Preparation of Geodatabase for Urban Planning in Nepal

Ashim Babu SHRESTHA, Punya Prasad OLI, Sumitra SHRESTHA, Nepal

Key words*:* GIS, Geodatabase, Urban Planning, Sustainable Urban Development, Decision Making

SUMMARY:
Geographical Information System (GIS) is capable of integrating geospatial data with various sources of information necessary for effective decision making in urban planning and sustainable urban development. Geodatabase is the input to modelling and analysis programs together with data and other database for analysis and mapping. It has been used to information retrieve, development, control, mapping, site selection, urban planning, suitability analysis, monitoring and decision making. The methodology of preparation of geodatabase from field survey and mapping (tabular data), Orthophoto generation from aerial photographs, satellite data from remote sensing and topography maps from aerial survey or field survey by total station. Geodatabase is an alternative way to store GIS information in one large file, which can contain multiple point, polyline, and polygon layers. Geodatabase is a collection of geographic datasets of various types of common file in single database. Urban Planning is the one of the main application of GIS. Urban planner use the GIS as well as spatial database and analysis tool. GIS increasingly an important component of planning support system. Recent advances in the database of GIS with planning models, visualization, and the internet will make GIS more useful tool for urban planning. The VDCs and municipality of Nepal lack proper base map. They are mostly dependent on 1:25,000 or 1:50,000 scale topographic maps, land resources maps or other available analogue maps which is not sufficient or too coarse to use for urban level planning. The available maps are also not much useful for proper decision making process of the urban development activities. The lacking of digital geographic information in Nepal, particularly large scale, has resulted ineffective and inefficient planning activities in urban development. Thus, the GIS database mostly important for urban activities, decision making process, and urban planning. Department of Urban Development and Building Construction (DUDBC) should expedite the digital database, maps creation of all municipalities of Nepal including the new ones and urbanized settlements for sustainable development of municipalities. It is also required the updating existing topographical maps and GIS database preparation of large scale maps of the whole country from high resolution satellite images. GIS database is an important aspect for sustainable urban development and urban planning. Geographic information science is mapping and spatial analysis for both spatial and attribute data to support decision making process and activities.

Preparation of Geodatabase for Urban Planning in Nepal

Ashim Babu SHRESTHA, Punya Prasad OLI, Sumitra SHRESTHA, Nepal

1. INTRODUCTION

Land is one of the important and precious natural resources of the earth surface. The demands for arable land, grazing, forestry, wild-life, tourism and urban development are greater than land resources available. In the developing countries, these demands become more pressing every year and the population dependent on the land for food, fuel and employment will double within the next 25 to 50 years (FAO, 1993). The economic and social lifestyles of most of the Nepalese are intimately related to land. Hence, urban planning for making the best use of the limited land resources is inevitable. However, space science technology known as satellite remote sensing (RS) and the Geographic Information System (GIS) can be helpful in acquiring spatial/temporal data, and preparing digital data base. These spatial databases together with data on different land characteristics that could be collected from field survey certainly will be helpful in decision making support system for an efficient management of resources in municipality level.

On the April 16, 2012, the Government of Nepal has approved the National Land Use Policy, 2012 with an intention to manage land use according to land use zoning policy of the Government of Nepal and outlined six zones such as Agricultural area, Residential area, Commercial area, Industrial area, Forest area and Public use area. The policy has defined the respective zones as per the land characteristics, capability and requirement of the lands. The VDCs and municipality of Nepal lack proper base map. They are mostly dependent on 1:25,000 or 1:50,000 scale topographic maps, Land resources maps or other available analogue maps which is not sufficient or too coarse to use for municipality level planning. The available maps are also not much useful for proper decision making process of the municipal development activities. The lacking of digital geographic information in Nepal, particularly large scale, has resulted ineffective and inefficient planning activities in urban development.

2. GEODATABASE

A database is a lot of information stored in a computer device, taking into account the existing technologies used to organize and structure the database, so we can easily manipulate the content. A database is collection of data organized in a structured way, so that; information can be retrieved quickly and reliably (Closa et al., 2010). The invention of information technology has led the database to be used in a management system, which is called database management system. A database management system is a set of programs that enables the management and access to a database. It generally hosts multiple database, which are designed with various software by themes.

The geodatabase is the common data storage and management framework for ArcGIS. It is a container for spatial and attribute data. A geodatabase is more than a collection of datasets. The multiple meaning of geodatabase in ArcGIS as below.

- The geodatabase is the native data structure for ArcGIS and is the primary data format used for editing and data management. While ArcGIS works with geographic information in numerous geographic information system (GIS) file formats, it is designed to work with and leverage the capabilities of the geodatabase.
- It is the physical store of geographic information, primarily using a database management system (DBMS) or file system. You can access and work with this physical instance of your collection of datasets either through ArcGIS or through a database management system using SQL.
- Geodatabases have a comprehensive information model for representing and managing geographic information. This comprehensive information model is implemented as a series of tables holding feature classes, raster datasets, and attributes. In addition, advanced GIS data objects add GIS behavior; rules for managing spatial integrity; and tools for working with numerous spatial relationships of the core features, rasters, and attributes.
- Geodatabase software logic provides the common application logic used throughout ArcGIS for accessing and working with all geographic data in a variety of files and formats. This supports working with the geodatabase, and it includes working with shapefiles, computer-aided drafting (CAD) files, triangulated irregular networks (TINs), grids, CAD data, imagery, Geography Markup Language (GML) files, and numerous other GIS data sources.
- Geodatabases have a transaction model for managing GIS data workflows.

