Preparation of Database for Urban Development

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Key words: Municipal Geographical Information System, infrastructures, metric house addressing system, cadastre data.

1. ABSTRACT

Most of the municipalities of Nepal were formed prior planning of whole area. The land use plans are usually prepared to the settlements where it is growing and development taking place. It is required the detail data base/mapping of all the area of municipality for urban development and provision of services. The spatial coverage of Nepal is topographical maps at the scale of 1:25,000- 1:5,000 and cadastral map coverage of private land at the scale of 1:500- 1:2,500 which is insufficient for urban planning and development.
The objectives of preparation of urban database or Municipal Geographical Information System(MGIS) is to carry out survey for data base including topography, infrastructures, socio economic situation, metric house addressing system, land and building ownership situation and link these data to tax system of the municipality. These data base will be use for sustainable urban development. Some time, these data base will contain simply topography and infrastructural situation for land use zoning of town areas.
These activities are being carried out in almost all municipalities and land pooling programmes in Nepal. Most of the people in Nepal live in rural areas and only 17% of people lives in city areas with urban population growth of 3.38% per annum (Population Census, 2011). It is also planning to develop additional 40 towns in addition to the existing 57 municipalities in different location of the country in order to avoid the developing megacities. The largest city of Nepal, Kathmandu has population of about 1.07 million.
Most of the municipalities have now medium high resolution database. The map and data base provide the basic information for sustainable urban planning. It alsoassisted to expedite the urban planning and sustainable development as well as urban data base preparation system in Nepal.
It is generally carried out by public private participation on the basis of high resolutionsatellite imagery or aerial photography, ground surveys and existing data like cadastre data, infrastructural drawings.
In this article, it is briefly described the objectives, contents of data base, methodologies the of data acquisition for MGIS and its contribution to sustainable urban development in Nepal.

2. BACKGROUND

The urban population of Nepal is 17.07% and gradually increasingat the rate of 3.38%annually and 85.25% population have their own housesas per the Population Census 2011.The education system is gradually improving in Nepal and it expected that the illiteracy will beeradicated by the end of 2015 and about one million persons will inter in city of Nepal and outside for employmentevery year. There are also one million persons are living in

landless settlements for whom land for housing will require tomanage in future.
Town development is taking place very slowlyin Nepal. There are 57 municipalities and it is planned to develop additional 40 new municipalities providing urban facilities in these settlements. Ten new towns are planned to develop in the middle hill of Nepal to avoid future development of megacitiesin few locations of Nepal.
As in the past, lack of funding with national mappingorganisation, the updating and upgrading of existing maps at the scale of 1:25,000- 1:50,000 are poor. The situation of upgrading cadastral maps prepared in1964- 98 at the scale of 1:500- 1:2,500 is also poor. Theupdating or replacement orthophoto prepared of57 municipalities at the scale of 1:5,000- 1:10,000 in 2001 is not planned by the Survey Department.
The Department of Urban Development and Building Construction(DUDBC) conducted creation ofrequired data base of selected municipalities which was necessary to town planning works. It needed to prepare data base at the scale of 1:2,500- 1:5,000 and at the scale of 1:10,000 for the remote forested area of the municipality.It is also required to conduct detail survey with cm resolution for implementation and construction of planned programmes. The urban development is carried out by site and services, guided land development or land pooling process. Most of the present town development is based on the land pooling, which develops the private land as well as the public land with the consent of majority of land owners. Theland pooling will be carried out only after feasibilities (technical, social and financial feasibilities) studies.

3. HISTORICAL DEVELOPMENT

The Nepalese society is basically a rural society and most of the people lived in villages in separate houses. Administrative head quarters were planned and developed in forest, government land or on acquired private land. Town development is started to accelerate now.
Apart from ortho photomapping of municipalities of Nepal by Survey Department in 2001,Department of Urban Development and Building Construction(DUDBC) is conducting preparation of geo-data base of municipalities. Presently, data base of 16 municipalities is available to public. Data base of ten new towns are being prepared. Some kinds of geo database is available of all municipalities which may not be sufficient for proper planning and implementation of planned objects.
The Urban Development Act, 2045 enacted in 1988 to cater the need of town development. The Colour Codes for Digital Base Maps and Planning Norms and Standards 2013 is also issued byDUDBC. Survey Department is also issued the “Specification for Urban Geographic Information Service in Nepal”.

