Potential Use of GPS Technology For Cadastral Surveys in Nepal

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Abstract

Global Positional Systems (GPS) now is competing with traditional surveying techniques in almost all fields of geodesy and cadastral surveying after the availability of highly productive new systems such as Real Time Kinematic (RTK) systems along with the use of Global Navigation Satellite Systems (GNSS). Although the cadastral mapping of the entire Nepal was completed in 1996 using graphical survey with plane table technique, derived information from the existing maps now are outdated and do not fulfil the needs of the general public. Updating cadastral maps is not only necessary but vital in Nepal. Survey Department under the Ministry of Land Reforms & Management, Government of Nepal now has to adopt an appropriate innovative approach for cadastral mapping in the country in order to meet the growing public demands on reliable land information system, to provide speedy land administrative services as well as for overall development of the country.

With continual research and development into GPS, the techniques and systems developed have become more reliable, cheaper and more productive, making GPS more attractive for a range of surveying solutions including cadastral mapping. Though high resources may be initially required for the RTK GPS technology for cadastral surveys in Nepal when compared to presently available optical surveying techniques, it would be justifiable in investing in GPS surveys. This technology, however, will not replace the existing survey techniques but it will provide another means in carrying out cadastral surveys especially in the area where the conventional technique is not economically and temporally viable.

1. Introduction

In the world, many tools and techniques have been applied in the past in the field of cadastral survey from chain surveying to plane table surveying (with plain alidade/telescope alidade). For the last few decades various techniques have been evolved in the cadastral surveys such as digital cadastre using Total Stations and Global Positional Systems (GPS) instruments, digital aerial photography, and cadastral mapping using high resolution satellite images.

Traditionally, GPS technology has been mainly used for high precision geodetic surveying, particularly in providing controls for developing national networks as well as for large engineering project works and cadastral mapping, but it is being increasingly used by surveyors for various surveying applications and solutions including large detail and contour works. With continual research and development into GPS, the techniques and systems developed have become more reliable, cheaper and more productive, making GPS more attractive for a range of surveying solutions. With the availability of highly productive new systems such as Real Time Kinematic (RTK) systems along with the use of Global Navigation Satellite Systems (GNSS), tasks for example; topographic surveying, engineering works and cadastral surveys all become potential GPS tasks. GPS now is competing with traditional surveying techniques in almost all fields of geodesy and cadastral surveying.

In Nepal cadastral survey of all 75 districts of the country was completed in 1995/96 using traditional graphical method with plane tables and telescopic/plane alidades. Derived information from the existing maps now are obsolete and do not fulfill the needs of the general public. An innovative survey technique must be adopted for the preparation of new series of cadastral maps for the country in order to create up-to-date land information database. The traditional graphical surveying methods are now very expensive and would take a long time. In most developed countries GPS survey methods are gradually replacing the traditional field survey works. GPS technologies for cadastral mapping have been applied in many developing nations of the world (e.g. Zimbabwe, India, Malaysia etc.) for the last few decades. RTK GPS technology, one of the latest technologies in the field of digital mapping, will provide accurate cadastral maps with relatively in short period of time and could be reasonably inexpensive. GPS technology probably could be another surveying tool for digital cadastral mapping as well as for developing land information systems for the country like Nepal. It has been noted that the accuracies of the observed points using RTK GPS technology are comparable to those obtained by conventional EDM/Total Station surveying for most cadastral purposes (Wan et al., 1999). Potential use of GPS technology for the preparation of new series of cadastral maps and developing land information systems in Nepal is briefly illustrated in this paper.

2. Need of Technological Changes in Cadastral Surveys in Nepal

Although the cadastral mapping of the entire Nepal was completed in 1996 using graphical survey with plane table technique, derived information from the existing maps now are outdated and do not fulfill the needs of the general public. Existing cadastral maps are not accurate enough for the present planning and development of the country. People are asking for updated and reliable land information based on new cadastral maps due to greater demand for land market and higher land values, especially in the urban and suburban areas. In addition, people are more aware of their ownership rights, areas and dimensions of land plots and values. Other reasons for the need of digital cadastral mapping in Nepal are land fragmentation resulting in small parcel size, problem of maintaining paper maps for the long period of time, scale factor in demarcation of plot boundary in the field, significant increase in property transactions etc. Considering all these facts Survey Department, Government of Nepal now has to adopt an appropriate innovative approach for cadastral mapping in the country in order to meet the growing public demands on reliable land information system and to provide speedy services. Updating cadastral maps is not only necessary but vital. Administratively, this process can be best performed by the persons who are already engaged in the preparation of cadastral records. As cadastral data is an essential component upon which all the development activities as well as land administration is based on, an alternative solution must be solicited for providing accurate and reliable land information for effective planning and sustainable development of country.

