Geographic Information Systems Essay, Research Paper

Strategic Planning and Management Through The Application of Computer Technology

On the walls of caves near Lascaux, France, Cro-Magnon hunters drew pictures of the

animals they hunted 35,000 years ago. Associated with the animal drawings is a map;

track lines and tallies thought to depict migration routes. These early records followed the

two-element structure of modern geographic information systems: a graphic file linked to

an attribute database. The map has been in existence in much the same form for thousands

of years. In the traditional form it suffers from a number of problems. Firstly, maps are

static and therefore difficult and expensive to keep up to date. This leads to a second

problem, in that because they are static they lose flexibility, for example, maps exist as

discrete sheets and inevitably your area of interest lies on the corner of four adjacent

sheets. In addition maps are often very complex and may require an expert to extract the

particular data which are of interest. Geographical Information Systems (GIS) can be

regarded as the enhanced, high-tech equivalent to maps. An individual computer generated

map contains information that is used in different ways by different individuals and

organizations. It represents the means of locating ourselves in relation to the world around

us. Maps are used in diverse applications; from locating telephone wires and gas mains

under our streets, to displaying the extent of de-forestation in the Brazilian Amazon. From

a management point of view, accurate and relevant information provides the key to

effective decision making. In today’s modern societies, decisions should be made quickly

and based on reliable data and sound processes even though there are many differing

viewpoints to consider and a large amount of information to process. Nowadays, the

impact of decisions is ever greater, often because they involve conflicts between society

and individuals, or between development and preservation. Due to this, information should

therefore be readily available to decision-makers. Without doubt, during the past few

years, the drastic increase in access to computers has altered our planning practices.

Planners that specialize in the application of computer technology to planning and

planning-related issues are concerned with ameliorating the crucial process of

decision-making by providing up-to-date information and new methods for looking and

analyzing physical, social, and economic data. In turn, Geographic Information Systems

and other similar new technologies are constantly and constructively changing the way we

view our physical environment, allowing planners to simultaneously study the physical,

social, and economic composition of geographic areas based on such hi-tech maps. The

objective of this essay is to study and demonstrate the benefits offered by Geographic

Information Systems, as a cost-effective managerial tool, to strategic planning and

management within all industries. Before commencing, the following section provides a

brief overview of the basic concepts and functions of a GIS. Concepts & Functions of

Geographic Information Systems Even though numerous attempts have been made to

determine the exact definition of a GIS, seldom to theorists directly relate it to the

strategic issue of planning and management. Nevertheless, the following is a rather

successful attempt of creating a full, well balanced and precise definition: “A system of

hardware, software, and procedures designed to support the capture, management,

manipulation, analysis, modeling and display of spatially-referenced data for solving

complex planning and management problems.” (NCGIA lecture by David Cowen, 1989).

A primary benefit of a GIS is that it integrates, in a generic manner, data and information

that may be scattered throughout an organization, in different departments and on

different documents. But it is the ability to integrate common database operations such as

query and statistical analysis with the unique visualization and geographic analysis benefits

offered by maps which distinguishes GIS from other information systems and makes it

valuable to a wide range of public and private enterprises for explaining events, predicting

outcomes, and planning strategies. More importantly, GIS offers decision makers at

various levels the capability of integrated and coordinated planning, efficient coordination

of construction, and development of preventative and routine maintenance programs on

the basis of reliable data and long-range plans. The GIS serves users on four levels:

Basic: archive or file for accessing up-to-date and reliable information on the various

elements in the system. Planning: accessing data for planning at all levels of detail, from

conceptual planning to detailed design. Management: decision-making at all levels of

management, from strategic to operational. General: aggregation of information for

businesses. At senior management levels, GIS serves as an indispensable aid to policy

definition and control of high priority and critical regions, and assists in decision making

with respect to planning and development on different time horizons, and in the

immediate, intermediate and long range. Generally speaking, a Geographic Information

System links spatial information (CAD) to alphanumeric information (database) – to

produce a geographically referenced database. GIS software allows the user to collect,

edit, analyze, and display this information, which are stored in the following three ways: 1.

