to halt urbanization processes by creating regional parks. A large number of spatial and non-spatial criteria are to be considered by stakeholders who structure trade-offs differently.
	The province of Bergamo in Northern Italy wants to halt urbanization processes by creating regional parks. A large number of spatial and non-spatial criteria are to be considered by stakeholders who structure trade-offs differently.
	A simple example of a criteria structure consists of a number of constraint maps such as location of existing parks, objectives such as restoration and mitigation and criteria maps such as distance from a new motorway.
	The values (e.g. distance or property values) and classes (e.g. land use) in maps are interpreted by planners and decision makers. For instance an optimum distance may exist.
	In the resulting evaluation map the more suitable locations are used in the design of four alternative parks

	Then we change from the design of alternatives mode to the decision making mode in which we can compare the four different parks. This time other, for instance less technical and more political criteria can be considered.
Alternative 1 — Average pixel utility value: 0.651 — Rank: 3 Alternative 2 — Average pixel utility value: 0.727 — Rank: 1 Alternative 3 — Average pixel utility value: 0.707 — Rank: 2 Alternative 4 — Average pixel utility value: 0.517 — Rank: 4	The four alternatives were ranked, where good and bad performing areas could be distinguished as well as overall performance of the alternatives. Decision makers were able to consider and structure large volumes of information and communicate their concerns.

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Tool 30: Backing up the EMIS

How to ensure the safety of the EMIS data
•   Why back up data?
•   What media to use for backups
•   Backup schedule
•   Backup software

Why back up data?

The EMIS data is valuable. It will cost you time and effort to re-create it, and that costs money; sometimes it isn't even possible to recreate the data. Since EMIS data is an investment, you should protect it and take steps to avoid losing it.

Computers are fast, accurate, and indispensable: however, this is an imperfect world, and things can still go wrong. There are basically four reasons why you might lose data: hardware failures, software bugs, human action, or disasters such as fire.

It is recommended that you back up the entire EMIS regularly. When a backup is performed, an exact copy of the system is copied onto a backup medium in compressed format (depending on the backup system). However, like everything else in the physical world, backups will fail sooner or later (physical depletion of the backup media over time).

What media to use for backups

The most important decision regarding backups is the choice of backup medium. You need to consider cost, reliability, speed, availability and usability. Several media can be used to back up data:

•   **Hard disks**
     are generally used for backups in networked systems: the data is copied from the workstation's local hard disk to a file server. You can also install a second hard disk (slave) in your computer and copy your files from the master hard disk to the slave. Size: up to 40 GB

•   **Floppies**
     are the cheapest medium, fairly reliable, very available, but unsuitable for large amounts of data. The software used is the MS Windows internal Backup System. Size: up to 1.4 MB.

•   **Zip-Drives**
     work like floppy drives but use media with more storage space. They can be fairly expensive. The accompanying software usually includes backup schedulers. Size: up to 250 MB.

- **Tapes**
  range from cheap to somewhat expensive, are very reliable, and quite available,. Access to individual files is slow. Internal and external tape drives are available. The accompanying software usually includes backup schedulers. Size: up to 3 GB.

- **CD-ROMs**
  are becoming more popular as backup media. Recordable CD-ROMs are cheap and easily available. Internal and external CD-ROM writers are available. The rate of copying failures is still quite high (approximately 30%, depending on the copied files, network interruptions of hard disc activities during copying). Size: up to 700 MB.

Backup schedule

Back up as much as possible. The major exception is software that can be easily reinstalled, but even software may have configuration files that are important to back up, lest you need to do all the work to configure them all over again. The obvious items to back up are user files and system configuration files.

A simple backup scheme is to back up everything once, and then to back up everything that has been modified since the previous backup. The first backup is called a full backup, the subsequent ones are incremental backups. A full backup is often more laborious than incremental ones, since there is more data to write to the tape and a full backup might not fit onto one tape (or floppy). Restoration can be optimised so that you always back up everything since the previous full backup: this way, backups take a bit more work, but you should never need to restore more than a full backup and an incremental backup.

If you want to make backups every day and have six tapes, you could use tape 1 for the first full backup (say, on a Friday), and tapes 2 to 5 for the incremental backups (Monday through Thursday). Then you make a new full backup on tape 6 (second Friday), and start making incremental ones with tapes 2-5 again.

> **Note:** You don't want to overwrite tape 1 until you've got a new full backup, in case a disaster happens while you're making the new full backup. After you've made a full backup on tape 6, you should keep tape 1 somewhere else, so that if your other backup tapes are destroyed in a disaster, you still have at least something left. When you make the next full backup, you use tape 1 and leave tape 6 in its place.

For more heavy-duty use, multilevel backups are more appropriate. The method has two backup levels: full and incremental backups. This can be generalised to any number of levels. A full backup would be level 0, and the different levels of incremental backups levels 1, 2, 3... At each incremental backup level you back up everything that has changed since the previous backup at the same or a previous level.

The purpose for doing this is that it allows a longer backup history. In the example given in the previous section, the backup history went back to the

previous full backup. This could be extended by having more tapes. A longer backup history is useful, since deleted or corrupted files are often not noticed for a long time. Even a version of a file that is not very up to date is better than no file at all.