3. Justification for GPS Cadastre

An appropriate innovative approach for resurveying in Nepal is needed in order to meet the growing public demands on reliable land information. Introduction of new approach in surveys as an integral part of the technological change-process in order to create reliable land information system and to provide speedy services to general public. The technological change has not only to be right but should also be made more acceptable to the general public as well as to all the stakeholders. Application of new technology whose appropriateness is to be proved through reducing cost, producing accurate maps, and generating more timely and reliable information. In other words, the new technology has to be professionally appropriate, socially acceptable (by a vast majority of land-owners and stakeholders), and economically viable (i.e. it should be less costly when compared to the traditional technology).

One of the presently used noble technologies in updating existing cadastral maps is the use of digital survey technique. This technique must be adopted for the preparation of cadastral maps in order to create up-to-date digital cadastral database.

Although optical surveying equipments such as total stations are often used for digital cadastral surveys, many technical requirements are needed to overcome major obstacles. One of the major problems in using total station instrument for cadastre in the field is the requirement of huge number of traverse stations to cover the mapping area. These stations as well must have inter-visibility. In addition, destruction of established control points by the people, farming tools and other development activities are numerous. All these problems can be readily overcome in the field using GPS technology. Some of the major advantages using GPS cadastre are as follows:

- Traverse stages in the field for providing control points as required in total station surveys (including reconnaissance, demarcation, establishment, observations and adjustment) are not needed.
- Not requiring inter-visibility between observing stations
- Ground control stations can be provided even for isolated areas (e.g. in village block areas).
- It is more accurate and simpler for establishing control points for cadastral surveys.
- The destruction of control point problems can be solved readily as the coordinates of the control points can be restored digitally.
- GPS observations are not hampered by day/night or weather.
- Realistic accuracy (with position accuracy of ± 1 cm and area accuracy of ± 2 cm^2).
- Simple field operation and appropriate.
- Economically viable
- Increase flexibility and save time.
- Height of each observed points can be recorded (for reference only).
- GPS observed data can be processed and transferred to CAD design and GIS formats.
- Seamless data transfer between field and office can also be produced through wireless communication, plus automatic file updates in real time (e.g. Trimble Access software).

A case study survey was conducted in New South Wales, Australia to compare the use of the RTK technique and total station surveys for cadastral surveys. It was found that the RTK technique competes well with digital total stations survey methods in terms of accuracy, cost and efficiency (Veersema, 2004). The study result as well showed that the differences in derived co-ordinates values from RTK GPS and total station surveys ranged from 22mm and 16mm in easting and northing directions respectively.

4. Basic Concepts of GPS Surveying

The basic concept of GPS positioning technique is a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to GPS satellites. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver. Basically, a receiver on the earth tracks signals transmitted from orbiting satellites. Using these signals, the range or distance, to each satellite is determined by multiplying the measured transit time of the satellite signal by the speed of light. Thus each GPS receiver on the earth uses these signals to calculate its three-dimensional location (latitude, longitude, and altitude) and the current time. GPS derived positions are related to a mathematical representation of the earth based on WGS84 datum. In practice, at least four satellites must be observed to estimate the users' location. GPS has been designed in such a way that generally there will be 5 to 12 satellites available above a user's horizon at any point on the earth.

The concept of GPS studies initially was carried out in the 1960s and it was however developed in 1973 by the U.S. Department of Defence, primarily for navigation purposes giving positions in real time with an accuracy of between 5 and 20 metres. It was originally run with 24 satellites and became fully operational in 1994. Presently, there are 35 satellites in medium Earth orbit of which 30 are operational.

