Building Spatial Database for NGII in Nepal

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Abstract

In Nepal, Survey Department is now in the process of transforming its traditional role of national surveying and mapping organization from paper maps production and sales to a NGII i.e. developing spatial database and building an infrastructure for sharing, dissemination and utilization of spatial and socio-economic data and their metadata. Such system generally requires heavy investment in terms of human-, hard-, and software resources. Nepal initiated development of spatial database with relatively cheap resources using PC ArcInfo and ArcView. In less than three years, digitalization of all topographic basemaps has been completed. Using ArcInfo data formats as de facto data standards has made the basis for NGII in Nepal relatively inexpensive and practically less problematic. The Nepalese NGII vision and the contribution of ArcGIS in its inception are given.

1.   Background

Nepal is a small mountainous landlocked country in South Asia located between latitudes 26°22'N to 30°27'N and longitudes 80°04'E to 88°12'E and lying between India and China. It has an area of 147,181 square kilometres and a population of 23.4 million inhabitants. It has a rich human culture and natural biodiversity with more than 61 ethnic groups and 70 spoken languages. Nepal- occupying only 0.1% of the earth- is home to 2% of all flowering plants in the world, 8% of all the world's population of birds (more than 848 species), 4% of mammals on earth, 11 of the world's 15 families of butterflies (more than 500 species), 600 indigenous plant families, and 319 species of exotic orchids. However, economically the situation is not that encouraging. The per capita income in Nepal is a mere US$ 240. Worst of all, the single indicator showing the condition of people in Nepal is the number of population living under the poverty line, which is 38%.

Nepal is limited by heavily diverse topography and fragile geological conditions coupled with extensive poverty and abundant illiteracy. The

thrust of the development problem in Nepal is a "poor management". One of the weaknesses of the Nepalese management process is the lack of adequate geographic information in decision-making thus resulting in poor-management. To support this gap, His Majesty's Government of Nepal initiated National Geographic information Infrastructure (NGII) Programme since 2002.

2. New Topographic Mapping: A Basis for Up-to-date Spatial Data

GIS activities were initiated in Nepal during Eighth Plan (1992-1997) period. Due to lack of a national perspective, sporadic creation of spatial databases and mushrooming of independent and isolated systems were witnessed. Most of the systems started from the digitisation of then existing 1" to one mile topographic maps of their areas of interests. Such maps were dated back to 1950's and 60's; and therefore a lot of resources were duplicated in these (out of date) efforts.

The Ninth Plan (1997-2002) states the importance of GIS in more than occasions. It states that "reliable information and data are necessary for programmes for agriculture and forest production, land-use, land-consolidation, the preparation of local and regional housing and physical plans, the preparation of environmental programmes to preserve, develop and use natural resources, and the preparation of poverty alleviation programme and sustainable development".

The base paper of Tenth Plan (2002-2007) is more pronounced on the importance of a "national" geographic information system. One of the key sectoral policies and strategies outlined in the Tenth Plan states that "development of a national geographic information system shall be pursued for the easy access and dissemination of geographic information".

During the period between 1992 to 2001 a complete new series of topographic base maps were published by the Survey Department to replace the old one inch to one mile maps. These maps were produced at a scale of 1:25,000 for the terai and the middle mountains; and at a scale of 1:50,000 for the high mountains and Himalayas.