With multiple levels, the backup history can be extended. For example, if we buy ten tapes, we could use tapes 1 and 2 for monthly backups (first Friday each month), tapes 3 to 6 for weekly backups (other Fridays; note that there can be five Fridays in one month, so we need four more tapes), and tapes 7 to 10 for daily backups (Monday to Thursday).

Further readings:
http://electron.phys.dal.ca/SAG/node96.html
http://www.iesco.com/backup.htm

Please also consult the manual of your backup system or refer to the tutorial or help function of the installation software.

Backup Software:

Backup Software included in Windows XP
How to back up your data is explained on http://www.argentuma.com/backup/software/windows-backup.html

Genie-Soft Back-up Software
Runs on Windows XP, Windows 2000 Professional, Windows NT Workstation 4.0. US$49.95 Home edition, US$69.95 Pro Edition. A free downloadable trial version is included on the EMIS CD.
http://www.genie-soft.com/products/gbm/default.html?AfID=13778,
Software review:
http://www.backup-software-reviews.com/review-genie-backup-manager.htm

New Tech Infosystems ("NTI")
Runs on Windows 98, ME, 2000, XP, US$ 69.99 (full version). A downloadable trial version is available on the web site, in various languages (English, French, Spanish, Chinese), a free trial version is available (registration necessary)
http://www.ntius.com/default.asp?p=backupnow/bun_main, Software review: http://www.backup-software-reviews.com/review-nti-backnow!.htm

Handy Back-up
Runs on Windows 95, 98, ME, 2000, NT, XP, US$ 30, no free trial version available. http://www.handybackup.com/?AfID=13778
Software review:
http://www.backup-software-reviews.com/review-handy-backup.htm

Argentum Back-up software
is available on the Argentum web site. Price US$ 25, runs on Windows 95, 98, ME, NT, 2000, XP and 2003. A free trial copy is also available on the web site, and is included on the EMIS CD. http://www.argentuma.com/backup/software/windows-backup.html

Tool 31: Training

How to organise and structure training for EMIS
- Example of a training organised by the local Sustainable Cities Project Team in Ibadan, Nigeria
- Example of Training of Trainers (ToT) on Environmental Management Information System (EMIS) (training material on EMIS CD-ROM)
- Example of training schedules for EMIS (Tool 31a on EMIS CD-ROM)
- Addresses for GIS and EMIS training courses

Example of a training organised by the local Sustainable Cities Project Team in Ibadan, Nigeria

TThe introduction of Geographic Information Systems (GIS) to management practices requires a comprehensive training programme that pays significant attention to issues of technological and personnel development. Such a training programme should also address decision-making and the allocation of responsibilities.

Three proposals on workshops and training, targeted at two broad classes of persons, were made for sensitisation and for initial capacity building. The first class of persons were senior level government officials who needed to be aware of the role GIS plays in decision-making and who could be influential in assisting its adoption. The second group of persons to whom a workshop was targeted consisted of middle level staff and of persons for whom a GIS facility might actually be established. Training for capacity building was targeted at those considered most likely to need to install GIS facilities within the next couple of years.

First Sensitisation Workshop
The aim of the Workshop was to sensitise the top level of management of government offices, parastatals and international donor agencies on the role of GIS in the management of the urban environment, and thereby to stimulate their interest in developing GIS facilities in relevant offices of government. The objectives were:

1. to provide a down-to-earth description of what GIS is and to show the relationship between GIS, the formulation of action plans and the attainment of sustainable management of the urban environment;
2. to demonstrate the potential uses of GIS in local level planning in the development of action plans for environmental management.

The Workshop was a one-day event. It was attended by sixty participants drawn from a cross-section of the stakeholders in the Ibadan environmental development process.

Second Sensitisation Workshop

A two-day sensitisation workshop on GIS was organised by the Sustainable Ibadan Project. It was a follow-up to the previous workshop. Participants consisting mainly of people selected from the staff of the eleven Local Governments in Ibadan Metropolis, Oyo State and federal government parastatals, as well as people from the private sector. In all, 54 participants attended this Workshop.

The aim of the Workshop was to demonstrate GIS and stimulate the interests of potential operators and users of the GIS facility. In order to do this, the following objectives were defined:

1. provide a down-to-earth description of what GIS is and show the relationship between it, the formulation of action plans and the attainment of a sustainable management of the urban environment
2. demonstrate potential uses of GIS in local level planning in the development of action plans for environmental management
3. teach basic principles of using GIS for the purposes of map production, illustration and decision-making.

The Workshop was organised on the basis of four major themes that pervade the use and application of GIS. The themes were
(a) The Creation for Spatial Databases
(b) Map Making
(c) Analysis involving Overlays and Queries, and
(d) Planning Applications.

Each theme ran for the two days with the aim of allowing participants to acquire a reasonable grasp of the issues involved in GIS in general, and in the pursuit of the themes in particular. The discussion of the themes was preceded by an introduction to the scope and content of GIS.

The approach adopted by the Workshop involved meetings at plenary sessions and in smaller groups. For the smaller group meetings, participants were divided into four groups and each group was assigned to the themes in sequential order. During the two-day Workshop, the themes were pursued in four presentations, each of approximately two hours. The presentations started with a description of the theme, and then an explanation of its theoretical and conceptual basis. This was then followed by a demonstration of how the theme could be made operational. Some time was then given to participants to try their hand at the process.

In order to facilitate the interaction of participants with the facilitators and GIS equipment, four computer systems were provided, all of them equipped with GIS peripherals such as digitizers and printers. Different GIS software were also loaded into these computers for practical demonstrations of the utilities of GIS in decision-making and planning.