Although the American Global Navigation Satellite Systems (GNSS) is the most popular, the Russian Federation operates its own constellation of satellites (presently 24 operational satellites) called GLONASS which was made fully available to civilians in 2007. GLONASS system (October, 2011) presently has a constellation of 31 satellites with an approximate of 5 metres accuracy. The European Union has recently launched the Galileo system (expected to be fully operational in 2013) to wean itself from dependence on foreign controlled constellations in providing spatial location information for their applications. Galileo has 30 satellites in its constellation. There are also other planned Navigation Satellite Systems which include Chinese Compass Navigation System (BeiDou Constellation System). On the regional constellation systems, Indian Regional Navigational Satellite System (IRNSS) with 7 satellites and Quasi-Zenith Satellite System (QZSS), Japan with 3 satellites are planned for future PNT (Position, Navigation and Timing) and non-PNT regional applications.

Presently, a concept of the use of multi-GNSS has emerged in the world in order to maximize the benefits to the users. In this system, all types of constellation systems (GNSS, GLONASS, Galileo, COMPASS, IRNSS & QZSS) will work together and will be compatible, interoperable and interchangeable among each other. This will have multiple benefits to the users with the increase in availability and coverage, more robust and reliable services, higher accuracy in bad conditions, less expensive high-end services and better atmospheric corrections. Therefore, the challenge facing GPS manufacturers is now to develop receivers that can simultaneously compatible to all these systems.

4.1 Kinds of GPS Receivers

GPS equipment comes in various levels of sophistication; ranging from the simple handheld recreational receivers to the sophisticated sub-centimeter receivers. The handheld GPS is characterized by code receivers that give positional accuracies of greater than 1m. It is possible to use differential post-processing to improve accuracies to obtain centimeter level positional accuracies. GPS receivers that are capable of tracking only the L1 band are termed single frequency. Dual frequency equipment is able to track both L1 and L2 bands. Each of GPS satellites broadcast on both L1 and L2 frequencies and one satellite is currently broadcasting on L5 band (with higher accuracy). Most of the cheap GPS receivers (like the one in phone or car) track only L1 frequency from the satellites. For better accuracy, we need to track two frequencies from each satellite. Dual-frequency receivers are more expensive than single-frequency, however they are more versatile. Dual-frequency observations can be used to correct for the ionospheric error which becomes significant on baselines longer than 10km.

The sophisticated GPS receivers are classified as single or dual frequency depending on whether they receive L1 or both L1 and the more precise L2 bands that are continuously transmitted by orbiting satellites. These receivers have accuracies of the order of less than centimeter although this varies according to the length of the baseline (Goodwin, 2002).

The GPS receivers can be used to obtain absolute or relative positioning. Absolute GPS positioning can be carried out using a single receiver, resulting in absolute position of the receiver's location. The magnitude of the accuracies obtainable in absolute positioning however makes the technique not suitable for cadastral surveys due to various systematic errors (Blick, 1999).

By using two GPS receivers tracking the same satellites simultaneously, it is possible to remove many systematic errors and determine their relative difference in position to better accuracies (millimetre-level). The relative difference in coordinates between the receivers can be determined using a number of techniques which include code based Differential GPS (DGPS) or carrier phase based differencing. DGPS eliminates most of the errors due to ionosphere, troposphere, signal noise, ephemeris data, clock drift and multi-path.

4.2 Static and Real-Time Kinematic DGPS

DGPS can be carried out in various configurations of either static or RTK modes. The static mode is good for establishing control points. In static positioning both receivers are always stationary and is the most precise form of GPS positioning. It requires longer observation times. The coordinates of the fixed points are obtained some time after the fieldwork.

In the RTK surveying techniques, one or more receivers are placed on control points/reference stations (base stations) with known coordinates. One or more rover receivers can then be used to determine the positions of boundaries by means of the radio connection between the reference station and the rover. At least 4 satellites and preferably 5 or more must be observed during kinematic surveys. RTK methods use a datalink, usually in the form of a radio, to transfer reference station measurements to the rover receivers. RTK techniques provide results with very little delay and therefore are suited to set-out applications. RTK methods however are limited in terms of the range that the rover can be from the reference. Furthermore, results are only obtained where there is radio coverage from the reference station. The position of the rover is computed in near real-time because the time between receiving GPS data at the base station and the moving rover is very minimum and this time delay is known as *latency*. In most modern equipment, *latency* is less than a single second and poses no major problems in computation of receivers' position. Cordini (2006) points out that the classical single baseline RTK methodology allows for operations only within a range of 10-15 kilometres from the base station due to the correlation of some GPS errors with distance.