Availability of a new completely up-to-date hardcopy base maps (1:25,000/ 1:50,000) and the users demands for spatial data at different resolutions for their specific GIS applications forms the standpoint for the development of spatial database and NGII in Nepal.
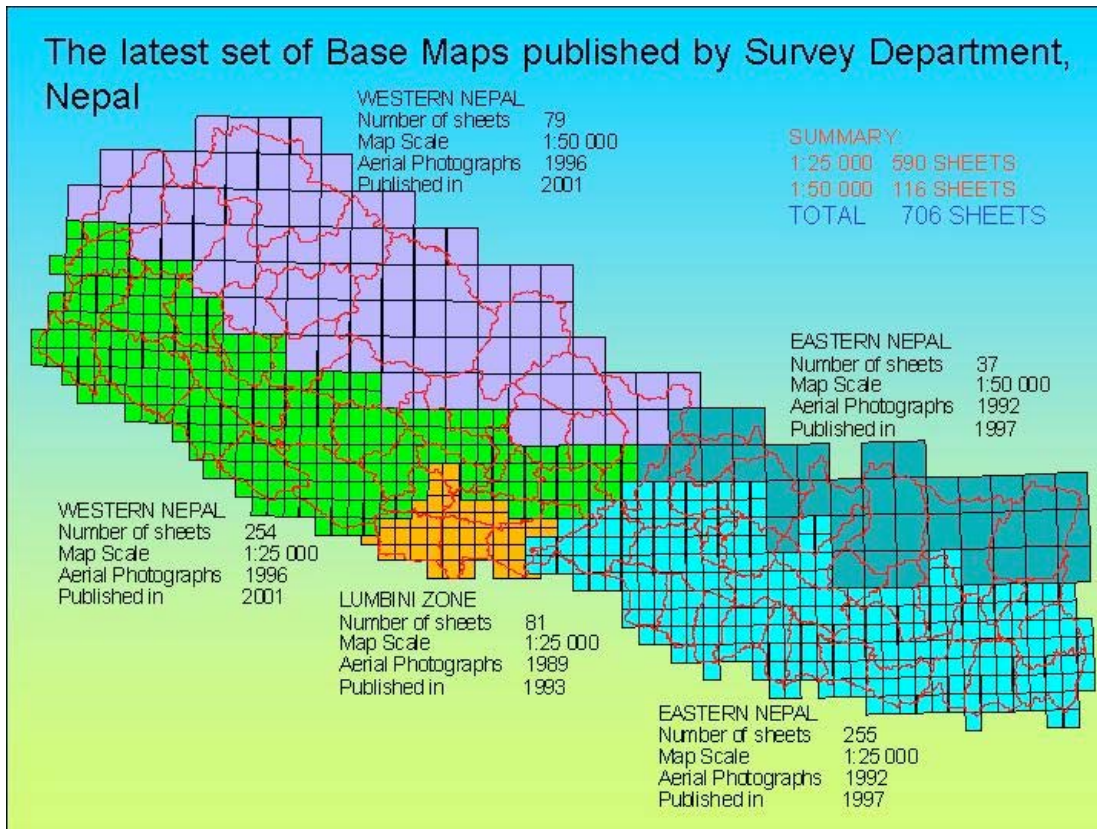
Figure 1: Topographic base map coverage of Nepal 1992- 2001

3. **National Geographic Information Infrastructure in Nepal**

NGII may be defined as the technologies, policies and people bound in an institutional framework in promotion of sharing of geospatial data throughout all levels of governmental and non-governmental sectors, and the academic community/ civic society. Traditional national surveying and mapping agencies (NMAs) used to publish paper basemaps and create a network of their distribution/ sales throughout their territories. All other users based their surveys and mapping based upon these basemaps. In the present circumstances when all most all map analysts and users use GIS for their purpose, a new scenario of the production and sharing of digital spatial database has emerged. This has necessitated the development of a NGII. The basic components of a NGII are the fundamental database, socio-economic (attributes) database and the metadata base shared and made available to/ by the users through a system of Clearinghouse; all of them having governed by Standards. Additionally the Nepalese NGII also considers supporting users having limited capacity of handling and manipulating data by a Geographic Information Service.
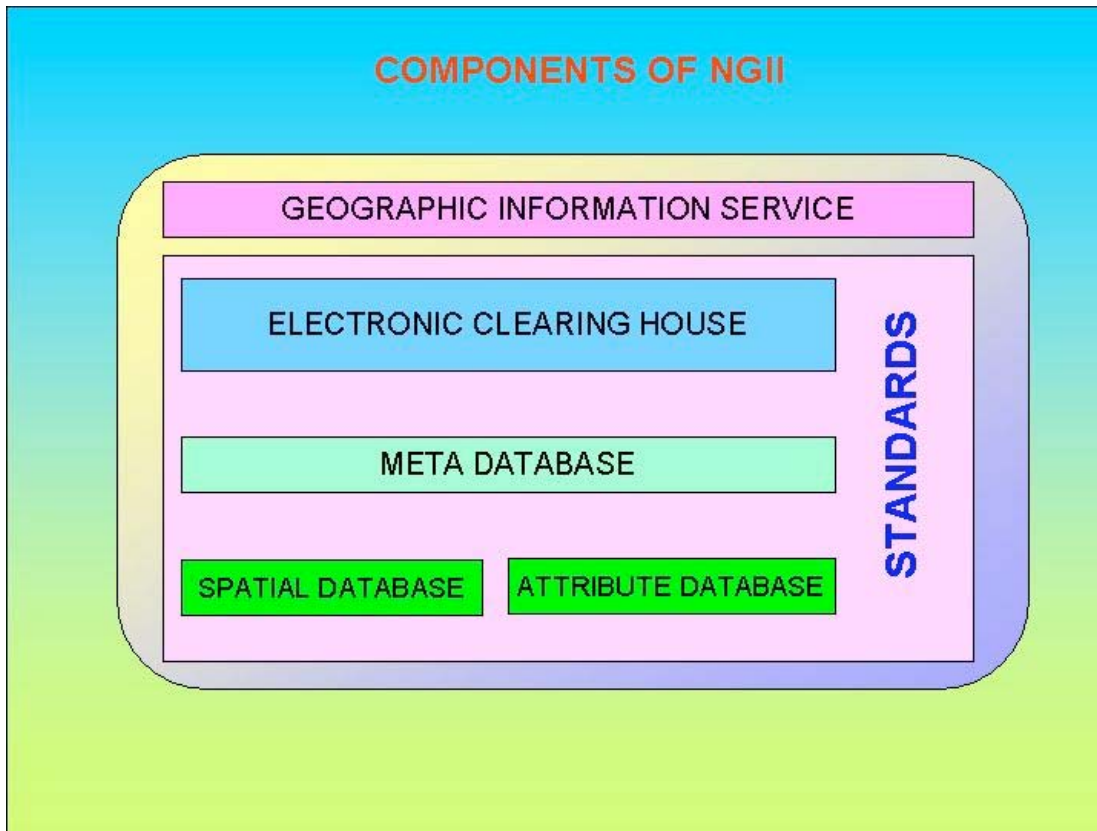
Figure 2:Components of NGII in Nepal