Initial Training and Capacity Building Workshop

The objective was to train a small group of key core people from the Sustainable Ibadan Project, the UNICEF Zonal Office, and certain key government offices, who would be able to operate the system. The focus was on training trainers. The Workshop lasted one week. The audience was made up of sixteen persons from various agencies of government.

The aim was to provide core persons with knowledge of the application of Geographic Information Systems. Given the newness of GIS in the planning and development pricess, such training as presently practicable within the SIP can at best be described as basic. The training is basic from two perspectives. First, it is necessarily an elementary introduction to what GIS is and secondly, it can only strive to teach the basic principles. GIS is a constantly expanding subject that continues to benefit from developments in information technology, computer science, geography and spatial analysis. Furthermore, much longer periods of training and practice are required than are ordinarily available for this type of exercise. Consequently, this training programme cannot supplant more formal training programmes.

Example of Training of Trainers (ToT) on Environmental Management Information System (EMIS)

The Sustainable Cities Programme (SCP) conducted the first Training of Trainers (ToT) on EMIS (Environmental Management Information System) from 21 to 23 November 2006 at the UN-headquarter in Nairobi. The workshop highlighted the linkages between the SCP's environmental planning and management approach (EPM) and EMIS. Furthermore, it aimed to enable the participants to hold their own training sessions on EMIS addressing local decision-makers, municipal council staff and stakeholders. The training of trainers consisted of an introduction to GIS (Geographic Information Systems) and five modules describing the linkages of EMIS to the EPM steps (EMIS and Environmental Profile, EMIS and City Consultation, EMIS and Working Groups, EMIS and Strategies and Action Plans, and Maintaining EMIS).

The official invitation included the timetable of the training session and background information on EMIS in order for the participants to prepare themselves. Requirements for participating in the EMIS ToT were basic knowledge of ArcView/ ARC GIS and understanding of the EPM approach. Nevertheless, Participants' knowledge about GIS ranged from over ten years to just three weeks. This was similar with EPM and EMIS: some had only heard about it from the website recommended for course preparations and others had already been involved in SCP cities and EPM City Consultations. This wide range of knowledge made it difficult to find the right pace for the workshop without overwhelming or boring individual participants.

Regarding the content of the Training of Trainers Session, a couple of PowerPoint presentations were prepared as well as detailed exercises for the five modules. The PowerPoint presentations, exercises and data for the exercises was compiled on a CD-ROM and in a training manual handed-out to the participants.

E MIS Training of Trainers – Modules

First Day

11.00 – 12.30   **Introduction to course – 1 hour**

Participants	interactive	20 min		list, addresses
Objectives	lecture, interactive	5 min	Flipchart	objectives
Programme	lecture, ppp	15 min	computer, projector	ppp – with notes, agenda
Rules and practical information	interactive	10 min	Flipchart	
Practicalities, organizational infos	interactive	10 min		

Lunch Break—1 hour

13.30 – 14.30   **Introduction to E MIS – 1 hour**

EPM - information needs	lecture, ppp	20 min	computer, projector	ppp, - with notes
EMIS – theory and praxis	lecture, ppp	30 min	computer, projector	ppp, - with notes
Questions, remarks, clarification	interactive	10 min		

14.30 – 17.30   **Introduction to GIS – 3 hours**

GIS – in urban planning and management	lecture, ppp	20 min	computer, projector	ppp, - with notes
GIS – methods, concepts, data sources, software, hardware	lecture, ppp	50 min	computer, projector	ppp, - with notes
Coffee/Tea Break – 15 min				
Introduction exercise ArcView GIS	computer, tutorial	90 min	computer, tutorial	
Questions, remarks, clarification	interactive	15 min		

Addresses for GIS and EMIS training courses

International Institute for Geo-Information Science and Earth Observation (ITC), Hengelosestraat 99, P.O. Box 6, 7500 AA Enschede, The Netherlands; http://www.itc.nl/
ITC provides a wide range of GIS training courses, both short-term and long-term. Sponsorships are available.

UCLAS – The Geo-Information Centre (GIC), P.O.Box 35176, Dar es Salaam, Tanzania; Tel: +255-22-2775004; Fax: +255-22-2775391 or 2771272; uclas@uclas.ac.tz; http://www.uclas.ac.tz/cict.html
UCLAS provides standard and tailored training courses in GIS and EMIS for people from the Eastern and Southern African region. Limited sponsorships are available.

Web addresses for on-line training courses in GIS in general

ESRI Software
ESRI Virtual Campus, self-paced GIS Education in the World-Wide Web; several courses are for free, http://campus.esri.com/
ESRI Software Training; contact local providers.
http://www.esri.com/training_events.html

ESRI E-mail lists offer you support from fellow ESRI users. E-mail Lists-ArcView-L and ESRI-L are available.
http://forums.esri.com

In this dictionary terms are collected from ESRI software documentation and various course materials.
http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway

ESRI Virtual Campus - Course Catalog GIS Applications Courses:
http://campus.esri.com/acb2000/Category.cfm?&DID=6&CATID=83&CFID=3340433&CFTOKEN=17705714

USGS - Planetary GIS Web Server:
http://webgis.wr.usgs.gov/gis_tutorials.htm
US Geological Survey Collection of links to tutorials for ArcView and ArViewIMS.