4. METHODOLOGY

The National Mapping Organisation, Survey Department is not yet preparing or updating larger scale topographical maps, new digital aerial photography or high resolution satellite imagery of municipalities or complete coverage of Nepal except ortho photo of some part of 57 municipalities for Population Census 2001.The preparation of GIS based Digital Base Maps of municipalities is being carried out private consultancies for DUDBC.
The main objectives of this assignment are to prepare the urban map of municipality, by using Geographical Information System with following objectives:

- Preperation of digital maps of the urban area at scale of 1:2500 best on high regulation (0.5m) panchromatic sattelite imageries, aerial photographs, available topographical maps and field survey data.
- Development of cadastral information system and superimposition of the cadastral map to the digital base map.

- Collect and develop municipal geographical information system incorporating the cadastral information, existing infrastructures, demography & socio-economy of each household, environment, administrative units etc.

- Development and establishment of effective house numbering and street addressing system

- Develop the system to link tax system software being used by the municipality.

The methodology of preparation of GIS based digital base maps of municipalities or new towns could be described as control point extension using DGPS or total station, geo-referencing satellite imagery or preparation of ortho photo, spot heighting with total station in flat area and /or creation of DTM and generation of contours using stereo images in hill area, vectorization of required information, field collection and completion of information and verification of maps, superimposition of cadastral and land owners data, street naming and house numbering, socio economic survey, infrastructure data added to data base and connectioncadastral and land owner database to Tax System of the municipality.The preparation of GIS based digital base maps of some of the municipalities do not have street naming and house numbering, socio economic survey and connection of database to Tax System of municipalities. The following Figure 4 will show the working methodology:

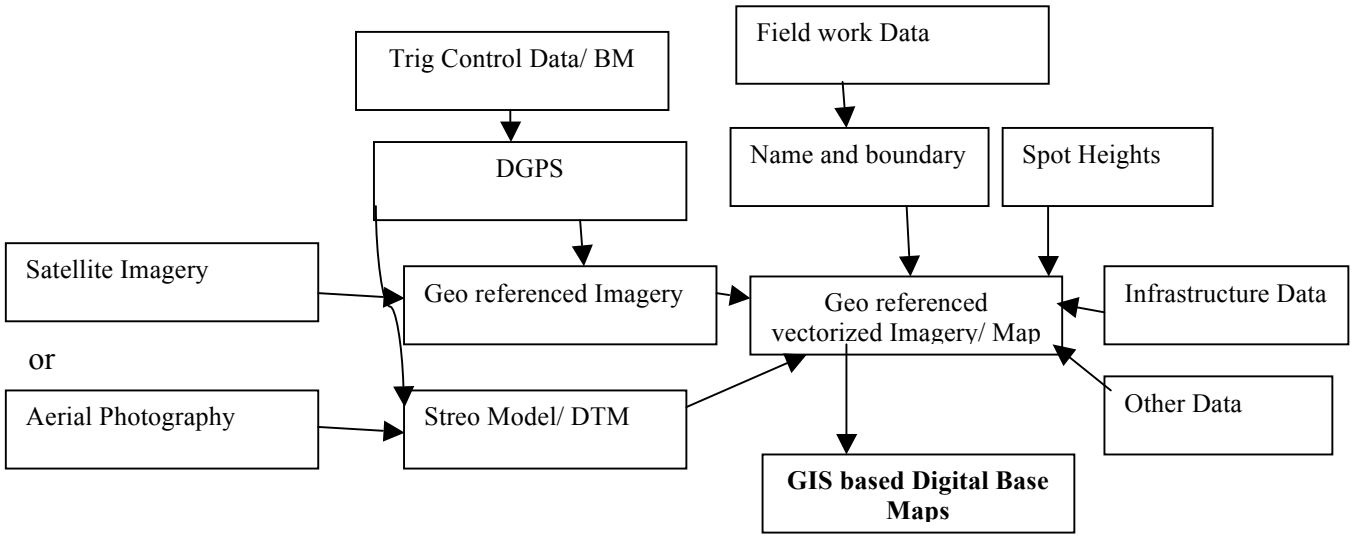

Figure 4: General Methodology

5. DATA MODEL

According to Hoberman (2009), "A data model is a wayfinding tool for both business and IT professionals, which uses a set of symbols and text to precisely explain a subset of real information to improve communication within the organization and thereby lead to a more flexible and stable application environment."
A data model explicitly determines the structure of data. Data models are specified in a data modeling notation, which is often graphical in form.

