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**A Network Approach to Environmental Information  
Management in Ghana**

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## **A network approach to environmental information management in Ghana\***

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### **Abstract**

Well-designed environmental information systems are necessary for improving decision-making, policy formulation and action. In Ghana the application of appropriate tools for analysing and presenting policy-relevant information has been identified as critical to the successful implementation of the National Environmental Action Plan (NEAP) that has been launched. The establishment of a GIS-based National Environmental Information System (NEIS) has been proposed. As a first step, however, the immediate need is to address the problem of information availability. Through a network of institutions a wide variety of data sets required for managing the environment will be produced.

A GIS platform offers the flexibility to produce data sets from different sources to a common geographic base. The main advantages provided by the platform include speed in data processing and information generation, and flexibility in the use of data to bring pertinent information to bear on the decision-making process. Furthermore the network approach ensures effective collaboration among different agencies. A large volume of compatible national level data will be made available to network partners and other users in a much shorter time than could otherwise be achieved by individual agencies. Also, it will facilitate dissemination of resource and environmental data available in the country and enhance their accessibility.

### **Introduction**

Environmental managers in developing countries are frequently faced with the task of providing timely, accurate, and relevant answers to a host of problems related to the difficult task of managing a rapidly depleting resource base and a deteriorating environment. The evolution of information technology have provided the tools necessary, in addition to the opportunities to use them in a variety of innovative ways, to address these problems. However, in economies in which governments are preoccupied with providing its citizens the very basic necessities of life, advances in information technologies seem to have had little impact on economic and social development. Ironically, the inability to adopt and apply these tools in the management of resources and the environment has meant that the vicious cycle of under-development, poverty and environmental degradation is maintained as planners and managers are unable to see the whole picture when they develop plans to exploit the environment.

Sound environmental management requires information. This is essential for the assessment of progress and achievement of environmental policy objectives, and for problem-solving, decision-making, and policy formulation. In addition, environmental managers need to be able to identify options available and to select among them, forecast their potential impacts, and

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make intelligent estimates regarding the cost-effectiveness of proposed interventions. Very many different types of information are required.

The paper discusses the experience of developing GIS for environmental management in Ghana. It reviews problems encountered by individual agencies in setting up GIS, and discusses a network approach to the adoption and use of the technology. It also discusses prospects and challenges envisaged.

#### Environmental information system development

The role of up to date and reliable information on environmental phenomena and processes in the management of environmental resources in Ghana has long been recognised. As a result of this recognition efforts were initiated to set up mechanisms to gather, process and disseminate environmental information. Staff was trained under a programme sponsored by the United Nations Institute for Training and Research (UNITAR) and the United Nations Environment Programme (UNEP). A GIS was installed in 1988 with the assistance of the United Nations Development Programme (UNDP), and pilot projects were set up. However, these ran into early problems which included the lack of commitment and appreciation on the part of senior Management of the workings of an operational GIS, lack of financial resources, and inadequate service support (Gyamfi-Aidoo, 1988).

The most serious problem has, however, been in the area of institutional arrangements. Simply put, institutional issues were grossly under-estimated in the early initiatives. These include lack of clear understanding and proper perception of the capabilities of a GIS. In addition, adequate attention was not paid to the relations among sector institutions who traditionally produce data. A major problem was distrust and suspicion that one's powers and functions were being usurped. Attitudes were not always positive and progressive.

The problem of technical back-stopping has also been a recurrent theme (EPC, 1992a). All the agencies that have set up GISs have complained of the lack of adequate system support, including basic supplies. In most cases equipment had been acquired through projects which made no provision for a recurrent budget to pay for support services. This situation has tended to perpetuate dependency on external sources and has undermined sustainability of GIS development. There are also a whole range of issues that require policy actions at the highest possible levels.

Another issue has been that of data quality. Several agencies have made independent efforts to establish their own GIS to meet their specific needs. In the absence of standard reference digital base maps the problem that began to emerge was that of the authenticity and accuracy of map information obtained from sources other than published maps from the national mapping authority.

Although the pilot projects were not abandoned it has taken a much longer period to execute them. Some of these projects were designed on the assumption that there would be collaboration and co-operation among institutions (EPC, 1992b). This did not materialise. However, an important lesson has been drawn from these early set-backs, that a GIS intended for the purpose of environmental management could not survive on its own. It was necessary to integrate it into a more coherent framework on environmental and resource information. The preparation of a National Environmental Action Plan (NEAP) provided a unique opportunity to address this.