Points: location of electric and telephone poles, fire hydrants, traffic lights etc. 2. Lines:

data defined topologically in a network or linear, such as water pipelines, road centerlines,

communication networks etc. 3. Polygons: closed areas, each with its own distinct

characteristics such as parcellation, land use, surface cover, structures etc. A Geographic

Information System can be divided into two basic types of data: graphic and non-graphic.

Graphic data, which are digital descriptions of map features, are used by the GIS to

generate a map or cartographic ‘picture’ on a display device, on paper or through other

media. On the other hand, nongraphic or textual data are representations of the

characteristics, qualities, or relationships of map features and geographic locations. The

following diagram illustrates the relationships of graphic elements to nongraphic data,

which allows the creation of graphic software, a GIS, that integrates visual material with

its appropriate data: (Antenucci et al., Geographic Information Systems; A Guide to the

Technology, USA, 1991, P.87) In order to operate, the GIS depends on the integration of

three aspects of computer technology, which are presented in the diagram below: The

database management is composed of graphic and nongraphic data, whereas the graphic

capabilities involve routines that manipulate, display, and plot graphic representations of

the data, and spatial analysis tools deal with algorithms and techniques that allow spatial

analysis. (Antenucci et al., Geographic Information Systems; A Guide to the Technology,

USA, 1991, p.21). A GIS provides the facility to extract the different sets of information

from a map (roads, settlements, vegetation, etc.) and use these as required. This provides

great flexibility, allowing a paper map to be quickly produced which exactly meets the

needs of the user. However, GIS goes further, because the data are stored on a computer,

analysis and modeling become possible. One might, for instance, point at two buildings,

ask the computer to describe each from an attached database (much more information than

could be displayed on a paper map) and then to calculate the best route between these.

Unquestionably, map making and geographic analysis are not new, but a GIS performs

these tasks better and faster than do the old manual methods. And, before GIS technology,

only a few people had the skills necessary to use geographic information to help with

decision making and problem solving. Developing a Geographic Information System GIS

belongs to the class of computer systems that require the building of large databases

before they become useful. Unlike many micro-computer applications where a user can

begin use after the purchase of the hardware and software, the use of a GIS requires that

large spatial databases be created, appropriate hardware and software be purchased,

applications be developed, and all components be installed, integrated and tested before

users can begin to use the GIS. The adoption of a GIS by an organization introduces

fundamental change into the organization in its thinking about data as prior information

technology allowed data to be collected and related to activities and projects individually.

Organized stores of data were the exception rather than common practice. This led to

duplicate data collection and storage (as in different departments) and to the possibility of

erroneous data existing in one or more locations. One of the goals of computer systems

and database development is to eliminate redundant data collection and storage. The

principle is that data should be collected only once and then accessed by all who need it.

This not only reduces redundancy; it also allows for more accurate data and a greater

understanding of how multiple departments use the same data. The necessary condition for

successful computer system and database development is for different departments and

agencies to cooperate in the development of the system. A database becomes an

organization-wide resource and is created and managed according to a set of database

principles. The “decision” to develop a GIS is made incrementally. The information needed

to determine the feasibility and desirability of developing a GIS is not available until

several of the planning steps have been completed. The key decision points are: Decision

to investigate GIS for the organization – the initial decision to begin the process. This is an

initial feasibility decision and is based on the likelihood that a GIS will be useful and

effective. It is fairly important to identify the major participants at this point – both

departments within organizations and the group of organizations, particularly key

organizations, those who represent a majority of the uses and who will contribute most of

the data. Decision to proceed with detailed planning and design of the database – at this

time, the applications, data required, and sources of the data have been identified.

