China's National Geographic Information Strategy: Lessons Learnt from First Generation Initiators

Yunfeng Kong Hui Lin

Department of Geography and Joint Laboratory for GeoInformatics
The Chinese University of Hong Kong
Shatin, NT, Hong Kong, China
E-mail: yfkong,huilin@cuhk.edu.hk

ABSTRACT This paper reviews the experiences of worldwide initiatives on their national geographic information strategies, and argues to introduce a five-stage model of GIS development in national/regional context. Based on the lessons learnt from the first generation NGISs, the author intends to evaluate the status of GIS development in China, and discusses some basic issues for China's strategic development of geographic information, such as data production and sharing, technological difficulties and application effectiveness. The author also raises several general questions for the understanding and constructing of China's geographic information strategy (NGIS).
KEY WORDS national geographic information strategy, five-stage model of GIS development, China

1. Introduction

The national or regional strategies of geospatial data infrastructure in more than twenty developed and developing countries, e.g. National Spatial Data Infrastructure in United States, National Geospatial Data Framework in United Kingdom, Austrian Spatial Data Infrastructure, Canadian Geospatial Data Infrastructure, Korea's National Geographic information systems, Malaysia's National Infrastructure for Land Information Systems, and GIS Infrastructure for Asia and the Pacific, are mainly resulting from the widely use of GIS, spatial data production, the need of data sharing, and maintaining or generating national/regional economic competitiveness.

Several surveys and reviews on first generation NSDIs have been finished. The Framework Data Survey conducted in United States (NSGIC/FGDC, 1999) and worldwide NSDI survey (Onsrud, 1998) are very beneficial to the understanding of fundamental data production, use and sharing. Ian Masser (1998) also empirically and theoretically summarizes the experiences and lessons from Britain, Netherlands, Austria and United States in his book "Government and Geographic Information". Relevant studies have diversity topics on GIS and institutional organization, the effectiveness and efficiency of geospatial data sharing, and GIS for national development (Masser, 1998; Burrough and Masser, eds. 1998; Campbell and Masser, 1995; National Research Council, 1993; NAPA, 1998; etc.).

After 5-10 years of development, it is essentially important to review and evaluate the first generation of national strategies, not only contributing to the next stage development, but also shedding some light on other countries such as China, where the national strategy for geographic information development is being planned. However, the development of geographic information in China will be not the simple repeat of the existing strategy, because China has very different social, political, economic and technologic backgrounds from western countries. Therefore, it is required to reexamine the development of first generation of national spatial data infrastructures from the perspectives of China.

In order to make appropriate/operational policy for China's geographic information strategy, the author widely examines the GIS historical development, current industrial tendency, new research trend and the national spatial data infrastructure worldwide, and introduces a five-stage model of GIS development, in which the GIS development is divided into five stages, 1) GIS innovation, 2) automatic mapping and GIS thematic application, 3) development of national/regional spatial data infrastructure, 4) interoperable open system and enterprise level GIS, and 5) public and daily GIS. The GIS applications and diffusions in a specific region usually begin at the second stage, and then are developed stage by stage sequentially, but not exactly or automatically.

At present, China still lacks the necessary conditions, in terms of financial support, policies and legislation, data standard and provision, effective use of GIS, acceptance of GIS in business organization, insufficient education and professionals, etc., to foster the development of geographic information systems. However, the Chinese scientists are trying to promote an ambitious project, i.e. Digital Earth/China, to boost the national geographic information strategy, including remote sensing and global positioning system. Thus, it is remarkably important to evaluate the status of GIS in China in software R&D, data standard, production and sharing, effectiveness and efficiency of GIS applications, institutional and organizational context of using GIS, etc. The comparison of China's contemporary status and the global GIS trends will benefit the formulation of China's national or subnational geographic information strategy.

This paper reviews the experiences of worldwide initiatives on their national geographic information strategies and argues to introduce a five-stage model of GIS development in regional context. Based on the lessons learnt from the first generation NGIS, the author intends to evaluate the status of GIS development in China, and discusses some basic issues for China's strategic development of geographic information, such as data production and sharing, technological difficulties and application effectiveness. The author also raises several general questions for the understanding and constructing of China's NGIS.