The Ghana NEAP is structured around seven action areas (EPC, 1991a): land management; forestry and wildlife; water management; marine and coastal ecosystems; mining, industry and hazardous chemicals; human settlements; and cross-sectoral issues, including information. The information requirements for management functions in these areas are very varied, and the NEAP proposes the establishment of a National Environment Information System (NEIS) to facilitate the information delivery process. GIS will be at the core of NEIS. The functions of the system, when operational, will include:

- \* serve as a readily accessible archive of homogeneous data sets on environmental quality;
- \* provide organised data and information on the state of the environment and to serve as information support for policy analysis and development planning; and

- \* provide a means for early warning and evaluating the impact of development activities and environmental interventions.

As a first step, however, the immediate need is to address the problem of data and information availability. A primary concern is the improvement of the consistency of information on the state of the environment (Figure 1).

The thrust of the NEAP is effective environmental management. This objective is being pursued through a series of initiatives designed to strengthen the capacity of national institutions to manage environmental resources using existing structures. The initiatives emphasise mechanisms and processes rather than being prescriptive about environmental action. Thus, in the area of information, the focus is on the development of a viable delivery system rather than setting up a central facility for the purpose.

### Networking

Environmental information in Ghana is collected, processed and analysed by a wide array of independent institutions. However the general economic decline that the country experienced in the recent past greatly affected the operations of all the institutions that gather and process data (WRR, 1987). The network approach was therefore dictated by the need to strengthen information management capabilities of these institutions, to the extent possible. Also, early experience (failures) had shown that the optimal approach to GIS development for environmental management in Ghana had to be through task-sharing in a network of information suppliers.

