Use of Geographical Information Systems for Thailand

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Abstract

Geographical Information Systems (GIS) are systems for capturing, storing, manipulating, analyzing and displaying data with geo-reference. GIS are comprised at least three different components: an information system on geospatial information and data, set of georeferenced or geospatial data, and a management component capable of analyzing und checking the data. This management component can be used to gain new insights into the data set and for the assessment and forecast of situations and scenarios related to geospatial data. Although GIS have been presented for decades serving different functions in many areas, their use for problems in Thailand has recently increased considerably. Typical domains, in which GIS is used, are the planning of transport and services, urban and environmental management, and the visualization of health and economic data. As Geographical Information Systems provide easy access to a variety of detailed geospatial objects, the problem of naming and retrieving them correctly remains important. These variations of names can lead to confusion about the correct name of a place, building, or other geospatial object as well as to poor or even incorrect search results in stand-alone, networked or Web based GIS. In this paper, the authors present a review of past and current GIS projects related to Thailand, with major application domains, and results reported. Furthermore, the paper shows some future work that will lead to a solution of the above mentioned problem.

Introduction

Geographical Information Systems (GIS) are information systems that capture, store, manipulate, analyze and display geospatial data. For the most part, GIS are seen as a part of geoinformatics. GIS are comprised of at least three different components: (1) an information system on geospatial information and data, (2) a set of georeferenced or geospatial data, and (3) a management component capable of analyzing und checking the data. Applications designed for various objectives, such as statistical analysis and conversion of map projections, make use of GIS or can be seen as part of it. The geospatial data covers very different levels of granularity and they come from various sources (primary data) or are derived by diverse methods (secondary data); for a comprehensive introduction to GIS (Chang, 2004). The various definitions of GIS primarily include four different approaches, which are process-oriented approach, application approach, toolbox approach, and database approach (Cowen, 1988). A further analysis of these approaches has developed the current view of GIS as a management tool (Peuquet, 1983) and a decision support system (Cowen, 1988).

GIS can be classified by different functions and properties. One of the ways to categorize GIS is done by the granularity of the data used. Land information systems use primary data on a very detailed level, down to allotments. Second, GIS can use the data domain they cover, such as soil information system, environment information system, and so on. A third classification takes into account the platforms and licenses under which the GIS are distributed, i.e. Open Source, proprietary, and Web based GIS. Open Source GIS, such as GRASS GIS, OpenJUMP and Quantum GIS, are licensed as open source; they can be copied, manipulated and redistributed (Ramsey, 2006). Proprietary GIS, such ArcGIS, Smallworld GIS, MapInfo, GeoMedia and Manifold, use special data formats different from the open source formats and have to be acquired by purchase. With the rapid evolution of the Internet, there is also a trend to share geospatial data via the World Wide Web (Dragićević, 2004; Samarakoon, 2004). The Web based GIS can be Open Source (Raghavan, Matsumoto, Santitamont, & Honda, 2002), or proprietary software.

Georeferenced or geospatial data (sometimes called geographically referenced data) are data that describe both the location and the characteristics of spatial features on the Earth. Basically, there are two distinct data models for spatial data: the raster and vector data model. The raster data model uses a grid and cells that represent the spatial variation of features. The vector data model uses points and their x/y-coordinates to show spatial features of geometric objects, such as points, lines and areas.

Since a well-designed GIS can add considerable value to spatial data, they are used in a variety of domains with different granularities of data, such as (1) socio-economic and government issues, (2) commercial and business data, (3) infrastructure management, (4) protection of the natural environment, and (5) data provision for military activities.
(1) Socio-economic and government applications cover amongst others health issues, urban management, local government problems, transport and service planning (for example public facilities).
(2) GIS applications for commercial and business data refer to regional analysis of market shares, fleet management of vehicles, various marketing activities (for example target and direct marketing), and retail site locations.
(3) In the infrastructure domain GIS are applied for network management and service provision of power and water supplies as well as telecommunication networks, and for emergency planning (repair and evacuation models).
(4) Applications for the protection of the natural environment comprise pollution monitoring and assessment, management of natural resources, environmental impact analysis of human activities, natural hazard assessment, landfill site selection and mineral mapping potential.
(5) GIS application for military activities comprise tactical planning and target site identification, and so on.
For almost all of these application domains there exist a number of questions which can be answered with the help of a GIS (Bateman, Jones, Lovett, Lake, & Day, 2002).