2. Review of Geographic Information Strategies in North America, Europe and Asia-Pacific

2.1. Definition of NSDI, GSDI, NGIS

The national spatial data infrastructure (NSDI) is the means to assemble geographic information that describes the arrangement and attributes of features and phenomena on the earth. The infrastructure includes the materials, technology and people necessary to acquire, process, store, and distribute such information to meet a wide variety of needs (National Research Council, 1993). Similar definitions are national/regional/global spatial/geographic/geospatial/land information/data infrastructure/framework/systems. All these definitions have almost same meanings in nature.

At regional level, European Geographic Information Infrastructure (EGII) is "a set of agreed rules, standard, procedures, guidelines, and incentives for creating, collecting, exchanging and using of geographic information" (Brand, 1995). The definition of global spatial data infrastructure GSDI encompasses the policies, organizational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives. (GSDI, see http://www.gsdi.org/).

National geographic information strategy (NGIS) - a more broader term in concept - is defined as "the technology, policies, standard and human resources needed to acquire, process, store, distribute, and improve utilization of geographic information" (Executive Office of the President, 1994). Almost all of the national projects/programs such as NSDI in U.S., NGDF (National Geospatial Data Framework) in U. K., NGIS (National Geographic Information Systems) in Korea, can be presented in this term. Therefore, NGIS is used as a general term in this paper, and I also names China's national geographic information strategy as CGIS rather than Digital Earth or Digital China.

2.2. The Natures and Importance of Geographic Information

Upon the fundamental understanding of data, information and knowledge, and comparing geographic information (as specific) with information (as generality), Masser (1998) provides four type of visions on geographic information in economy:

1. Geographic information as resources (from viewpoint of economy and compared with land, labor and capital): it is expandable, compressible, substitutable for other resources in economy, easily transportable, diffusive and shareable (Cleveland, 1985, cited in Masser, 1998).
2. Geographic information as commodity (from viewpoint of business): it is a special commodity with high cost production, high values in many field, value-added natures, and also very low marginal cost for reproduction.
3. Geographic information as an asset (from viewpoint of government): it is required to meet the needs for national defense and emergency services, as well as for effective public administration and maintaining economic competitiveness.
4. Geographic information as an infrastructure (from viewpoint of economy, compared with external physical infrastructure): it is the base to support economic activities, usually having positive effects on economic development. This view lends the public infrastructure managerial model to the implementation and maintenance of NGIS.

There is growing importance of geographic information in the coming era of digital technology and the need for some forms of government intervention to coordinate data acquisition and availability. The objectives of most national geographic information strategies is to promote economic development, to stimulate better governance and to foster environmental sustainability (Masser, 1998). For example:

1. "Geographic information is critical to promote

economic development, improve our stewardships of natural resources and to protect the environment" (Executive Office of the President, 1994).

2. "ANZLIC believes that Australia and New Zealand should have the spatial data infrastructure needed to support their economic growth and their social and environmental interests, backed by national standards, guidelines and policies on community access to the data" (ANZLIC, 1997)
3. Korea's National Geographic Information Systems is "recognized as one of the most fundamental infrastructure required in promoting national competitiveness and productivity" (MOCT, 1995)

2.3. Status of First Generation of National Geographic Information Strategies

The status of first generation of national geographic information strategies can be statistically drawn from "Compiled responses to selected questions" of Onsrud's (1998) global NSDI survey:

1. Most of NSDI strategies are coordinated or leaded by national agency or organization with legislative orders.
2. Most NGISs include the four types of data: land surface elevation and topographic, cadastral data and land ownership, geodetic, and administrative boundaries. Parts of them include hydrography, digital imagery, land use/land cover/ vegetation, and transportation/road.
3. Data in most NGISs are accessed by web/Internet, some of them (for example, Australia, Japan, Malaysia, and UK, US) by clearinghouse mechanisms.
4. The roles of private commercial firms in NGISs are mainly contracting partner, value-added player, or member of NGIS directly or indirectly.
5. At present stage, there are very few digital spatial data that are available freely or at low cost in public domain, except in Sweden (see http://www2.echo.lu/gi/en/intro/mapslist.html) and United States (see http://www.fgdc.fov).
6. Almost all NGISs include definitions of metadata, data standards, and fundamental data.
7. Different NGIS has different challenges/problems in practice, for example, spatial data production (Mexico), cooperation of governments (Australia), consistency of data (Finland), legal and economic aspects (Indonesia), standardization, effective development (Japan), administrative questions (Sweden), lack of resources (U.K.), etc.