## NEIS DEVELOPMENT

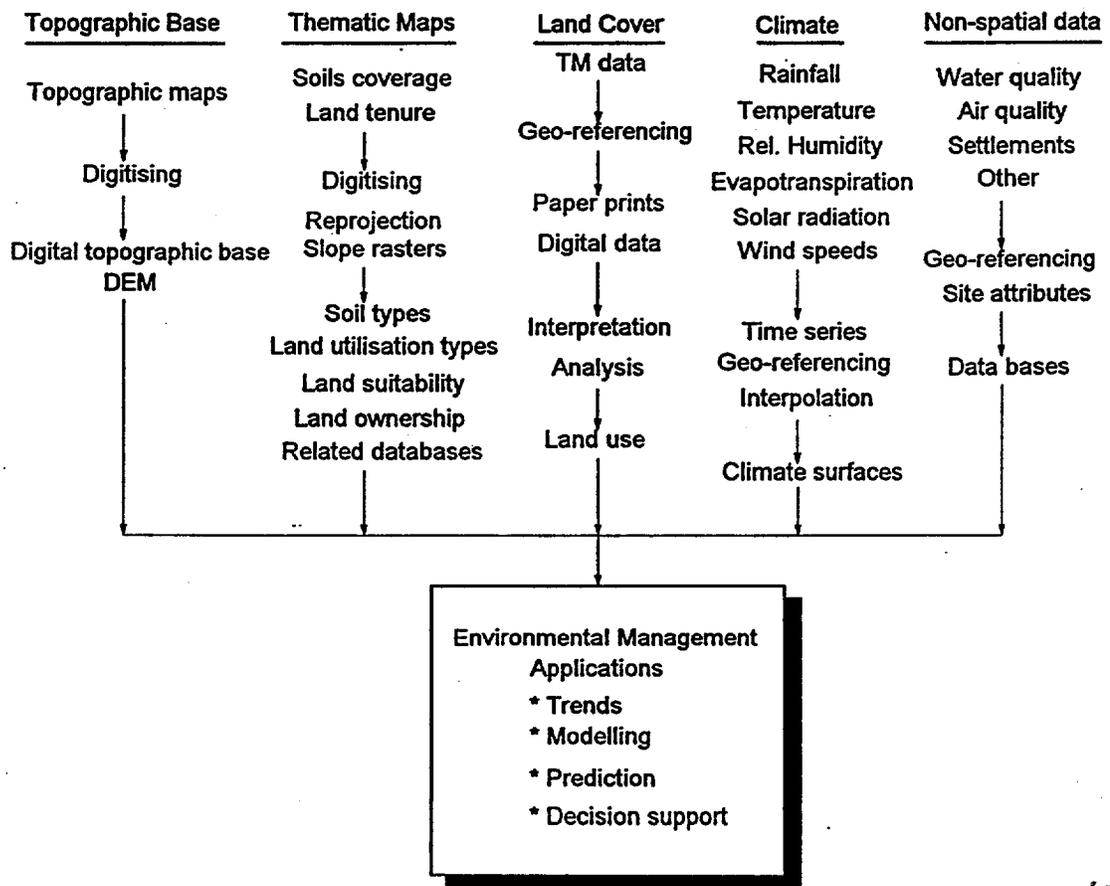


Figure 1. Chart showing data sources and steps in the development of NEIS

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Effort is aimed at strengthening institutions involved in the collection, processing and analysis to produce environmental information in their area of competence. The procedure for network development followed a strategy that has been adopted by the United Nations Sudano-Sahelian Office (UNSO), and is consistent with The World Bank's strategy and principles for supporting the development of information systems for environmental management (Falloux, 1989; UNSO, 1992).

Specific requirements were determined at a workshop which identified the purpose for which information would be used, and the manner in which it would intervene in environmental management. Priorities were also established, with emphasis on land-related information (EPC, 1991b). The NEAP had identified insufficient and inadequate information on present land use as a major stumbling block in any environmental interventions. It was recommended that basic land use and land capability maps be produced at a scale of 1:250,000, within a standard spatial framework, for use at the national and regional levels, to give broad outline of land use patterns for policy information, planning and monitoring. The initiative involves a number of key institutions, each with clearly defined tasks:

#### ***Topographic information***

It is recognised that a well-structured digital topographic data base is pre-requisite for the implementation of a successful GIS programme. In order to meet this need within the context of the NEIS development and future demands for digital map products, the Survey Department, the national mapping authority, has been tasked develop a digital map base for the entire country. The following will be produced, among other products:-

- \* conversion of existing 1:50,000 scale series of map sheets, covering the entire country (about 238,300 km<sup>2</sup> in area) into a digital base;
- \* derivation of a 1:250,000 map series from the 1:50,000 scale data set; and
- \* preparation of a Digital Elevation Model (DEM) from the digitised contours based on the 1:50,000 scale data set.

The digital topographic base will provide a basic spatial framework, support the geo-referencing of satellite imagery for land use mapping, and provide information on slope and aspect, as well as information on human settlements.

#### ***Land use***

Information on how land is presently utilised is a key factor in managing the environment effectively. There is, however, no up-to-date land use map of Ghana. To meet this need a Remote Sensing Applications Unit is to be established as part of the NEIS development to produce digital and paper copy maps of current land use for the whole of the country.

Maps will be produced at the scale of 1:250,000. At this level of generalisation it is considered that Landsat TM data would be most appropriate. Images will be validated with original field work. The base year will be 1993. Land use bulletins will be prepared on the basis of administrative regions.

#### ***Land suitability for agriculture***

The use to which a particular parcel of land is put is determined in great part by the characteristics of the land. Information on the suitability of the land for the intended use is therefore a key input in the environmental management process.

To meet this need a digital map coverage of the soil types of Ghana is to be produced. A database of agronomic suitability indices for selected crops will be developed as interpretations of the soil coverage at the scale of 1:250,000. Land suitability maps will also be produced at a scale equivalent to 1:1,000,000 for 10 major land utilisation types that will be determined. Agronomic suitability bulletins will be prepared according to the administrative regions of the country.

#### ***Land ownership***

Land tenure in Ghana is a complicated and delicate issue. The underlying principle, however, is that land is a common-good natural resource held in trust by a designated authority. As the

social system became more complex so have the patterns of land ownership. Since environmental management decisions ultimately influence what can or cannot be done with certain tracts of land, ownership maps are essential to complement land use and land suitability information.

A national digital map coverage of land ownership will be produced. Given the complexity of the land ownership issue the maps will be indicative only, having no legal status. Within the framework of the NEAP the primary use of these maps would be to promote the consideration of, and access to land ownership information in the environmental management process. Mapping will be according to five broad categories of land ownership, at a scale equivalent to 1:250,000. The data base will include records (history) of ownership, leases and concessions.

#### *Climate*

Information on climate is an essential ingredient in managing the environment. Climatological records have been kept for a long time in Ghana. However, these have not been rendered machine-readable and, in its current form, it remains effectively unavailable to users:

For environmental management functions under the NEAP the primary need for meteorological information is for land suitability mapping and other investigations that would require time series data. To meet this need a computerised data base of climatological records for the period since 1930 will be produced. Climatic variables of interest include rainfall, temperature, relative humidity and evapotranspiration. To render the data sets compatible for integration with other geo-coded data "climate surfaces" will be generated for these variables using appropriate data interpolation routines and a standard digital map reference.