Table 1 Examples of GIS queries

Type of question	***Example***
Identification	What is at a particular location?
Location	Where does a certain type of facility exist?
Trend	Which features are changing over time?
Routing	What is the best way to go from A to B?
Pattern	Is there a spatial association between two types of features?
Buffer	What features fall within a selected distance from a specified feature?
What if	What will happen if a particular change takes place?

In the following, the authors present an overview of publications delivered or serving as reviews of specific GIS problems and applications. The focus here is more on the use of GIS in general. The view on specific projects in and for Thailand is presented in the next section. We follow more or less the application structure mentioned above.

Socio-economic and government GIS applications are reviewed in (Bateman, Jones, Lovett, Lake, & Day, 2002), especially applications in environmental and resource economics in England. The upcoming 2010 Round of Population and Housing Census carried out by the United Nations is leading to an increased interest in the integration of GPS, digital imagery and GIS with census mapping (United Nations Statistics Division (DESA), 2004). Other surveys refer to techniques for handling geological data on a broader scale (Lewis, 1997). Progress has been made in GIS for health issues, such as finding determinants of Malaria (Prashanthi, Ranganathan, & Balasubramanian, 2007), and the provision of virtual emergency operation centers (VEOC) over the Internet (Chang & Li, 2007). Examples of the application of GIS for commercial and business purposes can be found for real estate and related industries (Thrall, 1998). Many industries need geographical data, for instance fisheries (Valavanis, 2002). Other applications cover crops and soil management, see (Matthews, Wassmann, & Arah, 2000). In the domain of natural environment protection, GIS play an increasingly important role. This can be seen by many studies, which use GIS as a basis for the findings, e.g. in waste water management (Mahmood & Mulligan, 2002).

As GIS computers are usually used in a networked environment, GIS should be capable of working in a network. This is carried out by using two approaches: the first make a number of different GIS, which work independently, collaborating in a network environment; the second uses one GIS (a complete application software) in a network as a multi-user system. For a review of network-enabling GIS see (Xu & Lee, 2002).

Other problems occur when time is used as an important factor of GIS. This leads to the notion of temporal GIS (TGIS) or spatiotemporal GIS. TGIS are capable of monitoring and analyzing successive states of spatial objects (events). Furthermore, they are able to find out dependencies between spatial objects (Claramunt & Thérault, 1995). Such spatial interactions can be modeled via the Dynamic Settlement Simulation Model (Piyathamrongchai & Batty, 2007), which can reflect complex relationships between urban regions for properties, such as transport structures. A more comprehensive overview on TGIS can be found in (Wang, Nakayama, Kobayashi, & Maekawa, 2005).

For almost all of these application domains there exist a number of questions which can be answered with the help of a GIS, such as (Bateman, Jones, Lovett, Lake, & Day, 2002).

Geographical names, or toponyms, refer to a locality, region, or some other part of the surface of a spatial macro-object (e.g. Earth, Moon, planets), including natural features, such as mountains, and artificial locations, such as cities. The regional character of toponyms leads to names that are in many cases used only locally, such as for the German city of München (anglicized to Munich, in Italian Monaco di Bavaria and so on). Furthermore, there is a temporal component in names as well, which results in changing names, e.g. the US-American city Columbia (later renamed to Washington) and the Thai city Song Kwae (later renamed to Phitsanulok).

Providing and retrieving GIS toponyms in writing systems other than the Latin alphabet is a real challenge. The above mentioned Thai city of Phitsanulok, in Thai writing พิษณุโลก, can also be found as Pitsanulok, Phitsanuloke, and so on. The same, or sometimes an even greater, challenge lies in the opposite process of representing toponyms from the Latin alphabet in non-Latin writing systems. As an example, London can be represented by ลอนดอน in Thai writing.

GIS Institutions in Thailand

Thailand, situated in South East Asia, is relying relatively long on tourism and agriculture as sustained sources of income. The country is now beginning an industrialization process, which leads to more difficult problems in terms of planning, managing, monitoring, and assessing environmental and commercial data and information.