2.4. Demand, Supply and User of Geographic Information in United States

The National States Geographic Information Council and the Federal Geographic Data Committee (NSGIC/FGDC, 1999) had finished a survey of over 5000 data users throughout the United States from November 1997 through October 2, 1998. This survey provides a snapshot of data being produced and used in state, regional and local governments. Such large-scale survey is helpful for understanding the spatial data need and supply. Table 1 shows the preliminary result of organizational distribution of GIS users in government. Table 2 shows the preliminary result of department/functional distribution of GIS users from 5258 samples. Departments of surveying and mapping, community development, land records, engineering, water, environmental, transportation, nature resources and public safety in government are the major geographic information suppliers and/or users.

Type of organization	Percentage	Class of organization	Percentage
National	5.1	Academia	4.1
State	14.4	City/town	22.5
Multi-county region or Consortium	7.3	County	36.3
Single country	26.3	Federal	5.1
Sub-Country region	22.5	Private industry	8.2
Municipality	4.1	Regional	7.3
Native American,etc	8.2	State	14.4
Others	2.0	Tribal	2.0

Table 1: Organizational distribution of GIS user (NSGIC/FGDC, 1999)

2.5. Lessons form Initiators

There is a great deal of diversity in the first generation of national geographic information strategies and it is also difficult to assess the degree of success or cost-benefit of them regionally or organizationally. However, the national organization, resource and technology are the most important factors that determine the success of national geographic information strategy. It is apparent to see that a specific national agency with a formal legislative order has advantages to coordinate the nation-wide cooperation. Besides government agency, professional organization and private enterprise usually also play important roles.

Department	Amount	Percentage
GIS/Mapping	2803	53.0
Land Records	1481	28.2
Community Development	1724	32.8
Public Safety	989	18.8
Transportation	1153	21.9
Water	1219	23.2
Wastewater	787	15.0
Other Public Works	691	13.1
Engineering	1405	26.7
Health and Human Services	357	6.8
Elections	480	9.1
Education	440	8.4
Libraries	127	2.4
Administrative and Finance	309	5.9
Information Services	802	15.3
Environmental	1204	22.9
Historical Preservation and Archeology	553	10.5
Natural Resources	1067	20.3
Agriculture	519	9.9
Other	482	9.2

Table 2: Department concerning spatial data within GIS organization (NSGIC/FGDC, 1999)

It is not surprise that most countries have no sufficient resources for development of NGIS, and seeking investment turns out to be rather challenging. Experiments show that low-cost cost recovery is one way for creating and maintaining geographic data store in government, though being criticized. The second efficient way is to regulate the value-added activities and thus promote private investment on data production. The third strategy is "sharing costs sharing benefits", which hopes to foster the cooperation between multiple organizations. In the domain of technology, OGC and ISO TC211 Committee have attempted to provide total solutions for data distribution and geo-processing services across the Internet. It is good to take part in or trace their technological development and engineering specifications.

3. Five Stages of GIS Research, Development and Application in Regional Context

In the second half of 1990s, there are great changes in research and development of GIS. First trend is the structural and organizational changes in GIS - from personal desktop GIS, small group department GIS, to enterprise level GIS and Web-based public GIS, from integrated one-tier structure, two-tier client-server structure to three-tier network- and web-enabled structure. Second trend is the OpenGIS (OGC, 1995), i.e. Internet-based, interoperable and public-participated GIS, which includes a series of technologies and specifications on spatial data clearinghouse, metadata and remote catalog service, geo-processing services, application service. CORBA, DCOM, Java and other distributed technologies play the most important role in the development of such open system. Third is the methodological diversity in GIS research and application: data-driven, technology-driven, application-driven and society-driven paradigms. Data-driven approach emphasis spatial data model and data clearinghouse; technology-driven approach means 3D/4D, AI and interoperability; application-driven approach focuses on the methodological framework for spatial problems; while society-driven approach integrates social theory into public GIS application. Forth is the increasingly use of GIS in business and economy. Pushed by NII (national information infrastructure), NSDI (national spatial data infrastructure) and public-participated information system, the web-based, business- and economic-oriented, regional-level GIS is coming.

