

An Assessment on Cadastral Map Update Technologies in Nepal

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Abstract

This paper provides background information on the cadastral system in Nepal. It discusses the technique of cadastre surveying available for preparing and updating cadastral maps. It mainly focuses on contemporary international trends for cadastral map updating techniques, highlighting their pros and cons, and then summarizes the present scenario of cadastral map update in Nepal in order to determine a suitable way of cadastral update. The cadastral boundary survey has vital significance in the procedure of public cadastral service. The Land Administration Office (LAO) of Nepal has two distinct offices including the Survey Office for handling spatial component and the Revenue Office for maintaining administrative attributes of the cadastre. A complete cadastral map update with advanced technology is one of the main visions of the central mapping agency of Nepal. Since physiological diversities of Nepal do not support any particular technology for cadastre update, hybrid techniques such as photogrammetry and digital cadaster would be recommended.

Key words: cadastre, update, LAO, photogrammetry, total station

1. Introduction

1. Introduction to Nepal

Nepal is a landlocked country situated in South Asia. It is known as the land of Mt. Everest and the birth place of Lord Buddha. Though Nepal occupies 0.03% and 0.3% of the total land area of the world and Asia respectively, the country has a diverse topography and climate. The country stretches from east to west with mean length of 885 kilometers and widens from north to south with

mean breadth of 193 kilometers. Geographically, the country is divided with East–West ecological belts i.e. the Northern Range – Mountain, the Mid Range – Hill and The Southern Range – Terai (flat land). The capital city of Nepal is Kathmandu which lies in middle range (Nepal in Figures, 2015). The Constitution of Nepal 2072 B.S. has declared the Federal Democratic State of Nepal with seven states.

2. Research Problem

Cadastral map update has been a great headache

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for the central mapping agency, Survey Department and the government of Nepal as a whole. Cadastral maps of Nepal were prepared from plane table survey which was initiated from 2021/2022 B.S. and lasted for a decade or so. The purposes of preparing the cadastral map were to execute land hold ceiling, levy scientific land taxes and identify tenants for securing their right on land. But at present, land has become commodity which can be traded even through it is immovable. Urbanization, scarcity on availability of land, and increase in value of land necessitate for precise and accurate cadastral map which can only be obtained by updating the cadastral map using advance and modern surveying techniques. But, developing countries like Nepal are unable to update whole cadastral system because of financial, technical and HR hindrances. So, there is a need of a system for owner driven participatory cadastral map update which principally follows sporadic cadastral map update based upon the demand of land owner. This situation demands the appropriate cadastral map update technology that is modern, reliable, and fit to purpose.

3. Research Objectives

- To make comprehensive study of the techniques accepted in international scenario for cadastral map update
- To propose an approach for cadastral map update in context of Nepal

4. Research Questions

- What are the effective and efficient techniques for updating Cadastral Maps in Nepal?
- How is Government of Nepal attempting to update cadastral map that best fits public demand?

5. History of Cadastre in Nepal

Based on the existing record, the history of cadastral survey goes back to early 17th century in Nepal. Since then, partial surveys of land have been conducted several times in the essential locations. A systematic cadastral survey (graphical survey with plane tabling technique using local control points) however was commenced in 1965 where special care was taken to map land parcels along with dimensions accurately. The basic objective of early cadastral mapping was to assist in land revenue, to support the land reform and management program. Other objectives of mapping are to provide security of land titles to private and public land, to assist in policy formulation and implementation of land reform and management programs, and to establish a central archive of cadastral information (Survey Department [SD], 2017). Cadastral mapping work of 75 districts of Nepal was completed throughout the country in the year of 2000. Out of which 38 districts were mapped without the National Coordinate System Network, while mapping works of the remaining 37 districts were completed using the National Geodetic Network after the establishment of Geodetic Survey Branch under Survey Department in 1973. A decision was taken to re-survey those districts where National Control System was not connected and also to prepare parcel plan in the urban areas. Previously established nine Survey "Goswara" Offices have got responsibilities to carry out cadastral re-mapping works of some districts and they have been doing this mapping work until the beginning of the year 2009. On 13th February 2009, the Government of Nepal has dissolved all the Survey "Goswara" Offices and mapping works of those offices have been

transferred to the corresponding district survey offices (SD, 2017).