The building of a spatial (NTDB) database as one of the basic components of the NGII, and the essential contribution of Survey Department to the Infrastructure being the limitation of this paper, other points will not be discussed further.

4. Fundamental Spatial Database in NGII in Nepal

4.1 Scale/ Data Resolution and Coverage

The fundamental spatial dataset in the NGII in Nepal are the National Topographic Database (NTDB) with a horizontal coverage covering the whole country and vertical coverage at resolutions comparable to the scales 1:25,000/ 1:50,000; 1:100,000; 1:250,000; 1:500,000 and 1:1M. The primary data input in the NTDB is the digitalization of the 1:25,000/ 1:50,000 topographic basemaps produced by the Survey Department between 1992- 2001. The base data are generalized for the reduced scales and separate data layers are archived in the database.

In summary, basic spatial datasets incorporated in NGII are:

- 1:25,000 scale (for terai and mountains areas) and 1:50,000 scale (for higher mountains and Himalya areas) topographic database,
- 1:100,000 scale topographic database for whole Nepal,
- 1:250,000 scale topographic database for whole Nepal,
- 1:500,000 scale topographic database for whole Nepal,
- 1:1M scale topographic database for whole Nepal.

4.2 Data Model

The basis of classification of data is limited by the classification of topographic features existing in the published topographic basemaps. The database model is based on classes, types (subclasses) and categories (sub subclasses), an example of data model for Transportation in NTDB being given as under.

Table 1: Example of data model for transportation

Feature Class	Feature Type	Feature Category	Remarks
Transportation	Roads	Highway	
		Feeder Road	
		District Road	
		Other Roads	
	Trails	Cart Tracks	
		Main trail	
		Footpath	
	Railway	Trunk	
		Other	
	Ropeway		
	Bridge	Road	
		Trail	
		Railway	
	Other crossing	Causeway	
		Ford	
		Ferry	
	Tunnel	Road	
		Railway	
		Canal	
	Airport	Runway	
		Taxiway	
		Tower	

Data model for other feature classes like building, topography, landcover, hydrography, utilities, administrative area, designated area are similarly categorised into types and categories.

4.3 ArcInfo database structure: de facto standard for database structure

It is estimated that most of the GIS users in Nepal (with few exceptions) use PC ArcInfo and ArcView as spatial analysis and mapping tools in their applications. PC ArcInfo with limited functionalities was easy to learn, cheap to acquire and less-complicated to handle. Moreover, the data could be directly made available to the users in as they use format. In Survey Department, we prepared spatial topographic database for whole of the country in PC ArcInfo coverage format in a period of about three years through they digitalisation of 1:25,000/ 1:50,000 base maps. Furthermore, database generalization and production of 1:100,000 and 1:250,000 scale data are under preparation and due for completion. The next step will be the database generalization and production of 1:500,000 and 1:1M scale data, which has still to be workout.