The GIS industry continuously increases in 1999 along with being reshaped by new entrants. IDC predicts the growth of GIS software will reach 15 to 20 percent, with total revenues for software, application and maintenance approaching US$1.2 billion. The releases of two new products - Oracle's Oracle8i Spatial and Microsoft's MapPoint 2000 - maybe the most important events in 1999 in GIS communities. Oracle Spatial is the first database component to successfully integrate spatial data and relational database management system, and has been widely accepted by many traditional GIS venders, such as MapInfo and ESRI. While the MapPoint, included in Microsoft Office and priced at US$109, will strongly reshape the desktop mapping segment of the market, and even makes inroads into enterprise by Microsoft's technological and market power. The trend of GIS gradually melting with mainstream information technology will profoundly boost the GIS development by leading IT enterprise's mature technology, low cost strategy, and marketing capability.

However, the research, development and application of GIS are extremely uneven globally and even within a specific nation. Therefore, it is meaningful to examine the degree of GIS development in regional context, not only supporting policy making for geographic information strategy, but also potentially improving the proper use of GIS. The term of GIS development in this paper means the widely use and diffusion of geographic data and geographic information technologies in a specific region effectively, efficiently and strategically in private and public sectors at every spatial level, promoted by governments, businesses, or professional organizations. The degree of GIS development may be measured by the following indexes: the general cost-benefit analysis of GIS applications (Kelly, 1995), the percentage of GIS use in government, the percentage of data sharing, the accumulative amount of GIS and spatial data investment, accumulative revenue of GIS industry, research and educational activities, etc. The degree of GIS diffusion and evolution in a specific region can be easily understood by the term of GIS development.

GIS development as a research topic has attracted some researchers' attention for different purposes. For example, compared with characteristics of data and information given by American Library Association in 1978, McLaughlin (1991, cited in National Research Council, 1993, p13) views building GIS into three interrelated Stages: stage I (circa 1960-1980) - discipline oriented, to develop a new paradigm for managing spatial data; Stage II (1975-2000) - mission oriented, marked by innovation and a broad vision, and the rapid emergence of commercial GIS and digital mapping software; Stage III (1990-beyond) - problem oriented, dominated by integration and applications, building mass database, and the shift from information technology to information use.

However, most of existing stage models of GIS development/evolution are mainly western oriented and have inherent limitations for guiding developing nations' GIS development. A comprehensive stage model in regional context, shown in table 3, is suggested according to the natures of technology, application, spatial data sharing and organizational management. This model include five stages of GIS development in terms of GIS innovation, automated mapping and thematic GIS applications, national/regional spatial data sharing, interoperable open GIS and enterprise level system, and public and daily GIS. The first stage, mainly in 1960s and 1970s, is a disciplinary approach to formulate the concept and vision of GIS, and results in multiple GIS innovations. The second stage, mainly in 1980s and 1990s, is automatic mapping and thematic GIS application, marked by the surge of GIS industry and widely use of GIS in military and government. After having mass volume of spatial data accumulated in stage two, the data sharing strategy, stage three mainly in 1990s, is naturally and rationally reached due to the high cost of data production. Stage four (1995 and beyond) is the commonly use of GIS in enterprise level for business efficiency, effectiveness and competitiveness. Stage five (2000 and beyond) is the commonly use of GIS in general communities for individual daily use or community development, like Maguire's predication that it is not fanciful to suggest that GIS will be used every day by everyone in the developed world for routine operations (Maguire et. al, 1991).

This model pursues the most important themes of development, such as the shifts in GIS technology, primary target, administrative framework, investment focuses etc, and thus has important implications for policy-making and strategic management of national/regional geographic information development, especially for developing countries. It is also needed to note that the five stages of GIS development/evolution are generally sequential rather than that one stage strictly depends on previous stages or automatically leads to next stage. These five stages are somewhat interrelated rather than clearly distinguished.

