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GIS as a Tool for Natural Resources and Environmental Policy Analysis

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Geography is an inseparable part of human affairs. From time immemorial, human beings have been affected by the geography of the world in which they live-available water and arable land, presence of strategic minerals, proximity to suitable trade routes, hazardous waste-generating industries in the vicinity, all have influenced how humans and human communities have developed. Mankind's technological advancement has not, in any way, changed this reality. In today's complex, ever-changing world, geography is becoming increasingly more important as we wrestle with problems that will affect our children's future natural resource base and environment.

Today's decision-makers are faced with solving complicated problems-problems that are no longer single-faceted or exclusive to one discipline. In addition to the complexities of the problems themselves, additional layers of complexity are introduced by diverse and sometimes contradictory government regulations and jurisdictions. Complex and shifting relationships exist between modern natural resources and environmental issues-geography, government regulations, ecology, economics, and even public opinion are important factors that need to be considered and balanced in the long run.

Generally speaking, public policy is made by elected officials or their appointed representatives. Policy, ideally, is used as a tool to influence *private* decisions or to develop *public* programs to achieve certain, desirable ends. Public policy should reflect the goals and objectives of some public authority, actions taken by this public authority should be consistent, in theory, with its stated policies. Change in various areas of public concern is usually driven by the actions of public agencies, private organizations, or private individuals. The theoretical intent of a set of public policies is to direct these actions to achieve desired goals.

Geography influences and is perhaps in turn influenced by public policy. While many natural resources and environmental decision-makers are inherently aware of this fact, others are oblivious to it and are thus potentially making decisions in a vacuum-the results can be seen all around us. It has often been said that good decisions require good information. It follows that a prerequisite for *good* natural resources and environmental policy will be precise, up-to-date natural resources and environmental information and a technology capable of analyzing this information-Geographic Information Systems (GIS). GIS, as its name implies, is a maturing database technology specially designed to handle spatial or geographic information. But GIS is much more than simply being the *United Parcel Services* of spatial information.[1] A GIS is a tool. It is a tool that supports an extremely wide range of techniques for spatial analysis eminently suited for investigating our environment-a tool suited for policy analysis. This article assesses some of the roles and factors influencing the use of GIS in public policy formulation for natural resources and environmental issues.

SPATIAL INFORMATION

Public policy dealing with natural resources and environmental issues must of necessity involve spatial information; almost all of the data concerning these issues are geographic or spatial information. In fact, New York City planners estimate that over 85 percent of all information they handle is geographic.[2] Traditionally, spatial information has been held in the form of maps. Paper maps and any accompanying documentation customarily constitute a geographic database. Geographic data are commonly characterized as having three fundamental components:[3]

- the **phenomena** being reported (physical dimensions, such as size or some type of class), *what*
- the **spatial location** of this phenomena, *where*
- the **time** when this phenomena was active, *when*

Spatial information describes phenomena existing at a certain location, at a specific point in time. It is information relating to a discrete place on the earth's surface, sometimes referred to as **georeferenced** data.

Physical dimensions might include population, width of a road, traffic volume, depth of a lake, cost of a piece of land, or the elevation of a mountain peak. The class of a phenomena might be the type of rock, a soil, a category of forest, or even the name of a city. The location-pointing out exactly where something can be found-is usually specified with reference to some type of coordinate system, such as latitude and longitude or even street addresses.

While usually not stated explicitly, the element of time is often a critical component of spatial information. Some types of spatial data such as soils and mountains, are fairly static, in theory changing little over time.[4] On the other hand, some spatial information, such as land use, is exceptionally dynamic, literally changing daily. If an area is undergoing rapid change, information can go out-of-date quickly, making it unsuitable for decision-making requiring the most current data. However, if one were interested in historical trends, as input into predictive models, this type of *dated* information becomes an extremely valuable asset. The temporal dimension is, therefore, of critical importance in considering information for policy analysis.

ASPECTS OF SPATIAL DATA IMPORTANT FOR PUBLIC POLICY

In using spatial information for policy analysis, we should keep in mind that this data is only an *abstraction of reality*; it is not feasible to assemble every bit of spatial information available over an area. It is not wanted nor is it needed-we want only data we think would be useful. The most important aspects of spatial data to consider are accuracy, precision, time, currency, and completeness.