Due to the increase in population and great demand for land market, people are asking for updated and reliable land information. The relationship between man and land is becoming more significant and the people are more aware about their ownership right. The value of land as well has significantly increased over the time. Considering all these facts, the Cadastral Survey Branch under Survey Department has prepared a proposal for new innovative approach for cadastral mapping. This new approach is digital cadastral mapping. Since last few years Cadastral Survey Branch has been carrying out digital cadastral mapping.

II. Literature Review

Different studies have been conducted and are still ongoing to test appropriate new mapping and property rights registration toolkit for faster, cheaper, citizen-centric cadastral mapping and recording of land rights. The push for multi-purpose cadastres has been made possible by the availability of technologies to capture spatial data. The advancement in technologies such as the Global Positioning System (GPS), satellite imaging and Total stations have all made the capture of digital spatial data a relatively quick and easy process. So, there is now a vast amount of spatial data in digital form, stored by several organizations at various locations across the globe (Phillips, *et. al.*, 1998). Electronic Tacheometry method was used in cadastre as a ground surveying method because of its speed and sensitivity after 1985 in Turkey (Demir,

et. al., 2008). Electronic Tacheometry has become very effective tool in cadastral works especially in the rough, plant covered and urban areas after integration with computer technology. Digital cadastral works using this technique still are being used.

Weissmann (1971) and Gavish (1987) studied the application of photogrammetric techniques to cadastral surveys in Switzerland. The base maps developed from photogrammetric stereo- compilation show physical features which coincide or coexist with the legal boundaries or are used to locate points of detail that can be used as control for simple ground surveys. The cadastral maps are then compiled from a combination of photogrammetric plotting of boundary points and lines that are visible from the air with simple graphical methods of survey to locate specific land parcel boundaries. This method has been used in the United States of America (Karns, 1981), Kenya and Uganda (Dale, 1979). Ortho-rectified photographs are photographs that have been corrected for tilts and displacement due to relief and then the parcel boundaries are identified and scaled off the ortho photographs monoscopically. According to Konecny (2008), such ortho photographs are sufficient for cadastral purposes. This approach has been used successfully for land registration in Palestine (Mikkonen & Corker, 2000), Australia and Canada (Dale, 1979) and is currently being considered for the renewal of cadastral maps in a number of countries (Al-Ruzouq & Dimitrova, 2006). The approach which has been used in Thailand (United Nations, 1990), Botswana, England and Wales (Dale, 1979) involves the use of simply enlarged but rectified photographs to identify land parcel boundaries. The enlargements are reproduced

in the form of photomaps and used as a backdrop for graphical compilation of parcel boundary outlines. This approach however is only appropriate for relatively flat terrain for reasonably accurate measurements of distance and area. The other approach entails the identification and plotting of land parcel boundaries using simply enlarged and unrectified photographs and has been used in Kenya to prepare the so called Preliminary Index Diagrams (PIDs), which are only approximate (Mwenda, 2001). This approach results in the lowest positional accuracy, because no due care has been expended to correct for effects due to tilt and displacement due to relief.

Remote Sensing (RS) imagery can be used as an alternative to traditional land surveying approach for spatial data acquisition where most measurements can be done in the office (Tuladhar, 2005). Zahir (2012) studied the use of QuickBird panchromatic/color imageries and the Garmin eTrex GPS navigation receiver to develop a method for cadastral surveying through on-screen digitization techniques on the soft copy of high-resolution satellite imagery (HRSI). In this work, the QuickBird HRSI and the GPS navigation receiver are used for cadastral survey in consultation with the stakeholders including land owners and land administration authorities. In this method, the Garmin eTrex GPS navigation receiver is used for the survey of control points and SPOT5 stereopair is used for generating DEM which were then used in the process of HRSI ortho-rectification. Using HRSI, more parcels can be surveyed in a less time as compared to the old fashioned cadastral parcel boundaries surveying method. Zahir, *et. al.* (2012) formulated an integrated approach for updating

cadastral maps in Pakistan using satellite remote sensing data.