4. GIS Development in China

4.1. The Need of National Geographic Information Strategy in China

Information is a supper 'currency' for restructuring or reshaping regional economy, including competitive adaptability and regional systems of innovation, on which the success of economic growth is becoming increasingly dependent. Some of the traditional economic factors, such as land, labor and capital, have been replaced by information, knowledge and communications. "Economic development is becoming more of an information business, or information game, where people demand detailed data on a broader range of topics" (Lang, 1994). Therefore, the geographic information production and sharing, the promotion of geographic information technologies is needed for information-based and knowledge-driven economic development.

The economic significance of geographic information lies in its general reference framework that provides for integrating large numbers of different data set from many application fields in both the public and private sectors (Masser, 1998). From the view of social and economic perspective, GIS is an important element in changing relations in market economy; in producing new demands, commodities, and forms of domination in the workplace; in defining, delimiting, and mapping space and nature; and in providing new tools and

Development stage	GIS innovation	Automatic mapping and thematic GIS application	National/regional spatial data sharing	Interoperable, comprehensive open GIS system; Enterprise system	Public GIS
Computing environment	Mainframe, workstation	PC, workstation	LAN, Internet, intranet	LAN, Internet, intranet	Internet
Primary target	Organization	Professional individual(s)	National/regional public and private cooperation	National/international industrial cooperation; Enterprise and government	Society
Administrative framework	Regulated monopoly	Free market	Top-down collaborate	Regulated free market	Collaborate, democracy, liberal
Examples of application		Thousands of applications based on popular GIS packages (e.g. ESRI, Intergraph, MapInfo, etc.)	NSDI (U.S.), ASDI(Australia), DDGI (Germany), NGDF (U.K.)	OpenGIS's Abstract Specification and Implementation Specifications Enterprise wide GIS - Town of Cary, NC Enterprise GIS - City of Ontario, CA Nassau County GIS	
Justification/main purpose	Organizational effectiveness	Productivity and efficiency	Data sharing, accumulation of data resource	Interoperable data sharing and geoprocessing services Competitive advantage	Improving quality of life Community development
Client/server architecture	Mainframe	Fat client/thin server	Fat server/thin client	Distributed, interoperable, component-based architecture Two-tier Client/server, three-tier web architecture Client/server balance	Three-tier and N-tier web architecture Fat server
Programming language(s) and IT protocol(s)	C	Customization or 4GL (e.g. macro language), C/C++	Java, DHTML, C/C++, SQL, 4GLs; ANSI Z39.50	Java, DHTML, C/C++, SQL, 4GLs; DCOM, CORBA, ActiveX, plug-ins	Java, DHTML, C/C++, SQL, 4GLs; DCOM, CORBA
Solution strategy	Discipline-oriented	Project-oriented Problem solving	Government coordination	Industrial strategic cooperation Integration of GIS and mainstream IT	Education Participation Collaboration
Product example	Canada GIS	ArcView, MapInfo	FGDC Metadata Entry System, Blue Angel Metadata manager	Oracle8i Spatial, ESRI's SDE, MapInfo for Oracle8I,	
Main R&D issues	System design	Spatial database Spatial presentation Spatial modeling Digital map production Thematic application	Spatial data quality and standard Spatial metadata Spatial data Clearinghouse	Web GIS Fully Integration of GIS and MIS	GIS and society GIS for community development
Incentives	Innovation-driven	Technology-driven Data-driven	Policy-driven	Industry-driven Business-driven	Society-driven
Period	1960s-1970s	1980s-1990s	1990s-2020s?	1995-	2000s-
Main stream GIS activities	Innovations in theory, technology and system	Widely use of GIS in government Mass digital data production Increase of GIS industry	Standardization of geographic data and technology Mass data production	Widely use of GIS in business GIS melts in IT	Widely use of GIS in daily work and life

Table 3: Five stages of GIS research, development and application in regional context

techniques for business and economy (Pickles, 1995). In each of these domains, GIS is a part of contemporary network of knowledge, ideology, and practice that defines, inscribes, and represent environmental and social patterns within a boarder economy (Pickles, 1995). The ultimate power of GIS lies its spatial representation for understanding, exploring, communicating, and marketing the extremely complex spatial world. For business, geographic information specifically and information technology generally, are determinate factors for organizational productivity/efficiency, individual and collective effectiveness, strategic management and business competitiveness, and organizational effectiveness in contemporary globalized business environment (Applegate, et. al, 1998). Geographic information technology has increasingly penetrated into many business organizations not only for daily operation (e.g. AM/FM), high-level management (e.g. strategic marketing analysis), but also potentially integrated into business value-chain (Porter, 1990) to gain business competitiveness.