The NTDB data are stored as separate ArcInfo Coverage files based on the basic topographic map format.

Table 2: NTDB Database

Scale	Database Name	Coverage Format	No of Sheets/ tyles	Spatial Coverage	Status
1:25,000 scale	Base NTDB	7'30" by 7'30"	563 tyles	Southern Nepal	Completed
1:50,000 scale	Base NTDB	15'00" by 15'00"	119 tyles	Northern Nepal	Completed
1:100,000 scale	NTDB100	15'00" by 15'00"	81 tyles	Whole country	Completed
1:250,000 scale	NTDB250	$1^030'$ by $1^000'$	19 tyles	Whole country	Under progress
1:500,000 scale	NTDB500	$3^000'$ by $4^000'$ (Maximum)	3 tyles	Whole country	Under design
1:1Million scale	NTDB1M	Whole Nepal	1 tyle	Whole country	Under design

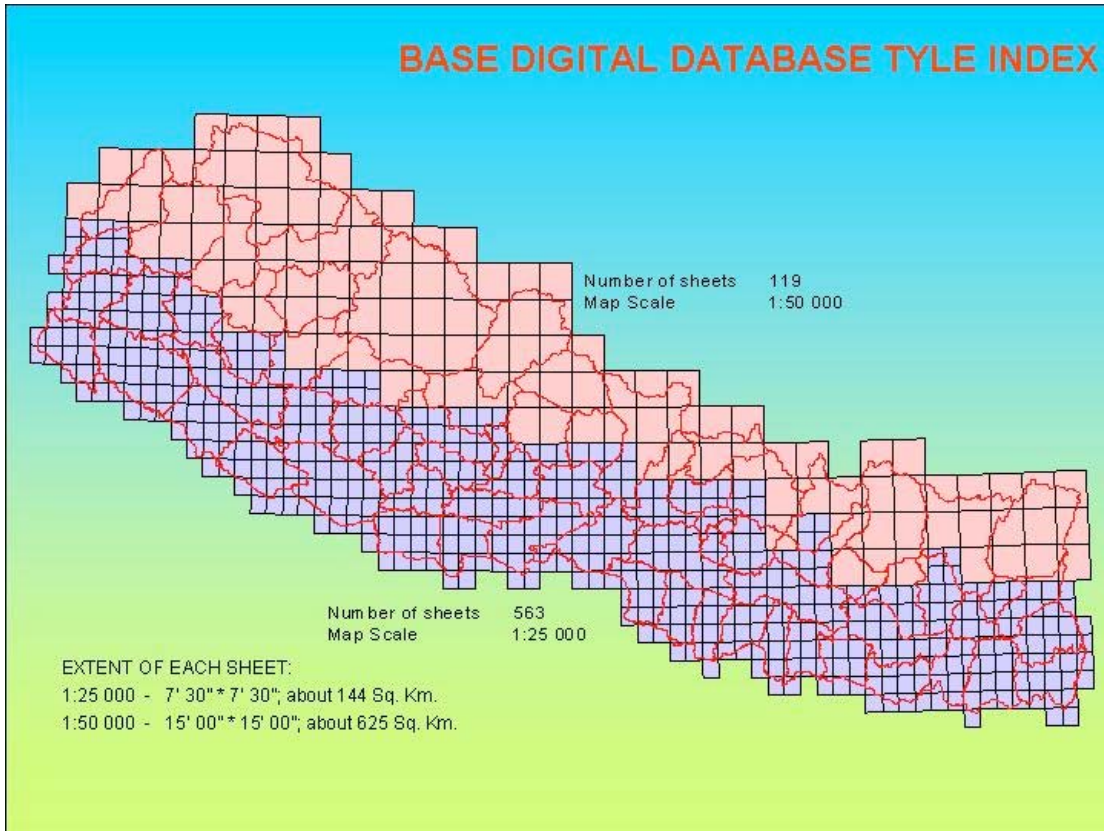The coverage of base NTDB is given in Figure 3 below.

Figure 3: Tyle Index of Base NTDB in Nepal

Data structure of base NTDB and derived NTDB100 and derived NTDB250 are given in the tables 3, 4 and 5 respectively as below.