The geodatabase design and structure from ESRI as below Figure 1.

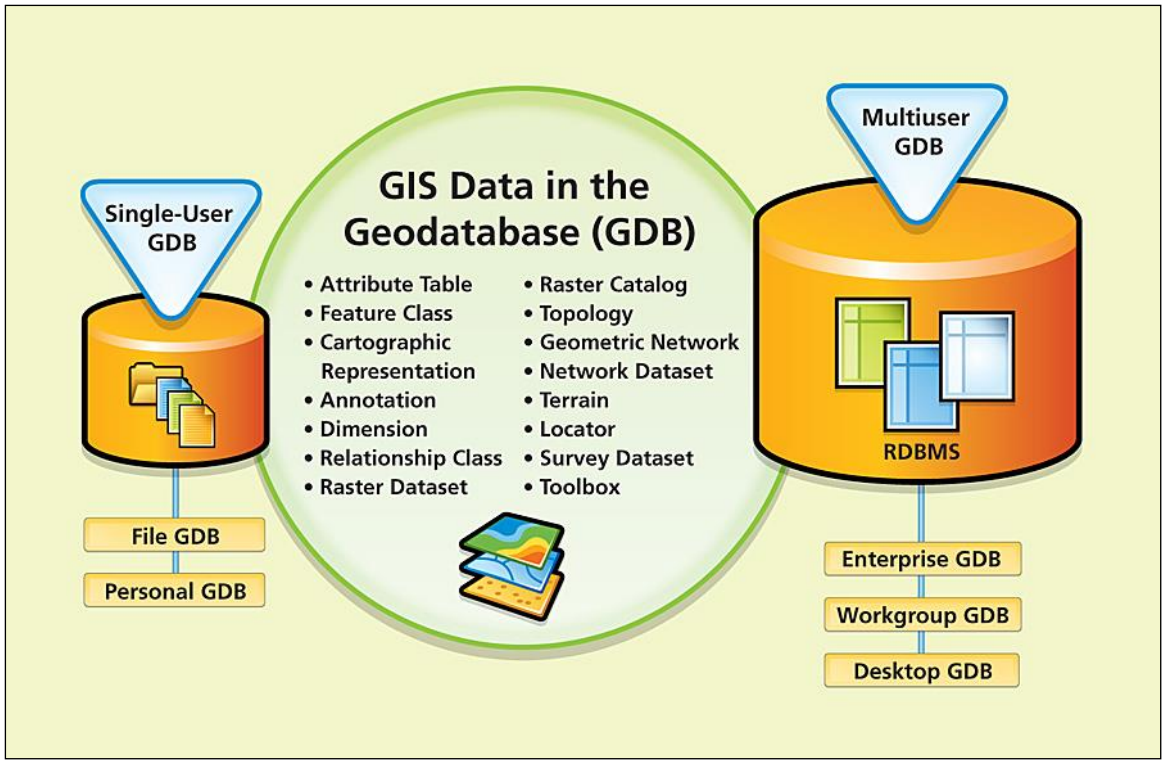


Figure 1: GIS Data in the Geodatabase (Source: ESRI)

Modern GIS users spatial database to integrate the geometry or features data with other types of data (Yeung and Hall, 2007). Spatial database facilities strong and querying data that is related to objects in space, including points, lines and polygons. Other typical database can understand various numeric and character types of data, while, spatial databases need additional supports to process spatial data in the form of geometry or feature. Spatial data, which is also called geographical data, focuses cartographic or mapping perspectives.

2.1 Types of Geodatabase

There are three types of ESRI Geodatabase. The short description of geodatabase as below;

1. **The File Geodatabase:** Dataset can weigh up to 1T. This database can be encrypted and secured.
2. **The Personal Geodatabase:** The data is stored in an access database. The maximum size of this database is 250 to 500 MB.
3. **The ArcSDE Geodatabase:** The data is stored in external databases and much more cumbersome to manage but also more efficient as Oracle, DB2, SQL Server.

The geodatabase can contain classes of entities (feature class), sets feature classes (feature dataset), and classes of objects (object class) also called tables and raster files. A (feature class) is a homogeneous set of entities that have the same geometry (point, line, and polygon) and the same attributes. These attributes are stored in the table of the (feature class). The notation of class of entities is similar to the concept of file (shapefile) formats. A table can be stored in a geodatabase it is characterized by a set of fields and records. The tables of a geodatabase can be linked or attached in same time to tables or features classes.