#### *Non-spatial data*

Air and water quality data will be generated through a separate network of institutions. In addition there will be substantial inputs from existing data sources, including national census, surveys and other Government sources, such as the Statistical Service and administrative files. There will also be information from studies commissioned on specific subjects. Where possible, data will be appropriately geo-referenced to facilitate their use within a GIS environment.

#### Co-ordination

Although the entire project is designed to evolve into a national information system on the environment, emphasis in the implementation is placed on developing and strengthening skills and capabilities of network partner agencies. Technology transfer and production of outputs takes into account the specific needs of the individual institutions. The development of skills is geared, first and foremost, towards their own unique applications. An important advantage is that data verification and validation is carried out by the agency that generates and, therefore, understands the original data set and is most sensitive to it. This would ensure a high quality standard. Another advantage of the network approach is also the promotion of GIS applications on a much broader front simultaneously.

Despite the advantages, however, there are serious coordination issues involved in the approach. Primary outputs must conform to the requirements of the individual institution while remaining compatible within the established framework. Priorities may differ. Effective co-ordination is therefore essential. This will be the responsibility of the Environmental Protection Council (EPC; Figure 2). The Council will take a lead role in setting up mechanisms for establishing guidelines for data compatibility and quality control, and in the choice of hardware and software for use across the board. It will also ensure the use of a standard digital spatial framework for data collection.

The EPC has prime interest in the use of GIS technology in managing the environment. This interest is primarily in the following areas:

- \* assessment of progress and achievement of environmental policy objectives;
- \* studying linkages between and trends between socio-economic and bio-physical conditions;

- \* bringing relevant information to bear on environmental problem solving, decision making, policy formulation and analysis; and
- \* reporting on the state of the environment.