ESLARP - East St. Luis Action Research Project:
http://www.eslarp.uiuc.edu/egrets/tutorials/
Contains ArcView and ArcMap tips and techniques

USGS Education - Trainings in ESRI Shape Format:
http://rockyweb.cr.usgs.gov/outreach/giseduc.html
Free downloads of Training Units on various topics. ESRI Shape Format.

ArcView Avenue:
http://www.sandia.gov/GIS/tech/avcsus.htm
Introduction to Scripting in Avenue.

Programming in Avenue:
http://web.mit.edu/gis/www/demclass/scripts.html
Short exercises on programming in Avenue for ArcView

Map Maker Tutorials
http://www.mapmaker.com/documents.htm
Downloadable tutorials and technical papers about Map Maker.

IDRISI Research Center Salzburg:
 http://www.sbg.ac.at/geo/idrisi/wwwtutor/tutindex.htm
Detailed tutorials about working with the IDRISI GIS.

GIS in general
Geocommunity - Educational Material:
http://spatialnews.geocomm.com/education/
Provides links to educational GIS material and college listings.

Web addresses for on-line training courses in GIS in general
ESRI Virtual Campus, self-paced GIS Education in the World-Wide Web;
several courses are for free, http://campus.esri.com/

ESRI E-mail lists offer you support from fellow ESRI users. E-mail Lists-ArcView-L and ESRI-L are available.
http://forums.esri.com/community/community.cfm

Tool 32: A budget for EMIS
What does an EMIS cost

Buying all the hardware, software and data to set up an EMIS costs a lot of money. You must also keep in mind that even after your EMIS office is fully equipped, you still have to spend a reasonable amount of money on hardware and software maintenance. Your computer or printer might break down. If you cannot identify the problem yourself, you have to have funds available to pay computer consultants to fix the problem. In some countries, the spare parts needed might not be available. When buying hardware, try to make sure that the hardware brands are available locally so that you will be able to get replacement parts for your hardware easily. You may also need to update your software or buy additional or up-to-date data after a while. Funds have to be available for this too.

Many EMIS units manage to equip their office but don't have enough funds left to fix the first problems that arise after they start to use their equipment. The table below gives you a broad idea how much the set-up and maintenance of an EMIS unit will cost. The prices in the column on the left refer to the US market. Unfortunately, due to high taxes in many developing countries, the prices given (found in the internet) may not reflect the real price situation in your country. The example of Kitwe, Zambia given in the middle column underlines this. The empty column on the right can be use to calculate the funds needed to set up and maintain the EMIS in your city/ country.

	General costs	**Example Kitwe, Zambia**	**Your city**
1. EMIS set-up (hardware)	**US market prices**		
DATA COLLECTION			
Digitiser	A3: US$ 600; A0: US$ 3,000	Not yet acquired	
GPS Global Positioning System (i. e. **Garmin eTrex**)	US$ 100-300	Not yet acquired	
Digital Camera (i. e. Sony)		US$ 920.00	
Scanner A4 or A3 flatbed Scanner (i. e. HP)	US$ 100-200 (A4)	US$ 1,254.30	
PROCESSING			
Computer #1 (HP Compaq dc7600, Windows platform, Microsoft Office 2003 software included??)	US$ 1,558.25 (Nairobi)	US$ 2,717.40	
Computer #2 (HP Compaq dc7600, Windows platform, Microsoft Office 2003 software included??)	US$ 1,558.25 (Nairobi)	Only one computer	

	General costs	Example Kitwe, Zambia	Your city
OUTPUT DEVICE			
Plotter A0 Inkjet colour plotter (HP DesignJet)	US$ 5,000 – 7,000	Not yet acquired	
Printer A4 Inkjet colour printer (i. e. HP DeskJet)	US$ 130	US$ 1,108.70	
LCD-Projector for Presentations		Not yet acquired	
2. EMIS set-up			
Operating system (Windows NT if networked)	Included in computer price	US$ 1,835.30	
Office software (i. e. MS Office 2000, XP)	Included in computer price	Included in computer price	
GIS Software (ESRI ArcView 9, MapMaker Pro)		Not yet acquired	
Image processing Software? (Adobe Photoshop or MS Photo Editor part of MS Office?)	MS Photoshop part of MS Office	Not yet acquired	
Database software (MS Access part of MS Office, Oracle)	MS Access part of MS Office	Not yet acquired	
Internet Browser, Mozilla Firefox)	(Internet Explorer part of MS Office)	Not yet acquired	
Backup Software		US$ 760.87	
3. EMIS set-up		**Spatial data**	
Satellite Image	Nairobi (800 km2): Quickbird resolution 0.6m, 22US$/km2 = 18,000 US$ Ikonos 1m resolution, 9US$/km2 = 7200 US$ SPOT 5: 1200.50 Euros	Not yet acquired	
Spatial data			
4. EMIS Set-up		**Office Equipment**	
Tables, chairs		US$ 2,174.00	
Map filing cabinet		Not yet acquired	
Light table		Not yet acquired	
Total costs for EMIS set-up			
5. EMIS maintenance		**Costs roughly per year/ month?**	
Hardware repair		US$ 1,304.35	
Software maintenance (contract-based?) fee			
Spare parts?			
New spatial data			

