Centre for Research on Settlements and Urbanism

Journal of Settlements and Spatial Planning

Journal homepage: http://jssp.reviste.ubbcluj.ro

Assessing Usefulness of High-Resolution Satellite Imagery (HRSI) in GIS-based Cadastral Land Information System

Zahir ALI [1,2]
1Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), Karachi, PAKISTAN
2University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), THE NETHERLANDS
E-mail: zali@itc.nl, seezahir@yahoo.com

Keywords: *cadastral mapping, LIS, image processing, HRSI, GPS data*

ABSTRACT

The development of a GIS-based cadastre primarily depends on the availability of reliable spatial and non-spatial datasets. Currently, the cadastral maps in Pakistan are mainly of paper format. Detailed study shows lack of standards in these paper mapping products with out-dated information. Therefore, these maps cannot be used directly as an input to a GIS-based cadastral Land Information System (LIS). Such a situation demands that all cadastral information in these traditional maps be timely maintained in standard forms with quality indicators as information for the users. Considering the present situation in Pakistan, this paper firstly elaborates the present cadastral mapping system and the methods used for producing, updating, and maintaining these cadastral data. This research paper investigates on the use of High-Resolution Satellite Imagery (HRSI) and Global Positional System (GPS) that constitute vital elements in timely maintaining many of the cadastral data in GIS-based cadastral LIS. The abilities of remote sensing imageries in cadastral mapping are then assessed using QuickBird high-resolution satellite images for two case study areas with different topography i.e. a flat and a mountainous area in the Khyber Pakhtunkhwa province of Pakistan. This study introduces the use of QuickBird panchromatic/colour imageries and the Garmin eTrex GPS navigation receiver to develop a method for cadastral surveying through on-screen digitization techniques in the field on the soft copy of HRSI. This study shows that the cost and time can be reduced to its half if the cadastral maps are generated using the newly developed technique. Finally, the results are concluded for the use of HRSI data as an input to GIS-based cadastral information system in general and especially in Pakistan.

1. INTRODUCTION

The emerging new satellite technologies enabling earth observation at a spatial resolution of 0.6m or even 0.41m together with powerful and high speed computing and processing capabilities have brought revolutionary changes in the field of GIS-based cadastral land information system. The high-resolution satellite imagery (HRSI) is showing its usefulness for cadastral surveys due to which traditional cadastre and land registration systems have been undergoing major changes worldwide [1]. In this way the traditional surveying concept has taken up into new shape from discipline-oriented technologies, such as geodesy, surveying, photogrammetry and cartography into a methodology-oriented integrated discipline of geo-information. Such methodologies are based on global positioning system (GPS), remote sensing (RS), and digital photography for spatial data acquisition [2]. The developments in the field of Geographic Information System (GIS) technologies have given a new insight in addressing a variety of land development, management, and planning activities for better use of land in resource management. Due to rapid development in the space born technology nowadays it is possible to generate thematic maps on various scales keeping in mind end users' requirements. The locational accuracy of maps is utmost important for certain applications like cadastral

survey, infrastructure/utility maps, urban land use, land planning and land consolidation works etc. Cay et al. [3] showed that using one-meter resolution imagery and GPS controls, it is possible to achieve an accuracy of +/- 2 meters. Recent advances in space-based data capturing techniques (imaging) have revolutionized the field of cadastral surveying and mapping. All these improvements in satellite imaging have led to availability of better quality data/pictures for mapping applications [4]. Mamoru et al. [5] considered the possibility of IKONOS imagery for making topo-cadastral maps and their results suggested that IKONOS imagery has advantageous characteristics of interpretation for making and updating middle-scale topographical maps such as 1:25,000 compared with analogue aerial photo. They showed that horizontal accuracy of IKONOS ortho-imagery varies between 1.0-1.2m in flat areas and is worse in mountainous areas.

Updating land related information is very important so that changes of ownership and division of property can be recorded in a timely fashioned manner for documentation. One advantage of using images (either aerial photographs or HRSI) is that they provide a historical record of the areas that can be revisited in the future to see what changes have taken place. In this way old images can provide valuable evidence where conflicts occur in parcel boundaries [6]. Furthermore, traditional land surveying approaches are time consuming and require lot of efforts. Sometimes it is very difficult to do cadastral survey in remote areas especially in mountainous areas when the weather is harsh. In this case HRSI can be used as an alternative to traditional land surveying approach for spatial data acquisition where most measurements can be done in the office [7]. Keeping in mind the importance of HRSI, this research work includes an assessment of HRSI as an input to GIS-based cadastral land information system. This research work focuses on the usefulness of HRSI for parcel boundary surveying and delineation to improve quality of existing cadastral maps with land administration agency. Furthermore, this study also highlights the usefulness of HRSI in cost & time estimation for cadastral surveying and mapping. In this research work, the potential use of Garmin eTrex GPS navigation receiver and ortho-rectified colored pan-sharpened QuickBird HRSI having 0.6m ground sample distance (GSD) is assessed for digitizing cadastral boundaries both in flat and mountainous terrain study areas.