## NEIS NETWORKING

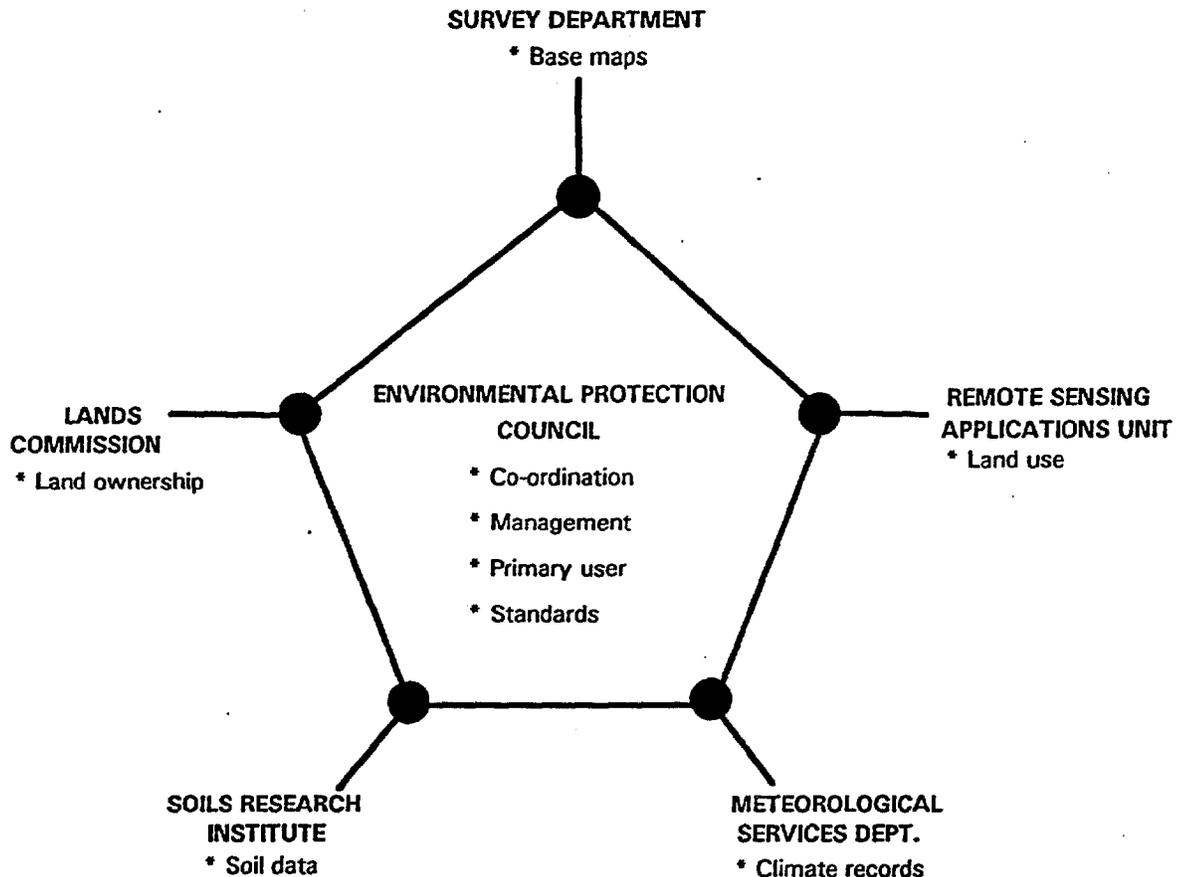


Figure 2. The institutional support base for NEIS

The Council has become the focus of donor support for implementing the NEAP and, in respect of its information requirements, serves as a hub for the development of GIS in Ghana. It will provide a platform for technical meetings, maintenance of information about existing data, and the sharing of experiences. A committee will be set up to supervise inter-agency provision of services, and ensure the timely production of information.

### GIS platform

GIS is providing an opportunity to decentralise the management of environmental information while ensuring compatibility at the same time. The platform is providing a focal point for inter-agency co-operation, something which has proven illusive for a long time. It has provided a point of convergence of varying interests and needs. It is now possible to work towards collating and updating a wide variety of generally incompatible and widely scattered information. There is also a unique opportunity to revitalise key national institutions involved in generating land-related information. The collaborative effort increases the sensitivity of agencies that generate or gather data to the requirements of user agencies.

It is also providing a stimulus for dialogue and discussion regarding common quality standards and specifications in the development of a truly national environmental information system. It is promoting the adoption of a common frame of reference for organising resource

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and environmental information. In addition there is the possibility to develop a common framework for reporting information relating to land, environment and natural resources. Dissemination of resource and environmental information available in the country is greatly facilitated, and their accessibility enhanced.

GIS offers the possibility to rapidly produce a combination of derived maps and data that would show how the environment is changing as a result of resource exploitation. However, more than its functionality, it is perhaps the element of integration that is most significant in the context of the development of NEIS. The technology is offering a platform for integrating disparate data types using the one common feature that links them together - a spatial reference. It provides the essential link between socio-economic issues and physical and geographical information, and offers a consistent framework for the analysis of policy information.

### Synergy

The network approach is a synergy - individual elements are so linked that the whole is greater than the sum of the parts. Synergy suggests co-operation, interaction, building on shared resources and assets, integration. GIS is an enabling technology in this context.

The approach takes advantage of economies of scale. It thus ensures that a large volume of compatible national level data will be made available to network partners and other users in a much shorter time than could otherwise be achieved by individual agencies. The initiative builds on the collective strengths of partner agencies to overcome individual limitations.

Duplication of effort is expensive and wasteful. With the high costs of man-power development and of acquiring equipment and data, the approach ensures effective rationalisation of limited resources. The work of each institution would complement others, and the limited trained personnel will focus on their area of competence.

The synergy ensures a speedy transfer of technology to several agencies in a systematic, cost-effective and demand-driven manner. It ensures compatibility of systems, techniques, procedures and outputs across a broad front of agencies with different needs. Man-power development is also more focussed on specific need areas, and because of the demand-driven nature, momentum can be sustained.

More importantly the network approach facilitates the building up of a critical mass of viable installations that can attract local computer service companies to develop support capabilities and expand the technological base.

### Challenges

The first hurdle of getting different institutions to agree to adopt a common approach to GIS development may have been cleared. Already there is considerable interaction and preparatory work towards implementation. However, there has to be a substantial shift in attitudes and perceptions to ensure harmony in implementation. Institutional mandates differ, and so are the issues and strategies that would otherwise be adopted. The real task is therefore in regard to sustaining the very good working relationships that have been developed to date.

Conflicts are expected on technical issues. The success of the initiative will depend on the degree to which issues such as standards, nomenclatures and procedural matters will be handled.