2.2 Conceptual Modeling of Database

Model as a simplification of reality and defined the reason for modeling as to better understand the system (Booch et al., 1999). Also they outlined four aims to be achieved through modeling systems;

- Visualization of a system as it is or as we intend it to be.
- Specification of the structure or behavior of a system.
- Models provide a temple for guidance while constructing a system.
- Documentation of decisions made during the design process.

Database modeling in the software system has similar consideration abstraction of the essential elements of the observed reality from nonessential elements (Lisbao Filho and Iochpe, 2008). A conceptual database modeling describes possible data content, structures and constraints applicable to them. Like other models, to express the database modeling descriptions in a convenient way, conceptual data modeling language is used. A conceptual data modeling language is used of formal expressions of tools and techniques used for data modeling.

According to the (Yeung and Hall, 2007) different modeling techniques used for database management systems can be classified in the following categories.

1. Hierarchical Systems
2. Network Systems
3. Relational Systems
4. Object-oriented Systems

According to the (Hoffer and McFadden, 2002), the two common approaches for data modeling are the entity relationship model and the object oriented model. The basic component of the entity relationship model are entities, relationship, and attributes. An entity is an object event or concept in the user environment about which is maintained. A relationship is a meaningful association between entities. Object oriented modeling represents the world as object class. Object class are similar to entities in the entity relationship model but in addition to having an attributes and relationships. Also, they exhibit behavior, which is represents how the object acts and reacts to events.

2.3 Database and Geodatabase Structures

A physical database object class are tables and attributes are columns in the table. An object is row in the table (object class), thus all objects in an object class have similar attributes. The database structures: classes, objects, and attributes demonstrates the figure as below Figure 2.

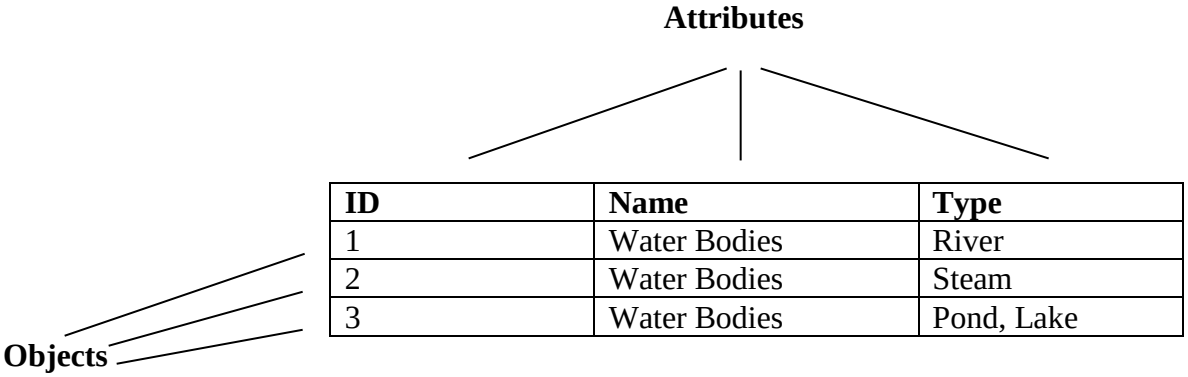


Figure 2: Database Structures: Classes, Objects, and Attributes

Geospatial database are distinct from other information systems by their capability to store spatial information using spatial classes and objects. The ArcGIS geodatabase is a physical store of geographical information inside a database management system (ESRI, 2003). The geodatabase spatial classes called feature classes and the shape file feature class geometry of the objects within the class. The feature classes used to represents the objects as points, lines and polygons. The polygon feature class as below Figure 3.

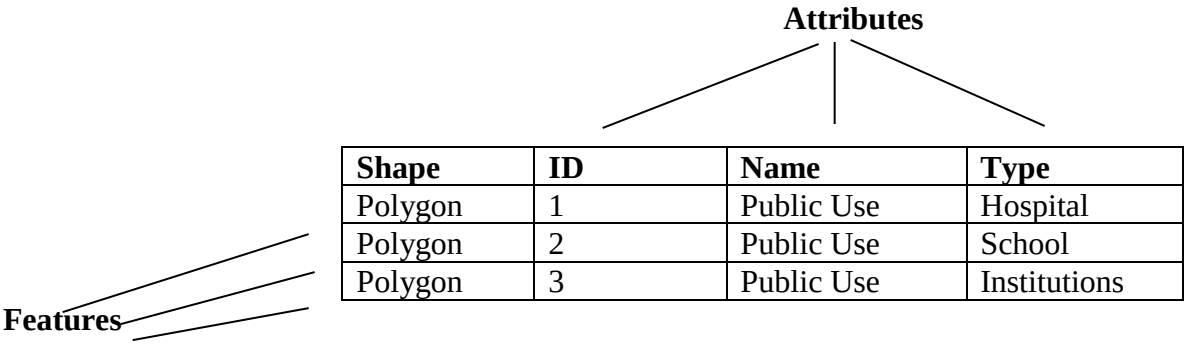


Figure 3: Polygon Feature Class

GIS database shows the detail information of urban planning in Nepal. This database is use for updating and future use in land use planning process. Present land use database prepared for this research is followed as Geo-database provided by NLUP specification and research knowledge as below Table 1.