	General costs	Example Kitwe, Zambia	Your city
4. EMIS Set-up		**Office Equipment**	
Tables, chairs		US$ 2,174.00	
Map filing cabinet		Not yet acquired	
Light table		Not yet acquired	
Total costs for EMIS set-up			
5. EMIS maintenance		**Costs roughly per year/ month?**	
Hardware repair		US$ 1,304.35	
Software maintenance (contract-based?) fee			
Spare parts?			
New spatial data			
6. Staff		**Costs per month**	
EMIS Officer		US$ 1,052.00	
EMIS Assistant 1 EMIS Assistant 2 Consultant to enter data? Other staff Technical Support Unit Office rent		US$ 1,052.00 Not yet engaged	
Total costs for EMIS maintenance per month/ year			
		US$ 1,304.35	

Reference 1: Further Reading

Helpful books on GIS and EMIS

The documents that will be most important to you are the handbooks which accompany your GIS software. For example, ArcInfo, ArcView GIS and Mapmaker Pro software each have very detailed handbooks which explain GIS in general and the specific software programme in particular. In addition, the following list of publications will be useful.

Bannur, A.B.B. (1995): Designing a Geo-Information System to Support City Planning and Management Functions in Dar es Salaam City Council, Tanzania, Enschede.

Belward, A.S., Valenzuela, C.R. (Editors) (1991): Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries, Kluwer Academic, Dordrecht, The Netherlands.

Burrough, P.A., McDonell, R. (1998): Principles of Geographic Information Systems, Oxford University Press, Oxford, UK.

Campbell, H., Masser, I. (1995): GIS and Organisations, Paperback, Taylor & Francis. ISBN: 0748402055.

Dawson, N.A. (1996): Site Selection for the Relocation of Squatters: A Case of the Msimbazi River Valley Dar es Salaam, Enschede.

De By, R.A. (Editor) (2004): The Principles of Geographic Information Systems, ITC Educational Textbook Series (third edition), ITC, Enschede, The Netherlands. ISBN: 9061642264.

Dent, B. D. (1999): Cartography: Thematic Map Design, (fifth edition), WCB/McGraw-Hill, Boston.

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Fleming, C. (Editor) (2005): The GIS Guide for Local Government Officials, ESRI Press. ISBN: 1589481410.

Heholt, D. (1996): A Community Based Approach to Urban Data Gathering and Monitoring in Dar es Salaam, Tanzania, Enschede.

Hohl, P. (Editor) (1998): GIS Data Conversion: Strategies, Techniques, and Management (first edition), OnWord Press. ISBN: 1566901758.

Huxhold, W., Fowler, E.M., Parr, B. (2004): ArcGIS and the Digital City: A hands-on approach for local government, ESRI Press. ISBN: 1589480740.

Hearnshaw, H.M., Unwin D.J. (Editors) (1994): Visualization in geographical Information Systems, John Wiley & Sons, London, UK.
Iliffe, J. (2000): Datums and Map Projections for Remote Sensing, GIS and Surveying, Whittles Publishing, CRC Press.

Kaiser, E.J., Godschalk, D.R., Klosterman, R., Esnard, A. -M. (1999): Hypothetical City Workbook: Exercises, Spreadsheets and GIS Data to Accompany Urban Land Use Planning (fourth edition, paperback), University of Illinois Pr. ISBN: 0252067711.

Kerle, N., Janssen, L.F., Huurneman, G.C. (Editors) (2004): Principles of Remote Sensing (third edition), ITC Eductional Textbook Series, ITC, Enschede, The Netherlands. ISBN: 9061642272.

Kennedy, M. (1996): The Global Positioning System and GIS: An Introduction (hardcover book and CD ROM edition), Ann Arbor Pr Inc. ISBN: 1575040174.

Korte, G. B. (1997): The GIS Book: Understanding the Value and Implementation of Geographic Information Systems (paperback, 4th edition), OnWord Press. ISBN: 1566901278.

Kraak, M.-J., Brown, A. (Editors) (2000): Web cartography, developments and prospects, Taylor & Francis, London, UK.

Kraak, M.-J., Ormeling, F.(2003): Cartography - Visualization of Geospatial Data (2nd edition), Prentice Hall

Lillesand, T.M., Kiefer, R.W., Chipman, J.W. (2004): Remote Sensing and Image interpretation (fifth edition), John Wiley & Sons, New York.

Maantay, J., Ziegler, J. (2006): GIS for the Urban Environment, ESRI Press. ISBN: 1589480821.

McDonald Jampoler, S. (Editor) (1999): GIS in Practice (paperback), OnWord Press. ISBN: 1566901928.

Mitchell, A. (1999): The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns & Relationships (paperback, first edition), ESRI Press. ISBN: 1879102064.

Ormsby, T., Alvi, J. (1999): Extending ArcView GIS: with Network Analyst, Spatial Analyst and 3D Analyst (paperback book & CD ROM edition), ESRI Press. ISBN: 1879102056.

Plewe, B. (1997): GIS Online: Information Retrieval, Mapping, and the Internet (paperback, first edition), OnWord Press. ISBN: 1566901375.

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Sliuzas, Richard (2004): Managing Informal Settlements. A study using geo-information in Dar es Salaam, Tanzania. Thesis Utrecht University and ITC with summaries in Dutch and Swahili. ISBN: 906164223-X

Slocum, T. A. et al. (2004): Thematic Cartography and Geographic Visualization (2nd edition), Prentice Hall

Sumberg, J. (1996): A Bibliography on Peri-Urban and Urban Agriculture in Africa - with Particular Reference to Livestock and Tanzania, Norwich.