Applications can be prioritized and scheduled and the benefits stream determined. Also,

applications to be tested during the pilot study and the specific questions to be answered

by the pilot study will have been determined. A preliminary decision will need to be made

as to which GIS software will be used to conduct the pilot study. Decision to acquire the

GIS hardware and software – this decision follows the preparation of the detailed database

plan, the pilot study and, if conducted, the benchmark tests. This is the first point in the

development process where the costs of the GIS can reasonably be estimated, the schedule

for data conversion developed, and targets for users to begin use determined. Developing

a GIS is more than simply buying the appropriate GIS hardware and software. The single

most demanding part of the GIS development process is building the database. This task

takes the longest time, costs the most money, and requires the most effort in terms of

planning and management. Most local governments, for instance, will acquire the GIS

hardware and software from a GIS vendor. Choosing the right GIS for a particular local

government involves matching the GIS needs to the functionality of the commercial GIS.

For many agencies, especially smaller local governments, choosing a GIS will require help

from larger, more experienced agencies, knowledgeable university persons and from

qualified consultants. The GIS development cycle is a set of eleven steps starting with the

needs assessment and ending with on-going use and maintenance of the GIS system. These

steps are presented here as a logical progression with each step being completed prior to

the initiation of the next step. While this view is logical, it is not the way the world always

works. Some of the activities in the process may happen concurrently, may be approached

in an iterative manner, or may need to be restructured depending on the size and character

of the organization conducting the study and the resources available to plan for the GIS.

Building a Geographic Information System is a highly consuming task, not only from a

systems development point of view, but also from the human resources aspect. The system

could perfectly function, technically speaking, and still bring forth deceiving results. Staff

training, education, and interaction with the GIS is as important as creating the system

itself. It is both the combination of an appropriately built system that meets the user’s

needs, in addition to well-trained personnel, that will allow an organization to exploit the

GIS’s full potential. GIS: A Vital Tool for Strategic Planning and Management: Today,

Geographic Information Systems are being applied in all different sorts of organizations,

ranging from government municipalities to marketing firms and finance corporations, as it

provides a decisive tool, through its incorporation of spatial graphics to data, towards

effective and productive decision making. Initially used by the government, such systems

have now increased popularity amongst a wide range of businesses and agencies, whose

astonishing success has echoed in the corners of all markets. Constructed specifically for

all sorts of geographic purposes, the system has demonstrated its ability to meet user

needs and provide significant benefits towards planning and management for all sectors.

London’s Heathrow Airport case presents an example of how a GIS is used to manage

vast amounts of information, thus dealing with large stores of constantly changing data

that is required for airport management. For the management and maintenance of the

airport, an estimated 400,000 technical and engineering plans are required. In addition,

with already more than 50 million travellers in 1994, the airport was in need of a system

which could meet the customer demands of an ever-increasing number of passengers, and

maintain accurate records of each change to the airport services and structures.

Nowadays, through a GIS, the Airport Planning group, for instance, “issues safety

regulations detailing what construction works is being carried out, which diversions are in

effect and other relevant information. Up-to-date information can be quickly accessed

from the database and used to produce high quality computer-drafted A3 or A4 plans

supporting safety notices.” Indeed, the GIS currently being used at Heathrow Airport has

showed real financial benefits and turning around times for record requests have been

greatly improved. By giving the “the right information to the people who want it [and]

when they need it,” the system is rapidly being accepted as part of the organization’s

decision making process (Mapping Awareness, Plane Language- Managing Information at

Heathrow Airport, October 1995). The UK water industry has greatly benefited from the

presence of GIS technology. East Surrey Water (ESW), a water company serving the

southern fringe of London, East Surrey, and West Kent, demonstrates one of many

success stories of the GIS in the private sector. By installing a Geographic Information

System, the water company managed to improve its planning and services to customers

through a more targeted and cost-effective works program to further improve water

quality and supply, which meant less paperwork and duplication of tasks, swift access to

vital information and a simple updating system (Mapping Awareness, Do Go Near the

Water: GIS Boosts East’s Surrey Water’s Planning, Efficiency and Service, December

