Digital Conversion of Analogue Cadastral Maps of Kathmandu Metropolitan City

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Abstract: Land is the only immovable property that can be used, as a means for agricultural production as well as a means for mortgage for financing industrial or commercial enterprises. Spatial technologies play a key role in managing our land, water and natural resources. Cadastral data is a major component for the development of Land Information System. Therefore, systematic land registration system based on accurate and scientific cadastral map are found inevitable for poverty alleviation, good governance and women empowerment through security of their rights on property, as well as the planning and development of a sustainable environmental protection within Metropolitan city. Digital cadastral parcel is the fundamental spatial unit on which database is designed, created, maintained and operated. Availability of accurate and updated cadastral maps is a primary requisite for successful planning, policy formulating and maintenance of city utility services, which need cadastral and utility information together. Flawed cadastral maps can put land, revenue and taxation system at stake. Kathmandu the capital city of Nepal still is lacking utility maps combining cadastral information with the utility. There is an urgent need to have an effective, accurate and easy to access land revenue and utility services system within the urban areas which could be achieved after the production of reliable base maps and land registration system to guarantee land allocation and property rights which can well be achieved by digital conversion and correction of base cadastral maps. This paper highlights the drawbacks of the conventional cadastral maps and the possible advantages of digital cadastral maps over these. Also the problems, issues and implications during digital conversion and creating database of the same will be discussed.

Keywords: Cadastral, Database, Topology, Land Information System

1. Introduction

Systematic cadastral mapping in Nepal began in 1964 with the promulgation of land reform act 1962. The focus was to enact new land reform act nationwide that requires land records to generate revenue after defining land holding by the individual citizens. Both neither the national geodetic network was established nor any national coordinate system was developed to base such mapping, ground controls based on local base lines were being used to map the parcels during cadastral mapping.

Authority of the Kathmandu Metropolitan City is actively involved in the development of its planning support system. One component of the system involves the establishment of an Urban Management Information System (UMIS) for the city. At the heart of the system are new digital topographic maps of Kathmandu Valley and Kathmandu Metropolitan City at the scales of 1:10,000 and 1:1,000, and a digital cadastral database at the scale of 1:500. The Survey Department of His Majesty's Government of Nepal has undertaken the above said task.

In addition to topographic mapping, KMC has decided to use urban digital cadastral database as major source of information for physical planning and improving urban service delivery of KMC. The cadastral maps will serve as the base map for urban planning and development, and to improve specific KMC activities such as tax collection, building permit issuance and billing processes.

2. Objectives

- Search a system that is more effective in serving the people concerning the maintenance of cadastre data that make land administration easier and effective.
- Support the land information system and land consolidation program.
- Evaluation of constraints in the conversion of graphical cadastral data into digital format.

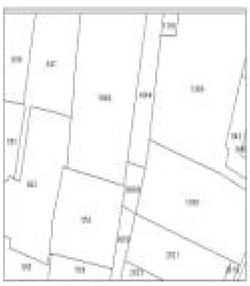
3. Existing Situation

The cadastral analogue data only bears georeferenced graphical map of parcels and parcel number with some symbols of transportation and building feature.

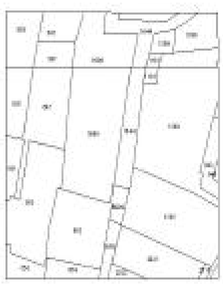
It does not bear other classified land cover features. It was only prepared for revenue collection. The Kathmandu metropolitan city requires LIS data for development process. It is not only limited to the formation of digital cadastral map but cadastral information with other land cover types. In a true sense, it needs large-scale topographic map with cadastral information.