Tafesse, A.G. (1995): Service Level Assessment of Public Health Facilities in Dar es Salaam Urban Area, Enschede.

Timothy, H. (1995): Unplanned Urban Development: Spatial Growth and Typology of Unplanned Settlements, Enschede.

Zabrano Gild, E.A. (no date): Utilisation of Public Health Care Facilities in Dar es Salaam, Tanzania, Enschede.

Reference 2: Useful web sites

Where to find more information about EMIS and GIS
•   Table of Content

Table of Content

The most relevant entry point for information on EMIS is the EMIS web site on the Sustainable Cities Programme homepage:
http://www.unhabitat.org/categories.asp?catid=369

The collection of web sites on the CD-ROM is also useful. They are sorted as follows:

Maps and digital data from the Web
    Map libraries
    Images

Software
    GIS and Remote Sensing Software
    Open Source Software
    Web-mapping Software

Hardware
    Computer, Printer, Scanner
    GPS
    Hardware
    Software

GIS Tutorials and Training
    ESRI products
    MapMaker products
    IDRISI products
    GPS
    Remote Sensing Tutorials
    Professional GIS training providers

GIS links
    Participatory GIS

Programmes on Urban Issues
    UN-HABITAT/ UNEP programmes and initiatives
    MILES
    Miscellaneous programmes related to cities

Please note that web sites are subject to change without notice. The authors have tried to list web sites which have been fairly stable in the past, but they are not responsible for the content of external web sites.

Reference 3: Sample Maps

Sample maps from SCP partner cities

This tool presents a small collection of sample maps generated by the EMIS units of various Sustainable Cities Programme partner cities from all over the world.

Map 1: Ibadan Basemap

The EMIS Unit of the Sustainable Ibadan Project (Nigeria) developed the Ibadan Basemap from old topographic maps at a scale of 1:25000, and updated them with satellite imagery (SPOT Image). A regional remote sensing institute provided the technical expertise in satellite interpretation and helped to convert the raster data into vector maps. The Basemap shows typical features such as the built-up areas, the agricultural areas, rivers, the road network and other features. The EMIS Unit uses ArcView GIS software on stand alone office computers.

Map 2: Zanzibar Municipality – Base Map

The EMIS Unit of the Sustainable Zanzibar Project (Tanzania) developed the base map by digitising existing topographic maps at a scale of 1:10000. The Unit is in the process of using recent aerial photographs to update parts of the Base Map which are relevant for specific action plans. The Unit applies a simple ortho-rectification process to fit the imagery together with the existing Base Map. The EMIS Unit uses ArcView GIS and MapMaker on a stand alone office computer.

Map 3: Entebbe Basic Map

A consultant sourced the Lands and Survey department digital data for Entebbe at scale of 1:25000 and converted it from AutoCAD to shapefile format. The annotation, which is the layer used to assign names on AutoCAD could not be imported and hence a topographic map sheet was used to assign names and contours values. As AutoCAD exports all features as polylines the data needed further conversion to attain the standard data types required in GIS of points, polygons, and polylines.

Map 4: Issues on Health related to Non-Sewered Areas in the City of Colombo

The EMIS Unit of the Sustainable Colombo Project (Sri Lanka) created overlays of environmental issues during a training course. This map shows the relationship between areas prone to water-borne diseases and the quality of the sewerage system. The areas in dark red are critical hotspots. The EMIS Unit uses ArcView GIS software.

Map 5: Shenyang – Air Quality

The EMIS Unit of the Sustainable Shenyang Project (China) developed a pollution map from point data (air quality monitoring stations). The data from the monitoring station was analysed and aggregated and converted into levels of pollution. The map gives additional information on the location of Shenyang within the province, an inset map shows the location of industries and bar charts show the type of chemicals measured in the air. The EMIS Unit uses ArcView GIS software on a stand alone office computer.

Map 6: Maseru City – Location and Physical features
The Sustainable Maseru project produced a number of thematic maps for the Environmental Profile using ArcGIS 9. The Location and Physical feature map combines the road layer with the contour lines. These contour lines are presented as 3-D-features, giving a clear indication of the elevation of the terrain.

Map 7: Industry in Ismailia
This map is part of an Atlas of Ismailia. The EMIS Unit of the Sustainable Ismailia Governorate Programme (Egypt) developed the Atlas as an information tool for decision-makers. The EMIS Officer used COREL Draw software for the design of the Atlas, into which he imported the map files. The well-chosen illustrations allow the maps to be read easily, even by people who do not read Arabic. The EMIS Unit uses AutoCad software and started converting maps into ArcView GIS format.

Map 8: Wuhan – Surface Water Function Division and Water Plant Distribution Chart
The GIS Unit of the Environmental Protection Bureau and the Sustainable Wuhan Project (China) developed a number of thematic maps showing air monitoring stations, and illustrating the groundwater situation and surface water issues. The GIS unit is well equipped, using server based ArcInfo, ArcView, image processing software and various database programmes.

Map 9: Pollution of Nairobi Rivers
A team of consultants developed the Nairobi River Basin Project Database (Kenya) from an existing roadmap with a scale of 1:20000 and a topographic map with a scale of 1:100000. Although the source material is quite outdated, it serves the purpose for which it is needed, illustrating the sampling points for river water testing and the resulting intensity of pollution along the rivers. The maps were produced in ArcInfo and ArcView GIS.