1995). On the other hand, UK water companies still currently face up to 30 per cent loss

of the water they produce, but this time due to a different reason: water leakage. Reducing

water leakage is the prime concern of British water companies, as they are endlessly

developing new modelling and water-distribution management systems to combat this

massive problem. At Thames Water Utilities, though, a PC-based GIS system was

installed as an alternative solution to this financially devastating problem. The system,

which simplified the updating of records and viewing of information from databases, made

it extraordinarily easy to find solutions to operational obstacles, allowing them to be

overcome in a shorter period of time via more efficient techniques (Mapping Awareness,

GIS Plugs the Gap as Water Leakage Companies Combat Leakage, April 1996). With

over 50 per cent of the population as customers each month, Boots the Chemist is one of

the most popular chains of shops in the UK. Despite its supremacy over its industry,

increasing competition is forcing Boots to hone its competitive edge by mastering new

technologies, making it one of the first retailers to integrate a GIS into its mainstream IT

infrastructure. Due to its disparate existing sets of data, such as CCN’s Marketing Environ

system for customer-profiling data and census demographics and GOAD plans for paper

maps of towns, detailing units, occupiers and their goods and services, Boots wanted a

system that would collect all sources together into a single system. Overall, Boots required

“a flexible GIS, capable of business analysis and planning primarily for site location and

research.” In addition, as customer trends change daily, the company hopes to use the

system to fine-tune its inventory to ensure that it is supplying what customers require.

Despite this, developing a GIS remains a complex, effort and time-consuming task, for it

has taken Boots over 18 months to capture and integrate its data into the GIS database.

One definite strategic benefit, though; the new technology has changed the firm’s focus

from stores to customers, towns and competitors, which will be critical to the future

success of the business (Mapping Awareness, Fighting the Supermarket Sweep, June

1997). The case of the British Royal Navy proves that GIS technology can even be

utilized for military purposes. Recently, the Royal Navy has equipped some of its warships

with a stand-alone plotting system that offers greater accuracy and increases the amount

of tactical information plotted through the implementation of GIS technology. This new

system, which is proving invaluable as a flexible, low-cost planning tool, may even save

lives. A modern warship needs sophisticated data-handling technology to help deploy its

sensors and weapons systems quickly and effectively. To ensure its warships are prepared,

the Royal Navy is investing heavily in bespoke computer systems in order to handle the

enormous amounts of tactical data now available. To operate successfully in the Royal

Navy, a system must be able to provide rapid processing, with a minimum number of

operators, which would give a clear and concise overview of the tactical situation.

Previously, the ships had to manually update positions on a paper chart every 10 to 15

minutes. The new system, interfaced with satellite navigation data, now allows them to

achieve an update almost instantly using computer graphics display. Although the GIS is

still at the trial stage, “it provides a low-cost, customized, commercial off-the-shelf system

that is now being used as an amphibious planning tool for sea-going commanders.”

Worldwide, GIS consultants are confident that the technology will flourish in the

foreseeable future – but in a different form; in a few years the GIS market will comprise

(1) fewer suppliers, (2) more lower-cost systems, (3) and easy-to-use desktop systems that

are integrated into main-stream corporate solutions. Even though GIS’s flexibility will

increase in general, the utilities and local government remain the healthiest market sectors,

with industry/manufacturing the least promising. As to specific changes and areas of focus

in the near future of this tool, its rapid growth will be coupled with low-end GIS and

desktop PC-Based solutions, as they are expected to be the main areas for expansion.

Business GIS is the first area expected to boom, since it has the greatest potential for

expansion, such that mapping technology will be on the desktop. GIS is seen as a

specialist area now, restricted to specialist industries and specific types of organizations.

Nevertheless, in five years it will undoubtedly be an enhancement to many applications

whose increased benefits for users and suppliers will rapidly evolve as open systems

become the norm. Obviously, there is an enormous growth potential for the GIS, which

should come through broader proliferation in different markets, due to lower cost

software/hardware and data availability. With time, the systems are expected to become

more user-focused as both users and buyers will expect quality, cost-effective, and

significantly simpler application-based GIS solutions.