In the year 2000, Netherland's Cadastre and Land Registry Agency introduced real time kinematics (RTK) GPS to measure cadastral boundaries. Until that time, GPS was only used to survey control networks by the Agency for the National Triangulation Network. This use was limited to static survey, but when Fast Static and finally Real Time surveying with high relative precision was possible, GPS became an option as an instrument for measuring cadastral boundaries. The reliability issue is solved by measuring each point twice (with interrupted initialization) or three points in a line. Furthermore some additional surveys with a tape measure or total station and integrated adjustment of all those observations enable to ensure the reliability of the survey. When external GPS networks are used for cadastral survey, the antennas of those networks have to be certified by the Agency. This means that the co-ordinates should fit correctly in the National Triangulation Network. As soon as the technical part of surveying with GPS was under control, all local offices were confident with the new tool and investigation was conducted in the summer of 2002 to identify all possibilities and limitations of GPS in cadastral boundary survey, including the efficiency of the GPS-method. A study of the survey process revealed that GPS would have a positive effect on the whole process of cadastral survey. Surveyors and management would be more flexible in choice of instruments and the staffing of survey teams. When each survey is conducted with the most suitable instrument, the efficiency will increase. A GPS set is slightly more expensive than a total station thus

also increases investments (Wakker, *et. al.*, 2003). Meinel, *et. al.*(2001) and Herold, *et. al.*(2002) have carried out numbers of object-based classification applications using high resolution image which can be equally useful in cadastral map update.

Kosovo Cadastral Agency (KCA) with aid of World Bank in 2013 and 2014 successfully piloted the use of unmanned aerial vehicles (UAVs) or “drones” as a way to produce faster, fit-for- purpose spatial data (aerial photographs, orthophoto maps, and 3-D models) in Kosovo with the purpose to support the national cadastral reconstruction program. The team’s tests in 2014 demonstrated how UAVs allow local map production with very high accuracy (4–8 cm) in a matter of days. In addition to maps, the technology can produce 3-D models that can be used for multiple purposes (Meha, *et. al.*, 2016).

III. Research Methodology

This paper followed the qualitative research methodology which contains focus group discussion, interview with experts and developing a questionnaire for determining suitable technology for cadastre update in Nepal. Different levels of government employees of Survey Office, Dhulikhel, Kavre were brought in group discussion. They clearly provided present scenario of Cadastral maps of Kavre and other various districts in which they had served before. They presented their view on urgency for update of cadastral map using appropriate modern surveying technologies for immediate solution of problems encountered by them considering the demand and need of people. The value and use of land at particular area determine the accuracy with which a parcel is to be measured.

They also identified the government policies and taken steps to update cadastral map which are almost passive at present. Similarly, the interviews with the experts of Land Management Training Centre (LMTC) showed why present policies for cadastre update are heading to failure and what could be the better solutions. They also informed about initiations of government of Nepal for updating the cadastre. Social media Focus Groups were provided with the questionnaire and their digital responses were taken into account. In addition to that, some copies of the questionnaire were filled in hard copy too. Literature review was done to learn the international trends in cadastre update and to investigate the appropriate techniques in the context of Nepal.

IV. Data Analysis / Result

Cadastral update techniques from focus group discussion, interview, questionnaire and literature review was gathered and documented. Later, that information was analyzed to determine the present status of cadastre in Nepal, its update attempts, successes and failures. Many attempts from government of Nepal, Survey Department, are still going on but are unable to achieve the aim proposed when they were initiated. Re-Survey program using Plane table technique was initiated but could not be successful due to dissolve of “Goswara” in 2009. Considering all these facts, the Cadastral Survey Branch has prepared a proposal for new innovative approach for cadastral mapping i.e. the digital cadastral mapping. This approach has been carried out since last few years as pilot project in some parts of the country. Cadastre from photogrammetry