Space technology has been used for cartography and geospatial data collection in Thailand since 1981, when the first Southeast Asian ground receiving station was established (Ditsariyakul, Sutheparuks, & Limlamai, 1993). Nowadays, the station is using data from various satellites, such as IRS, LANDSAT 5, IKONOS, and RADARSAT.

Main resources for GIS research and education in Thailand are Department of Geography, Chulalongkorn University, Bangkok, Department of Forest Engineering, Kasetsart University, Bangkok, Department of Geography, Chiang Mai University, Graduate School (Space Technology and Geo-Informatics), Naresuan University, Phitsanulok (Sanguansermsri, 2004). These institutions carry out a wide range of regional GIS projects, see for example (Chaowagul, 2006).

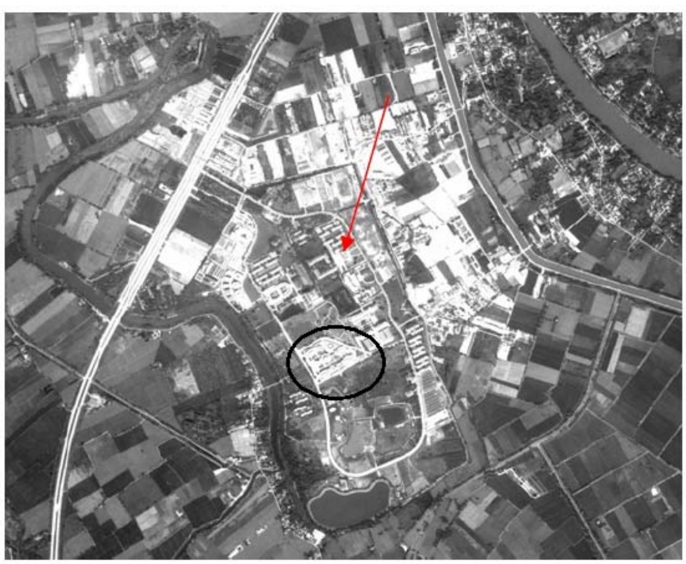

Figure 1 Naresuan University map

As a preparation for a country-wide basis for GIS Intermap analyzed the critical components of a national land information system for Thailand (Hisdal, Li, & Mills). The model used for creating the so called digital library of geospatial data is shown in Figure 2, including GIS, maps, images, GPS data, imports from spreadsheet software and remotely sensed sources.

Landscape characterization plays an important role for this kind of GIS, as is shown by (Crews-Meyer, 2000). In most countries transport costs are based on distance and load weights. The solution to this question needs a reliably searchable database, not only in Latin but also in Thai writing system. A further research on this topic can be found in (Synergy One, 2006).

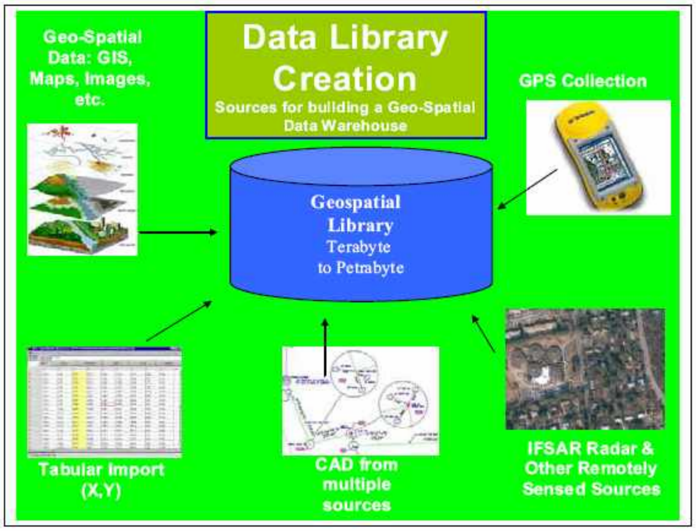

Figure 2 Digital Library Model according to Hisdal, Li, & Mills

- GIS Projects for Socio-Economic and Government Applications in Thailand

Thailand has a long history of land administration, mostly related to the Royal family and officials. Since the advent of the constitutional monarchy the economic management of land has been diversified. Hence, it is not surprising that GIS has been used for land titling and land administration relatively early (Williamson, 1994).