5. Need to Develop Guidelines for GPS Surveys in Nepal

In order to use GPS technology for cadastral surveys in the country, there is a need to develop a set of guidelines for the survey planning and design, testing/calibration of GPS equipments and field procedures for operating the equipment. In addition, guidelines should include how the coordinates are to be determined through survey control points, quality assurance, verification processes, and office procedures for data analysis.

6. GPS Surveys for Control Networks in Nepal

Although GPS technology has not been adopted for cadastral mapping in Nepal, it is basically used for establishing the National Geodetic Network System in the country by Geodetic Survey Branch of Survey Department. GPS was initially introduced in Nepal by a Japanese consultant in 1988 for the establishment of control points through photogrammetric triangulation process in the Lumbini Zone Mapping Project. Later, Survey Department in collaboration with University of Colorado and Massachusetts Institute of Technology, USA, has set up the precise GPS Geodetic Network throughout the country in 1991. Major objective of establishing this precise GPS Geodetic Network was to provide a precise control grid for the geodetic survey throughout the country. For establishing these high order control points, GPS instruments such as Trimble 4000SST and Ashtech Sll GPS receivers were used for the observations. During the observations, each GPS station was occupied with minimum of five days of at least 8 hours per day with each data measurement. The raw observed data in Ashtech and Tremble formats then were transformed to RINEX format using Berness V.3.3 GPS software. The coordinates of GPS control points were based on WGS84 reference datum. There were 28 such precise GPS controls in the network (Manandhar and Bhattrai, 2003).

In 1994, Eastern and Western Nepal Topographical Mapping Project under Survey Department as well have established GPS control points for producing new topographical map series of the country. While establishing these controls, static relative GPS surveys were conducted using dual frequency Astech LD-XII GPS receivers with 12 channels. All together 101 stations were established and observed for the mapping project, with the network consisting of 29 primary and 72 secondary stations.

Based on the latest information, Geodetic Survey Branch obesrved a national first order geodetic network consisting of 68 points by using Global Positioning System (GPS) all over the country. Determination of transformation parmater based on this controlled point of the network is underway. In addition, more than two thousand two hundred third order control points have been established in the country. Furthermore, this branch has planned to establish 10 Continuous Operating Reference Stations (CORS) in various locations of Nepal. In the first phase, it has planned to set up 3 such stations in Nagarkot, Jumla and Dhankuta areas. Geodetic Survey Branch as well is preparing to establish a GNSS/QZSS (Quasi-Zenith Satellite System) receiving station at Nagarkot in order to develop PNT (Position, Navigation and Timing) and non-PNT applications in Nepal, with the financial and technical cooperation from Japan Aerospace Exploration Agency (JAXA), Japan. Finally, the branch was able to derive preliminary Nepal Geoid result in the year 2011 based on 2010 Air Borne Gravity Survey data set of Nepal. National Space Institute (NSI) in cooperation with International Gravity Field Services (IGFS) of International Association of Geodesy (IAG) has funded to obtain the air borne gravity survey data set of entire country.

7. General Processes in GPS Technique in Cadastral Surveys

7.1 Equipment Calibration

GPS equipment that is to be used for cadastral surveys should be calibrated and standardized by surveyors before using it in the field. The quality of the calibration will affect the accuracy and consistency of the GPS coordinates of the points. Calibration should be based on the standard norms and guidelines specified by the Survey Department. The testing and calibration of GPS systems ensures that GPS-derived coordinates are of uniformly high quality (Wan et al, 1999) and also that GPS measurements are legally acceptable. The Survey Department should make it mandatory that each

GPS system to be used for cadastral work to undergo baseline and site calibration.

7.2. Establishing Control Points

Geodetic control points are the network of the GPS stations based on the National Coordinate Systems, which is surveyed to control all subsequent GPS cadastral measurements. The traverse should start and finish at known control points and traverse closure checks should be performed just as with conventional traversing. It may be established at the same time the cadastral observations are made. Geodetic control networks shall be established by either static or fast-static survey methods. Static and fast static techniques are suitable for setting up control networks. Normally, static GPS surveying technique is used to fix the control points in the area to be surveyed for cadastral purposes.

A well-designed control point network will offer the surveyors more flexibility in RTK survey methods for the cadastral mapping area. It provides an adequate amount of reference stations, ties the cadastral observation points together, allows for expanding area of the survey and provides accurate checks throughout survey area. The number of stations in the geodetic control network depends upon factors such as mapping area, topography, positioning method used, and access. A minimum of two or more geodetic control stations should be established as a reference for the cadastral surveys. As far as possible all the geodetic control networks should be referenced (tied) to at least two High Precision Geodetic Network or CORS.