Table 3: Base NTDB data structure

Class	Coverage			Feature Types
	Point	**Line**	**Area**	
Topography	Topog_pt	Topog_ln		Contours and spot elevation
Transportation		Trans_ln	Trans_ar	Roads and trails
Landcover			Landc_ar	Landcover type
Hydrography		Hydro_ln	Hydro_ar	Streams and rivers
Designated Area		Desig_ln	Desig_ar	National parks and protected areas
Utilities		Utili_ln	Utili_pt	Electricity Lines
Adminve Area		Admin_ln	Admin_ar	Administrative boundary
Place Name	Vilname			Place names
Building	Build_pt		Build-ar	Building and builtup areas

Table 4: Derived NTDB100 data structure

Class	Coverage			Remarks
	Point	**Line**	**Area**	
Topography	To100_pt	To100_ln		Contours and spot elevation
Transportation	Tr100_pt	Tr100_ln	Tr100_ar	Roads
Landcover	La100_pt	La100_ln	La100_ar	Landcover area
Hydrography	Hy100_pt	Hy100_ln	Hy100_ar	River edges
Designated Area	De100_pt	De100_ln	Des100_ar	National parks and protected areas
Administrative Area	Ad100_pt	Ad100_ln	Ad100_ar	Administrative boundary Region/District/VDC/Ward
Place Name	Vi100_pt			Place names
Building	Bu100_pt	Bu100_ln	Bu100_ar	Settlement

Table 5: Derived NTDB250 data structure

Class	Coverage			Remarks
	Point	**Line**	**Area**	
Topography	To25o_pt	To250_ln		Contours and spot elevation
Transportation	Tr250_pt	Tr250_ln	Tr250_ar	Roads
Landcover	La250_pt	La250_ln	La250_ar	Landcover area
Hydrography	Hy250_pt	Hy250_ln	Hy250_ar	River edges
Designated Area	De250_pt	De250_ln	Des250_ar	National parks and protected areas
Administrative Area	Ad250_pt	Ad250_ln	Ad250_ar	Administrative boundary Region/District/VDC/Ward
Place Name	Vi250_pt			Place names
Building	Bu250_pt	Bu250_ln	Bu250_ar	Settlement

Preparation of Data models and ArcInfo data structures for NTDB500 and NTDB1M is still under progress.

5. Creation of Base NTDB

Creation of base NTDB is based on the scanning of original maps originals and vectorisation and cleaning for building topology. They are conducted in the following steps:

- Touch up and photographic combination of scribe originals of map sheets to create hardcopy scan originals,
- Scanning of scan originals to create scan files,
- Vectorization to create vector files,
- Conversion to ArcInfo coverage files,
- Editing and cleaning to create topologically clean coverage files,
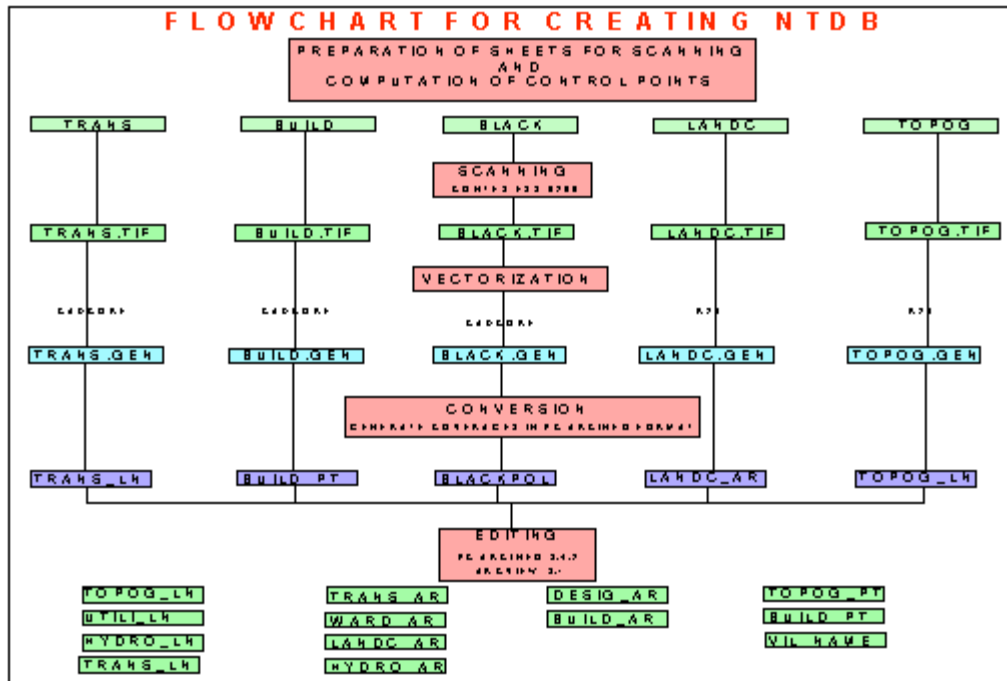- Edge matching to adjoining sheets to create seamless database.