Table 1: Database for Present Land Use Land Cover

Field	Data Type	Description	Remarks
FID	Feature Id	Feature	FID
SHAPE	Geometry	Geometric Object type	SHAPE
ID	Long	Unique Object ID	ID
LEVEL1	String	Land Use Class	LEVEL1
AREA	Double	Area in Square KM	AREA

3. STUDY AREA

Rampur Municipality is located in northern part of Palpa district. It covers the area of 123.34 sq. km. The municipality is surrounded by Wakamalang VDC in east, Heklang VDC in the west, Chapakot Municipality, Sekam, and Sakhar VDCs of Salyan district and Gajarkot VDC of Tanahu district in the north, and Birkot, Ringneraha, Siluwa, Galdha, Jhirubas and Sahalkot VDCs in the south. It is situated at the altitude 250m to 1850m and 270 48' 9.84" to 270 55' 38.32" N latitude and 830 39' 23.73" to 840 0' 8.57" E longitude.

5. MATERIALS AND METHODS

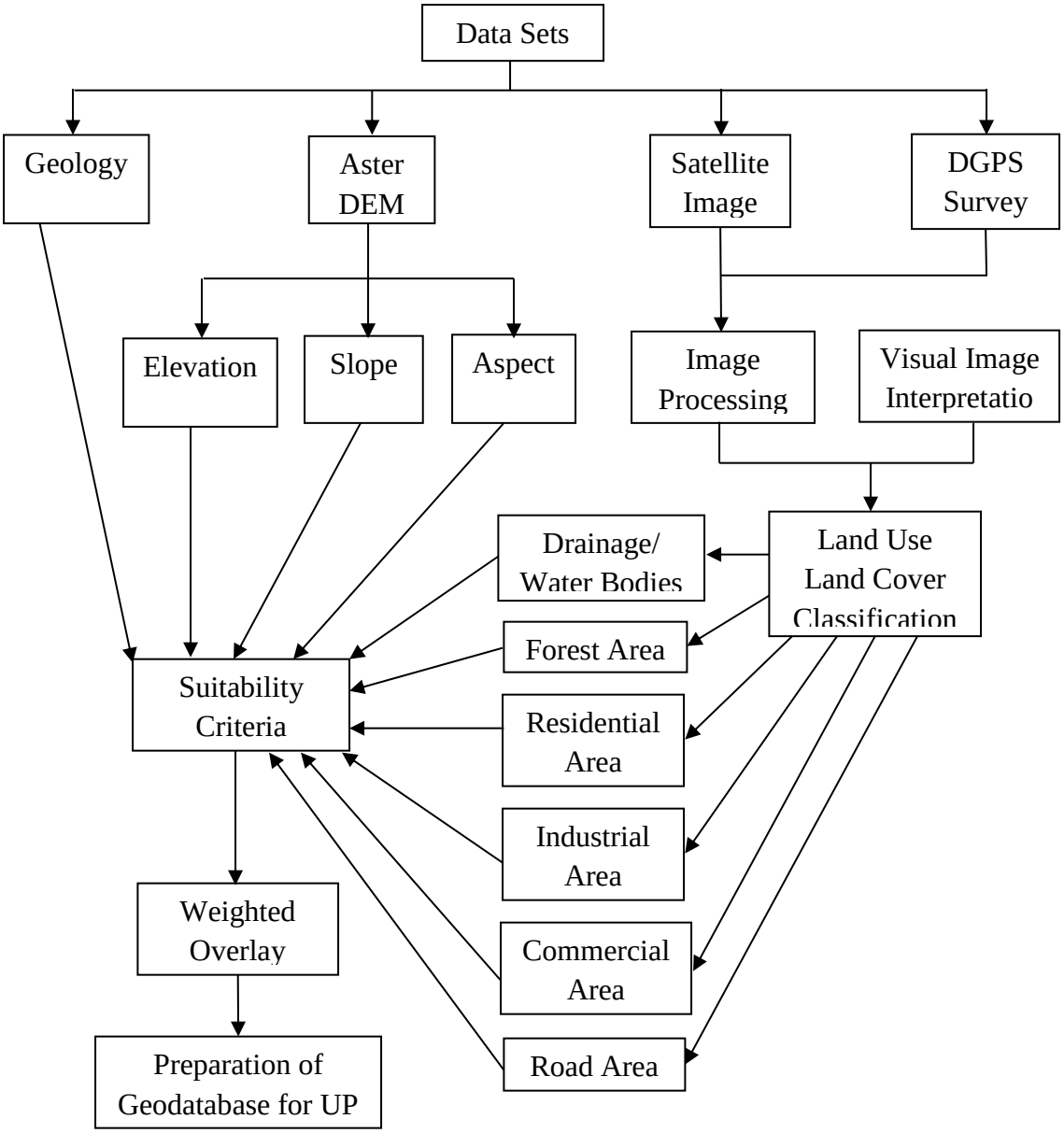
6.