A data model instance may be one of three kinds according to ANSI in 1975:
Conceptual data model : describes the semantics of a domain, being the scope of the model.
Logical data model : describes the semantics, as represented by a particular data manipulation technology. This consists of descriptions of tables and columns, object oriented classes, and XML tags, among other things.
Physical data model : describes the physical means by which data are stored. This is concerned with partitions, CPUs, tablespaces, and the like.
Following Fig. 5 will show the Municipal Data Model:

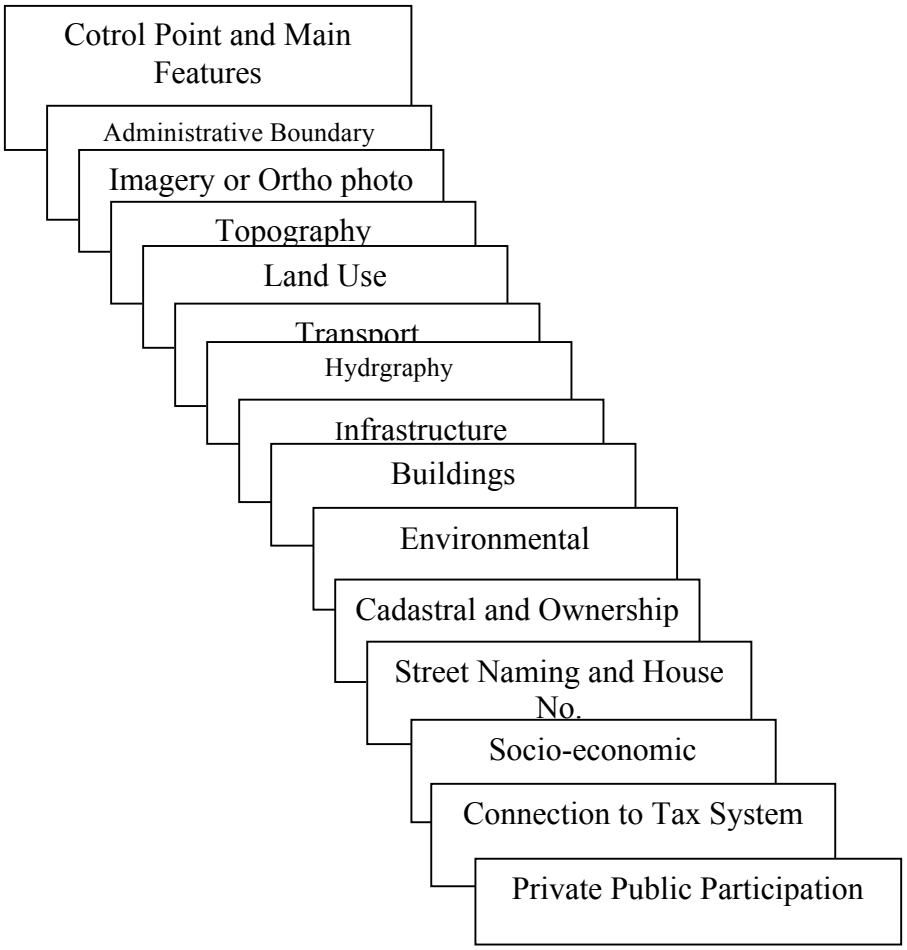

Fig. 5 Data Model

6. DESCRIPTION OF DATABASE

Data base is designed for thematic layers, entities and topological relationships between feature classes. The location of physiographic regions and status of development of the municipality will also affect the feature classes of geo data base. It is briefly describe as following:

6.1 Geo Database Design

There are various thematic layers which are required to prepare geo data base of urban area and nine layers are commonly prepared. Four other thematic layers are used for some municipalities. They are briefly described as following:
Thematic layers
1. Base map-control points- trig. points, BMs, new establishes points, main features
2. Administrative boundary- District, VDC/ municipality, ward,national parks, services area,
3. Topographical and hypsographic features-peak, pass, pit, land slide, embankment, escarpment, cliff, landslide, cutting, contour, depth contour, hill shading,
4. Transport- Road- category, surface types, width, status, name; airport- category, surface types, status, name; bridge- category, structureand crossing types, width, name; railwaycategory, width, status, name;
5. Hydrography- River, lake, ponds, canal, dam, sluicegate, spillway, weir, and snow covered area, glacier, crevasse,
6. Land use-cultivation, orchard, nursery, plantation, forest,shrubs, grass land, river/stream, sand and gravel bed, lake /pond, snow covered area, other, tree species, cultivation type, intensity, functional use zones,
7. Infrastructures- water supply-scheme type, house hold served, capacity,name, organisation, source, reservoir, treatment plant, pipeline,water valve,hydrant, other source; sewerage- pipe line, storm water, manhole, treatment plant; electricity- electric line, pylon, transformer; Telephone- line, cabinet and poles,
8. Buildings- Functional category, functional use, other structures
9. Environment- watershed, hazards, flood hazard, flora and fauna,
10. Cadastre- administrative boundary, parcel number and its boundary, ownership data
11. Street names and house number- Street names decision, metrichouse number,
12. Socio-economic data- Population, literacy, health and occupation status,metric house number, status of infrastructure,
13. Linkage of data with Tax System- cadastral parcel, building, ownership data, and tax system

6.2 Data Descriptions

Data are described as point, line, polygon and attribute table which is described for each data. Location, coordinates, area, name, class etc are common features of attribute data. Some sample data described as following Table 6.2:

Table 6.2: Data description

Feature Class Category	Description	Feature Geometry	Feature Attributes	Symbol	Colour
Municipal/VDC Boundary Line	Municipal/VDC area boundary line	Line	Feature Code: <integer> VDC Name:<string> VDC Code:<integer> Length:<double>		
Municipal/VDC Area	Municipal/VDCcover age area	Polygon	Feature Code: <integer> District Name:<string> District Code:<string> VDC Name: <string> VDC Code:<integer> Area:<double> Perimeter:<double>		
Ward Boundary Line	Ward boundary line	Line	Feature Code: <integer> Length:<double>		
Ward Area	Ward coverage area	Polygon	Feature Code: <integer> VDC Name: <string> VDC Code:<integer> Ward Number:<integer> Area:<double> Perimeter:<double>		
TLO Boundary Line	TLO boundary line	Line	Feature Code: <integer> Length:<double>		
TLO Area	TLO coverage area	Polygon	Feature Code: <integer> Ward Number: <integer> TLO Code:<string> TLO Name:<string> Area:<double> Perimeter:<double>		
Service Area Boundary Line	Service area boundary line	Line	Feature Code: <integer> Length:<double>		
Service Area	Service area coverage	Polygon	Feature Code: <integer> Service Area Code:<string> Service Area Type: <string> Service Area Authority:<string> Area:<double> Perimeter:<double>		
Locations	Location of designated places	Point	Feature Code: <integer> Location ID:<integer> X Coordinate: <double> Y Coordinate:<double> Designated Name:<string>		

6.3 Topological Relationship of between Features:

The topological relationship of between features like boundary may be river, road or parcel. The complete feature falls completely either inside or outside the boundary. Generally northern and western feature falls outside the boundary.

6.4 Cartographic design

The colour, symbol, conventional sign, intensity, maturity class, like of features are also decided and marked on attribute table of feature as Table 6.2.

7. LAND SUITABILITY DECISION

Two methodologies SLEUTH model and Multi Criteria Analysis (MCA)are used for land suitability analysis for urban development. Suitable methodology is adopted based on the characteristic of the location and availability of the data during the project period.

7.1 SLEUTH Model

SLEUTH stands for Slope, Land cover, Exclusion, Urbanization, Transportation and Hill shade. This computer model is developed by Yuanhong Zhu and Rick Day from Department of Crop and Soil Sciences (The Pennsylvania State University). The conceptual model of SLEUTH is developed earlier by Keith C. Clarke at the UC, Santa Barbara under the support of USGS and NSF. His model is based on Cellular automaton model. In this study, not all the parameters of SLEUTH model will be used and proximity to forest and rivers will betaken in addition based on local context, availability of data and analysis of individual parameter.