The SEMIS II (Subregional Environmental Monitoring and Information System Phase 2) project carried out by the Asian Development Bank, proposed five major objectives: 1) to increase the capacity of national governments to make informed decisions regarding development investments relating to sustainable utilization of natural resources; 2) to enhance the ability of GMS national governments to conduct integrated economic and environmental planning with relevant data; 3) to assess the availability of useful and relevant data for planning purposes; 4) to increase and strengthen the capacity of national governments to collect data; and 5) to conduct, store, manipulate, and share actual integrated planning information using the data collected in pilot projects for some "hot spot" areas (Starbuck, March 2001). SEMIS II was actually a follow-up project of SEMIS I and used the results of earlier projects, such as Strategic Environment Framework (SEF) for the Greater Mekong Subregion and the Early Warning and Information System (EWIS). These three earlier projects resulted amongst others in the definition of a core dataset for the topography and hydrography, the spatial database design and metadata standards. SEMIS II paved the way to fill a GIS with data by naming the available data and information sources and investigating critical data gaps.

- GIS Projects for Commercial and Business Applications in Thailand

Thailand is a tropical country, which benefits from warm climate and suitable soil conditions in terms both of agriculture and stock farming. But even for such an environment timely and reliable data and information is necessary for policy making and planning. GIS applications for these problems have a relatively long history for Thailand. In the early nineties, Supan and Virchan carried out a study on the use of GIS for planning agricultural activities in Thailand with the help of Landsat-5 data (Karnchanasutham & Amarakul, 1991). They could provide a map on soil suitability for improvements in agricultural production.

In a broader context, the effects of global warming on rice leaf blast epidemics has been analyzed for five Asian countries in different ecological zones, including Thailand, Japan, Korea, China, and the Philippines (Luol, Tenga, Fabellara, & TeBeest, 1998). GIS was used to show the results of the simulation models.

- GIS Projects for the Protection of the Natural Environment in Thailand

Thailand has a variety of protected areas covering 60,000 km² of the land mass as well as 6,000 km² of the sea belonging to the country. Obviously, protected areas, such as national parks, are important candidates being treated with the help of GIS. As an example, the Department of Forest Biology, Kasetsart University, Bangkok, carried out a gap analysis and a comparison index to evaluate protected areas in Thailand (Trisurat, 2007).

Following the accelerating industrialization process of the country, Thailand faces increasing environmental problems, which have to be addressed by different means. 1997, Billie Dugger used a GIS for the assessment of environmental impacts of solid disposal sites in Northern and Central Thailand (Dugger, 1997). A similar investigation has been carried out by Anat and Hudak assessing the pollution of groundwater pollution by pesticides in Kanchanaburi, Ratchaburi and Suphanburi, Central Thailand (Thapinta & Hudak, 2003). In this study, vulnerability factors were assigned considering pesticide concentrations and groundwater maps were generated for several pesticides.

Remote sensing and GIS were used to monitor the mangrove vegetation of Thailand in some projects. 1994 a project focused on a mangrove vegetation mapping in Phangnga Province (Aschbacher, Ofren, Delsol, Suselo, Vibulsresth, & Charrupat, 1995). After the 2004 Tsunami incidence the mangrove vegetation has been studied again in order to find out potential damage (Sirikulchayanon, 2006).

- GIS Projects for Military Applications in Thailand

In a research article following an extensive exercise (COBRA GOLD) in Thailand, the problem of a simulated influenza epidemic was analyzed (DeFraites & Chambers, 2007). The proliferation and maturation of GIS has been highlighted in this research.

Conclusions and further work

This research has shown the state of the art of GIS in the Thailand together with some relevant and published project details. As there are a lot of activities on geospatial data in the region, a summary of Thai GIS cover a large amount of information, ranging from administrative, commercial, environmental to monitoring data and information.

As the Thai writing system is very complicated and does not reflect a one-to-one matching of phonemes to graphemes, there is a need for an elaborate transcription system to carry out the job of automatical transcription of Thai place names (toponyms) in accordance with a transcription standard, such as the Royal Thai General System of Transcription, RTGS (Royal Thai Institute, 1999). The next steps in this research will be to implement such a system with the help of the MetaSound algorithm, which has been up to now applied to anthroponyms, and perform tests with a suitable sample of Thai toponyms.

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