The Topographical Maps of the Study area are covered under 2880 04D, 08A, 08B, 08C, 01C, 05A, 05C in the scale of 1:25,000 scale bearing supplementary contour of interval 10m. These maps are published in 1996 and are compiled from 1:50,000 scale aerial photography of December, 1990 and field verification done in December, 1991. The Topographical Maps were used for planning process of GCPs collection with DGPS survey and also used for feature extraction of dataset such as Municipality boundary, location name, and additional data for GIS based analysis. The list of data types and sources as below in Table 2.

Table 2: Data Types and Sources

Data Type	Year	Scale / Resolution	Source
Topographical Maps	1996	1:25000	Department of Survey
Geology Map	1978/79	1:125000	Department of Survey
Digital Globe 4 Band Satellite Image, PAN & MSS	March 07, 2015	1m PAN and 2m MSS	National Land Use Project
Aster DEM	2011	PS. 30*30	Download from USGS Website
DGPS Survey for GCPs and field verification	2015	Boundary & Land Use	ERMC team including me

The research work is basically spatial data preparation from the high resolution satellite image by visual image interpretation method. The suitability analysis and weighted overlay analysis is the specific approaches and methods adopted to Preparation of Geodatabase for Urban Planning in Nepal. The work flow diagram in Figure 4 as below.



Suitability Criteria for Urban Development

The urban development carried out on the basis of GIS based spatial analysis using weighted overlay analysis on several available data sets. The data files comprised the various parameters like geology, elevation, slope, aspect, and land use land cover parameters used for identifying the areas for suitable for urban development. A rule base was developed by using multiple-criteria on the basis of research knowledge for land use planning. These criteria were used to identifying a suitable areas for urban development area and geodatabase for urban planning. The ArcGIS 10.2 software was used for GIS analysis. The process for identifying the suitable areas map begins with ensuring all data are in the appropriate raster format. The polygon shapefiles such as geology buffer, forest area buffer, drainage/water bodies buffer, residential area buffer, commercial area buffer, industrial area buffer and road area buffer should be converted from vector to raster using Feature to raster tool. A slope raster was created using the elevation raster using spatial analyst tool. All raster files should be reclassified using reclassify tool. The appropriate distance values were binned into four classes based on Table 2 and favourability values were assigned. The all criteria types (1-4) elevation and slope raster were assigned to correct favourability classes, which is started were: 1= not suitable, 2= least suitable, 3= moderately suitable, and 4= highly suitable. All reclassified raster were added as inputs in the weighted overlay tool. This resulted in a final suitability raster for suitable areas for urban development final map production.

Table 3: Weight for Areas Suitable for Geodatabase Preparation of Urban Planning

S. N.	Category	Criteria	Value	Suitability Level
1.	Geology	Unconsolidated Sediments	4	Highly Suitable
		Sallyan Series	3	Moderately Suitable
		Midland Metasediments Group	2	Least Suitable
		Thrust Buffer 100m	1	Not suitable
2.	Elevation	< 500m	4	Highly Suitable
		500 – 750m	3	Moderately Suitable
		750 – 1000m	2	Least Suitable
		> 1000m	1	Not Suitable
3.	Slope	0 – 10 Degree	4	Highly Suitable
		10 – 20 Degree	3	Moderately Suitable
		20 – 30 Degree	2	Least Suitable
		> 30 Degrees	1	Not Suitable
4.	Aspect	157.5 – 202.5	4	Highly Suitable
		112.5 – 157.5 and 202.5 – 247.5	3	Moderately Suitable
		90 – 112.5 and 247.5 - 270	2	Least Suitable
		0 – 90 and 270 - 360	1	Not Suitable
5.	LULC	Agriculture	4	Highly Suitable

		Buffer of Forest 100m, River 40m, Stream 20m, Commercial 20m, Residential 20m, Public Use 20m, Industrial 20m and Road 20m	1	Not Suitable

Weighted Overlay Analysis

Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis (ESRI, 2015). Weighted overlay only accepts raster input such as geology, elevation, slope, aspect, and LULC in this research. The raster is required reclassified before they can be used. The values of raster are grouped into ranges must be assigned a single value before it can be used in weighted overlay tool. The assign weights at the time of reclassifying the cells in the raster will already be set according to suitability. The output raster can be weighted by importance and added to produce an output raster using weighted overlay tool using in ArcGIS. The tool was used for to locate suitable areas, higher values generally indicate that a location is more suitable.

5. PROCESS

The weighted overlay analysis process used for identifying the suitable areas for urban development and geodatabase for urban planning. In this research, the five subjective criteria ware used for urban development area selection.

5.1 Geology

Rampur Municipality of Palpa district is mainly composed of red soil and clay in the Lesser Himalaya. Geologically, it has 1) recent and Pleistocene formation by alluvium, the work of water including river terraces. It also has 2 major fault along the Kaligandaki River and foot of the hills in the south 2) Southern Part of the area consists of Precambrian to recent Cambrian with Jarbutta formation with shale and lime stones. In this research geological data has been used for the analysis of terrain and slop of study area which is helpful for the analysis of urban planning at present and future urban development. In the base of geological map study identified the suitable area of urbanization and other infrastructure development. According to the analysis thrust area is identified which is support for the development process.