Accuracy measures how often, by how much, and how predictably the data will be correct. **Precision** measures the fineness of the scale used to describe the data and at which scale it was collected. Scaling is an important concept that is very often misunderstood by decision-makers unfamiliar with cartographic principles. The scale at which data are collected will determine future usage. A soil map sampled at a scale of 1:50,000 will **never** have the precision or accuracy of a 1:10,000 scale map, regardless of the scale to which the map graphic is enlarged. Very often people will try to mix drastically different map scales-resulting in the creation of unscientific garbage. A map may thus have an apparent precision that does not match its true precision-a situation that will lead to incorrect decisions based on an *apparently* accurate map. A general rule-of-thumb in combining map scales is to always progress toward coarser map scales (for example, combining 1:50,000 and 1:25,000 scale maps, the resulting product would normally be used at 1:50,000).

Time indicates at what point or over what period of time the data were collected. **Currency** designates how recently the data were collected. As pointed out above, the *freshness* of information can have drastic consequences on policy analysis. For example, common sense dictates that we would use the most up-to-date information in estimating urban sprawl and its consequences on quality of life.

Completeness refers to how much of the area of interest is covered by the available data. Completeness is of particular importance to decision-making concerning environmental issues. Air or water quality, for example, is very often sampled at only a single point in a province. This single, **isolated** bit of information is frequently used to represent the entire province-leading to woefully wrong impressions about the actual environmental quality.

GUIDELINES FOR COLLECTING SPATIAL INFORMATION

There are several principles or guidelines generally applied to the collection and use of spatial information which have relevance to policy analysis: [5]

- **You can't use data that you don't have**. The pieces of information that are collected will have an impact on the type and the level of analysis that can be accomplished. Who holds spatial information and what **policies** govern its availability also play an important role.
- **The most cost-effective data collection method is to collect only data that you really need.** It is costly to collect, store and analyze data. Excess data can hinder analysis by making access to the data really needed that much harder.
- **The ideal data quality is only as good as you need it** (the minimum level that will get the job done).
- **It costs more and more to get less and less data quality**. The law of diminishing returns also applies to spatial data collection. Each gain in data quality usually costs more effort (money, time, etc.) to acquire.
- **Data is of no value unless it is the right data, in the right place, at the right time**. The way that we organize spatial data plays a major role in its successful use. Geographical databases are usually so large that, when computerized, the form and organization will have a major impact on the productiveness of the system. Poorly-designed or implemented systems will almost always fail.
- **The best data model is the simplest one that does the most with the least data**. Modeling always involves costs. These costs may be budget, time or wrong answers. The more complex the model, the more costly it is to use.
- **A too high or too low performance level is expensive**. A level of data collection or modeling above that which is required can sometimes be costly because it produces results that do not contribute much to success; while under-performing will add costs by producing incorrect results, by being late, or by losing opportunities due to better solutions.

SPATIAL ANALYSIS

Spatial analysis functions associated with public policy can be grouped into four broad categories:[6]

- *intelligence system* functionality requires that a policy-making organization maintain an extensive database of socio-economic and physical variables. A GIS allows planners the opportunity to assemble this diverse suite of data into an integrated format from which they can determine and perhaps anticipate trends.
- *pulse taking (or canary-in-a-coal-mine)* functions serve as early warning systems and require very in-depth analysis of existing conditions and trends. Meaningful statistics need to be derived from miscellaneous, disaggregated information. GIS functions dealing with statistical mapping and analysis can readily handle this type of analysis requirement.[7]
- *policy clarification* functions compare various scenarios arising from public issues. It has been suggested that the very essence of planning revolves around understanding the implications of various policy alternatives and developing recommendations from those alternatives most likely to meet required goals and objectives.[8] GIS enables a planner to measure and portray the required information as well as rapidly generate the various scenarios. An organization's specific objectives can thus be sharpened, and attention focused on the most probable courses of action.
- *detailed development planning* is for specific private and public programs as part of a comprehensive plan of action. A delicate part of this process is the balancing of economic development and further degradation of resource base or environmental quality. The classic NIMBY (*not in my back yard*) attitude about the siting of toxic waste disposal facilities is a case in point. A GIS can potentially provide *objective solutions* based upon replicable and explicit decision-making procedures. This would serve as a starting point to the process of finding a common ground among competing interests.
- *feedback and monitoring* functions are essential in following up policy goals and objectives. In theory, predicted and actual outcomes are compared and policy instruments are adjusted as required.

Ideally, these functions are part and parcel of a functioning democracy-citizens have the right to know how their lives are being affected and how their tax money is being spent. Historically, information control as been one of the foundations of political power. Modern information technology has helped change this process by making more and more information available to a wider audience.