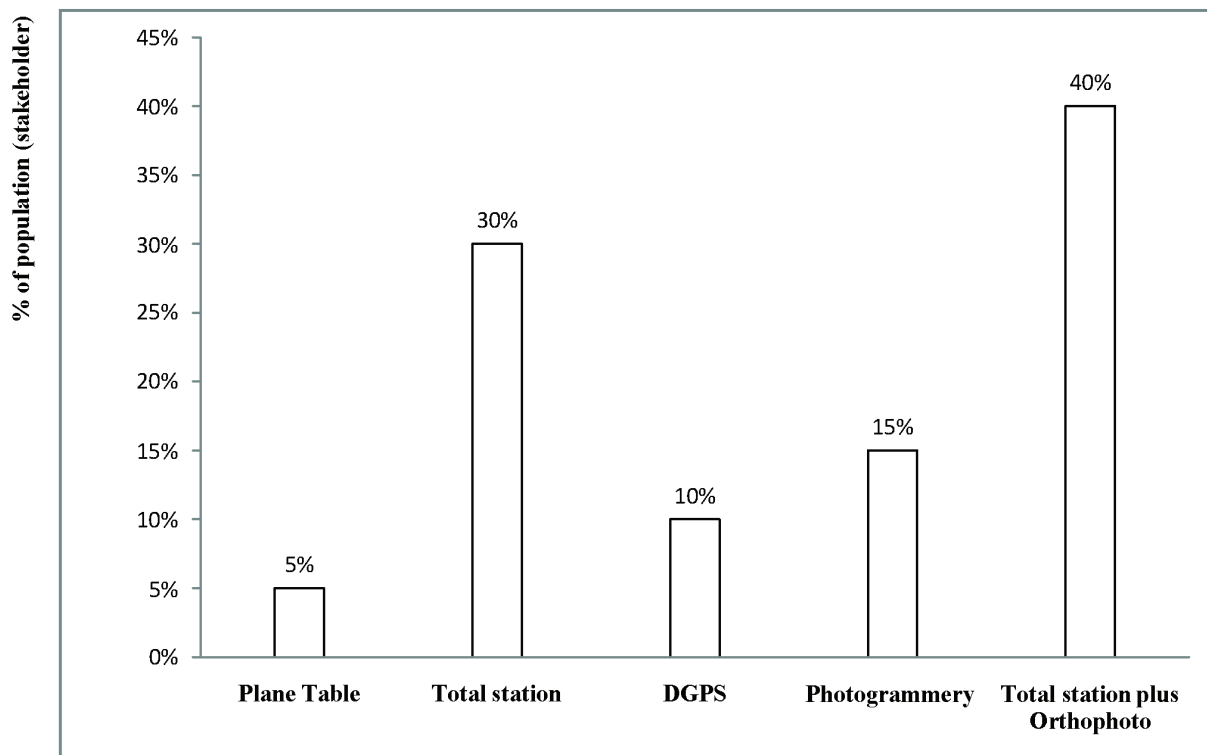


Figure 1. Summary of the questionnaire identifying better cadastral update techniques for Nepal

and Differential GPS (DGPS) is under study in Nepal. Although these technologies are commonly used in international scenario, they do not seem absolute in Nepal due to diversities in geography. The concept of cadastral update technologies based on terrain is indispensable. Similarly, the concept of 'fit for purpose' cadastral is emerging in order to support the process economically and technically. This study proposes the combination of various technologies for cadastral update in Nepal. For the plain terrain of southern part of Nepal, Terai, photogrammetry is suitable and for the rest parts of the country the field based digital cadastral using Total station is appropriate.

A very few stakeholders preferred plane table for cadastral update which was justified by the availability of human resource at present to operate it. Similarly, some suggested the use of GPS and DGPS for updating Cadastral map but it may not

be suitable for mountainous countries like Nepal due to some limitations. Some emphasized on photogrammetry technique for rapid and efficient creation of cadastral map. Lots of pilot projects of the cadastral map are ongoing in Nepal based upon total station therefore remarkable stakeholders preferred this techniques for cadastral map update. Regarding current plan and policy of Nepal Government for cadastral map update, bulk portion of stakeholders suggested the use of orthophoto and total station.