Map 10: Lusaka – Development Plan
The Lusaka City Council (Zambia) contracted an external consulting firm to develop the Lusaka Development Plan. This map shows some draft layers which are being consolidated into a tool for the Forward-Planning Unit of the Council. However, the Development Plan lacks close, local and long-term consultation and was not developed through an Issue-Specific Working Group approach.

Map 11: Dar Es Salaam – Environmental Management Framework
The Sustainable Dar es Salaam Project used an intensive consultative process to develop the Strategic Urban Development Plan (SUDP). The Environmental Management Framework is part of the SUDP and combines information on existing built-up areas, service delivery and development potential. The maps for the SUDP have been produced in Atlas GIS software and are being converted into ArcView GIS format.

Map 12: Action Plan: Proposal for fares of bicycle taxis in Bayamo
The Local Agenda 21 Project in Bayamo had built up an extensive EMIS database using MapInfo. During the working group process the system was

mainly used for information outreach purposes, creating strategy and action plan posters illustrating the proposed changes with maps, pictures and text descriptions. The map "Proposal for fares of bicycle taxis" was used to start discussion about differentiating the fares for the bicycle taxis depending on the distance to the destination.

Map I

Ibadan
Basemap

River
Seasonnal River

Express Way
Main Roads
Secondary Roads
Railway
Powerlines

Agriculture
Built-up Area
Institutions
Forests
Lakes
Reserve Zones

1:200000

N

Sustainable Ibadan Project 1996

ZANZIBAR MUNICIPALITY
Base Map

Map 2

9327000

9324000

9321000

9318000

9315000

9312000

Kicimbani

Matonda

Bububu

Bububu river

Mtoni

Mtoni river

Chumbuni river

Changuu

Kibandiko

Chapwani

Dunga

Bawi

Mwembe makumbi

ZANZIBAR PORT

Chumbuni

Kwamtipura

Makadara

Amani

STONE TOWN

Michenzani

Kwahani

Sebleni

Kikwajuni

Jang'ombe

Mwana kwerekwe

Murogo

Pange

Mpendae

Makunduchi

Kiembe samaki

Nyange

ZANZIBAR
AIRPORT

Chukwani

Fumba

Bweju

Z a n z i b a r   C h a n n e l

516000 519000 522000 525000

	Legend	
Primary Road		Permanent River
Secondary Road		Seasonal River
Urban Road		
Airport Boundary		Mangrove
Municipal Boundary		Swamp
Stone Town Conservation Area		
Town Planning Boundary		

1:60000

1   0   1   2   3 Kilometers

N

Zanzibar Sustainable Programme
November,1998/BM2-1\basemap.apr

Map 3

Entebbe Municipality

Legend

Lake Victoria

UN-HABITAT

Map 4

ISSUES ON HEALTH RELATED TO NON SEWERED AREAS IN THE CITY OF COLOMBO

N

Unsewer-health
1 - 2
3 - 4
5 - 6
7 - 8
No Data

GIS facility -CMC
24.11.2000

1:90000

5   0   5   Kilometers

Map 5

Shenyang Air Quality

Air Monitoring Points
Distribution of Pollutants

- TSP
- SO2
- NOx
- BaP
- Pb
- CO

Road Network
Railway
Open Space

Air pollution (aggregated data)
- very low
- low
- medium
- high
- very high

Map 6

Map 7

Map 8

图3-2 武汉市城区地面水域功能类别划分及水厂分布图
Fig.3-2 Surface Waters Function Division and Water Plant Distribution Chart in Wuhan-Proper

Map 9

Pollution of Nairobi Rivers

Nairobi Rivers

Intensity of Pollution

- very high
- high
- moderate
- moderately low
- low
- no data

Landuse in select. Areas

- Settlements
- Forests
- Industrial Area

1:74908325

UNEP/UNCHS (Habitat) 2001

N

Nairobi R.

EMBAKASI

Airport

KASARANI

Karura Forest

Mathare R.

CENTRE

MAKADARA

Ngong R.

Nairobi National Park

Nairobi Dam

PARKLANDS/ WESTLANDS

DAGORETTI

Nairobi R.

Motoine R.

Ngong Forest

Dagoretti Forest

KIBERA

Map 10

Lusaka - Development Plan

Roads
Rivers
Railway
Lusaka Development Plan
ADMINISTRATION
AGRICULTURE
BUSINESS
CAMP AND CARAVAN SITE
CEMETERY OR CREMATORIUM
COMMUNICATIONS
DRIVE IN CINEMA
EDUCATIONAL INSTITUTIONS
ELECTRICITY
FIRE STATION
GENERAL AGRICULTURAL
GENERAL INDUSTRY
HEALTH INSTITUTIONS
HEAVY INDUSTRY
HOSPITAL
INDUSTRY
INSTITUTION
INSTITUTIONS
LAND COVERED BY WATER
LIGHT INDUSTRY
MENTAL HOSPITAL
MILITARY USES
MOTEL
NOT COVERED BT DEVELOPMENT PLAN
NURSERY AND MARKET GARDEN
OFFICES
OPEN SPACES
POLICE STATION AND CAMP
PRIMARY SCHOOL
PRISON
PRIVATE GOLF COURSE
PRIVATE PLAYING FIELDS, TENNIS COURTS
PRIVATE RACE TRACK
PUBLIC BUILDINGS AND CULTURAL USES
PUBLIC OPEN SPACES
PUBLIC PLAYING FIELDS, TENNIS COURTS
PUBLIC RACE TRACK, STADIUM, SHOWGROUND
RAILWAY RESERVATIONS
RESIDENTIAL
RURAL
SECONDARY SCHOOL
SEWAGE DISPOSAL
SPECIAL RESIDENTIAL
UNIVERSITY
WATER
WATER PROTECTION AREA