4. Problems

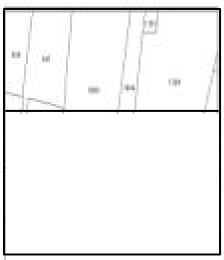
It was soon realized that conversion of cadastral maps into the digital form is not an easy task. Already the cadastral maps bears lot of edge matching problems. The cadastral maps have been adapted to the conformal modified UTM projection, which is the problem beforehand. Some of the maps are fragmented into different sheets, which had to be brought into the same sheets. Basic problem in the conversion process is the physical condition of maps, in many cases they were found very bad due to continuous use for long time such as dimensional distortion and legibility of drawings. Inconsistencies in basic data to be used for digital conversion created a lot of problems in edge matching. Second problem is the degree of update of details and thirdly mismatching of details at the edges of the map sheets. Parcel boundaries were found updated where as other features like building geometry and land use type was not updated. There are problems associated with conversion of parcel map/file maps.

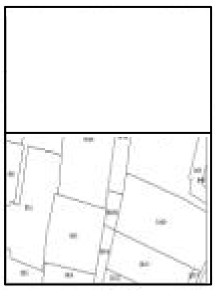


(i) A cadastral map having no data in the upper boundary.



(ii) Edge matched cadastral map





Sheet fragmented into different sheets.

5. Finding the Solution

Erroneous data were examined and solutions were found out, in some cases, by defining logical consistencies. Some map sheets were rescanned and re-vectorized. In some cases, data were re-georeferenced. Unmatched data but falling within error limit was ignored. Since cadastral data are not subject to change without any justification and at the same time other land cover details had to be incorporated on to the final map, the final product was not treated as digital cadastral map but the topographic map, just to liberalize the edge matching procedure.

6. Input Raw Data

As the primary requisite on a GIS is the input of raw data by processing which one can go forward for geo-processing to get the desired output, it is supposed to be supplied by the KVMP (Kathmandu Valley Mapping Programme) itself. The input raw data should have been vectorized with line and polygon information both having feature identity. At the same time, all these 1:500 scale digital data sheets should have been edge matched.

Digital mapping unit under Survey Department then proposed the following norms for digitization to the Kathmandu Valley Mapping Programme.

1. All ARC (linear) data in the master coverage (coverage with all layers) should have the user_id that would indicate which feature boundary it encompass of. (Superficially it seems that arc ids for the polygon feature are not needed for the work proposed, but it is indispensable for data processing in the operational level.)
2. All lines in the master coverage must be assigned by the unique feature type code.
3. It is suggested that CFCODE (Cadastral Feature Code) to be assigned according as priority order expressed below in case of common boundary.

   River, Road, Curb, Building, Fence, Pond, ... Parcel
4. If a common boundary occurs between features of same type, CFCODE must be assigned in the order provided by KVMP itself. E.g. CFCODE of a line between a concrete building (Pakki) and a ruined house (Bhatkieko) may be the assigned as that of the Pakki building.
5. Polygon features in master coverage must be assigned by label point of arc/info database
6. All sheets should be provided edge matched (except in case of arcs of parcel boundary going beyond threshold value indicated).
7. After Vectorization, data referring to each feature (only from indicated part) must be usable for printing to make a reference base map for fieldwork for updating.

7. Field Survey

Four 1:500 scale digitized maps was merged into one to generate a digital map sheet of 1:1000 scale map. Accordingly, this map was printed and was taken in the field to pick up the any change in data. After the filed work, the updated data are traced into different layers depending upon the feature class. The Field Section of the Topographical Survey Branch adopted plane tabling or tachometric survey for data acquisition to update the data printed in the scale of 1:1000 using the geodetic control points established by GPS.

8. Symbol Design

Since it is the first time that the work of conversion of cadastral data from analogue to digital form (also in the form of cartographic database) took place, a hard time was felt to design the digital symbol that to be incorporated into the hard copy final map (along with digital) to be delivered to the Kathmandu Metropolitan City (KMC). Since the GIS data were numerical as well as attribute code based, a proper significant symbol had to be designed which are symbolic and at the same time show the characteristics of the feature of reality. Similarly most of the features become conspicuous in the map if they are assigned with the same symbol as used in the conventional hard copy maps. Considering the time frame of the project, only point symbols were digitally created in the same pictorial form. Line symbol and polygon symbols were managed to prepare by manipulating the existing symbol that comes with the software.

9. Software Used

Following are the tools used to generate the data in the GIS.