V. Discussion

Regarding the available technologies and desired spatial accuracy of the cadastral maps, it is vital to consider an appropriate technology for cadastral update in Nepal. Since the topography of Nepal ranges from flat area to mountain so, single

technology may not be self sufficient for entire country. Field based Plane Table can be used for area which does not require much spatial accuracy. But, this technology is almost out dated along with unavailability of its accessories. At present situation, we ought to cope with new technologies developed in international scenario and replace old technology with new one so that we won't be left behind in Cadastral update technologies. Digital cadastre using Total station can be used in hilly and mountainous area with grid of control points. The national grid of control points present in the country should be updated, maintained and further populated so that all the area can be surveyed using Total station. This technology also helps in creation of cadastral database, an important portion of land information system which will further initiate development of National Spatial Data Infrastructure (NSDI). Photogrammetry is another modern technology for cadastre update which is more appropriate for flat terrain. In photogrammetry, aerial flight is made along the flight path to capture images of the area. The images are processed in photographic workstations to produce Orthophoto which is free from tilt and relief displacement. Then, the orthophoto is used for production of cadastral map along with digital cadastre database. Both these technologies are modern and support digital cadastre. So, Total station and Orthophoto can be used for cadastre update in Nepal.

VI. Conclusion

Cadastre update is considered as a cumbersome process in Nepal. Cadastral Maps that are still used in the cadastral public services were preliminary

prepared for purpose of collecting the record of cultivated land in order to define land holding ceiling, to levy land revenue based on scientific method and to determine land tenants for securing their rights. But, land values particularly in urban areas are skyrocketing so, there is an urge for updated and more spatial accurate cadastral maps. These environmental settings for cadastre require modern digital technologies that generate digital cadastre database. The graphical methods of cadastre such as plane table are out dated and their instruments and accessories are difficult to access. So, plain areas of the country are required to be surveyed using photogrammetry generating cadastre map via Orthophoto and rest of the parts using Total station in national grid of control points.

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Appendix. Questionnaires for Cadastral Maps Update System in Nepal

Section A. Information concerning respondent(s)

	Respondent Details
1. Name	
2. Address	
3. Position	
4. Affiliation	
5. E-mail	
6. Comments	

Section B. Questionnaires for cadastral maps update system

Questions	Responses
1. How often the cadastral maps is updated (e.g. sporadic, periodic, cyclic, etc) in Nepal?	
2. Please indicate the public bodies responsible for update of national cadastral map in Nepal.	
3. Can regular parcel fragmentation record on cadastral map be termed as update? If yes/no, please mention why?	
4. What are the ways adopted currently by the mapping authority for update of cadastral maps?	
5. Which method is more appropriate in Nepal for cadastral map update (Orthophoto, T.S., DGPS, etc)?	
6. Please mention factors (e.g. market, tax value, maps condition) that trigger mapping agency for cadastral map update.	
7. What are the constraints that hinder in update of cadastral maps?	
8. Please mention the public registry datasets (e.g. cadastre, land registry, building registry) that are used in update of cadastral maps system.	
9. Is there any special cadastral maps database used for update of cadastral maps? If yes, please give the name of database, indicate responsible authority, and describe its content.	
10. Is there a web-based dissemination of cadastral maps? If yes, please indicate which data is open to the public.	
11. Do taxpayers have a right to appeal for national cadastral map update? If yes, please indicate how.	
12. Do we have a (computer aided) mass appraisal (evaluation) system in our country? If yes, please indicate also responsible authorities	
13. If there is to be national cadastral map update, what factors should be considered for it?	
14. Is three-dimensional (3D) information available in cadastral map? If no, is it to be considered in national cadastral map update?	
15. Do you think if 3D information is a necessity in cadastral map update? If yes, please mention, why do you think so?	
16. Is land-use and land-cover information need to be considered in cadastral map update? If yes, please mention, why do you think so?	
17. What do you think about land owner driven participatory cadastre map update system?	
18. How can a land owner participate in the process of cadastral map update?	
19. Any suggestions to the authorities concerning cadastral map update?	
20. Any last words?	