2. METHODOLOGY AND DATA USED

2.1. Methodology

In a GIS-based cadastral land information system, the attribute information (such as ownership, rights, area etc.) in the land registers are linked with the graphical information (such as boundary, shape, location etc.) on the cadastral maps using GIS technologies. The graphical information including cadastral boundary, shape, and location are prepared through cadastral surveys.

A cadastral surveying is a land measurement activity whose purpose is to describe new or changed land parcels boundaries and includes recovery and restoration of lost boundaries. The description may be textual, numerical, graphical or a combination of these. Cadastral surveys provide basic information about geometric description of land parcels including spatial location, size, and shape [8].

Generally cadastral surveys can be divided in direct and indirect methods. In direct method, the relative position of points is located first and the distance is measured later on. On the other hand, in the indirect method, the surveyors use aerial photographs to delimitate parcel boundaries and the polygons are digitized in a second step [9].

In this way, the cadastral surveying can be done by three possible options including; a) ground survey, b) aerial survey, and c) satellite images.

The first option comes under direct method while the remaining two options come within indirect method [10].

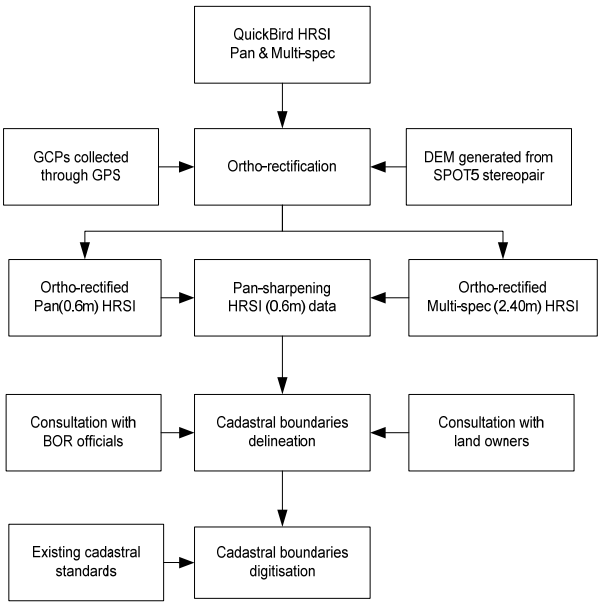

Fig. 1. Workflow for digitising cadastral boundaries using HRSI.

A GIS-based cadastral land information system primarily depends upon the available spatial and non-spatial datasets. In case of Pakistan, the available cadastral maps with land administration authority do not comply with the barest minimum standards for being used directly as an input to GIS-based cadastral mapping [11]. Such a situation demands that all these traditional maps to be updated and revised to a standard format in which the existing maps can serve as input in the process of updating or revision. The workflow to be used in this research work

for assessing usefulness of HRSI in cadastral boundaries digitization is shown in Figure 1.

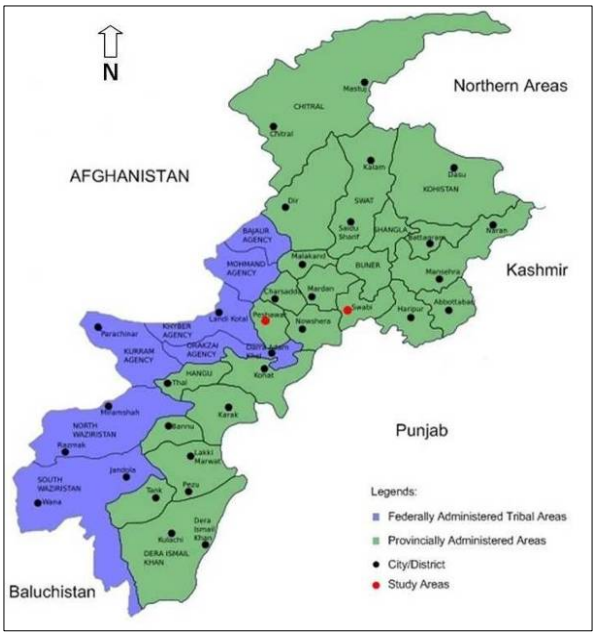

Fig. 2. Location of study areas on provincial map.

High-resolution QuickBird panchromatic images of 0.6m and colored images of 2.4 m GSD were acquired for both study areas. A SPOT5 stereopair with 2.5m GSD was also acquired for the Shalmani area to extract digital elevation model (DEM) information that can be used in ortho-rectification of this area. Due to flat nature of the Zormandi area, no DEM was used in this research work.

Two types of data were integrated in this research work; namely QuickBird ortho-images and field data including GCPs collected. Pre-processing techniques were carried out with HRSI to assess usefulness of remote sensing data during this research work. Field visits were carried out in consultation with BOR officials and land owners to locate and draw cadastral boundaries using field data and photogrammetric techniques. Ground surveys were also carried out for collecting ground control points (GCPs) using hand held GPS (Garmin eTrex navigation receiver) for ortho-rectifying these high-resolution satellite images.

3. DIGITISING CADASTRAL BOUNDARIES

After doing the pre-processing, the use of HRSI is to be assessed in cadastral boundaries delineation/digitization and cost & time required for cadastral mapping.