5.2 Elevation

The elevation will show the elevation situation of the Rampur municipality. Almost all the area of Rampur falls under the slopping land. Elevation of this municipality ranges at the altitude 250m to 1850m above mean sea level. There are four class of elevation i.e. < 500m, 500m – 750m, 750m – 1000m and > 1000m. The elevation of < 500m is useful for residential, commercial, and industrial suitable areas for urban development. The < 500m is highly suitable areas for urban development

and it gives the high weight and > 1000m is not suitable for urban areas so it gives the low value for planning criteria.

5.3 Slope

The terrain of middle hill of Rampur municipality is flat to very steep. The slope degree (^{o}) of this municipality is 0^o to 84^o. There are four class of slope i.e. 0^o – 10^o, 10^o – 20^o, 20^o – 30^o and the maximum gradient is 30^o and above. The slope of 0^o – 10^o is more useful for residential, commercial and industrial areas suitable for urban development. The > 30^o slope is not suitable for planning. The suitable area slope is high weight value and not suitable areas for low weight value.

5.4 Aspect

Aspect identifiers the downslope direction of the maximum rate of change in value from each cell to its neighbors. Aspect can be thought of as the slope direction. The values of the output raster will be the compass direction of the aspect (ArcGIS ESRI, 2016). Aspect is better for urban development as a face of East or South direction according to sun light direction. Sun always rise from East direction and set in West direction. According to the sun light direction East and South face sufficient light for winter season. North face very poor light so it is always cold. So, South direction is highly suitable i.e. high weight and North direction not suitable i.e. less weight.

5.5 Land Use Land Cover

The land use land cover map is the basic criteria for identifying suitable areas for urban development. The criteria parameters as geology buffer, forest area buffer, drainage/ water bodies buffer, existing residential area buffer, existing commercial area buffer, existing industrial area buffer and existing road area buffer are not suitable for urban development.

6. RESULT AND DISCUSSION

Suitability Analysis for Identifying Suitable Areas

The weighted was provided to the criteria on the value of 1 to 4 based on the research knowledge. 1 is being assigned to completely restrict for weighted overlay analysis. The suitability level and values of identifying suitable areas for urban development Suitability Level and Value Table 4 as below.

Table 4: Suitability Level and value

S. N.	Value	Suitability Level
1.	4	Highly Suitable
2.	3	Moderately Suitable
3.	2	Least Suitable
4.	1	Not Suitable

6.1 Geology

The geological categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Geology Weighted Value Table 5 as below.

Table 5: Criteria for Geology Weighted Value

S. N.	Category Geology	Value	Suitability Level
1.	Unconsolidated Sediments	4	Highly Suitable
2.	Sallyan Series	3	Moderately Suitable
3.	Midland Metasediments Group	2	Least Suitable
4.	Thrust Buffer 100m	1	Not Suitable

6.2 Elevation

The elevation categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Elevation Weighted Value Table 6 as below.

Table 6: Criteria for Elevation Weighted Value

S. N.	Category Elevation	Value	Suitability Level
1.	< 500m	4	Highly Suitable
2.	500 – 750m	3	Moderately Suitable
3.	750 – 1000m	2	Least Suitable
4.	> 1000m	1	Not Suitable

6.3 Slope

The slope categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Slope Weighted Value Table 7 as below.

Table 7: Criteria for Slope Weighted Value

S. N.	Category Slope	Value	Suitability Level
1.	0 – 10 Degree	4	Highly Suitable
2.	10 – 20 Degree	3	Moderately Suitable
3.	20 – 30 Degree	2	Least Suitable
4.	> 30 Degrees	1	Not Suitable

6.4 Aspect

The aspect categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for Aspect Weighted Value Table 8 as below.

Table 8: Criteria for Aspect Weighted Value

S. N.	Category Aspect Direction	Value	Suitability Level
1.	157.5-202.5	4	Highly Suitable
2.	112.5-157.5 & 202.5-247.5	3	Moderately Suitable
3.	90-112.5 & 247.5-270	2	Least Suitable
4.	0-90 & 270-360	1	Not Suitable

6.5 LULC

The LULC categories with weighted value as below. The sub-classified into four sub-criteria which are 1 to 4 values i.e. not suitable to highly suitable. The presented Criteria for LULC Weighted Value Table 9 as below.

Table 9: Criteria for LULC Weighted Value

S. N.	Category LULC	Value	Suitability Level
1.	Agriculture	4	Highly Suitable
2.	Buffer of Forest 100m, River 40m, Stream 20m, Commercial 20m, Industrial 20m and Road 20m	1	Not Suitable

Suitable Areas for Urban Development

The suitable areas for urban development and preparation of geodatabase for urban planning was prepared on the basis of geology, elevation, slope, aspect and LULC with weighted value 1 to 4 i.e. not suitable to highly suitable where 1 is restricted value with weighted overlay analysis in ArcGIS software. Data for the Rampur municipality has been organized into six feature datasets in which twenty feature classes are stored. The dataset also includes two raster datasets which includes satellite imagery for study area for 2015, Digital Elevation Model, Slope for the Rampur municipality. It includes demographics table from census 2011.