7.3. RTK GPS Cadastral Field Procedures

In the RTK field stage it generally includes preparing sketches, observing and measuring points, and picking up all detail points of each land parcel. A thorough reconnaissance survey however is needed prior to the field work. The area to be mapped must be identified and the parcels drawn in a field sketch to facilitate the systematic identification of all parcel corners. Old maps can be used as a guide sketches to simplify the surveying process. A minimum of three GPS receivers, two base and one rover, are required for field surveys. Individual surveyors would require a rover unit to carry out cadastral surveys using RTK GPS. Before proceeding to the survey site, the surveyor should occupy two known control points. This provides a general check that the GPS receiver as configured is delivering the required accuracy. During GPS surveys it is essential to ensure that sufficient satellites (at least five or more at the base and rover stations) are available at the time of survey. X, Y and Z coordinates of each point is recorded in the field using GPS. Attributes data for the parcels are as well collected according to the designed database during the survey. RTK GPS cadastre surveying includes detailed measurements and setting out. This method allows the surveyor to make corner moves (stake out) similar to total station/data collector methods. A roving receiver will have an on-line connection to a reference receiver placed on known control points. This task implies real time surveying, where instantaneous position data are transferred from the reference station (control points) to the roving receiver in order to provide the coordinates of the roving receiver with respect to those of the stationary receiver with. The base station and rover should be set up on stable observation platforms and tripods should be used to stabilize plumbing poles. The surveyor should be wary of possible problems with loss of communication (radio link loss) between the base station and the rover. The surveyor can test this link by observation to an unknown point some distance from the base station and repeat this measurement at the end of the observation routine. In most instances, to achieve the radio link, the base station is placed on higher ground so that there is inter-visibility between the base and the rover.

A field book should be kept to record the names and order of the points observed and a graphic plan of the parcel layout. At the end of the surveys, the pair of known control points should be reoccupied to check that the receiver is still delivering the required accuracy.

It is important to check the following during RTK GPS cadastral surveys:

- The correct reference base stations are occupied.
- The GPS antenna height is correctly measured and entered at the base and rover.
- The receiver antennas are plumb over station at base and rover.
- The base coordinates are in the correct projections
- The reference base stations have not been disturbed.

- The radio-communication link is working.
- The RTK system is initialized correctly.

7.4. Post-Processing of GPS Observed Data

At the end of each day in the field the rover data should be downloaded to a personal computer and archived on a removable diskette prior to any processing for keeping back up field data. This ensures that a back-up copy of all raw data is maintained in case the data becomes corrupted in the post-processing stage. Differential data should be acquired from the two base stations.

Once data from the data collector has been backed up and base data acquired, the rover data can be differentially corrected. It is important to ensure that the reference coordinates, coordinate system and datum of the reference base station are correctly set in the processing software. All processing should be done in the national projection system. Differential correction need to be carried out, and it essentially involves the determination of corrections (in X,Y,Z) by comparing the pseudorange position of the base station point with its known position. These corrections are then applied to all pseudorange positions determined at the rover receiver location. This effectively removes pseudorange errors (due to clock, orbital, atmospheric and selective availability errors) from the rover positions. It is only through such differential correction that sub-meter accuracies can be achieved.

Most post-processing software handles data in its own format. In order to use other software on the data, it is necessary to convert the differentially corrected positions and the attribute data to a format that conforms to the specific software. Most GPS processing software provides a capability to export data files in a number of different GIS formats, including ASCII and DXF.

In order to present the GPS data in a graphical form and compute parcel dimensions and areas from the GPS coordinates, the data should be exported to a software package such as Auto Cad. This will typically require a conversion of the data from an ASCII to a DXF format or Arc GIS software format. This conversion can be done using surveying softwares or other add-on softwares (such as Terramodel, Ashtech Solutions, Business Centre-TBC, Survey Controller Software, Digital Field Book-TDFB etc.).

8. Limitations of GPS Cadastral Survey

One of the shortcomings of the proposed RTK GPS methodology is that it cannot easily be used in the areas under the forest canopy coverage. Some problems may be encountered when observing under trees with thick foliage. In such situation it would be better to place two or three marks in clearer locations, coordinate these marks using RTK techniques and then radiate or intersect the cadastral detail required using optical methodology e.g. a total station.