(i) Arc View (ii) R2V Able Software (iii) Arc/Info (iv) Macromedia Fontograph (to design in new fonts, which were ultimately converted into point symbol)

10. Application Development for Perpetuating the Process

Programs necessary to automate the tasks of editing, data integration and visualization have been designed to accomplish the total work within the given period. Hundreds of customized programs were designed to carry the GIS work efficiently in the environment where some of the working personnel were even untouched with the computer and at the same time they are expert in mapping by manual method. Training and teaching were performed within the working clusters during the performance of the digital data creation. Programs regarding datum conversion, Projection, transformation and final visualization have been designed within the Survey Department to accomplish the task in the predefined time period.

11. Methodology

The workflow diagram in general form has been shown in the flowchart at the last of the paper. The real practice done due to inconsistency of the primary data supplied by the first party has been given in the flow chart, Annex-1.

12. Preparation of Digital Updated Element

The re-traced field-picked hardcopy element are scanned in the tiff format and then vectorized in the R2v software. They are assigned by the proper user_id (later to be converted into CFCODE.) The database model was kept in mind to incorporate the attribute data to each feature while they are being assigned by the user ids.

13. Data Conversion

The R2V prepared format of the point and arc data was converted into the arc info format by using the customized program named as R2V2INFO.sml. It is this program, which adds attribute field necessary for updating and generates topology. The status of the existing old arc data was numerically assigned as 4 where as the new updated data will have the status as 2. An extra column called FCODE is added for further code-security for technical purpose.

14. Data Overlaying and Updating

The new vectorized updated (geo-referenced) element is overlaid onto the old data. It is here the actual digital updating work starts. The data are interpreted by the code already assigned. Referring to the hard-copy updated map brought from the field, the data are updated in the computer. Finally, different layers are generated from the master coverage by using the code assigned.

15. Edge Matching

When updating is finished, all the sheets are undergone into edge matching. An attribute "fixed" or "Edit" assign each alternate sheet. All "edit" sheets were edge matched with respect to the "fixed" sheets. After the edge matching, the data are undergone checking and supposed to be prepared for printing. A fantastic methodology was designed for edge matching procedure. If it were done as mentioned by the general methodology described in the Arc/info system, it would almost difficult to accomplish as expected, though the editing as well as edge matching was done in the arc/info environment.

16. Visualization of data

After having all the data edge-matched they are transferred from the Arc/Info system to the Arc View environment. Any polygon assigned by false feature code is checked and corrected. Data are loaded into the view by the automated system, which triggers them to be visualized with the pre-specified symbol of consistent size. In this way a consistent cartographic database is generated and finally printed the hardcopy maps. The maps so generated are put forward to the Mapping Committee of HMG/Nepal, which gives guidelines if there are any comments to be checked and corrected.

17. Conclusion

Digital cadastral database is fundamental to the success of land information system. In order to enhance the capability of the system, it is therefore, imperative that data on land parcel must be available in proper format, which will enable the system to gradually migrate to full-fledged multi purpose cadastral system.

Cadastral database design is not a single step phenomenon, which starts and ends within the performance of the same nature of works. It is, in fact, by virtue of different natured performance by integrating, which an integrated information system can be modeled.

Cadastral Information System can be a basis for effective Land Administration of 21st Century since updating the fragmented land parcel is easier if done digitally.

Data accessibility can be made via the web (easy accessibility) but data security issue is equally sensitive. They tend to negate each other in real functioning.

Attributes of Cadastral data are highly volatile (in Urban area as the rate of transaction is high and effect of prevailing law of inheritance) and sensitive since it is connected to the property of people so that the metadata should be regularly maintained.
Technically, it is very sensitive to deal with the cadastral data in editing since any small inherent movement in geometry of data may raise legal issues. (E.g. an arc must be snapped at the ends to form a polygon, which may tend to alter the area of the parcel). Moreover, if there exist problems of mismatch between map sheets of original data, then it needs to be focused to analyze and rectify prior to the GIS input. Due to serious mismatch of data between sheets of cadastral maps, the final output of data was considered to be the topographic maps with the physical features since the metropolitan city needs such maps for infrastructure development.

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Annex-1

Work Flow Chart