Table 10: List of All Datasets in Geodatabase

Feature Dataset	Feature Class	Feature Class Type	Description
Administrative Boundary	Municipality_Boundary	Polygon	Municipality Boundary

LULC	Land_Use_Land_Cover	Polygon	Land use land cover
Raster Datasets	DEM	Raster	Digital elevation model
	Geology	Raster	Geology Raster
	Elevation	Raster	Elevation Raster
	Slope	Raster	Slope model
	Aspect	Raster	Aspect Model
	LULC	Raster	LULC Raster
	Weighted_Final	Raster	Final Map
	Satellite_Image_PAN	Raster	Panchromatic Satellite Image

The ArcCatalog structure of geodatabase as below Figure 5.

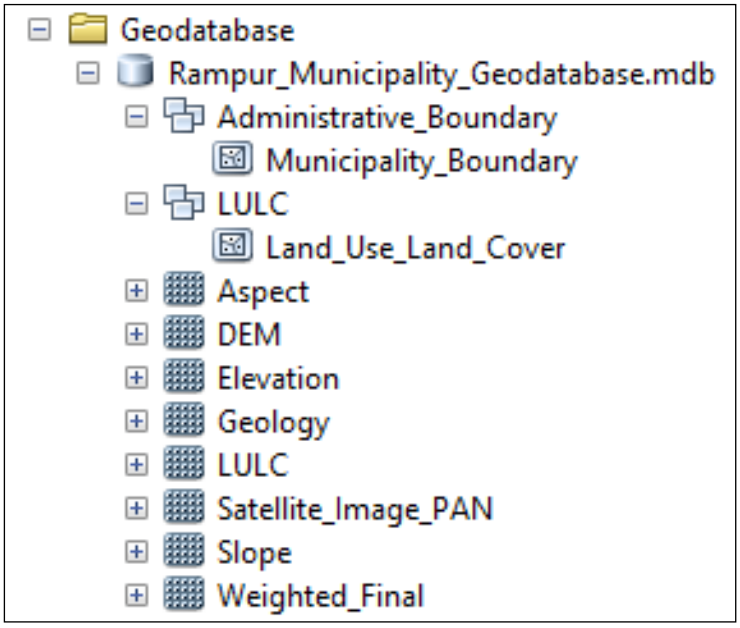


Figure 5: ArcCatalog Geodatabase

7. CONCLUSION

Urban growth and land use study is very useful in local government as well as in urban planners for the appropriate plans of land use planning in sustainable urban development. Urban development provides the knowledge for the planners and decision makers, the required information about the current state of development and the nature of changes that have occurred, physical conditions, public service accessibility, economic opportunities, local market, population growth, and government plans and policies are the driving forces of planning process. GIS and Remote Sensing provides spatial analysis tools which can be applied at the municipality, city and district level urban development planning. The present land use pattern of the municipality under study is classified by using remotely sensed image with the help of ground based information.

Lack of clear guidelines on the classification system has posed a level of difficulty in assigning the classes of different hierarchy in land use categories. Hierarchical classification system helped in incorporation of complex land use pattern of this municipality. NLUP specification and research knowledge classification system used in the study attribute to standardization in the land use land cover result among this municipality. Digitization and visual image interpretation incorporated with extensive field visit and use of ancillary data such as geology map, and topographical map. The land use classes yield better accuracy because the classes are designated manually based on ground knowledge and visual interpretation rather than automatic classification.

8. REFERENCES

ArcGIS ESRI, 2016, *ArcGIS Desktop 9.3 Help*, [Online] http://webhelp.esri.com/arcgisdesktop/9.3/index.cfm?TopicName=How%20Aspect%20works (10 February 2016).

ArcGIS Pro, 2016, *ArcGIS for Desktop, How Weighted Overlay Works*, [Online] http://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-weighted-overlay-works.htm (9 February 2016).

Booch, G., Rumbaugh, J., and Jacobson, I., 1999, *The Unified Modeling Language User Guide*, Addison-Wesley, Reading Mass.

Christiana Ade, 2016, *Suitability Analysis and Weighted Overlay*, NC State University GIS 520 Spring 2015, [Online] https://cadencsugis520.wordpress.com/suitability-analysis-and-weighted-overlay/ (9 February 2016).

Closa, D., Gardiner, A., Giemsa, F., and Machek, J., 2010, *Database and Database Management System*, Parent Law for Computer Scientists, Springer, Berlin, pp. 75-85.

DeBie, C. A., Leeuwen, J. A. V., and Zuidema, P. A., 1996, *The Land Use Database: Knowledge-based Software Program for Structured Storage and Retrieval of User-defined*.

Devogele, T., Parent, C., and Spaccapietra, S., 1998, *On Spatial Database Integration*, International Journal on Geographical Information Systems, Taylor and Francis, (12),:pp. 335-352.