Lusaka City Council - 1998

1:200000

16 Kilometers

12   8   4   0   4

Map 11

Dar es Salaam - Environmental Management Framework

Legend

Built-up area 1997
Planned Areas
Unplanned Areas
Industry
Recreation
Rural Settlements
Main and Minor Roads
Railway
Regices
Regices
Regices

Utilities

Inadequate Services
Low Services
Fair Services
Moderate Services
Good Services
Very Good Services

Development Potential

High Potential
Moderate Potential
Low Potential
Very Low Potential
Conservation Area

BAGAMOYO

KIBAHA

KISARAWE

in km / 1:100000

0 2 4 6 8 10

Dar es Salaam City Commission (DCC)
Sustainable Dar es Salaam Project
Source: GDP
December 1997
zoning.prl
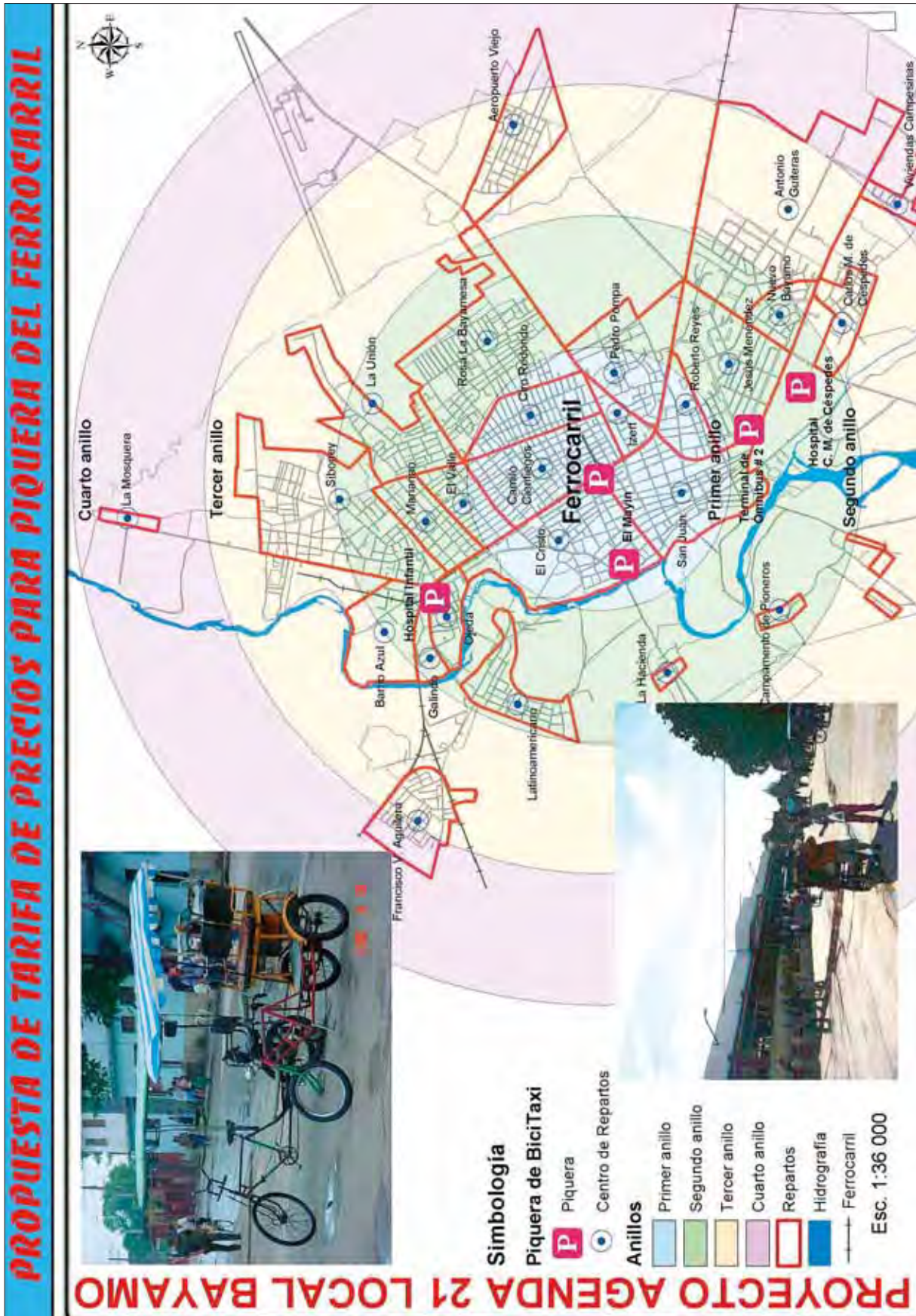
Map 10

UN-HABITAT

United Nations Human Settlements Programme
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