Traditionally GIS plays an important role in regional science, such as urban/regional planning, land management, environment management and protection. GIS is one of the most effective and 'rational' tools for the management of regional development. Since the beginning of 1990s, various geographic information strategies have been launched for 'national/national competitiveness', economic development, and development sustainability in many countries. For example, in Geographic Information for the 21st Century - Building a Strategy for the Nation, NAPA (National Academy of Public Administration, 1998) suggested that geographic information is important to over half of the areas of economic activities at global, national, regional, local and personal levels. NAPA also identified 12 major public fields of federal government - such as property right, voting, agriculture and nature resource development, and emergency management - that now relatively rely on geographic information

4.2. Institutional Context for Geographic Information Strategy

Like most other countries such as Australia and United States, the fundamental national surveying and mapping activities in China are centrally administrated by national agency - State Bureau of Surveying and Mapping of China. At the same time, the large scale urban surveying and mapping is invested and managed by local government, mainly the urban planning department or related agencies. The thematic surveying and mapping, for example, land surveying, geological surveying and mapping, is performed by relevant state agencies. All surveying and mapping activities and use of map production are governed by state law of surveying and mapping. And the map production at every scale is highly standardized by a series of national standards, except the digital map standard.

Hardcopy maps of China at scale of 1:100,000 and smaller had been finished and available for specific use, maps at scales of 1:10,000 - 1:50,000 also available in most urban area and relatively developed regions (as shown in table 4). However, only the 1:1,000,000 maps and part of 1:500,000 maps are digitized in GIS format. At local level, some large-scale maps in urban area are produced in or transformed into digitized format, for example in Guangdong province, most of 1:500 urban maps in Zhongshan, Nanhai, Shenzhen, part of 1:500 maps in Zhuhai, Dongguan, are already transformed into digital form, but mainly in AutoDesk's CAD format.

Scale	Total maps	Finished (hardcopy map)	Percentage
1:10000	372325	146437	39%
1:25000	96398	23525	24%
1:50000	24091	19297	80%
1:100000	6170	6170	100%
1:250000	819	819	100%
1:500000	252	252	100%
1:1000000	77	77	100%

(Source: State Bureau of Surveying and mapping of China, http://www2.sbsm.gov.cn/, 1999)

Table 4: Map production in China

However, according to author's more than five-year working experiences in Guangdong, it is easily perceived that there are many intrinsic disadvantages of GIS applications in China's current administrative framework on surveying and mapping. First, the use of map product at many scale levels is highly restricted by national laws and local rules. Second, use of map at local level is cost-recovery based and at a relatively high cost. Third, there is still no qualified national standard on digital map product. Forth, most of the fundamental digital data in Guangdong, China are in AutoCAD format without attribute information for only mapping purpose. Fifth, at present, there is no operational national strategy on digital map production and GIS promotion.

Many scientists in China have been trying to formulate a national project/program to promote the so-called Digital Earth or Digital China or China Spatial Dada Infrastructure. However, there are much diversity visions/opinions toward such strategy on financial budget, national executive administration, the scopes covered in this strategy, and many others beyond technology. Even many scientists have been widely discussed the fundamental concepts of 'Digital Earth' since 1998 in several panel meetings and workshops, there are too few deep investigations or surveys that are available to guide the strategic policy making for geographic information development. Besides the technological issues, more studies in broader context are needed urgently.