GIS AND PUBLIC POLICY ANALYSIS

In order for a GIS to assist in the analysis of public policy, two broad conditions must be met:

- the process to formulate policy must be **rational** (or at least partially rational)
- the significant attributes of the policy must be **quantifiable**.

If these conditions are not met, GIS technology can not play a meaningful role in policy analysis-one is left to wonder whether any policy not rational and quantifiable would be worth pursuing. In the U.S., for example, public policy decisions are a transparent process, accompanied by public hearings, open access to all information used in decision-making and, where the legal system mandates, reasonable analytical procedures. GIS technology often plays a predominant role in natural resources and environmental issues.

Assuming these two conditions are met, a fully-functioning GIS can be used in policy analysis to:

- project and display potential or probable patterns to aid decision-makers in visualizing future economic activities, land-use patterns, pollution trends, resource depletion, etc.
- create and test alternative plans and provide **all** of this information to planners, prior to any implementation. The GIS can be used as a neutral judge in determining the merits or demerits of any plan.
- monitor changes resulting from implementation of formulated policy. Monitoring functions are extremely important in the public sector, as there are no in-built regulatory devices as in the private sector, where profit and competition determines when and if a given activity is worthwhile.[9]

The quantification of policy is a sometimes difficult and controversial process. While it is fairly clear that not all policy issues can be reduced to measurable factors, these are mainly issues perhaps best left to human processes of negotiation and consensus-building. However, for the most part-assuming rational policy formulation-one can expect policy attributes to be quantifiable. Five general questions need to be answered in the evaluation of natural resources and environmental public policy statements:

- What is the initial condition of the environment and/or resource base? In order to fully answer this question, historical data are usually required.
- What are the subsequent conditions of the environment and/or resource base at the end of each planning period? Periodic and timely updates of the natural resources and environmental database must, therefore, be carried out-requiring institutional commitment. In so debatable an area as this, it is perhaps best left to neutral third parties to perform this task.
- What changes have taken place during this time period? Change detection may at times be extremely subtle. Proper scaling and sampling techniques must therefore be employed to assure a reasonable chance of discovering any important changes. This becomes problematic if the changes we wish to assess are cumulative. What you don't know **will** hurt you.
- Are these changes attributable to public policies, government programs, or private sector practices, or are they simply random? The range of processes-both physical and social-active in an area must be fully understood to have any hope of attributing these changes to pertinent sources.
- How does the present state of the environment and/or resource base compare to what was planned?

The question then arises of the willingness of policy-makers to commit themselves to specific, well-defined targets for important public issues. The contribution and interaction of each individual policy and government program must also be quantifiable if undefined, seemingly random factors are to be isolated and studied. Public policies can only be meaningfully evaluated if a fairly clear, casual relationship exists between the policies in question and any changes thought to be associated or derived from them. In practice, GIS technology can be expected to:[10]

- provide as much **high-quality** information to the policy-maker as is needed
- be able to describe important relationships within this information
- predict the impacts of selected decisions
- monitor results of these decisions

Another important function for GIS technology in support of public policy is in the evaluation of **unanticipated** change. If one considers that, ideally, all change in a given area is the result of public policy, then any unanticipated changes occurring will need to be identified, analyzed for contributing factors, and examined in light of the affects (pro *versus* con) they would have on public policies. In reality, private-sector actions will often produce changes which would need to be differentiated, quantified, and their affects on policy objectives analyzed.

A sound, systems approach to policy analysis also involves the concept of monitoring. Public policies generally extend over long periods of time. Expectations and perceptions of policy issues do not remain constant. Often we see well-intentioned policy solving one problem, but creating several others of equal severity. Monitoring both environmental changes and performance of public policies is, therefore, essential to reliable policy formulation. GIS technology has an important role to play in this process.

CONCLUSION

GIS technology is rapidly expanding into almost every Royal Thai Government agency concerned with natural resources and the environment. The private sector is fast following suit. Spatial databases are growing in size and complexity, more and more practical applications are being evolved and, perhaps most importantly, Thailand is developing a cadre of dedicated, experienced GIS practitioners. The long-term impacts of this technological development will be profound-better and more timely information and analysis resulting in hopefully better decisions. Much as the printing press transformed the way information flowed through society by making the production of printed material faster and less expensive, a GIS will significantly change the rate at which spatial information is produced, updated, and distributed. GIS will change the way public policy analysis can be approached by changing the way we perceive and make use of spatial information-it will be more malleable, more easily shaped to best fit a policy maker's analytical needs. The only proviso is that the policy be rationally-formulated and quantifiable.