Another limitation of the use of RTK GPS methodology for cadastre survey is that it might not be suitable to some areas such as dense built up areas where satellite visibility is poor. For cadastral survey in the thick settlement areas with marginal sky visibility, conventional optical methods such as total station instrument are recommended instead of using RTK GPS.

9. Some Recommendations for GPS Cadastre

Though high resources may be initially required for the RTK GPS technology for cadastral surveys in the developing countries such as Nepal when compared to optical surveying techniques, it would be justifiable in investing in GPS surveys. In order to evaluate the newer technology for cadastral surveys, it is recommended to gain some practical experiences using both optical and RTK techniques to analyse the efficiencies of the technologies in terms of speed, cost, realistic accuracy, field operations etc. At the initial stage, and in order to increase acceptability of the RTK technology, the some jobs should be done in selected areas as a pilot project by Survey Department.

Once the RTK technology is justifiable, a series of workshop or training session should be conducted by Survey Department in giving exposure to the existing surveyors of the District Survey Offices to get familiar with this new technique in conducting cadastral surveys. It is necessary at this stage to educate the surveyors on the beauty and simplicity of using GPS surveying technique without being haunted by the complexity of the system. In addition, they must be well trained and educated in the use of GPS techniques, the testing and calibrations of equipment plus the appropriate field/office procedures associated with it. The RTK GPS technology then will be soon accepted as an alternative tool for cadastral surveys. However, it will not replace the existing survey techniques but it will provide another means in carrying out cadastral surveys especially in the area where conventional technique is not economically viable.

References

Barnes, G., M. Sartori, B. Chaplin, 1995. "A GPS Methodology for Surveying and Mapping Cadastral Parcels in Albania." Proceedings of ACSM-ASPRS Annual Convention, Charlotte, N.C.

Barnes, G., M. Eckl, 1996. Pioneering A GPS Methodology For Cadastral Surveying: Experience in Albania and Belize. Geomatics Program, University of Florida, Gainesville. USA.

Blick G., 1999. GPS Guidelines for Cadastral Surveys-OSG Technical Report 11, Office of the Surveyor General, New Zealand.

Cordini, C., 2006. Researching the Potential of NRTK in GPS Technical Support Newsletter, Issue 20 February, 2006, Victoria, Australia.

Economic Commission for Africa, 2008. Proposed GPS Survey Method for Cadastral Surveying of A2 Model Farms in Zimbabwe in Land Management Information Systems in the Knowledge Economy: Discussion and Guiding Principles for Africa, Addis Ababa, Ethiopia.

Goodwin, D., 2002. Guidelines for the use of GPS in Cadastral Surveys in Zimbabwe, unpublished.

Manandhar, N, M. Bhattrai., 2002. An Overview of Time Series of Geodetic and GPS Network of Nepal. Nepalese Journal on Geomatics, May-June, 2002, Number 2, 53-57. Survey Department, Government of Nepal, Kathmandu, Nepal.

Misra, P., 2005. Cadastral Surveys in India in Coordinates, Monthly Magazine, New Delhi, India.

Nassif, E.N., 2002. A Radical Solution for the Cadastre Problem in Egypt Using Integrated GPS-GIS System. FIG XXII International Congress. Washington, D.C. USA, April 19-26 2002.

Ses, S., M. K. Tong, C. W., T. C. Boo, 2000. Potential Use of GPS For Cadastral Surveys in Malaysia. Faculty of Geo-information Science and Engineering Universiti Teknologi Malaysia.

SGV, 2006. Guidelines for Cadastral Surveying using Global Navigation Satellite Systems (GNSS), The Surveyor-General of Victoria (SGV), Australia.

Tamrakar, R.M 2011. Impacts of Climate Change and Remote Sensing Technology in its Mitigation Options through Forest Management. Nepalese Journal on Geomatics, May-June, 2011, Number 10, 16-21. Survey Department, Government of Nepal, Kathmandu, Nepal.

Tamrakar, R.M 2012. A Prospect of Digital Airborne Photogrammetry Approach for Cadastral Mapping in Nepal. Nepalese Journal on Geomatics, May-June, 2012, Number 11, 1-6. Survey Department, Government of Nepal, Kathmandu, Nepal.

USDI, 2001. Standards and Guidelines for Cadastral Surveys using Global Positional Systems Methods Version 1.0. Bureau of Land Management, Washington, US

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