Figure 4: Flowchart for creating NTDB

6. Generalization of database to create derived database

Generalization of database is a complex process. However, we have been able to obtain reasonably acceptable results using semi-automatic processes in PC ESRI products ArcInfo and ArcView. The general steps adopted are as following:
- Generalization by feature class,
- Editing of geometry and attributes,
- Feature matching horizontally among edges,
- Feature matching vertically among layers,
- Derived database preparation.

Creating multi-resolution database entails stepped generalization, which is carried out as following:
- Scanning/ Vectorization/ Conversion   : Base data NTDB,
- Generalization to NTDB100 data model : NTDB100,
- Generalization to NTDB250 data model : NTDB250,
- Generalization to NTDB500 data model : NTDB500,
- Generalization to NTDB1M data model : NTDB1M.

7. Conclusion

Using defacto industry standards make creation of spatial database relatively less expensive and practically less problematic. Choice of industry standards should, however, be based on the general acceptability of the data format to the users and ease of transformation to other formats. In Nepal, since most of the users used ESRI PC ArcInfo and Arcview, and this had export import facilities to several other data formats, the choice was easy. However, it was quite a new experience to venture on such a large project with relatively small resources. With the dedication and sense of ownership from all project members, creation of a NTDB for an area of 147,181 square kilometres and consisting of 682 topographic base map sheets (119 map sheets at 1:25,000 and 563 map sheets at 1:50,000) could be accomplished within three years. Moreover production of generalised database at 1:100,000 (82 map sheets) and 1:250,000 (19 sheets) subsequently is nearly completed in another one year. The data are available to the users.

The NGII programme in Nepal is in the phase of creating a clearinghouse approach to data dissemination. With the growing demands for web based applications of GIS, work is under progress to transform ArcInfo coverage data to ArcSDE formats. The database creation had been relatively inexpensive and practically less problematic using PC ArcInfo. However, transforming data using ArcGIS has become more robust, complicated and relatively expensive. However, while these transformations continue, users will still continue getting ArcInfo coverages or ArcView shape files for their applications.

References:
Chhatkuli, R.R. (1996); Geoinformatics: A New Challenge to Surveying and Mapping Professionals in Nepal, Nepal Surveyor, Volume 1996.
_____ (2002); Concepts and Challenges of National Geographic Information infrastructure Programme in Nepal, Valedictory Lecture, 5th ESRI India Users Conference, New Delhi, 23 January 2002.
_____ (2002); National Geographic Information infrastructure Programme to Support National Geographic Information System in Nepal, Nepalese Journal on Geoinformatics, Number 1, May-June 2002.
_____ (2003); National Geographic Information Infrastructure in Nepal for Strengthening Planning and Resource Management, Global Mapping Forum 2003, 12-15 July, 2003, Okinawa, Japan.
_____, Shrestha, S.M., Manandhar,N. (2003); Transformation of datum and projection of spatial data in GIS applications in the context of NGII in Nepal, Convention papers of 8th National Convention and Fiesca Regional Meet, 3-5 April 2003, Kathmandu, Nepal.
Harvey, Francis (2001); US National Spatial Data Infrastructure (NSDI), GIM Volume 3, March 2001.

Kayastha, D.M. (2002), Database Generalization and production of derived maps at 1:100,000 and 1:250,000 scales using NTDB in NGII context, Nepalese Journal on Geoinformatics, Number 1, May-June 2002.

_____, Budhathoki, N.R., Pant,N., Hamal,S. (2002); Building National Geographic Information Infrastructure (NGII) in Nepal, Unpublished technical needs assessment Report, NGII, Kathmandu, Nepal.

Maser, Ian (2001); The Indian National Geospatial Data Infrastructure, GIM Volume 15, August 2001.

National Planning Commission Secretariat (1997); Ninth Plan, plan document published by the Commission.

_____ (2002); Tenth Plan Base paper, base paper document published by the Commission in Nepali.

Nepal Tourism Board (2002); Nepal Guidebook, Kathmandu, Nepal.

Survey Department (1999); Specifications for Geographic Information Service and National Topographic Database, Kathmandu, Nepal. June 1999.