7.1.1 Land Cover/Use

Analysis of urban trend from 1992 (from aerial photograph) to 2013 (satellite image) will be conducted to identify the origin of the built up area as well as the changes in other land cover class. Based on these analyses prime land cover class will be selected where urbanization is possible.

7.1.2 Slope

Slope analysis is considered as one of the important part of site analysis with respect to different terrain areas of the proposed development area. Treatment for these factors requires base information in the form of contours and elevation. The slope and pattern of the site provides the basic information regarding the planning like the drainage patterns and problems, potentials on-site and off-site views, erosion and sediment potential, as well as potential for development. A typical slope breakdown included in this study is as follows:

<=2%	Not suitable for urban promotion due to drainage logging problem
2-10%	Most suitable for urban promotion area
10-15%	Restricted for agriculture preservation or moderately suitable for urban area
>=15%	Not suitable for urban development

Proximity/Distance from the forest area is also one of the important parameters for urban growth from environmental and ecological perspective. Cases of human wildlife conflict (HWC) has been reported in many built up area situated near the forest. Besides this, deforestation rate also seems to increase in such forest area. Different national bylaws also recommend maintaining certain distance between built up area and forest. Generally recommendation of these national bylaws found in different literature can be summarized as below and used in this study.

100 meter buffer from forest boundary	Restriction for Industrial Promotion
20 meter buffer from forest boundary	Restriction for Residential Promotion

7.2 Multi Criteria Analysis

Urban development is influenced by both natural and social-economic conditions. The basic

criteria for urban land suitability assessment are presented here. It could adapt the criteria according to the qualitative analysis of the urbanization of the proposed area together with suggestions from concept on urban planning and development, land resources, ecology. An integrated evaluation criteria system could be set up containing different factors belonging to different categories: (1) Environmental (geographical, meteorological) factors including elevation, slope, geomorphological types, rainfall, temperature (2) Biophysical Factor including water resource (distance to water), land resources, river density, existing land use, land with irrigation, adequate site drainage, on-site sewage disposal, on-site solid waste management, favourable slope and probability of landslides/ erosion (3) Socioeconomic factors , available building and physical infrastructures including road density (road length per 1000 population and road length per square kilometre area), distance to major roads, total population, population density, building density, distance to population centre.
An urban development suitability index (UDSI) could be calculated by using the standard formula. The USDI of each 100 m x 100 m grid cell will be calculated. Pixels with higher USDI will indicate that it is more suitable for urban development. The USDI data for the study area will be grouped into three levels: (1) most suitable; (2) moderately suitable; (3) least suitable.