Dikau, R., Cavallin, A., and Jager, S., 1996, *Databases and GIS for Landslide Research in Europe*, Geomorphology, (15),: pp. 227-239.

English, M, B., 2008, "*Geodatabase Design for Resource and Land Management GIS: Missoula Field Office BLM Case Study*", MSc Thesis in Geography, GIS and Cartography, The University of Montana, Missoula, MT.

FAO, 1993, "*Guidelines for Land Use Planning*", Food and Agriculture Organization of the United Nations, Rome, Italy.

Hoffer, J. A., and McFadden, F. R., 2002, *Modern Database Management*, 6th Edition, Prentice Hall, Upper Saddle River, NJ.

Kumar, S., and Kumar R., 2014, *Site Suitability Analysis for Urban Development of Hill Town Using GIS Based Multicriteria Evaluation Technique: A Case Study of Nahan Town, Himachal Pradesh, India*, International Journal of Advanced Remote Sensing and GIS, 3(1),:pp. 516-524.

NLUP Report, 2015, "*Preparation of VDC Level Land Resource Maps Database and Reports, Package - 20, Profile of Rampur Village Development Committee"*, Prepared by ERMC JV Satyam Consultancy P. Ltd., Government of Nepal, Ministry of Land Reform and management, National Land Use Project, Kathmandu, Nepal.

NLUP Report, 2015, "*Preparation of VDC Level Land Resource Maps Database and Reports, Package - 20, Present Land Use of Rampur Village Development Committee"*, Prepared by ERMC JV Satyam Consultancy P. Ltd., Government of Nepal, Ministry of Land Reform and management, National Land Use Project, Kathmandu, Nepal.

NLUP Specification and Policy, 2012, *National Land Use Project*, Ministry of Land Reform and Management, Government of Nepal.

Oli, P. P., 2014, *Preparation of Database for Urban Development*, FIG Congress, Engaging the Challenges - Enhancing the Relevance, Kuala Lumpur, Malaysia.

Oli, P. P., 2014, *Preparation of Database for Urban Development*, FIG Congress, Engaging the Challenges - Enhancing the Relevance, Kuala Lumpur, Malaysia.

Strassberg, G., 2005, "*A Geographical Data Model for Groundwater Systems*", Ph. D. Thesis, Faculty of the Graduate School, University of Texas, Austin.

Weerakoon, K., 2002, *Integration of GIS Based Suitability Analysis and Multi Criteria Evaluation for Urban Land Use Planning; Contribution from the Analytic Hierachy Process*, ResearchGate, University of Sri Jayewardenepura.

Williams, E., McMillan, B., Russell, C., Gruttemeyer, P., Miller, T., and Fife, K., 2008, "*Innovative Land Use Planning Techniques*", A Handbook for Sustainable Development, NH Department of Environmental Services.

Yeung, A. K., and Hall, G. B., 2007, *Spatial Database System*, Springer, Dordrecht.

ACKNOWLEDGEMENTS

We would like to express our heartily appreciation to Department of Survey, National Land Use Project, USGS Website, Environment and Resource Management Consultant Pvt. Ltd., and Geospatial Innovation Solution (GIS) Pvt. Ltd. for providing information and data sources for this research.

BIOGRAPHICAL NOTES

Ashim Babu Shrestha holds a BE in Geomatic Engineering from Purbanchal University, Nepal and MSc in Geographical Information Science and Systems (GIS) from University of Salzburg, Austria. He works on a Department of Mines and Geology, National Seismological Center, Lainchaur, Kathmandu, Nepal. He is currently affiliated to Nepal Geomatics Engineering Society (NGES), Nepal Remote Sensing and Photogrammetry Society (NRSPS), Nepal Surveyors Association (NESA), Diploma Engineers' Association, Nepal (DEAN), Nepal GIS Society, Nepal Engineers' Association (NEA), and Nepal Engineering Council (NEC).

CONTACT ADDRESS

1. Mr. Ashim Babu Shrestha
Institution: Department of Mines and Geology, Ministry of Industry, Government of Nepal
Position: Surveyor
Address: Lainchaur, Kathmandu
City: Kathmandu
Country: Nepal
Tel: +977-01-4410141
Fax: +977-01-4412056
Mobile: +977-9851045361
Email: ashimbabu@gmail.com
Website: www.ashimbabu.com.np

2. Mr. Punya Prasad Oli
Himalayan College of Geomatic Engineering and Land Resource Management
Coordinator
Address: Minbhawon Kathmandu,
City: Kathmandu
Country: Nepal
Mobile: +977-9841610545
Email: punyaoli@gmail.com

3. Mrs. Sumitra Shrestha
Institution: Geospatial Innovation Solution (GIS) Pvt. Ltd.
Position: Research Officer
Address: Chabahil-7, Gaurighat, Kathmandu
City: Kathmandu
Country: Nepal
Mobile: +977-9841003143
Email: sumitra.shrestha77@gmail.com
Website: www.geospatialnepal.com.np