4.3. Multiple Approaches for An Ideal NGIS in China

There are three most important technologic issues for China's geographic information strategy:

1. Data production at low price: Data production is extremely costly, for example, the US federal agencies spend US$4 billion annually to collect and management domestic geospatial data (FGDC, 1994), and in Korea, US$288.5 million is allocated to fundamental digital mapping in a five-year project (MOCT, 1995);
2. Data standard including spatial reference standard, data quality and content standard, data transfer standard and thematic standard not only in conceptual level but also specification-enabled;
3. Metadata, catalog service and spatial clearinghouse: based on ANSI Z39.50, a library-model solution is popular in US for spatial data catalog services across Internet, which is mainly implemented by client (web browser) and server (Z39.50 server) communication and server-side matedata management. A node of web-based spatial database with catalog service and coordinated with other nodes turns out to be a clearinghouse for providing public spatial data index, access and other geo-processing services.

Technology is important but not the biggest issue for national geographic information strategies, since building NGIS is for sharing rather than accumulating geographic information, for economic development rather than technologic development. Beyond technology, the following topics are fundamental for NGIS:

1. Business GIS: to investigate how effective, efficient of using GIS in business operation;
2. GIS for regional development: how GIS can be used in regional development at any spatial level, such as economic development, environment protection, nature resource management;
3. GIS in government: how government can be efficiently, effectively operated;
4. GIS and society: to explore the interrelationship and interactions between GIS and institution, organization, legislation, community;
5. Investment on GIS: to assess the long/short term cost-benefit of GIS investment in public sector and private business at every spatial level.

On the other hand, several organizational approaches are critical for development of NGIS:

1. Government approach: an organizational model for development of the GSDI based on government agencies who usually have permanent resource and executive ability for national-wide coordination; e.g. Federal Geographic Data Committee (FGDC) in United States and Working Committee of the Surveying Administrations of the States of Germany;
2. Business approach: to motivate private sector to solve technological problems in value-added manner, e.g. most complicated technical issues are being addressed in ISO TC 211 and OGC through a cooperative step-by-step engineering process;
3. Professional approach: professional organizations from the whole community with wide research interests are very flexible in cooperation and will provide innovative and critical knowledge for NGIS, e.g. University Consortium of Geographic Information Systems, U.S. (UCGIS) and National Center for Geographic information Analysis (NCGIA);
4. Regional approach: to integrate national, regional and local government and private sectors and formulate top-down, bottom-up and interregional cooperation.

Learnt from different 'successful' examples, such as United States and United Kingdom, the following operational issues need to be considered carefully for the promotion of CGIS:

1. Pricing and cost recovery: there are four basic models in use of geographic information: low cost cost-recovery in UK and Australia, free use of data in US, sharing costs and sharing benefits in New York State and other regions, restricted use of data in Malaysia and Japan.
2. Policies including executive order, legislative mandate and standards: a recent survey in U.S. (NSGIS and FGDC, 1999) show that the policy is the mostly helpful for creating, updating, integrating or distributing fundamental spatial data;

3. Organizational coordination and cooperation: such as the Cooperative Agreements Program, Community/Federal Information Partnership in US.
4. Data provider, core data and metadata: main data providers of geographic information in many countries are land titles and cadastral information, national mapping agencies and socio-economic statistics; and experiences show that the metadata management is technically challenging.

5. Conclusion - Future of China's NGIS

It is not easy to predict the future of China's geographic information strategy due to the institutional disadvantages in policies and legislation, few data provision and GIS applications, shortage of government financial budget, and lack of research and development. It is therefore difficult to formulate a practical strategy for geographic information development in China since there are too few related research on organizational, managerial, political, legal, social and economic issues. Furthermore, the most important thing for CGIS maybe the lack of digital spatial data and lack of investment on data. Based on the discussions in this paper, several suggestions are concluded for the forthcoming China's geographic information strategy:

1. To launch a series of research/survey of CGIS in a wider context, especially on GIS and national/regional development, GIS and society, geographic information supply and need at national, regional and local levels;
2. To make national strategic policies on production, maintenance, use, distribution, value-added of geographic information though the wide range consultations, and launch a program/project to promote the CGIS;
3. To set up or grant a national authority to administrate and coordinate the planning and implementing of CGIS.
4. Pricing geographic information: to carefully choose/balance the four pricing models for different purposes: free use, low cost cost-recovery, sharing cost sharing benefits, and restricted use. Value-added activities in private sector is also needed to be regulated.
5. Learning from initiators and international organizations, such as PCGIAP (Permanent Committee on GIS Infrastructure for Asia and Pacific), EUROGI (European Organization for Geographic Information), ISO TC 211 committee, etc.