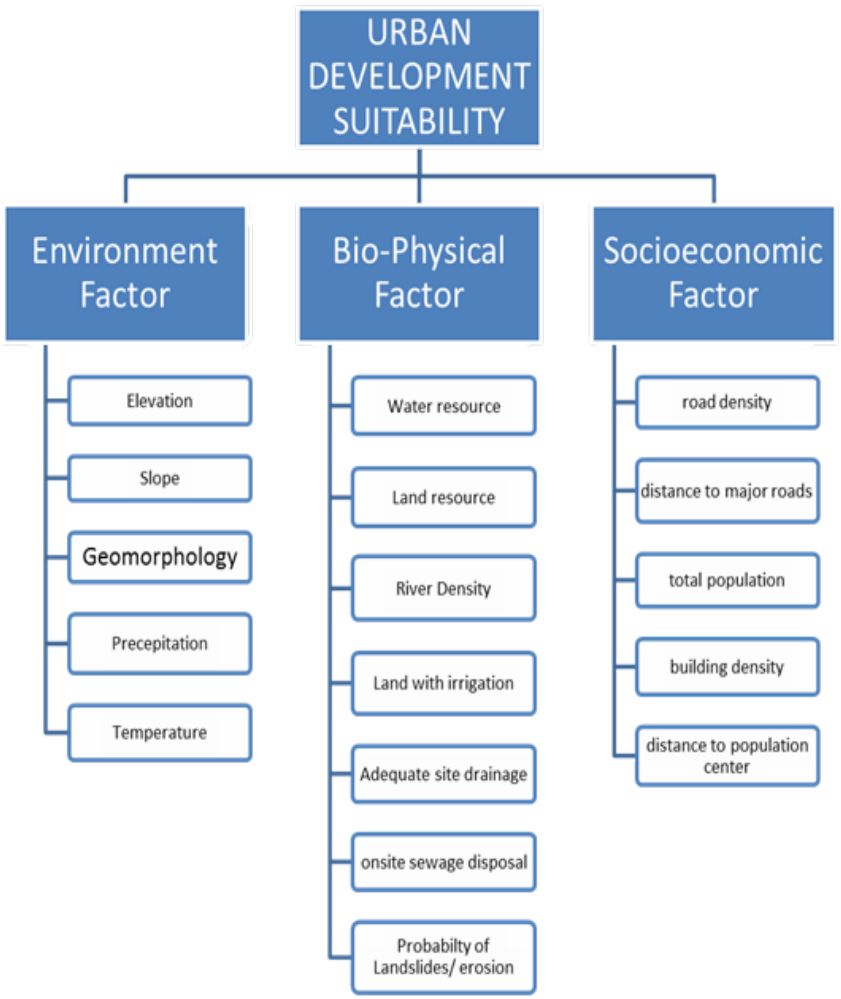

Figure: Hierarchical Structure of the Suitability Factors for urban Development

8. CONTRIBUTION OF BASE MAPS FOR SUSTAINABLE URBAN DEVELOPMENT

National planning in Nepal started since 1956 based on demands/ programmes forwarded from lower government or local government offices to national planning commission and decided the programmes on the basis of resources available and the resources allocated ad hock basis. Therefore, the country remained LDC despite the honest effort to develop the country for 60 years. If they have given priority to surveying and mapping and development was based on the basis of scientific planning, Nepal would have got rid of poverty cycle long back.Lack of detail geo-database, will definitely delay the development programmes 2-3 years and accordingly cost of project will increase.
The detail digital base maps will show the present situation of land use, status of development, available infrastructures, demographic and socio-economic condition and biophysical situation of the area.
The urban development is generally planned for 20-50 years based on the suitability assessment on existing biophysical situation, urban transportation and infrastructures facilities. The detail digital base maps/data will provide above data of the situation of the area. Areas for parks, open spaces, greenery, agricultural production, future urban development and conservation of nature and culture will also be planned and assigned during urban planning. It will also expedite the collection of taxes and assist in expansion of new tax generating areas of the municipalities.The urban development will improve the sustainable capacity of municipality by generating income whereby it may employ required personnel and have resourcesfordevelopment and maintenance of past developments.
During planning phase, sufficient data will be collected to carry out technical, social and financial feasibilities as well as future sustainability of development.

9. PROBLEMS ENCOUNTER

The main problems of establishment of GIS based digital base maps of municipalities or towns are technological, land form and maintenance of existing survey data. It is required to carryout field works for establishment of control points, field data collection and verification. Rainy season, fog- cold wave, extreme altitude/slope and temperature situation are main physical problems in the field.
Technological problems are Survey Department like organizations are not updated with the technological changes like software, imagery, aerial camera, photogrammetric instrumentation and ortho photo or DTM generation facilities. Local surveyors are required to train to adopt the digital technology.
It is difficult to acquire sufficient suitable required land for urban development due land form which is either too steep or too flat. The steep land form is prone to land slide and expensive to develop infrastructure and flat land are flooded in rainy seasonevery year.
The prepared GIS based digital base maps were handed over to municipalities where trained manpowerand facilities are poor. Therefore, the data are not adequately utilized or

maintained. Similarly, national control networks which is required to base/connect digital base maps of municipalities are sparsely located some area and poorly maintainedand recorded.

10. CONCLUSION

The urban population will increase with greater rate annually and urban development will necessitate take place at greater speed to provide housing and infrastructure to the urban people whether the city is planned or not. Therefore, DUDBC should expedite the digital data base / maps creation of all municipalities including the new ones and urbanized settlements for sustainable development of municipalities.
It is also require updating existing topographical maps and creation of new ortho photo, and commencing preparation of large scale maps of the whole country at the resolution of 0.5m - 1m with priority of municipal areas as well as maintain existing geodetic /control net work points. At the same time,LandManagement Training Centre should gear to train all surveyors to work in digital environment.

11. AKNOWLEGEMENT

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