There is recognition of the need for an active and interested private sector to provide technical back-stopping, particularly in respect of maintenance and servicing, including supplies, for GIS installations in the country. Computer companies have to be encouraged to expand their services to include GIS technology. Already there is a growing interest by the private sector. One might say that this is due to the potential large in-flow of financial resources that would be made available under the current initiatives. The positive side of this development, however, is the support that would thus be offered by local computer service companies who now appreciate current trends and the potential for business that would be developed. The involvement of the private sector will ensure sustainability of GIS applications when donor funds dry up!

Continuous education and training of GIS operatives is paramount for the successful adoption of the technology. Training programmes should include technicians and the various

institutions, and also involve local computer companies who would be expected to offer support to the various GIS installations in the country.

It is clear that much remains to be done. However, there is currently in Ghana a growing following in the application of GIS to resource and environmental management. This means that there is a cadre of personnel in the country knowledgeable in the principles and available technologies. It also means that there are opportunities for dialogue and discussion. The challenge, therefore, is one of sustained commitment on the part of all involved in this unique effort.

#### Acknowledgement

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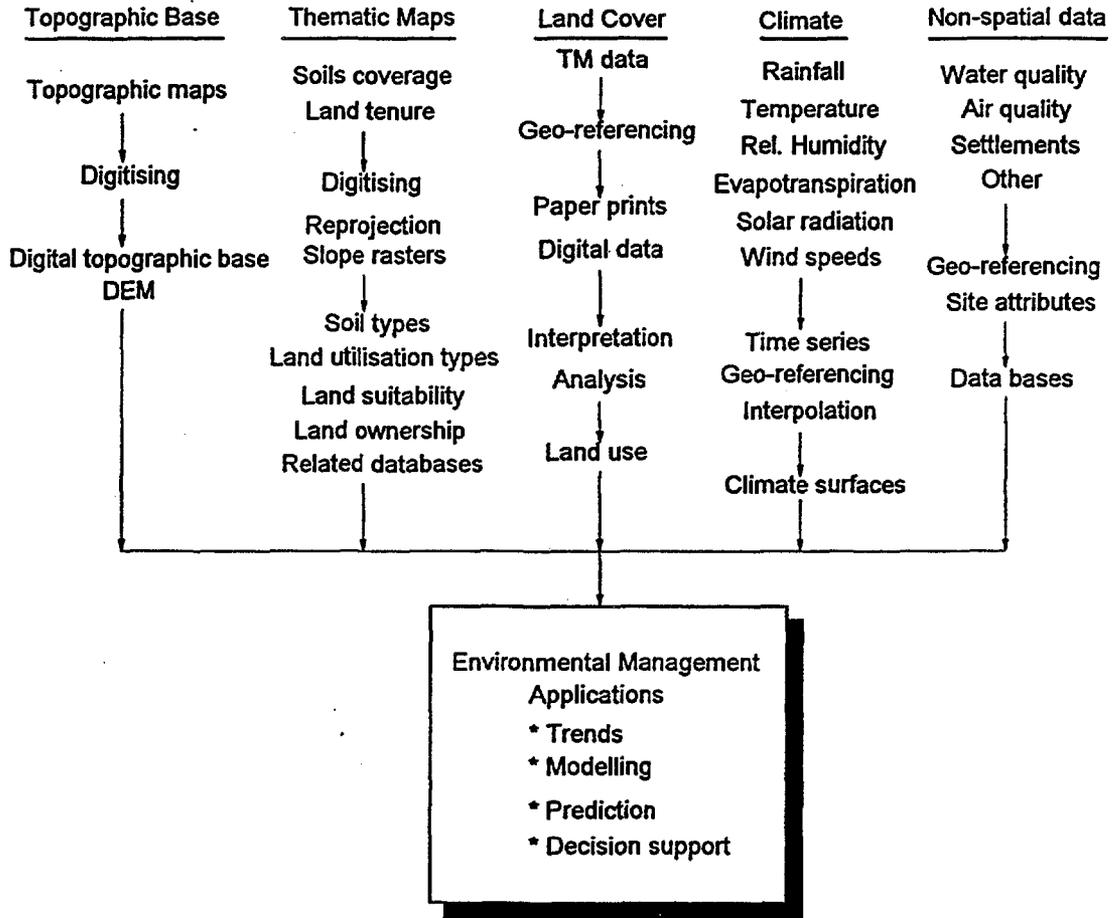
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# NEIS DEVELOPMENT



## NEIS NETWORKING