The field of geographic information is rather immature, most of GISs are too experimental, and it is very difficult to assess the values of them (NAPA, 1998). This fact is also true for Chinese scientists to evaluate the costs and benefits of future CGIS among individuals, organizations, components of society, and national development. It should be noted that CGIS are political, economical and management issues rather than technical issues. Strategic policy making for CGIS is challenging both Chinese politicians and researchers.

Reference

ANZLIZ, 1998, Spatial data infrastructure for Australia and New Zealand, http://www.auzlic.org.au

Applegate, L. M., McFarlan, F. W., and McKenney, J. L., 1999, Corporate information systems management: text and cases, 5th ed., Boston: Irwin/McGraw-Hill

Brand, M. J. D., 1995, The European geographic information infrastructure, http://eurogi.org/forum/esig.html

Burrough, P., and Masser, I. (eds.), 1998, European geographic information infrastructures: opportunities and pitfalls, London: Taylor & Francis.

Callon, J. D. ,1996, Competitive advantage through information technology, New York: McGraw-Hill

Campbell, H. and Masser, I., 1995, GIS and organization: how effective are GIS in practice? London: Taylor & Francis.

Cowen, D., 1989, "A GIS Based Support System for Economic Development," Urban and Regional Information System Association Proceedings, 2, 1989, pp.138-148

Drummond, W., 1995, "Towards a Design Framework for Economic Development Geographic Information Systems," Conference Overheads, Urban and Regional Information System Association, 1995

Executive Office of the President, 1994, Coordinating geographic information acquisition and access, the national spatial data infrastructure, executive order 12906, http://www.fgdc.gov/publications/documents/geninfo/exexord.html

Federal Geographic Technology Conference, 1994, GIS in government: the federal perspective, Washington D.C.

FGDC, 1994, The 1994 plan for the National Spatial Data Infrastructure: building the foundation of an information based society, Federal Geographic Data Committee, USGS

Kelly, K, 1995, A framework for evaluating public sector geographic information systems, A research report of the Center for Technology in Government, University at Albany - SUNY

Kelly, K, et al, 1995, Sharing the costs, sharing the benefits: the NYS GIS cooperative project, Center for Technology in Government

Kelly, K. 1995, "Compelling Reasons for GIS

Coordination in NYS," Center for Technology in Government, December, 1995 (CTG.GIS-004)

Lang, L. 1994, "South Carolina Win Corporate Investments," Government Technology, Vol. 7(7)

Laudon K. C., and Paudon, J. P, 1998, Management information systems: new approaches to organization and technology, 5th ed., Prentice Hall

Maguire, D.J. (1991) An Overview and Definition of GIS. In: *Geographic Information Systems: Principles and Applications, Vol. 1*, editied by D.J. Maguire, M.F. Goodchild, and D.W. Rhind, pp. 9-20. London: Longman Scientific and Technical

Masser, I., 1998, Government and geographic information, London: Taylor & Francis

MOST, 1995, A master plan for National Geographic Information Systems (NGIS) in Korea, Seoul: Ministry of Construction and Transportation

NAPA, 1998, Geographic information for the 21st century - building a strategy for the nation, http://www.napawath.org/napa/index.html

National Research Council, 1993, Toward coordinated spatial data infrastructure for the nation, Washington D.C.: National Academy Press

NSGIC/FGDC (The National States Geographic Information Council and the Federal Geographic Data Committee), 1999, NSGIC/FGDC Framework Survey, http://www.fgdc.gov/framework/survey_results/readme.html

OGC, 1998, The OpenGIS Guide G Introduction to Interoperable Geoprocessing, Version 3, http://www.opengis.org

Onsrud, H. J., 1998, Survey of national and regional spatial data infrastructure activities around the globe, http://www.spatial.maine.edu/harlan/gsdi/GSDI.html

Pickles, J. (ed.) 1995, Ground truth, the social implication of geographic information systems, New York: Guilford

Porter, M. E., 1990, The competitive advantage of nations, London: Macmillan