3.1. Digitizing cadastral boundaries in Zormandi area

The cadastral boundaries in Zormandi area were easily identified on the enhanced ortho-rectified HRSI as observed in figure 16. In this case, the field borders were trees, open area or presence of vegetation, roads or foot paths and water drainage with the presence of low height vegetation. The boundaries were digitized on ortho-rectified HRSI through consultation with Patwari and land owners in the field. In this case, field visits were carried out along with map prints of the HRSI and land owners were asked to find out their fields on the imagery.

The boundaries were then digitized using on-screen digitizing techniques using laptop after confirmation from the land owners and Patwari in their presence. These boundaries were digitized through ArcGIS v9.3 software. The boundaries drawn on HRSI in Zormandi area are shown in Figure 3.

Fig. 3. Digitised cadastral boundaries on HRSI in Zormandi area.

Due to flat nature of the study area, it was not so difficult to identify respective cadastral boundaries on HRSI. Moreover, the existence of trees on field boundaries also helped to draw cadastral boundaries easily and the field sizes were also according to the resolution of acquired imagery.

3.2. Digitising cadastral boundaries in Shalmani area

The cadastral boundaries in Shalmani area were digitized on ortho-rectified HRSI through consultation with Patwari and land owners in the field. In this case, field visits were carried out along with map prints of the HRSI and land owners were asked to find out their fields on the imagery.

The boundaries were then digitized using on-screen digitizing techniques using laptop after confirmation from the land owners and Patwari in their presence. The boundaries were digitized using ArcGIS v 9.3 software. The boundaries drawn on HRSI in Shalmani area are shown in Figure 4.

Shalmani area is mountainous in nature and it was not so easy to identify cadastral boundaries on

HRSI. The field shapes were not regular and field sizes were very small to identify on HRSI easily. Moreover, the HRSI data quality was not so good due to mountainous terrain and irregular scattering that affect quality of the data during acquisition. The shadow effect was also observed on HRSI in some parts of the study area creating problem in identifying boundaries efficiently.

Fig. 4. Digitised cadastral boundaries on HRSI in Shalmani area.

4. CONCLUSIONS

This study introduces 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 in the field on the soft copy of 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.

ACKNOWLEDGMENTS

I acknowledge Mr. Nouman Shah Jadoon (MBR), Mr. Kifayatullah Khan (DLR), Mr. Ajmal Bhatti (SO) of the Board of Revenue for their guidance and assistance with data collection. I also thank Pakistan Space & Upper Atmosphere Research Commission (SUPARCO), International Institute for Geo-Information Science and Earth Observation (ITC), the Netherlands, Higher Education Commission (HEC) of Pakistan and the Netherlands Organization for International Cooperation in Higher Education (NUFFIC) for providing this research opportunity and funding assistance.

REFERENCES

[1] **UN-FIG** (1999), *Bathurst declaration on land administration for sustainable development:* 18th and 22th October 1999, Bathurst, Australia. Copenhagen: the International Federation of Surveyors (FIG).

[2] **Tuladhar, A. M.** (2005), *Innovative Land Tools, Surveying and Geo-information Technologies,* presented at the Global Network for Pro-poor Land Tool Developers, Stockholm, Sweden, 2005.

[3] **Cay, T., Corumluoglu, O., Iscan, F.** (2004), *A Study on Productivity of Satellite Images in the Planning Phase of Land Consolidation Projects,* presented at the XXth ISPRS Congress "Geo-Imagery Bridging Continents", Istanbul, Turkey.

[4] **Ajai** (2002), *Mapping for Micro-Level Planning: The Issues & Challenges,* Indian Cartographer, vol. 22, 2002.

[5] **Mamoru, K., Toshihiro, K., Nobuyuki, W., Kaoru, M. J.** (2002), *Interpretation Characteristics of IKONOS Imagery and its Coordinate Accuracy Validation,* Journal of the Geographical Survey Institute, vol. 94, pp. pp. 38-47.

[1] **Dale, P. F., McLaughlin, J.** (1999), *Land Administration.* Oxford: Oxford University Press.

[1] **Tuladhar, A. M.** (2005), *Innovative use of remote sensing images for pro poor land management,* presented at the Secure land tenure: new legal frameworks and tools in Asia and the Pacific, Bangkok, Thailand.

[1] **Silayo, E. H.** (2005), *Searching for an Affordable and Acceptable Cadastral Survey Method,* presented at the From Pharaohs to Geoinformatics, Cairo, Egypt.

[1] **Corlazzoli, M., Fernandez, L. O.** (2004), *Spot 5 Cadastral Validation Project In Izabal, Guatemala,* International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. 35, pp. pp. 291-296.

[1] **Zahir, A., Arbind, T., Jaap, Z.** (2012), *An integrated approach for updating cadastral maps in Pakistan using satellite remote sensing data.* International Journal of Applied Earth Observation and Geoinformation, Vol. 18 (August 2012), 386-398.

[1] **Zahir, A., Muhammad, S.** (2012), *Implementing GIS-based Cadastral and Land Information System in Pakistan.* Journal of Settlements and Spatial Planning, Vol. 3 (1), pp. 43-49.